The IACLE Contact Lens Course

MODULE 3

Contact Lens Fitting

First Edition

Published in Australia by
The International Association of Contact Lens Educators

First Edition 2000

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Acknowledgements

The IACLE Curriculum Project is the result of a desire to raise the standard of eyecare education, to make contact lens wear safer and more successful, and to develop the contact lens business by creating the educational infrastructure that will produce the teachers, students and practitioners of the future.

The concept of the world's best educators making available their most creative educational contributions for the common good without any recompense, other than a sense of satisfaction, was born out of IACLE's idealism.

The Curriculum Project could not be successful without the assistance and generosity of a large number of talented and dedicated people. To all those contributors of lectures, laboratory notes, videos, slides, etc., we say thank you. Your generosity of spirit will benefit many educators, hundreds of thousands of students and millions of patients throughout the world.

The Vice President of IACLE, Professor Desmond Fonn, has made a tremendous contribution since the inception of IACLE, and has provided his considerable expertise in the final editing stage of the Curriculum. This project was commenced under Professor Brien Holden's leadership. The original plan and layout for the Curriculum was prepared by Sylvie Sulaiman, IACLE's Director of Education. Sylvie's dedication and excellent understanding of practitioner and community requirements have given the Project focus and depth.

More recently, the IACLE Curriculum Project has benefited from the work of Dr Lewis Williams as Manager, Educational Development. Dr Williams has done an amazing amount of work to achieve an impressive collation of diverse material, and has created what I believe to be an invaluable collection of contact lens knowledge. Dr Williams has also been assisted by Rob Terry's considerable experience and understanding of the contact lens field.

Kylie Knox has done an excellent job as Project Editor. To complement the efforts of the editors, layout coordinators Barry Brown and Shane Parker have done an admirable job, as have the rest of the graphics team. The Cornea and Contact Lens Research Unit (CCLRU) at the University of New South Wales has contributed substantially to this project through the donation of time, resources and editorial support.

The IACLE global staff including Director of Administration Yvette Waddell, Global Coordinator Pamela O'Brien and Executive Secretary Gail van Heerden, have expertly managed the considerable tasks of production and distribution.

No acknowledgments page in an IACLE document would be complete without a reference to its sponsors. Bausch & Lomb have been a major corporate sponsor since 1990, providing the original stimulus for IACLE's growth by contributing financial support and the involvement of individuals from their International Division. It was Dr Juan Carlos Aragon (when he was at Bausch & Lomb) who first suggested that if IACLE was to be taken seriously by industry, it needed a global plan to address the educational requirements for the safe, effective growth of the contact lens business. Johnson & Johnson Vision Products is our other major corporate sponsor. They have provided excellent assistance through their provision of industry coordinators for Europe, Africa, and the Middle East. CIBA Vision has been a corporate contributor and also provided excellent industry coordination in Latin America. Allergan and

Wesley Jessen/PBH have contributed generously as corporate donors, with Alcon Laboratories, contributing as IACLE donor.

IACLE is a cooperative effort, and none of its activities are more collective than the Curriculum Project. The IACLE Contact Lens Course which resulted from this project is provided to assist educators in accredited institutions to impart eyecare and contact lens knowledge. All the contributors deserve recognition for their selflessness and talent.

Debbie Sweeney

President of IACLE

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Educators Guide to the IACLE Contact Lens Course

Overview

The IACLE Contact Lens Course is a comprehensive package of educational materials and other resources for teaching the subject of contact lenses. This package was designed to encompass *The IACLE Contact Lens Course Syllabus* and covers 360 hours of lectures, practicals and tutorials in ten modules, containing material at basic, intermediate and advanced levels.

The teaching resources have been designed for flexibility, allowing the educator to select the materials appropriate to the students' knowledge and the educational requirements of the class, school, institution or country. The separate document, *The IACLE Contact Lens Course Syllabus,* summarizes the course and includes outlines of Modules 1 to 10.

The English language reference used for the IACLE Contact Lens Course is: Brown L (Ed.). *The New Shorter Oxford English Dictionary.* 1993 ed. Clarendon Press, Oxford (UK). The only spelling exception is *mold* and *mould.* The Oxford dictionary suggests *mould* in all contexts. We chose to use *mold* for manufacturing-related matters and *mould* for fungi since both meanings and spellings appear regularly in contact lens literature. This differentiation is based on common usage. Where words are 'borrowed' from a language other than English they are reproduced in their native form where possible.

Where standards have been ratified by the International Organization for Standardization (ISO), or where draft ISO standards are at an advanced stage, their relevant terminology and symbology are used. Système International (SI) units of measure are used wherever possible.

Many major contact lens textbooks from around the world, and some important journal articles, are referenced in the Course, and copyright illustrations are reproduced with permission of the original publishers and/or copyright owners. The reference section at the end of each unit details the information sources used throughout.

Teaching Resources - Module 3

Module 3 of the IACLE Contact Lens Course has the following materials:

1. Contact lens manual

The contact lens manual consists of:

- Course overviews
- Lecture outlines and notes
- Practical outlines, exercises and notes*
- Tutorial exercises and notes*

* Not all units have these sections.

The suggested lecture, practical and tutorial hours of the module are outlined in the Summary of Module 3 on page *xi*. The manual provides recommended activities, references, textbooks and evaluation techniques in the interests of their standardization. Ultimately however, the design and

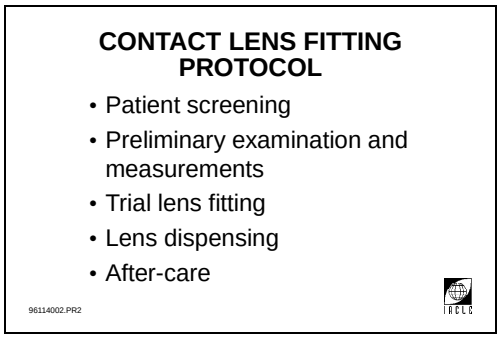
methodology of the course is left to the discretion of the contact lens educator.

2. Slides for lectures, practicals and tutorials

The slides have been numbered according to the sequence in which they appear in each lecture, practical and tutorial. Single or dual slide projection can be accommodated. Each slide has an identification code which is based on a cataloguing system in use at the IACLE Secretariat and which should be used in any communication with IACLE regarding the slides.

For example:

To re-order this slide please quote this identification code



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Symbols, Abbreviations and Acronyms Used in the IACLE Contact Lens Course

SYMBOLS			
↑	increase, high	{	collectively produced by
↓	decrease, low	}	collectively produces
→	produces, towards	Σ	sum of
←	produced by, from	±	plus or minΣus the value of
↔	no change, not obvious	+	plus, add, include, and
↑↑	significant/great increase	–	minus, reduce
↓↓	significant/great decrease	≈	Approximately equal to
%	percentage	=	equal to, the same as
<	less than	&	and, as well as
>	greater than	*x*°	degrees: e.g. 45°
≥	equal to or greater than	@	in the meridian of
≤	equal to or less than	D	dioptres
?	unknown, questionable	X	axis: e.g. –1.00 X 175. –1.00D cylinder, axis in 175° meridian
n, n_{sub}, n_{sub}´	refractive indices	Δ	prism dioptres or difference
∝	proportional		

ABBREVIATIONS			
μg	micrograms (.001 g)	min	minute, minutes
μL	microlitres (.001 mL)	mL	millilitres (.001L)
μm	microns (.001 mm)	mm	millimetres
μmol	micromoles, micromolar	mmol	millimole, millimolar
cm	centimetres (.01m)	mOsm	milliosmole

cm	centimetres (.01m)	mOsm	milliosmole
d	day, days	nm	nanometres (10^{-9} m)
Endo.	endothelium	Px	patient
Epi.	epithelium	Rx	prescription
h	hour, hours	s	second, seconds
Inf.	inferior	Sup.	superior
kg	kilograms	*t*	thickness
L	litre		

ACRONYMS			
ADP	adenosine diphosphate	LPS	levator palpebrae superioris
ATP	adenosine triphosphate	NADPH	nicotinamide adenine dinucleotide phosphate
ATR	against-the-rule	NIBUT	non-invasive break-up time
BS	best sphere	OD	right eye (Latin: *oculus dexter*)
BUT	break-up time	OO	orbicularis oculi muscle
CCC	central corneal clouding	OS	left eye (Latin: *oculus sinister)*
CCD	charge-coupled device	OU	both eyes (Latin: *oculus uterque* - each eye, or *oculi uterque* - both eyes)
cf.	compared to/with	PD	interpupillary distance
CL	contact lens	PMMA	poly(methyl methacrylate)
Dk	oxygen permeability	R	right
DW	daily wear	R&L	right and left
e.g.	for example (Latin: *exempli gratia*)	RE	right eye
EW	extended wear	RGP	rigid gas permeable
GAG	glycosaminoglycan	SCL	soft contact lens
GPC	giant papillary conjunctivitis	SL	spectacle lens
HCL	hard contact lens	TBUT	tear break-up time
HVID	horizontal visible iris diameter	TCA	tricarboxylic acid
i.e.	that is (Latin: *id est*)	UV	ultraviolet
K	keratometry result	VVID	vertical visible iris diameter
L	left	WTR	with-the-rule
LE	left eye		

Summary of Module 3: Contact Lens Fitting

Course Program

Lecture			Practical Session			Tutorial (Small Group Teaching)		
Title	***Hrs***	***Level****	***Title***	***Hrs***	***Level****	***Title***	***Hrs***	***Level****
L 3.1 Introduction to Contact Lens Fitting	1	1	P 3.1 Insertion and Removal of Contact Lenses	2	1			
L 3.2 Spherical SCL Fitting and the Effects of Parameter Changes	2	1	P. 3.2 Spherical SCL Fitting and Assessment	3	1	T 3.2 Fitting Assessment of Soft Contact Lenses	1	1
L 3.3 Astigmatism	1	2				T 3.3 Astigmatism and Toric SCLs	1	2
L 3.4.1 Fitting Spherical RGP Contact Lenses	2	1	P 3.4 Spherical RGP Contact Lens Fitting and Assessment	6	1	T 3.4 Fitting Assessment of RGP Contact Lenses	1	1
L 3.4.2 The Effects of RGP Contact Lens Parameter Changes	1	2						
L 3.5 Toric SCL Types and Designs	1	2						
L 3.6 Fitting Toric Soft Contact Lenses	1	2	P 3.6 Toric SCL Fitting and Assessment	2	2			
L 3.7 Toric RGP Contact Lens Types and Designs	1	3				T 3.7 Corneal Astigmatism and Toric RGP Contact Lens Parameters	1	3
L 3.8 Fitting Toric RGP Contact Lenses	2	3	P 3.8 Toric RGP Contact Lens Fitting and Assessment	3	3			

* Level 1 = Basic: essential knowledge
Level 2 = Intermediate: desirable knowledge
Level 3 = Advanced: useful knowledge

Course Time Allocation

Level	Lecture	Practical (Laboratory)	Tutorial (Small Group Teaching)	Total Hours
Basic	5	11	2	**18**
Intermediate	4	2	1	**7**
Advanced	3	3	1	**7**
TOTAL	**12**	**16**	**4**	**32**

Request for Feedback

As this is the first edition it is our intention to revise and update it periodically. To ensure each revision is an improvement on its predecessor we request your help. We invite you to provide feedback in the form of comments, corrections or suggestions for improvement which you feel will enhance the accuracy or quality of the Course. Such feedback may then be incorporated in subsequent revisions of the Course. We are particularly interested in receiving corrections to, and suggestions for improvements in, the text and slides of the lectures.

To facilitate this feedback process a *pro forma* is included on the next page. This can be photocopied. Please complete your contact details as the team may wish to discuss your suggestions in greater detail or even ask you to participate in any revision resulting from your input.

The IACLE Contact Lens Course
Feedback / Corrections / Suggestions Form

Name: _____ Date: _____
(dd-mm-yy)

Institution: _____

Address: _____

_____

_____

_____

_____

Module: _____ Unit: _____ Page Number: _____

Slide Code: _____ Section: _____

Comments:

Thank you

Please return this form to:

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RANDWICK NSW 2031
AUSTRALIA

Office Use Only:
Response #: _____
Forward to: _____
Action:

Unit 3.1

(3 Hours)

Lecture 3.1: Introduction to Contact Lens Fitting

Practical 3.1: Insertion and Removal of Contact Lenses

Course Outline

Lecture 3.1: Introduction to Contact Lens Fitting

I. Basic Principles of Contact Lens Fitting
II. Glossary of Contact Lens Fitting Terms
III. Soft Contact Lens Quick Reference Guide

Practical 3.1: Insertion and Removal of RGP and Soft Contact Lenses

- Insertion and Removal of RGP Lenses
- Insertion and Removal of Soft Contact Lenses

Lecture 3.1

(1 Hour)

Introduction to Contact Lens Fitting

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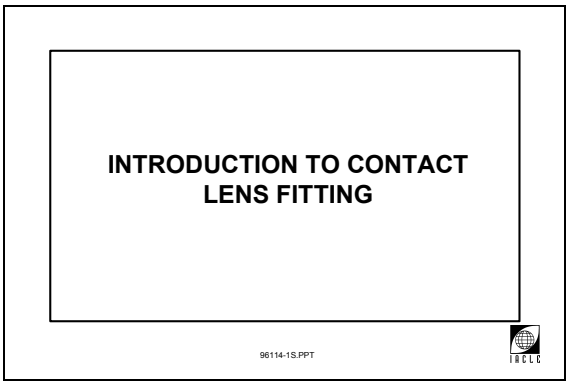
I.D Lens Dispensing 18
I.E After-Care 19
Glossary of Contact Lens Terms **21**
Soft Contact Lens Quick Reference Guide **25**

I The Contact Lens Prescribing Protocol

1



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Introduction to Contact Lens Fitting

This unit presents the general principles involved in the fitting of contact lenses. Lens-specific fitting procedures are dealt with in subsequent units in this module.

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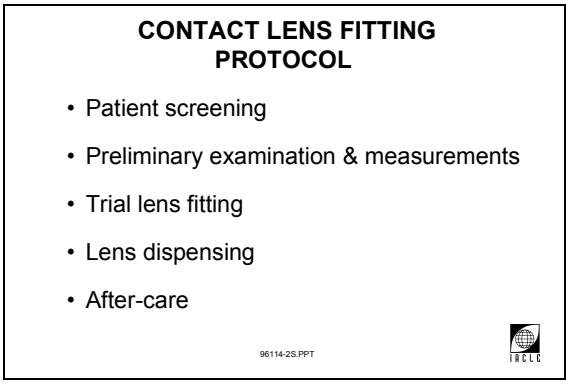

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Contact Lens Prescribing Protocol

A systematic procedure is essential to ensure thorough and efficient management of the contact lens patient. Such a procedure involves the following steps:

- Patient screening.

  Screening is usually the first contact that the patient will have with a practitioner. If a practitioner is to obtain the necessary information from a prospective contact lens patient, steps should be taken to establish good rapport. It is during this time that an initial determination of the suitability of the patient for contact lenses is made. It is also an opportunity to discuss the benefits of contact lenses.

- Preliminary examination and measurements.

  Following a decision to try contact lenses, an examination is conducted, and relevant measurements made, preparatory to trialing suitable contact lenses.

- Trial lens fitting.

  Trial lens parameters as close to the final lens order as possible should be chosen. The trial fitting routine is aimed at determining the final lens specifications. These specifications will be central to patient satisfaction with the lenses.

- Lens dispensing.

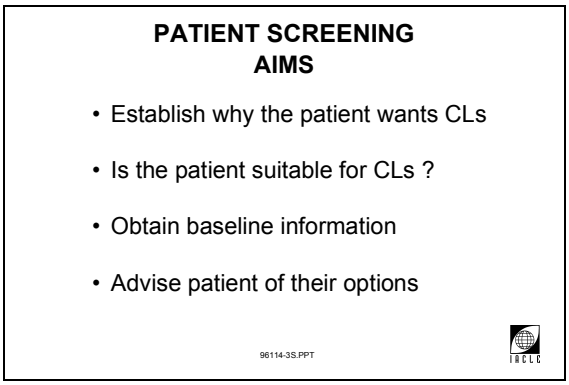
  The contact lenses are dispensed after appropriate verification. Once the lenses are confirmed as being acceptable, the patient is instructed about contact lenses generally, the modes of lens wear being recommended and proper lens care.

- After-care.

  After-care visits are necessary to monitor the patient's adaptation to the contact lenses. The visits are scheduled at regular intervals after dispensing. After-care visits are usually the practitioner's only opportunity to assess the eye's response to contact lenses. Of special interest are objective signs which are not reflected in the patient's subjective response to lens wear, e.g. superficial corneal staining, corneal oedema, etc.

I.A Patient Screening

3



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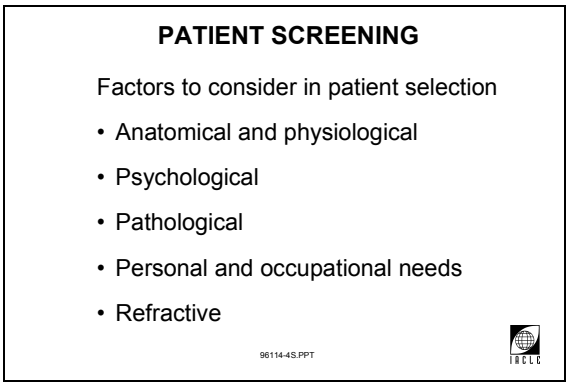
Patient Screening

Aims:

- Patients who indicate a desire to be fitted with contact lenses are usually well motivated. The reasons for wanting contact lenses range from recommendations from friends or relatives to specific work needs, sport or recreation needs.
- After inquiring about the patient's interest in contact lenses, investigate their criteria for success relative to the types of lenses available, e.g. some contact lenses are made in a limited range of lens parameters. A local quick reference guide is useful for reviewing the range of lenses available (see Soft Contact Lens Quick Reference Guide at the end of this lecture). More comprehensive lists are published internationally, e.g. *Tyler's Quarterly Soft Contact Lens Parameter Guide*, *Contact Lens Data Book* (see reference list at back of this unit) and supplements to contact lens journals.
- At the preliminary examination baseline information on ocular variables should be collected. Such data is useful for future reference and for comparison with post-fitting information.
- Screening may indicate that the patient would be better served by spectacles rather than contact lenses. The options (if any) should be presented to the patient.

4



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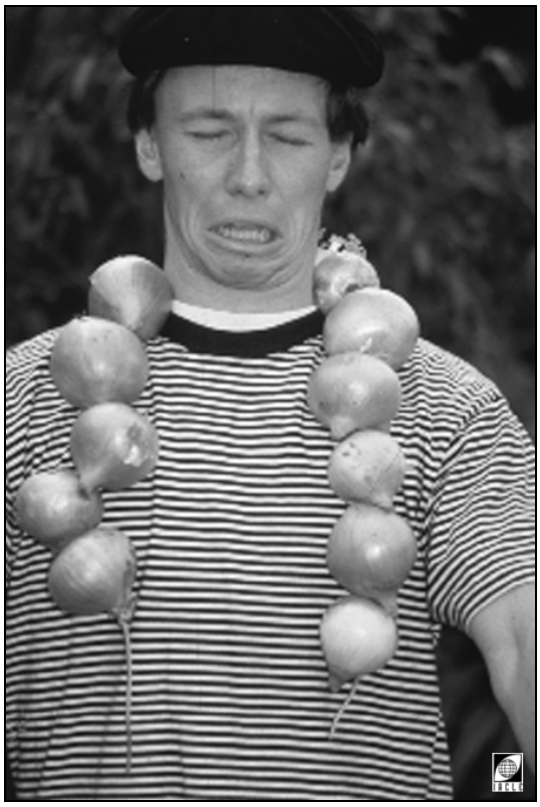
Patient Screening

Factors to consider in patient selection are:

- **Anatomical and physiological.** Examination of the structure, shape and clarity of the anterior segment may reveal whether the eye is 'normal'. The measured features of the eye will suggest the type and design of contact lens to be trialed.

5



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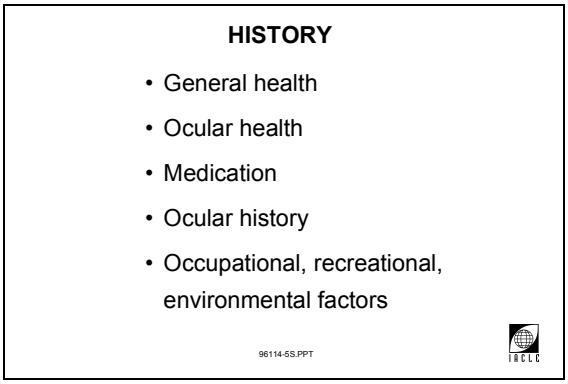

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- **Psychological.** Motivation, intelligence and personality influence the likely success rate of contact lens wear. A patient, such as the one shown in slide 5, who expresses extreme sensitivity, may be suggestive of a potentially unsuccessful lens wearer. A comprehensive explanation of the advantages that can be derived from contact lens wear may dispel some of the fallacies of contact lens wear. Monitoring the compliance of such patients to the prescribed care regimen is necessary.

  Pathological. A thorough history and subsequent eye examination may provide indications or contra-indications for contact lens

  wear. The important aspects of history taking are:

  - general health
  - ocular health
  - medication
  - ocular history including vision corrections
  - special occupational, recreational and environmental factors.

  Ocular abnormalities such as senile ectropion, Sjögren's Syndrome, etc. may contra-indicate contact lens wear or help identify the type and/or design which may be suitable.

- **Personal and occupational needs.** Consideration of age, gender, cosmetic, occupational, recreational, environmental and other factors may help the choice of type and design of contact lenses to be prescribed.

- **Refractive.** Previous and current records of the patient's refractive status should always be referred to, especially where binocular functions need to be considered. Referral letters and record cards are good sources of such information.

7

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Once fitted, contact lenses may perform differently from the patient's expectations. It is the responsibility of the practitioner to explain the benefits and limitations of the lenses being prescribed. Problems arising are much easier to deal with if their possibility was raised beforehand. However, some problems can be 'induced' by their mere suggestion by the practitioner. Clinical judgment based on sound experience is essential.

NOTE: Patient selection is discussed in further detail in Unit 4.1.

Examples of Factors to Consider in Patient Selection

A young progressive myope may benefit more from RGPs than from soft contact lenses. The role of contact lenses in binocular vision must also be recognized.

8

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A surfer requiring a distance correction may benefit from disposable or scleral contact lenses. He should also be given the appropriate care regimen which will ensure optimum comfort and health during and after exposure to a wet and salty environment containing unknown levels of pollution.

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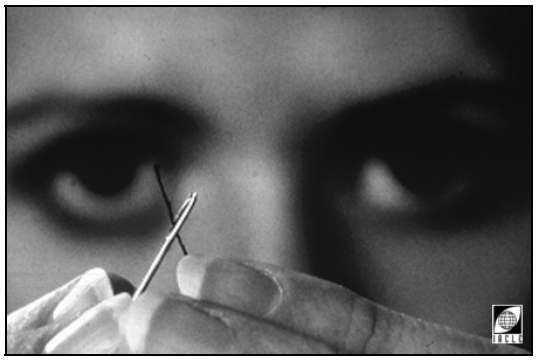

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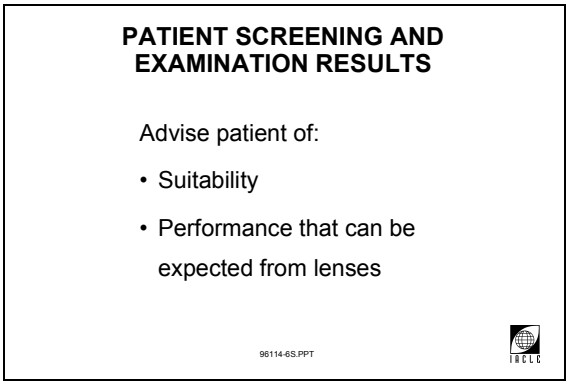
Where a patient is engaged in close work for many hours of the day, age and the requirement for near correction need to be considered. An overview of the benefits that a presbyope might derive from bifocal, monovision or near spectacle corrections may need to presented.

10



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Patient Screening and Examination Results

The patient should be informed that their suitability for contact lenses depends on the results of the screening, preliminary and trial fitting examinations.

Patient selection and the appropriateness of the contact lenses prescribed, are crucial to ensuring successful contact lens wear. An inquiring and conservative practitioner attitude is required.

11

3L100321-91

Patient Screening

Lens Options

Where screening suggests the patient is a good candidate for contact lenses, the benefits and limitations of each of the lens types suitable, should be explained. Trial fitting should begin with the lenses chosen by the practitioner, bearing in mind the needs of the patient and the findings of the preliminary examination.

I.B Preliminary Examination and Measurements

12

PRELIMINARY EXAMINATION AND MEASUREMENT

- Slit-lamp examination of the anterior segment
- Measurement of ocular dimensions
- Assessment of the tears
- Spectacle refraction

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13

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Preliminary Examination

A comprehensive preliminary examination of the eye (see Units 1.2, 1.3, 1.4 and 4.1) provides the basis for determining whether contact lenses are a viable alternative, and if so, what trial lenses would be appropriate.

A preliminary examination should include:

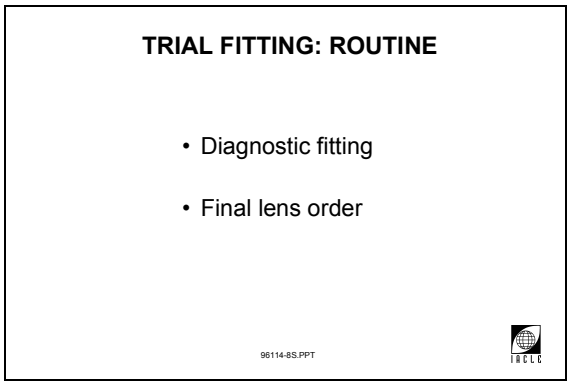
A slit-lamp examination of the anterior segment.

- Keratometry.
- Corneal and pupil size measurements.
- Assessment of lid characteristics.
- A tear assessment.
- A spectacle refraction and calculation of the ocular Rx (corneal-plane refraction).

NOTE: A separate and detailed discussion of this sub-section is found in Unit 4.1.

I.C Trial Fitting Routine

14



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Trial Fitting: Routine

The trial fitting routine involves the following steps:

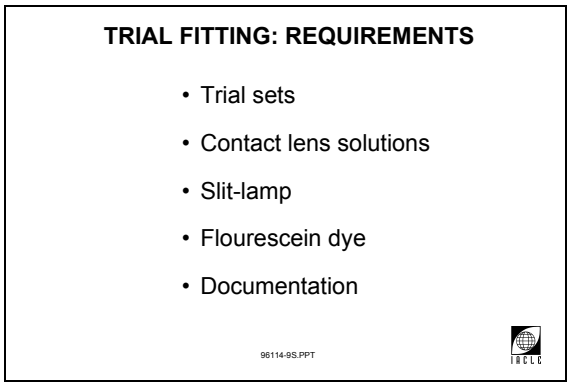
- Diagnostic fitting.

  A diagnostic or trial fitting uses a series of lenses, chosen on the basis of the findings of the preliminary examination. Lenses are assessed sequentially until a desirable fit is obtained. The aim of the trial fit is ensure a good lens-cornea relationship with the design chosen and to confirm the final Rx required. The practitioner must recognize that each lens type has its own set of fitting criteria and the 'optimum' fit for *each* lens type should be their goal.

- Final lens order.

  The specifications of the prescription lens to be ordered are firmly based on the outcome of the trial lens fit and the ocular Rx. The lens should interfere minimally with corneal metabolism and provide crisp, clear stable vision while being comfortable at all times.

15



3L196114-9

Trial Fitting: Requirements

- Trial sets.

  A comprehensive range of both rigid and soft trial lenses should be held by the practitioner. The range should include the designs and products of several companies and only lenses which are readily available (locally available) should be used routinely. Lenses which are difficult to procure may be justifiable in special cases. Lens series may be *stock* items or *custom* products.

  A wide range of RGP trial lenses is useful for an expeditious and accurate trial fitting.

16

3L11431-92

- Contact lens solutions.

  The use of appropriate solutions (if any) preparatory to lens insertion is desirable for initial comfort and vision. Their use also presents an opportunity to explain the role of such solutions to the patient. This will save time at the dispensing visit.

- Slit-lamp or illuminated magnifier (Burton Lamp).

  Competency in the use of a slit-lamp is essential for assessing lens fit.

  In the absence of a slit-lamp, a Burton lamp or other illuminated magnifier, while more limited than a slit-lamp, may be used to examine lens movement, centration and fluorescein patterns (with near-UV illumination) of rigid lenses.

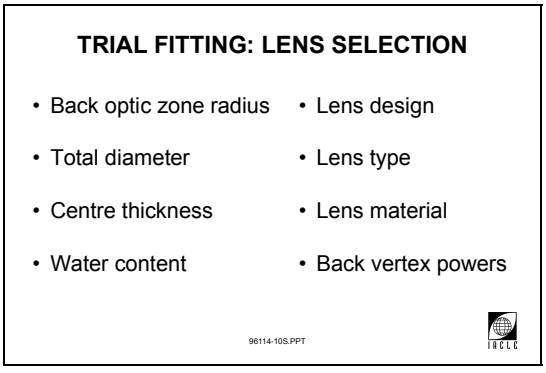
- Fluorescein dye.

  Sodium fluorescein dye instillation is an indispensable step in the trial fitting of rigid lenses. Fluorescein is also useful following removal of the lens, to ensure that the trial lenses have not had an adverse effect on the anterior eye. Its routine use at every after-care visit is also considered essential.

- Documentation.

  Complete and systematic documentation of the trial fitting (see the forms in the practical sessions for guidance) is necessary and enables a decision to be made at the end of the trial, as to which lens(es) was/were the most suitable.

17



3L196114-10

Trial Fitting: Lens Selection

Trial lens selection includes a tentative determination of appropriate lens parameters/features. These might include:

- Back optic zone radius (BOZR).

  Corneal curvature measurements (in millimetres) can be used as a starting point for choosing the initial BOZR.

- Total diameter (TD).

  The trial lens TD is generally found by measuring the Horizontal Visible Iris Diameter (HVID) and adding or subtracting 2 mm for soft and rigid lenses, respectively.

- Centre thickness.

  This is a function of the BVP of the contact lens. Generally, plus lenses have a greater centre thickness than most minus lenses.

- Water content (for soft contact lenses).

  The lens BVP and the wearing modality desired will influence how the eye's oxygen requirements will be met or approximated. Water content is an essential factor in such deliberations.

- Lens design (lenticular, multicurve, surface shape, etc.).

  The desired lens fit can be better achieved by trialing various lens designs, e.g. using lenticulation to improve lens centration in a highly myopic patient or using a back surface multicurve design to improve the lens-cornea relationship.

- Lens type (spherical, toric, bifocal, etc.).

- This choice is dependent on the refractive and curvature measurements of the eye. Providing the best spherical refraction may not always give satisfactory visual acuity and toric lenses may be needed.

- Lens material.

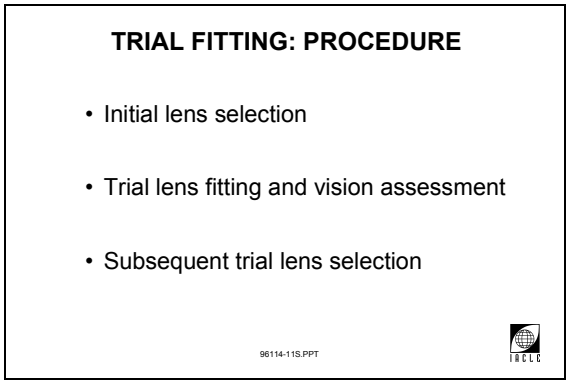
  Oxygen transmissibility, Dk/*t*, is a most important material property of the lenses to be prescribed. Ideally, trial lenses should be of the same material as the lenses to be ordered because material choice can significantly affect their fitting behaviour.

- Back vertex powers (BVP) - near

and distance.

Select the trial lens that is closest to the patient's refractive error, particularly for high prescriptions. Over time, and the occasional failure, a practitioner will build a collection of lenses, including special lenses such as bifocal and toric lenses, to complement their standard trial sets.

18

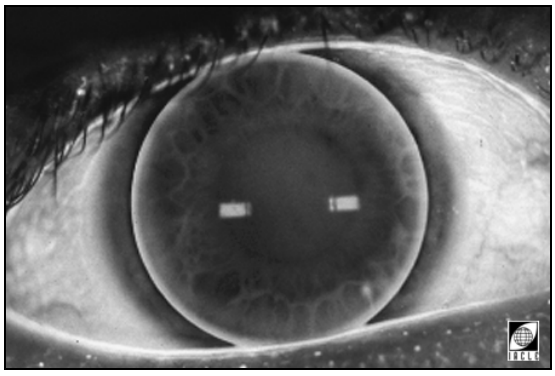


3L196114-11

Trial Fitting: Procedure

- **Initial lens selection**. After baseline measurements have been recorded, the first trial lenses are selected and inserted.
- **Trial lens fitting and vision assessment.** After the lenses have settled, their fit and resultant vision are assessed. Assessment should be both quantitative and qualitative (see record forms in the practicals of Units 3.2 and 3.3 for guidance). Once a satisfactory fit is achieved, the prescription can be finalized and the lenses ordered.
- **Subsequent trial lens selection.** If the initial lenses prove to be unsatisfactory, further trials are required.
  When the trial lenses required are not available, the practitioner may have to resort to empirical prescribing. Empirical prescribing involves no trial lenses. Rather, the final lens order is based on the results of the preliminary examination and the ocular Rx as calculated from the spectacle Rx.

19



3L1-335-94

Trial Fitting: Desired RGP Lens Fit

- Central alignment.

  The example opposite shows no fluorescein under the central portion of the lens. This suggests that the BOZR of the lens closely matches the central corneal curvature.
- Moderate edge clearance.

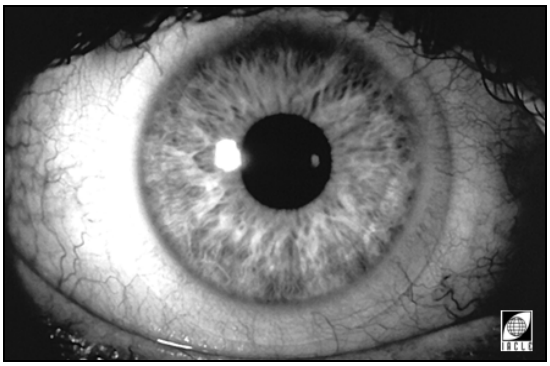
  This manifests itself as a bright band of fluorescein at the periphery of the

lens.

- Good centration.

  Lens positioned so that it is concentric with the limbus in the rest position and its BOZD covers the pupil adequately. While lens movement is essential, rapid recentration after blink is highly desirable.

20



3L10172-95

- Adequate size.

  The lens diameter in this example should allow the possibility of top lid attachment in normal gaze without excessive lens movement. Viewed dynamically, it would probably be a stable fit.

- Vision.

  With an accurate over-refraction, the vision should be clear and stable.

Desired SCL Fit

- Lens centration.

  Good SCL centration is characterized by a uniform amount of lens overlap of the sclera. Blink-induced lens movement should be followed by rapid recentration.

- Complete corneal coverage.

  Although some lens decentration may be unavoidable, the practitioner has to ensure the lens covers the cornea under all reasonable circumstances.

- Adequate movement.

  While some minimum movement is required for all lenses, the actual amount depends on the lens type. Generally the amount will be between 0.2 and 1 mm. The prime reason for lens movement being required is the dispersal of metabolic waste from the post-lens space. Tear exchange has been demonstrated to be minimal under soft lenses largely because of the thinness of the post-lens tear film.

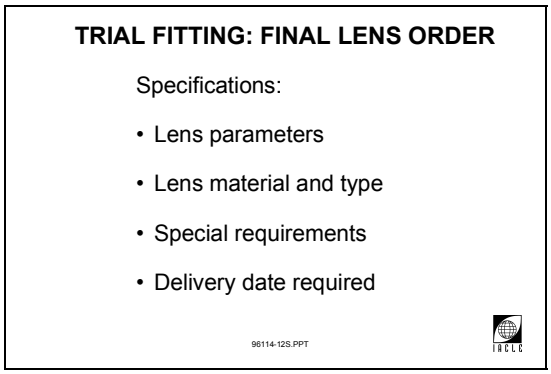
- Comfort.

  Soft lenses are usually very comfortable initially. Any fitting factor that can compromise ocular health may cause some wearer discomfort some time after insertion (usually 20 - 120 minutes after insertion).

- Good and stable vision.

  With an accurate over-refraction, the result should be clear and stable vision.

21



3L196114-12

Trial Fitting: Final Lens Order

The final lens order includes:

- Lens parameters.

  Generally, as a minimum, BOZR, TD, BVP and centre thickness are the lens parameters that should be recorded on an order form.

- Lens material and type.

  In addition to the material and type of lens it is customary to write the trade name of the lenses if they are *stock* items.

- Special requirements.

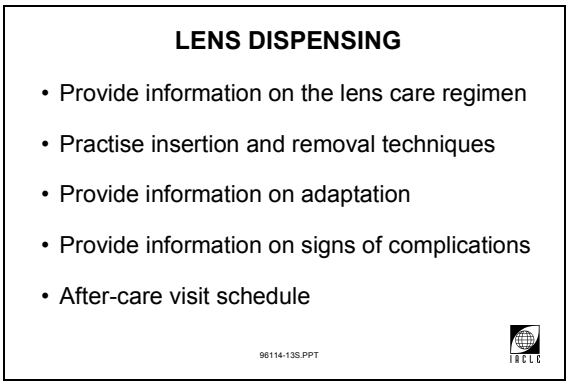
  Requests for a specific centre thickness, tint, blending requirement, lenticulation, type of bifocal, etc. are included as a separate part of a lens order.

- Delivery date required.

  Nominating an expected lens delivery date assists the supplier in determining the priority of the order. Establishing credibility with a supplier is essential if true urgencies are to be attended to appropriately. If all orders are claimed to be *urgent* then eventually all orders will be treated with disdain.

I.D Lens Dispensing

22



3L196114-13

Lens Dispensing

Verification of lens parameters should be performed prior to the dispensing visit to ensure their suitability. Patient education is crucial to ensuring compliance with the necessary care and maintenance regimen. Arguably, compliance with lens care instructions forms the basis of successful contact lens wear.

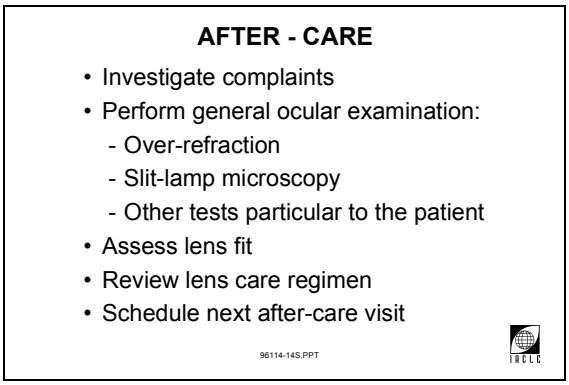
The procedures recommended for the dispensing visit follow:

- Verbal and written instructions including symptoms (adaptive and non-adaptive), periods of adaptation, as well as the *dos and don'ts* of contact lens wear, should be provided.
- Insertion and removal of lenses should be practised until the patient is proficient enough to be able to do both without coaching or assistance. The ability to remove lenses is possibly the more important (if the wearer is unable to insert lenses the potential for harm is non-existent unless the insertion process itself poses a threat to the eyes).
- The practitioner should ensure the patient understands the likely signs of possible complications and the appropriate action to take (*if in doubt, take them out*).

The schedule of after-care visits should be presented in written form to serve as a reminder. A database (computer or card based) system should be created to assist practice staff to manage patients who fail to comply with their after-care schedule.

I.E After-Care

23



3L196114-14

After-Care

Contact lens wearers should be scheduled for regular after-care visits. The frequency of visits depends on their ocular and refractive conditions, lens type and patient-specific needs.

- A case history is a vital component of the regular after-care visit and should include provision for a progress report on events since the last consultation. If the patient visit is unscheduled, information should be sought as to why and what has transpired since the complaint or problem arose. Unless the person taking the initial call or inquiry has considerable experience and is aware of their limitations, preliminary advice should probably be sought from the practitioner, since the potential for professional misadventure in any intervening period is considerable.
- A decline in visual acuity may be indicative of some ocular or fitting complication (i.e. oedema, ghosting, diplopia, excessive lens movement, etc.) or inaccurate BVP.
- An examination should include:
  - over-refraction
  - slit-lamp biomicroscopy
  - other tests particular to the case (referral may be necessary for complications requiring treatment by other professions, e.g. ophthalmology).
- With time and experience, patients can become quite complacent about their lens care regimen (familiarity breeds contempt!). A review provided in the form of printed material, videos (waiting room, consulting room or taken home) or a personal presentation will raise the wearer's awareness of the issues presented previously.
- A schedule of the next after-care visit

should be presented before the end of the consultation. This is also an opportunity for the practitioner to stress the need for ongoing care of both eyes and contact lenses.

NOTE: Modules 4 and 5 provide more in-depth discussions of lens dispensing, care and maintenance, and after-care.

Glossary of Contact Lens Terms*

Adaptive symptoms

Manifest adaptive sensations experienced by the contact lens wearer upon commencement of contact lens wear which usually cease after a few days or weeks of regular lens wear. More applicable to rigid lenses.

Break-Up-Time (BUT)

The time it takes for the first observable break in the tear film on either the cornea or contact lens surface.

Central corneal clouding

Oedema of the cornea seen as a 'clouding' of the central region. It is best observed with sclerotic scatter slit-lamp illumination.

Central fitting

Subjective assessment of the fluorescein pattern under the central region (BOZD) of a rigid contact lens.

Centration

Contact lens position on the eye with reference to the geometric centre of the cornea (Alternatively, this approximates to the lens being concentric with the limbus). Qualitative descriptions of any displacement are commonly used for simplification (e.g. low-riding, high-riding).

Low-riding

Inferior decentration of the contact lens.

High-riding

Superior decentration of the contact lens.

Daily wear

The wearing of contact lenses only during waking hours.

Desiccation

Drying out of either the lens surface or the cornea. The latter may lead to staining.

Dimple veiling

Discrete pooling of fluorescein in the corneal surface having the appearance of golf ball pits. These pits are depressions of the epithelium caused by air bubbles trapped underneath a contact lens.

Disposable lenses

Contact lenses that are disposed of on a daily, weekly or bi-weekly basis. The lenses may be worn on a daily or extended wear basis.

Edge clearance

The distance between the posterior edge bevel of a rigid contact lens and the cornea.

Edge lift, axial

* Unless stated otherwise, all definitions refer to both rigid and soft contact lenses.

Peripheral clearance due to the flattening of the peripheral curve(s) relative to the BOZR. It is the axial distance from the lens edge to the imaginary surface formed by the extension of the base curve (BOZR) to the lens edge. The axial edge lift is measured parallel to the optic axis.

Edge lift, radial

Peripheral clearance due to the flattening of the peripheral curve(s) relative to the BOZR. It is the radial distance from the lens edge to the imaginary surface formed by the extension of the base curve (BOZR) to the lens edge.

Extended wear

The use of lenses which are worn continuously (without removal) during sleep and waking hours. The wearing period may vary from 24 hours to seven days (usually) or longer.

Fitting, inter-palpebral

The rigid contact lens is not covered by the upper lid (although it may touch it). The resting position of the lens is between the lids because the diameter is usually smaller than the inter-palpebral aperture. The BOZR is usually steeper than the cornea.

Fitting, lid-attached

The rigid contact lens is partially covered by, and held in position by, the upper lid. The lens is usually larger and the BOZR is fitted either aligned with, or slightly flatter than, the cornea.

Fitting, loose

A lens that appears to move excessively. *Loose* is often used synonymously with flat as a fitting description.

Fitting, tight

A lens that has very little movement. *Tight* is often used synonymously with steep as a fitting description.

Flexible wear

Contact lens wear modality in which lenses are inserted and removed primarily on a daily basis with *occasional* overnight wear scheduled.

Fluorescein pattern

Pattern observed underneath a contact lens after instilling fluorescein dye in the tear film and using filtered ultra-violet or cobalt blue light for observation.

Frequent/planned replacement

Lenses are replaced regularly at pre-determined intervals. Typically, the replacement is made at one month, three month, or six month intervals.

K, flatter than

Where the BOZR of an RGP or soft lens is flatter than the flattest keratometer (K) reading of the cornea.

K ("on-K")

Where the BOZR of an RGP or soft lens is the same as the flattest keratometer (K) reading of the cornea.

K, steeper than

Where the BOZR of an RGP or soft lens is steeper than the flattest keratometer (K) reading of the cornea.

Lag

Contact lens movement, or the difference between eye and lens movement, that occurs following lateral or upward eye movement.

Lens adherence

Also described as lens 'binding' where the lens is immobile (zero movement). Typically the phenomenon is observed after eye opening following overnight wear. The term is especially applicable to EW RGPs.

Lens design

A description of the lens form, lens parameters and method of manufacture.

Lens material

The polymer from which the lens is manufactured.

Mid-peripheral fitting

The fitting relationship between the mid-peripheral portion of the rigid lens and the paracentral zone of the cornea.

Movement

The excursion of the contact lens on the eye during and after a blink. It is easier to assess the movement after the blink.

Subclassification of rigid lens movement:

Smooth movement

A smooth continuous line of excursion following a blink.

Two-part movement

A discontinuous, two-step excursion of a contact lens following a blink.

Apical rotation

The excursion of a contact lens about the corneal apex following a blink.

Rocking movement

The lens rocking about the corneal apex (acting as a fulcrum) or flatter meridian of the cornea.

Over-refraction

The spherical or sphero-cylindrical correction needed over and above the Rx of the contact lens being worn, to neutralize the distance or near residual refractive error.

Best sphere

When performing a refraction or an over-refraction, this is the Rx with the most plus or the least minus sphere which provides the best possible visual acuity.

Pooling

The accumulation of tears in the space between the rigid lens and the cornea following fluorescein instillation. This term is more commonly used in conjunction with apical clearance fittings denoting central pooling. Edge clearance is usually the term

used to describe and quantify the tear layer under the edge of a lens - see Edge Clearance.

Spectacle blur

The subjective blur observed when wearing spectacles immediately after removal of contact lenses. It may last several hours.

Staining

Disruption of the corneal or conjunctival surface (and deeper layers) which is best observed with the aid of fluorescein. Such disruptions allow the entry and retention of fluorescein within and between surface cells.

Staining, 3 & 9 o'clock

Peripheral corneal staining at the 3 and 9 o'clock positions (sometimes 4 and 8 o'clock) that results from desiccation in RGP lens wear.

Tear lens

More applicable to rigid contact lenses. It is the tear fluid 'lens' formed between the cornea and the back surface of the lens.

Wettability, *in vitro*

Refers to the measurement of the 'contact' or 'wetting' angle of the lens surface with water, saline or tears.

Wettability, *in vivo*

How retentive the lens surface is of the tear film.

Soft Contact Lens Quick Reference Guide

(after Tyler's Quarterly Soft Contact Lens Parameter Guide, Vol. 13, No.4, September 1996)

MANUFACTURER	SERIES™	BOZR (mm)	POWER (D)
DISPOSABLE: CLEAR OR VISIBILITY TINTED SPHERICALS			
Bausch & Lomb	Seequence	8.7	Pl to -9.00
	Optima FW Seequence	8.4, 8.7, 9.0	+4.00 to -9.00
	New Day (daily disposable)	8.7	-0.50 to -6.00
CIBA Vision	NewVues	8.4, 8.8	+4.00 to -10.00
Vistakon	Acuvue	8.4, 8.8,9.3	-0.50 to -9.00
		9.1	+0.50 to +6.00
	1-Day Acuvue	9.0	-0.50 to -6.00
Wesley Jessen-PBH	Fresh Look Lite Tint	median	-0.25 to -8.00
DISPOSABLE: TINTED SPHERICALS			
CIBA Vision	NewVues Soft Colors	8.4, 8.8	+4.00 to -6.00
Vistakon	Surevue	8.4, 8.8	-9.00 to -0.50
		9.1	+0.50 to +6.00
Wesley Jessen-PBH	Fresh Look Colors	median	Pl to -8.00
DISPOSABLE: UV PROTECTION SPHERICALS			
Wesley Jessen-PBH	Precision UV	8.7	+8.00 to -10.00
DAILY WEAR SPHERICALS: CLEAR			
Bausch & Lomb	Sofspin		-0.25 to -5.00, -5.50 to -6.00
	B3		+6.00 to -20.00, +11.00 to +12.00
	B4		+6.00 to -9.00
	U3		+6.00 to -9.00
	U4		+6.00 to -9.00
	Plano T		Plano
	HO3/HO4		-8.00 to -20.00
	H3/H4		+6.50 to +20.00
	N		+6.50 to +18.50

MANUFACTURER	SERIES™	BOZR (mm)	POWER (D)
	F3		+6.50 to +20.00
CIBA Vision	CibaSoft Standard Clear	8.3, 8.6, 8.9	Pl to ± 6.00
	CibaSoft	8.3, 8.6, 8.9	+6.00 to -10.00
		8.6, 8.9, 9.2	Pl to -10.00
	AOSoft	8.1, 8.4, 8.7	Pl to -9.50
Wesley Jessen-PBH	Soft Mate B	8.7, 9.0	+7.00 to -12.00
	CSI Clarity DW Clear	8.0, 8.3, 8.6	+8.00 to -20.00
		8.6, 8.9, 9.35	Pl to -20.00
	Hydrocurve II	8.3, 8.6, 8.9	+7.00 to -12.00
	Hydrocurve Aphakic DW	8.3, 8.6, 8.9	+7.50 to 20.00
		8.9	+12 to +16.00
Wesley-Jessen-PBH	Aquaflex	8.2, 8.5, 8.8, 9.1	-0.25 to -20.00, +0.25 to +9.75
		7.9, 8.5, 8.8, 9.1	Pl to -9.75
	Durasoft 2 (D2-T3)	8.2, 8.5	Pl to ± 20.00
	Durasoft 2 (D2-T4)	8.3, 8.6, 9.0	Pl to ± 20.00
EXTENDED/FLEXIBLE WEAR SPHERICALS: CLEAR			
Bausch & Lomb	B & L 70	8.4, 8.7, 9.0	Pl to -6.00
		8.7, 8.9	Pl to +6.00
	CW79	8.1, 8.4, 8.7	+10.00 to +20.00
	O3		-1.00 to -6.00
	O4		-6.50 to -9.00
	Silsoft Aphakic (Adult)	7.5, 7.7, 7.9, 8.1, 8.3	+12 00 to +20.00
	Silsoft Super Plus (Pediatric)	7.5, 7.7, 7.9	+23.00 to +32.00
CIBA Vision	CibaThin	8.6, 8.9	Pl to -6.00
Wesley Jessen-PBH	Hydrocurve II	8.5, 8.8	+7.00 to -12.00
	Hydrocurve II High Plus	8.5, 8.8, 9.5, 9.8	+7.50 to +20.00

MANUFACTURER	SERIES™	BOZR (mm)	POWER (D)
		9.2	+12.00 to +16.00
	Softmate II	8.7, 9.0	+4.00 to -8.00
	CSI Clarity FW	8.0, 8.3, 8.6,8.9	Pl to -10.00
		8.6, 8.9, 9.35	Pl to -7.00
Wesley Jessen-PBH	Durasoft 3 Flexiwear (D3-X4)	8.3, 8.6, 9.0	Pl to ± 20.00
	Durasoft 3 Flexiwear (D3-X3)	8.2, 8.5	Pl to ± 6.00
VISIBILITY/HANDLING TINT SPHERICALS			
Bausch & Lomb	Optima FW Visibility Tint	8.4, 8.7, 9.0	Pl, +4.00 to -9.00
	Optima 38 Visibility Tint	8.7, 8.4	+5.00 to -12.00
CIBA Vision	CibaSoft Visitint	8.3, 8.6, 8.9	+6.00 to -10.00
		8.6, 8.9, 9.2	Pl to -10.00
	CibaSoft Standard Visitint	8.3, 8.6, 8.9	Pl to ± 6.00
Wesley Jessen-PBH	Clearview	8.4, 8.7	Pl to -6.00
	CSI Clarity DW Locator Tint	8.0, 8.3, 8.6	+8.00 to -6.00
Wesley Jessen-PBH	DuraSoft 3 Litetine (D3-LT)	8.3, 8.6, 9.0	Pl to ± 20.00
	DuraSoft 2 Litetine (D2-LT)	8.0, 8.3, 8.6	Pl to ± 20.00
TINTED DAILY WEAR SPHERICALS: TRANSPARENT/ENHANCING COLORS			
Bausch & Lomb	Optima 38 Natural Tint	8.4, 8.7	Pl to +5.00
	Natural Tint - B3		-0.25 to -6.00
	Natural Tint - U3		-0.25 to -6.00
	Natural Tint - U4		-0.25 to -6.00
CIBA Vision	CibaSoft SoftColors	8.3, 8.6, 8.9	+6.00 to -0.00
		8.6, 8.9, 9.2	Pl to -10.00

MANUFACTURER	SERIES™	BOZR (mm)	POWER (D)
	Ciba Soft Standard SoftColors	8.3, 8.6, 8.9	Pl to ±6.00
Wesley Jessen-PBH	Natural Touch Enhancers	8.4, 8.7	Pl to -6.00
	CSI Clarity DW Colours	8.3, 8.6	Pl to -6.00
	CTL Cosmetic Tint	8.4, 8.7	+5.00 to -8.00
Wesley-Jessen PBH	DuraSoft 2 (D2-LE)	8.6	+4.00 to -8.00
		8.3, 9.0	Pl to -4.00
TINTED EXTENDED/FLEX WEAR SPHERICALS: TRANSPARENT/ENHANCING COLORS			
Bausch & Lomb	Natural Tint - O3		-1.00 to -6.00
	Natural Tint - O4		Pl, -1.00 to -6.00
	Optima FW Natural Tint	8.7	-0.25 to -9.00
CIBA Vision	CibaThin SoftColors	8.6, 8.9	Pl to -6.00
Wesley Jessen-PBH	Soft Mate Custom Eyes (FW)	9.0	+6.00 to -6.00
		8.7	Pl to -6.00
EXTENDED/FLEX WEAR TORICS			
Bausch & Lomb	Bausch & Lomb FW Toric	8.7, 8.9	+4.00 to -6.00 Sph -0.75, -1.25, -1.75 Cyl (full circle every 10°)
Wesley Jessen-PBH	Hydrocurve 3	8.8	+4.00 to -8.00 Sph -0.75, -1.25, -2.00 Cyl (full circle every 1°)
TINTED TORICS			
CIBA Vision	ToriSoft SoftColors (DW)	9.2	Pl to -7.00 Sph -1.00, -1.75 Cyl 180 ±20°, 90±20° (every 10°)
		8.6, 8.9	Pl to -7.00 Sph +0.25 to +4.00 Sph -1.00, -1.75 Cyl (full circle every 10°)
		8.6, 8.9	Pl to -7.00 Sph -2.50 Cyl

MANUFACTURER	SERIES™	BOZR (mm)	POWER (D)
			180 ±20°, 90±20° (every 10°)
Wesley Jessen-PBH	CSI Clarity Toric (DW)	8.3, 8.6	+4.00 to -8.00 Sph -1.00, -1.75, -2.50 Cyl (full circle every 10°, 5° steps for 180 ±20°, 90±20°)
Wesley Jessen-PBH	DuraSoft 3 Optifit Toric Colors (FW)	8.6, median	Pl to -4.00 Sph -1.25, -1.75 Cyl 180 ±20°, 90±20° (every 5°)
	DuraSoft 2 Optifit (DW)	8.6, median	+4.00 to -12.00 Sph -0.75, -3.75 Cyl (full circle every 5°)
	DuraSoft 3 Optifit (FW)	8.6, median	+4.00 to -8.00 Sph -0.75, -1.25, -1.75, -2.25 Cyl 180 ±30°, 90±30° (every 5°)
DAILY WEAR TORICS: CLEAR			
Bausch & Lomb	Optima Toric	8.3, 8.6	+4.00 to -9.00 Sph -0.75, -1.25, -1.75 Cyl (full circle every 10°)
	Optima Toric (made to order)	8.3, 8.6, 8.9	+6.00 to -9.00 Sph -0.75, -1.25, -1.75, -2.25, -2.75, -3.25, -3.75, -4.25 Cyl (full circle every 5°)
CIBA Vision	ToriSoft	9.2	Pl to -7.00 Sph -1.00, -1.75 Cyl 180 ±20°, 90±20° (every 10°)
		8.6, 8.9	Pl to -7.00 Sph +0.25 to +4.00 Sph -1.00, -1.75 cyl (full circle every 10°)
		8.6, 8.9	Pl to -7.00 Sph -2.50 Cyl 180 ±20°, 90±20° (every 10°)

Practical 3.1

(2 Hours)

Insertion and Removal of Contact Lenses

Purpose of Practical

The purpose of this exercise is to teach students how to insert and remove lenses from patients' eyes. In attempting these procedures, especially when students are inexperienced or when patients are apprehensive, lenses may decentre off the cornea (more so with rigid lenses). Therefore students should learn how to locate the lenses and how to recentre them.

The lenses should be relatively comfortable shortly after insertion and if the patient is obviously uncomfortable, the student should be able to recognize and correct this by either moving the lens off centre and then recentring, or removing the lens and reinserting it after appropriate cleaning, rinsing or wetting depending on whether it is a soft or rigid lens.

Practise insertion, removal and recentration on your partner during the allotted time.

Practical Session

Video presentation or demonstration by an instructor of insertion, removal and recentring procedures of rigid and soft contact lenses.

Students should work in pairs and lenses should be inserted, removed and decentred and recentred on both eyes.

Rigid Contact Lenses

A. Preparation of rigid lenses prior to insertion.

- The following materials are required for this practical: rigid lens trial sets, slit-lamp, Burton lamp(optional), rigid lens wetting/soaking/conditioning solution, suction cup(DMV remover), tissues, graticule (hand loupe), table stand (tiltable) mirrors.
- Examine the eyes of the student who is serving as the patient to ensure that the ocular surfaces are in a healthy state. Record the keratometric measurements and the selected lens parameters on the assignment sheet.
- Most of the rigid lens trial sets are dry stored. This is to avoid having to replace the storage/conditioning solution at frequent intervals before it dries out. Generally rigid lenses are stored dry. If the lenses are stored in a disinfecting/conditioning solution they will invariably 'wet' better when placed on the eye.
- The student who is to insert the lenses must wash his/her hands. The rigid lens is then removed from the trial case or the lens vial. Rub and rinse the lens with saline solution and then apply 3-5 drops of wetting/conditioning solution to the lens and rub it for 5- 10 seconds between the thumb and index finger or with an index finger in the palm of the hand.

B. Insertion, recentring and removal of rigid lenses.

1. Insertion:
    - Stand to the side of the patient.
    - Place the lens on the tip of a dry index finger. Use the hand which would be most convenient for lens insertion. Inspect the lens to ensure that it is not damaged and is free of debris.
    - Instruct the patient to fixate at an object in the straight ahead position.
    - Pull the lower lid margin down with the middle finger of the hand holding the lens. Now instruct the patient to look down and lift the upper lid with the thumb of the other hand while resting this hand on the patient's forehead.
    - Gently move the rigid contact lens towards the cornea until a 'touch' is felt.
    - Emphasise that the patient should continue looking down. Release the lower lid and slowly release the upper lid. This direction of gaze should be maintained because the patient usually experiences less discomfort with this posture. Several attempts may be needed before mastery of the technique is achieved.
    - After one or two minutes insert the other lens.
    - With the appropriate lens powers, the patient should be able to see fairly well as their gaze alters to look across the room. This means that the lens

is centred on the cornea. With lacrimation (which is common at this stage due to relative discomfort) and lid force it is possible for the patient to move the lens off the cornea.

2. Locating and Recentring rigid lenses.
   - If the lens is displaced from the cornea, locate the lens by retracting the lids from the bulbar conjunctiva.
   - The lens is most likely to be inferiorly displaced because of the force of the upper lid, so to expose the inferior *cul de sac,* request the patient to look up while retracting the lower lid.
   - To look for the lens under the superior lid, get the patient to look down and retract the superior lid.
   - If the lens is located on the temporal or nasal conjunctiva it should be easily visible.
   - To slide the lens back on to the cornea, contact the edge of the lens with the lid margin and push gently towards the centre of the cornea. The other lid should be retracted during this procedure. Encourage the patient to keep the other eye open.
   - Do not force the lens against the globe because this may increase the negative pressure under the lens.
   - Ensure that the edge of the lens is able to slide gently across the limbus and on to the cornea without the edge abrading the cornea.
3. Removal
   1. One finger technique:
      - Instruct the patient to open their eyes as in a wide staring expression while looking in a straight ahead position .
      - While ensuring that the patient's eyes remain wide open, place your thumb or forefinger at the outer canthus and then instruct the patient to blink firmly.
      - Cup the other hand under the eye to catch the lens as it is ejected.
   2. Two finger technique:
      - With the forefingers of both hands hold the upper and lower lid margins close to the upper and lower lens edges at the widest point of the lens.
      - Gently push the lower lid upwards and inwards and towards the globe and at the same time push the top lid downwards contacting the edge of the lens. This will enable the lens to slide over the lower lid and out of the eye.
      - The lens should now be positioned on the nail of the forefinger and it can be held with the adjacent finger to prevent it from falling.
   3. Suction cup removal technique:
      - Holding the suction cup (DMV remover) between thumb and forefinger, squeeze the air out and touch the lens with the cup while releasing the pressure slightly. This will cause the lens to adhere to the suction cup. It can then be removed from the eye.
   4. Cleaning the lens after removal:

- After removal place a few drops of cleaning solution of the lens and rub it for 5-10 seconds. Then rinse the lens with saline and dry the lens with a tissue. Place the lens in the dry storage trial case. If the lens is to be stored in a conditioning/disinfecting solution, refill the case with fresh solution and restore the lens after rinsing it with saline.

Soft Contact Lenses

A. Preparation of soft lenses prior to insertion

- The following materials are required for this practical: Soft lenses, aerosol or preserved saline solution, slit-lamp, soft lens; tweezers, table stand (tiltable) mirrors.
- Examine the eyes of the student who is serving as the patient to ensure that the ocular surfaces are in a healthy state. Record the keratometric measurements and the soft lens parameters on the assignment sheet.
- Trial soft lenses are either stored in vials or in blister packs. Ensure that the lens has been disinfected prior to use. The vial should contain a lens in solution which should be clear when shaking the bottle. and the vial rubber stopper should be crimped. Trial lenses in blister packs can only be used once.
- Wash your hands, rinse well and dry with a lint-free towel. Remove the lens from the vial by lifting the lens out with the rubber tip of the tweezers, or alternatively pour the contents of the vial into the palm of your hand and pour off the excess solution. While the lens is positioned in the palm of your hand (convex side down) pour saline solution on to the lens and then rub the lens well for 5 - 10 seconds. After rubbing, rinse the lens well with saline solution.

B. Insertion, recentring and Removal of soft contact lenses

1. Insertion.
    - Stand to the side of the patient.
    - Place the lens on the tip of a dry index finger. Use the hand which would be most convenient for lens insertion. Inspect the lens to ensure that it is oriented correctly, i.e. not inside out, that it is clean and free of debris and not damaged.
    - Instruct the patient to fixate at an object in the straight ahead position.
    - Pull the lower lid margin down with the middle finger of the hand holding the lens. Now instruct the patient to look down. Lift the upper lid with the thumb of the other hand while resting this hand on the patient's forehead.
    - Now ask the patient to look straight ahead again and gently move the soft lens towards the cornea until contact is made. Because of capillary attraction the lens should adhere to the ocular surface.
    - Slowly release the lower lid and then the upper lid so that the lens is not displaced by the force of the upper lid. Several attempts may be needed before mastery of the technique is achieved.
    - Minimal discomfort should be experienced because soft lenses are flexible and large. If discomfort is experienced it may mean that the lens is inside out or that debris is trapped under the lens which is likely to result in hyperlacrimation.
2. Locating and Recentring soft lenses.
    - If the lens is displaced from the cornea, locate the lens by retracting the lids from the bulbar conjunctiva.

- Soft lenses are more likely to be superiorly displaced and occasionally the lens may be folded as well. To expose the superior bulbar conjunctiva, ask the patient to look down and retract the superior lid.
- To search for the lens under the lower lid, ask the patient to look up while retracting the lower lid.
- If the lens is displaced, touch the centre of the lens with the tip of the index finger while retracting the lid and gently slide it over the cornea.
- If the lens is folded and displaced, remove the lens, rinse it and then ensure that it is the right way around before it is reinserted.
- Because soft lenses are large it may be possible to recentre the lens (particularly if it is laterally displaced) by merely asking the patient to look in the direction of the lens.

3. Removal of soft lenses.
    1. Pinching Technique:
        - Ensure that the lens is centred on the cornea before attempting to remove it.
        - The patient is asked to look nasally while the practitioner retracts the bottom lid with the third finger of the one hand and the top lid is retracted with the thumb of the other hand.
        - Touch the lens with the index finger of the of the hand that is retracting the bottom lid and slide the lens on to the temporal sclera.
        - While still holding the lids apart, pinch the lens gently with the thumb and index finger while ensuring the fingernails do not touch the lens
        - Remove the lens.
    2. Alternate technique:
        - Ask the patient to look up. Then retract the lower lid with the middle finger and slide the lens down with the index finger. As soon as the lens is halfway off the cornea, pinch the lens with the thumb and index finger.
    3. Scissors technique:
        - The patient looks straight ahead.
        - The upper and lower lids are held apart at the lid margins midway between the inner and outer canthi.
        - Gently stretch the lids. This will squeeze the lens out of the eye.
4. Place the lens in the palm of the hand. Place a few drops of cleaning solution on the lens and rub the lens with the index finger for about 10 seconds . Repeat this procedure twice again using saline solution. Put the lens back into the vial with fresh disinfecting solution. Close the vial with a rubber stopper and crimp the stopper and vial. If saline solution is used, the vial should be thermally disinfected.

🕮 References

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White P, Scott C (1996). *Contact Lenses and Solutions Summary*. Contact Lens Spectrum, Cardinal Business Media, Inc., PA. 11(suppl.)(8).

Talbett G, Lauriola S, Wales R (1996). *Contact Lens Data Book*. Australian Optometrical Association.

Unit 3.2

(6 Hours)

Lecture 3.2: Spherical SCL Fitting and the Effects of Parameter Changes

Practical 3.2: Spherical SCL Fitting and Assessment

Tutorial 3.2: SCL Fitting Assessment and Problem Solving

Course Overview

Lecture 3.2: Spherical SCL Fitting and the Effect of Parameter Changes

I. Lens Selection
II. Assessment of Fit
III. Final Lens Order
IV. Effect of Varying BOZR, Diameter, Thickness, Water Content on Lens Fitting
V. Parameter Relationships

Practical 3.2: Spherical SCL Fitting and Assessment

- Lens Selection
- Assessment of Fit
- Decision on Whether to Alter Lens Parameters
- Assessing the Fit of Lens Combinations

Tutorial 3.2: Fitting Assessment of Soft Contact Lenses

Lecture 3.2

(2 Hours)

Spherical Soft Contact Lens Fitting and the Effects of Parameter Changes

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I Introduction to Soft Contact Lenses

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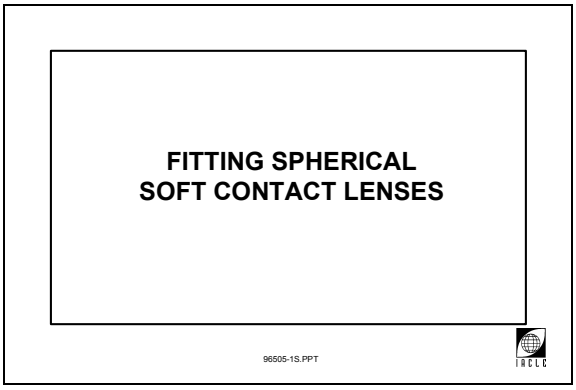

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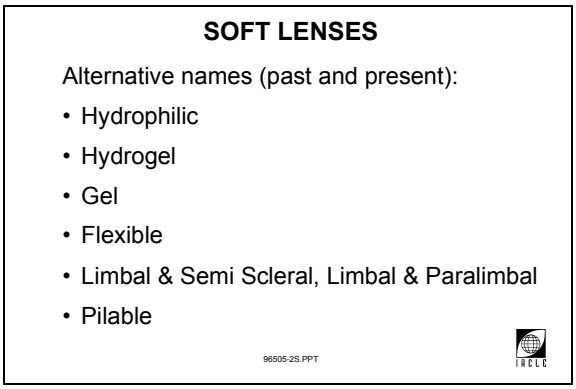

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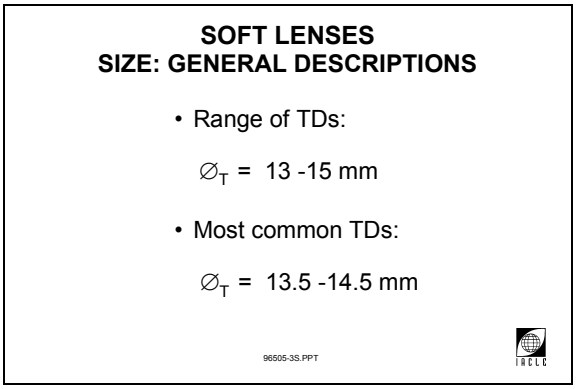

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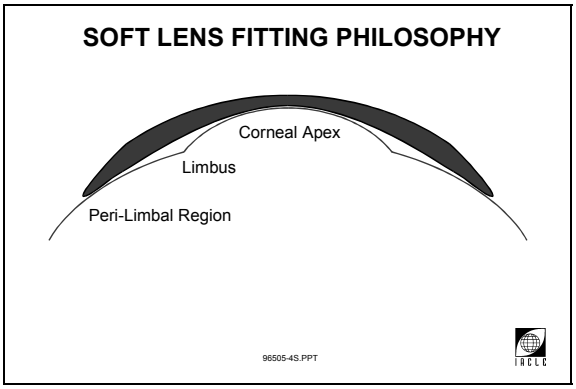
Soft Lenses

Total Lens Diameter:

TDs outside the common range are used for custom orders for individuals with uncommon interpebral apertures and HVIDs.

4



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General Soft Contact Lens Fitting Philosophy

To allow the lens to conform to the cornea/scleral contours, SCLs should always be larger than the cornea with a BOZR flatter than the cornea. Lens movement, which is generated by the blinking action of the lids, should be such that the lens edge does not cross the limbus.

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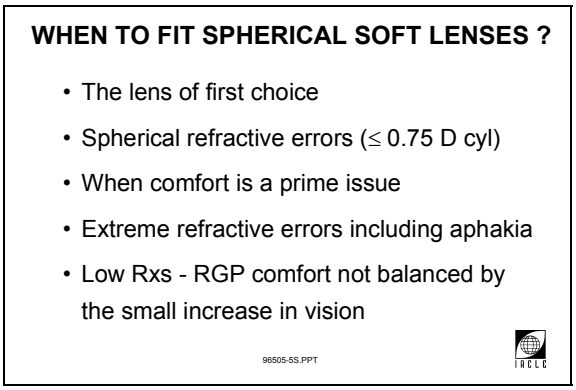

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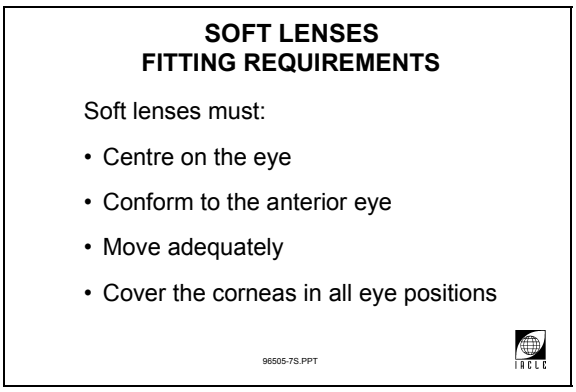
When are Spherical Soft Lenses Applicable?

- Spherical soft lenses are the lenses of first choice because they are easier to fit, are comfortable, require little adaptation and are economical.
- Relatively spherical refractive errors. (astigmatism ≤ 0.75 D cyl). Opinions vary on what is the maximum acceptable uncorrected astigmatic error. While 0.50 D is probably a more prudent choice, the perception that toric soft lens with small cylinders enjoy a lower success rate means that prescribers tend to err on the higher side of 0.50 D. Few will accept that 1.00 D cylinder can be ignored. The influence of the cylinder axis on the visual outcome is also relevant. Generally, uncorrected astigmatism with an on or near horizontal or vertical orientation, allows a better visual result.
- When comfort is a prime issue. While comfort is always an issue, some wearers find the initial comfort of an RGP lens an insuperable barrier to wearing success. If contact lens wear is to be pursued further, soft lenses become the only viable alternative.
- Extreme refractive errors including aphakia. Rigid lenses in extreme Rxs are difficult to fit, offer poorer physiological conditions to the cornea they cover and are difficult to get to remain centred.

- Low Rxs where RGP comfort is not balanced by the small improvement in vision.
- Significant corneal astigmatism present but where the manifest Rx is spherical. On such a cornea, the use of an RGP with a spherical BOZR will induce residual astigmatism. Correction with an RGP then becomes more complicated than with a simple spherical soft lens.

II Fitting Requirements

6



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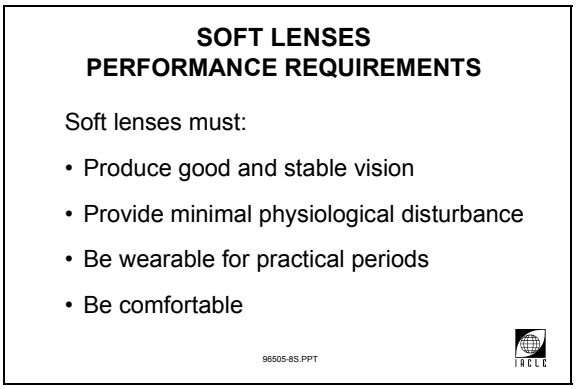

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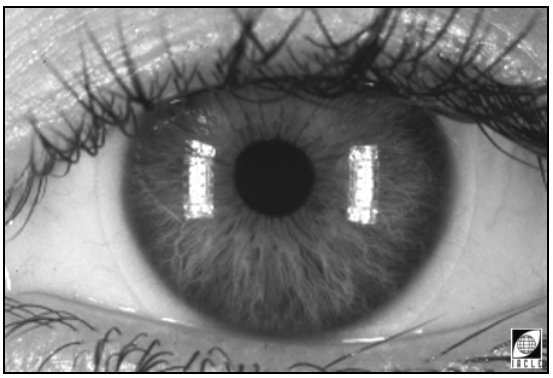
III Centration

8



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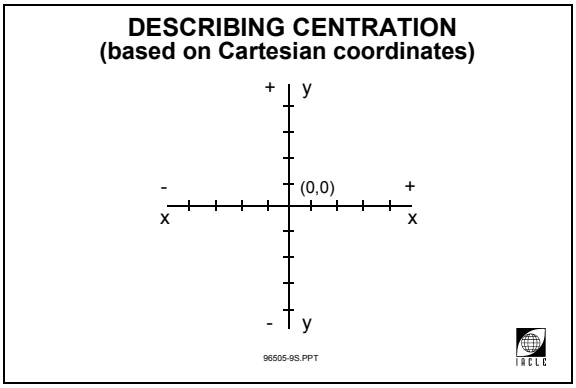
A Well-Centred Soft Lens

This illustration depicts a well-centred soft lens. The amount of limbal overlap is normal for this type of lens and, even with the desired amount of lens movement on the eye (a good fit), corneal coverage is maintained in all eye positions.

9



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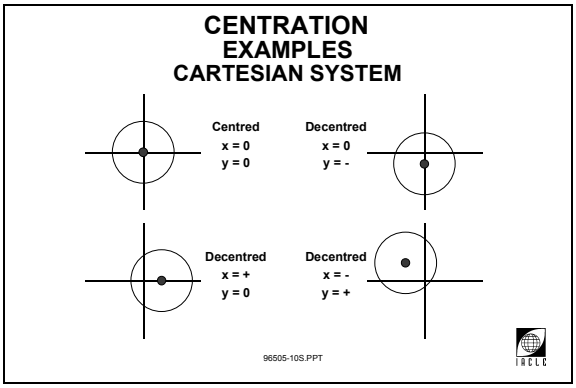
Describing Lens Centration

Various methods of describing lens position have evolved over time but the two with the widest acceptance are based on Cartesian coordinates as used in applied mathematics, or a 'bi-nasal' variation of it. Both are presented here because usage depends on local custom.

The difficulty for both of these systems is the inconsistency of the horizontal coordinates, i.e. +x for the *right* eye is a nasal decentration while +x for the *left* eye is a temporal decentration. The vertical coordinates present no such difficulty.

10



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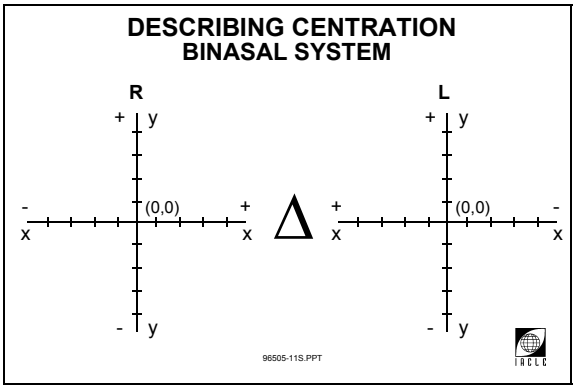
Centration Examples: Cartesian System

The location of the geometric centre of a contact lens, within a Cartesian coordinate system, is the basis of the description of its centration. The primary advantage of this system is its widespread use in mathematics and optics. This diagram shows simple and compound examples of decentred soft lenses. The same system can also be applied to rigid lenses.

11



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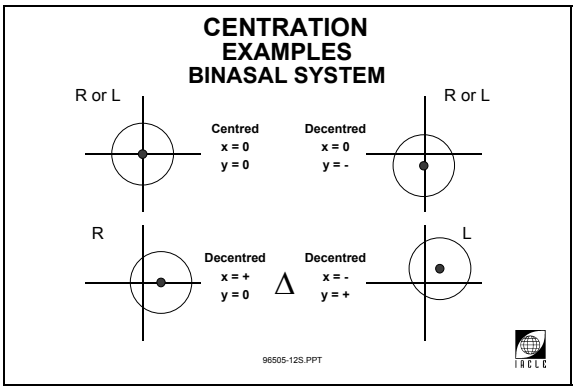
Describing Lens Centration: Binasal System

In this system nasal centration is described as positive (+ve) regardless of which eye is being referred to. The *y* coordinates are signed the same as in the Cartesian system, i.e. up is +ve and down –ve.

12



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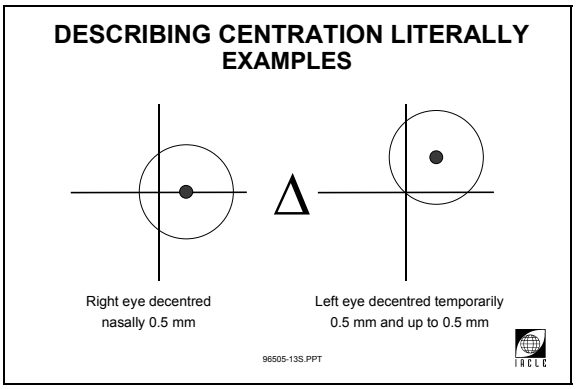
Centration Examples: Binasal System

The location of the geometric centre of a contact lens within a bi-nasal coordinate system is the basis of the description of its centration. In this system decentration nasally is always plus (+ve). A factor in favour of the bi-nasal system is the simplicity of data recording, e.g. + is always a nasal decentration, no reference to which eye is involved is necessary. This diagram shows simple and compound examples of decentred soft lenses. The same system can also be applied to rigid lenses.

13



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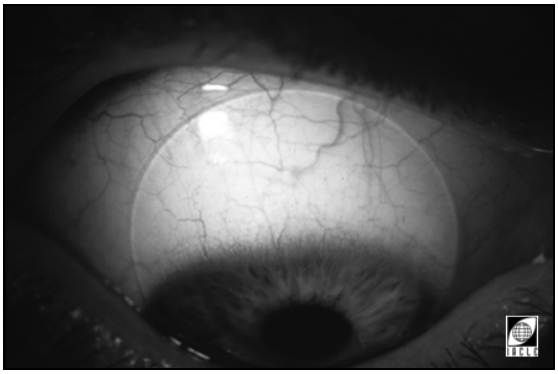
Describing Lens Centration: Literal

The preceding descriptions of centration are essentially numerical. The third, and probably the most common and unambiguous, method of describing decentration is by a *literal description*, e.g. 0.5 mm temporal decentration RE (or OD depending on local usage), RE decentred temporally 0.5 mm or temporal decentration of 0.05 mm RE.

14



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Decentred Soft Lens

A lens which is too loose will generally be excessively mobile and will not centre well. This is an example of a very loose fitting lens which not only decentres significantly on downgaze, but also does not completely cover the cornea. It is probable that in the upgaze position the lens will slide off the cornea almost completely. This lens is almost certainly uncomfortable and the vision must be affected because some of the lens periphery will cover the pupil zone (entrance pupil).

IV Altering Lens Fit

15

FITTING DESCRIPTIONS

- Good, optimum, ideal
- Steep, tight, bound
- Flat, loose, mobile
- Centred, decentred
- Low riding, high riding
- Superior, inferior, nasal, temporal

and combinations of the above

96505-14S.PPT

3L296505-14

Fitting Descriptions

As well as the descriptors appearing in the slide, variations of them and similar words may be used as required, e.g.: Steeper, Tighter, Flatter, Looser etc.

Many of these terms tend to be used interchangeably. The steep/flat descriptions probably owe much to their usage in rigid lens fitting. A complication is the fact that the BOZR of soft lenses is usually fitted *flatter* than the cornea to achieve a *normal* fit.

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WHAT GOVERNS LENS FIT ?

- Relationship between sagittal heights of lens and anterior eye (lens>eye)
- Anterior eye topography including cornea
- Blink-induced negative pressure under the lens
- Physical properties of the lens:
  - physical properties of the material
  - Rx
  - thicknesses
  - lens design
- Lid characteristics, lid/lens interaction

96505-15S.PPT

3L296505-15

17

HOW IS LENS FIT ALTERED ?

By altering one or more factors which govern lens fit *but* . . . the constants are:

- Anterior eye topography
- Rx
- Lid characteristics

96505-16S.PPT

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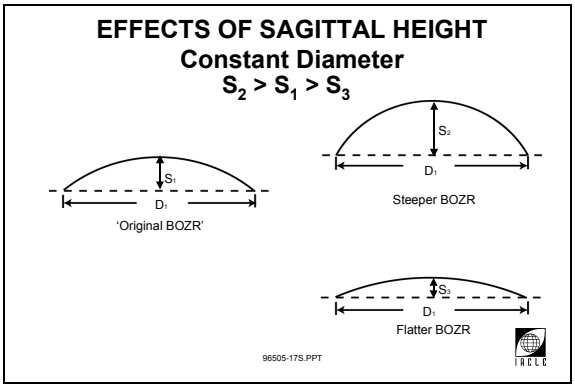
18



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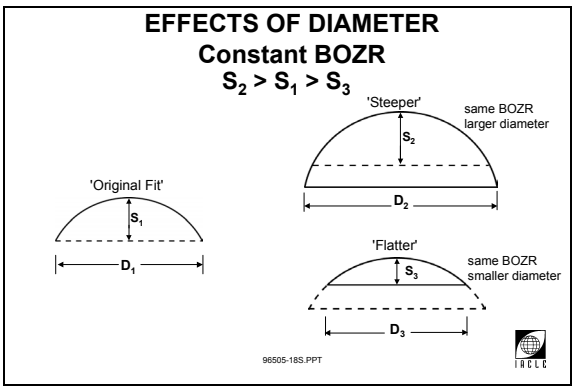

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Sagittal Height, Total Diameter

To alter the fit of a lens the relationship between the sagittal heights of the lens and the anterior eye must be changed. In most cases, a successful fit requires the inner sagittal height of the lens to be greater than that of the anterior eye (Snyder, 1984). Therefore, to *tighten* the fit, the lens height must be made even greater than that of the anterior eye. Conversely, to *loosen* the fit the height must be made less than normal even though this sagittal height may still be greater than that of the anterior eye.

The sagittal height of the anterior eye is governed by:

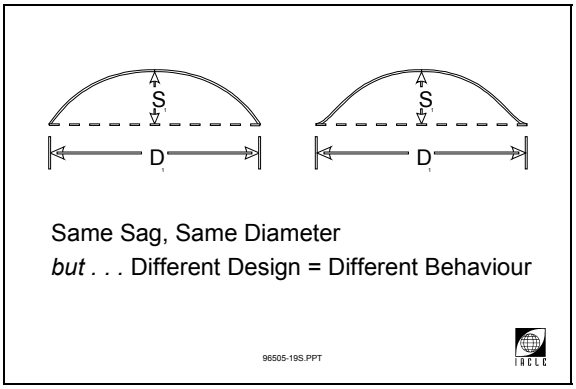
- Central corneal curvature.
- Degree of corneal asphericity.
- Corneal diameter.
- Curvature of the paralimbal sclera/conjunctiva. (Young, 1993)

While the variation in corneal asphericity influences the sagittal height of the anterior eye more than the variation in corneal curvature, it is corneal diameter which is the most influential overall (Young, 1993).

The influence of asphericity and corneal diameter on anterior eye sagittal height, and therefore lens fit, illustrates why keratometry alone is a relatively poor indicator of the soft lens required for a good fit. However, in the absence of other information it is a useful guide to initial trial lens selection. Final lens selection is then based on the results of trial lens fitting(s).

The sagittal height of a lens can be altered by changing the BOZR, the total diameter or both.

20



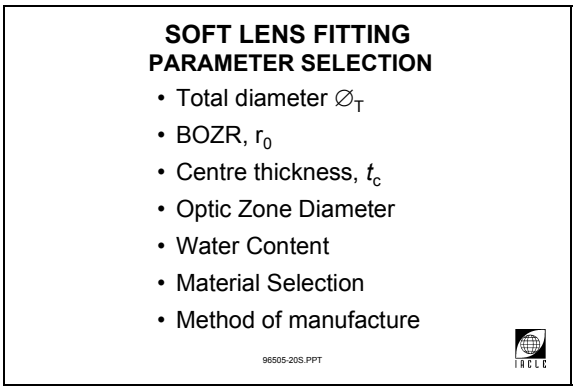
3L296505-19

Effects of Lens Design

Assuming all other factors are identical, lenses having the same sagittal height and total diameter will not necessarily exhibit similar behaviour if the back surface designs are different. This factor alone makes it difficult to base expectations of the behaviour of one lens series on the fitting characteristics of another. Different materials, Rxs, thicknesses etc. compound the potential performance differences between lenses.

Back surface design in particular is influential in determining the 'on-eye' behaviour of a lens. Factors to be considered include the basis of the shape (spherical or aspherical), the number of peripheral curves (if any) and the radii and widths of any such curves.

21



3L296505-20

IV.A Total Diameter

22

SOFT LENS FITTING
TOTAL DIAMETER SELECTION

- Measure HVID

Then either:

- Add 2mm to HVID and select trial lens set with nearest diameter ***or***
- Follow manufacture's recommendation and select suggested diameter

96505-21S.PPT

3L296505-21

23

SOFT LENS FITTING
TD SELECTION

- Larger diameters are often required with higher Rxs to improve lens fit and centration
- 0.5mm added to trial lens diameter for high water (>60%) lenses
  - accounts for on-eye shrinkage due to water loss
  - thicker lens profile (low *n*) results in greater lens/lid interaction
  - aids stability to fit and centration

96505-22S.PPT

3L296505-22

24

MEASURING HVID

- PD Rule
- Wessley Keratometer
- Graticule in eyepiece of slit-lamp
- Photographic or video image
- Comparator scale (of scaled semi-circles)

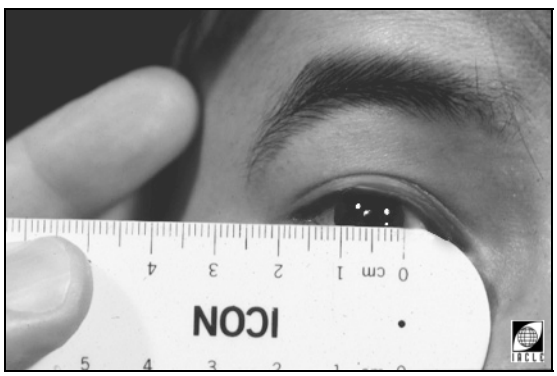
96505-23S.PPT

3L296505-11

Measuring HVID

- PD Rule.
  A standard interpupillary distance measuring rule is a suitable device for measuring the HVID. Care must be taken not to introduce parallax error into the measurement.

25



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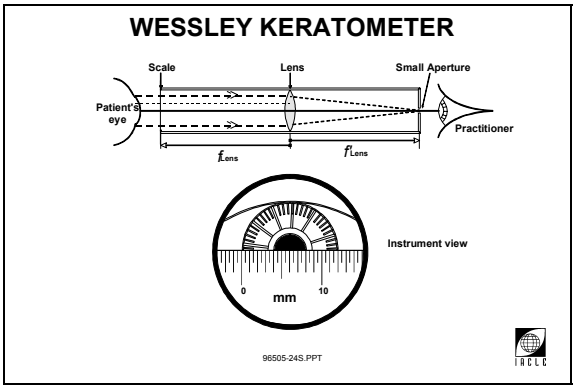
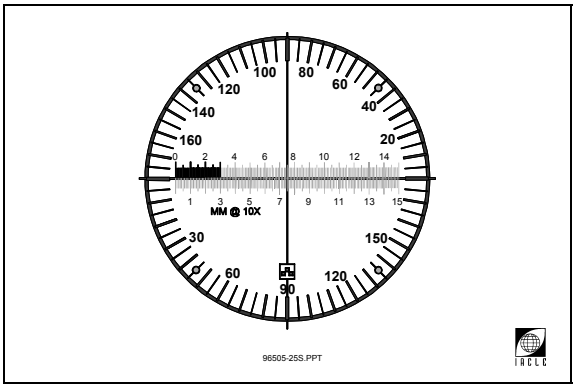
26



3L296505-24

- Wessely Keratometer.
  This simple device consists of a lens of between +5 and +10D mounted in a tube. It is based on the *telecentric* principle. The telecentric stop is located in the practitioner end of the tube at the second principal focus of the lens (*f´*). A measuring scale is located on the patient end of the tube, at the first principal focus of the lens (*f*). The HVID is read from the scale directly.

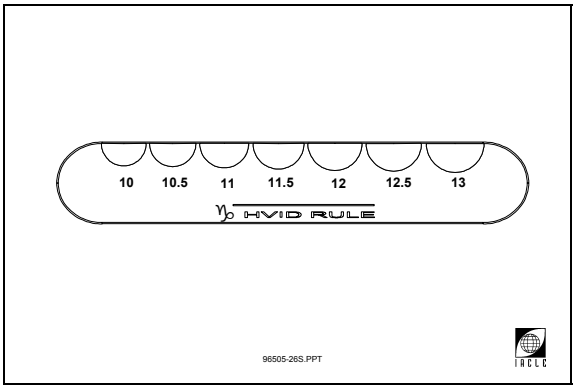
27



3L296505-25

- Graticule in eyepiece of slit-lamp.
  A measuring graticule is an accessory available for most slit-lamps. Eyepiece graticules are usually calibrated for one viewing magnification only (usually 10X). Other magnifications can be used but the actual measurement must then be calculated. Frequently, the scale also includes a protractor scale. One design uses a free-moving metal ball under the influence of gravity to indicate the angle through which the scale has been rotated to align with an observed feature, e.g. toric lens reference marks.

28

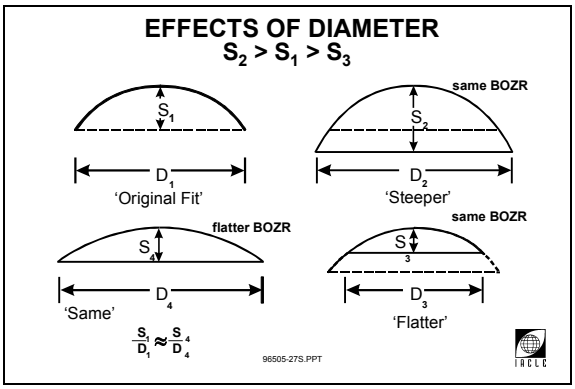


3L296505-26

- Comparator scale (of scaled semi-circles).
  This type of comparator scale has been incorporated into the design of some PD rules. Usually the range of diameters featured covers small pupils to large soft lenses in 0.5 mm steps.
- Photographic or video image.
  Images in photographic negatives, prints or slides can be measured if the camera system is pre-calibrated or calibration data is included in the image. Similarly, video monitor images can yield quantitative data. However, if the image is produced by an analogue camera and/or an analogue screen, calibration must take into account the likelihood of regional variations in magnification. The

combination of digital camera and digital screen is unlikely to exhibit this problem. Such systems are primarily used for research.

29



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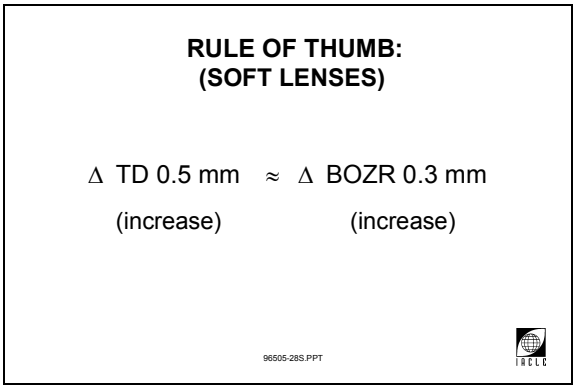


3L296505-28

Altering Soft Lens Fit: Changing Total Diameter

An increase in lens diameter will tighten the fit if all other factors remain unaltered. This is because the sagittal height is increased. A decrease in diameter will loosen the fit.

To retain the same fit:

If the diameter is increased, the BOZR must also be increased to offset the effect the diameter change has on the ratio of sagittal height to total lens diameter. Retention of lens fit requires an approximately constant ratio of sagittal height to total diameter (Gasson, Morris, 1992).

Rule of Thumb (Soft Lenses):

Increase diameter by 0.5 mm ≈ *Increase* BOZR by 0.3 mm.

If the lens diameter is increased by 0.5 mm then the BOZR should be increased by 0.3 mm to retain the same fitting characteristics.

Example:
BOZR = 8.6 mm, TD = 13.5 mm.

Desired TD = 14.0 mm.

Final lens:
BOZR = 8.9, TD = 14.0 mm

Changing TD from 13.5 mm to 14.0 mm will tighten the lens fit by increasing the sagittal height. This necessitates 'flattening' the original BOZR of 8.6 mm to 8.9 mm, to retain (approximately) the original ratio of sagittal height to total diameter, and therefore lens fit.

Lens series which are supplied in 0.2 mm BOZR steps may require a different 'rule of thumb' since the BOZR step size usually indicates a clinically significant change.

These rules of thumb **do not** apply to *aspheric* lenses. With aspheric lenses, alterations to the TD are much less significant. To tighten or loosen a lens fit, an appropriate alteration to the back surface curvature is required.

IV.B. Back Optic Zone Radius (BOZR)

31

SOFT LENS FITTING
BOZR SELECTION

Measure Ks (mm) then add either:

- 0.3 - 0.9 mm to flattest K
- 1 mm to average of Ks
- 4 D flatter than average K

Select lens of nearest BOZR from $\varnothing_T$ trial set

or . . .

96505-29S.PPT

3L296505-29

32

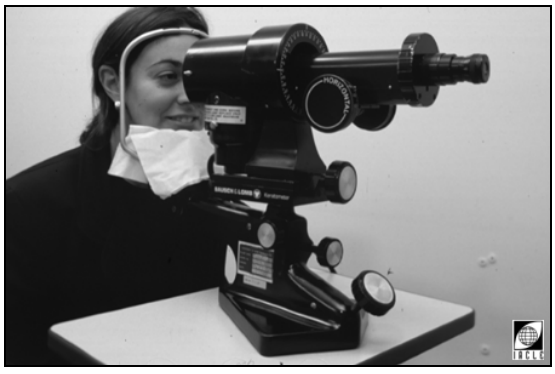
SOFT LENS FITTING
BOZR SELECTION

- Measure Ks
- Select trial lens from manufacturer's fitting guide for $\varnothing_T$ lenses
- Add 0.7 mm or more to flattest K for less flexible lens materials (thicker, low water)
- Add 0.3 - 0.6 mm for standard and flexible materials (thinner, high water)

96505-30S.PPT

3L296505-30

33



3L21652-96

The Keratometer

Many practitioners use the 'K readings' as a guide to BOZR selection. A limitation is the fact that the instrument measures approximately only 3 mm of the cornea, symmetrical about the visual axis. No significant information about the peripheral corneal topography is provided.

In addition to measuring the corneal curvature, keratometers can also be used to qualitatively assess the tear film and/or pre-lens tear film properties.

34

BOZR CALCULATION
FLATTEST K = 7.80mm
STEEPER K = 7.70 mm

Suggested Lens

+ 0.7 mm: BOZR = 8.50

- 4 D to Avg: BOZR = 8.53

- This data suggests a BOZR steps are about 0.3 mm, select an 8.5 or 8.6
- These are guides or starting points only but all methods yield similar results

96505-31S.PPT

3L2196505-31

35

3L21651-96

Fitting Guides

Manufacturer-supplied fitting guides take many forms. Some are tables of suggested trial lenses while others are flow charts or written instructions. Where few fitting options are available the fitting guides are, of necessity, brief and may contain little more than acceptance or rejection criteria.

36

SOFT LENS FITTING
BOZR

- Range: 7.90 - 9.30 mm
- More significant in thicker, less flexible lenses
- Almost irrelevant in thin, very flexible lenses
- Steep corneas are fitted relatively flatter than normal or flat corneas

96505-32S.PPT

3L296505-32

Soft Lens Fitting

BOZR

The BOZR is:

- Range: 7.90 - 9.30 mm
  Custom lenses can be ordered in any BOZR but most fall into the range presented here. Aspheric BOZRs cannot be presented in this way but some manufacturers of aspheric lenses provide an 'equivalent spherical fit' as a guide to the fitter.
- More significant in thicker, less flexible lenses.
- Almost irrelevant in thin, very flexible lenses.
- Many stock designs, especially disposable enses, can cater for up to 80% or more of thepopulation with a single BOZR.
- Steep corneas are fitted relatively flatter than normal or flat corneas.

37

SOFT LENS FITTING
BOZR SELECTION

- Use trial lens from centre of base curve range of $Ø_T$ trial lenses

  Or

- If no BOZR options available trial a lens whose BVP is close to ocular Rx

96505-33S.PPT

3L296505-33

Soft Lens Fitting

BOZR Selection

Alternative methods of selecting BOZR, especially in the absence of other information such as K readings, include:

- Use a trial lens from the centre of the base curve range of a set of $Ø_T$ trial lenses.

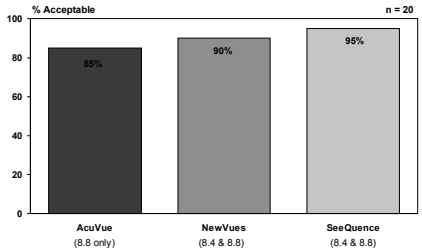
OR:

- If no BOZR options are available, trial a lens whose BVP is close to that of the ocular Rx (using the best sphere as the basis if necessary).

Results of a study of disposable hydrogel lenses are shown opposite. They demonstrate clearly that even with only one or two fitting options, the flexibility of such lenses allows the vast majority of potential contact lens wearers (with spherical or near spherical Rxs) to be fitted successfully.

38

DISPOSABLE LENS FITTING TRIAL
ACCEPTABLE FIT



96505-34S.PPT

3L296505-34

39

SOFT LENS FITTING
STOCK LENS RANGE OF BOZRs

- Usually 2 - 4 BOZRs for each diameter
- More fitting increases may be required with more rigid materials

96505-35S.PPT

3L296505-35

Soft Lens Fitting

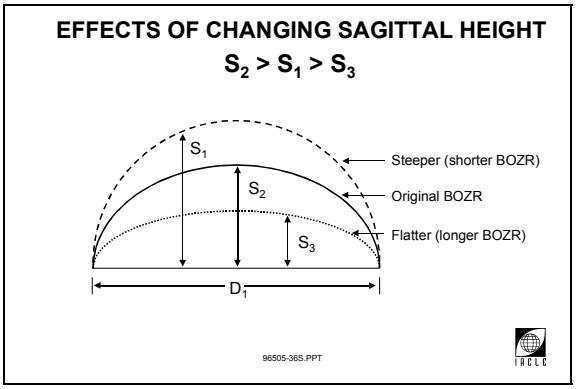
Stock Lens Range of BOZRs

Usually 2 - 4 BOZRs for each diameter. More fitting increments are required with more rigid materials.

Relatively rigid materials may also require the fitting steps to be smaller, e.g. 0.2 mm steps rather than the more common 0.3 mm steps.

Less rigid materials require fewer increments and each step may be larger, e.g. 0.4 mm rather than 0.3 mm steps.

40



3L296505-36

Altering Lens Fit: BOZR

If all factors remain unaltered, especially the total diameter of the lens, then *decreasing* the BOZR will steepen the lens fit and *increasing* the BOZR will loosen the fit. This is because these steps increase and decrease the sagittal height respectively.

To replicate a lens fit, both BOZR and total diameter must be altered in order to maintain the ratio of sagittal height to total diameter.

Rule of thumb:

Δ 0.3 mm BOZR $\approx \Delta$ 0.5 mm in TD
(increase) (increase)

This Rule of Thumb has already been presented in reverse form (see slide 30).

Changing the back surface design of a lens substantially, especially from a spherical to an aspherical design, will alter its behaviour significantly. It would be prudent to trial a lens in the new design rather than anticipate its behaviour based on the performance of the previous lens.

Similarly, the effects of any alteration to the number and/or widths and radii of back peripheral curves should be assessed rather than assumptions made.

IV.C. Trial Lens BVP

41

Soft Lens Fitting

SOFT LENS FITTING
TRIAL LENS BVP

- Select trial BVP nearest to vertex corrected spectacle Rx result
- If only ± 3.00 D (or similar) available use appropriate type (ie plus or minus)
- If Rx high but only low Rx trial lenses available, consider getting more appropriate trial lens(es)
- If large difference between trial and Rx, remember to correct over-Rx for vertex distance

96505-37S.PPT

3L296505-37

IV.D. Centre Thickness

42

SOFT LENS FITTING
t_c SELECTION

If optional select t_c based on:

- BVP
- Dk/*t*
- Intended application (DW, EW, FW)
- Duration of intended wearing period
- Durability
- Handling

96505-38S.PPT

3L296505-38

Soft Lens Fitting

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SOFT LENS FITTING
t_c SELECTION

If t_c is standard for a series ask:

- Is the Dk/t adequate for its intended use ?
- How well will the lens handle ?

96505-39S.PPT

3L296505-39

44

SOFT LENS FITTING
THICKNESS DESCRIPTION

- Spherical, Minus Lenses:
  - < 0.06 mm, ultra-thin
  - 0.06 - 0.10 mm, thin
  - 0.10 - 0.15 mm, standard
  - > 0.15 mm, thick (obsolete)
- For a given series, Plus & Toric Lenses have their t_c governed by BVP, & lens design and BVP, respectively

96505-40S.PPT

3L296505-40

Soft Lens Fitting

Thickness Description

Additionally, the term *hyper-thin* has been used for 0.035 to 0.04 mm thick lenses but this description has not gained widespread acceptance.

45

EFFECT OF THICKNESS CHANGE ON LENS FIT

- Thick lenses move more than thin
- "On-eye' behaviour not necessarily directly related to lens thickness
- Effect of lens profile/design on thickness is relevant

96505-41S.PPT

3L296505-41

Effect of Thickness Change on Lens Fit

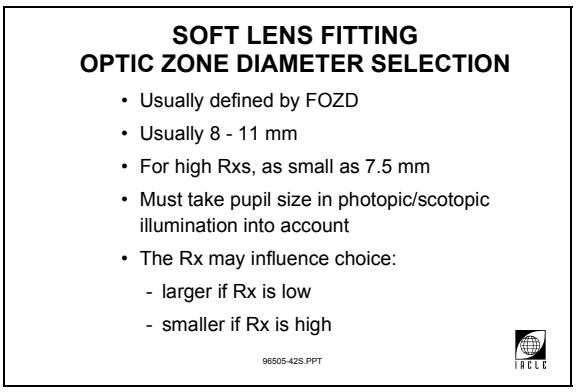
Two extremes exist.

- Thick lenses interact more with the lids and therefore move more on a blink. The greater relative lens mass of such lenses is of little consequence compared with the other factors acting on them. Thick lenses and/or lenses with thick edges will also result in greater lens decentration.

- Very thin lenses, especially if their edges are also very thin, interact less with the lids and tend to move less. Thin lenses and/or lenses with thin edges will also tend to centre better and be more comfortable.
  - Because of their flexibility, very thin lenses conform to the anterior eye shape very closely such that the very thin post-lens tear film makes lens movement difficult (thin film in shear requires a displacing force which is proportional to the inverse of the film thickness (Hayashi, 1977)). Such lenses move little with each blink. Because of reduced movement, thin and very thin lenses require fewer fitting parameters (increments). This is because the steps which are usually clinically significantly different, produce little, if any, alteration in 'on-eye' behaviour of such lenses.
- There is **not** necessarily a continuum of behaviour between the two extremes represented by thick and very thin lenses. Other factors, including the physical properties of the lens material, are relevant.
- The effect of BVP on the thickness profile, especially in high minus Rxs, cannot be ignored. The increased peripheral rigidity of such lenses alters the lens behaviour and tends to make the lens fit tighter.

IV.E. Optic Zone Diameters

46



3L296505-42

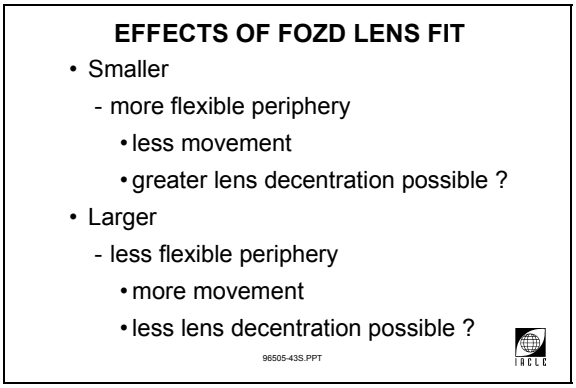
Optic Zone Diameter Selection

Where no choice of FOZD is offered it is prudent to ascertain what the FOZD is, so that the likelihood of problems related to an inadequate FOZD can be estimated.

In high BVPs, it is necessary to keep the BOZD as small as possible in the interests of regional and overall lens thickness. A limiting factor is the wearer's pupil size in the light levels applicable.

Alterations in lens thickness can be expected to alter the fit of the lens.

47



3L296505-43

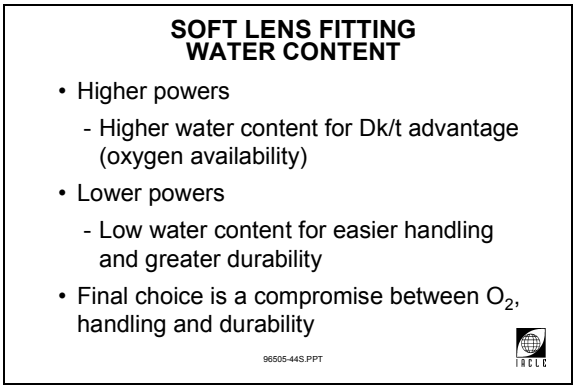
Effect of FOZD on Lens Fit

For SCLs, smaller FOZDs result in a more flexible *periphery.* The greater resultant lens conformity increases viscous drag, thereby *decreasing* lens movement. However, the reduction in peripheral rigidity *may* allow the lens to decentre more (albeit more slowly because of the greater viscous forces). This is because it is now less able to resist the lens flexure that accompanies decentration.

Conversely, larger FOZDs result in a thicker mid-periphery and periphery. Because of reduced lens conformity (less viscous drag), greater movement can be expected. However, the more rigid periphery resists decentration flexure more, thereby reducing the amount of decentration likely.

IV.F. Material Water Content

48



3L296505-44

Soft Lens Fitting

Water Content

- Higher powers:

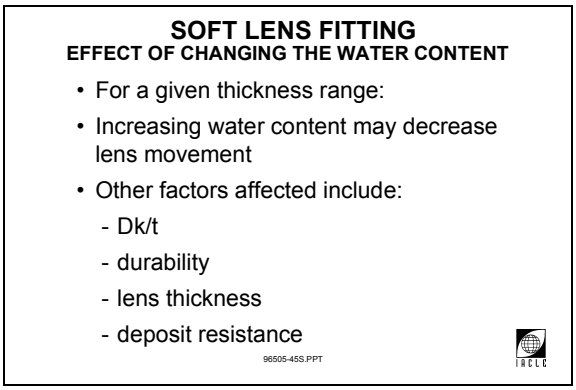
  Higher water content for Dk/*t* advantage (oxygen availability).
  The higher oxygen transmissibility of higher water content materials usually more than offsets the disadvantage of the greater lens thickness inherent in such materials.

- Lower powers:

  Low water content for easier handling and greater durability.
  The greater rigidity and durability of low water materials make them more attractive in lower powers. This is due largely to the perception that their reduced thickness decreases the need to pursue the physiological performance of the lens.

- Final choice is a compromise between oxygen availability, lens handling and durability.

49



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Soft Lens Fitting: Effect of Changing the Water Content

- Effect on lens fit.
  Any factor which alters lens rigidity alters the fitting behaviour of a lens. A lower rigidity increases lens conformity which thins the post-lens tear film, thereby increasing viscous drag on the lens. *Less* movement results. Therefore, when a lens material is changed to one with a higher water content, less movement is expected. However, for a given prescription a shift to a higher water material has an attendant increase in lens thickness. This offsets some of the rigidity loss and also results in more lens-lid interaction. Little alteration in lens behaviour may be apparent and may depend to some extent on the original physical properties of the lens material.

- Other factors which may need to be considered include:

– Dk/*t*
– durability
– lens thickness
– deposit resistance.

50

SOFT LENS FITTING
EFFECT OF METHOD OF MANUFACTURE

For a given chemistry, the manufacturing method influences lens rigidity and therefore fit.

In order of increasing rigidity:

- Spin-cast
- Spin-cast with lathed back surface
- Molded with lathed front surface
- Molded both sides
- Lathed from a cast button

96505-46S.PPT

3L296505-46

Soft Lens Fitting: Effect of Method of Manufacture

The manufacturing method used to fabricate soft contact lenses greatly influences their fitting behaviour. With little or no differences in basic chemistry, the physical properties of a lens depend largely on the method used. Differing physical properties translates to different fitting behaviour. These differences are best illustrated by the example of HEMA lenses. With the possible exception of the rate of cross-linking within the polymer, chemically, most HEMA lenses are identical. Most contain the same cross-linking agent. However, for lenses of similar parameters their physical properties vary depending on the manufacturing technique. The least rigid and most elastic variant is represented by spin-cast material. The most rigid and inelastic material is lathe cut from a cast button. The other manufacturing methods occupy the middle ground.

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SOFT LENS FITTING
LENS RIGIDITY

Depends on:

- Chemistry
- Method of manufacture
- Water content
- Thickness
- Other material properties

96505-47S.PPT

3L296505-47

52

SOFT LENS FITTING

Lens rigidity least with:

- Thinner lenses
- Spin-cast manufacture
- High water contents

96505-48S.PPT

3L296505-48

53

SOFT LENS FITTING

Lens rigidity greatest with:

- Thick lenses
- Lathe cut lenses
- Low water materials or;
- Materials with MMA or PVA

96505-49S.PPT

3L296505-49

V Empirical Prescribing

54

SOFT LENS FITTING
EMPIRICAL PRESCRIBING

Patient data required for lens choice:

- HVID
- Ks
- Spectacle Rx
- Vertex distance
- Inter-palpebral aperture data ?

96505-50S.PPT

3L296505-50

55

SOFT LENS FITTING
EMPIRICAL PRESCRIBING

Advantages:

- Simple and quick for the practitioner
- No trial lenses required
  - cheaper for manufacturer
  - no lens maintenance/storage by practitioner
  - no public health issue with trial lens reuse
- Uses the 'experience' (database) of the manufacturer to prescriber's advantage

96505-51S.PPT

3L296505-51

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SOFT LENS FITTING
EMPIRICAL PRESCRIBING

Disadvantages:

- Exceptions always exist
- Patients don't experience lens wear before delivery
- Practitioner cannot observe patient's response to lenses
- Practitioner seen to be abdicating their responsibility
- Accuracy of outcome ?
- Fit is more complicated than just HVID & Ks

96505-52S.PPT

3L296505-52

Soft Lens Fitting

Empirical Prescribing

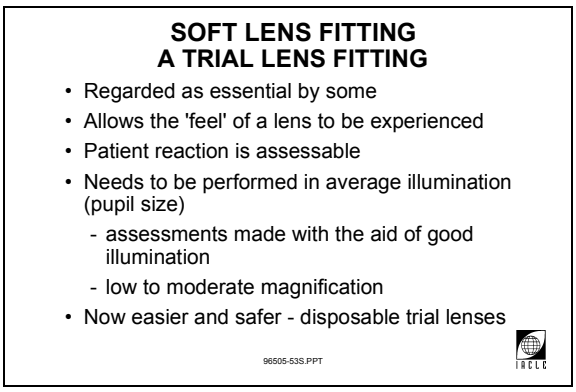
Disadvantages:

Only experience will indicate whether the patient's and practitioner's expectations are met by using this prescribing method.

Further, lens fitting is more complicated than just measuring HVID & Ks. While this is especially true for RGP lenses rather than soft, it is prudent to remember that keratometers only measure the central 3 mm (approximately) of the cornea. No knowledge of the rest of the cornea is available unless a topographical assessment is made.

VI The Trial Fit

57



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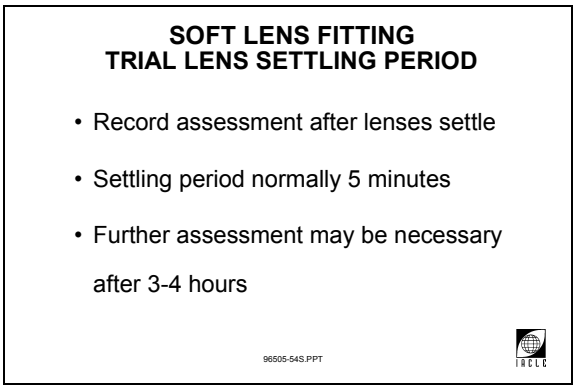


3L296505-54

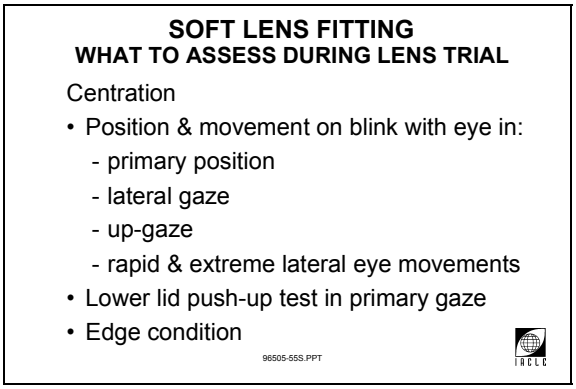
Soft Lens Fitting

Trial Lens Settling Period

- An assessment of the trial lens should be recorded after a 5 minute period which is normally sufficient for an uncomplicated lens fit.
  - Settling time may depend on water content, BVP and material chemistry.
    These factors govern the volume of water in a soft lens. Water content can influence lens parameters and therefore, the lens fit.
  - High water and high power lenses take longer to settle (equilibrate with their environment) probably because the volume of water they contain is greater, necessitating a longer equilibration process.

Where practical, a longer settling time may be necessary to evaluate the lens fit and/or how the patient has adapted to lens wear. This can be done after 3 - 4 hours or at the progress evaluation stage after lenses have been dispensed.

59



3L296505-55

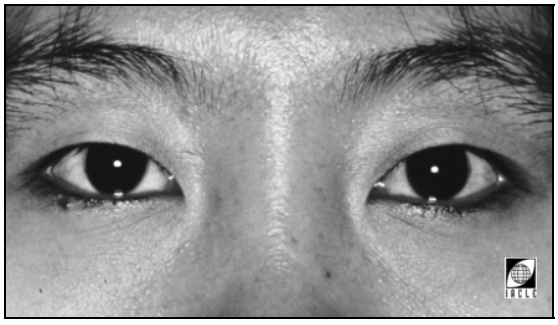
Soft Lens Fitting

What to Assess During Lens Trial

- Lens centration.
  In the primary gaze position, decentrations of 0.2 – 0.75 mm are acceptable.
- Position and movement of the lens resulting from a blink with the eye in the positions listed.
- Outcome of a lower lid push-up test in primary gaze position.
  - observe ease of moving lens from its static position
  - speed of recentration following intentional displacement
- observe the quality of centration after displacement.
- Edge buckling, pleating or lifting.
  One sign of an excessively flat lens, or a lens inside out, is a buckled or pleated lens edge lifting away from the eye.

  Other signs of excessive flatness may be air bubbles or simple atmospheric ingression into the areas of edge lift-off.

60



3L21372-91

Primary Gaze Position: Asian and Caucasian Eyes

The differences in eyelid position, angle and shape are apparent in slides 60 and 61. Each of these factors or a combination of two or more of them can influence lens behaviour especially lens movement and centration.

61

3L21370-91

62

3L20143-93

Lateral Gaze, Lateral Versions

Directing fixation laterally or requesting the fixation alternate rapidly (e.g. between right and left) can reveal much about the fitting behaviour of a lens. Of greatest interest are any tendencies for the lens to decentre or for the lens position and movement
to lag behind that of the eye's. Excessive decentration or lag may indicate the lens is too loose or flat. No lag or decentration could mean that the lens is too tight.

Up-gaze and up-gaze blink tests are covered later (see slides 76 and 77)**.**

63

SOFT LENS FITTING
WHAT TO ASSESS DURING LENS TRIAL

- Observe decentration and/or lag:
  - Primary gaze (0.2 - 0.75 mm acceptable)
  - Upgaze (up to 1.5 mm acceptable)
  - Lateral eye movements (up to 1.5 mm acceptable)

96505-56S.PPT

3L296505-56

Soft Lens Fitting

What to Assess During Lens Trial

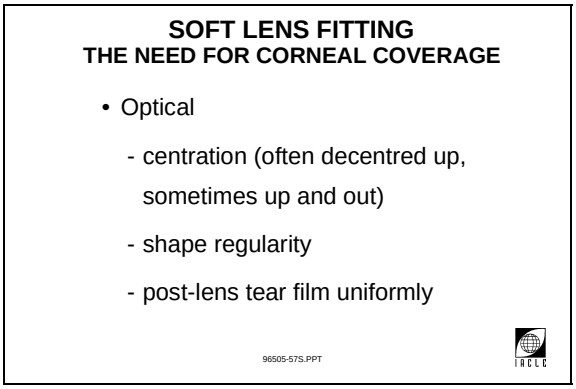
- Observe lens decentration and/or lag under the following circumstances:
- Primary gaze (while 0.2 to 0.5 mm is more common, 1.0 mm is probably excessive, depending on lens flexibility). Young, 1996 showed that while 31% of tightly fitting lenses showed > 0.3 mm decentration, 0.3 mm was the optimum cut-off point for identifying loose lenses.
- Upgaze (up to 1.5 mm acceptable provided it is consistent).
- Lateral eye movements (up to 1.5 mm acceptable providing it is consistent).

  As discussed previously, very flexible lenses move little due to conformity, the resulting thin post-lens tear film and the larger shear forces thin films induce.

Corneal coverage under all reasonable circumstances is still required. This needs to be ascertained.

VII Corneal Coverage

64



3L296505-57

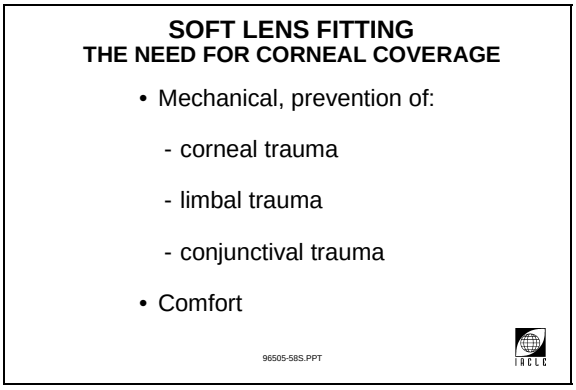
Soft Lens Fitting

The Need for Corneal Coverage

- Optical:
  - centration (soft lenses often decentre up and sometimes up and out)
  - shape regularity
    A decentred lens, when conforming to the anterior eye shape, may affect the optical performance
  - post-lens tear film uniformity

    A decentred, conforming soft lens will have some localized thinning of the post-lens tear film in the regions of heaviest touch (greatest bearing pressure).

65



3L296505-58

Soft Lens Fitting

The Need for Corneal Coverage

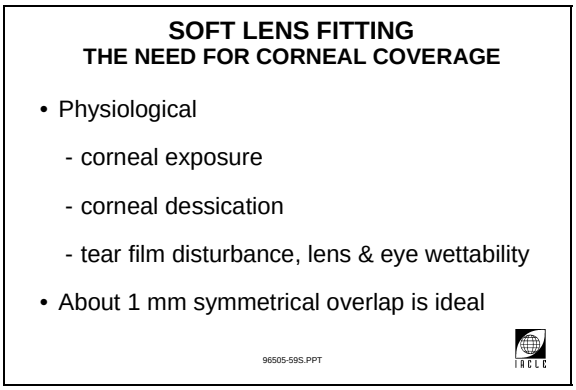
- Mechanical:
  - prevent trauma of

    Cornea

    Limbus

    Conjunctiva.
- Comfort.
  A decentred lens, especially a mobile decentred lens, may be less comfortable than a centred lens exhibiting optimal soft lens movement.

66



3L296505-59

Soft Lens Fitting

The Need for Corneal Coverage

- Physiological:
  - corneal exposure can lead to discomfort
  - corneal dessication in the areas exposed
    Any loss of the aqueous phase of the tears by evaporation may lead to corneal desiccation. Tear film thinning due to the meniscus at the lens edge may also affect the exposed areas (a similar

mechanism is used to explain 3 & 9 o'clock staining with RGP lenses).

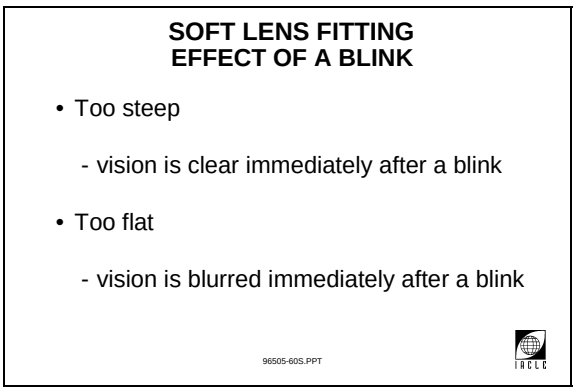
- tear film disturbance, lens and eye wettability.

  Loss of the aqueous phase may lead to lipid contamination of the mucin layer potentially affecting the eye's wettability.

- About 1 mm symmetrical overlap, and in all positions of gaze, is considered ideal.

VIII The Effect of a Blink

67



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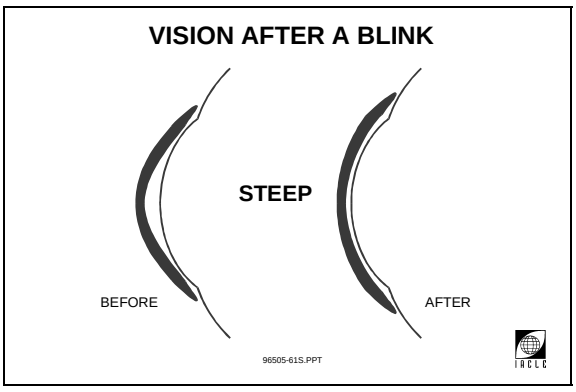
68



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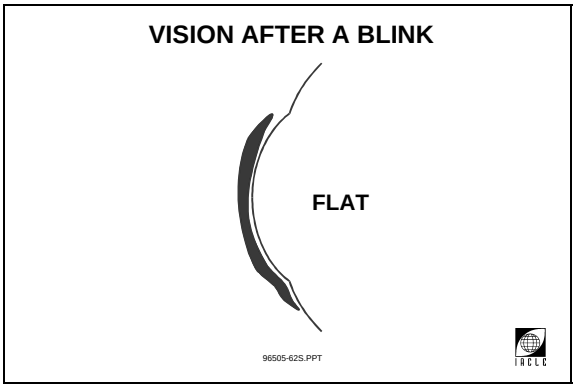
69



3L296505-62

Soft Lens Fitting

Effect of a Blink

Too steep:

– Vision clears *immediately* after a blink and then quickly reverts to a lesser quality. The latter is due to a tendency of the lens to attain an irregular aspheric shape when standing off from the cornea.

  The pressure of the lids during a blink forces the lens to conform to the central cornea. This results in a transient improvement in the vision quality.

  Between blinks the visco-elastic properties of the lens return it to the 'stand off' position, and the vision decreases due to irregularities in its shape. However, this is very unlikely as all soft lenses are fitted flatter than the cornea.

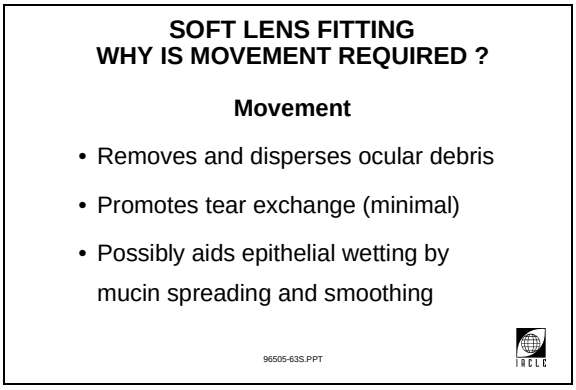
Too flat:

– Vision is generally good in the primary gaze position but blurs *immediately* after a blink. It may then revert to its previous better quality.

  A loose fitting lens will tend to decentre. Regardless of the direction, the decentred lens will be forced to conform to the shape of the anterior eye. Not only is this shape undesirable optically but the resultant distortion can be transferred to adjacent lens areas as well. This exaggerates any adverse optical effects of lens decentration. Vision cannot improve significantly until the lens moves towards a more central position and a more optically desirable lens shape is restored.

IX Lens Movement

70

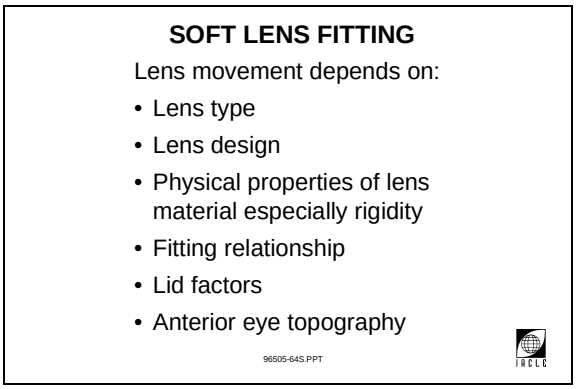


3L296505-63

Soft Lens Fitting

A slight inferior lag in the primary position may assist debris dispersal by lens movement. Low-grade inflammation may be a consequence of excessive tightness.

71



3L296505-64

Soft Lens Fitting

Lens Movement Depends On:

- Lens type.
  Plus or minus, high or low power, lenticulated or full aperture.
- Lens design.
  This includes manufacturer-specific aspects as well as thickness, front surface profile, BOZD/FOZD and back surface design (aspheric, monocurve, bicurve, etc.).
- Physical properties of lens material, especially rigidity (i.e. less movement with less rigid lenses).

  The physical properties depend largely on material chemistry, water content and manufacturing method (i.e. spin-cast, molded, lathed or a combination of these).
- Fitting relationship.
  Optimal, steep, flat.
- Lid factors.
  The shape, position and angle of the lids all have the potential to affect the freedom with which a lens may move.
- Anterior eye topography.
  The presence or absence of a significant corneo-scleral junction angle (e.g. Japanese eyes have almost none, making soft lens fitting different to other racial groups).

72

SOFT LENS FITTING
ASSESSMENT OF MOBILITY ?

- Movement on a blink
- Lag following eye movement
- Movement on up-gaze blink
- Lower lid push-up test

96505-65S.PPT

3L296505-65

Soft lens Fitting: Assessment of Mobility

Soft lens movement can be assessed and/or measured with a slit-lamp eyepiece graticule. The various observations listed should be consistent with an overall lens assessment e.g. if the lens is 'tight' all observations should indicate this.

73

SOFT LENS FITTING
MOVEMENT ASSESSMENT PRECAUTIONS

- If conjunctiva is loose, edge indentation may be more noticeable
- loose conjunctiva flexes with lens giving false impression of lens movement
  - none may be present ?
- Loose conjunctiva may decrease lens movement by enveloping lens edge

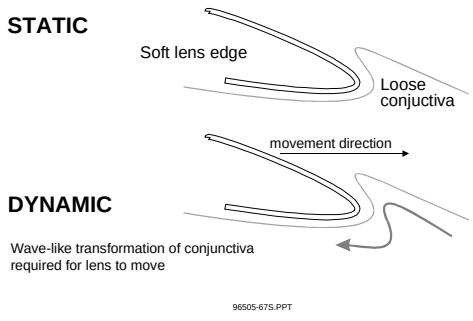
96505-66S.PPT

3L296505-66

Soft Lens Fitting

74

LENS EDGE ENVELOPMENT



96505-67S.PPT

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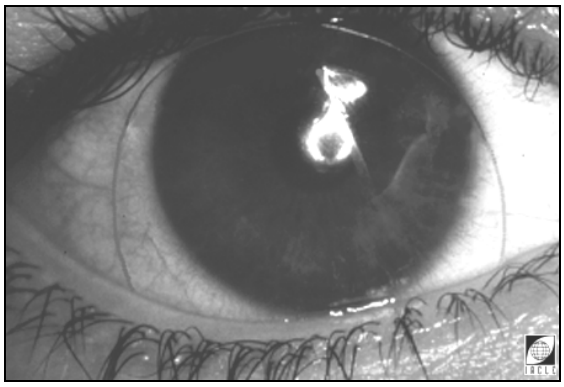
Real lens movement on a loose conjunctiva necessitates a wave-like transformation of the enveloping conjunctiva. This requirement will reduce or prevent lens movement.

X Lens Lag

X.A Primary Gaze Lag

75



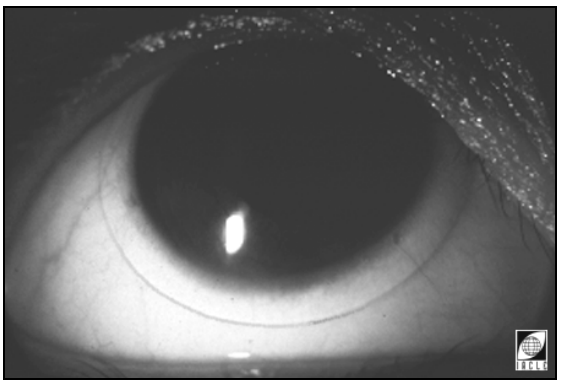
3L21069-93

Primary Gaze Lag and/or Primary Gaze Decentration

With the eyes in the straight ahead position (the so-called 'primary gaze' position) the patient is instructed to maintain their eye position and not blink. The lens position (decentration) is noted using any of the recording systems presented previously. Lens lag is defined as the amount by which the lens trails the movement of the eye under stated conditions. Lens lag is commonly assessed following supraversions ('up-gaze') and lateral versions rather than in the primary gaze position.

X.B Up-Gaze Lens Lag

76



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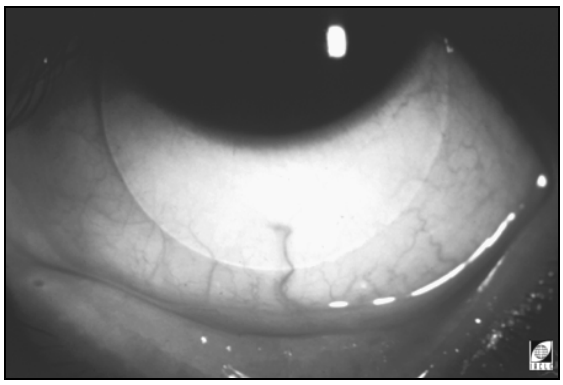
77



3L21297-91

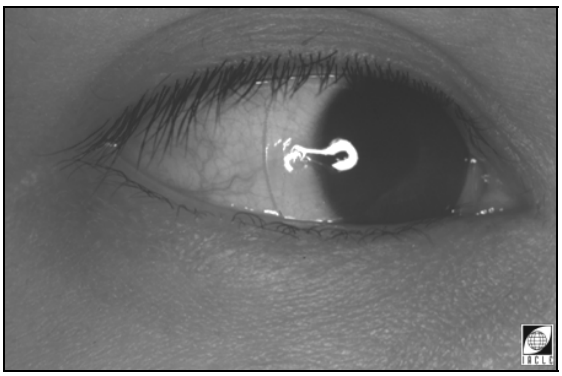
Up-Gaze Lens Lag Assessment

With the eye looking up (the 'up-gaze' position), the patient is instructed to maintain their eye position and not blink. The resultant lens behaviour, particularly its centration, is noted. The assessment can be repeated several times. If no movement is apparent then a lower lid push-up test (see later) should be used to 'unsettle' the lens and the assessment repeated.

If the lens slides down from the cornea despite the supraversion of the eye, it is reasonable to assume that the fit is either *good* to *loose,* or *loose.* If the lens remains in its original position it is potentially too *tight.* In such circumstances, a lower lid push-up test should be performed.

X.C Lateral Version Lag

78



3L21659-96

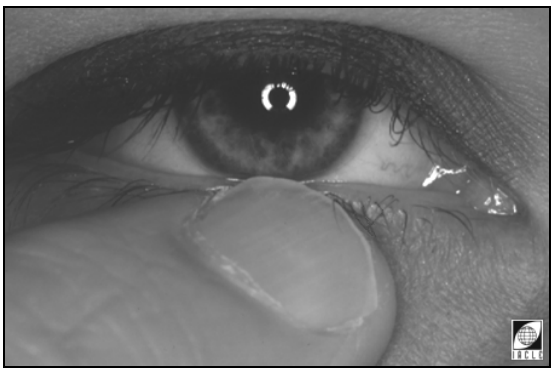
Lateral Version Lens Lag

When horizontal eye excursions are requested, the lens fit can be assessed, at least partially, by the extent the lens follows the eye. With the eye looking laterally does the lens centre or is it displaced significantly? After several full-sweep oscillations of the eye does the lens follow closely and then recentre quickly when the eye returns to the straight ahead position?

If its behaviour is not consistent, or its recentration unreliable, the fit may be too *loose*, especially for particular occupations (drivers) or lifestyles (particularly body-contact sports).

XI Lower Lid Push-Up Test

79



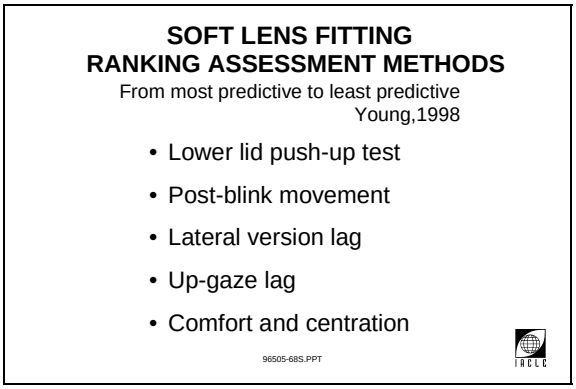
3L21658-96

Lower Lid Push-Up Test

When performing this test it is important to keep the square rear lid margin apposed to the globe so that the lens can be engaged usefully. When a finger is applied to the centre of the lower lid there is a natural tendency for the lower lid to 'gape' away from the globe thus rendering this test impossible.

What is desired is an easy displacement of the lens across or over from the cornea while the eye is in the primary position. Once lid manipulation is ceased, it is expected that the lens will rapidly and reliably recentre on the cornea. Should the lens be difficult to displace, and then be sluggish to recentre, it can be assumed that the lens fit is tending towards *tight.* If the lens fails to return at all then the fit is *tight* to *very tight.*

80



3L296505-68

Ranking Assessment Methods

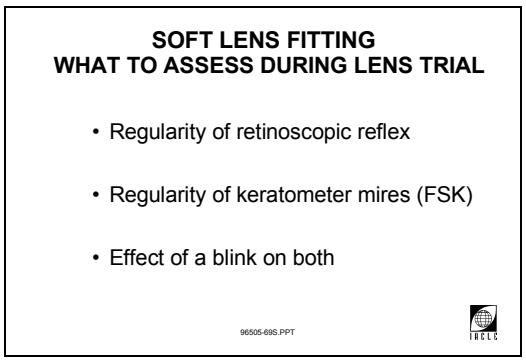
The following list, ranked from the most predictive to the least, is taken from Young, 1996. The factor to which each test is more applicable is presented in brackets.

- Lower lid push-up test (tight > loose).
- Post-blink movement (tight).
- Lateral version lag (loose).
- Up-gaze lag (tight).
- Comfort *and* centration are of some value in loose fits only.

Importantly, Young concludes; 'Most of the observed characteristics are poorly predictive of lens fit when used alone'.

XII Supplementary Tests

81



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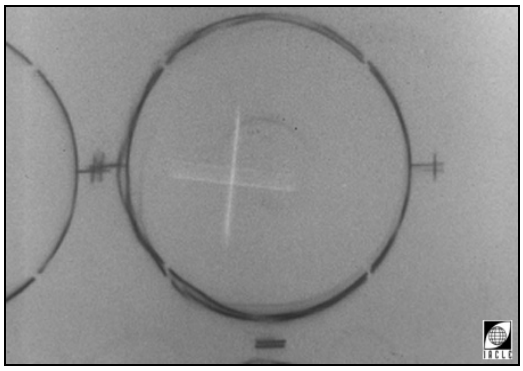
82



3L23064-93

Soft Lens Fitting

Supplementary Tests During Lens Trial

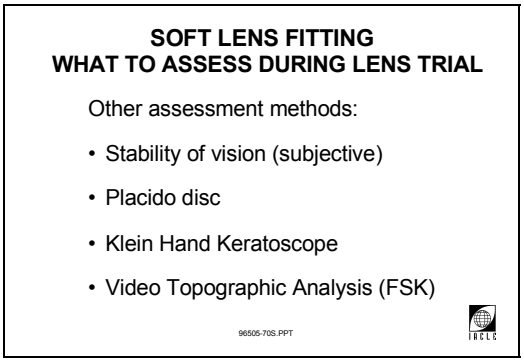
The regularity of retinoscopic reflex.

The regularity of keratometer mires reflected from the front surface of the contact lens (FSKs) see slide 82.

Distortion of the mire circles is indicative of irregularity of the reflecting surface. If the mire quality is distorted when performing front surface keratometry (FSK) with a soft lens in place then the fit should be regarded suspiciously.

– The effect of a blink on the regularity of both the retinoscopic reflex and keratometer mires. The keratometer mire image quality throughout a full blink cycle should also be ascertained and the effect of the lids determined. The FSK mire appearance is likely to be more acceptable immediately *after* a blink for a steep fitting lens, and immediately *before* a blink for a flat fitting lens. The former is due to forced conformance, the latter is due to greater regularity of the lens before it is decentred and becomes less regular. If a lens is only *slightly* flat or steep then little difference in vision or mire quality may occur especially if the lens material is very elastic. If the lens is *very* flat then it may resist conformation and acquire a convoluted shape instead.
Similarly, the refractive effects of irregular lens shapes alters the quality of the retinoscopic reflex. The effect is probably more noticeable in *steep* fitting lenses.

83



3L296505-70

Soft Lens Fitting

Alternative Tests During Lens Trial

Other methods of assessing the effects of blinking, lens position and lens movement include:

- Stability of vision (assessed subjectively).
- Hand-held keratoscope:

  Placido disc.

  Klein Hand Keratoscope.

  This instrument enables a qualitative assessment of the regularity of the front surface shape of a soft contact lens. It consists of a set of reflective or luminous concentric rings whose images, reflected from the pre-lens tear film, provides qualitative information on the regularity of the contact lens in its role as the tear film's substrate.
- Video Topographic Analysis (FSK). Data from the image formed by the pre-lens tear film can be used both quantitatively (front surface keratometry or FSK) and qualitatively to assess regularity and behaviour of the lens on the eye.

XIII Lens Fit

XIII.A The Movement Desired

84

SOFT LENS FITTING
DESCRIPTIONS TO FIT

- Steep - Tight
- Good, Optimum, Normal, Average
- Flat - Loose

96505-71S.PPT

3L296505-71

Soft Lens Fitting: Descriptions of Fit

Although these terms are often used interchangeably inconsistencies exist, e.g. a flat lens is not always loose. Also a lens may decentre and under some circumstances this can limit lens movement.

85

SOFT LENS FITTING
ASSESSMENT OF TIGHTNESS

- Movement in millimeters
- % Tightness
  - 100% = bound
  - 60 - 40 % desired
  - 0% = lens won't stay on eye
- Ease of lens push-up

96505-72S.PPT

3L296505-72

Soft Lens Fitting: Assessment of Tightness

Lens 'tightness' is usually assessed using digital pressure on the lower lid to nudge the lens.

86

SOFT LENS FITTING
TIGHTNESS: WHAT IS ACCEPTABLE?

- Post blink movement 0.25 to 0.75 mm
- Slightly less movement may be acceptable with higher Dk/t_c lenses

96505-73S.PPT

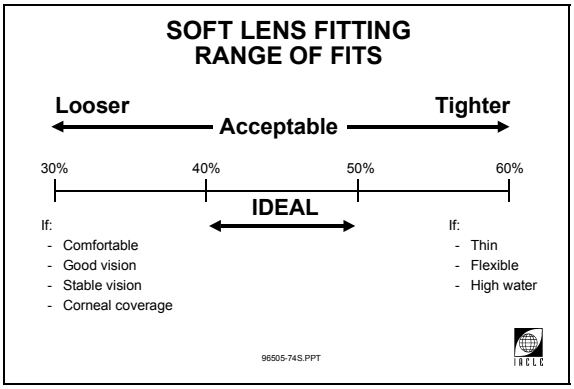
3L296505-73

Soft Lens Fitting

Tightness: What is Acceptable?

- Slightly less movement *may* be clinically acceptable with lenses offering better physiological performance (higher water content or ultra-thin lenses, i.e. higher Dk/t_c). However, it must be remembered that lens movement is not a significant contributor of oxygen through tear exchange under a soft lens. Regardless of lens factors or performance some movement is always required.

87



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Soft Lens Fitting

40 to 60% Tightness

- 60% acceptable if lens:
  - is thin
  - is flexible
  - has a high water content.
- 30 - 40% acceptable if lens:
  - is comfortable
  - provides good and stable vision
  - gives full corneal coverage.

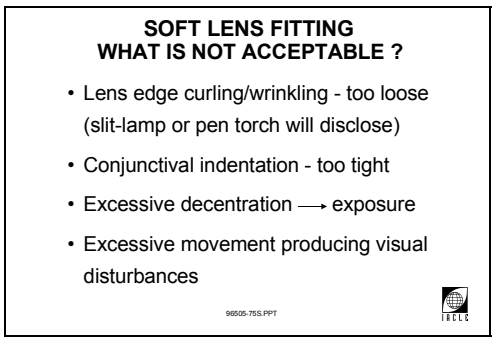
Some practitioners interpret 50% tightness according to the lens type, i.e. 50% is the desired fit for each lens type rather than it being an absolute measure. Regardless of the rating system used it must be applied consistently and be based on significant clinical experience.

Some practitioners prefer a relatively loose fitting lens. They argue that there is no such thing as *too much* movement provided the following criteria are satisfied:

- Good and stable vision.
- Good comfort.
- Corneal coverage under all reasonable circumstances.

XIII.B What is Unacceptable?

88



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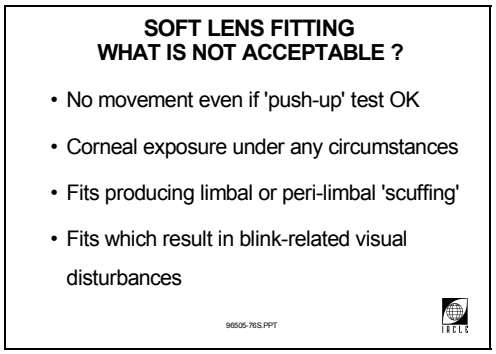
89



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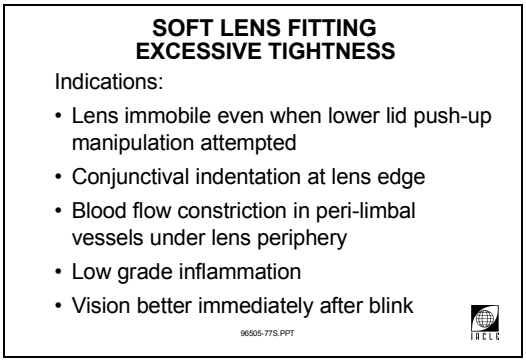
Soft Lens Fitting

What is NOT Acceptable?

- Lens edge curling/wrinkling. This is an obvious sign of a lens fit which is too loose (a slit-lamp illumination system or a pen torch, directed obliquely outwards *towards* the lens edge will disclose any edge stand-off).
- Conjunctival indentation is indicative of a lens fit which is too tight.
- Excessive decentration leading to corneal exposure. This can be a common feature of a flat/loose fitting lens.
- Excessive movement producing visual disturbances, e.g. poor vision or fluctuating vision. This suggests a fit which is excessively loose.
- No movement even if a ‘push-up’ test is satisfactory. While the ‘push-up’ test suggests a satisfactory fit, the inability of the lids and eye movement to produce any lens movement may result in stagnation of the post-lens tear film. Clinically, this is known to be unacceptable.
- Corneal exposure under any circumstances.
- Fits producing limbal or peri-limbal ‘scuffing’. This may result from of a steep back peripheral design combined with a relatively tight lens fit. It is likely to be due to the mechanical effects associated with lens movement and the lens edge.
- Fits which result in blink-related visual disturbances.
  Excessive lens movement, especially in higher Rxs, can result in disturbances of vision including apparent image shift and fluctuations in vision quality.

90



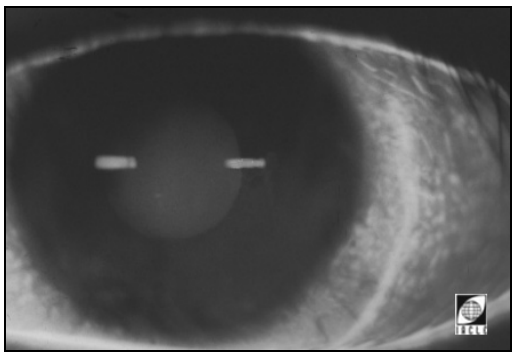
3L296505-77

Soft Lens Fitting
Excessive Tightness

Indications:

- Lens is immobile even when lower lid push-up manipulation is attempted.
- Conjunctival indentation at the lens edge.
- Blood flow constriction in peri-limbal conjunctival vessels under lens periphery.
  This includes blanching of the vessels under the edge of the lens and/or any apparent 'step' in blood vessel calibre which coincides with the lens edge.
- Low-grade inflammation. This may be the result of chronic exposure to adverse condition under a tight lens.
- Vision is better immediately after a blink.
-

91

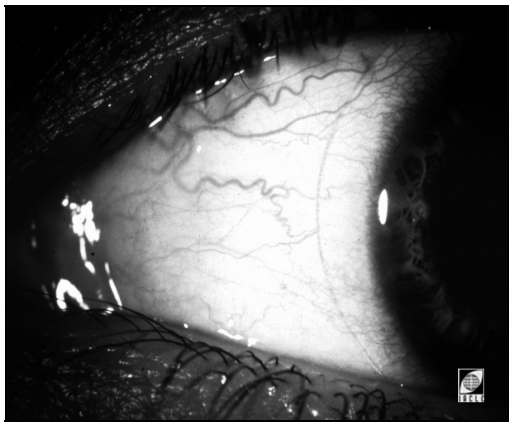


3L23093-93

Conjunctival Indentation

This slide shows the result of conjunctival indentation *after* lens removal. Sodium fluorescein is filling the depression left in the conjunctiva and disclosing the conjunctival epithelial cell damage caused by the excessive pressure at the edge of the lens.

92



3L22612-93

Conjunctival Redness

Blood vessel engorgement as well as vasodilation of vessels under the lens periphery, are apparent in this slide. These are common clinical signs of excessive lens tightness. Little apparent lens movement and blood vessel blanching under the lens edge, are usually indicative of a tight lens fit.

93

SOFT LENS FITTING

- It is useful to remember that 'on-eye' dehydration tends to tighten the fit

96505-78S.PPT

3L296505-78

94

SOFT LENS FITTING
EXCESSIVE LOOSENESS

Indications:

- If extreme, lens will not stay in eye
- Excessive lens movement
- Wrinkling/buckling of lens edge
- Vision variable but worse immediately after blink if decentred
  - if lens centred blink may be little or no difference

96505-79S.PPT

3L296505-79

95

SOFT LENS FITTING
EXCESSIVE LOOSENESS

Indications:

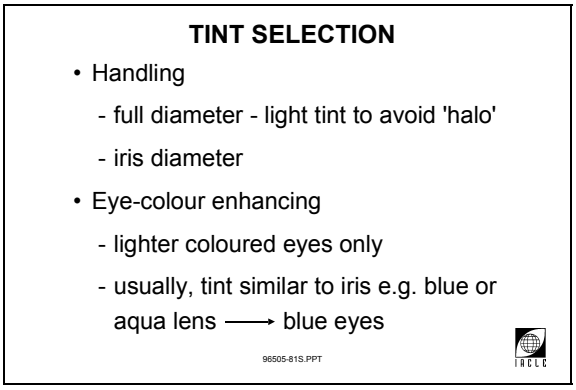
- Inferior lens lag even in primary eye position
- Lens may slip off cornea in up-gaze and/or up-gaze blink
- Subjective discomfort due to lens mobility

96505-80S.PPT

3L296505-80

XIV Tinted Lenses

96



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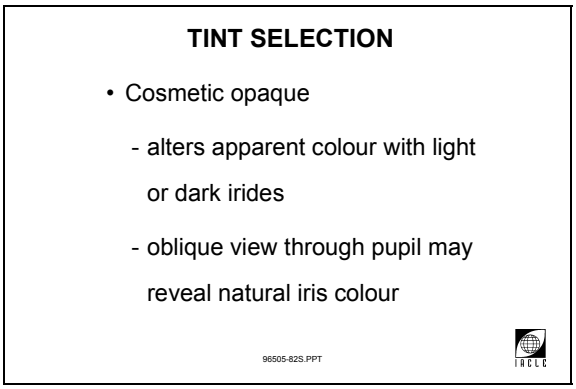

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Tint Selection

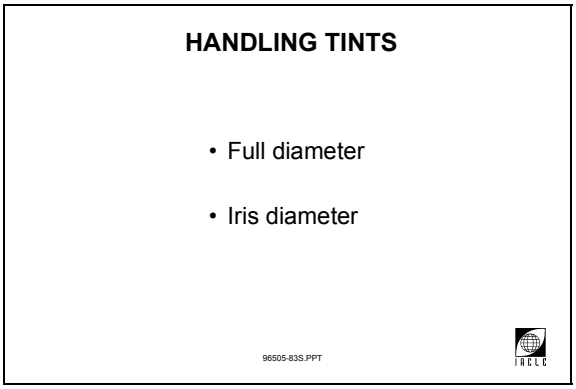
Contact lens tints can be divided into several broad categories. These are:

- Handling.
- Eye-colour enhancing.
- Cosmetic opaque.

Other categories such as therapeutic opaque exist but are uncommon.

Each of the categories listed above are covered in detail in the following slides.

98



3L296505-83

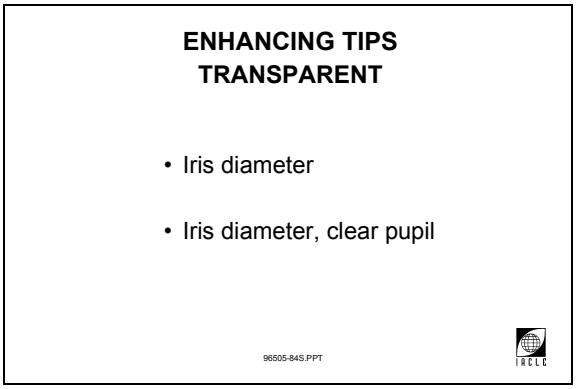
Handling Tints

- Full diameter.
  This is the most common form of handling tint. To contain costs it is necessary to avoid any unnecessary manufacturing steps. A clear periphery necessitates special molds which protect the lens area which is to remain untinted. A full-diameter tint allows the bulk tinting of unmounted lenses. However, to prevent this type of tint appearing as a circumcorneal coloured halo contrasted by the sclera, it is necessary to limit the tint density to very light only.
- Iris diameter.
  While more costly to manufacture, this tint type allows a wider range of tint densities and colours to be used. However, in cases of excessive lens movement, the use of darker handling tints is still potentially a problem. Under these circumstances the colour of a decentred lens may become

conspicuous against the sclera.

Generally, the incorporation of a clear pupil should not be necessary as this suggests that the tint is darker than what is needed to aid 'handling'.

99



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Enhancing Tints

Enhancing tints are transparent tints which alter, but cannot change substantially, the natural colour of the wearer's eye. The colour chosen is usually related in some way to the eye's colour and such tints are only satisfactory with relatively lightly coloured irides. Attempting to alter the appearance of a relatively dark iris by increasing the tint density is not feasible.

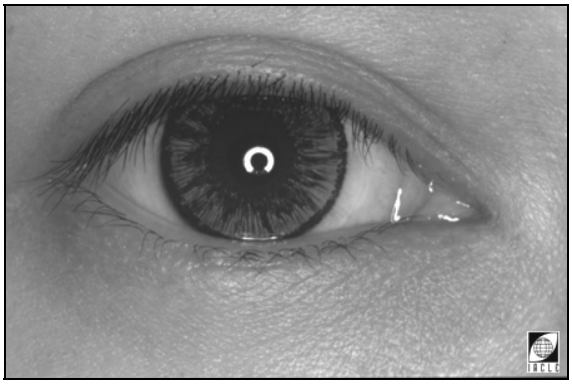
This is because:

- Light entering the eye is attenuated by the tint.
- A dark iris has a low reflectance.
- Any light reflected by the iris is again attenuated by the tint on exiting.

The result of combining a relatively dark tint with a relatively dark eye is an even darker eye with little or no apparent effect on colour or little colour of any description.

- Iris diameter
  For tints darker than handling tints it is necessary to retain a clear lens periphery. Choice of colour and density must take into account occupational and safety factors. An iris diameter tint, especially in a darker shade, can affect colour perception adversely.
- Iris diameter, clear pupil
  Where occupational and safety factors are a significant consideration, the use of a clear pupil is warranted. It could be argued that, under these circumstances, a clear lens may be more suitable.

100



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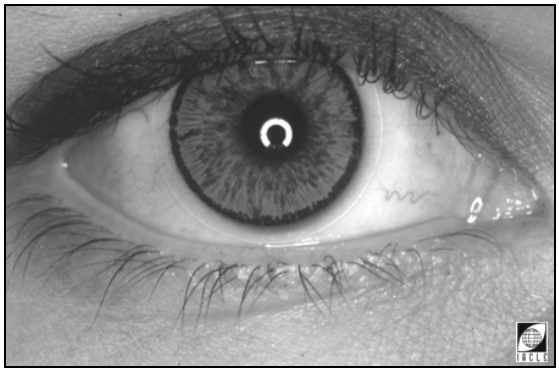


3L21655-96

Cosmetic Opaque: Picture

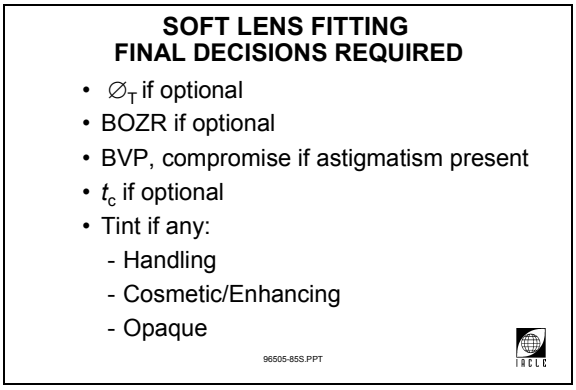
The first slide shows an blue opaque cosmetic (Barnes-Hind Elegance) on an eye with a dark iris.

The second slide illustrates the same lens on an eye with a very light blue iris.

The effect of the natural iris showing through the ‘artwork’, which incompletely covers the lens front surface, is apparent. The incomplete coverage aims (and largely succeeds) to give a natural depth to the apparent iris colour. Completely covering the anterior of the lens, except for the pupil zone, makes the eye colour look false because the eye ‘colour’ is some 2 -4 mm anterior of the expected position.

XV Final Decisions

102



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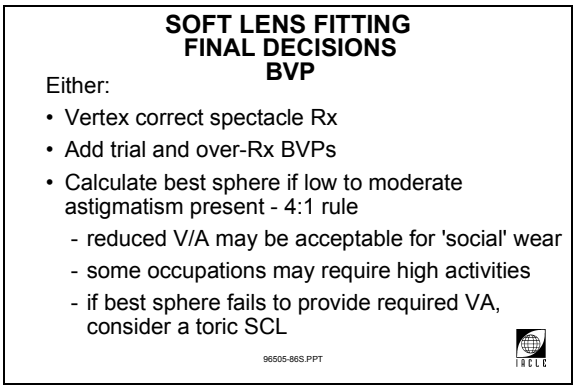
Soft Lens Fitting

Final Decisions Required

Before ordering, decisions must be made about the final prescription which should include all the listed parameters.

103



3L296505-86

Soft Lens Fitting

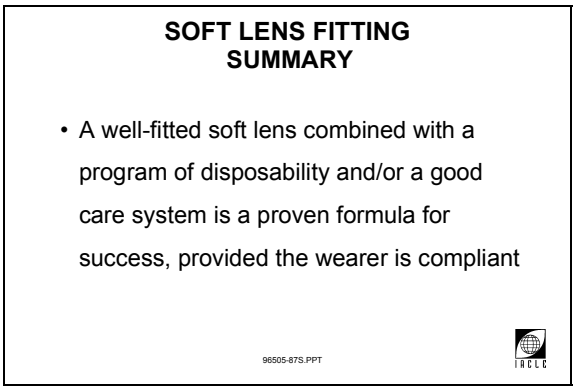
Final Decisions

BVP for Spherical SCLs:

- 4:1 Rule: As a very general rule, if the sphere component of an astigmatic Rx is Σ 4X the cylinder component, there is a reasonable chance that the vision with the Rx's best sphere result, will be acceptable. This rule-of thumb may not be applicable to cases where the magnitude of the cylinder is considerable (Σ 1.50 D).
- Reduced V/A may be acceptable for some 'social', occupational and other occasional wear situations.
- Other occupations may require high acuities and compromises may be unacceptable.
- Some wearers have higher expectations than others and compromises may be unacceptable to them.
- If the best sphere fails to provide the acuity required, a toric lens will be required if contact lenses are to be pursued further.
- The final BVP should be close ($\pm$0.25 D,
  $\pm$0.50 D at the most) to the ocular Rx (sphere or best sphere). Despite claims to the contrary, current generation spherical soft lenses do not significantly mask astigmatism. When combined with the insignificant tear

lens powers present under thin soft lenses, the final BVP of the contact lens to be ordered should differ little from the ocular Rx. Any significant discrepancy should be investigated and an explanation sought.

104



3L296505-87

Soft Lens Fitting

Summary

The physiological effects of factors such as lens wear, fit, wearing time and possibly the wearer's environment, need to be considered. These are explored in detail in Module 6 of this course.

Practical 3.2

(3 Hours)

Spherical Soft Contact Lens Fitting and Assessment

Purpose of Practical

The purpose of this exercise is to learn how to assess the fit of a soft contact lens and how the fit may change if lens parameters are altered.

Video Presentation: Examples of soft contact lens fits. (IACLE video # 102)

Instructions. When the video program has ended the students are to examine their partners by following the procedure outlined below:

Soft contact lens fitting assessment on:

- Centration.
- Movement.
- Tightness.
- Corneal coverage.
- Comfort.

Assess the fit of the lens combinations below. Document the findings on the record form provided and answer the question at the end of the exercise:

1. Steep (recommended) and flat BOZR (use considerable differences)
2. Large and small diameter (13.5 mm and 14.5 mm)
3. Thickness (0.035 mm and 0.12 mm)
4. High vs low water content (35% and 60%)

RECORD FORM

Name:_____ **Date:**_____

Partner:_____

ASSESSMENT VARIABLES	BOZR	
	RECOMMENDED	**RECOMMENDED**
Eye	Right	Left
Keratometry Reading	_____ D _____D @_____ _____ D _____D @_____ Low K radius _____ mm	_____ D _____D @_____ _____ D _____D @_____ Low K radius _____ mm
HVID	_____ mm	_____ mm
Baseline Eye Check _____Supervisor	☐clear ☐ slightly red ☐irritated ☐staining	☐clear ☐ slightly red ☐irritated ☐staining
Trial Lens _____	BOZR:_____mm Power _D Water content _____ Thickness _____ mm Lens diameter _____	BOZR:_____mm Power _D Water content _____ Thickness _____ mm Lens diameter _____
Lens Fit Assessment		
Centration	horizontal (N/T)_____ vertical (S/I) _____	horizontal (N/T)_____ vertical (S/I) _____
Corneal Coverage	☐ complete ☐ partial	☐ complete ☐ partial
Movement with Blink	Primary gaze _____ _____ mm Upgaze _____mm	Primary gaze _____ _____ mm Upgaze _____mm
Upgaze Lag	_____ mm	_____ mm
Horizontal Lag	_____ mm	_____ mm
Lens Tightness (push-up)	_____ %	_____ %
Fit Classification	☐loose ☐ tight ☐	☐loose ☐ tight ☐

	☐accept ☐ reject	☐accept ☐ reject
Patient Comfort Rating	0 1 2 3 4	0 1 2 3 4

Question: Is there a difference in lens fit between the left and right eyes? State the reasons for your answer.

RECORD FORM

Name:_____ **Date:**_____

Partner:_____

ASSESSMENT VARIABLES	BOZR	
	STEEP	**FLAT**
Eye	Right	Left
Keratometry Reading	_____ D _____D @_____ _____ D _____D @_____ Low K radius _____ mm	_____ D _____D @_____ _____ D _____D @_____ Low K radius _____ mm
HVID	_____ mm	_____ mm
Baseline Eye Check _____Supervisor	☐clear ☐ slightly red ☐irritated ☐staining	☐clear ☐ slightly red ☐irritated ☐staining
Trial Lens _____	BOZR:_____mm Power _D Water content _____ Thickness _____ mm Lens diameter _____	BOZR:_____mm Power _D Water content _____ Thickness _____ mm Lens diameter _____
Lens Fit Assessment		
Centration	horizontal (N/T)_____ vertical (S/I) _____	horizontal (N/T)_____ vertical (S/I) _____
Corneal Coverage	☐ complete ☐ partial	☐ complete ☐ partial
Movement with Blink	Primary gaze _____ _____ mm Upgaze _____mm	Primary gaze _____ _____ mm Upgaze _____mm
Upgaze Lag	_____ mm	_____ mm
Horizontal Lag	_____ mm	_____ mm
Lens Tightness (push-up)	_____ %	_____ %
Fit Classification	☐loose ☐ tight ☐	☐loose ☐ tight ☐

	☐accept ☐ reject	☐accept ☐ reject
Patient Comfort Rating	0 1 2 3 4	0 1 2 3 4

Question: Is there a difference in lens fit between the left and right eyes? State the reasons for your answer.

RECORD FORM

Name:_____ **Date:**_____

Partner:_____

ASSESSMENT VARIABLES	WATER CONTENT	
	LOW	**HIGH**
Eye	Right	Left
Keratometry Reading	_____ D _____D @_____ _____ D _____D @_____ Low K radius _____ mm	_____ D _____D @_____ _____ D _____D @_____ Low K radius _____ mm
HVID	_____ mm	_____ mm
Baseline Eye Check _____Supervisor	☐clear ☐ slightly red ☐irritated ☐staining	☐clear ☐ slightly red ☐irritated ☐staining
Trial Lens _____	BOZR:_____mm Power _D Water content _____ Thickness _____ mm Lens diameter _____	BOZR:_____mm Power _D Water content _____ Thickness _____ mm Lens diameter _____
Lens Fit Assessment		
Centration	horizontal (N/T)_____ vertical (S/I) _____	horizontal (N/T)_____ vertical (S/I) _____
Corneal Coverage	☐ complete ☐ partial	☐ complete ☐ partial
Movement with Blink	Primary gaze _____ _____ mm Upgaze _____mm	Primary gaze _____ _____ mm Upgaze _____mm
Upgaze Lag	_____ mm	_____ mm
Horizontal Lag	_____ mm	_____ mm
Lens Tightness (push-up)	_____ %	_____ %
Fit Classification	☐loose ☐ tight ☐	☐loose ☐ tight ☐

	☐accept ☐ reject	☐accept ☐ reject
Patient Comfort Rating	0 1 2 3 4	0 1 2 3 4

Question: Is there a difference in lens fit between the left and right eyes? State the reasons for your answer.

RECORD FORM

Name:_____ **Date:**_____

Partner:_____

ASSESSMENT VARIABLES	THICKNESS	
	THIN	**THICK**
Eye	Right	Left
Keratometry Reading	_____ D _____D @_____ _____ D _____D @_____ Low K radius _____ mm	_____ D _____D @_____ _____ D _____D @_____ Low K radius _____ mm
HVID	_____ mm	_____ mm
Baseline Eye Check _____Supervisor	☐clear ☐ slightly red ☐irritated ☐staining	☐clear ☐ slightly red ☐irritated ☐staining
Trial Lens _____	BOZR:_____mm Power _D Water content _____ Thickness _____ mm Lens diameter _____	BOZR:_____mm Power _D Water content _____ Thickness _____ mm Lens diameter _____
Lens Fit Assessment		
Centration	horizontal (N/T)_____ vertical (S/I) _____	horizontal (N/T)_____ vertical (S/I) _____
Corneal Coverage	☐ complete ☐ partial	☐ complete ☐ partial
Movement with Blink	Primary gaze _____ _____ mm Upgaze _____mm	Primary gaze _____ _____ mm Upgaze _____mm
Upgaze Lag	_____ mm	_____ mm
Horizontal Lag	_____ mm	_____ mm
Lens Tightness (push-up)	_____ %	_____ %
Fit Classification	☐loose ☐ tight ☐	☐loose ☐ tight ☐

	☐accept ☐ reject	☐accept ☐ reject
Patient Comfort Rating	0 1 2 3 4	0 1 2 3 4

Question: Is there a difference in lens fit between the left and right eyes? State the reasons for your answer.

RECORD FORM

Name:_____ **Date:**_____

Partner:_____

	LENS DIAMETER	
ASSESSMENT VARIABLES	**SMALL**	**LARGE**
Eye	Right	Left
Keratometry Reading	_____ D _____D @_____ _____ D _____D @_____ Low K radius _____ mm	_____ D _____D @_____ _____ D _____D @_____ Low K radius _____ mm
HVID	_____ mm	_____ mm
Baseline Eye Check _____Supervisor	☐clear ☐ slightly red ☐irritated ☐staining	☐clear ☐ slightly red ☐irritated ☐staining
Trial Lens _____	BOZR:_____mm Power _D Water content _____ Thickness _____ mm Lens diameter _____	BOZR:_____mm Power _D Water content _____ Thickness _____ mm Lens diameter _____
Lens Fit Assessment		
Centration	horizontal (N/T)_____ vertical (S/I) _____	horizontal (N/T)_____ vertical (S/I) _____
Corneal Coverage	☐ complete ☐ partial	☐ complete ☐ partial
Movement with Blink	Primary gaze _____ _____ mm Upgaze _____mm	Primary gaze _____ _____ mm Upgaze _____mm
Upgaze Lag	_____ mm	_____ mm
Horizontal Lag	_____ mm	_____ mm
Lens Tightness (push-up)	_____ %	_____ %
Fit Classification	☐loose ☐ tight ☐	☐loose ☐ tight ☐

	☐accept ☐ reject	☐accept ☐ reject
Patient Comfort Rating	0 1 2 3 4	0 1 2 3 4

Question: Is there a difference in lens fit between the left and right eyes? State the reasons for your answer.

Tutorial 3.2

(1 Hour)

Fitting Assessment of Soft Contact Lenses

Observe the soft lens fits on the video (IACLE #103) and complete the form for each of the cases.

Case 1

Lens Evaluation	
Centration	horizontal (Nasal/Temporal)_____ mm vertical (Inferior/Superior)_____ mm
Corneal Coverage	☐ complete ☐ partial
Movement with Blink	_____ mm
Upgaze Lag	_____ mm
Horizontal Lag	_____ mm
Lens Tightness (push-up test)	_____ %
Fit Classification	☐ loose ☐ tight ☐ optimal ☐ accept ☐ reject
If rejected, how can it be improved?	

Case 2

Lens Evaluation	
Centration	horizontal (Nasal/Temporal)_____ mm vertical (Inferior/Superior)_____ mm
Corneal Coverage	☐ complete ☐ partial
Movement with Blink	_____ mm
Upgaze Lag	_____ mm
Horizontal Lag	_____ mm
Lens Tightness (push-up test)	_____ %
Fit Classification	☐ loose ☐ tight ☐ optimal

	☐ accept ☐ reject
If rejected, how can it be improved?	

🕮 References

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Unit 3.3

(2 Hours)

Lecture 3.3: Astigmatism

Tutorial 3.3: Astigmatism and Toric SCLs

Course Overview

Lecture 3.3: Astigmatism

I. Review of the Basic Principles of Astigmatism
II. The Measurement of Astigmatism
III. Residual Astigmatism

Tutorial 3.3: Astigmatism and Toric Soft Lenses (Quiz)

Lecture 3.3

(1 Hour)

Astigmatism

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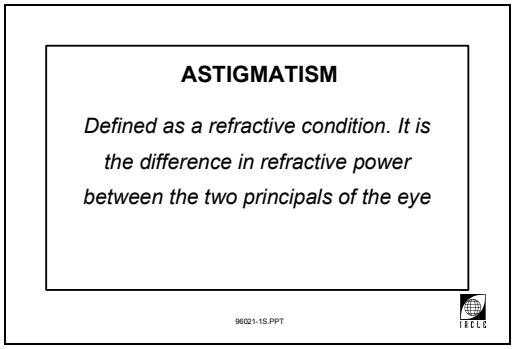
I Definition of Astigmatism

1



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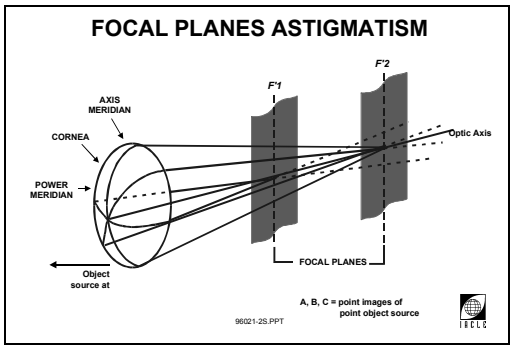

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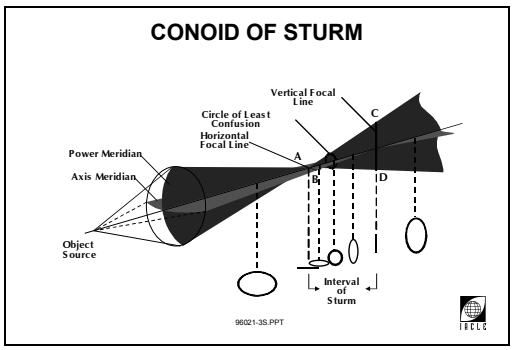

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Astigmatism: Definition

The word *astigmatism* is derived from the Greek words *a* meaning not, and *stigma* meaning spot or point. Literally, astigmatism means any condition in which the optical system is not 'point forming'.

Optically, astigmatism is a refractive condition in which a point object is not rendered as a point image by an optical system.

In the context of the eye and contact lenses, *astigmatism* is the existence of meridional differences in refractive 'power'. It is regarded as a *refractive* ametropia.

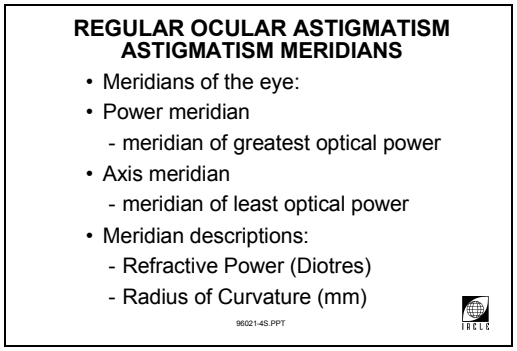
Regular astigmatic systems incorporate two mutually perpendicular *principal meridians* each having a *principal power* different from the other. The existence of two principal powers gives rise to two mutually perpendicular *principal foci* (the image planes for an object at infinity). The power of the system as a whole varies from a maximum in one of the principal meridians to a minimum in the other in a regular and predictable manner. The smooth gradation of refractive power between meridians results in an image continuum called the *astigmatic pencil.* The distance between the line foci is called *The Interval of Sturm*[*].

The amount of astigmatism depends on the magnitude of any such meridional differences.

Irregular meridional differences give rise to *irregular* astigmatism.

[*] *Historical note:* Bennett (1961) claims that 'The Interval of Sturm' should be attributed to Sir Isaac Newton (1642 - 1727) and 'Sturm's Conoid' to Thomas Young (1773 - 1829) who was himself an astigmat (Duke-Elder and Abrams, 1970). Jacques Charles François Sturm (1803 - 1855) published his study of the properties of the astigmatic pencil in 1838 lending credence to Bennett's claim that Young's work preceded that of Sturm by 'many years'.

4



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Regular Ocular Astigmatism: Astigmatic Meridians:

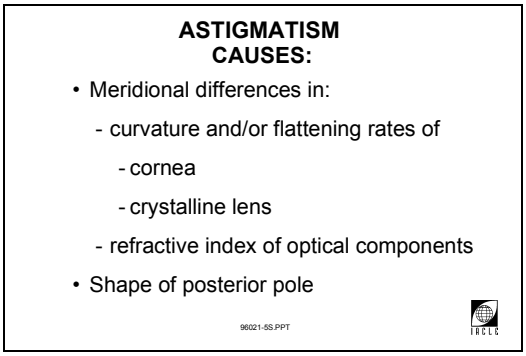
Meridional differences are usually expressed in terms of refractive power (in *dioptres*) or where a surface is being described, as radii (usually in mm).

The two *principal meridians* in regular ocular astigmatism are:

- *Power meridian* - meridian of greatest curvature/optical power.
- *Axis meridian* - meridian of least curvature/optical power.

Light rays refracted by meridians other than the principal meridians have their image points somewhere between the two astigmatic foci, i.e. somewhere along the Interval of Sturm.

5



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Astigmatism: Causes

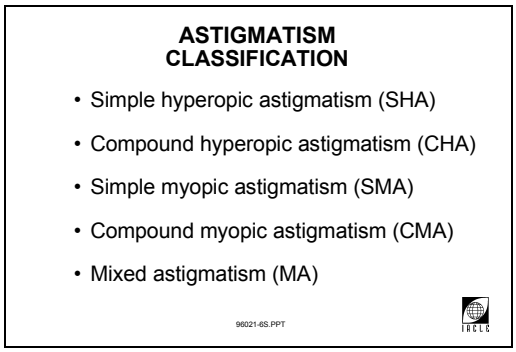
Meridional differences in curvature and/or the flattening rates of the peripheral cornea and crystalline lens can contribute to ocular astigmatism, as can the shape of the posterior pole. Meridional differences in the refractive index of the optical components can also have similar (but probably lesser) effects to shape-induced differences.

Initially it is difficult to ascertain the aetiology of any astigmatism detected since the visual outcomes of the different astigmata may be only slightly or insignificantly different.

II Classification and Types of Astigmatism

II.A Classification by Focal Line Position

6



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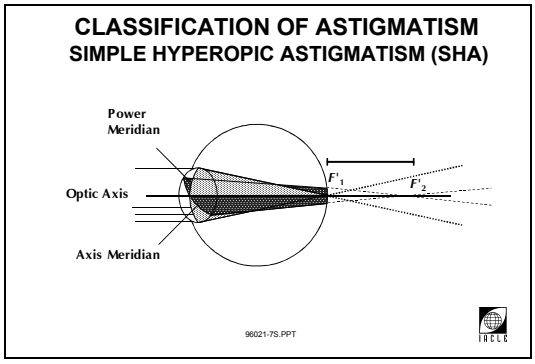

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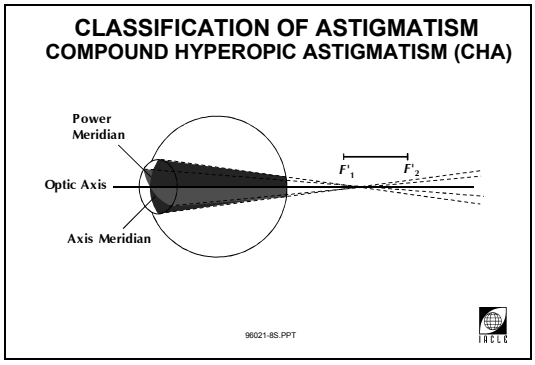

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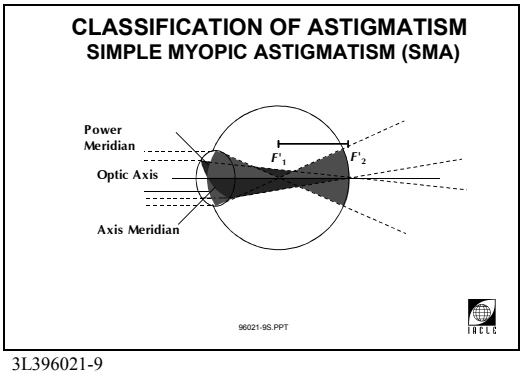

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Classification of Astigmatism

The existence of two line foci provides a convenient basis for the classification of the types of astigmatism. The basis is the location of the foci, i.e. in front, on or behind the retina.

An unaccommodated astigmatic eye can be classified five different ways:

- **Simple Hypermetropic/Hyperopic Astigmatism (SHA).** One focal line ($F_1´$) lies on the retina, the other ($F_2´$) is located behind.
- **Compound Hypermetropic/Hyperopic Astigmatism (CHA).** Both focal lines are located behind the retina.
- **Simple Myopic Astigmatism (SMA).** One focal line ($F_2´$) is on the retina, the other ($F_1´$) is located in front.
- **Compound Myopic Astigmatism (CMA).** Both focal lines are located in front of the retina.
- **Mixed Astigmatism (MA).** One line ($F_1´$) is in front of the retina and the other ($F_2´$) is located behind.

In the uncorrected astigmatic eye, best vision is attained when the 'neck' of the Interval of Sturm is located on the retina. This 'neck' is called the *circle of least confusion* (COLC).

This situation arises when the *best sphere* result (in either contact lens or spectacle form) is in place. The *best sphere* is defined as the best spherical correction (maximum plus, minimum minus) which results in optimum (albeit compromised) vision.

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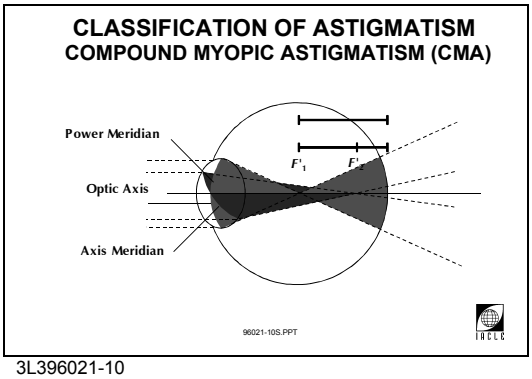

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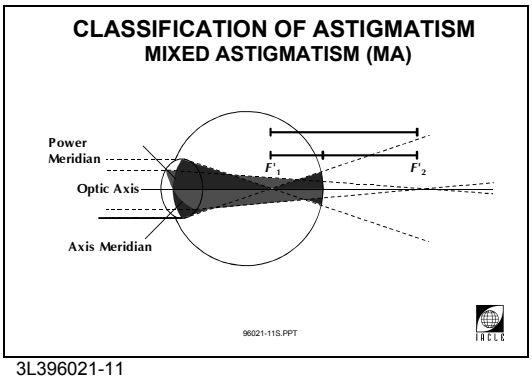

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II.B Classification by Structure

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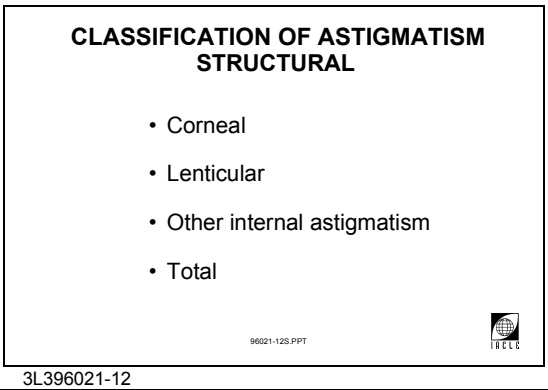

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Classification of Astigmatism: Structural

Astigmatism can be classified on the basis of the structure which is causing the meridional refractive power differences within an eye.

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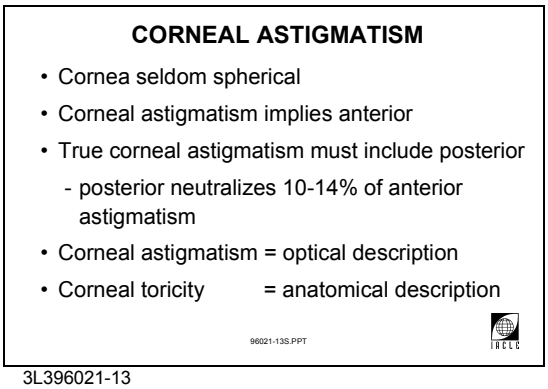

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Corneal Astigmatism

The cornea is seldom truly spherical even in the immediate vicinity of the eye's optical axis (Bennett, Rabbetts 1984). As the cornea accounts for approximately two-thirds of the total refractive power of the eye, any corneal astigmatism can be visually significant.

The term *corneal astigmatism* is usually applied to anterior surface astigmatism. True corneal astigmatism should take into account the refractive effects of the posterior cornea as well as any refractive index anomalies in the cornea as a whole. However, the posterior corneal curvature is not easily measured with current instrumentation. Further, the optical effectiveness of the posterior corneal interface is low because of the small refractive index differences at the cornea/anterior chamber interface.

It is believed that, especially in the cases of marked astigmatism, the general shape configuration of the anterior surface is mirrored by the back surface shape. As a result, about 10% of the anterior surface astigmatism is *neutralized* by the much less effective back surface (Bennett, Rabbetts 1984). This approximation is the basis of the refractive index used for most keratometers (n = 1.3375 whereas the cornea is accepted as being 1.376). The keratometer's determination of corneal astigmatism (the difference in the dioptric power estimates of the principal meridians) incorporates the 10% reduction attributed to the posterior cornea's astigmatism.

Corneal astigmatism should be regarded as an optical effect of corneal toricity, the latter being the anatomical analogue of astigmatism.

14

LENTICULAR ASTIGMATISM

- Due to differences in:
  - meridian refractive power
    - either surface
    - both surfaces
  - refractive indicies of lens layers
  - surface flattening rates of lens layers
  - symmetry of lens
- Tilting and/or decentration of crystalline lens

96021-14S.PPT

3L396021-14

Lenticular Astigmatism

Meridional differences in refractive power of the crystalline lens are an obvious internal source of ocular astigmatism. One or both surfaces may be involved. It is also possible for differences in the refractive index or surface flattening rates of the various lens layers and/or asymmetry in the layers, to result in meridional power differences. Since the lens is surrounded by aqueous humor whose refractive index is somewhat different to that of the lens, any lenticular contribution to astigmatism will be reduced. However, the short radii of curvature of the surfaces mean that significant optical effects can still be induced.

A tilted and/or decentred crystalline lens can also induce significant astigmatism.

15

INTERNAL ASTIGMATISM OTHER

The posterior pole (retina) may be:

- Toric in shape
- Tilted
- Decentred

96021-15S.PPT

3L39605-15

Internal Astigmatism: Other

Apart from corneal and lenticular astigmata, the other main ocular factor is the posterior pole.

There is no support in the literature for any contribution to ocular astigmatism by refractive index anomalies in the vitreous body and/or the interface between the vitreous and posterior aqueous at the patellar fossa.

16

TOTAL ASTIGMATISM

Total astigmatism is the combination of:

- Corneal astigmatism
- Lenticular astigmatism
- Other internal astigmatism

96021-16S.PPT

3L396021-16

Total Astigmatism

Total astigmatism is defined as an uncorrected eye's manifest ocular astigmatism. It is the summation of all the astigmata present in that eye. The various astigmata present may be additive or subtractive.

II.C Classification by Type

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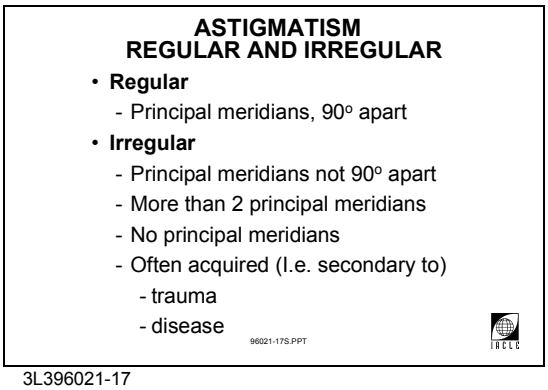

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Astigmatism: Regular and Irregular

Regular astigmatism is an optical system that has two principal meridians 90° apart.

Random or irregular differences in curvature or refractive index of the optic components and/or misalignment of any optical component may lead to *irregular astigmatism.* The concept of two principal meridians and their 90° separation or even the existence of principal meridians may not apply to irregular astigmatism. It is often the result of trauma or disease processes. In the latter cases the astigmatism may be called *acquired astigmatism* because it is the optical manifestation of an underlying acquired condition.

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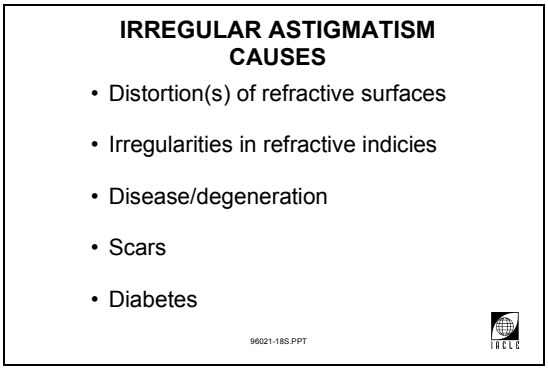

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Irregular Astigmatism: Causes

Possible causes of irregular astigmatism are:

- Distortion(s) of the refractive surfaces.
- Irregularities in the refractive index of the optical media (especially the crystalline lens).
- Active disease/degeneration processes. In many countries a common example of such processes is the occurrence of pterygium.
- Scars and the effects of contracting scar tissue on surface shapes.
  - To pursue the pterygium example, the presence of surgical scars following surgical removal leads to local corneal distortion, visual disturbance and often significant variation in cylinder axis (over months) in those cases where a sphero-cylindrical correction is useful.
- Diabetes.

Where no symmetry of the meridional curves exists, principal meridians are not 90° apart or principal meridians are non-existent, a cylindrical or sphero-cylindrical lens may not provide a useful correction let

alone a full correction. In such cases contact lenses probably offer the best chance of providing the best possible vision.

II.D Classification by Orientation

19

ASTIGMATISM TYPES

According to axis orientation (minus Cyl form)

- Regular
  - with-the-rule
  - against-the-rule
  - oblique
- Irregular

96021-19S.PPT

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TYPES OF ASTIGMATISM WITH-THE-RULE

- Ocular astigmatism in which the refractive power of the vertical (or near vertical) meridian is the greatest

  Millodot, 1989

- Refractive cylinder axis 0-30°, 150-180°

96021-20S.PPT

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21

TYPES OF ASTIGMATISM AGAINST-THE-RULE

- Ocular astigmatism in which the refractive power of the horizontal (or near horizontal) meridian is the greatest

  Millodot, 1989

- Refractive cylinder axis 60-120°

96021-21S.PPT

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22

TYPES OF ASTIGMATISM OBLIQUE ASTIGMATISM

- Astigmatism in which the two principal meridians lie somewhere between the axes defining either WTR or ATR astigmatism

  Millodot, 1989

- Refractive cylinder axis 31-59°, 121-149°

96021-22S.PPT

3L396021-22

Classification of Astigmatism: Meridional

The *axis* of the minus cylinder in an Rx provides a means of further sub-dividing and classifying regular astigmatism.

- With-the-rule (WTR):

  This is defined as ocular astigmatism in which the refractive power of the vertical (or near vertical) meridian is the greatest (Millodot, 1986). The axis meridian (the meridian of least refractive power) is therefore located horizontally. For the definition of WTR to apply, the cylinder axis must lie between the limits of axis 180 ± 30°, i.e. axes 0 to 30, 150 to 180.

  Well documented studies have shown that corneal astigmatism is with-the-rule at birth. The anatomical structure and tension of the lids have been postulated as a cause of corneal flattening above and below the horizontal meridian.

An alternative name for WTR astigmatism is *direct*.

- Against-the-rule (ATR):

  Millodot (1986) has defined this as ocular astigmatism in which the refractive power of the horizontal (or near horizontal) meridian is the greatest. The axis is therefore located vertically . For the definition of ATR to apply, the cylinder axis must lie between the limits of axis 90 ± 30°, i.e. axes 60 to 90, 90 to 120.

  The magnitude of the refractive cylinder is usually different from the corneal cylinder. The difference is likely to be a lenticular component.

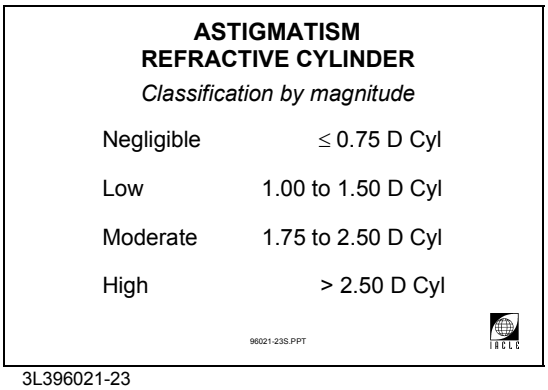
  Alternative names for ATR astigmatism include indirect or inverse.

- Oblique:

  Defined as astigmatism in which the two principal meridians lie somewhere between the axes defining either WTR or ATR astigmatism. By Millodot's definition the numerical limits for oblique cylinder axes are: 31 to 59 and 121 to 149°. Clinically, such a numerical approach is probably too rigorous.

II.E Classification by Magnitude

23



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III Incidence of Astigmatism

24

ASTIGMATISM
INCIDENCE BY DEGREE

	Holden (1974)	Cavara (1922)
< 0.50 D Cyl	39%	23%
0.50 to 1.00 D Cyl	37%	42%
1.25 to 2.00 D Cyl	15%	25%
2.25 to 3.00 D Cyl	7%	6%
> 3.00 D Cyl	3%	3%

96021-24S.PPT

3L396021-24

25

ASTIGMATISM
INCIDENCE BY DEGREE

	F&S (1996)	MoH (1962)
< 0.50 D Cyl	53.6%	66.6%
0.60 to 1.00 D Cyl	29.4%	17.7%
1.10 to 3.00 D Cyl	15.6%	13.6%
3.00 to 4.50 D Cyl	1.3%	2.1%

96021-25S.PPT

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Incidence of Astigmatism by Degree

Holden (1975) and Cavara (1922) reported the incidence of total astigmatism in a population.

Fledelius and Stubgaard's (1986) and the UK Ministry of Health (1962) provide comparable figures using different cylinder ranges to Cavara and Holden.

Since these results were acquired using different populations (health care systems, hospitals, contact lens clinics etc.) consisting of different ethnic groups it is conceivable that some of the differences observed are study-dependent. When this possibility is considered, the results show reasonably similar distributions.

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ASTIGMATISM
INCIDENCE BY TYPES
Fledelius, 1984

	16 - 55	56+
With-the-rule	60%	25%
Against-the-rule	17%	58%
Oblique	23%	17%

96021-26S.PPT

3L396021-26

27

ASTIGMATISM
INCIDENCE SHIFT WITH AGE

Infants:

- Against-the-rule ⇒ Oblique/With-the-rule

Adults:

- With-the-rule ⇒ Against-the-rule/Oblique

96021-27S.PPT

3L396021-27

Incidence of Astigmatism by Type

Following an investigation of 600 Danish eyes whose subjective astigmatism was □ 0.75 D, Fledelius (1984) reported theresults in slide 26.

The shift to ATR astigmatism in later years is apparent.

A possible explanation (Grosvenor, 1976) is eyelid pressure combined with lower ocular rigidity in the young, inducing WTR astigmatism. The significance of lid pressure was confirmed by Grey and Yap (1986).

However, decreasing lid pressure (looser lids) and increasing ocular rigidity do not appear to explain the shift towards ATR with increasing age. Baldwin and Mills (1981) confirmed the shift towards ATR with increasing age but showed it was due to a *steepening* of the horizontal corneal meridian. Their conclusion was that decreasing crystalline lens power was the most likely explanation and that, somewhat surprisingly, such power changes were mainly or totally spherical.

It would appear however that the orientation of astigmatism over a lifetime is cyclic since Howland and Sayles (1984) found a prevalence of ATR in children up to the age of two years, with a shift towards WTR and oblique astigmatism by preschool age.

IV Measuring Astigmatism

28

ASTIGMATISM COMPONENTS

- Total
- Corneal
- Lenticular/Internal

Relationship:
Total = Corneal + Lenticular

96021-28S.PPT

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29

DETERMINING THE OCULAR ASTIGMATISM FROM THE CORNEAL ASTIGMATISM

Javal's Rule (1890):

Total Astigmatism = 1.25 Corneal Astigmatism – 0.50

Grosvenor et al (1988):

Total Astigmatism = Corneal Astigmatism – 0.50

WTR Corneal Astigmatism = +

ATR Corneal Astigmatism = +

96021-29S.PPT

3L396021-29

Relationship Between Corneal and Total Astigmatism

Although corneal astigmatism is just one component of total astigmatism (usually a significant one), much work has been done on the relationship between total and corneal astigmatism. Differences exist in the amount and/or orientation of corneal and total astigmatism.

The best known of these is Javal's Rule (1890).

Javal's Rule states:

Total Astig. = 1.25 X Corneal. Astig. – 0.50 D (ATR)

Several reviews and revisions have confirmed the utility of Javal's initial equation and the relationships derived more recently vary in detail only. There is also some evidence that the results can vary slightly when eyes with larger amounts of total astigmatism (>2.50 D Cyl) are included (Grosvenor, Ratnakaram, 1990).

The currently accepted 'rule' is as follows (Grosvenor *et al.* 1988):

Total Astig. = Corneal. Astig. – 0.50 D (ATR)

(Total Astig. is measured in the spectacle plane and corneal astigmatism (always in the **minus cylinder form**) is ***positive if WTR*** and ***negative if ATR***).

Example 1:

Corneal Astigmatism = –1.00 D Cyl X 90

Total Astig. = –1.00 D –0.50 D

Total Astig. = –1.50 D (minus = ATR)

Total Astig. = –1.50 X 90

Example 2:

Corneal Astigmatism = –1.00 D Cyl X 180

Total Astig. = +1.00 D –0.50 D

Total Astig. = +0.50 D (plus = WTR)

Total Astig. = –0.50 X 180

While this equation (or other slight variations of it) is strongly supported by many studies using grouped data, the application of the rule to individual cases is

imprudent. It has been suggested that myopes may require more cylinder, and hyperopes less cylinder, than the rule indicates (Neumueller, 1930) and that errors up to 1.50 D Cyl can be induced (Mote and Fry, 1939).

All such rules are inapplicable in cases of oblique astigmatism (defined as axis 90 or 180 ±30°) and where the astigmatism is neither axis 90 nor 180 (approximately) then calculations pertaining to obliquely crossed cylinders must be employed. The complexity of such an approach is hard to justify when the basis of such a rule is so general.

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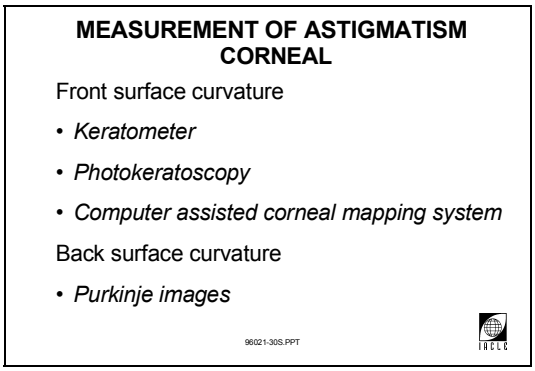

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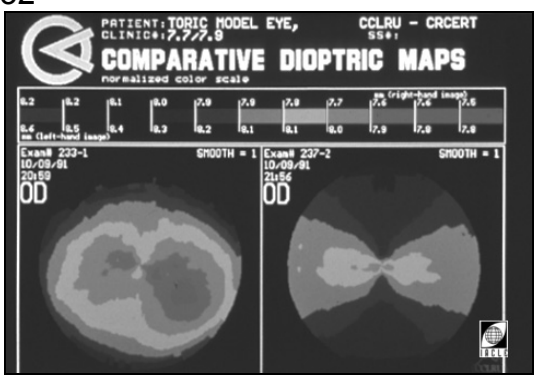

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Measurement of the Corneal Astigmatism

Direct and photographic measurement techniques can be used to determine the central and peripheral corneal shape.

Front surface curvature

The curvature of the cornea's front surface can be determined by:

- Keratometer.
  This is still the most common consulting room instrument and, while only measuring the central 3 mm (approximately), it is quick, simple and accurate. A keratometer is also the most economic solution for basic curvature determination. The qualitative information given by mire image quality should also not be underestimated.

- Photokeratoscopy.
  A technique which was largely limited to the research laboratory, this technique provided curvature information over a much broader corneal area than was possible with a keratometer. Sophisticated attempts were made in later years to scan the photokeratograph produced and base a lens order on the extracted data. This method met with only limited success, especially outside the USA its country of origin, and has been largely replaced by the more recent generation of computer assisted

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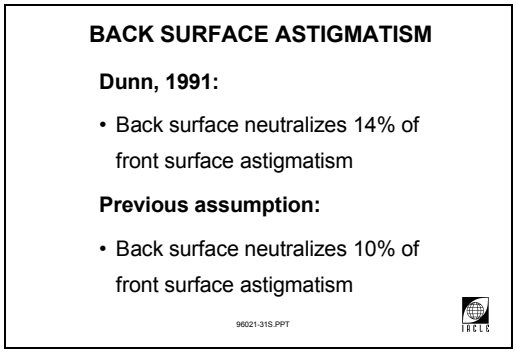

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corneal mapping systems.

- Computer assisted corneal mapping system.
  Because of their keratometer-like precision, their wide area of coverage and their comprehensive data output, corneal mapping systems have superseded all previous instrumentation. However, their high initial cost and potentially high running costs mean that it will be some time before the keratometer is replaced in most consulting rooms. While the instruments are objective with various safety and validity checks built in, practitioner skill may still be a factor in the accuracy of some instruments.

Back surface astigmatism

Back surface shape is not normally assessed in contact lens practice. It is difficult, the Purkinje-Sanson (P-S) image #2 is only about one-hundredth the brightness of the corneal reflex (Bennett, Rabbetts, 1984) and is obscured by it (Dunne, 1992), some calculation is required, and no instrument to measure it routinely is available.

While it is generally assumed that approximately 10% of anterior corneal astigmatism is neutralized by the posterior cornea, a study by Dunne *et al*. (1991) showed a reduction of 14%. However, calculations using the data of Patel *et al* (1993) taken from the eyes of 19 - 23 year olds suggest a figure as low as 2.4% (3.1% using their published rounded data).

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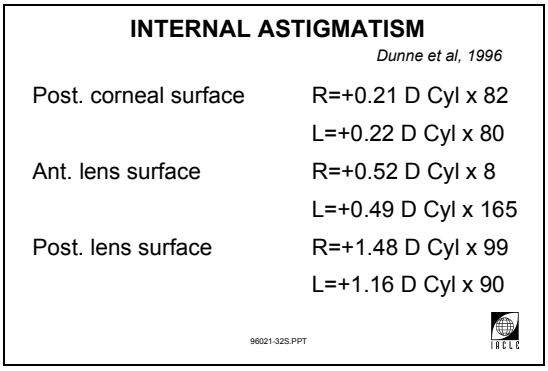

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Measurement of the Internal Astigmatism

Astigmatism from internal ocular components is difficult to both assess and measure.

Dunne *et al*. (1996) developed a technique for measuring/calculating internal ocular surfaces using videography, A-scan ultrasonography, autorefractometry and phakometric measurements of P-S images 1, 2 and 4. The anterior crystalline surface power was computed because the quality of P-S image #3 is usually poor (Bennett,

Rabbetts, 1984).

Data from Dunne *et al* of the levels of internal astigmatism for both the R and L eyes, is shown in the accompanying slide.

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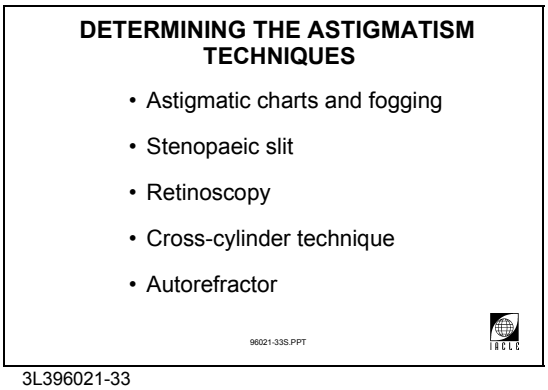

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Techniques for Determining Total Astigmatism: Subjective

Various subjective clinical techniques have been used to determine the amount of total astigmatism present in an eye. Current clinical techniques include:

- Astigmatic charts and fogging.

  Various astigmatic charts have been designed to determine the principal meridians of, and the cylinder power required for, the astigmatic eye. Commonly used charts include the clock dial, fan chart, Raubitschek parabolic chart and the T-chart. In testing for astigmatism the aim is to determine the amount of cylinder required to collapse the Interval of Sturm to zero. Once this is achieved the now coincident line foci need to be relocated to the retina (for the unaccommodated eye) by means of a spherical lens to correct any remaining myopic or hyperopic component. A fogging technique is usually employed to control accommodation during the refraction.

- Stenopaeic slit.

  This is basically a meridian by meridian (principal meridians) sphere-sphere measuring technique. A narrow slit in an opaque disc is used to eliminate virtually all other meridians. The slit is rotated to one of two positions (which are mutually perpendicular in regular astigmatism) which give the clearest images.

  A spherical-only refraction is performed for each principal meridian. A sphero-cylindrical prescription is then derived. Difficulties include the control of accommodation in younger subjects.

- Retinoscopy.

- Cross-cylinder.

  The Jackson cross-cylinder (cylinders of equal power but opposite signs, perpendicular to each other) technique is

based on the principle of an introduced circle of least confusion (COLC) being on the retina when total astigmatism is corrected fully. In all other circumstances, a preference for one orientation of the cross-cylinder over the other indicates incomplete correction and the direction of change required for a full correction to be achieved. A disadvantage is the need to alter the sphere power (half of any cylinder power change but of the opposite sign) of the tentative correction to keep the COLC on or very near the retina.

- Autorefractor.

  All automated optometers produce sphero-cylindrical Rxs. These objective instruments are frequently able to generate an Rx when all other methods, especially subjective methods, have failed.

V Residual Astigmatism

V.A Residual Astigmatism: Definition

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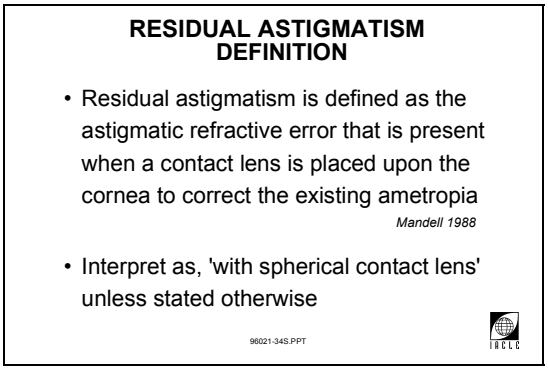

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Residual Astigmatism: Definition

Residual astigmatism is defined as the astigmatic refractive error that is left uncorrected when a contact lens is placed upon the cornea to correct the existing ametropia. Note this definition does not contain the lens type (i.e. toric, spherical, rigid or soft).

Because the lens type is not included in this definition, the use of the term *residual astigmatism* without any additional qualifications should be interpreted to mean **with a spherical contact lens** in place.

Residual astigmatism can be sub-divided into *physiological* and *induced* residual astigmata.

V.B Physiological Residual Astigmatism

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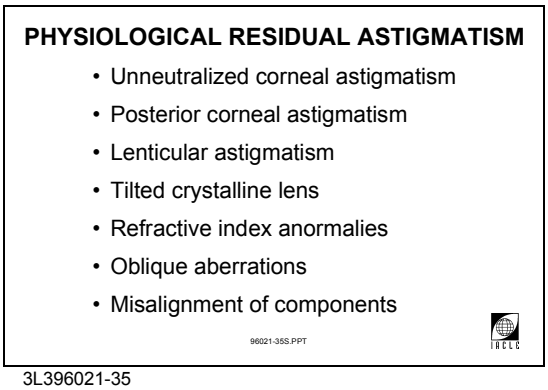

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Physiological Residual Astigmatism

Physiological residual astigmatism is the residual astigmatic component of the ocular refractive system attributable to one, several or all of the following (after Mandell, 1988):

- Corneal astigmatism that remains unneutralized by the tear lens.
- Posterior corneal astigmatism.
- Anterior and posterior crystalline lens surface astigmatism.
- A tilted crystalline lens.
- Anomalies in the refractive indices of the optical components of the eye especially the crystalline lens and cornea.
- Oblique aberrations of the eye especially the cornea, which accounts for approximately two-thirds of the eye's refractive power.
- Any misalignment of the eye's optical components including the foveal position in relation to the visual axis.
- Any posterior pole shape, inclination or centration anomaly especially of the foveal or macular areas.

V.C Induced Residual Astigmatism

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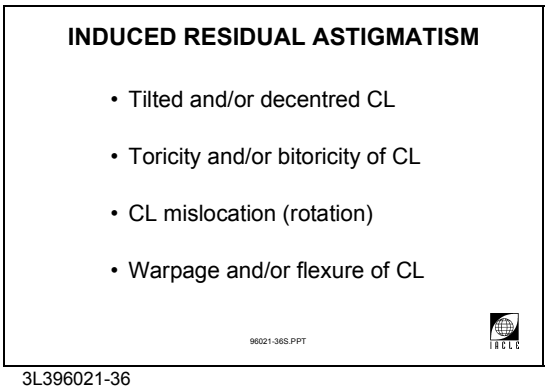

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Induced Residual Astigmatism

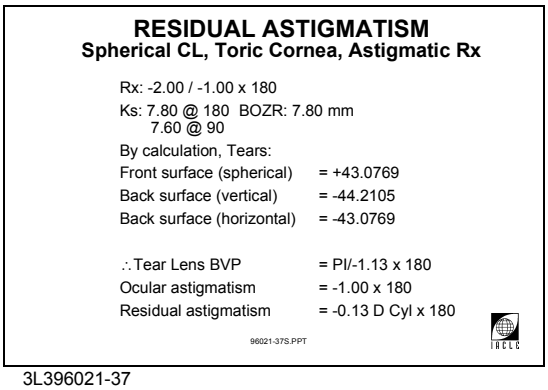
Induced residual astigmatism is the residual astigmatism introduced into the contact lens-eye system by the presence of the contact lens itself.

Possible causes are (after Mandell, 1988):

- A tilted and/or decentred contact lens especially in RGP contact lenses or contact lenses of high BVP.
- Toricity and/or bitoricity of the contact lens. In addition to these factors, manufacturing defects and/or inaccuracies as well as prescribing errors could be included.
- Mislocation of the contact lens cylinder axis relative to the ocular Rx cylinder (total astigmatism) axis. A table relating mislocation to the over-refraction appears as an appendix to this unit.
- Warpage and/or flexure of rigid and soft contact lenses.

V.D Calculating Residual Astigmatism

41



3L396021-37

Residual Astigmatism: Spherical Rigid Lens On a Toric Cornea, Astigmatic Manifest Ametropia

The use of spherical back surface rigid contact lenses in cases of low to moderate astigmatism usually (but not always) provides an adequate correction of astigmatism. This is a result of the post-lens tear film (the tear lens) neutralizing approximately 90% of the corneal astigmatism which is assumed to account for most of the total astigmatism (see page 136, Unit 2.3). The tear lens is bound by the back surface of the contact lens and the cornea. This tear lens is not present in soft contact lenses because they conform to the corneal shape.

By calculating the surface powers of the tear lens in air for each meridian, the residual astigmatism can be calculated and then compared with the ocular Rx.

Given:

Ocular Rx: –2.00 / -1.00 X 180

K Readings:

7.80 mm (43.27 D) @ 180
7.60 mm (44.41 D) @ 90

BOZR of spherical RGP lens: 7.80 mm

BVP of spherical RGP trial lens: –2.00 D Sph

1. Calculate the power of the tear lens front surface in air using the BOZR of the contact lens:

   Tears: Front surface

   $$F_{F\ Tears} = \frac{n' - n}{r}$$

   $$F_{F\ Tears} = \frac{1.336 - 1.000}{0.0078}$$

   $$F_{F\ Tears} = +43.0769$$

2. Calculate the power of each of the tear lens back surface meridians in air, using the K readings as the radii:

   Tears: Back surface, Vertical meridian

$$F_{BV\ Tears} = \frac{n' - n}{r}$$

$$F_{BV\ Tears} = \frac{1.000 - 1.336}{0.0076}$$

$F_{BV\ Tears}$ = –44.2105

Tear Lens Power: Vertical

$F_{V\ Tears}$ = (Front + Back) Tear Lens Powers

$F_{V\ Tears}$ = +43.0769 + (– 44.2105)

$F_{V\ Tears}$ = –1.1336 D

Tears: Back surface, Horizontal meridian

$$F_{BH\ Tears} = \frac{1.000 - 1.336}{0.0078}$$

$F_{BH\ Tears}$ = –43.0769

$F_{H\ Tears}$ = (Front + Back) Tear Lens Powers

$F_{H\ Tears}$ = +43.0769 + (– 43.0769)

$F_{H\ Tears}$ = Plano

∴ Tear Lens BVP = Pl / –1.13 X 180

When compared with the ocular Rx it can be seen that the tear lens exceeds the correction required (–1.00 D) slightly. The induced residual astigmatism is the difference between the ocular Rx cylinder and the tear lens cylinder.

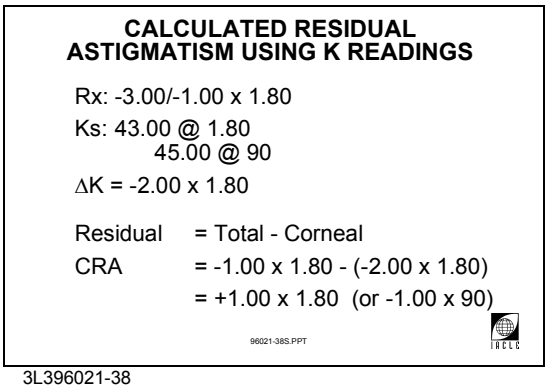
Residual Astig. = –0.13 D Cyl X 180

(In all these examples the tear film thickness is considered negligible and is ignored. No corrections for the effects of vertex distance are required since all powers are <4.00 D)

This residual astigmatism (about 10%) is usually ignored when considering a spherical RGP lens on an astigmatic eye.

Note: The issues of residual astigmatism in cases of astigmatic corneas and spherical or astigmatic manifest ocular Rxs, are dealt with in Unit 3.8.

42



3L396021-38

Calculated Residual Astigmatism (CRA) Using K Readings

A keratometer's estimate of corneal powers based on the assumption *n* = 1.3375, fairly accurately (actual 89.36%, Ks estimate 89.76%) estimates the amount of corneal astigmatism that a tear lens under a rigid lens will correct (see page 133, Unit 2.3).

Example:

Spectacle Rx:–3.00 / –1.00 X 180

∴ Total ocular astigmatism = –1.00 X 180

Ks: 43.00 @ 180 / 45.00 @ 90

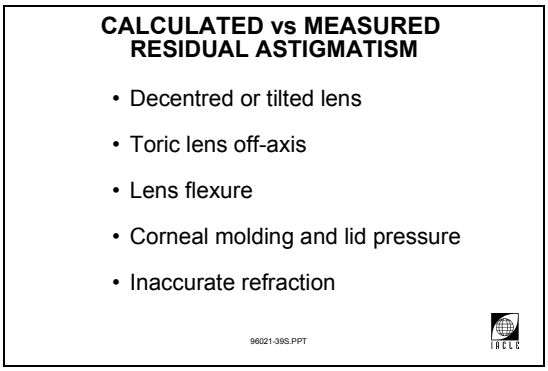
∴ Corneal astigmatism = θ Ks = –2.00 X 180

Residual astig. = Total astig. – Corneal astig.

CRA = –1.00 X 180 – (–2.00 X 180)

= +1.00 X 180 (or –1.00 X 90)

43



3L396021-39

Residual Astigmatism (RA): Calculated *versus* Measured

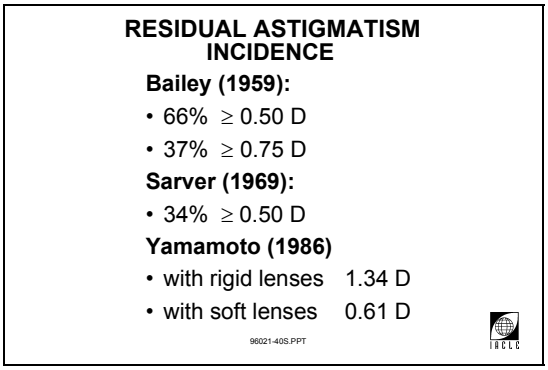
The calculated residual astigmatism (CRA) may differ from the measured residual astigmatism (MRA) for the following reasons:

- A low-riding, decentred or tilted contact lens on the eye may induce astigmatism, especially if the lens has a high Rx.
- A mislocating toric lens induces residual astigmatism. The RA is the resultant of the obliquely crossed cylinder components from the contact lens and the ocular Rx.
- Lens flexure and warpage, especially of thin rigid lenses, can occur with ATR or WTR corneal astigmatism.
- Corneal molding by the lens and/or lid pressure.
- Inaccurate refraction or keratometry.

Obliquely incident light can add significantly to residual astigmatism, e.g. a 5° obliquity to the visual axis (horizontal plane) is capable of inducing a 0.50 D ATR astigmatism (Mandell, 1988). While obliquity is not normally included in calculation of residual astigmatism, it may affect the measured result.

Sarver (1969) calculated residual astigmatism to be –0.51 X 90 ± 30° for PMMA lenses (n = 408) but measured the residual astigmatism to be only –0.23 X90 ± 30°.

44



3L396201-40

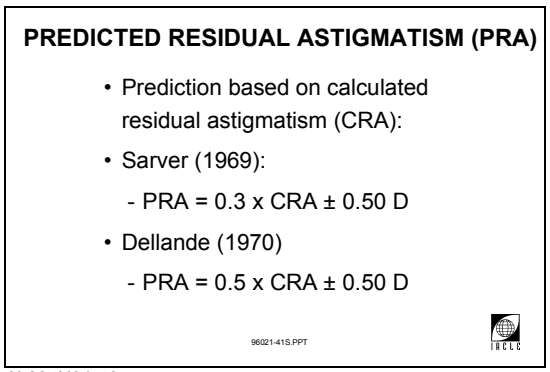
Residual Astigmatism: Incidence

The incidence of residual astigmatism is probably higher than realized by most practitioners. Bailey (1959) found 66% of spherical PMMA lens wearers had residual astigmatism of at least 0.50 D, and 37% showed 0.75 D or more. Sarver (1969) showed 34% of spherical PMMA wearers had 0.50 or more residual astigmatism and that the mean value was approximately –0.25 D against the rule.

In a study of residual astigmatism by Yamamoto (1986) the average for soft contact lens wearers was found to be 0.61 D and for rigid lens wearers, 1.34 D.

The amount of residual astigmatism does not diminish over time and only rarely does a tilted or decentred high Rx lens (plus or minus) induce measurable astigmatism in the contact lens-eye system (Mandell, 1988).

45



3L394N31-40

Predicted Residual Astigmatism (PRA)

Attempts have been made to predict residual astigmatism (PRA) using calculated residual astigmatism (CRA) as a basis.

The two approaches, one by Sarver the other by Dellande, which appear in the literature differ in detail only.

PRA = 0.3 X CRA ± 0.50 D (Sarver, 1969)

PRA = 0.5 X CRA ± 0.50 D (Dellande, 1970)

While these equations predict a *range* of residual astigmatism (1 D in both cases), a trial lens fitting and over-refraction are still required to determine the actual level of residual astigmatism when a spherical lens is used.

Examples:

CRA = –2.00 D

Sarver's approach:

PRA = 0.3 X (–2.00) ± 0.50

PRA = –0.6 ± 0.50

PRA = –0.10 to –1.10 D Cyl X 180

Dellande's approach:

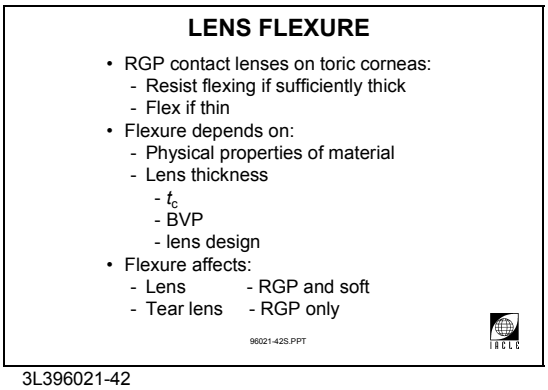
PRA = 0.5 X (–2.00) ± 0.50

PRA = –1.00 ± 0.50

PRA = –0.50 to –1.50 D Cyl X 180

V.E Lens Flexure

46



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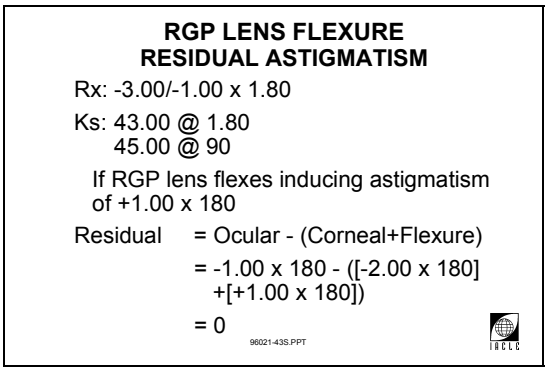
47



3L396021-43

Lens Flexure

When a rigid contact lens is fitted to a toric cornea the influence of lid pressure, blinking and capillary attraction combine to induce some level of conformity of the lens to the cornea. If the lens is made sufficiently thick it is able to resist these forces but in practical or physiologically desirable thicknesses, some conformance is inevitable. Flexure depends largely on the physical properties of the lens material, the lens thickness and the fitting relationship (including the amount of corneal toricity). Lens thickness is also influenced by the BVP of the contact lens.

When strictly applied, the term *rigid* is probably a misnomer since all lenses exhibit some flexibility regardless of thickness and material properties. The term is largely relative and much depends on the scale used for reference purposes, i.e. nm, mm, etc. RGPs are quite *rigid* relative to hydrogels although within the RGP class, there is a relative scale of *rigidity* as well.

To a lesser extent, lens design (which also affects lens thickness) also plays a part in lens flexure. In rigid lens flexure, not only are the optics of the contact lens altered, but that of the *tear lens* as well.

Lens flexure will induce a plus cylinder whose axis is aligned with the flattest corneal meridian.

Lens flexure may partially correct residual astigmatism or it may exaggerate it.

Example:

Spectacle cylinder: –1.00 X 180 (Total ocular astig.)

K Readings (n = 1.3375):

43.00 D @ 180
45.00 D @ 90

$\therefore$ Corneal astigmatism: –2.00 X 180

If an RGP lens flexes, inducing astig. of +1.00 X 180 the *tear lens* will now only correct –1.00 X 180
(–2.00 + {+1.00})

$\therefore$ Residual astigmatism with lens flexure:

= Ocular astig. – (Corneal astig. + Flexure

astig.)

= –1.00 X 180 – ({–2.00 X 180} + {+1.00 X 180})

= 0 (i.e. lens flexure has been beneficial)

Clinically, the following rules apply to rigid lenses:

If corneal astigmatism > total astigmatism and *both* are WTR, then lens flexing will *decrease* the amount of residual astigmatism.

If a lens flexes by an amount *equal* to the difference between corneal and total astigmatism *and* both astigmata are of the same orientation, no residual astigmatism will remain.

(After Mandell, 1988)

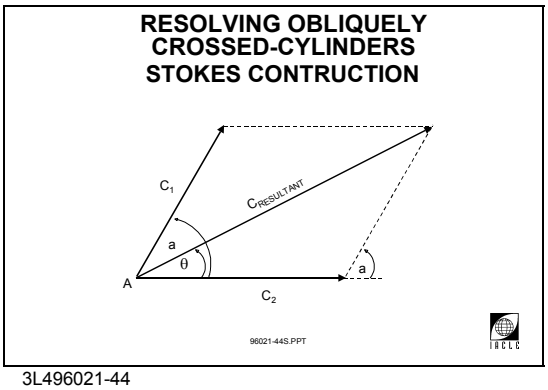
In the consulting room FSK readings (keratometry performed on the front surface of a contact lens *in situ*) will reveal the extent (if any) of lens flexure.

Rigid lens flexure is covered more fully in Unit 2.5.

Soft lens flexure is a controversial subject which is still not well understood. In high Rx lenses, the effect can affect both the spherical and cylindrical powers. There is no general agreement on the 'model' to explain the data empirically derived, especially for toric lenses. Clinically, significant losses in plus power, as well as alterations in the cylinder power, can be found (see Holden *et al* 1976).

V.F Residual Astigmatism: Obliquely-Crossed Cylinders

48



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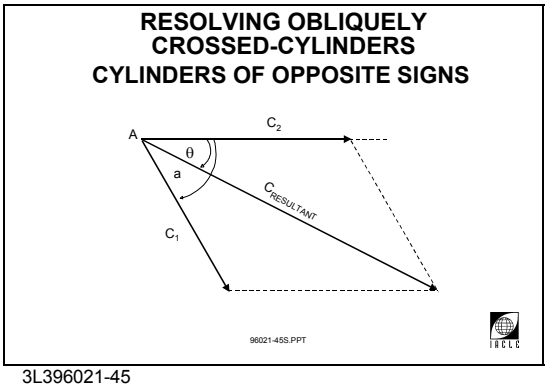
49



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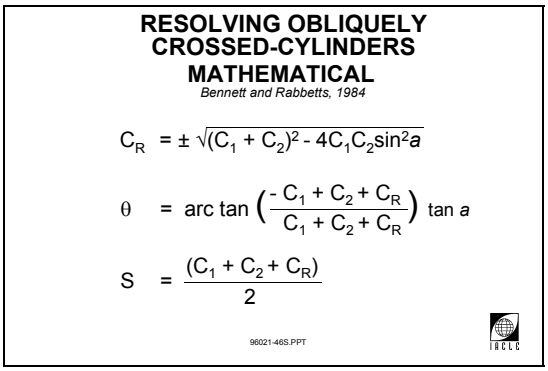
50



3L396021-46

Residual Astigmatism: Role of Obliquely-Crossed Cylinders

When significant amounts of residual and corneal astigmatism are present, bitoric lenses may be required to provide both a satisfactory fit and vision correction.

The problem becomes more complex when the axes of the astigmatic front and back surfaces required for fit and correction reasons, are neither coincident nor mutually perpendicular. This may occur when the cornea's principal meridians and those of the total astigmatism are not coincident. The resulting lens is called an *oblique bitoric*.

To resolve this issue of obliquely-crossed cylinders, either a mathematical or graphical approach can be taken. Because of the care required with the graphical approach as well as the availability of programmable calculators or computers the graphical approach is now uncommon.

In the **graphical approach**, the magnitude and axis of the resultant cylinder is found using Stokes' construction (1883) in which the cylinder powers, C_1 and C_2, create a resultant cylinder (C_R) whose axis is situated between them (see slide 48). The dimensions of C_1 and C_2 are drawn proportionally as shown with the angle '*a*' separating them. The angle □ separates C_R from C_1.

If the powers of C_1 and C_2 are of opposite sign then the vector representing one of the powers must be drawn in the opposite direction as shown in slide 49.

For the application of Stoke's construction to a mislocating contact lens whose BVP accurately matches the ocular Rx see Dain (1979). For a table of such data see the appendix to this unit.

The **mathematical approach** to determine the equivalent *sphere, cylinder and axis* involves using the following formulae (Bennett and Rabbetts, 1984):

The resultant cylinder power C_R is given by:

$$C_R = \pm \sqrt{(C_1 + C_2)^2 - 4\,C_1\,C_2\,\sin^2 a}$$

And

$$\theta = \arctan\left(\frac{-C_1 + C_2 + C_R}{C_1 + C_2 + C_R}\right) \tan a$$

(Note arc tan and tan⁻1 are one and the same function, i.e. θ = arc tan (x) and □ = $\tan^{-1}$ (x) mean that θ is the angle *whose tangent is* x).

The resultant spherical power S = $\frac{(C_1 + C_2 - C_R)}{2}$

where:

C_R = resultant cylinder

C_1 = first cylinder power

C_2 = second cylinder

a = angle between cylinder axes of $C_1 + C_2$

θ = angle between axes C_1 and C_R

S = resultant sphere

Appendix A: Vertex-Distance Correction Table

			MINUS						PLUS			
SPEC Rx	12 mm	13 mm	**14 mm**	15 mm	16 mm	**SPEC Rx**	12 mm	13 mm	**14 mm**	15 mm	16 mm	**SPEC Rx**
-3.75	-3.59	-3.58	**-3.56**	-3.55	-3.54	**3.75**	+3.93	+3.94	**+3.96**	+3.97	+3.99	**+3.75**
-4.00	-3.82	-3.80	**-3.79**	-3.77	-3.76	**4.00**	+4.20	+4.22	**+4.24**	+4.26	+4.27	**+4.00**
-4.25	-4.04	-4.03	**-4.01**	-4.00	-3.98	**4.25**	+4.48	+4.50	**+4.52**	+4.54	+4.56	**+4.25**
-4.50	-4.27	-4.25	**-4.23**	-4.22	-4.20	**4.50**	+4.76	+4.78	**+4.80**	+4.83	+4.85	**+4.50**
-4.75	-4.49	-4.47	**-4.45**	-4.43	-4.41	**4.75**	+5.04	+5.06	**+5.09**	+5.11	+5.14	**+4.75**
-5.00	-4.72	-4.69	**-4.67**	-4.65	-4.63	**5.00**	+5.32	+5.35	**+5.38**	+5.41	+5.43	**+5.00**
-5.25	-4.94	-4.91	**-4.89**	-4.87	-4.84	**5.25**	+5.60	+5.63	**+5.67**	+5.70	+5.73	**+5.25**
-5.50	-5.16	-5.13	**-5.11**	-5.08	-5.06	**5.50**	+5.89	+5.92	**+5.96**	+5.99	+6.03	**+5.50**
-5.75	-5.38	-5.35	**-5.32**	-5.29	-5.27	**5.75**	+6.18	+6.21	**+6.25**	+6.29	+6.33	**+5.75**
-6.00	-5.60	-5.57	**-5.54**	-5.50	-5.47	**6.00**	+6.47	+6.51	**+6.55**	+6.59	+6.64	**+6.00**
-6.25	-5.81	-5.78	**-5.75**	-5.71	-5.68	**6.25**	+6.76	+6.80	**+6.85**	+6.90	+6.94	**+6.25**
-6.50	-6.03	-5.99	**-5.96**	-5.92	-5.89	**6.50**	+7.05	+7.10	**+7.15**	+7.20	+7.25	**+6.50**
-6.75	-6.24	-6.21	**-6.17**	-6.13	-6.09	**6.75**	+7.34	+7.40	**+7.45**	+7.51	+7.57	**+6.75**
-7.00	-6.46	-6.42	**-6.38**	-6.33	-6.29	**7.00**	+7.64	+7.70	**+7.76**	+7.82	+7.88	**+7.00**
-7.25	-6.67	-6.63	**-6.58**	-6.54	-6.50	**7.25**	+7.94	+8.00	**+8.07**	+8.13	+8.20	**+7.25**
-7.50	-6.88	-6.83	**-6.79**	-6.74	-6.70	**7.50**	+8.24	+8.31	**+8.38**	+8.45	+8.52	**+7.50**
-7.75	-7.09	-7.04	**-6.99**	-6.94	-6.90	**7.75**	+8.54	+8.62	**+8.69**	+8.77	+8.85	**+7.75**
-8.00	-7.30	-7.25	**-7.19**	-7.14	-7.09	**8.00**	+8.85	+8.93	**+9.01**	+9.09	+9.17	**+8.00**
-8.25	-7.51	-7.45	**-7.40**	-7.34	-7.29	**8.25**	+9.16	+9.24	**+9.33**	+9.42	+9.50	**+8.25**
-8.50	-7.71	-7.65	**-7.60**	-7.54	-7.48	**8.50**	+9.47	+9.56	**+9.65**	+9.74	+9.84	**+8.50**
-8.75	-7.92	-7.86	**-7.80**	-7.73	-7.68	**8.75**	+9.78	+9.87	**+9.97**	+10.07	+10.17	**+8.75**
-9.00	-8.12	-8.06	**-7.99**	-7.93	-7.87	**9.00**	+10.09	+10.19	**+10.30**	+10.40	+10.51	**+9.00**
-9.25	-8.33	-8.26	**-8.19**	-8.12	-8.06	**9.25**	+10.40	+10.51	**+10.63**	+10.74	+10.86	**+9.25**
-9.50	-8.53	-8.46	**-8.38**	-8.32	-8.25	**9.50**	+10.72	+10.84	**+10.96**	+11.08	+11.20	**+9.50**
-9.75	-8.73	-8.65	**-8.58**	-8.51	-8.43	**9.75**	+11.04	+11.17	**+11.29**	+11.42	+11.55	**+9.75**
-10.00	-8.93	-8.85	**-8.77**	-8.70	-8.62	**10.00**	+11.36	+11.49	**+11.63**	+11.76	+11.90	**+10.00**
-10.50	-9.33	-9.24	**-9.15**	-9.07	-8.99	**10.50**	+12.01	+12.16	**+12.31**	+12.46	+12.62	**+10.50**
-11.00	-9.72	-9.62	**-9.53**	-9.44	-9.35	**11.00**	+12.67	+12.84	**+13.00**	+13.17	+13.35	**+11.00**
-11.50	-10.11	-10.00	**-9.91**	-9.81	-9.71	**11.50**	+13.34	+13.52	**+13.71**	+13.90	+14.09	**+11.50**
-12.00	-10.49	-10.38	**-10.27**	-10.17	-10.07	**12.00**	+14.02	+14.22	**+14.42**	+14.63	+14.85	**+12.00**
-12.50	-10.87	-10.75	**-10.64**	-10.53	-10.42	**12.50**	+14.71	+14.93	**+15.15**	+15.38	+15.63	**+12.50**
-13.00	-11.25	-11.12	**-11.00**	-10.88	-10.76	**13.00**	+15.40	+15.64	**+15.89**	+16.15	+16.41	**+13.00**
-13.50	-11.62	-11.48	**-11.35**	-11.23	-11.10	**13.50**	+16.11	+16.37	**+16.65**	+16.93	+17.22	**+13.50**
-14.00	-11.99	-11.84	**-11.71**	-11.57	-11.44	**14.00**	+16.83	+17.11	**+17.41**	+17.72	+18.04	**+14.00**
-14.50	-12.35	-12.20	**-12.05**	-11.91	-11.77	**14.50**	+17.55	+17.87	**+18.19**	+18.53	+18.88	**+14.50**
-15.00	-12.71	-12.55	**-12.40**	-12.24	-12.10	**15.00**	+18.29	+18.63	**+18.99**	+19.35	+19.74	**+15.00**
-15.50	-13.07	-12.90	**-12.74**	-12.58	-12.42	**15.50**	+19.04	+19.41	**+19.80**			**+15.50**
-16.00	-13.42	-13.25	**-13.07**	-12.90	-12.74	**16.00**	+19.80					**+16.00**
-16.50	-13.77	-13.59	**-13.40**	-13.23	-13.05	**16.50**						
-17.00	-14.12	-13.92	**-13.73**	-13.55	-13.36	**17.00**						
-17.50	-14.46	-14.26	**-14.06**	-13.86	-13.67	**17.50**						
-18.00	-14.80	-14.59	**-14.38**	-14.17	-13.98	**18.00**						
-18.50	-15.14	-14.91	**-14.69**	-14.48	-14.27	**18.50**						
-19.00	-15.47	-15.24	**-15.01**	-14.79	-14.57	**19.00**						
-19.50	-15.80	-15.56	**-15.32**	-15.09	-14.86	**19.50**						
-20.00	-16.13	-15.87	**-15.63**	-15.38	-15.15	**20.00**						
-20.50	-16.45	-16.19	**-15.93**	-15.68	-15.44	**20.50**						
-21.00	-16.77	-16.50	**-16.23**	-15.97	-15.72	**21.00**						
-21.50	-17.09	-16.80	**-16.53**	-16.26	-16.00	**21.50**						
-22.00	-17.41	-17.11	**-16.82**	-16.54	-16.27	**22.00**						
-22.50	-17.72	-17.41	**-17.11**	-16.82	-16.54	**22.50**						
-23.00	-18.03	-17.71	**-17.40**	-17.10	-16.81	**23.00**						
-23.50	-18.33	-18.00	**-17.68**	-17.38	-17.08	**23.50**						
-24.00	-18.63	-18.29	**-17.96**	-17.65	-17.34	**24.00**						
-24.50	-18.93	-18.58	**-18.24**	-17.92	-17.60	**24.50**						
-25.00	-19.23	-18.87	**-18.52**	-18.18	-17.86	**25.00**						
-25.50	-19.53	-19.15	**-18.79**	-18.44	-18.11	**25.50**						
-26.00	-19.82	-19.43	**-19.06**	-18.71	-18.36	**26.00**						
-26.50	-20.11	-19.71	**-19.33**	-18.96	-18.61	**26.50**						
-27.00		-19.99	**-19.59**	-19.22	-18.85	**27.00**						
-27.50			**-19.86**	-19.47	-19.10	**27.50**						
-28.00			**-20.11**	-19.72	-19.34	**28.00**						
-28.50				-19.96	-19.57	**28.50**						
-29.00					-19.81	**29.00**						
-29.50					-20.04	**29.50**						

BVP_{CL} = ±20.00 D ±0.12 D

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Appendix B: Toric Contact Lenses: Expected *Over-Rxs* due to *Mislocation Only*

Contact Lens Cylinder

MISLOC	–0.75 Cyl Sph	–0.75 Cyl Cyl	–1.00 Cyl Sph	–1.00 Cyl Cyl	–1.25 Cyl Sph	–1.25 Cyl Cyl	–1.50 Cyl Sph	–1.50 Cyl Cyl	–1.75 Cyl Sph	–1.75 Cyl Cyl	Axis ERR
Clockwise(+) → *Anticlock(–)*											
Anticlock(–) → *Clockwise(+)*											
0	+0.00	–0.00	+0.00	–0.00	+0.00	–0.00	+0.00	–0.00	+0.00	–0.00	**45.0**
5	+0.07	-0.13	+0.09	-0.17	+0.11	-0.22	+0.13	-0.26	+0.15	-0.31	**42.5**
10	+0.13	-0.26	+0.17	-0.35	+0.22	-0.43	+0.26	-0.52	+0.30	-0.61	**40.0**
15	+0.19	-0.39	+0.26	-0.52	+0.32	-0.65	+0.39	-0.78	+0.45	-0.91	**37.5**
20	+0.26	-0.51	+0.34	-0.68	+0.43	-0.86	+0.51	-1.03	+0.60	-1.20	**35.0**
25	+0.32	-0.63	+0.42	-0.85	+0.53	-1.06	+0.63	-1.27	+0.74	-1.48	**32.5**
30	+0.38	**-0.75**	+0.50	**-1.00**	+0.63	**-1.25**	+0.75	**-1.50**	+0.88	**-1.75**	**30.0**
35	+0.43	-0.86	+0.57	-1.15	+0.72	-1.43	+0.86	-1.72	+1.00	-2.01	**27.5**
40	+0.48	-0.96	+0.64	-1.29	+0.80	-1.61	+0.96	-1.93	+1.12	-2.25	**25.0**
45	+0.53	-1.06	+0.71	-1.41	+0.88	-1.77	+1.06	-2.12	+1.24	-2.47	**22.5**

Contact Lens Cylinder

MISLOC	–2.00 Cyl Sph	–2.00 Cyl Cyl	–2.25 Cyl Sph	–2.25 Cyl Cyl	–2.50 Cyl Sph	–2.50 Cyl Cyl	–2.75 Cyl Sph	–2.75 Cyl Cyl	–3.00 Cyl Sph	–3.00 Cyl Cyl	Axis ERR
Clockwise(+) → *Anticlock(–)*											
Anticlock(–) → *Clockwise(+)*											
0	+0.00	–0.00	+0.00	–0.00	+0.00	–0.00	+0.00	–0.00	+0.00	–0.00	**45.0**
5	+0.17	-0.35	+0.20	-0.39	+0.22	-0.44	+0.24	-0.48	+0.26	-0.52	**42.5**
10	+0.35	-0.69	+0.39	-0.78	+0.43	-0.87	+0.48	-0.96	+0.52	-1.04	**40.0**
15	+0.52	-1.04	+0.58	-1.16	+0.65	-1.29	+0.71	-1.42	+0.78	-1.55	**37.5**
20	+0.68	-1.37	+0.77	-1.54	+0.86	-1.71	+0.94	-1.88	+1.03	-2.05	**35.0**
25	+0.85	-1.69	+0.95	-1.90	+1.06	-2.11	+1.16	-2.32	+1.27	-2.54	**32.5**
30	+1.00	**-2.00**	+1.13	**-2.25**	+1.25	**-2.50**	+1.38	**-2.75**	+1.50	**-3.00**	**30.0**
35	+1.15	-2.29	+1.29	-2.58	+1.43	-2.87	+1.58	-3.15	+1.72	-3.44	**27.5**
40	+1.29	-2.57	+1.45	-2.89	+1.61	-3.21	+1.77	-3.54	+1.93	-3.86	**25.0**
45	+1.41	-2.83	+1.59	-3.18	+1.77	-3.54	+1.94	-3.89	+2.12	-4.24	**22.5**

MISLOC = Angle ***FROM*** Oc-Rx Axis ***TO*** *CL Cyl Axis*

Axis ERR = Angle ***FROM*** Oc-Rx Axis ***TO*** Over-Rx Axis

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Note that the over-Rx cylinder for a **30°** mislocation **equals** the contact lens cylinder.
It is assumed that the BVP of the toric contact lens is correct, i.e. BVP_{CL} = Ocular Rx.

Tutorial 3.3

(1 Hour)

Astigmatism and Toric Soft Lenses

1. Draw and describe the main categories of toric lens designs and how each of these are able to facilitate meridional stability of cylindrical correction.

a.

b.

c.

d.

2. Show the distribution of toric SCL axis orientation for the population, by either a graph or using right and left eyes in diagrammatic form.

3. Calculation of final toric lens prescription.

a. Ocular refraction –2.00 / –1.50 X 10
Diagnostic toric lens: meridional orientation 20° clockwise.

Final lens Rx _____

b. Spectacle refraction –6.00 / –2.50 X 160
Diagnostic toric lens: meridional orientation 25° clockwise.

Final lens Rx _____

c. Spectacle refraction +4.50 / –3.00 X 90
Diagnostic toric lens: meridional orientation 15° anti-clockwise.

Final lens Rx _____

4. A patient has been wearing a toric soft lens dispensed one week ago and presents complaining of blurred distance and near vision when wearing the lens. List the precise sequence of tests to establish the cause of blurred vision.

5. From the tables of cylinder mislocation, calculate the predicted resultant sph/cyl and axis for the following examples.

a. –1.00 D Cyl X 180 mislocating 15° clockwise.

b. –2.00 D Cyl X 30 mislocating 30° clockwise.

c. –2.50 D Cyl X 20 mislocating 20° anti-clockwise.

🕮 References

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Unit 3.4

(Ten Hours)

Lecture 3.4.1: Fitting Spherical RGP Contact Lenses

Lecture 3.4.2: The Effects of RGP Parameter Changes

Practical 3.4: Spherical RGP Contact Lens Fitting and Assessment

Tutorial 3.4: Fitting Assessment of RGP Contact Lenses

Course Overview

Lecture 3.4.1: Fitting Spherical RGP Contact Lenses

I. Lens Selection
II. Fitting Assessment
III. Evaluation of Fluorescein Pattern
IV. Forces Affecting Lens Fit
V. Final Lens Order Specifications

Lecture 3.4.2: The Effects of RGP Contact Lens Parameter Changes

I. Parameter Variations
II. Lens Fitting and Parameter Relationships

Practical 3.4: Spherical RGP Contact Lens Fitting and Assessment

Tutorial 3.4: Fitting Assessment of RGP Contact Lenses (video)

Lecture 3.4.1

(2 Hours)

Fitting Spherical Rigid Gas Permeable Lenses

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I.C Trial Lens Fitting Assessment 164
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I.C.2 Static Fitting Assessment *172*
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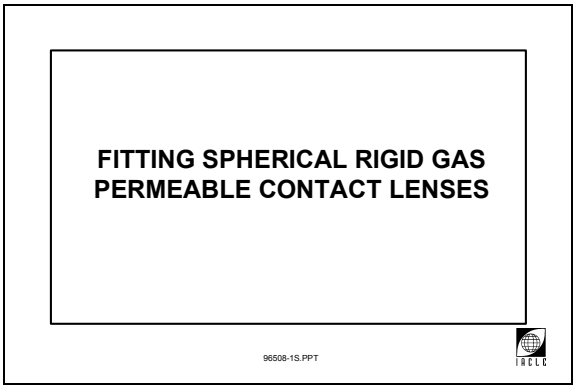
I.E Tight Fitting Characteristics 182
I.F Loose Fitting Characteristics 184

I Fitting Spherical RGP Lenses

I.A Patient Selection

1



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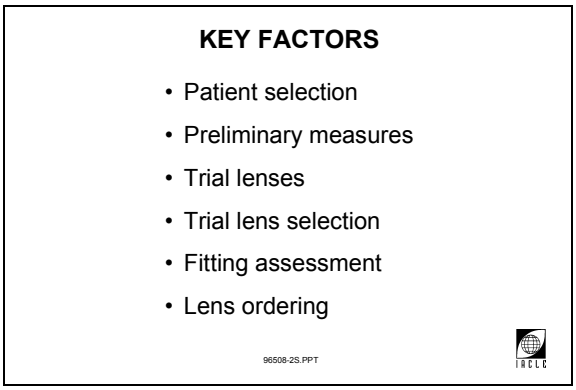

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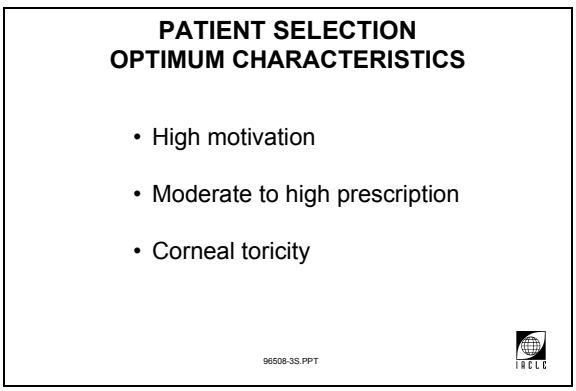

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Patient Selection: Optimum Characteristics

High motivation

A highly motivated patient is more likely to be successful. Motivation is a key factor in RGP lens wear as the initial adaptation period will not be tolerated by wearers lacking the desire to be successful.

Moderate to high prescription

Patients with a moderate to high prescription tend to be more motivated than those with a low power requirement. The desire for an alternative to glasses is stronger among these patients. As their unaided acuity is poorer they cannot function without some form of visual correction.

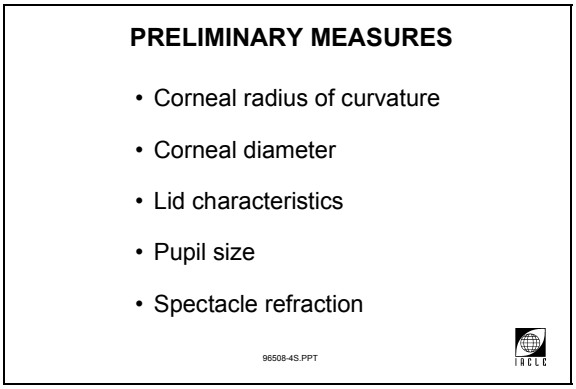
Corneal toricity

As a general rule, those patients who require an astigmatic visual correction are

better suited to RGP lenses as the quality of vision is superior to soft lenses.

Patients with significant against the rule corneal toricity often have less success with spherical RGP lenses because of lens decentration and residual astigmatism.

4



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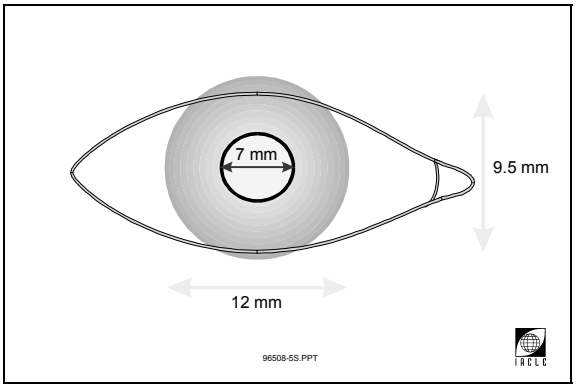

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Preliminary Measurements

Corneal radius of curvature

An understanding of corneal topography is essential for selecting the BOZR for the trial lens fitting. The measurement is usually made with a keratometer. However, a more sophisticated analysis can be performed using a photo or video based keratoscope.

Corneal diameter

A measure of the corneal diameter is useful as a guide to the lens total diameter that is most suitable for the patient. As the corneal periphery is difficult to define, the horizontal visible iris diameter is used as a guide to the corneal diameter.

The HVID can be measured by using a hand held millimetre ruler or by utilizing a graticule in the eyepiece of a slit-lamp biomicroscope.

As a general rule the lens total diameter will be
2.3 - 2.5 mm less than the HVID.

Lid characteristics

The position of the upper and lower lids is important in determining the lens total diameter that is required. Their locations should be assessed by having the patient maintain primary gaze. The positions where the lid margins cross the upper and lower limbus should be recorded as a diagram in the clinical record. The inter-palpebral aperture may be measured with a millimetre rule. This value is used to determine the optimal lens total diameter for the patient.

The tonus in the upper lid can be assessed when the lid is everted for examination. It can be graded as loose, average or tight.

Pupil size

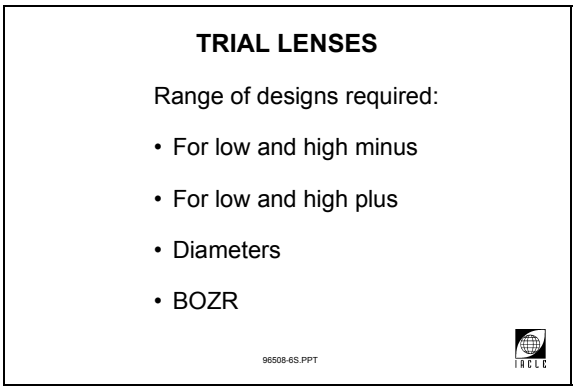
The size of the pupil in both bright and dim illumination should be measured. The dilated pupil size is important for the selection of the appropriate BOZD. When the optical zone is too small significant visual disturbance may result.

Spectacle refraction

It is necessary to obtain a precise spectacle refraction when fitting RGP lenses. The relationship between the refraction, corneal topography and visual acuity will indicate the type of lens which will most suit the patient.

I.B Trial Lenses

6



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Trial Lenses

Low and high minus

A key requirement in fitting patients with RGP lenses is a large trial set. This makes it possible to fit a lens that is close to the final design required for their eye.

The recommended BVP selection is -3.00D for the low minus and -6.00D for the higher minus powers. These powers allow for the fitting of a lens that is close to the final power required, and as such, the fitting observed with the trial lens will be similar to that of the ordered lens.

Low and high plus

The recommended BVP selection is +2.00D for the low plus and +5.00D for the higher plus requirements. The gravitational effects on the plus lens designs is significant, and great care must be taken to ensure that the trial lens is close to the BVP required.

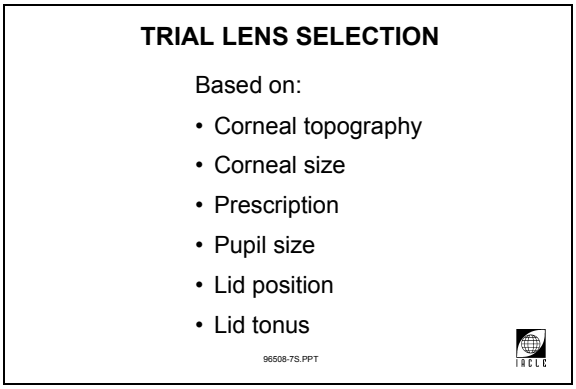
Diameters

The lens total diameter is a very important variable in fitting. For each BVP in the trial set it is valuable to have two diameters with which to fit the patient. A smaller diameter of 9.20 mm and a larger diameter of 9.60 mm should be sufficient to fit the majority of patients.

Back Optic Zone Radius

A range of BOZRs is required from 7.00 to approximately 8.40 mm in 0.1 mm steps and 0.05 mm steps between the radii of 7.60 to 8.00 mm.

7



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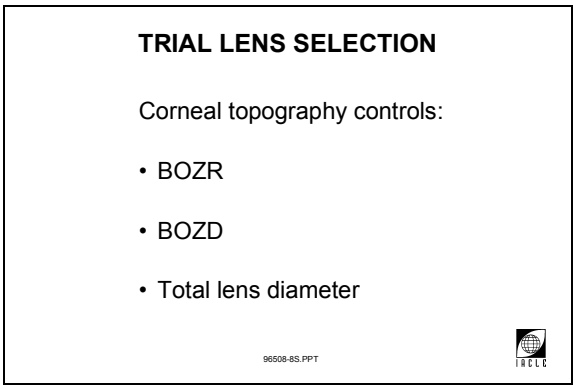

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Trial Lens Selection: Corneal Topography

Careful measurement of the corneal shape will enable the selection of the BOZR of the trial lens. The BOZR that is typically chosen is related to the flattest corneal radius of curvature and is generally in the range of +/- 0.10 mm of that value.

A number of factors will dictate the suitability of the chosen BOZR. These include:

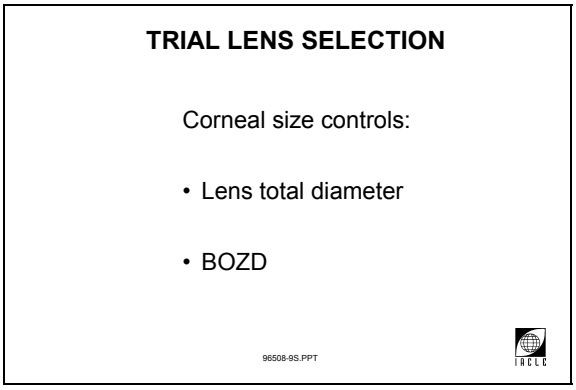
- Corneal toricity.
- BOZD.
- Dynamic fitting characteristics.

The evaluation of the fitting characteristics determines the final BOZR to be ordered for the patient.

The corneal topography also plays a role in the choice of the BOZD for the lens.

- A smaller BOZD is used for steeper corneas
- A larger BOZD is use for flatter corneas.

9



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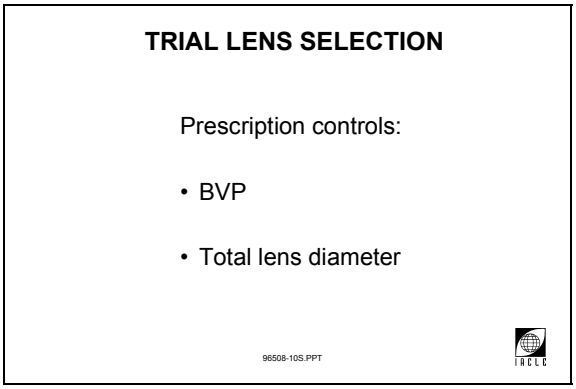
Trial Lens Selection: Corneal Size

The lens total diameter may be selected on the basis of the corneal diameter. This is assessed clinically by measuring the horizontal visible iris diameter (HVID).

When the corneal diameter is small (<11.00 mm), both the BOZD *and* the lens total diameter may need to be decreased to provide the best possible static and dynamic fitting characteristics.

Usually, an RGP lens whose diameter is some
2 mm smaller than the HVID is chosen for the initial trial. However, when choosing lens diameter, the positions of the lids are more important selection criteria than HVID alone.

10



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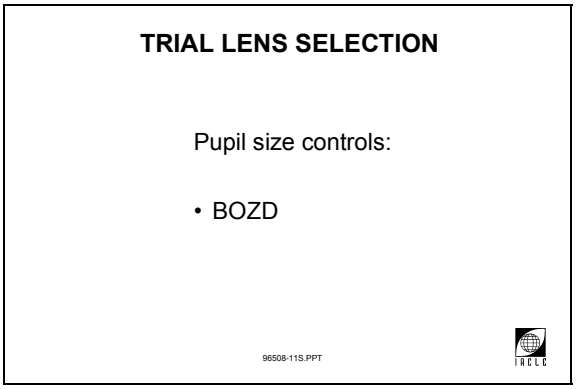

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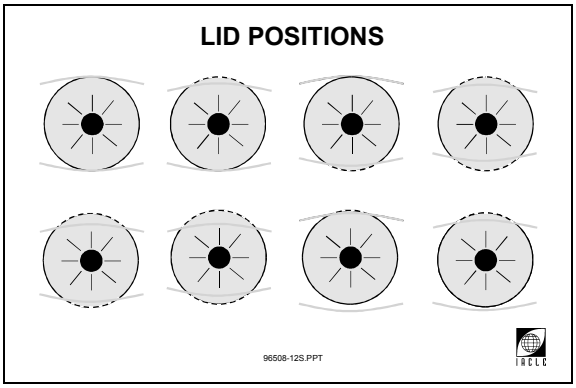
Trial Lens Selection: Pupil Size

To provide the best possible visual performance, the BOZD should be sufficiently large to cover the pupil in both bright and dim illumination.

Although it is difficult to determine accurately, the pupil diameter in dim illumination should be measured. The BOZD will need to be larger than that value by about 1.0 mm.

The lens centration will also be a factor in determining the optimum BOZD. A lens with a BOZD that is too small and decentres on the cornea may cause visual problems.

12



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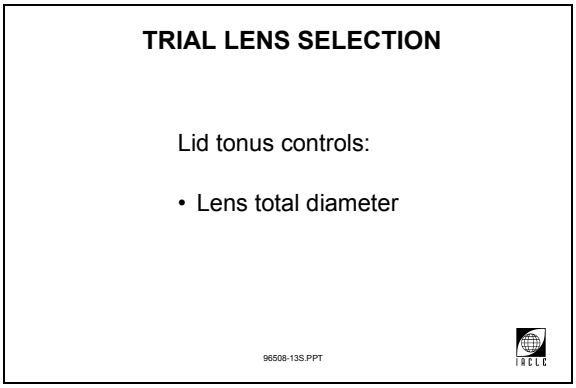
Trial Lens Selection: Lid Position

It is important to examine the position of the upper and lower lids when the patient is looking in the primary gaze direction. The palpebral aperture size may influence the lens total diameter selection.

In the typical lid position, the lower lid margin is in opposition to the limbus at the 6 o'clock visible iris position and the upper lid margin crosses the visible iris at 10 and 2 o'clock. This position gives a interpalpebral aperture of about 9.5 mm.

If the palpebral aperture is significantly smaller than average, the lens total diameter should also be reduced. This general rule is only a guide, and final selection of the lens total diameter must be based on an assessment of all fitting characteristics.

13



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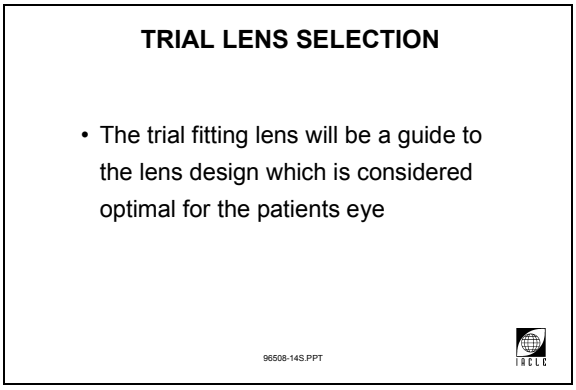
Trial Lens Selection: Lid Tonus

Accurate assessment of the lid tonus is almost impossible. A subjective guide to the degree of tonus may be made when the lids are everted for the evaluation of the upper palpebral conjunctiva.

If the lids are loose and flaccid then, typically, a larger than average lens total diameter is required to provide optimum performance.

When the lids are tight, the lens total diameter does not necessarily have to be reduced. However a reduction may be required if the dynamic fitting characteristics are unsatisfactory.

14



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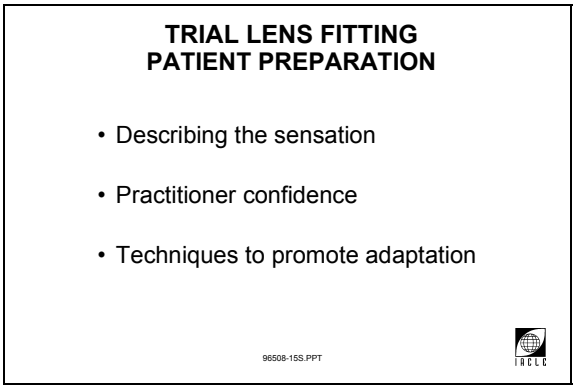
Trial Lens Selection: Trial Lens Fitting

The trial lenses used in the fitting of a patient provide the practitioner with the opportunity to assess the dynamic and static fitting characteristics of each lens. On the basis of these assessments an optimal lens design can be determined and ordered.

Each aspect of the trial lens design and its impact on the fitting performance should be carefully analyzed when designing the final lens for the patient.

15



3L496508-15

Trial Lens Fitting: Patient Preparation

One of the keys to successful RGP lens fitting is correct management of the patient prior to the first lens application to the cornea.

Upon lens application, the initial feeling of a foreign body sensation is experienced by all patients. Therefore, the practitioner must explain the reason for the discomfort, the need for lens adaptation and the likely time course for that adaptation to take place.

When the edge profile of an RGP lens is well rounded, the initial sensation for the wearer is generally one of mild irritation. Adaptation is usually rapid and, within the time of the trial lens fitting, the patient will notice that the lenses have become more comfortable.

If only minimal adaptation has occurred, the edge profile of the lens should be assessed to determine if that is the reason for the prolonged discomfort. Should the lens edge be found to be optimal, slow adaptation is often an indication of a potential problematic RGP wearer.

If the practitioner is confident in their lens handling and application, the patient is likely to be more receptive of their advice. A practitioner who is not confident handling RGP lenses will have difficulty in explaining to the patient why they feel some discomfort upon initial lens application.

There is no one correct method of applying an RGP lens to a patient for the first time. However, certain techniques may be used to promote adaptation:

- Apply the lens with a moderately viscous wetting solution and then get the patient to look in a downward direction with their eyes closed.
- Maintain eye closure for about 5-10 seconds which allows the wetting solution and the tear film to mix. This minimizes the risk of lens mislocation due to excessive blinking following

lens application.

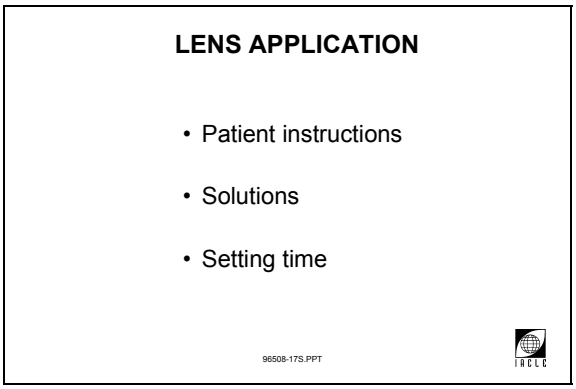
- After opening the eyes, lens adaptation is promoted if the patient maintains downward gaze in a dimly illuminated room and blinks as gently as possible.
- Have the patient refrain from looking in a primary gaze or superior direction during the first few minutes of lens wear. This minimizes reflex tearing following lens application and allows an accurate assessment of the fluorescein pattern and dynamic lens fitting characteristics.

I.C Trial Lens Fitting Assessment

16

3L4196508-16

17



3L4196508-17

Lens Application

Before applying the lens, the practitioner must counsel the patient on the sensation they will notice when the lens is placed on the cornea.

The patient must be made aware of the lid-lens interaction and the consequent sensations. However you should describe the sensations in terms that do not alarm the patient.

Advise them to keep their eyes shut for the first few seconds after the lens has gone on the eye to minimize the risk of lens mislocation, and then to maintain an inferior direction of gaze when they begin to blink. Primary gaze or upward gaze causes excessive discomfort, irritation and tearing.

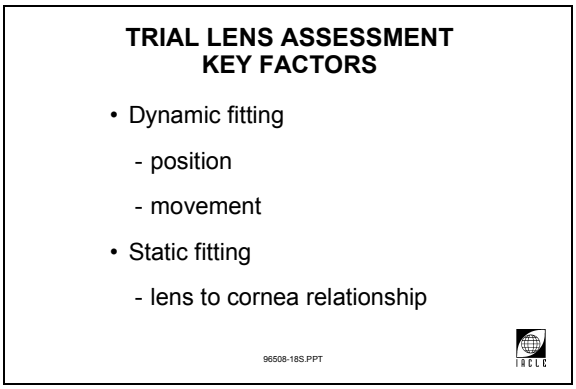
There is a wide choice of solutions to use for the lens application. Usually a wetting agent is best. One that is slightly viscous may offer the greatest initial comfort following application. For an experienced patient, a non-viscous solution such as normal saline may be sufficient.

An adequate amount of time must be given to allow the lens to settle as much as possible on the eye prior to any lens assessment. Any excessive tearing results in an inaccurate static or dynamic appearance. This is because:

- The fluorescein may be washed away too quickly, resulting in a misleading dark pattern.

- The dynamic fitting will be more unstable with a tendency toward an excessive amount of lens movement.

18



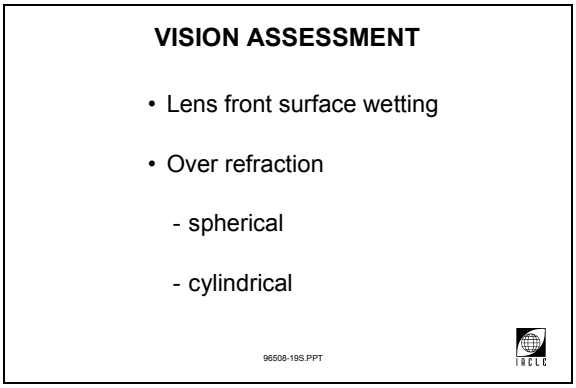
3L4196508-18

Trial Lens Assessment: Key Factors

During the trial lens fitting procedure the practitioner must make a careful assessment of the fitting characteristics of each lens placed on the cornea.

By analyzing the dynamic and static fitting, the optimum lens design for each patient can be determined. Document the fitting of each lens and from that information order the design which appears to be most suited to the patient.

19



3L4196508-19

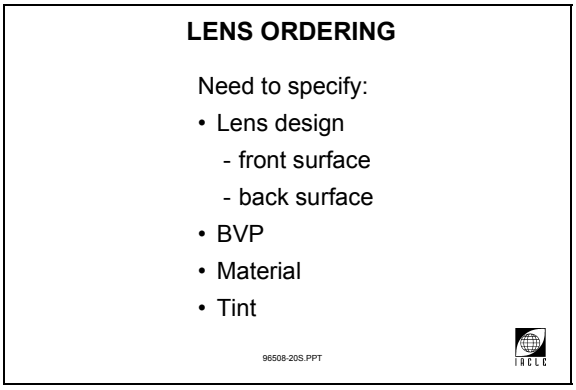
Vision Assessment

It is important to assess accurately the required BVP with the trial lens in place. Prior to performing an over-refraction, the practitioner should take care to check the quality of the wetting of the front surface of the lens. If the lens is wetting poorly, the end point of the refraction will be uncertain due to the irregular refractive surface.

If the trial lens wets poorly it should be removed and, before reapplication, rewetted by rubbing wetting solution onto its surfaces. Using contact lens cleaner on the lens may render the surfaces more hydrophobic.

A full sphero-cylindrical over-refraction will be required if an unacceptable level of vision is obtained with spherical lenses alone. The over-refraction result will dictate the BVP to be ordered. If a significant cylinder is found, consideration of the need for toric RGP lenses is required.

20



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Lens Ordering

Care must be taken when writing the RGP lens order for the patient.

If the practitioner has a full understanding of the trial lens design, the written order is based on the features of that lens. Where possible the front and back surface design characteristics of the trial lens are used in the lens order.

Other characteristics of the lens such as the BVP, centre thickness, material type and tinting should also be determined by the practitioner and specified to the manufacturer.

I.C.1 Dynamic Assessment

21

DYNAMIC FIT ASSESSMENT METHOD

- Patient initially looks straight ahead (primary gaze position)
- Use Burton lamp and/or biomicroscope with white light
- Alter patient's direction of gaze as required

96508-21S.PPT

3L4196508-21

Dynamic Fitting Assessment Method

Once the lens has settled on the eye and the patient has reached a suitable level of adaptation, the fitting characteristics can be assessed. The time needed for adaptation is generally 20-30 minutes.

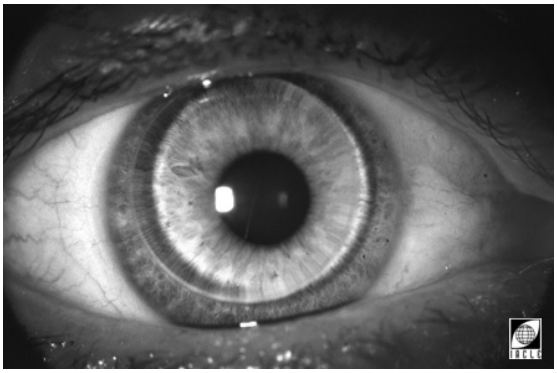
The dynamic aspects of the fitting are first observed with the eye in primary gaze and blinking normally. Observation can be made with the Burton lamp which provides illumination and magnification.

One advantage of the Burton lamp over the slit-lamp is that the patient can maintain normal head and eye posture.

The slit-lamp may be employed with diffuse illumination for a higher magnification view of the lens dynamic fitting characteristics.

The patient may be asked to alter the direction of gaze to enable the practitioner to obtain a better understanding of the nature of the dynamic fitting.

22



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23

DYNAMIC FITTING ASSESSMENT CLINICAL OBSERVATIONS

- Decentration
- Stability
- Movement after blinking
- Movement with lateral gaze
- Lower lid influence
- Upper lid influence

96508-22S.PPT

3L4196508-22

24

DYNAMIC FITTING ASSESSMENT DECENTRATION

- Relative to the centre of the cornea
- Measured horizontally and vertically in millimetres
- High riding
- Low riding

96508-23S.PPT

3L4196508-23

Dynamic Fitting Assessment: Decentration

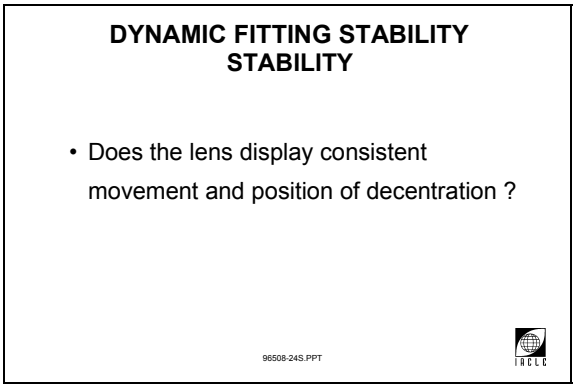
It is necessary to examine the lens location on the cornea and to assess the degree of decentration.

It is rare for an RGP lens to be perfectly centred on the cornea. There are no hard and fast rules for what is considered to be an acceptable degree of decentration. Excessive decentration may cause significant problems with visual performance, limbal and conjunctival

irritation and lens instability. Patient symptomatology is often the best indicator of poor lens centration.

The decentration of the lens is determined by comparing the relative position of the geometrical centre of the cornea and the geometrical centre of the lens. This can be done for both the horizontal and vertical meridians. The simplest method is to use the known values for the HVID and the lens total diameter.

25



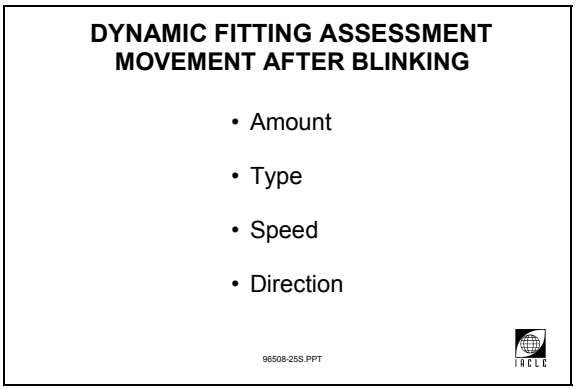
3L4196508-24

Dynamic Fitting Assessment: Stability

The stability of the lens on the cornea is very important for long-term patient satisfaction. A lens that has consistent, acceptable movement and position of rest is most likely to perform successfully.

In the early stages of lens adaptation, stability may be compromised due to excess tearing. Judge the stability only after an adequate degree of adaptation has been achieved.

26



3L4196508-25

Dynamic Fitting Assessment: Movement After Blinking

The quality of lens movement is one of the most important considerations in judging the acceptability of an RGP lens fitting.

The lens movement is initiated by the action of the lids when blinking. The listed components should be assessed:

- Amount.
- Type.
- Speed.
- Direction.

27

LENS MOVEMENT AMOUNT

- Post blink
- Vertical meridian
- Observe the inferior lens edge
- Record in millimeters

96508-26S.PPT

3L4196508-26

Lens Movement: Amount

The blinking action of the upper eyelid will cause the lens to move. The three phases of lens movement are:

- With the downward motion of the lid.
- With the upward motion of the lid.
- Recentring movement following the blink.

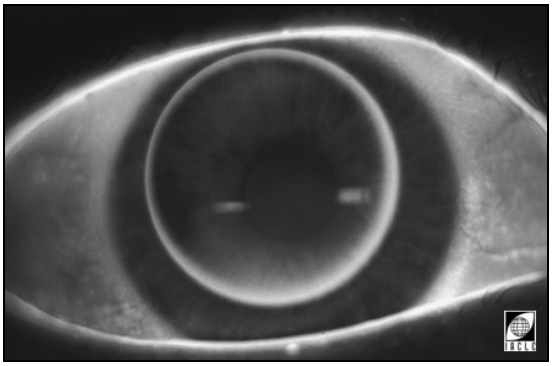
The first two are difficult, if not impossible, to measure due to the speed and coverage of the lid.

The amount of movement that can be most easily measured is the post-blink recentration of the lens. This measurement involves assessing the highest point on the cornea that the inferior edge of the lens has reached on eye opening and then determining the amount that the lens moves to regain its position of rest.

The amount of post-blink lens movement will depend on the nature of the lens fitting. The post-blink movement may be as much as 3.0 mm.

Examples of the extent of movement are shown in these 2 slides where the top lid has lifted the lens and, after release, the lens has dropped to an inferior position.

28



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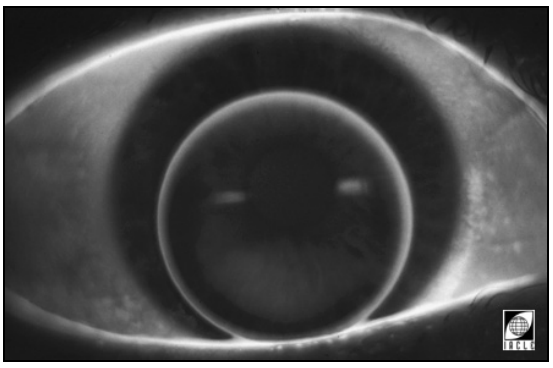

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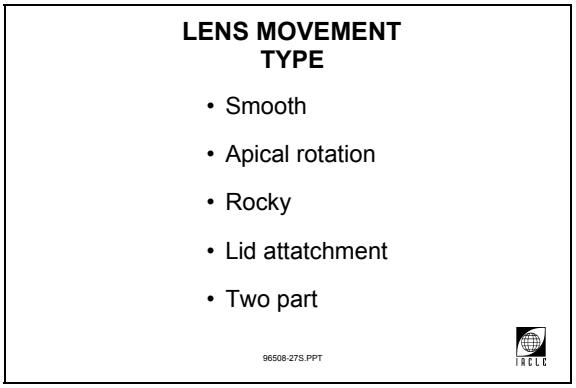


3L4196508-27

Lens Movement: Type

The type of lens movement observed is usually indicative of the fitting relationship between the lens back surface and the cornea.

Ideally the lens should show a smooth movement across the corneal surface with, and following, each blink. Such movement optimizes comfort and stable vision.

Smooth movement is usually associated with a near to alignment fitting pattern.

If the lens is fitted with central corneal touch, the movement is likely to rotate about the corneal apex from superior to an inferior position.

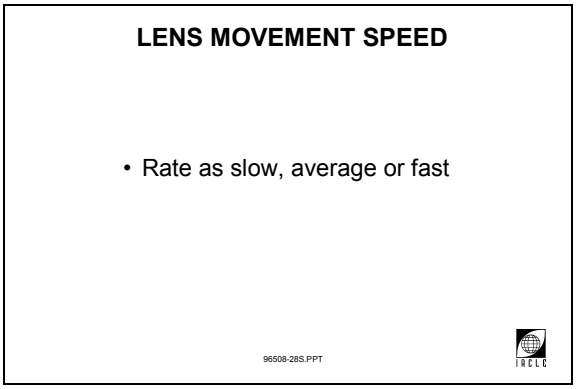
As the central radius of curvature of the lens is flatter than the corneal apex, the path of least resistance for the lens to move is around the apex. This may be either on the nasal or the temporal side.

As corneal toricity increases, lens stability and movement may become more erratic. If the lens is fitted slightly tight to improve stability, the movement may be limited to a small amount of rocking about the flatter meridian.

A lens fitting philosophy known as ‘lid attachment’ results in the lens maintaining a high riding position on the cornea between blinks. With each blink the lens moves as though it is firmly attached to the lid. When the eye is fully opened after each blink the lens displays very little post-blink movement.

The lens-lid interaction may in some fittings be sufficient to cause the lens to move with two distinct phases. This may apply to smooth and apical rotation types of movement. In such cases, the lens movement can be noted in the record as, for example, smooth/two part.

31

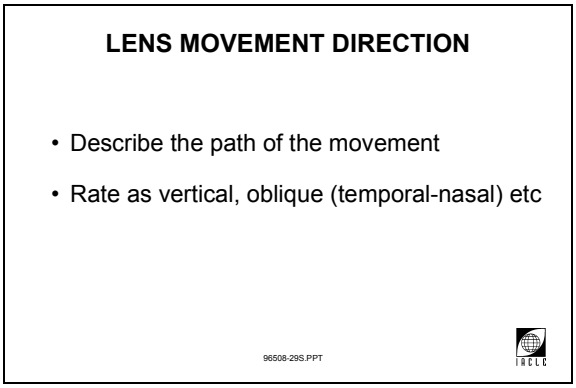


3L4196508-28

Lens Movement: Speed

The speed at which a lens moves following a blink can be assessed by the practitioner as either slow, average or fast. Intermediate gradings can be made if required.

32



3L4196508-29

Lens Movement: Direction

The final notation in the record regarding the lens movement is to indicate the direction in which the lens moves across the cornea.

A near vertical direction with each blink is desirable. If the lens rotates about the apex, indicate whether it is most commonly on the nasal or the temporal side.

If the movement is more in an oblique or diagonal direction, indicate the starting and the finishing quadrants, e.g. sup/nas to inf/temp.

The simplest way to record this aspect of the lens movement is to draw a diagram on the patient's record notes.

I.C.2 Static Fitting Assessment

33

STATIC FITTING ASSESSMENT

- Evaluated in the primary gaze position
- Lens centred on the cornea
- No lid influence
- Fluorescein and cobalt blue light
- Assess the tear layer thickness

96508-30S.PPT

3L4196508-30

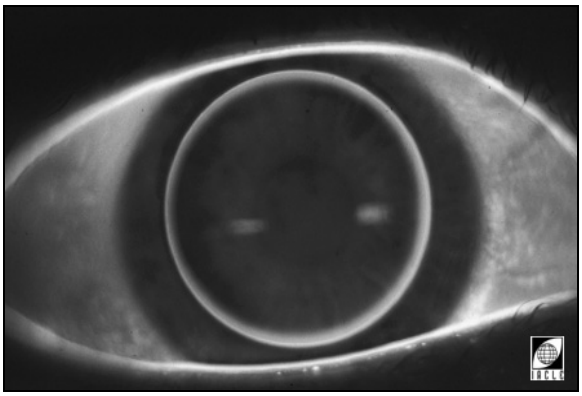
Static Fitting Assessment

The assessment of the static fitting of an RGP lens enables the practitioner to determine the relationship between the lens back surface and the anterior corneal surface.

This assessment is vital and it should be done in a highly repeatable manner to allow comparison from one examination to the next.

The static fitting should be assessed with the patient looking in the primary gaze position. The lens should be centred on the cornea, or in its natural resting position.

34



3L411423-92

The upper lid can be held away from the superior part of the lens by digital manipulation. The lower and upper lids can be used by the practitioner to manipulate the lens so that it is centred on the cornea.

With the lens centred, the fluorescein pattern is assessed and recorded. The detectable presence of fluorescein indicates a region of clearance between the lens and the cornea, and the tear layer thickness beneath the lens can be estimated.

35

STATIC FITTING ASSESSMENT

- Moisten strip with sterile saline
- Shake off excess
- Gently contact upper bulbar conjunctiva
- Use minimum amount necessary

96508-31S.PPT

3L4196508-31

Static Fitting Assessment: Fluorescein Application

The use of fluorescein is essential for a full understanding of the interaction between the RGP back surface and the corneal surface.

If used incorrectly fluorescein may make an accurate assessment of the static pattern very difficult. The most common mistake made when using fluorescein is application of an excessive amount to the eye. This may cause:

- Irritation.
- Tearing.
- Front surface film.
- Altered dynamic fitting characteristics.

For RGP lens analysis, the fluorescein

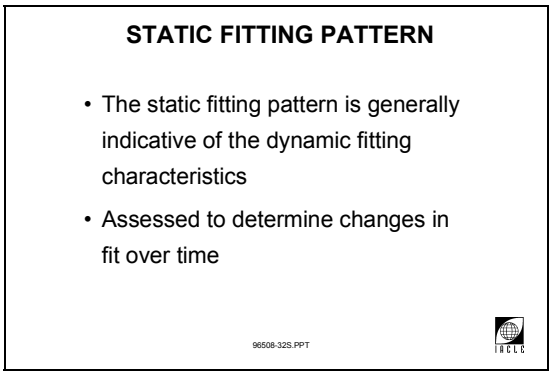
should be applied to the eye with a sterile paper strip coated with fluorescein sodium.

Sterile saline should be applied to the paper strip and the excess fluid removed by shaking the paper prior to ocular instillation.

For safety and ease of application, have the patient look in an infero-nasal direction and gently raise the upper lid. Lightly touch the strip to the superior-temporal bulbar conjunctiva.
If the fluorescein is applied correctly the solution should not run over the conjunctiva.

When the patient blinks the fluorescein is spread across the eye by the lid and tear film movement.

36



3L4196508-32

Static Fitting Pattern

The static fitting pattern generally shows a good correlation with the dynamic fitting characteristics. For example, a lens that has a central touch zone with a wide and/or flat peripheral edge is very likely to display an apical rotation type of movement following the blink.

The practitioner should not necessarily think of the fitting assessment in two distinct components. Both the static and dynamic features are important to fully understanding the overall fitting characteristics of an RGP lens.

The dynamic characteristics are influenced by a wide range of factors such as the direction of gaze and the force of the blink. The static assessment is therefore the only way in which the practitioner can be confident a valid comparison can be made between two lens designs when evaluating the trial fitting to determine the optimum design for the patient.

Changes in the lens fitting over time can also be assessed accurately by comparing the static pattern.

37

STATIC FITTING ASSESSMENT TECHNIQUES

- Central zone
- Mid peripheral zone
- Peripheral zone
- Contact or clearance
- Horizontal and vertical meridians

96508-33S.PPT

3L4196508-33

Static Fitting Assessment

The three zones that are assessed when looking at the lens in the static position are the central, mid peripheral and peripheral.

The use of fluorescein allows the practitioner to identify very subtle changes in the tear layer thickness behind the lens. In general, the practitioner is assessing the relationship between the lens back surface and the corneal front surface by looking for the presence or absence of fluorescein, i.e. lens clearance or contact on the cornea.

In most cases the lens fitting is assessed along the horizontal and vertical meridians of the cornea. However it is possible to define the fitting characteristics along any meridian.

38

STATIC FITTING ASSESSMENT CENTRAL

- Pooling - steep
- Alignment
- Touch - flat
- Width of pooling or touch zone

96508-34S.PPT

3L4196508-34

Static Fitting Assessment: Central

When the lens is held in the static position, the practitioner can assess the central fitting relationship. For a certain BOZR the fluorescein pattern will show a parallel, or alignment, relationship between the lens and the cornea. In this case a thin, parallel layer of fluorescein may not be apparent as shown in slide 39.

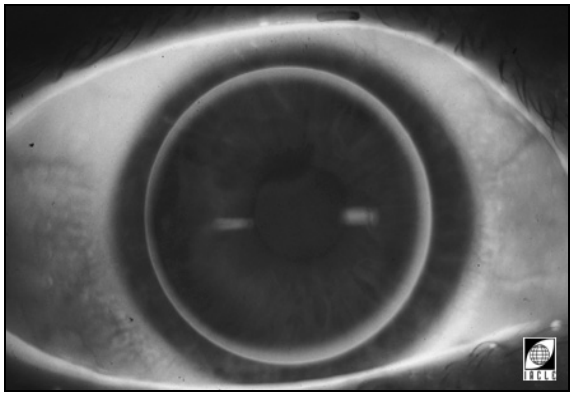
If the BOZR is made shorter, a pooling of fluorescein is evident as the lens back surface vaults the corneal surface. This is a steep fitting, which is shown in slide 40.

The degree of fluorescein pooling can be graded as:

- Slightly steep.
- Steep.
- Very steep.

If the BOZR is made longer than the value which produces an alignment fitting then the centre of the lens will touch the cornea. As no fluorescein is apparent, a near-circular black zone will be evident along with excessive edge clearance. This is a flat fitting (see slide 41).

39



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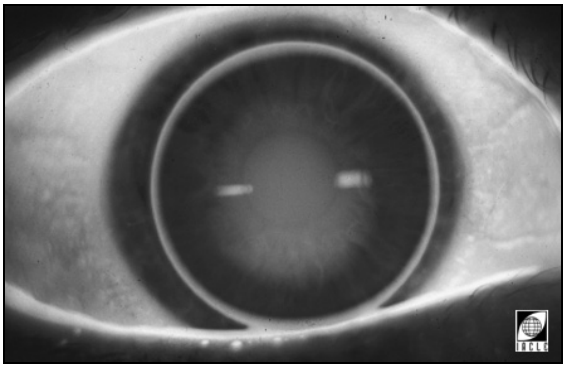

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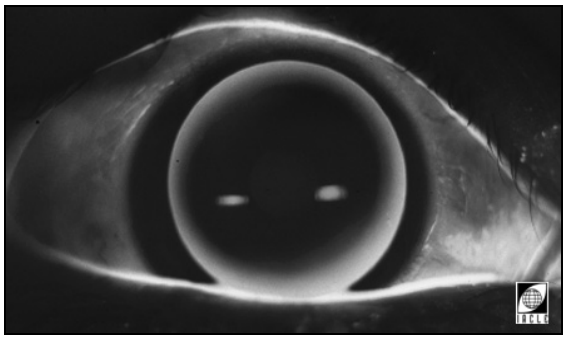


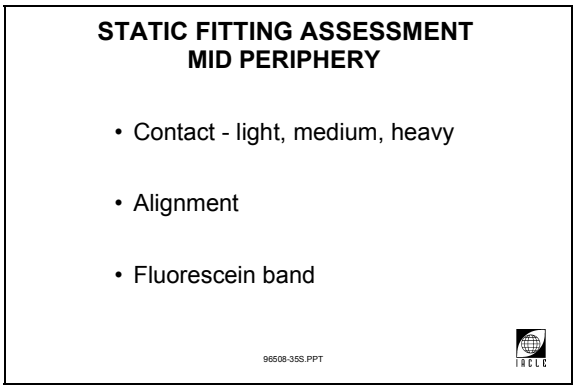
3L410681-92

The degree of contact between the lens and the cornea can be graded as:

- Slightly flat.
- Flat.
- Very flat.

When the lens shows either apical pooling or contact, the diameter of the zone can be measured and recorded. This is most easily done along the horizontal meridian.

42



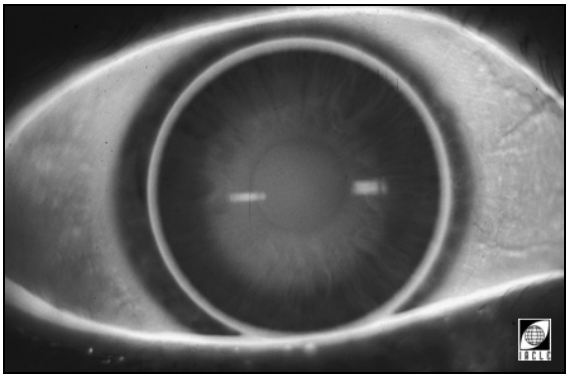
3L4196508-35

Static Fitting Assessment: Mid Periphery

The mid periphery of an RGP lens is a very ill-defined zone. It is not the midpoint between the centre of the lens and the edge as, in most cases, that point is well within the optical zone of the back surface.

An assessment of the mid periphery generally describes the contact zone if the BOZR is steeper than the cornea or the lack of contact when the BOZR is flatter than the cornea.

43



3L410306-91

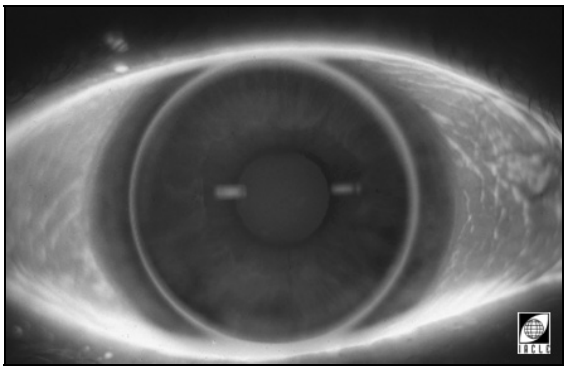
When a central pool of fluorescein exists, a band of contact is observed adjacent to the zone of pooling. This bearing area may be seen as a 360 degree band.

The bearing or contact zone in slide 43 can be classified as being medium.

Light bearing would mean that the lens has central alignment such as in shown slide 44 and therefore little or no localized bearing.

In most cases, an alignment fitting centrally also produces an alignment area extending to the optic zone junction.

44



3L411422-92

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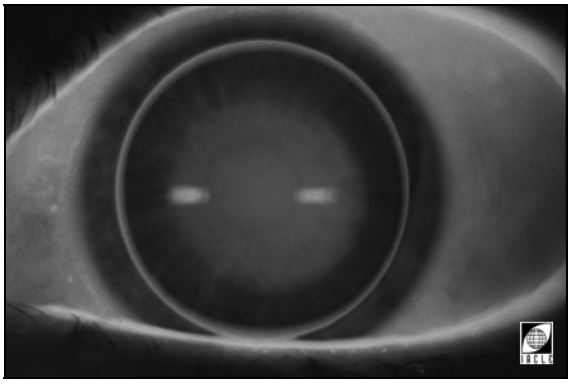


3L4.11379-91

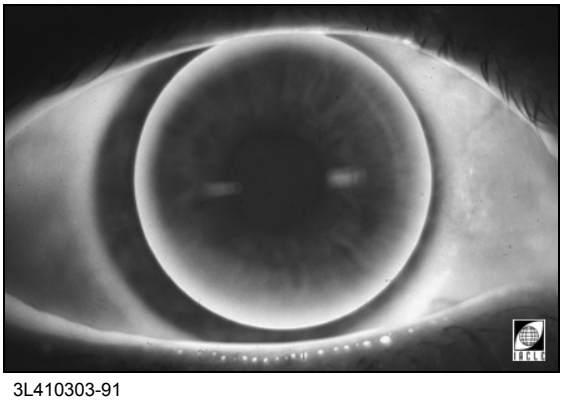
Slide 45 shows an example of heavy localized bearing.

When the central zone exhibits apical touch (flat fitting), the mid-periphery should exhibit clearance from the cornea. This clearance is disclosed by the presence of fluorescein which, within limits, becomes brighter with increasing clearance (see slide 46).

The degree of clearance can be classified as:

- Slightly flat.
- Flat.
- Very flat.

46



3L410303-91

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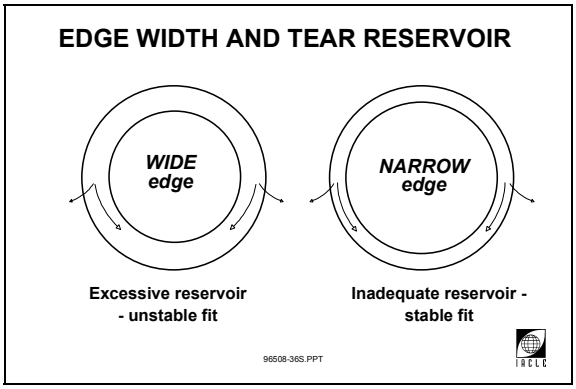


3L4196508-36

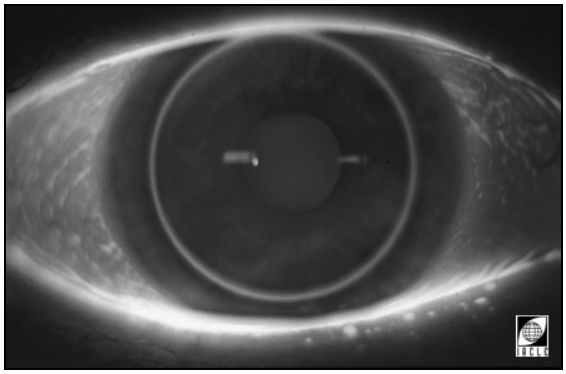
Static Fitting Assessment: Periphery

Analyzing the peripheral fit of an RGP lens is an important component of the static fitting assessment routine.

The peripheral zone as seen with fluorescein must be considered multi-dimensionally.

When observing the band of fluorescein at the periphery of the lens, the practitioner should attempt to classify the width and depth of the clearance and whether a meniscus exists.

48

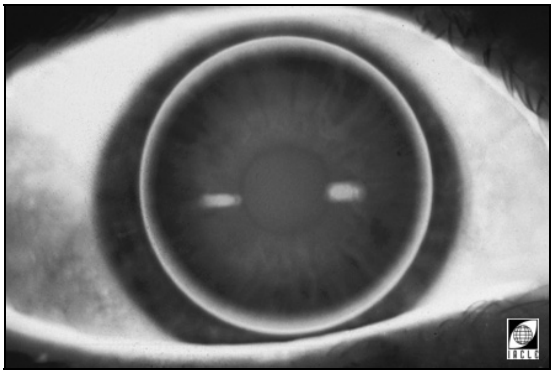


3L411012-94

Peripheral fluorescein pattern examples:

Narrow edge width and inadequate clearance.

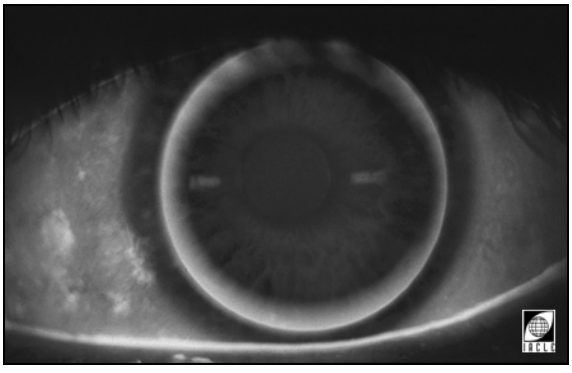
49



3L410305-91

Optimal edge width and adequate clearance.

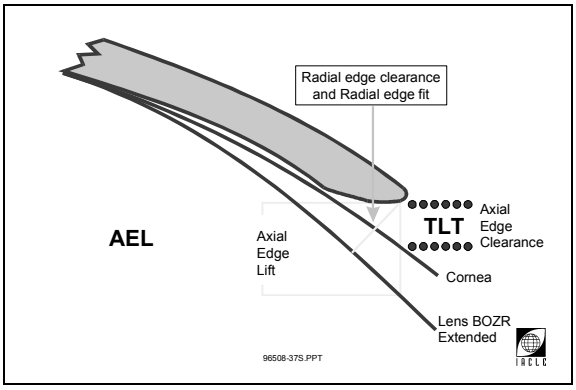
50



3L410614-94

Wide edge width and excessive clearance.

51



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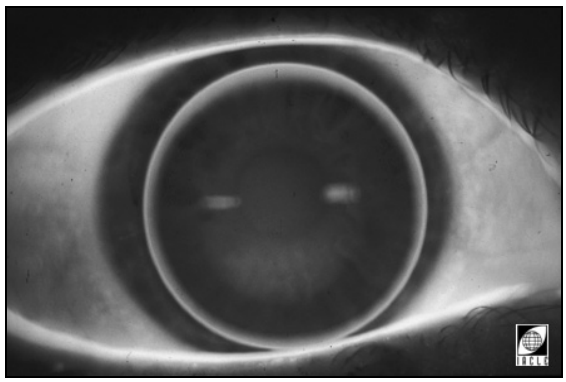
52



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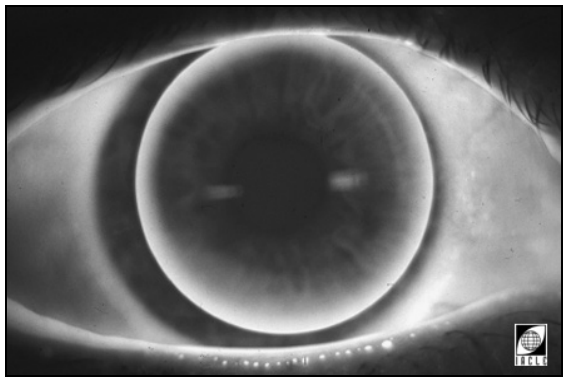
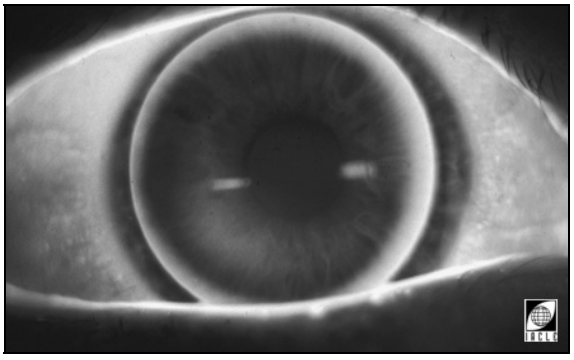
53



3L410303-91

54



3L410304-91

Static Fitting Assessment: Periphery

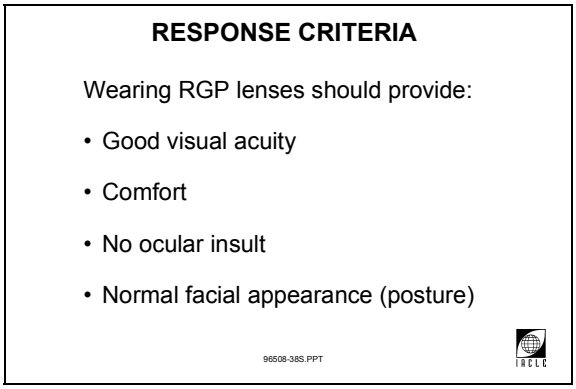
The second component of the peripheral fitting assessment involves the depth or clearance between the lens back surface and the cornea.

As the lens periphery lifts further away from the cornea the fluorescein will be brighter. This variation allows the practitioner to estimate the axial edge clearance (AEC). It is possible for the clearance to be excessive while the width of the peripheral zone is minimal.

Another useful guide to the degree of axial edge clearance is the formation of a meniscus at the lens periphery. Due to surface tension effects, the tear film forms a meniscus as long as the axial edge clearance is not too great. The absence of a meniscus is indicative of excessive clearance.

In the following three pattern examples the AEC ranges from minimal (slide 52) to excessive (slide 54).

55



3L4196508-38

Successful Wearing of RGP Lenses

Regardless of lens fit, the desired patient responses to RGP contact lens wear are as listed in the slide. In order to meet these criteria an optimal lens fit is desirable. These characteristics are suggested in the following pages.

I.D Optimal Fitting Characteristics

56

OPTIMAL FITTING CHARACTERISTICS
STATIC FITTING

- Minimal central clearance
- Light mid peripheral contact zone
- Optimal edge width
- Average edge clearance

96508-39S.PPT

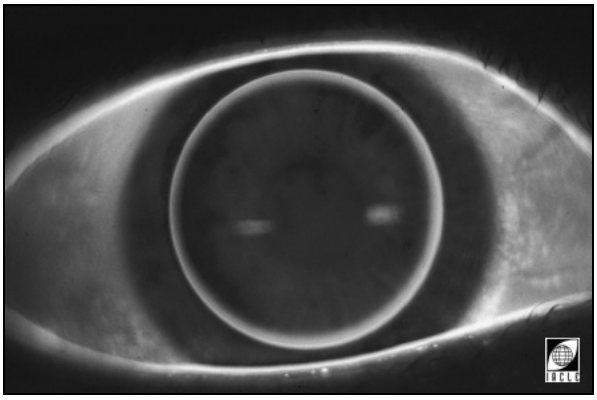
3L4196508-39

Optimal Fitting: Static Fitting

Individual practitioners have personal preferences for characteristics that constitute an optimally fitted RGP lens.

In most cases, a lens that shows very slight apical clearance with a corresponding light mid peripheral contact zone as well as sufficient edge width and clearance will provide an optimal RGP fitting. An example of this appears in slide 57.

57



3L411423-93

58

OPTIMAL FITTING CHARACTERISTICS
DYNAMIC FITTING

- Centred (± 0.5 mm)
- Stable
- Superior lid coverage

96508-40S.PPT

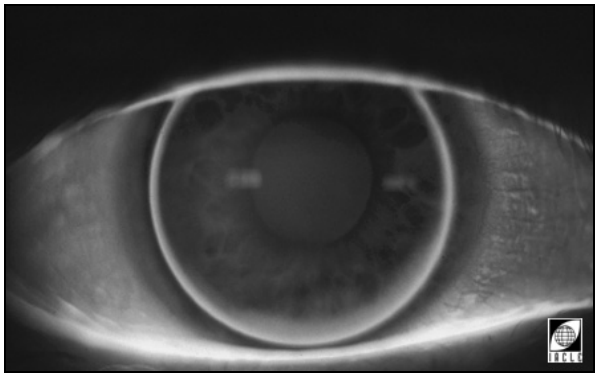
3L4196508-40

Optimal Fitting: Dynamic Fitting

If the optimum static characteristics are observed then the dynamic assessment usually shows a well centred and stable lens.

If the lens total diameter is about 9.60 mm or larger and the upper lid crosses the cornea in a normal position, it is likely that the lid will cover the superior part of the lens when the patient looks in a primary gaze direction. This may be an advantage for some patients as the level of comfort may be increased.

59



3L411574-93

60

OPTIMAL FITTING CHARACTERISTICS
DYNAMIC FITTING

- Movement
  - smooth
  - vertical
  - average speed
  - 1-2 mm

96508-41S.PPT

3L4196508-41

Dynamic Fitting: Movement

Achieving the optimal movement characteristics of an RGP lens is very important for long term successful wear.

A lens that moves smoothly over a distance of
1-2 mm in a vertical direction at an average speed generally provides good comfort and stable vision as well as allowing for the removal of tear debris.

If the fitting is one of lid attachment then the proposed optimal dynamic fitting values for lens movement should still apply. Lens movement is more difficult to visualize because the lens moves with the top lid.

I.E Tight Fitting Characteristics

61

TIGHT FITTING CHARACTERISTICS
STATIC FITTING

- Excessive central clearance
- Heavy mid peripheral contact zone
- Narrow edge width
- Reduced edge clearance

96508-42S.PPT

3L4196508-42

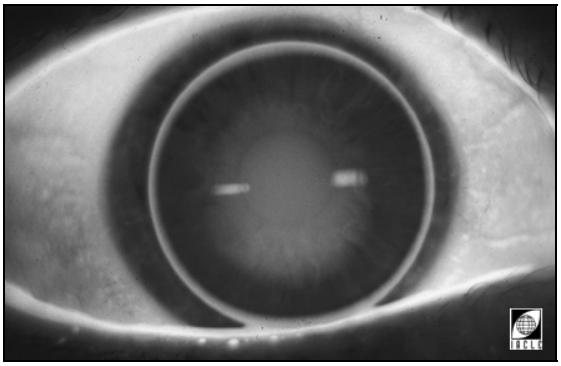
Tight Fitting: Static Fitting

The fluorescein pattern associated with a tight fitting RGP lens generally shows a distinct apical pool indicating excessive central clearance. As the BOZR is shortened, the degree of clearance increases. This also results in a heavy contact zone in the mid-periphery of the cornea. This region of high pressure may result in deformation or warpage of the corneal topography.

The peripheral appearance generally shows a reduced amount of edge clearance as well as a narrow edge width. This can be described as a 'tight' periphery.

Each component of the static fitting must be assessed independently. Central apical pooling of fluorescein is not necessarily associated with a tight periphery.

62



3L411738-93

63

TIGHT FITTING CHARACTERISTICS
DYNAMIC FITTING

- Centred (± 0.5 mm)
- Stable
- Superior lid coverage

96508-43S.PPT

3L4196508-43

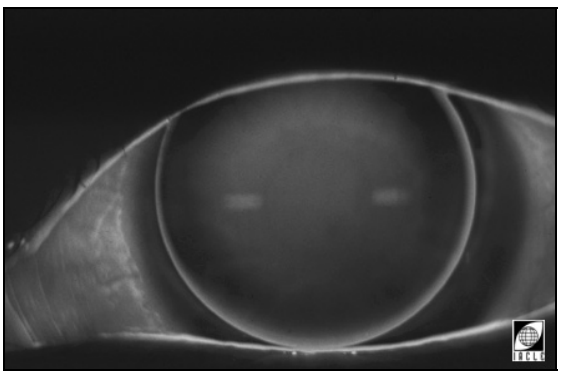
Tight Fitting: Dynamic Fitting

A tight fitting lens usually displays some of the same dynamic characteristics as an optimally fitted lens. The lens is generally well centred or slightly inferior and stable.

Good centration is due to a balance of forces acting on the lens (surface tension at the lens edge, a centred parabolic pressure profile under the lens (Hayashi and Fatt, 1980) (relative to atmospheric pressure, positive centrally and slightly negative at the very edge as proved by a *concave* meniscus there), gravity, viscous resistance, lid pressure (see Carney *et al.,* 1996) and the lid-lens pre-lens tear film meniscus.

When decentration is attempted the differences in the curvatures of the back surface of the lens and the aspheric cornea means that an *increase* in the post-lens tear film *volume* is attempted. This necessitates the imbibition of tear fluid from under the lens periphery and the edge meniscus itself. This the

64

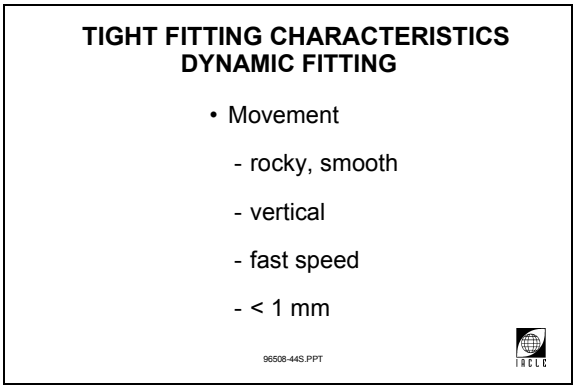


3L411755-93

meniscus resists because it is in a state of relatively insufficiency already.

Further, a tight (steep) lens is in close apposition to the cornea thereby restricting any movement of tears from the periphery towards the apical pool. If the fit is very tight, the reduced clearance may mean the lens is resting on or near the more viscous mucin layer of the tear film. This not only restricts tear fluid flow but also 'damp' the lens movement *per se* by the increased viscous drag.

65



3L4196508-44

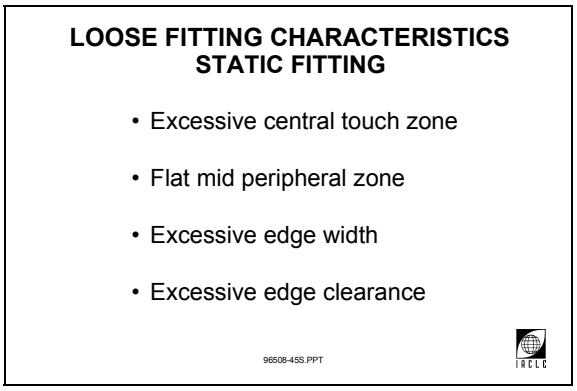
Dynamic Fitting: Movement

The most apparent difference between a tight and an optimally fitted lens is in the assessment of the lens movement characteristics.

A tight lens generally displays a limited amount of movement, usually less than 1.0 mm. The speed is fast but in most cases smooth and in a vertical direction. As the corneal toricity increases the type of movement may be described as "rocky" as the tendency of the lens is to rock about the flatter corneal meridian.

I.F Loose Fitting Characteristics

66



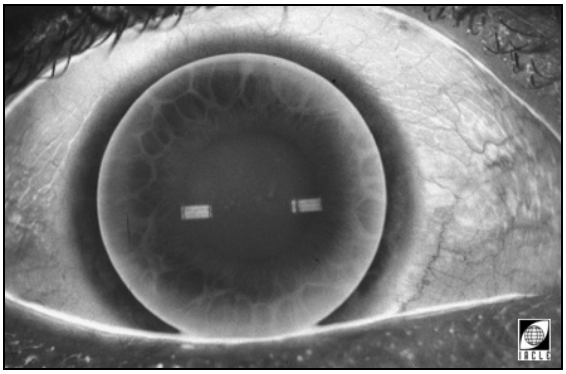
3L4196508-45

Loose Fitting: Static Fitting

A tendency toward a loose fitting will be evident in a lens that has a limited zone of central corneal touch. When the BOZR is lengthened (made flatter), the centre of the lens back surface rests against the relatively steeper central cornea.

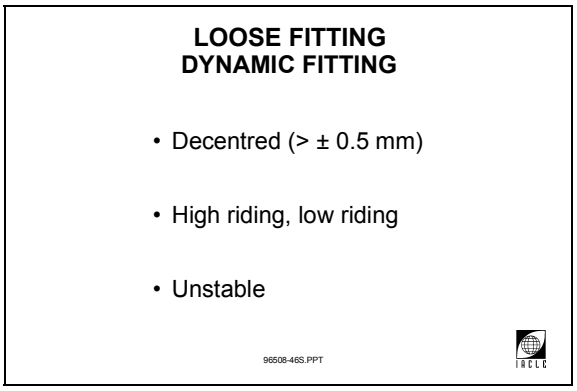
A loose fitting lens shows an excessive amount of fluorescein in the mid-periphery and peripheral zone. Such a lens will, in many cases, display poor dynamic fitting characteristics due to the reduction in the centring forces acting on the lens.

67



3L410334-94

68



3L4196508-46

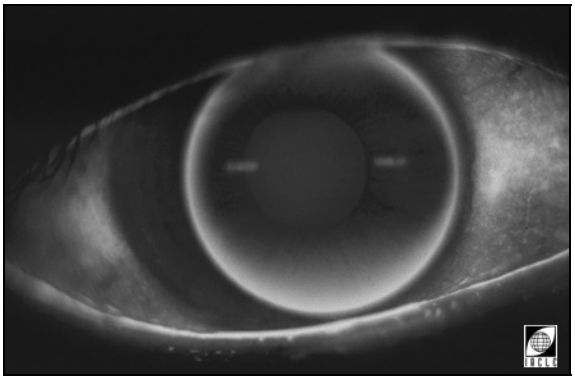
Loose Fitting: Dynamic Fitting

The typical appearance of a loose fitting RGP lens is an excessive amount of decentration. This may result in either a high or lateral riding position on the cornea. The superior location of the lens is mostly due to the upper lid forces acting on the lens. When the upper lid is unable to hold the lens it typically falls slowly to an inferior location on the cornea.

The resting position of the lens may be inconsistent and the instability may cause the patient physical or visual discomfort.

A loose fitting lens often shows a considerable lag or delay in its movement following a change in the position of gaze of the eye.

69



3L410850-94

70

LOOSE FITTING
DYNAMIC FITTING

- Movement
  - apical rotation
  - lid attachment
  - variable speed
  - > 2.0 mm

96508-47S.PPT

3L4196508-47

Dynamic Fitting: Movement

A loose fitting lens typically shows highly abnormal movement characteristics. When the BOZR is too flat, the lens is likely to rotate around the corneal apex on either the nasal or the temporal side, as it returns to a low resting position on the cornea.

The speed is usually slow but may be very variable. The amount of movement may be excessive.

If the lens displays a lid-attachment fitting then there may be no movement following the blink.

Lecture 3.4.2

(1 Hour)

The Effects of RGP Parameter Changes

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II Effects of Varying RGP Parameters on Lens Fitting **190**
II.A Lens Diameter 190
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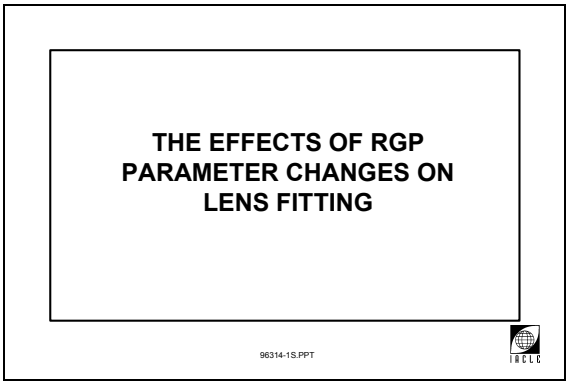
II.C Effects of Changing Surface Design Parameters 199
II.C.1 Back Surface Design.....*199*
II.C.2 Front Surface Design.....*211*

I RGP Parameters That Affect Fitting

1

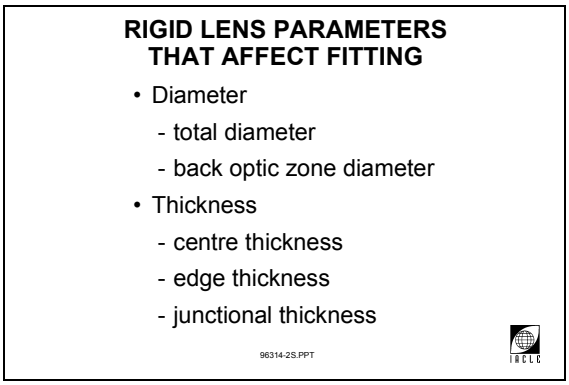


3L4.296314-1

The Effects of RGP (Rigid Gas Permeable) Parameter Changes on Lens Fitting

Achieving a satisfactory RGP contact lens fitting may sometimes require modification of its parameters. An understanding of the relationship between parameters is a prerequisite to applying any modification procedure. Clinicians should then be able to determine the clinical implications of any parameter change made to an RGP lens in trying to achieve the desired fitting.

2

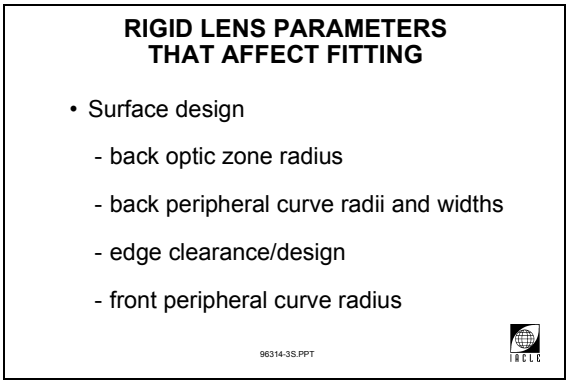


3L4.296314-2

RGP Contact Lens Parameters that Affect Fitting

The lens parameters that play a key role in providing good vision and most importantly, a satisfactory lens-cornea relationship are listed in Unit 3.4.1 (Fitting of Spherical RGP Contact Lenses). This lecture will be discussed following the outline of the listed lens parameters shown in the two slides opposite.

3



3L4.296314-3

II Effects of Varying RGP Parameters on Lens Fitting

II.A Lens Diameter

4

RIGID LENS PARAMETER CHANGE

Influences:

- Other lens parameters
- Lens fitting characteristics
  - static
  - dynamic
- Physiological responses
- Subjective responses

96314-4S.PPT

3L4.296314-4

RGP Lens Parameter Change

Prescribing RGP lenses require the provision of concise specifications to avoid lens related complications while providing optimum vision and comfort. The inter-relationship between lens parameters, as well as their potential effects on the eye, comfort and vision, can present complications for the prescriber at any stage. When changing an existing lens parameter, its effects on other lens parameters need to be allowed for. This lecture will show how changing RGP lens parameters can affect the following:

- Other lens parameters.
- Static lens fitting characteristics.
- Dynamic lens fitting characteristics.
- Physiological responses.
- Subjective responses.

NOTE: Although interdependency between parameters exists, to avoid excessive complexity, the following discussion will assume that all other parameters remain unaltered unless otherwise stated.

5

CHANGING LENS TOTAL DIAMETER

Affects other parameters:

- Centre of gravity
- Peripheral curve width
- Axial edge lift
- Edge profile

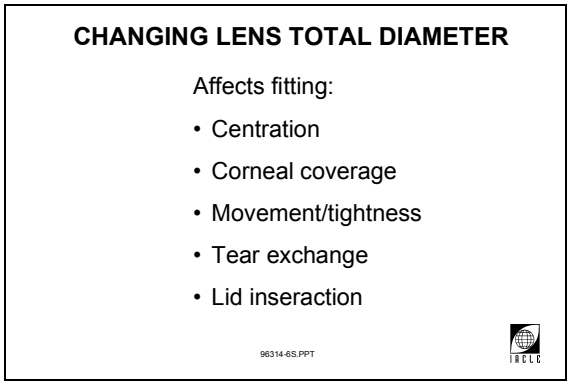
96314-5S.PPT

3L4.296314-5

Effects of Changing the Lens Total Diameter

RGP contact lens diameter changes usually refer to alterations in the Total Diameter (TD). Changes in other parameters may occur as a result of a flow-on effect following TD changes. These can bring about consequent changes to the fitting as well as subjective and physiological effects.

6



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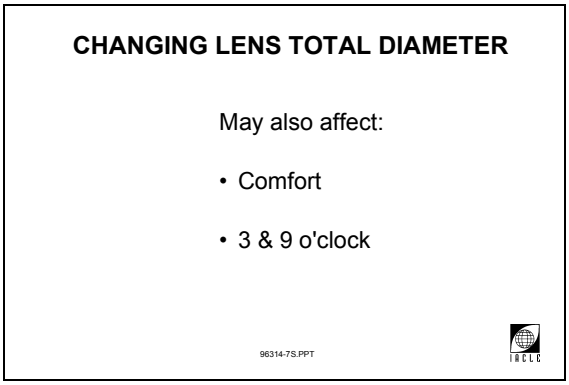
7



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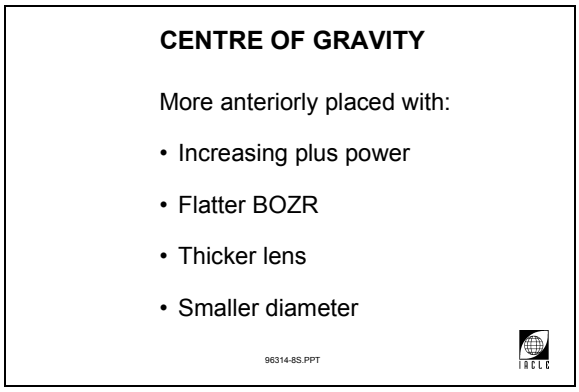
8

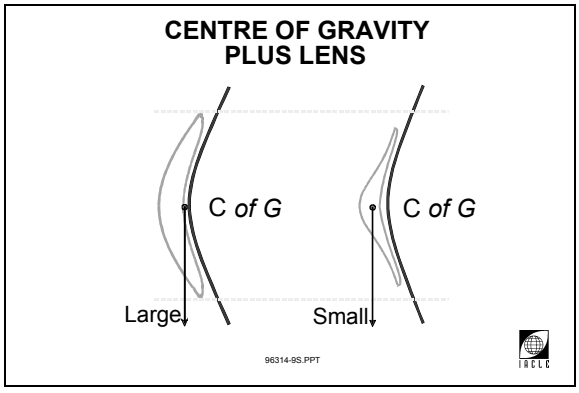


3L4.296314-8

Centre of Gravity (C of G)

The position of the C of G is related to the BVP, BOZR, lens thickness and lens diameter. With a more anteriorly placed C of G, these design changes will have an overall effect of loosening the lens and creating more movement. Opposite conditions will result in moving the C of G posteriorly.

9



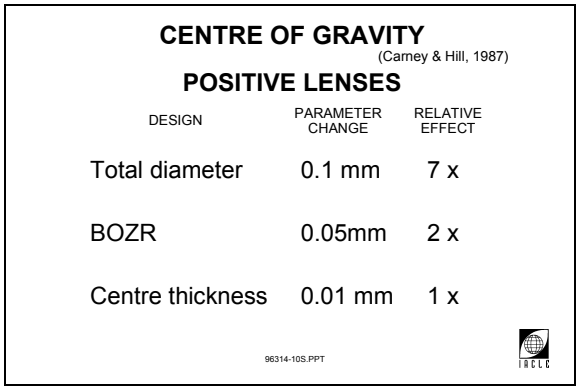
3L4.296220-9

Centre of Gravity: Plus Lens

Changing the Lens Total Diameter:

This diagram illustrates the effect that diameter reduction has on the location of the C of G of *plus* lenses. A larger diameter plus lens places the C of G more posteriorly. The more anterior the C of G is located, the potentially less stable will be the fit because of the greater mislocation force (rotational moment) produced by gravity. Lenticulation produces a small *anterior*

10

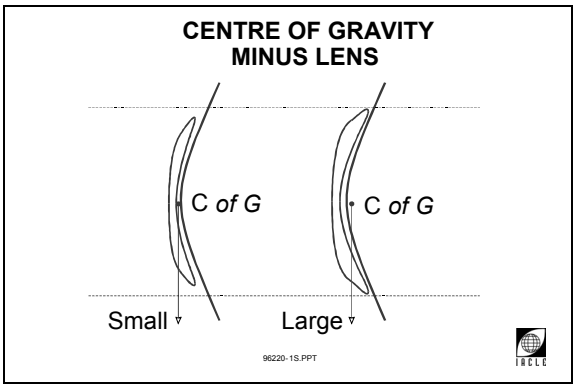


3L4.296314-10

shift of the C of G. However, the overall effect on fit may be difficult to predict because other flow-on effects, e.g. the decrease in rigidity of the lens periphery, also affect lens fit.

The work of Carney and Hill (1987) has clearly demonstrated that the main design change with RGP lenses that significantly affects the C of G is the lens TD. For plus lenses, a diameter change of 0.1 mm produces a 7x greater effect on the position of the centre of gravity than does a 0.01 mm change in the lens centre thickness.

11



3L4.296220-11

Centre of Gravity: Minus Lens

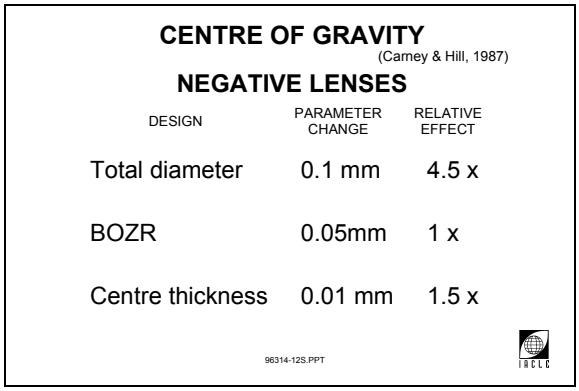
Changing the Lens Total Diameter:

This diagram illustrates the effect lens diameter can have on the location of the C of G of minus lenses. A more anterior C of G is located in a smaller lens creating a less stable fit because of the greater mislocation force (rotational moment) produced by gravity.

For minus lenses, a change in the lens TD produces a slightly reduced effect on the C of G compared with plus power lenses.

However, the effect is still significantly greater than that which occurs with other design changes.

12



3L4.296314-12

13

REDUCING THE TOTAL DIAMETER

Effect on the static fitting:

- Reduced edge width and clearance

Effect on dynamic fitting:

- Loosening of lens fit
- Increased lens movement
- Decentration more likely

96314-13S.PPT

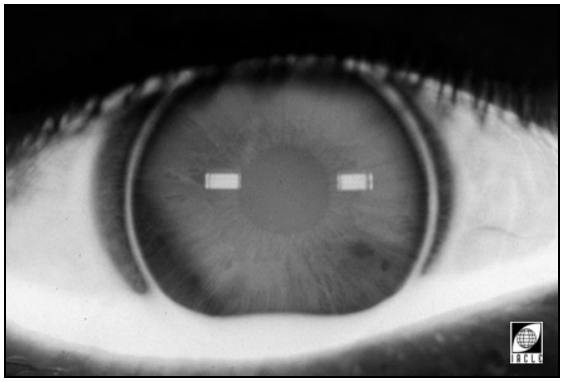
3L4.296314-13

Reducing the Lens Total Diameter

Total Diameter (TD) and Edge Width:

A reduction of the TD without changing the BOZD reduces the edge width. This will be apparent during the fitting assessment. The limited tear exchange this induces will necessitate widening the peripheral curve width and reducing the BOZD if the secondary curve width remains unaltered from its original specification.

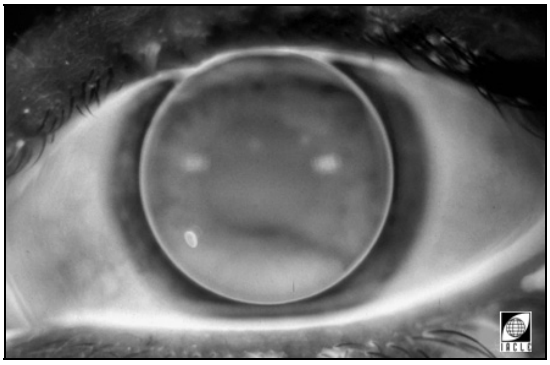
14



3L4.21728-93

Slide 14 shows a large diameter lens. The large BOZD and narrow edge width indicates the need for their alteration when the lens TD is reduced. When this is done, an acceptable fluorescein pattern is noted and good centration is maintained (see slide 15).

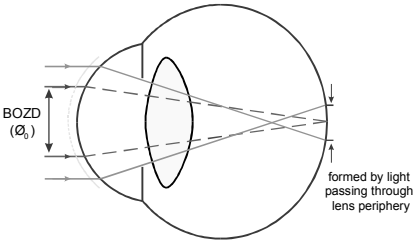
15



3L4.21729-93

16

VISION EFFECT OF BOZD



96314-14S.PPT

3L4.296314-14

Changing the Back Optic Zone Diameter (BOZD)

Alterations to the TD may require BOZD changes to maintain enough edge clearance for adequate tear exchange. To avoid night vision problems, a precautionary measure when reducing the BOZD is to ensure that the pupil is still covered.

The vision effects of a BOZD which is smaller than the entrance pupil size (the image of the anatomical pupil formed by the optics of the cornea and anterior

17

CHANGING THE BACK OPTIC ZONE DIAMETER

- Increasing the BOZD increases apical clearance: tightens fit
  - improves centration
- Decreasing the BOZD decreases apical clearance: loosens fit
  - increases decentration

96314-15S.PPT

3L4.296314-15

chamber) are illustrated in this diagram. Once the BOZD is exceeded in diameter by the entrance pupil, light is refracted by the optic zone, the first curve junction and the lens periphery. 'Ghosting' and decreased image contrast will result in this circumstance.

When alterations to the BOZD are made, the lens-to-cornea relationship changes as does the Tear Layer Thickness (TLT). By increasing the BOZD, the lens sag is increased which results in an increase in the TLT and the fit will tighten. The opposite will occur if the BOZD is reduced (see slides 37 and 38).

After significant changes to the BOZD are made the spherical over-refraction and dynamic fit should be assessed.

18

CHANGING BOZD
(Theodoroff & Lowther, 1990)

Effects on movement and centration

- Small BOZD (7.40 mm) lenses showed slightly less movement but greater decentration than larger (7.90, 8.40 mm) lenses

96314-16S.PPT

3L4.296314-16

Changing the Back Optic Zone Diameter (BOZD)

Theodoroff and Lowther (1990) found that a lens with a smaller BOZD results in less movement but greater decentration than a larger BOZD.

For a constant lens TD, increasing the BOZD will also reduce the edge clearance. Conversely, reducing the BOZD by widening the peripheral curve width will increase edge clearance.

Although altering the BOZD influences lens movement, centration and edge clearance, a balance should be reached to maintain adequate tear exchange and good vision until an alteration to the peripheral curves is called for.

II.B Lens Thickness

19

CHANGING THE CENTRE THICKNESS

Affects other parameters:

- Front surface profile
- Edge profile

Affects the fitting:

- Centre of gravity
- movement
- Stability

96314-17S.PPT

3L4.296314-17

20

CHANGING THE CENTRE THICKNESS

Also affects:

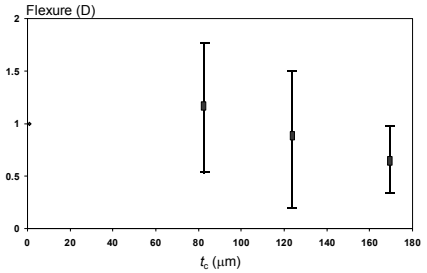
- Comfort
- Dk/t
  - corneal swelling

96314-18S.PPT

3L4.296314-18

21

'ON-EYE' FLEXURE vs t_c
CORNEAL C yl = 1.82 ± 0.74 D



96314-19S.PPT

3L4.296314-19

Effects of Changing the Lens Centre Thickness

Increasing thickness:

- Decreases transmissibility.

An inverse relationship between oxygen permeability and lens thickness, otherwise known as oxygen transmissibility (Dk/*t*), has been well established. In general, increasing oxygen transmission by decreasing the centre thickness (t_c) will reduce the level of corneal oedema during lens wear.

- Moves C of G anteriorly.

  Weight distribution changes across the cornea are brought about by variations in lens thickness and alterations in the position of the C of G. Thinning a lens causes an inward shift of the C of G which translates into improved lens stability.

- Increases rigidity.

  RGP lenses have been known to flex on the cornea. This lens flexure, as shown by the graph in slide 21, occurs at varying lens thicknesses when fitted to a population of astigmatic corneas whose toricity is 1.82 ± 0.74 D. From the data, it can be surmised that a thickness >0.16 mm is required to reduce flexure to an acceptable level.

- Increases movement.

  Due to the anterior shift of the C of G, greater movement accompanied by a looser fitting lens may be exhibited. Increased lens-lid interaction may also develop which, if excessive, may cause instability of the lens fitting.

22

CHANGING THE CENTRE THICKNESS COMFORT STUDY

RANK, 30 MINS

t_c(mm)	BEST	WORST
0.08	11%	50%
0.12	56%	28%
0.16	33%	22%

96314-20S.PPT

3L4.296314-19

Changing the Lens Thickness

Centre Thickness: Comfort Study

Generally, thinner lenses are more comfortable. However, in a study by Cornish and Sulaiman (1996), very thin lenses (0.08 mm) were significantly more uncomfortable than thicker lenses (0.12 and 0.16 mm). They hypothesized this was due to deformation of the thinner lens during a blink. The deformation would result from the greater flexibility of the lens.

23

CHANGING THE LENS THICKNESS EDGE PROFILE

Affects other parameters:
- Edge thickness
- Apex position and location

Affects fitting:
- Lid interaction
- Vertical centration
- Tear meniscus
- Lens removal

96314-21S.PPT

3L4.296314-21

24

CHANGING THE LENS THICKNESS EDGE PROFILE

Influences subjective response:
- Comfort
- Vision

Creates physiological changes:
- 3 & 9 o'clock
- Conjunctival chemosis/staining
- Bulbar redness

96314-22S.PPT

3L4.296314-22

Changing the Lens Thickness

Edge Profile:

Because changes to lens thickness can influence edge thickness, the following observations are relevant:

- Alterations to the edge profile are ideally directed towards producing an edge with a well rounded, centrally or posteriorly located apex to attain maximum comfort. A thin edge lessens lens-lid interaction and therefore, increases comfort.
- Changes to lens edge thickness also change the axial, radial and carrier junction thicknesses; and/or junction angles. This influences the lens-lid interaction and the vertical centration, often causing the lens to ride lower if the lens is made thicker (due to the upper lid pushing the lens down) or higher (when the upper lid carries the lens). Where thickness changes to the edge profile result from decreasing the TD there will be a reduced tear meniscus and lens removal will be more difficult.
- After alterations to lens thickness, any further modification of the edge profile to give a reduced edge lift and clearance will have little effect on comfort (Orsborn *et al*., 1988).
- Physiological disturbances like 3 and 9 o'clock staining and conjunctival redness, chemosis or staining may be negated and/or reduced by improving the lens edge profile.

25

EDGE CONFIGURATION

Affects:

- Comfort
- Durability
- Tear meniscus

96314-23S.PPT

3L4.296314-23

Edge Configuration

Edge configuration can affect:

- Comfort. Generally, the thinner, rounder and smoother the edge, the better.
- Durability. If the edge is too thin, the risk of lens fragility is increased and if it is too thick, comfort is adversely affected.
- Tear meniscus. The edge clearance, apex location and material wettability largely define the tear meniscus at the lens edge.

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EDGE CONFIGURATION
COMFORT vs EDGE SHAPE
(La Hood, 1988)

- RGP lenses with rounded and square posterior edge profiles are more comfortable
- Comfort is determined by interaction of lens edge with the lid

96314-24S.PPT

3L4.296314-24

Edge Configuration

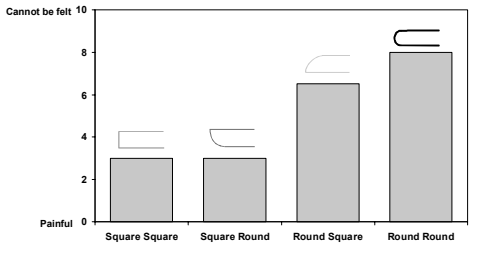
Comfort *versus* Edge Shape:

Studies of comfort *versus* edge shape (La Hood, 1988) revealed that:

- RGP lenses with rounded edges are more comfortable. The posterior surface shape is not as significant. This suggests that as long as the apex is not biased towards the anterior surface, the actual shape is less significant.
- Comfort is determined by the interaction of the lens edge with the lid and not the interaction of the edge with the cornea.

27

EDGE CONFIGURATION
EDGE SHAPE vs COMFORT
(La Hood, 1988a)



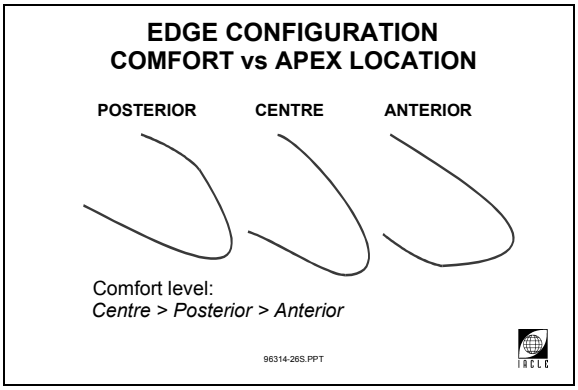
96314-25S.PPT

3L4.296314-25

This graph shows the comfort ratings found for each of the edge profiles trialed in the study. A depiction of each profile appears above the relevant bar on the graph.

The lens with the square shaped anterior and posterior surface profile was the least comfortable. Rounding the posterior surface did not improve the comfort if the anterior surface remained blunt and/or square. The two lenses with a rounded anterior surface were much more comfortable.

28



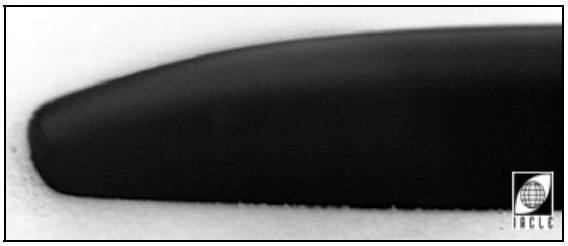
3L4.296314-26

Edge Configuration

Comfort *versus* Apex Location:

In a detailed study of custom fitted lenses, Orsborn (1988) found a centrally located edge apex was more comfortable than either a posterior or anterior location.

29

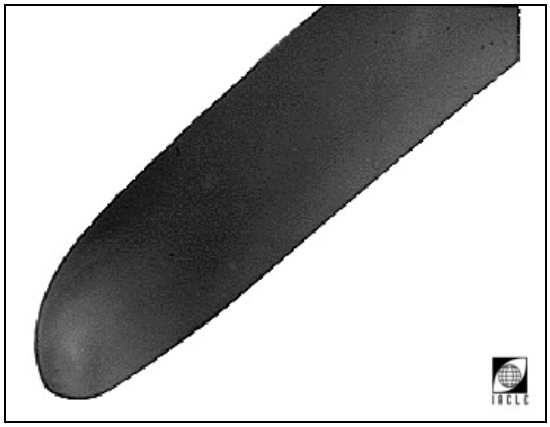


3L4.21434-92

Examples of Edge Configuration

Thick, square edge with apex anteriorly located.

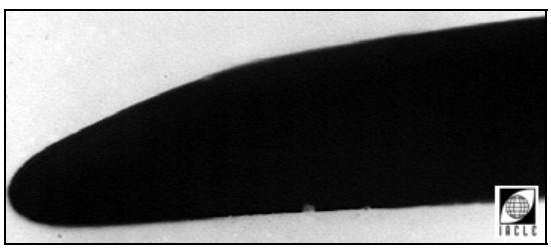
30



3L4.20868-92

Thick, rounded edge with apex posteriorly located.

31



3L4.21435-92

Thinner, rounded edge with apex centrally located.

II.C Effects of Changing Surface Design Parameters

II.C.1 Back Surface Design

32

BACK SURFACE DESIGN

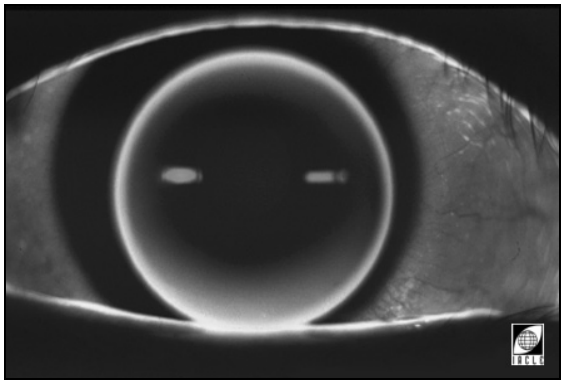
Changes will affect:

- Fluoroscein pattern
- Centration
- Movement
- Tear exchange

96314-27S.PPT

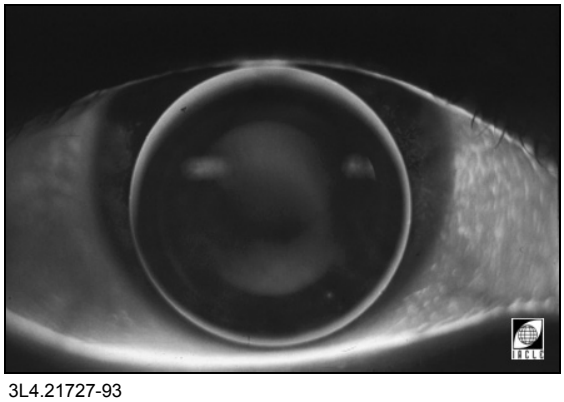
3L4.296314-27

33



3L4.21731-93

34



3L4.21727-93

Back Surface Design

Changes to the back surface design will affect the:

- Fluorescein pattern.

  The use of sodium fluorescein is a very sensitive means of comparing the cornea's shape to that of a trial contact lens (back surface). Changes to the back surface geometry can be observed by the effect the varying regional differences in the post-lens tear film thickness have on fluorescein brightness. The data can be both qualitative and quantitative. Slides 33 and 34 demonstrate the fluorescein patterns of a flat and steep fitting RGP lens on the same cornea.

- Centration.

  An alignment fit is desirable to achieve good lens centration, but this is influenced by the back surface curvature of the RGP lens in relation to the curvature and sphericity of the corneal surface.

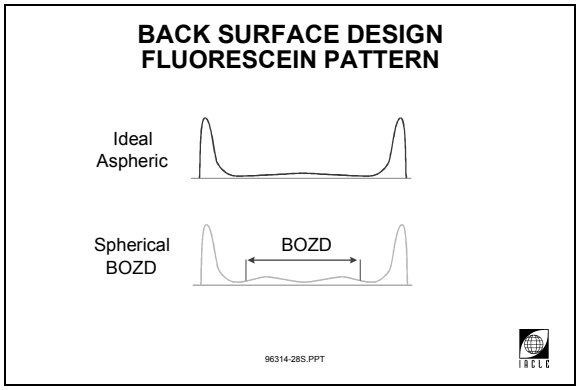
- Movement.

  Movement is a function created by the interaction between the RGP lens and the lid forces against the lens during blink, particularly the upper lid. Because movement facilitates tear exchange, adequate movement is desired.

- Tear exchange.

  The back peripheral surface geometry is crucial to allowing a good tear exchange. A tight back periphery can greatly limit tear exchange.

35

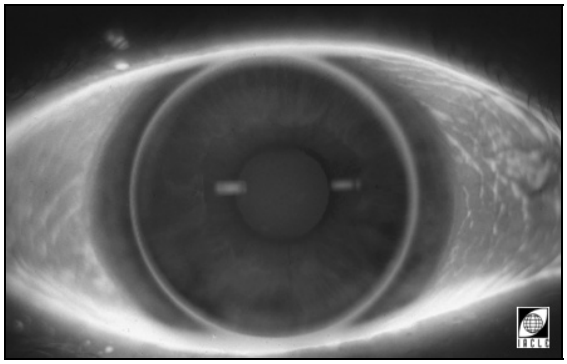


3L4.296314-28

Back Surface Design and Fluorescein Pattern

The fluorescein pattern observed under an RGP lens depends on its back surface shape. This diagram shows the expected patterns from three shapes. The aspheric ideally aligns with the cornea, hence little or no fluorescein is seen anywhere except at the lens edge tear reservoir. The diagram of a spherical lens with a large BOZD shows the effect of a spherical curve not aligning with the aspheric cornea. Increasing the BOZD causes an increase in the sagittal depth and therefore, greater central clearance. This effect is much less pronounced with a small BOZD.

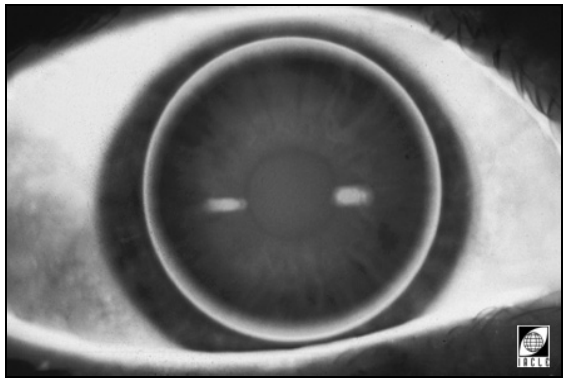
36



3L4.21422-92

Aspheric lens fitted on a patient showing even fluorescein distribution and a narrow bright circular band in the region of the back periphery.

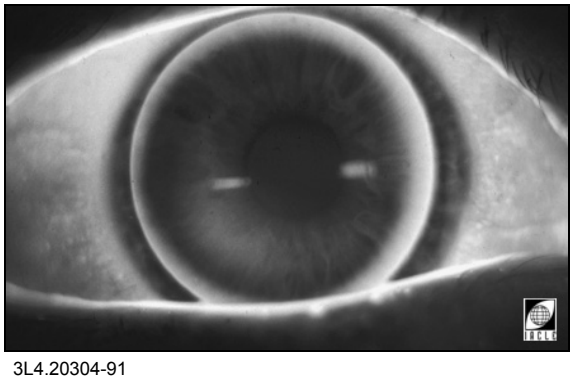
37



3L4.20305-91

RGP lens with a large BOZD fitted on the same patient showing a bright central pool of fluorescein.

38



3L4.20304-91

RGP lens with a small BOZD fitted on the same patient showing a light central touch.

39

BACK SURFACE DESIGN
TEAR LAYER THICKNESS

LENS DESIGN	TLT cent	TLT 1st PC	TLT 2nd PC
7.40 : 7.70/8.20 : 8.40/9.10 : 9.20	**19**	**20**	**80**
7.80 : 7.70/8.60 : 8.40/9.90 : 9.20	**15**	**18**	**80**
8.20 : 7.70/9.00 : 8.40/10.70 : 9.20	**13**	**16**	**80**

96314-29S.PPT

3L4.296314-29

40

BACK SURFACE DESIGN
TEAR LAYER THICKNESS

LENS DESIGN	TLT cent	TLT 1st PC	TLT edge
7.40 : 8.20/8.20 : 9.00/8.80 : 9.80	**25**	**25**	**80**
7.80 : 8.20/8.60 : 9.00/9.50 : 9.80	**21**	**22**	**80**
8.20 : 8.20/9.00 : 9.00/10.30 : 9.80	**17**	**20**	**80**

96314-30S.PPT

3L4.296314-30

41

BACK SURFACE DESIGN
FOR A CONSTANT CENTRAL TLT OF 15

	BOZR		
P	**7.40**	**7.80**	**8.20**
		BOZD	
0.70	6.8	7.1	7.4
0.75	7.1	7.4	7.7
0.80	7.4	7.7	8.0
0.85	7.9	8.2	8.5

96314-31S.PPT

3L4.296314-31

Back Surface Design and Tear Layer Thickness

For an RGP tricurve trial lens (fixed BOZD, first peripheral curve width and total diameter), with a fixed relationship between the BOZR and the first peripheral curve radius, the TLT under the lens will vary depending on the corneal curvature.

In the following examples, the lenses are fitted aligned with the flattest corneal meridian. In slide 39, note the variation in the central TLT when the lens with a fixed BOZD of 7.70 mm is fitted to progressively flatter corneal radii. Even though the lens is fitted 'on-K' the central TLT is dictated to some extent by the size of the BOZD.

In the second lens series (slide 40), the larger BOZD results in a greater vaulting of the corneal surface and an increased central TLT.
This is an exercise to demonstrate that the BOZD can be altered to maintain a fixed 15 μm central TLT without changing the respective BOZR.

For example, a lens with a BOZR of 7.80 mm fitted on a cornea with a radius of curvature of 7.80 mm and a shape factor (P) of 0.75, requires a BOZD of 7.4 mm to achieve the central TLT of 15 μm.

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BOZR/BOZD RELATIONSHIPS

3 lens fitted 0.1 mm steeper than K, p=0.79

BOZR : BOZD	**K (mm)**	
7.00 : 7.00	K = 7.10	TLT=29 μm
7.80 : 7.00	K = 7.90	TLT=21 μm
8.70 : 7.00	K = 8.80	TLT=16 μm

96314-32S.PPT

3L4.296314-32

Relationship Between BOZR and BOZD

In these examples of a series of lenses with a fixed BOZD of 7.00 mm, as the corneal radius of curvature (based on keratometry readings - K) *flattens,* the central TLT *decreases,* even though the fitting relationship with the flattest corneal meridian is maintained.

This highlights the association between the BOZR and the BOZD with regard to the central TLT as disclosed by

43

BOZR/BOZD RELATIONSHIPS THEORETICAL EQUIVALENTS

To maintain central TLT on a cornea of p=0.79, K=7.90 mm

BOZR : BOZD

7.80 : 7.00 TLT = μm

7.85 : 7.70

7.90 : 8.50

96314-33S.PPT

3L4.296314-33

fluorescein.

Note the relationship between the BOZR and the BOZD where the lens is designed to maintain the same central TLT for a constant corneal shape.

For each 0.05 mm increase in BOZR, the BOZD must be increased by 0.7 mm to maintain the same sagittal relationship and the central TLT constant at 22 microns.

44

BOZR/BOZD RELATIONSHIP

Rule of thumb:

For every 0.5 mm increase in BOZD, there must be 0.05 mm increase in BOZR to maintain the same *fluorescein fitting* pattern

96314-34S.PPT

3L4.296314-34

This Rule of Thumb is a useful guide to determining the effect of BOZD changes to the BOZR while trying to maintain the same central TLT.

In a study by Atkinson (1984), an 0.7 mm change in BOZD is required for every change of 0.5 mm BOZR to maintain the same fluorescein fitting pattern.

45

BOZR/BVP RELATIONSHIP

Rule of thumb:

BVP compensation for BOZR changes if the BOZR is increased (flattened) by 0.05 mm, the tear lens power will increase by -0.25 D

96314-35S.PPT

3L4.296314-35

Relationship Between BOZR and BVP

When a change to the BOZR is made BVP compensation is required. This Rule of Thumb provides a good approximation for determining the actual BVP for RGP lenses.

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BOZR/CORNEAL ASTIGMATISM RELATIONSHIP

Corneal Astigmatism > 1.50 D

Decrease BOZR 0.05 mm for each 0.50 D increase in corneal astigmatism

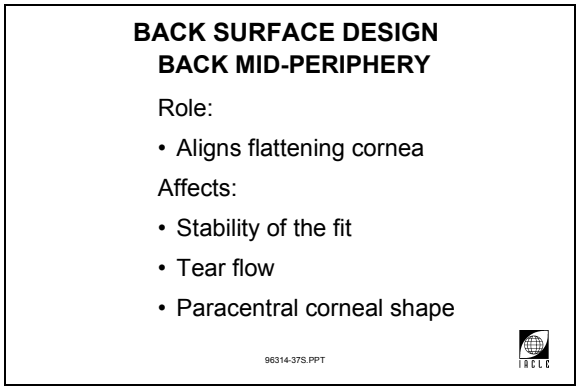
96314-36S.PPT

3L4.296314-36

Relationship Between BOZR and Corneal Astigmatism

In cases of corneal astigmatism (>1.50 D) in which a spherical lens is fitted, the BOZR should be decreased by 0.05 mm for each 0.50 D that the corneal astigmatism exceeds 1.50 D.

47



3L4.296314-37

Back Surface Design

Back Mid-Periphery:

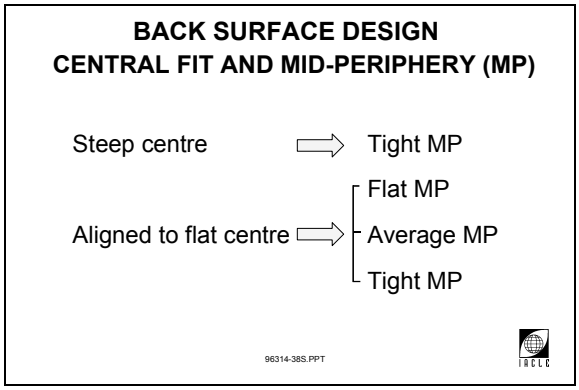
Role:

- Aligns flattening cornea. Since the cornea flattens paracentrally, the lens periphery must have curves which are flatter than the BOZR, preferably on a progressive basis. This can be achieved by a series of progressively flattening blended spherical curves or by a continuous aspheric curve such as an ellipsoid.

Affects:

- Stability of fit. Failure to align the lens with the cornea, especially in the mid-periphery, may lead to an unsatisfactory fit.
- Tear flow. The physical relationship between lens and cornea affects the post-lens tear film thickness and volume. Tear flow and tear exchange is controlled by this relationship.
- Paracentral corneal shape. As with the central region, corneal shape can be affected by the lens fitting relationship, e.g. localised bearing may cause arcuate indentation.

48



3L4.296314-38

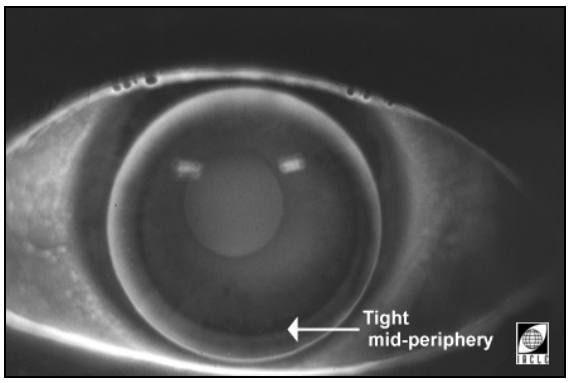
Back Surface Design

Central Fit and Mid-Periphery:

A steep central fit is likely to produce a tight mid-peripheral fit (slide 49) unless the secondary zone is wide and well blended and the optic zone is small.

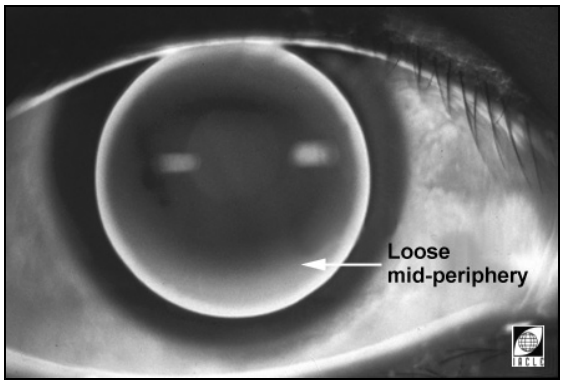
An aligned or flat central fit will usually result in an aligned or flat mid-peripheral fit (slide 50).

49



3L4.21752-93

50



3L4.201730-93

51

BACK SURFACE DESIGN
MID-PERIPHERAL FIT

Flat	- Unstable fit
	- Poor Centration
Steep	- Stable fitting
	- Corneal shape changes
	- Reduced tear flow
	- Trapped tear debris

96314-39S.PPT

3L4.296314-39

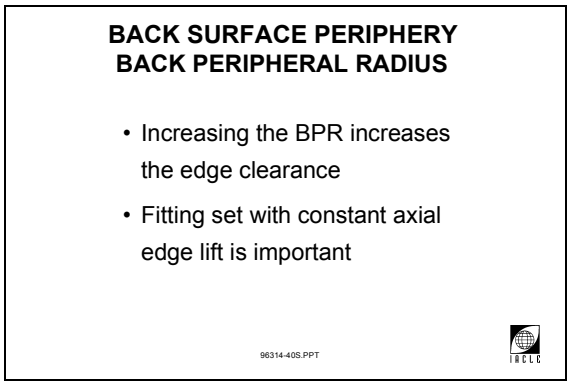
Back Surface Design

Consequences of Mid-Peripheral Fit Changes:

- Flat:
  - Unstable fit. The lens rocks on the corneal apex or the apex and the flat meridian because of excessive edge lift.
  - Poor centration. When the lens is not in apposition with the cornea the interaction with the lids is increased. The fit is unstable and the lens mobility increased.
- Steep:
  - Stable fitting. With lens edges close to the cornea, lid interaction is minimized. If a seal is formed around the paracentral area of the lens, significant negative pressure can be generated in the post-lens tear film which will reduce the lability of the tears under the lens, thereby damping lens movement.

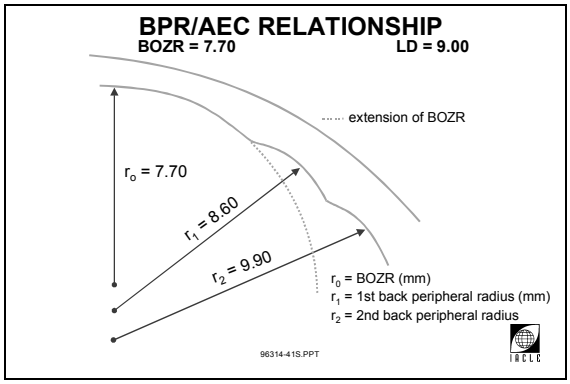
- Peripheral shape changes. With increased localised bearing pressure in the mid-periphery, epithelial compression is a possibility.
- Reduced tear flow.
- Trapped tear debris. With reduced tear lability the dispersal of cellular and tear debris from under the lens is reduced or even prevented. This may limit the wearing time and cause discomfort.

52



3L4.296314-40

53



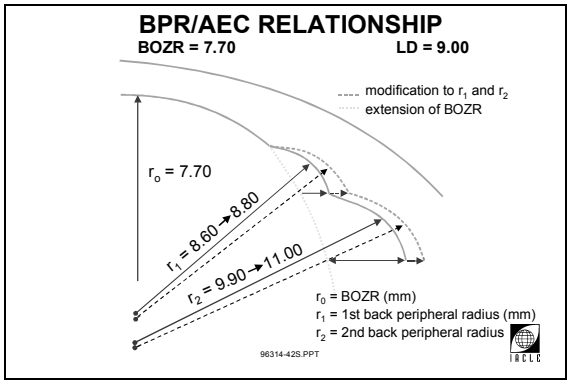
3L4.296314-41

Back Surface Periphery

Back Peripheral Radius and Axial Edge Clearance:

The edge clearance of the lens is dependent on the radii and widths of the intermediate and peripheral curves. In these examples, the lens shown in slide 53 is used as a template whose BOZR radius is 7.70 mm and a LD of 9.00 mm. The following slides will show changes to the AEC as effected by changes to the back peripheral radius and width.

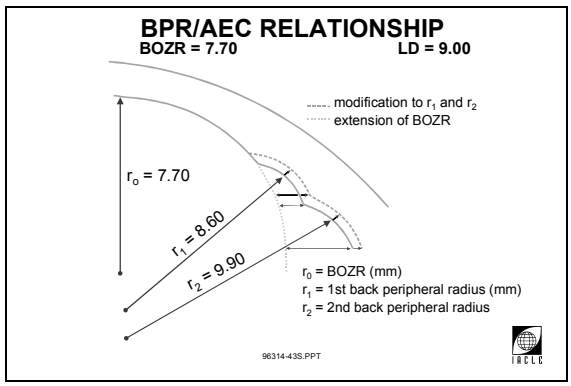
54



3L4.296314-42

This slide shows that increasing the radius of the back peripheral curves increases the AEC.

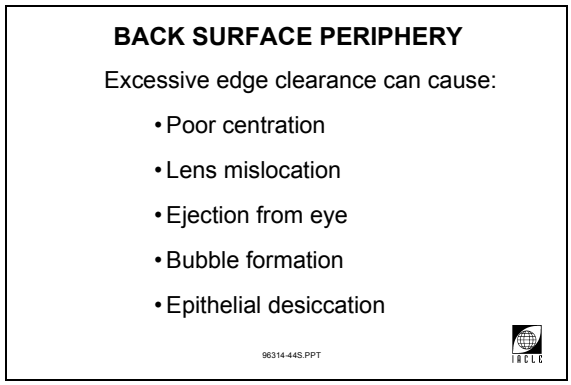
55



3L4.296314-43

This slide shows that increasing the width of the back peripheral curves increases the AEC.

56



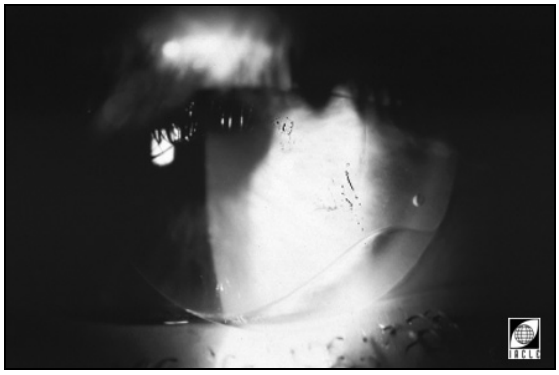
3L4.296314-44

Back Surface Periphery

Excessive edge clearance can cause:

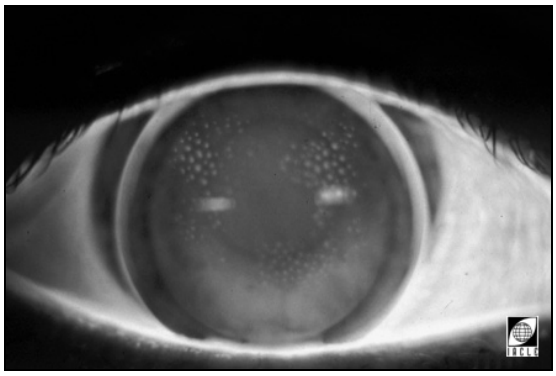
- Poor centration. The lens is likely to decentre more (usually superior) when the edge clearance is excessive. This is because of the alterations in the surface tension forces which help to maintain lens centration.
- Lens mislocation. As the lens can move very easily over the cornea, the risk of mislocation (onto the conjunctiva) is increased because of increased lens-lid interaction (slide 57).
- Ejection from eye. Excessive clearance will increase the likelihood that the upper lid will eject the lens from the eye during a blink.
- Bubble formation. With each blink, tear exchange may result in bubble formation. Most bubbles will resolve spontaneously. Some may also be trapped under the centre of the lens. This can lead to dimple veiling (slide 58).
- Epithelial desiccation. Excessive edge clearance may result in a thinning of the corneal tear film adjacent to the lens edge. Persistent thinning may ultimately cause disruption of the epithelial surface.

57



3L4.21767-93

58



3L4.21763-93

59

BACK SURFACE PERIPHERY

Inadequate edge clearance can cause:

- Minimal tear exchange
- Corneal indentation
- Reduced movement
- Difficult removal
- Epithelial dessiccation

96314-45S.PPT

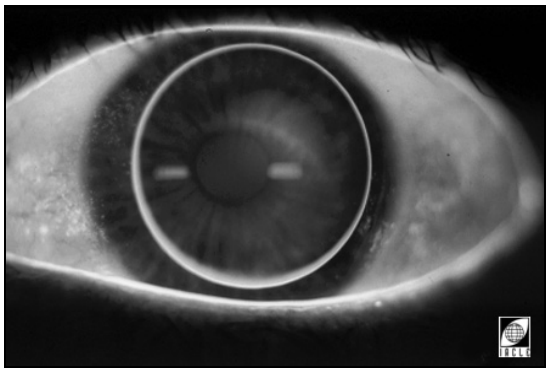
3L4.296314-45

Back Surface Periphery

Inadequate edge clearance can cause:

- Minimal tear exchange. A tight edge will restrict the flow of tears under the lens and minimize the removal of metabolic and cellular debris from under the lens.
- Corneal indentation. Indentation of the cornea may be noted after lens removal. The edge of the lens will cause an indentation due to bearing pressure which is increased by blinking.
- Reduced movement. Minimal movement may be exhibited because the tight edge results in a thinned viscous tear film which does not allow the lens to glide freely across the eye.
- Difficult removal. Most lens removal methods involve the engagement of the lid margins and the lens edge. If edge lift is minimal, such engagement is difficult (slide 60).
- Epithelial desiccation. A lens with a tight edge that shows minimal movement may cause epithelial disruption due to tear film disruption adjacent to the lens edge (slide 60).

60



3L4.21760-93

61

BACK SURFACE PERIPHERY
AXIAL EDGE CLEARANCE - TLT

K 7.80 mm @ 180
7.60 mm @ 90

p = 0.75

range of lens designs
calculated AEC or TLT

96314-46S.PPT

3L4.296314-46

Back Surface Periphery

Axial Edge Clearance (AEC) - Tear Lens Thickness (TLT)

A cornea of 'average' dimensions (p = 0.75) is fitted with lenses where the peripheral curve is varied.

62

BACK SURFACE PERIPHERY
AXIAL EDGE CLEARANCE - TLT
VARIATION IN PCR

LENS DESIGN	AEC (μm)
7.70 : 8.00/8.50 : 9.00/10.00 : 9.60	**72**
7.70 : 8.00/8.50 : 9.00/11.00 : 9.60	**89**
7.70 : 8.00/8.50 : 9.00/12.00 : 9.60	**103**

96314-47S.PPT

3L4.296314-47

63

BACK SURFACE PERIPHERY
AXIAL EDGE CLEARANCE - TLT
VARIATION IN PCW

LENS DESIGN	AEC (μm)
7.70 : 8.00/8.50 : 9.00/11.00 : 9.60	**8**
7.70 : 8.00/8.50 : 9.00/11.00 : 10.00	**13**
7.70 : 8.00/8.50 : 9.00/11.00 : 10.40	**19**

96314-48S.PPT

3L4.29314-48

64

BACK SURFACE PERIPHERY
AXIAL EDGE CLEARANCE

To maintain the same AEC:

- Decrease PCR as the lens total diameter increases (for a given PCW)
- Decrease PCR as the PCW increases
- Increase PCR as the corneal shape flattens i.e. e increases, p decreases

96314-49S.PPT

3L4.296314-49

65

BACK SURFACE PERIPHERY
AXIAL EDGE CLEARANCE

Increase with:

- Increase in PCR
- Increase in PCW
- Increase in AEL

96314-50S.PPT

3L4.296314-50

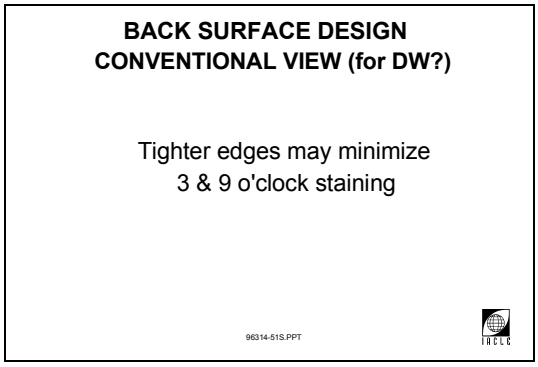
In this first example, the peripheral curve radius is made progressively flatter by 1.0 mm increments. This shows that the AEC increases as the radius flattens.

In most cases, when changing the peripheral curve radius, a much larger alteration is required for a significant effect on clinical performance. This can be compared with the much smaller changes required for the BOZR where an alteration of
0.05 mm is sufficient to produce a significant clinical effect.
The second example shows the effect of varying the peripheral curve width on the AEC. The peripheral radius remains constant and the width is increased by 0.2 mm steps. A very significant effect on the axial edge clearance is achieved by a relatively small variation in the width of the curve.

These results indicate that a change in the peripheral curve width will have a greater effect on the axial edge clearance than will a small change in the peripheral curve radius.

When fitting RGP lenses, it is important to keep in mind the relationship between the peripheral curve radius and the peripheral curve width with regard to the axial edge clearance. A change in either value will always have some effect on the lens relationship with the cornea. It is therefore possible to alter both values to have an additive effect.

66



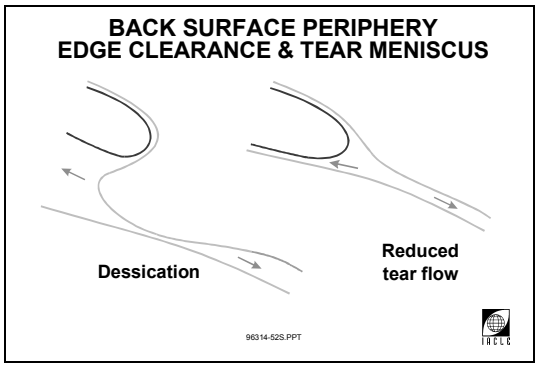
3L4.296314-51

Back Surface Periphery: Conventional View (for DW?)

Tighter edges may minimize 3 and 9 o'clock staining. This view is normally presented on the basis that the less stand-off the lens edge exhibits, the less bridging of the corneal epithelium there will be by the lid margin when resting on the lens and the peripheral region of the cornea at the 3 and 9 o'clock positions.

Sometimes the staining can be more accurately referred to as 4 and 8 o'clock staining. Such staining is usually an open-eye (daily wear) phenomenon.

67



3L4.296220-52

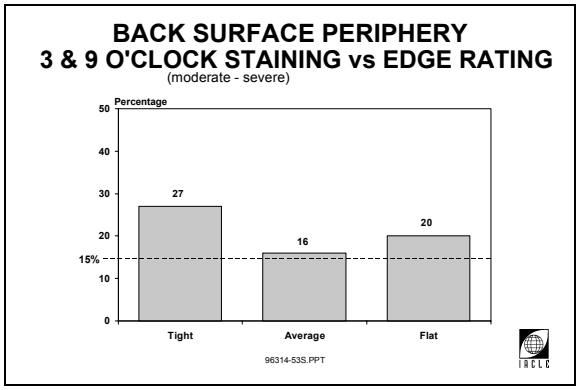
Back Surface Periphery

Edge Clearance and Tear Meniscus

It is widely believed that tear film thinning just outside the lens edge is at least partially responsible for 3 and 9 o'clock staining. A diagrammatic explanation of this theory is presented in slide 67.

It is postulated that film thinning may be due to poorer wetting of RGP materials. However, clinical data suggests that it is possible to have a very close relationship between lens edge and cornea to the extent that the mucin layer of the tears (under lens edge and outside lens) may be disrupted and the tears may no longer wet the epithelium well or may even form dry spots. Epithelial desiccation will ensue.

68



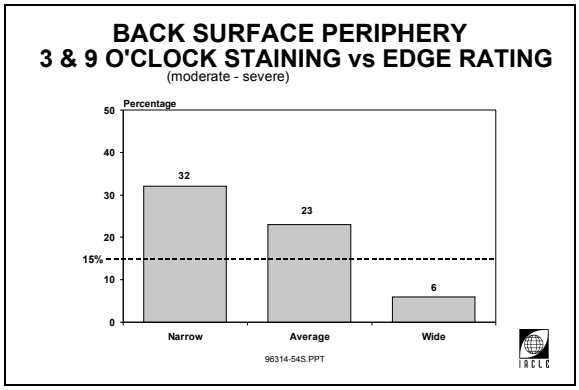
3L4.296314-53

Back Surface Periphery

3 and 9 o'clock Staining *versus* Edge Rating:

In RGP extended wear, when the incidence of moderate to severe 3 and 9 o'clock staining is plotted against edge clearance ratings, paradoxically, the tighter 'fitting' edge is implicated in a higher incidence of staining. Average and flat edge clearances have similar incidences. This would seem to confirm the view that it is possible to have too little edge clearance.

69



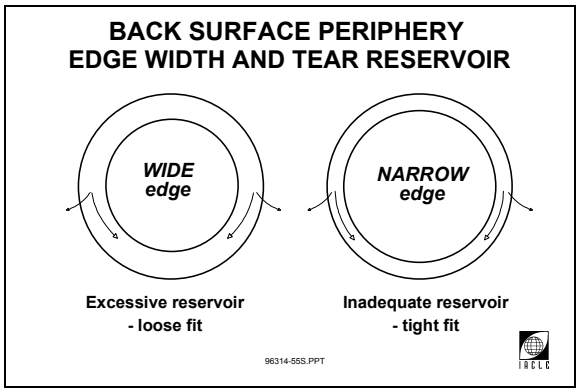
3L4.96314-54

Back Surface Periphery

3 and 9 o'clock Staining (moderate-severe) *versus* Edge Width:

When the incidence of 3 and 9 o'clock staining is plotted against edge width it shows a lower incidence of staining with wider edge widths than with narrower edge finishes. This may be related to the thickness and/or volume of the tear film's edge reservoir.

70



3L4.296314-55

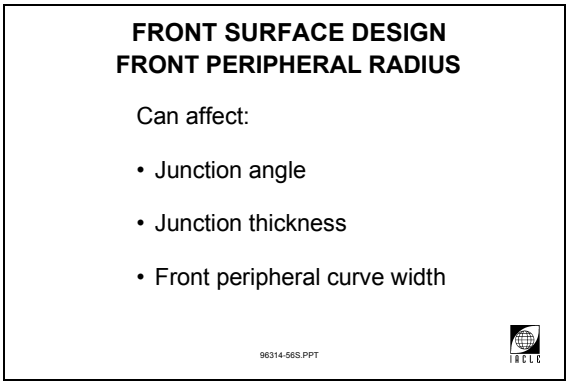
Back Surface Periphery

Edge Width and Tear Reservoir:

This diagram shows the competing issues involved in selecting edge widths. While a wide edge will increase the volume of tears stored in the edge reservoir, the stability of lens fit may be adversely affected. A balance between these forces is required.

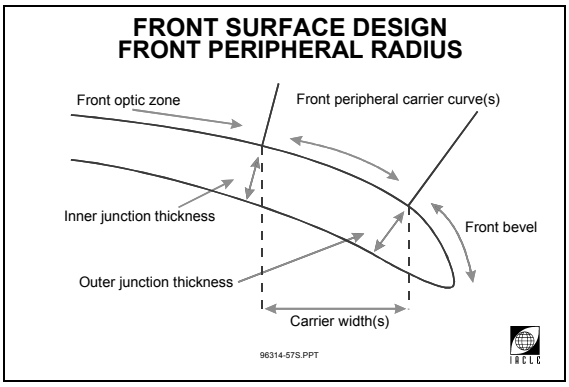
II.C.2 Front Surface Design

71



3L4.296314-56

72



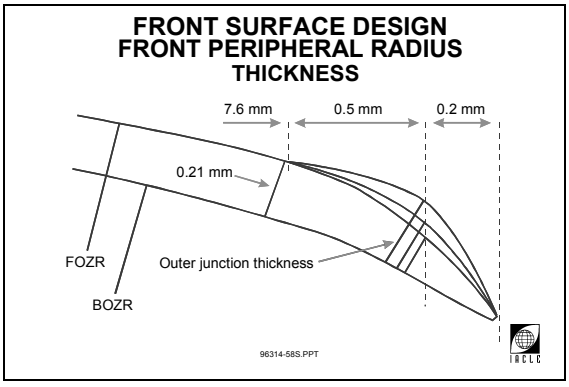
3L4.296314-57

Front Surface Design

Front Peripheral Radius (FPR):

The lens peripheral profile is defined by the front peripheral radius (FPR), the back peripheral radius (BPR) and their angular separation. The relationship between the front peripheral carrier, junction thicknesses and front bevel is diagrammatically represented in slide 72. Changing the parameter values or profile of any of these aspects is reflected as changes affecting the front surface design. These are demonstrated in the following slides.

73



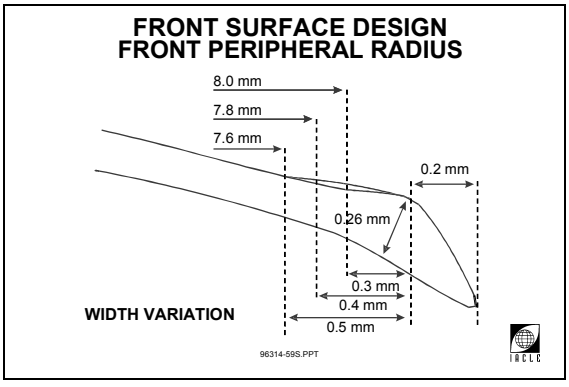
3L4.296314-58

Front Surface Design

Front Peripheral Radius (FPR): Thickness Variation

This diagram shows the peripheral thickness variations resulting from progressive steepening of the FPR without alterations to the FOZD. Note the 'minus carrier' formation corresponding to the increasing junction thicknesses beyond the optic zone.

74



3L4.296314-59

Front Surface Design

Front Peripheral Radius (FPR): Width Variation

Increasing the FOZD results in a narrowing of the front peripheral width (FPW). In the case of a thick lens edge, this will tend to create a minus carrier, possibly causing the lens to ride high with the upper lid (lid attachment).

The primary intention of increasing the junction thickness of the lens is to enable

75

FRONT SURFACE DESIGN
INCREASING JUNCTION THICKNESS

The effects:

- Decreases comfort
- Increases upper lid interaction
- Superior/central lens decentration

96314-60S.PPT

3L4.296314-60

76

FRONT SURFACE DESIGN
DECREASING JUNCTION THICKNESS

The effects:

- Improves comfort
- Minimises upper lid interaction
- Central/lower lens position

96314-61S.PPT

3L4.296314-61

the lens to position in a central or slightly higher corneal location. As the upper is more likely to have greater interaction because of the increased edge thickness this could become a lid-attachment fitting, therefore position more superiorly. The increase in thickness is also likely to adversely affect comfort.

Minimising the junction thickness and therefore thinning the edge profile will invariably improve the comfort. The reduced thickness will also minimize the top lid interaction and therefore the lens is more likely to position slightly lower than previously. This is the primary intention of decreasing the junction thickness.

77

FRONT SURFACE DESIGN
EDGE THICKNESS

Calculation of the unfinished edge thickness will dictate the type of anterior peripheral lenticulation that is required

96314-62S.PPT

3L4.296314-62

78

FRONT SURFACE DESIGN
EDGE THICKNESS

For the following lens design the unfinished edge thickness will vary depending on the BVP:

7.76 : 8.20/9.90 : 9.60

t_c 0.14 mm

96314-63S.PPT

3L4.296314-63

Front Surface Design

Edge Thickness:

The edge thickness of an RGP lens is a key design feature affecting level of comfort experienced by the patient. The edge thickness (measured as the radial edge thickness, t_{ER}) is dependent on the lens BVP, lens design, material properties, manufacturing process, etc. The manufacturer will attempt to determine the type of lenticulation and edge design that is most appropriate.

For a given RGP lens design, as the minus BVP increases, the unfinished edge thickness also increases. Based on an edge thickness calculation, the lenticulation process should be chosen that provides the most effective reduction in the finished edge thickness.

An edge thickness of about 0.12 mm is considered to be optimal for comfort and lens durability. A thinner lens edge will be prone to breakage, whereas a thicker

79

FRONT SURFACE DESIGN
EDGE THICKNESS

BVP (D)	t_{ER} (mm)
- 2.00	0.12
- 5.00	0.20
-10.00	0.30

96314-64S.PPT

3L4.296314-64

edge may reduce comfort.

For the –2.00D lens the calculated edge thickness of 0.12 mm is optimal. Such an edge requires no lenticulation, only adequate rounding of the edge profile to promote comfort.

The lenticulation process involves either a straight line taper using a conical modification tool, or a lathe-cut peripheral curve. A taper may generally be used up to an edge thickness of 0.20 mm. For thicker edges, the use of a lathed edge curve will be more suitable.

Practical 3.4

(6 Hours)

Spherical RGP Contact Lens Fitting and Assessment

Purpose of Practical

The purpose of this exercise is to learn how to assess the fit of a rigid lens and how the fit may change if lens parameters are altered.

Video Presentation: Examples of rigid lens fits (IACLE video #101).

Instructions:

The students are to work in pairs, and as most students are not rigid lens wearers the assessment of rigid lens performance should be done on anaesthetized and unanaesthetized eyes. This will allow students to observe the influence of lacrimation and lid-activity on lens performance.

When the video program has ended the students are to examine their partners by following the procedure outlined below and document their findings on the record form provided:

1. RGP contact lens fitting assessment with the Burton lamp and the slit-lamp on:
    - Centration.
    - Movement.
    - Corneal coverage.
    - Fluorescein pattern (central, mid-periphery and edge).
    - Comfort (not necessarily related to fit).

Assess the fit of the lens combinations below . Document the findings on the record form provided and answer the question at the end of the exercise:

1. Steep, alignment and flat BOZR (0.2 mm steeper and 0.2 mm fatter than flat K or the alignment lens)
2. Large and small diameter (8.7 mm and 9.6 mm)
3. Small BOZD (excess edge lift) and large BOZD (minimum edge lift).
4. PMMA and high Dk (rigid and flexible material)
5. Design (aspheric and spherical)

RECORD FORM

Name:_____ **Date:**_____

Partner:_____

ASSESSMENT VARIABLES	**BOZR**	
	ALIGNMENT	**ALIGNMENT**
Eye	☐Right	☐Left
Keratometry Reading	_____ D _____ D@____ Low K radius _____ mm	_____ D _____ D@____ Low K radius _____ mm
Spectacle Rx	_____ DS _____ DCx____	_____ DS _____ DCx____
HVID	_____ mm	_____ mm
Baseline Eye Check _____Supervisor	☐clear ☐slightly red ☐irritated ☐staining	☐clear ☐slightly red ☐irritated ☐staining
Trial Lens:_____ Material: ___	BOZR _____ mm Power _____ D Thickness _____ mm Lens diameter _____ mm Design	BOZR _____ mm Power _____ D Thickness _____ mm Lens diameter Design
Lens Fit Assessment		
Centration	horizontal (N/T) _____ mm vertical (S/I) _____ mm	horizontal (N/T) vertical (S/I) _____ mm
Movement with Blink	_____ mm	_____ mm
Movement Type	☐smooth☐jerky ☐apical rotation	☐smooth☐jerky ☐apical rotation
Speed of Movement	☐fast ☐average ☐slow	☐fast ☐average ☐slow
Stability	☐yes ☐no	☐yes ☐no

	If no, please explain _____ _____ _____	If no, please explain _____ _____ _____
Central Fluorescein Pattern	☐pooling ☐alignment ☐touch	☐pooling ☐alignment ☐touch
Mid-peripheral Fluorescein Pattern	☐pooling ☐wide touch (alignment) ☐narrow touch	☐pooling ☐wide touch (alignment) ☐narrow touch
Edge Width Horizontal (nasal/temporal) Vertical (top/bottom)	_____ / _____ mm _____ / _____ mm	_____ / _____ mm _____ / _____ mm
Edge Clearance	☐low ☐average ☐high	☐low ☐average ☐high
Fit Classification	☐flat ☐steep ☐optimal ☐accept ☐reject	☐flat ☐steep ☐optimal ☐accept ☐reject
Over refraction	_____ DS VA _____ _____ DS _____ DCx _____ VA ___	_____ DS VA _____ _____ DS _____ DCx ____ VA ___
If rejected, what can be improved?		
Patient Comfort Rating	0 1 2 3 4 5	0 1 2 3 4 5

Question. Is there any difference in lens fit between the right and left eyes? State the reasons for your answer.

RECORD FORM

Name:_____ **Date:**_____

Partner:_____

ASSESSMENT VARIABLES	**BOZR**	
	STEEP	**FLAT**
Eye	☐Right	☐Left
Keratometry Reading	_____ D _____ D@____ Low K radius _____ mm	_____ D _____ D@_____ Low K radius _____ mm
Spectacle Rx	_____ DS _____ DCx____	_____ DS _____ DCx_____
HVID	_____ mm	_____ mm
Baseline Eye Check _____Supervisor	☐clear ☐slightly red ☐irritated ☐staining	☐clear ☐slightly red ☐irritated ☐staining
Trial Lens: Material:	BOZR _____ Power _____ Thickness _____ Lens diameter _____ mm Design	BOZR _____ mm Power _____ D Thickness _____ mm Lens diameter Design
Lens Fit Assessment		
Centration	horizontal (N/T) _____ mm vertical (S/I) _____ mm	horizontal (N/T) vertical (S/I) _____ mm
Movement with Blink	_____ mm	_____ mm
Movement Type	☐smooth☐jerky ☐apical rotation	☐smooth☐jerky ☐apical rotation
Speed of Movement	☐fast ☐average ☐slow	☐fast ☐average ☐slow

Stability	☐yes ☐no If no, please explain _____ _____ _____	☐yes ☐no If no, please explain _____ _____ _____
Central Fluorescein Pattern	☐pooling ☐alignment ☐touch	☐pooling ☐alignment ☐touch
Mid-peripheral Fluorescein Pattern	☐pooling ☐wide touch (alignment) ☐narrow touch	☐pooling ☐wide touch (alignment) ☐narrow touch
Edge Width Horizontal (nasal/temporal) Vertical (top/bottom)	_____ / _____ mm _____ / _____ mm	_____ / _____ mm _____ / _____ mm
Edge Clearance	☐low ☐average ☐high	☐low ☐average ☐high
Fit Classification	☐flat ☐steep ☐optimal ☐accept ☐reject	☐flat ☐steep ☐optimal ☐accept ☐reject
Over refraction	_____ DS VA _____ _____ DS _____ DCx _____ VA ___	_____ DS VA _____ _____ DS _____ DCx _____ VA ___
If rejected, what can be improved?		
Patient Comfort Rating	0 1 2 3 4 5	0 1 2 3 4 5

Question. Is there any difference in lens fit between the right and left eyes? State the reasons for your answer.

RECORD FORM

Name:_____ **Date:**_____

Partner:_____

ASSESSMENT VARIABLES	LENS DIAMETER	
	SMALL	**LARGE**
Eye	☐Right	☐Left
Keratometry Reading	_____ D _____ D@____ Low K radius _____ mm	_____ D _____ D@_____ Low K radius _____ mm
Spectacle Rx	_____ DS _____ DCx____	_____ DS _____ DCx_____
HVID	_____ mm	_____ mm
Baseline Eye Check _____Supervisor	☐clear ☐slightly red ☐irritated ☐staining	☐clear ☐slightly red ☐irritated ☐staining
Trial Lens:_____ Material: ___	BOZR _____ mm Power _____ D Thickness _____ mm Lens diameter _____ mm Design	BOZR _____ mm Power _____ D Thickness _____ mm Lens diameter Design
Lens Fit Assessment		
Centration	horizontal (N/T) _____ mm vertical (S/I) _____ mm	horizontal (N/T) vertical (S/I) _____ mm
Movement with Blink	_____ mm	_____ mm
Movement Type	☐smooth☐jerky ☐apical rotation	☐smooth☐jerky ☐apical rotation
Speed of Movement	☐fast ☐average ☐slow	☐fast ☐average ☐slow
Stability	☐yes ☐no	☐yes ☐no

	If no, please explain _____ _____ _____	If no, please explain _____ _____ _____
Central Fluorescein Pattern	☐pooling ☐alignment ☐touch	☐pooling ☐alignment ☐touch
Mid-peripheral Fluorescein Pattern	☐pooling ☐wide touch (alignment) ☐narrow touch	☐pooling ☐wide touch (alignment) ☐narrow touch
Edge Width Horizontal (nasal/temporal) Vertical (top/bottom)	_____ / _____ mm _____ / _____ mm	_____ / _____ mm _____ / _____ mm
Edge Clearance	☐low ☐average ☐high	☐low ☐average ☐high
Fit Classification	☐flat ☐steep ☐optimal ☐accept ☐reject	☐flat ☐steep ☐optimal ☐accept ☐reject
Over refraction	_____ DS VA _____ _____ DS _____ DCx _____ VA ___	_____ DS VA _____ _____ DS _____ DCx ____ VA ___
If rejected, what can be improved?		
Patient Comfort Rating	0 1 2 3 4 5	0 1 2 3 4 5

Question. Is there any difference in lens fit between the right and left eyes? State the reasons for your answer.

RECORD FORM

Name:_____ **Date:**_____

Partner:_____

ASSESSMENT VARIABLES	LENS EDGE LIFT	
	LARGE BOZD	**SMALL BOZD**
Eye	☐Right	☐Left
Keratometry Reading	_____ D _____ D@____ Low K radius _____ mm	_____ D _____ D@_____ Low K radius _____ mm
Spectacle Rx	_____ DS _____ DCx____	_____ DS _____ DCx_____
HVID	_____ mm	_____ mm
Baseline Eye Check _____Supervisor	☐clear ☐slightly red ☐irritated ☐staining	☐clear ☐slightly red ☐irritated ☐staining
Trial Lens:_____ Material: ___	BOZR _____ mm Power _____ D Thickness _____ mm Lens diameter _____ mm Design	BOZR _____ mm Power _____ D Thickness _____ mm Lens diameter Design
Lens Fit Assessment		
Centration	horizontal (N/T) _____ mm vertical (S/I) _____ mm	horizontal (N/T) vertical (S/I) _____ mm
Movement with Blink	_____ mm	_____ mm
Movement Type	☐smooth☐jerky ☐apical rotation	☐smooth☐jerky ☐apical rotation
Speed of Movement	☐fast ☐average ☐slow	☐fast ☐average ☐slow
Stability	☐yes ☐no	☐yes ☐no

	If no, please explain _____ _____ _____	If no, please explain _____ _____ _____
Central Fluorescein Pattern	☐pooling ☐alignment ☐touch	☐pooling ☐alignment ☐touch
Mid-peripheral Fluorescein Pattern	☐pooling ☐wide touch (alignment) ☐narrow touch	☐pooling ☐wide touch (alignment) ☐narrow touch
Edge Width Horizontal (nasal/temporal) Vertical (top/bottom)	_____ / _____ mm _____ / _____ mm	_____ / _____ mm _____ / _____ mm
Edge Clearance	☐low ☐average ☐high	☐low ☐average ☐high
Fit Classification	☐flat ☐steep ☐optimal ☐accept ☐reject	☐flat ☐steep ☐optimal ☐accept ☐reject
Over refraction	_____ DS VA _____ _____ DS _____ DCx _____ VA ___	_____ DS VA _____ _____ DS _____ DCx ____ VA ___
If rejected, what can be improved?		
Patient Comfort Rating	0 1 2 3 4 5	0 1 2 3 4 5

Question. Is there any difference in lens fit between the right and left eyes? State the reasons for your answer.

RECORD FORM

Name:_____ **Date:**_____

Partner:_____

ASSESSMENT VARIABLES	LENS MATERIAL	
	PMMA	**HIGH DK**
Eye	☐Right	☐Left
Keratometry Reading	_____ D _____ D@____ Low K radius _____ mm	_____ D _____ D@_____ Low K radius _____ mm
Spectacle Rx	_____ DS _____ DCx____	_____ DS _____ DCx_____
HVID	_____ mm	_____ mm
Baseline Eye Check _____Supervisor	☐clear ☐slightly red ☐irritated ☐staining	☐clear ☐slightly red ☐irritated ☐staining
Trial Lens:_____ Material: ___	BOZR _____ mm Power _____ D Thickness _____ mm Lens diameter _____ mm Design	BOZR _____ mm Power _____ D Thickness _____ mm Lens diameter Design
Lens Fit Assessment		
Centration	horizontal (N/T) _____ mm vertical (S/I) _____ mm	horizontal (N/T) vertical (S/I) _____ mm
Movement with Blink	_____ mm	_____ mm
Movement Type	☐smooth☐jerky ☐apical rotation	☐smooth☐jerky ☐apical rotation
Speed of Movement	☐fast ☐average ☐slow	☐fast ☐average ☐slow
Stability	☐yes ☐no	☐yes ☐no

	If no, please explain _____ _____ _____	If no, please explain _____ _____ _____
Central Fluorescein Pattern	☐pooling ☐alignment ☐touch	☐pooling ☐alignment ☐touch
Mid-peripheral Fluorescein Pattern	☐pooling ☐wide touch (alignment) ☐narrow touch	☐pooling ☐wide touch (alignment) ☐narrow touch
Edge Width Horizontal (nasal/temporal) Vertical (top/bottom)	_____ / _____ mm _____ / _____ mm	_____ / _____ mm _____ / _____ mm
Edge Clearance	☐low ☐average ☐high	☐low ☐average ☐high
Fit Classification	☐flat ☐steep ☐optimal ☐accept ☐reject	☐flat ☐steep ☐optimal ☐accept ☐reject
Over refraction	_____ DS VA _____ _____ DS _____ DCx _____ VA ___	_____ DS VA _____ _____ DS _____ DCx ____ VA ___
If rejected, what can be improved?		
Patient Comfort Rating	0 1 2 3 4 5	0 1 2 3 4 5

Question. Is there any difference in lens fit between the right and left eyes? State the reasons for your answer.

RECORD FORM

Name:_____ **Date:**_____

Partner:_____

ASSESSMENT VARIABLES	DESIGN	
	ASPHERIC	**TRICURVE**
Eye	☐Right	☐Left
Keratometry Reading	_____ D _____ D@____ Low K radius _____ mm	_____ D _____ D@_____ Low K radius _____ mm
Spectacle Rx	_____ DS _____ DCx____	_____ DS _____ DCx_____
HVID	_____ mm	_____ mm
Baseline Eye Check _____Supervisor	☐clear ☐slightly red ☐irritated ☐staining	☐clear ☐slightly red ☐irritated ☐staining
Trial Lens:_____ Material: ___	BOZR _____ mm Power _____ D Thickness _____ mm Lens diameter _____ mm Design	BOZR _____ mm Power _____ D Thickness _____ mm Lens diameter Design
Lens Fit Assessment		
Centration	horizontal (N/T) _____ mm vertical (S/I) _____ mm	horizontal (N/T) vertical (S/I) _____ mm
Movement with Blink	_____ mm	_____ mm
Movement Type	☐smooth☐jerky ☐apical rotation	☐smooth☐jerky ☐apical rotation
Speed of Movement	☐fast ☐average ☐slow	☐fast ☐average ☐slow
Stability	☐yes ☐no	☐yes ☐no

	If no, please explain _____ _____ _____	If no, please explain _____ _____ _____
Central Fluorescein Pattern	☐pooling ☐alignment ☐touch	☐pooling ☐alignment ☐touch
Mid-peripheral Fluorescein Pattern	☐pooling ☐wide touch (alignment) ☐narrow touch	☐pooling ☐wide touch (alignment) ☐narrow touch
Edge Width Horizontal (nasal/temporal) Vertical (top/bottom)	_____ / _____ mm _____ / _____ mm	_____ / _____ mm _____ / _____ mm
Edge Clearance	☐low ☐average ☐high	☐low ☐average ☐high
Fit Classification	☐flat ☐steep ☐optimal ☐accept ☐reject	☐flat ☐steep ☐optimal ☐accept ☐reject
Over refraction	_____ DS VA _____ _____ DS _____ DCx _____ VA ___	_____ DS VA _____ _____ DS _____ DCx ____ VA ___
If rejected, what can be improved?		
Patient Comfort Rating	0 1 2 3 4 5	0 1 2 3 4 5

Question. Is there any difference in lens fit between the right and left eyes? State the reasons for your answer.

Tutorial 3.4

(1 Hour)

Fitting Assessment of RGP Contact Lenses

Observe the RGP lens fittings on the video (IACLE#101) and complete the forms for each of the cases.

Case 1

Lens Fit Assessment	
Decentration	horizontal (N/T) _____ mm vertical (S/I) _____ mm
Movement with Blink	_____ mm
Movement Type	☐smooth rotation ☐jerky ☐apical
Speed of Movement	☐fast ☐average ☐slow
Stability	☐yes ☐no If no, please explain_____ _____
Central Fluorescein Pattern	☐pooling ☐alignment ☐apical touch
Mid-peripheral Fluorescein Pattern	☐pooling ☐wide touch (alignment) ☐narrow touch
Edge Width Horizontal Vertical	 Nasal _____mm Temporal ___ mm Superior _____mm Inferior ___ mm
Edge Clearance	☐low ☐average ☐high
Fit Classification	☐flat ☐steep ☐optimal ☐accept ☐reject
If rejected, what can be improved?	

Case 2

Lens Fit Assessment	
Decentration	horizontal (N/T) _____ mm vertical (S/I) _____ mm
Movement with Blink	_____ mm
Movement Type	☐smooth rotation ☐jerky ☐apical
Speed of Movement	☐fast ☐average ☐slow
Stability	☐yes ☐no If no, please explain_____ _____
Central Fluorescein Pattern	☐pooling ☐alignment ☐apical touch
Mid-peripheral Fluorescein Pattern	☐pooling ☐wide touch (alignment) ☐narrow touch
Edge Width Horizontal Vertical	 Nasal _____mm Temporal ___ mm Superior _____mm Inferior ___ mm
Edge Clearance	☐low ☐average ☐high
Fit Classification	☐flat ☐steep ☐optimal ☐accept ☐reject
If rejected, what can be improved?	

Case 3

Lens Fit Assessment			
Decentration	horizontal (N/T) _____ mm vertical (S/I) _____ mm		
Movement with Blink	_____ mm		
Movement Type	☐smooth rotation	☐jerky	☐apical
Speed of Movement	☐fast	☐average	☐slow
Stability	☐yes ☐no If no, please explain_____ _____		
Central Fluorescein Pattern	☐pooling	☐alignment	☐apical touch
Mid-peripheral Fluorescein Pattern	☐pooling	☐wide touch (alignment)	☐narrow touch
Edge Width Horizontal Vertical	 Nasal _____mm Temporal ___ mm Superior _____mm Inferior ___ mm		
Edge Clearance	☐low	☐average	☐high
Fit Classification	☐flat ☐accept	☐steep ☐reject	☐optimal
If rejected, what can be improved?			

Observe and record the fluorescein patterns of each of the following photographic slides and record your comments in the table below.

Centration	**Case 1**	**Case 2**	**Case 3**	**Case 4**
Central area				
Mid-peripheral area				
Edge clearance				
Accept/reject				
How to correct?				

🕮 References

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Unit 3.5

(1 Hour)

Lecture 3.5: Toric Soft Contact Lenses

Course Overview

Lecture 3.5: Toric Soft Contact Lenses

I. Toric Lens Designs
II. Principles of Toric Soft Contact Lenses
III. Axis-Induced Behavioural Differences

Lecture 3.5

(1 Hour)

Toric Soft Contact Lenses

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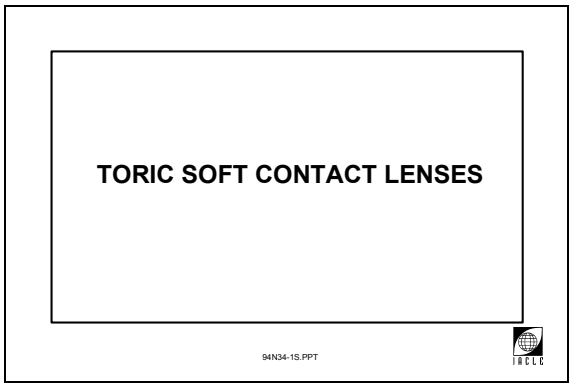
I Introduction to Toric Soft Contact Lens Designs

1



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Toric Soft Contact Lens Types and Designs

The development of PHEMA (poly(hydroxyethyl methacrylate)) in the 1950s by Wichterle and Lim ultimately led to an increase in demand for contact lenses of all types. For patients unable (or unwilling) to wear rigid contact lenses, the advent of soft contact lenses (SCLs) was an opportunity to try again. Others were attracted to the concept of a 'soft' contact lens and even the use of the word *soft* carried the promise of a more widely acceptable product. As a result of the widespread acceptance of soft lenses, the use of contact lenses of all types rose to unprecedented levels. Within a short period of time, soft lenses dominated most world markets.

The expanded market size also stimulated developments in manufacturing technology which led to the release of soft contact lenses that could correct astigmatism. By its very nature, a soft contact lens conforms to the shape of the anterior eye. As a direct result of conformance, any corneal surface toricity results in a bitoric soft lens *in situ.* This can result in considerable amounts of induced residual astigmatism.

The concept of correcting astigmatism with toric PMMA contact lenses was introduced by Stimson in 1950. In rigid lenses the role of the tear lens in the correction of astigmatism can be significant.

With SCLs the tear lens is practically absent. Therefore, fitting and optical considerations are different from those for toric rigid contact lenses. However, like RGP lenses, stabilization and the effects of lens parameters on fitting dynamics are major toric SCL considerations.

The aim of this lecture is to discuss the various designs of toric SCLs. The effects of design on toric SCL fitting will be discussed in Unit 3.6.

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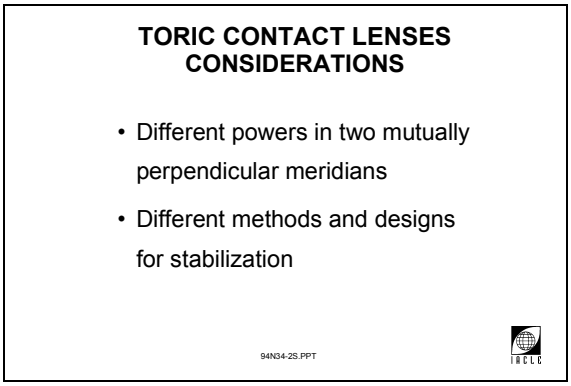

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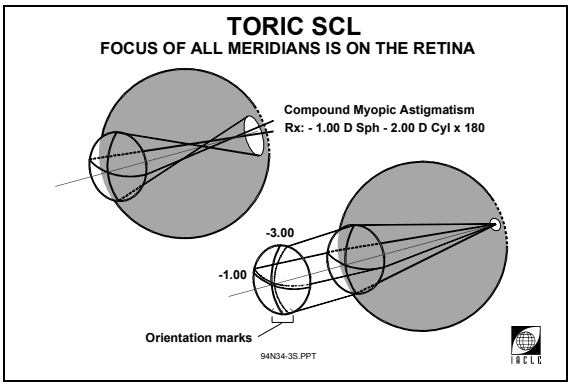

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Principle of Toric Lens Design Systems

The underlying principle of all toric lens designs is to supply a full correction for each of the principal meridians. This neutralizes the meridional refractive errors and brings light from all meridians to a common focus *on* the retina.

Meridional power variations involve thickness variations which affect the stability of the lens on the eye. 'On-eye' lens dynamics and stabilization are influenced by gravity, lid pressure, tear fluid forces and thickness differentials due to lens design and/or BVP.

In the interest of optimum visual performance, toric SCLs must maintain their correct meridional orientation under all reasonable circumstances and eye positions. In the interests of eye physiology the lens must move on the eye. The requirement of movement while maintaining a particular orientation is, on rare occasions, particularly challenging.

II Toric Soft Contact Lens Design Considerations

4

DESIGN CONSIDERATIONS

- Surface design (manufacture)
- Stabilization
- Reference marks (type and position)
- Lens thickness variation
- Water content

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5

TORIC SOFT CONTACT LENSES MANUFACTURING TECHNIQUES

- Crimping and lathing
  - Toric machining
- Molding (or molding and lathing)
- Spin-casting (or spin-casting and lathing)

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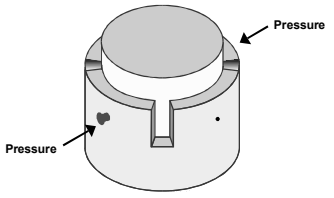
6

SCL TORIC SURFACE DESIGNS



Surface toricity generated using diametrically - opposed crimping pressure on lens button

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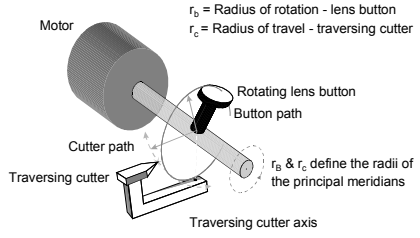
FRONT SURFACE TORIC GENERATOR (FLYING CUTTER)



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Toric Soft Contact Lenses Manufacturing Techniques

Toric SCLs are manufactured using one or more of the following methods:

- Crimping and lathing.

  The normal lathing technique is modified to provide the powers of the principal meridians.

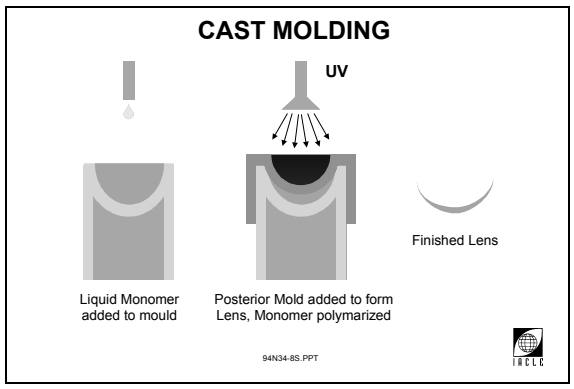
  A xerogel button is crimped by diametrically opposed pressure points in a special chuck. When the surface is lathed a sphere results. On releasing the crimping pressure the surface will be toric. The crimping pressure and location of the pressure points control the magnitude and orientation of the resulting cylinder.

  Toric machining.
  As an alternative, the front or back surface of lens can be machined using a 'flying cutter' which creates a toric front surface by applying a traversing cutter to the rotating lens button. A front surface toric generator is shown diagrammatically in slide 7).

- Molding.

  A pair of matching molds (one male, one female) are used, only one of which incorporates the correct toric surface. After the molds are mated and clamped together the space between is filled with liquid monomer and cured (often with the aid of UV) (see slide 8). After separating the molds, the finished lens then passes

8



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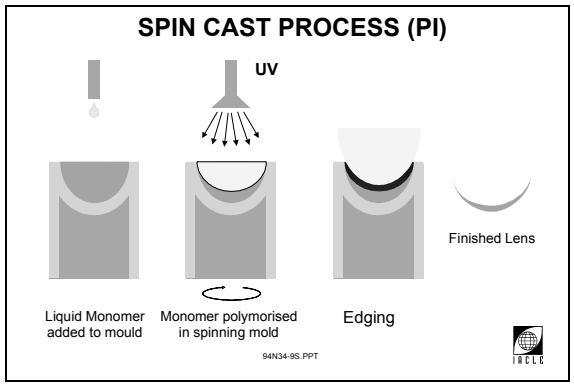

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to secondary manufacture (if any) and final hydration and packaging.

- Combinations: Molding or Spin-casting and Lathing.

  Spin-casting can be used to fabricate the spherical front surface and 'body' of a lens which is to become a toric. A toric surface generator (special lathe) is then used to produce a toric back surface of the correct power and orientation while the semi-finished lens is still in its original mold. Alternatively, one surface and the lens body can be fabricated by molding and the toric surface added by a toric generator.

*The reader is referred to **Unit 2.2** for more details on manufacturing techniques.*

II.A Toric Soft Contact Lens Surface Designs

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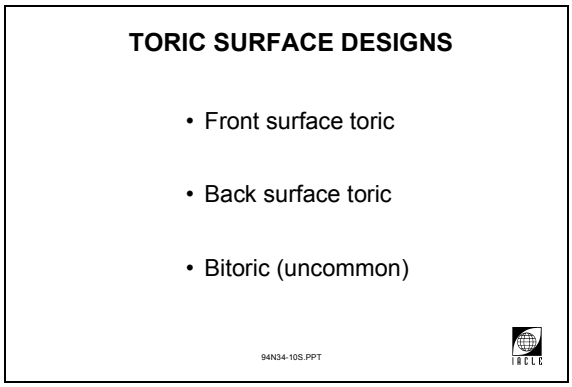

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Toric SCL Surface Designs

- A cylindrical surface can be made on the front, back or both surfaces of a contact lens. For manufacturing convenience and quality control reasons, soft lenses are not traditionally manufactured in bitoric form. To manufacture a bitoric lens, not only is control over two toric surfaces required, but also tight control of the orientation of the surfaces with respect to each other.

Regardless of the lens design, all toric soft lenses (and for that matter, all spherical lenses as well) become bitoric *in situ* when the cornea is toric. This is due to conformance of lens to the topography of the anterior eye especially the cornea.

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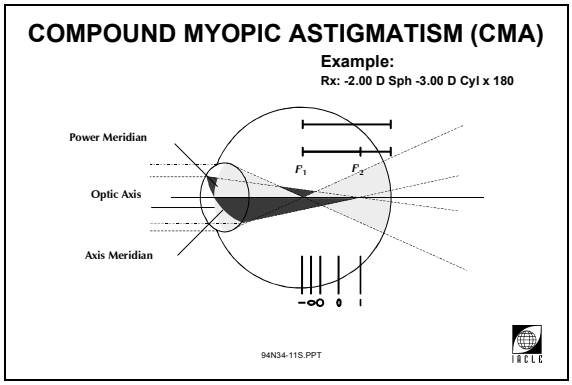

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Toric SCL Surface Designs: Examples

The parameters for front and back surface torics to correct a compound myopic astigmat (CMA) can be calculated as follows:
(See Unit 2.3 for details of calculating surface powers of contact lenses.)

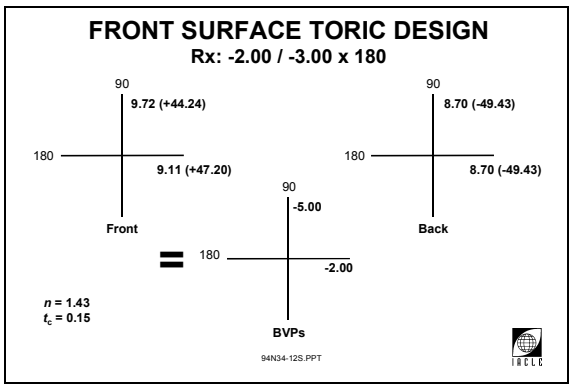
Subjective Rx

–2.00 / –3.00 X 180
(All Rxs are written and dealt with as the *minus* cylinder form)

n_{SCL} = 1.43

t_c = 0.15 mm

12



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Front Surface Toric:

BOZR = 8.70 mm

Meridional back vertex powers (BVPs):

–2.00 @ 180, –5.00 @ 90

At manufacture (in vial) front surface toric SCLs have a spherical back surface and a toric front surface.

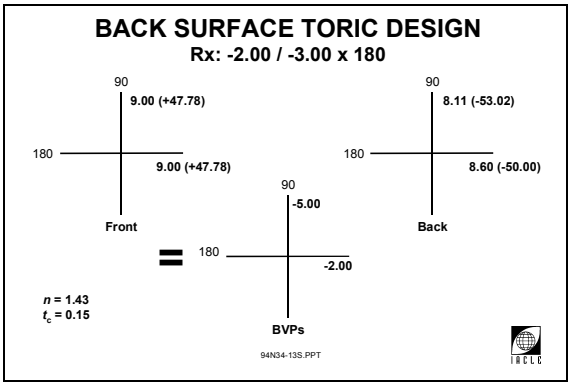
FOZR @ 180 = 9.11 mm

FOZR @ 90 = 9.72 mm

Back Surface Toric:

A back surface toric SCLs has a spherical front surface and a toric back

13



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surface.

FOZR = 9.00

By calculation:

$BOZR_{-2.00\ D}$ = 8.60 mm

$BOZR_{-5.00\ D}$ = 8.11 mm

If any residual astigmatism is to be corrected, then obviously the cylinder correction is incorporated on the front surface of a FST or the back surface of a BST.

II.B Toric Soft Contact Lens Stabilization Techniques

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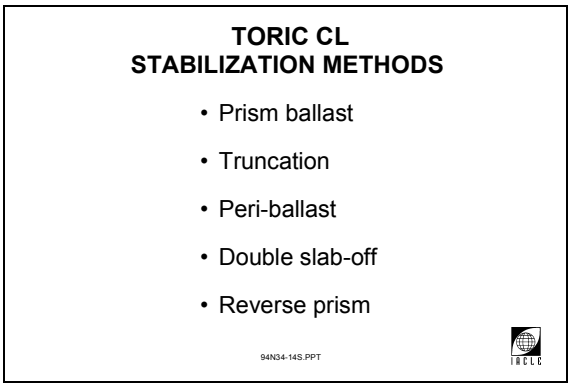

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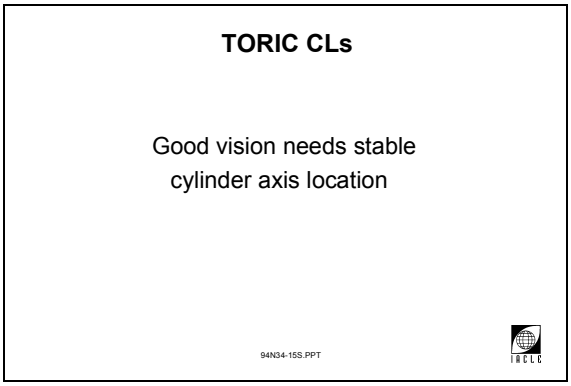

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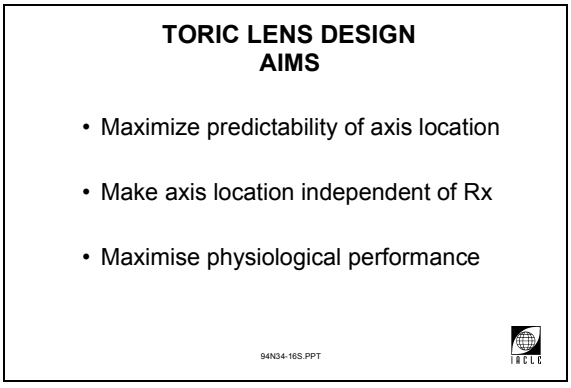

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Toric SCL Stabilization Techniques

The correction of astigmatism relies on the principle of collapsing the astigmatic pencil to a point on the retina by correcting each of the principal meridians.

With spectacle lenses this task is accomplished by a lens that has a fixed location and orientation. Generally however, while contact lenses have a reasonably well defined location (approximately centred on the cornea with some limited amount of movement), they do not have the benefit of a fixed orientation. With toric SCLs, the astigmatic axes have to be stable, and aligned with the ocular astigmatic axes, for good vision to be realized. Lens features which stabilize a toric SCL's locational behaviour must therefore be incorporated into the lens design. The following stabilization techniques are used:

- Prism ballast
  Examples: Hydrasoft Toric XW™

WJ Hydrocurve 3™

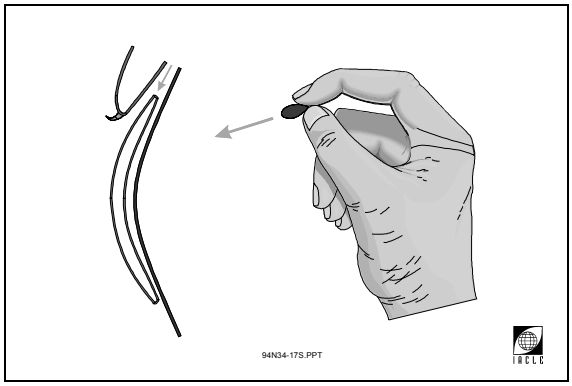
CooperVision Preference™

B&L Optima Toric™,

- Truncation
  Example: Hydroflex TS™
- Peri-ballast
  Example: Sof-Form 55 Toric™.
- Double slab-off
  Examples: Torisoft™
  Westhin Toric™, Weicon-T™.
- Reverse prism
  Examples: Hydron RP Toric™, WJ OptiFit™

Arguably, when total astigmatism is largely or completely corneal in origin, a back surface toric design constitutes a stabilizing technique in itself. However, low amounts of corneal toricity provide little stabilization.

17



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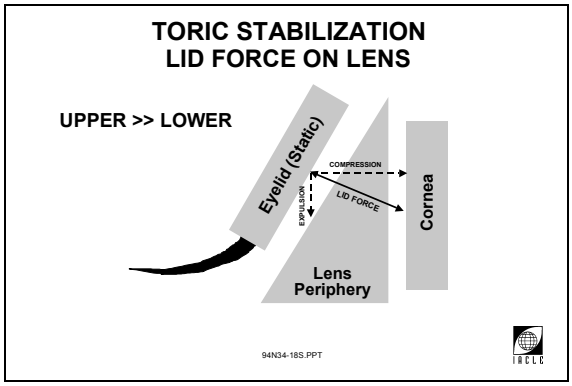
Stabilization Techniques: General
The watermelon seed principle.

If a fresh fruit seed (watermelon) is squeezed between the thumb and forefinger it is rapidly expelled from the convergent (v-shaped) space between the fingers. Expulsion is a direct result of one of the two force vectors of the pressure applied by each finger to the seed's tapered surface. One vector attempts to compress the seed, the other attempts to expel the seed. Expulsion is facilitated by the 'slippery' moist surface of the seed.

The contact lens analogy to the watermelon seed is the tapered lens edge, especilally the taper created by either prism ballast or double slab-off design features incorporated in toric lenses.

The tears provide lubrication and the lid tonus provides the 'squeeze' presure attempting to expel the lens from under both lids.

18



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Stabilization Techniques: General
Upper and Lower Lid Forces Acting on the Lens Periphery

Regardless of the lens type (rigid, soft, spherical or toric) the lids and lid forces (static and dynamic) hold contact lenses 'captive' in the interpalpebral space. Lid movement will attempt to move the lens in the *same* direction as itself. This is assisted by the viscosity of the pre-lens tear film and counteracted by post-lens tear film, the viscoelastic properties of a soft lens and surface tension forces at the exposed lens edges. Gravity and the inertia of lens and tear fluid, play relatively insignificant roles.

In the case of *toric* lenses, lens movement tends to be rotationally stable about the vertical, or near vertical axis. While partly due to the direction of lid forces and blink action (dealt with later in this lecture), some of this stability is due to the thickness differences introduced by the stabilization systems incorporated in

such lenses. Any attempt by the lens to rotate in either direction will result in *thicker* zones of the lens being forced under either lid. This is resisted by the lids. Some rotational resistance is also provided by tear film viscosity.

Compression forces applied to the lens have little effect on lens thickness but play a significant role in effecting lens conformance to the topography of the anterior eye. Such conformance occurs progressively over a short time period and requires more than one blink.

The forces applied by the upper lid are much more significant than those of the lower lid. The interpalpebral aperture, lid tonus and TD of the contact lens are also relevant.

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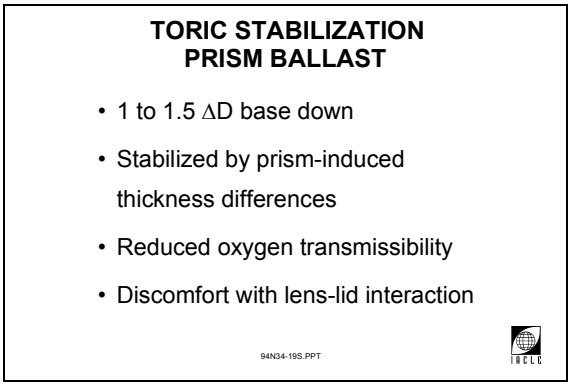

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Toric SCL Stabilization Techniques

Prism Ballast

In its simplest form this lens design incorporates a base down prism and relies on lid forces (mainly upper lid forces) acting on the thickness differences induced by the base down prism (thickness taper) to orient the lens on the eye (see the watermelon seed principle). Base down prism of 1 to 1.5 prism dioptres) is used. While this increases the thickness of the lens inferiorly, all edges, especially the edge at 6 o'clock are thinned in the interests of comfort and physiology. The disadvantages of this design include:

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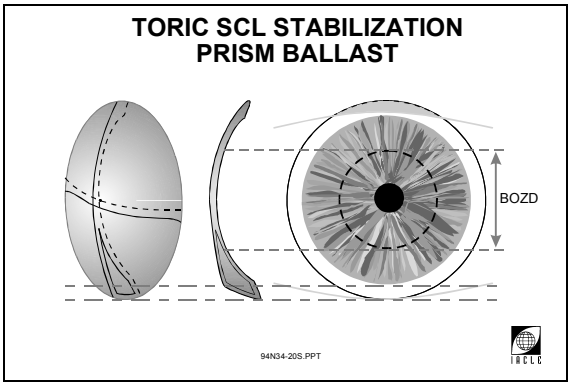

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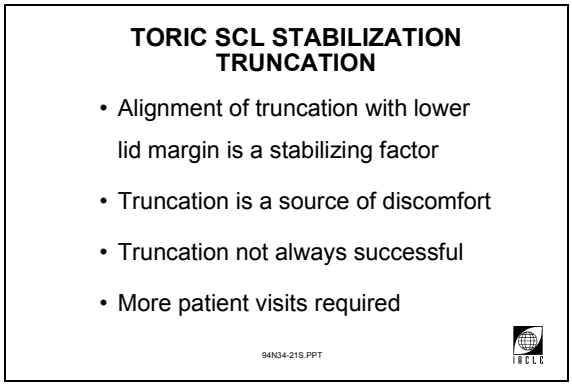
- Vertical prismatic imbalance can be induced by the use of a prism ballasted lens in one eye only. In most cases this seems to be less of a problem than theory would suggest and it is unusual for a spherical lens with similar prism to be prescribed for the other eye.
- Reduced oxygen transmissibility in the areas of greater thickness.

  Discomfort along the lower lid margin caused by the increased thickness of the prism base and/or inadequate chamfering of the lens profile inferiorly.

21



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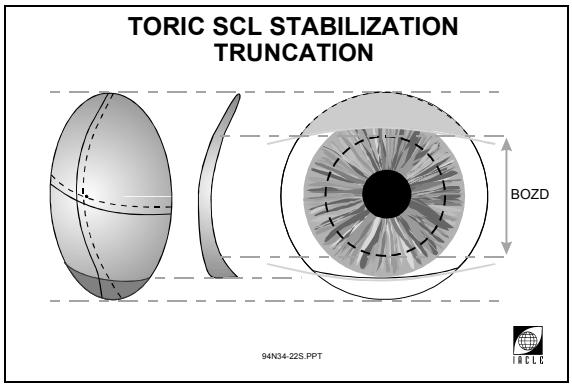

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Toric SCL Stabilization Techniques

Truncation

A prism ballasted toric lens can be truncated inferiorly along a chord 0.5 to 1.5 mm from the 6 o'clock position. In theory the truncation is shaped to align with the lower lid margin thereby increasing the lid-lens interaction and adding to the forces orienting the lens correctly.

In practice this does not always happen because the truncation alters the thickness profiles and differentials. This is especially true in cases of oblique astigmatism and an entirely new orientation can result with the truncation grossly misaligned with the lower lid margin. It is not considered a *current* technique but can be employed as a last resort.

Truncation's disadvantages include:

- The truncated edge/s, even when refinished, may be a source of discomfort.
- Especially for the inexperienced, truncating a lens may prove to be an expensive, frustrating and ultimately unsuccessful process.
- More patient visits may be required.
- Manufacturing and finishing truncated lenses is more difficult. Truncation is often done on a returned lens as a last resort. Secondary manufacture of a hydrated hydrogel lens is difficult and not particularly reproducible. Further, the return of worn lenses to a manufacturer is undesirable from a microbiological point of view.

23

TORIC SCL STABILIZATION PERI-BALLAST

- Minus carrier converted into a prism base down effect
- Uses thickness differences as the stabilizing component
- Discomfort with lens-lid interaction at the thicker inferior half
- Reduced oxygen transmissibity in thicker regions

94N34-23S.PPT

3L594N34-23

24

TORIC SCL STABILIZATION PERI-BALLAST

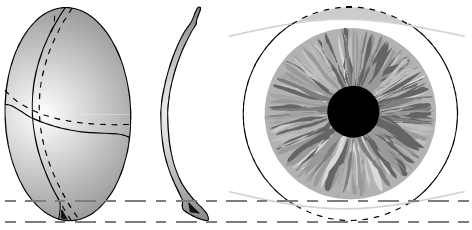
- Thinner superiorly, thicker inferiorly
- Orientation principle similar to prism ballast
- Similar overall thickness to spherical lens
- Prism-free optic

94N34-24S.PPT

3L594N34-24

25

TORIC SCL STABILIZATION PERI-BALLAST



94N34-25S.PPT

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Toric SCL Stabilization Techniques

Peri-ballast

This technique starts with a minus carrier design. To create a prism base down effect, the superior carrier is slabbed-off or chamfered superiorly to reduce its thickness and influence. This process allows the lens periphery to position comfortably under the lids. The advantage of this technique is that it limits the prism to the areas outside the optic zone. Disadvantages are similar to prism ballasted designs, i.e.:

- Reduced oxygen transmissibility in the areas of greater thickness.
- Reduced comfort along the lower lid margin due to the increased thickness of the minus carrier inferiorly.

26

TORIC SCL STABILIZATION DOUBLE SLAB-OFF

- Better comfort because of reduced lens thickness

94N34-26S.PPT

3L594N34-26

Toric SCL Stabilization Techniques

Double Slab-Off (DSO)

This lens design originated from Fanti of Germany and was announced in 1974. Other terms used in association with this lens are *thin zones* and *dynamic stabilization*. This design, perhaps more than any other toric lens design, confirms the dominant role of lid forces in lens orientation control, as opposed to the insignificant role of gravity. This design has no lens region which is obviously *heavier* than any other, yet

27

TORIC SCL STABILIZATION
DOUBLE SLAB-OFF

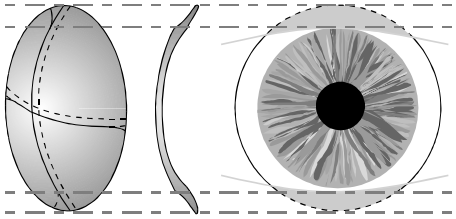
- Thin zone superiorly and inferiorly
- Lid forces maintain orientation
- Overall thinner lens
- Lens is symmetrical

94N34-27S.PPT

3L594N34-27

28

TORIC SCL STABILIZATION
DOUBLE SLAB-OFF



94N34-28S.PPT

3L594N34-28

rotational stability can be obtained. Killpatrick (1983) and Hanks (1983) conducted research to confirm that gravity was an insignificant factor in toric lens orientation by observing prism ballasted toric SCLs in patients while they were inverted (standing on their heads). The lenses behaved in the same way when the wearer was standing normally and did not relocate under the influence of gravity. Their observations led to the conclusion that lid interaction and thickness profile are the major influencing factors in the stabilization of the orientation of toric SCLs. The double slab-off design (DSO) relies on these principles only. Because the design has thin zones superiorly and inferiorly and is prismless and symmetrical, the lenses are thinner than alternative designs available. The interaction of the thin zones (upper and lower) with the lids (especially the upper lid) positions and stabilizes the lens on the eye and gave rise to the term *dynamic stabilization*. Although a popular technique, it is not without disadvantages:

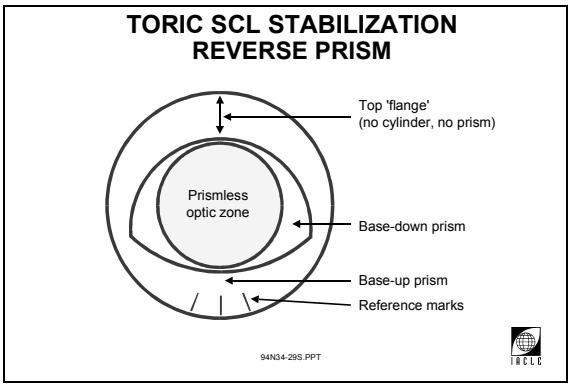
- Lid tension (lid tonus) is an individual variable and lens fit may vary from patient to patient.

– DSO toric lenses may not be as reliable in patients with loose lids.

- Generally, because of the reliance on lid interaction, DSO lenses need to be fitted with a larger TD to guarantee satisfactory performance in a majority of wearers.

A study by Castellano *et al*. (1990) showed that hyperopes, low myopes, and with-the-rule astigmats showed greater rotational instability with DSO toric soft lenses.

29



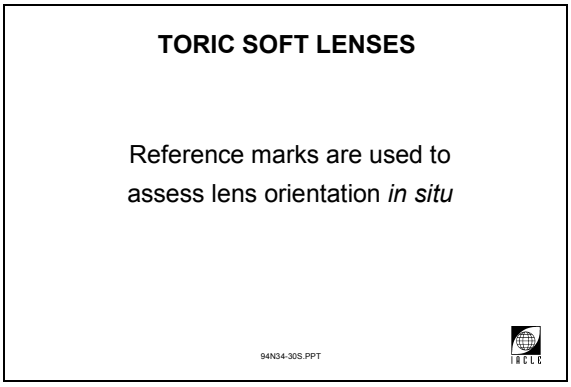
3L594N34-29

Toric SCL Stabilization Techniques Reverse Prism Designs

This design is an evolutionary and logical follow-on from true prism ballast designs. Because of the lens thickness inherent in the incorporation of prism, and the resultant need to chamfer the inferior lens edge in the interests of comfort, it was logical to incorporate both prism (base down) and the inferior chamfer (base up) into an integrated design which should be both thinner and more comfortable. The base-to-base line is located *below* the geometric centre of the lens in deference to the greater role the upper lid plays in lens orientation. This design, which is now common, has been further evolved and now usually has the cylindrical component limited to the optical zone which is prismless, and flanges or lenticulation zones superiorly in the interests of lens thinness.

III Toric Soft Contact Lens Reference Marks

30



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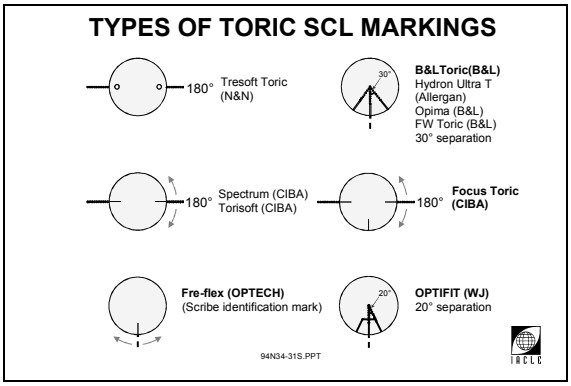

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Toric SCL Reference Marks

When fitting toric soft contact lenses it is essential to know where, and how reliably, the lens is orienting on the eye. While some of this information can be determined indirectly (e.g. the sphero-cylindrical over-refraction axis or even the reliability of the subjective refraction process itself) some form of reference mark is required if the dynamics of orientation are to be assessed accurately.

If a lens, whether a prescription lens or a trial lens, is to form the basis of a lens order, its orientation must also be measured accurately. This can only be done by observing some reference point(s) or mark(s) on the lens. Traditionally, manufacturers have provided special markings for just this purpose. They are usually located a short distance in from the lens edge at either 6 o'clock, 3 & 9 o'clock or in all three positions. The advantage of a horizontal location is that the eyelids do not have to be disturbed to observe the lens' orientational behaviour. The need to disturb the lids to observe markings at 6 o'clock is not only inconvenient but such a perturbation can invalidate the assessment because a locating force, albeit not the most significant, is removed in so doing.

Reference marks may be of a temporary nature (an ink or dye) or permanent (a laser or mechanical engraving or a photochemical mark).

Slide 31 shows some of the markings in current use by different manufacturers around the world.

Lens mislocation is measured as the deviation from the vertical (with markings nominally located at 6 o'clock) or from the horizontal (with markings nominally located at 3 & 9 o'clock).

The magnitude **and direction** of any deviation must be determined and used to *compensate* the **ocular astigmatic axis** for any angular mislocation.

IV Toric Soft Contact Lens Thickness Variations

32

TORIC SCL THICKNESS VARIATION

Centre thickness

vs

Average and/or local thickness

94N34-32S.PPT

3L594N34-32

Toric SCL Thickness Variations

Toric soft contact lenses exhibit significant regional and meridional thickness differences due to meridional power differences and the design features responsible for meridional orientation control. Greater thicknesses, as well as a greater *range* of thicknesses, are present in toric lenses compared with spherical lenses.

Lens thicknesses quoted in relation to toric soft lenses are usually geometrical centre thicknesses and can be quite misleading. Thicknesses greater than the quoted figure may exist and many peripheral zones can be thinner.

It is probable that more specific thickness data should be provided by manufacturers.

As a result of a 1985 study, Wechsler advocated the use of *average* thickness based on the specific gravity of a lens and its weight.

The implications of variations in lens thickness can be considered in the following ways:

33

IMPLICATIONS OF TORIC SCL THICKNESS VARIATION

- Fitting
- Oxygen transmissibility
- Mechanical and physiological corneal changes

94N34-33S.PPT

3L594N34-33

- Fitting and orientation.
- Oxygen transmissibility.
- Mechanical and physiological corneal changes.

34

TORIC SCL THICKNESS VARIATION FITTING IMPLICATIONS

Harris and Chu (1972)

- Lens orientation is thickness-difference dependent
- Thickness difference are the result of lens design and Rx factors

94N34-34S.PPT

3L594N34-34

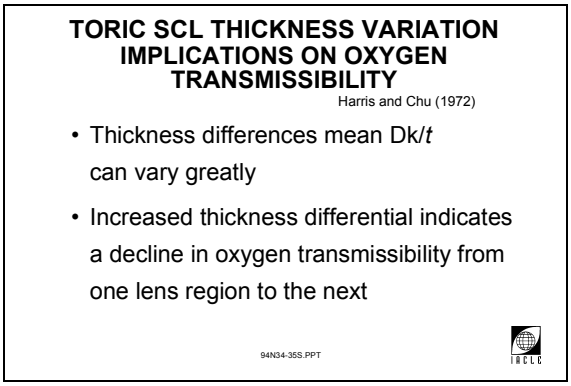
Toric SCL Thickness Variation:

Fitting Implications

It is clear from much of the foregoing that the fitting and orientation of a toric SCL depend on lens-lid interactions, lens thickness profile and thickness differences.

However, the interactions between meridional thickness differences and the stabilization technique(s) used can be significant to both fit and orientation. This will be covered in more detail later in this unit.

35



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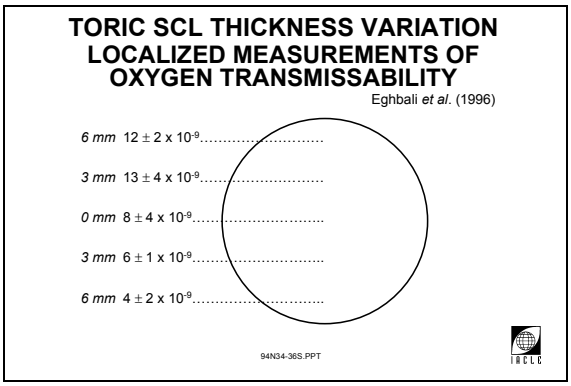

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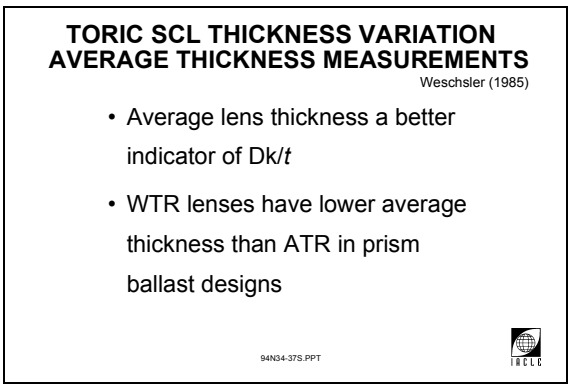

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Toric SCL Thickness Variation

Implications for Oxygen Transmissibility

Whether corneal compromise in the areas of greater lens thickness is caused by mechanical irritation, hypoxia or both, the effects of oxygen deprivation cannot be over emphasized. As thickness increases, a decline in oxygen transmissibility is inevitable.

The differences in the level of oxygen transmissibility between superior, central and inferior areas of prism ballasted lenses was examined by Eghbali *et al*. (1996). Their data is summarized in the following:

Superior (6 mm from centre): $12 \pm 2 \times 10^{-9}$

Superior (3 mm from centre): $13 \pm 4 \times 10^{-9}$

Centre: $8 \pm 4 \times 10^{-9}$

Inferior (3 mm from centre): $6 \pm 1 \times 10^{-9}$

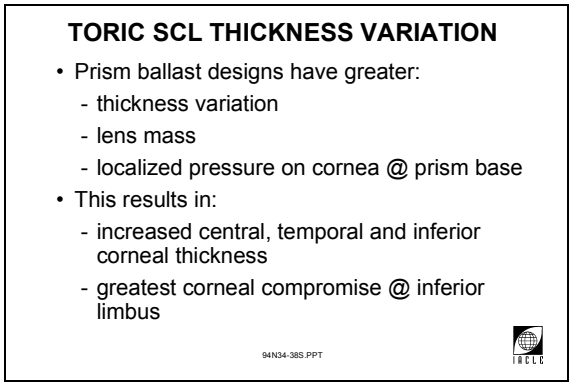
Inferior (6 mm from centre): $4 \pm 2 \times 10^{-9}$

NOTE: Double slab-off design and spherical lenses were also studied and showed minimal difference along the vertical meridian.

The findings of Wechsler (1985) imply that average thickness may be a better indicator of oxygen transmissibility than centre thickness.

With-the-rule prism ballasted toric lenses showed a lower average thickness than against-the-rule lenses. The reasons for this will be covered later in this unit.

38



3L594N34-38

Lens Thickness Variation:

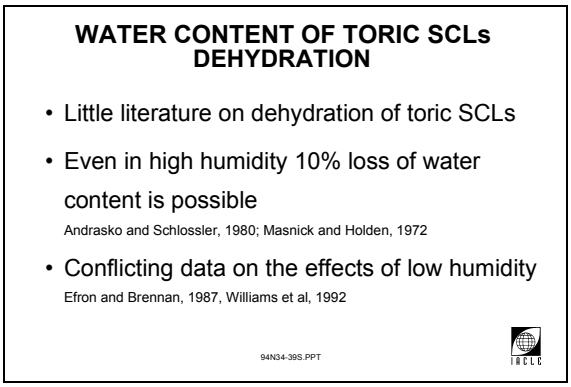
Implications for Mechanical and Physiological Corneal Changes

Soni *et al*. (1979) studied the changes in corneal thickness in the central, nasal, temporal, superior and inferior regions. They confirmed that significant thickness changes in the central, temporal and inferior regions occurred when prism-ballasted lenses were replaced by alternative designs as a result of a full days wear.

Of clinical significance was evidence of corneal compromise at the inferior limbus with prism-ballasted lenses especially in high minus Rxs. Vascularization, which was more apparent in the eye with the higher vertical meridional power, has been reported by Westin *et al*. (1989).

V Water Content of Toric Soft Contact Lenses

39



3L594N34-39

Water Content of Toric SCLs

Several methods of measuring the water content of SCLs have been used, e.g. differential scanning calorimetry and thermogravimetric analysis.

The Atago CL-1 Soft Contact Lens Refractometer was evolved by Efron and Brennan (1985) as a simple clinical device to verify the water content of SCLs.

Dehydration:

While dehydration of SCLs has been studied by several investigators there is little literature specific to toric SCLs. Some general inferences can be made from existing spherical studies.

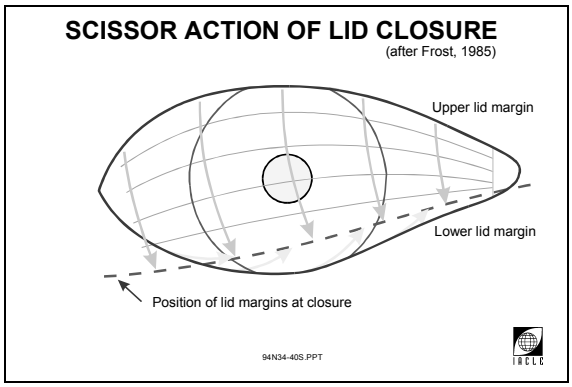
Changes in humidity and temperature can affect the water content of SCLs *in vivo*. Frequently, decreases in lens water content are reported by patients as a feeling of 'dryness' after several hours of wear and in conditions of low relative humidity. However, these symptoms may be unrelated to dehydration (Pritchard and Fonn, 1995). Andrasko and Schoessler (1980) reported that about 10% of total lens hydration is lost after 30 minutes of wear even in conditions of high relative humidity. This was also observed by Masnick and Holden (1972) with medium water content lenses at relative humidities of 60% to 80%.

While no relationship with temperature or humidity was found by Efron and Brennan (1987), Williams *et al* (1992 unpublished) found some subjective symptoms, but few objective signs of corneal compromise, when humidities of 30 - 40% were applied at a constant 24°C (55% water lenses, 0.06 or 0.1 mm thick).

It could be deducted from these findings that a variety of *other* factors may influence dehydration and comfort of SCLs during lens wear and the issues are more complex than first thought.

VI Behavioural Differences: WTR, ATR, Oblique Astigmatism

40

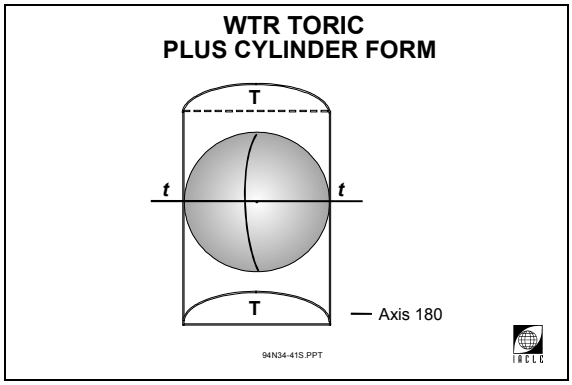


3L594N34-40

The Scissor Action of Lid Closure (after Forst, 1985)

Using high-speed cine techniques Forst (1985) analyzed the action of eyelid closure. The results of that analysis are reproduced opposite. In most cases Forst found lid closure to be *incomplete*. The line along which the lids meet (or almost meet) is shown. Importantly, the directional aspects of both lids and the dominance of the upper lid, are apparent from the 'lines of action' in the diagram. Sometimes this action is referred to as the *scissor action* of the eyelids. The potential effects of this action on the rotational behaviour of lens will be explored in this section in relation to oblique cylinder axes.

41

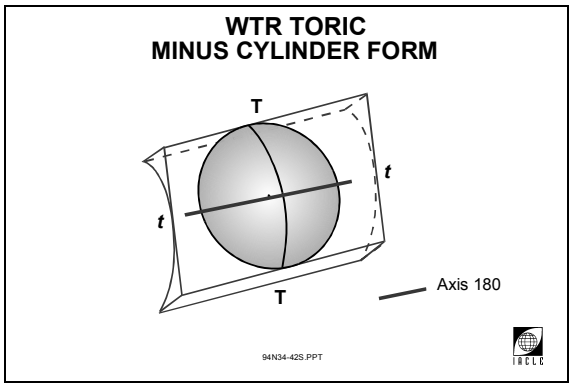


3L594N34-41

Toric Soft Contact Lens: With-the-Rule Cylinder

Largely for manufacturing reasons, *most* toric lenses are manufactured in the *plus* cylinder form. A diagrammatic representation of a WTR toric lens in the *plus* cylinder form is presented in slide 41. Only the *cylindrical* component of a WTR toric lens is shown. The relative contributions to lens thickness are shown as '*t*' for the thinner zones of the cylinder and 'T' for the thicker zones.

42



3L594N34-49

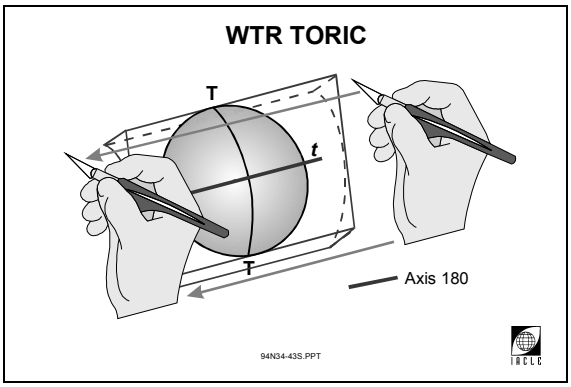
However, because of the *minus* cylinder convention used when writing Rxs, it is easier to envisage the cylindrical component of an astigmatic Rx in the *minus* cylinder form. Additionally, no consideration of the sphere component generated by the transposition of the Rx into the plus cylinder form is required. The minus cylinder form for WTR astigmatism appears as slide 42. As can be seen, the contributions to lens thickness by the cylinder *only,* are identical (as would be expected because the Rx is the same regardless of the manufacturing, or Rx-writing, conventions used), i.e. the thickest zones of the cylindrical component are located at 6 and 12 o'clock.

In situ, all soft lenses conform to the anterior eye and the form in which the lens was manufactured has relatively little influence on the actual *in situ* shape of the lens (commonly bitoric).

Because the *minus* cylinder form is easier to relate to a conventionally written Rx, the *minus* cylinder form is used for the remaining illustrations.

If there is little or no spherical component then this diagram represents the contribution the contact lens BVP makes to the overall lens thickness *differences.* Other thickness differences are contributed by the toric lens design used (e.g. prism ballast or double slab-off).

43

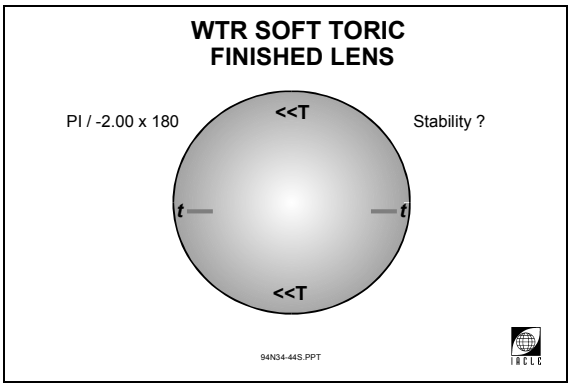


3L594N34-43

Toric Soft Contact Lens: With-the-Rule Cylinder. Incorporation of Toric Lens Design

Regardless of which lens design is used, but most especially when prism ballast and DSO designs are pursued, manufacturing steps *thin* the lens both superiorly and inferiorly. DSO designs are thinned symmetrically, prism ballast designs are not. The net effect is to remove much of the cylinder contribution to thickness *differences* at the 6 and 12 o'clock positions. This has potentially serious ramifications for rotational stability of the finished lens.

44



3L594N34-44

Toric Soft Contact Lens: With-the-Rule Cylinder. Finished Lens Thicknesses.

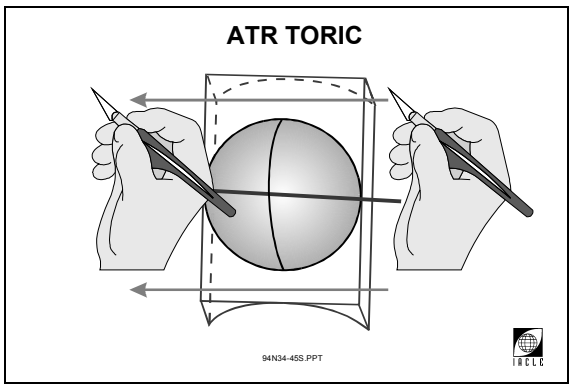
In this case, in which the Rx is Plano / –2.00 X 180, the thinning of the lens leaves the lens thickness at 6 and 12 o'clock much less than it was prior to the chamfering process. The loss of thickness is probably more significant in cases of DSO designs because there is no thickness enhancement by the incorporation of overall prism as occurs in prism ballast designs and the chamfering is symmetrical. This chamfering means that the thicknesses at 6 and 12 o'clock approach the thicknesses at 3 and 9 o'clock. This amounts to a loss of thickness differences *around* the lens and rotational stabilizing forces have their

effectiveness reduced. In extreme cases the lens can orient quite unpredictably. Mislocations of vertical cylinder axes are much less common than for either oblique or horizontal axes.

In cases of prism ballast, the lens is usually thicker inferiorly and such lenses tend to show less extreme behaviour than DSO lenses of the same Rx.

With Rxs of this form it is prudent to use a trial lens with an Rx similar to that required and of a design identical to that envisaged. If the trial lens is rotationally unstable another design, an RGP lens or spectacles should be considered.

45

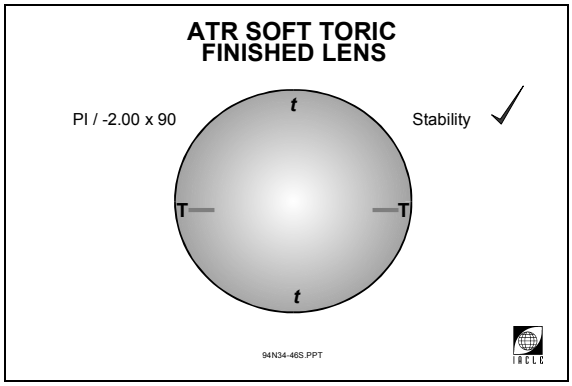


3L594N34-45

Toric Soft Contact Lens: Against-the-Rule Cylinder

If an Rx of Plano / –2.00 X 90 is considered, i.e. an ATR Rx, the situation is the reverse and most designs actually tend to enhance the desirable thickness profile, i.e. the thickness differences horizontally *versus* vertically are exaggerated rather than diminished as in the WTR case.

46

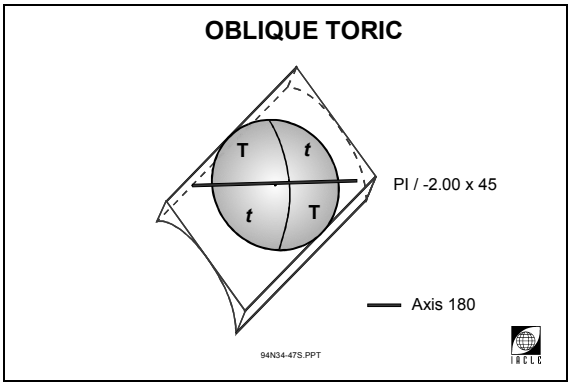


3L594N34-46

Toric Soft Contact Lens: Against-the-Rule Cylinder. Finished Lens Thicknesses.

Any chamfering of the lens superiorly and inferiorly has maximum effect at 6 and 12 o'clock and minimal effect at 3 and 9 o'clock. The thicknesses are as depicted opposite. This situation is desirable for rotational stability and generally ATR lenses are more reliable and predictable.

47



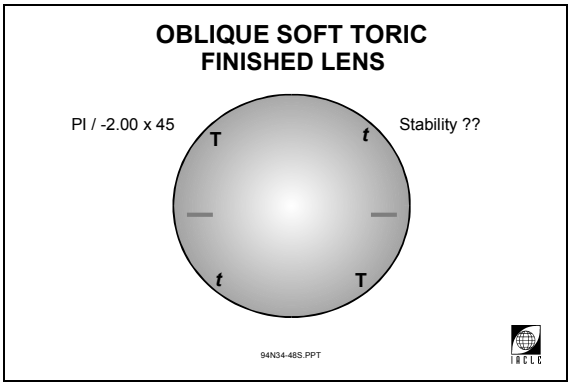
3L594N34-44

Toric Soft Contact Lens: Oblique Cylinder

When oblique cylinders are considered, the possibility of predictable lens rotation due to the cylindrical component becomes more obvious.

In this case of an Rx of Plano / –2.00 X 45, the greatest thickness contributed by the cylindrical component is at 135°, the least at 45°. Chamfering the lens has a minimal effect of the relative thickness contributions of these meridians.

48



3L594N34-48

Toric Soft Contact Lens: Oblique Cylinder. Finished Lens Thicknesses.

The diagram presents the thickness differences contributed by the oblique cylinder.

By referring to the scissor action of the lids detailed previously, it is possible to predict the likely rotational moment that can be expected from lid closure. Assuming this Rx is worn on a *right eye,* the upper lid will meet the thicker 135° meridian before the thinner 45° meridian. Similarly, but less significantly, the lower lid will meet the thinner 45° meridian first. The rotational tendency will be *anticlockwise* for this Rx in the right eye. If the lens was in the *left* eye the tendency will probably be similar, i.e. anticlockwise. The question of which eye is involved takes on greater significance for oblique axes nearer to axis 90.

If the cylinder axis was 135, then the lens would probably rotate *clockwise* in either eye.

The success rate with oblique toric lenses is generally lower. As with WTR astigmats, large axis compensations are less likely to result in success because the new lens incorporating the compensated axis is a different entity to the 'trial' lens, i.e. the lens tried at fitting or any subsequent lens used as the basis of a new lens order.

Difficult Rxs are dealt with further in Unit 3.6.

🕮 References

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Unit 3.6

(3 Hours)

Lecture 3.6: Fitting Toric Soft Contact Lenses

Practical 3.6: Toric Soft Contact Lens Fitting and Assessment

Course Overview

Lecture 3.6: Fitting Toric Soft Contact Lenses

I. Lens Selection.
II. Assessment of Fit.
III. Final Lens Order.

Practical 3.6: Toric Soft Contact Lens Fitting and Assessment

- Introduction to Fitting Principles.
- Select Lens Type.
- Select Lens Based on Stabilization Design.
- Select Fitting Method.
- Lens Insertion.
- Assessment of Fit.
- Decision on Whether to Alter Lens Parameters.
- Lens Removal.

Lecture 3.6

(1 Hour)

Fitting Toric Soft Contact Lenses

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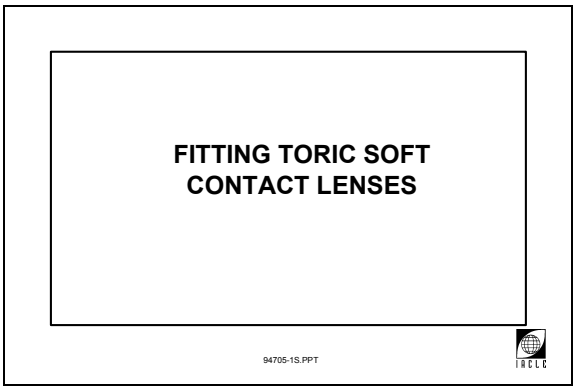
I Introduction

1



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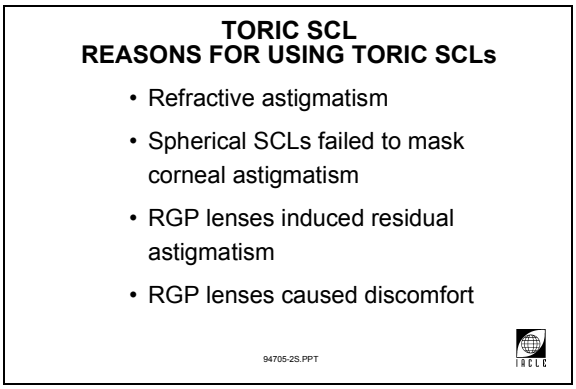
Fitting Toric Soft Contact Lenses

2



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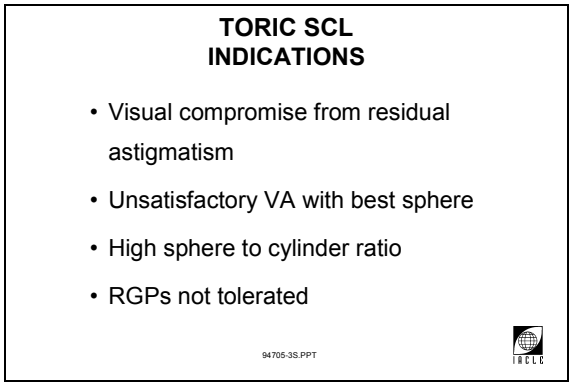
Why Toric Soft Contact Lenses?

Unlike Rigid Gas Permeable (RGP) contact lenses, normal spherical Soft Contact Lenses (SCLs) do not mask corneal astigmatism but rather conform to the shape of the cornea. A high correlation is observed between the residual cylinder with a soft lens in place and the original cylindrical refractive error (Bernstein *et al.,* 1991). Consequently, if we wish to correct astigmatism with SCLs we must prescribe toric lenses.

If the astigmatism is lenticular or partly non-corneal, it will be easier to correct with a toric SCL as opposed to an RGP toric or spherical RGP.

For some patients who are unable to adapt to RGP lenses because of discomfort, toric SCLs should be used.

3



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Indications for Prescribing Toric SCLs

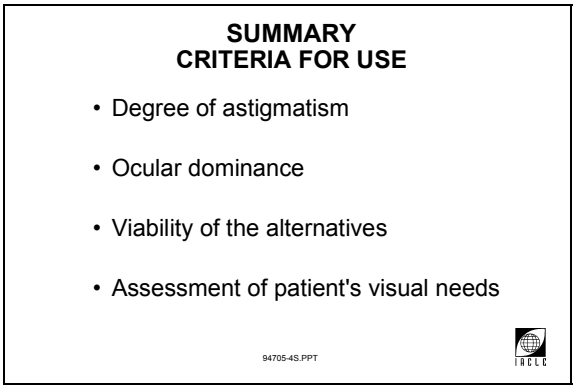
Although modern manufacturing technology is quite capable of providing practitioners with reproducible and precise toric contact lenses, the manufacturing costs still place a considerable overhead on the price of toric SCLs. Careful consideration should be made, therefore, before prescribing toric SCLs. The following indications will serve as guidelines:

- When too much visual compromise occurs with the acceptable limit for uncorrected residual astigmatism. Holden (1975) has estimated that 45.4% of SCL wearers have residual

astigmatism of 0.75 D or more and therefore, require toric SCLs.

- When the Best Sphere (BS) does not give satisfactory visual acuity.
- When the sphere-to-cylinder ratio is less than 4:1.
- When RGP contact lenses are not tolerated by the patient.

4



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Criteria for Use of Toric SCLs

A number of factors must be taken into account:

- Degree of astigmatism

  Generally, 1.00 D or more should be corrected. However this statement is a generalization as there will be significant variation between patients. For example, some SCL wearers will tolerate uncorrected cylinder of 1.50 D in one eye or for short periods of wear. On the other hand, some patients with particular visual needs will require a cylinder correction of 0.75 D.

- Ocular dominance

  Uncorrected astigmatism is far more likely to be accepted by the patient if it is in the non-dominant eye.

- Viability of the alternatives

  Are toric SCLs the best option or would the patient be better off with spectacles or RGP contact lenses? A patient with high corneal astigmatism (>5.00 D) may be better suited to bitoric RGP lenses.

- Assessment of patient's visual needs

  The less critical the visual task, the greater the amount of astigmatism that can be left uncorrected (and *vice versa*).

II Fitting Toric SCL

II.A Fitting Methods

5

TORIC SCL
ASSESSMENT OF FIT

Good fit:	Full corneal coverage, good centration and movement, quick return to axis if mislocated
Tight fit:	good centration, initially comfortable, little or no movement. Slow return to axis if mislocated
Loose fit:	excessive movement, poor centration, uncomfortable. Lens orientation unstable and inconsistent

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6

TORIC SCL
FITTING METHODS

- Special spherical trial lens (toric design)
  - sphero-cylindrical over-refraction
  - compensate for lens orientation
- Toric SCL trial lens
  - compensate for lens orientation
- Empirical prescribing
  - no trial lens fitting or . . .
  - Spherical trial lens + over-refraction

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7

TORIC SCL FITTING

- Full corneal coverage, 0.2-0.5 mm movement
- Err on large side with respect to TD
- Good fit - quick return to axis if mislocated
- Tight fit - slow return to axis if mislocated
- Loose fit - lens orientation unstable and inconsistent

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Toric SCL Fitting Methods

While meridional orientation requires special consideration, toric SCLs must be primarily considered and fitted as soft lenses. The fitting issues covered in Unit 3.2 apply equally to toric SCLs.

- Special spherical trial lens (toric design) method.

  Some trial lenses are available that are manufactured in a toric design (e.g. with dynamic stabilization) *without* the incorporation of a cylinder in the lens.

  In this case, the trial lens is chosen based on the BOZR, and a sphero-cylindrical over-refraction performed. The fit of the lens is then assessed and the orientation of the trial lens determined. Other fitting aspects are as for spherical SCLs.

- Toric trial lens method.

  This method involves the use of a trial lens which incorporates a cylinder. Its stabilization features are therefore representative of any lens ordered from the same series. The refractive error is measured and, if necessary, corrected for the effects of vertex distance to give a corneal-plane refraction (for a suitable table see Unit 3.3, Appendix A). A toric trial lens is chosen incorporating this prescription or one that is close to the final prescription. If an approximation is to be made then the cylinder axis and power are more relevant than the sphere power. No over-refraction is necessary since the correction has already been determined (the corneal-plane refraction).

  However, the trial lens fit needs to be assessed and its orientation behaviour determined. Any angular mislocation must then be considered in the final prescription (see slide 18).

- Empirical method.

- No lens fitting

  In this method, the order for the toric soft lens is based on the refractive error and measurement of other ocular parameters. The BOZR is based on the keratometer readings and the lens diameter is usually established by the lens design. Some manufacturers may routinely make an allowance for axis mislocation, unless the practitioner requests otherwise.

- Spherical soft trial lens

  This obviates the need for a toric trial lens set. A sphero-cylindrical over-refraction is performed and an allowance for rotation may or may not need to be incorporated in the final prescription. The other parameters of the lens prescription are determined empirically from the trial lens design.

In some cases, empirical lens determination may be the preferred method because it eliminates the need for multiple trial lens sets. Additionally, the performance and consistency of modern toric SCLs are such that the lenses delivered can be expected to match closely both the practitioner's previous experience with the design and the original lens order.

However, the most reliable technique is the toric trial lens fitting method in which the chosen lens design's meridional orientation can be accurately measured.

II.B Lens Rotation

8

TORIC SCL
MEASUREMENT OF LENS ROTATION

- Reference mark on lens at 3 and 9 o'clock or 6 o'clock
- Lens markings are for reference only
- Measure rotation:
  - narrow slit-lamp beam
  - spectacle cylinder in trial frame
  - protractor scale eyepiece graticule
- Estimate the degree of lens rotation

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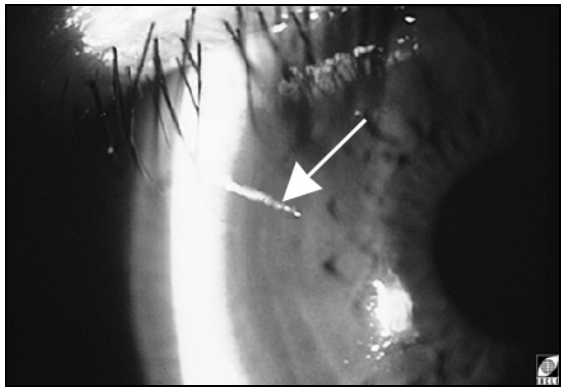

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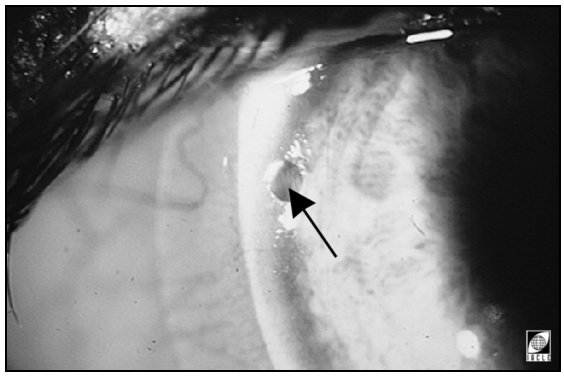

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Measurement of Lens Rotation

The laboratory making the lens will usually place a reference mark(s) on the lens so that its rotational behaviour can be assessed when the lens is on the eye. Note that this mark is a *reference* point - **it does *not* represent the cylinder *axis***.

These markings may either be at 3 and 9 o'clock (see slides 9 and 10) or at 6 o'clock (see slides 11 and 12). The lateral position is preferable as this location allows the markings to be observed without retracting the lids. The markings may be in the form of ink or photochemical dots, laser marks, scribe lines or engraved dots.

Methods of measuring lens rotation include:

- Measurement with a trial frame and cylindrical lens.

  A low cylinder power trial case lens is placed in a trial frame. Once the trial frame is correctly adjusted on the patient, the trial case lens axis is aligned with the contact lens reference mark(s). The use of some form of external lighting is necessary. This technique is not as accurate as the slit-lamp method.

- Use of the rotating slit beam on the slit-lamp.

  The majority of slit-lamps have a protractor scale to determine the angle of the slit beam. With the illumination arm located centrally and a narrow slit selected, the slit is aligned with the reference mark(s) on the lens. The angle of rotation can be read from the slit's protractor scale.

- Protractor scale slit-lamp eyepiece graticule.

  Special purpose protractor scale eyepiece graticules for measuring toric lens rotation are available for most slit-lamps. The scale, which is in one eyepiece only, can be left in place

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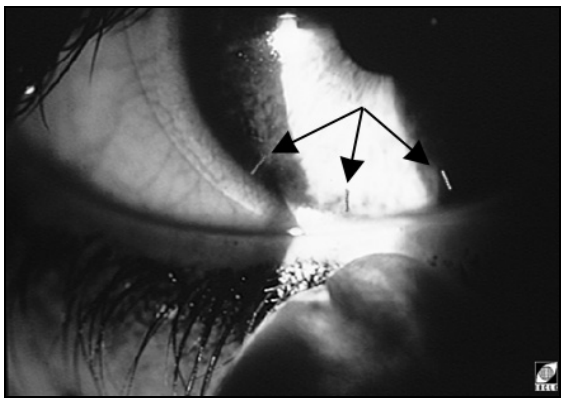

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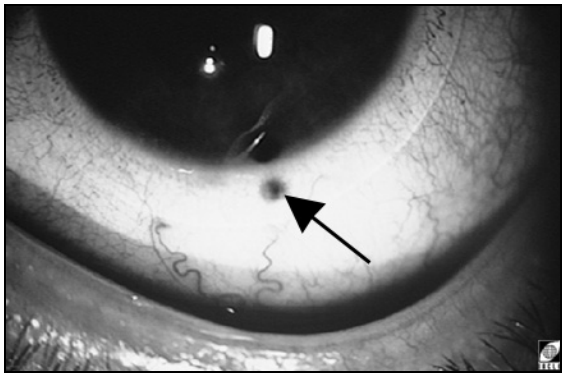

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during normal slit-lamp use. The orientation of the reference mark(s) can be read directly while observing the lens *in situ*. This is perhaps the most direct and accurate method.

- Estimation.

  Some toric lenses have more than one reference mark about the 6 o'clock position. For example, the Bausch & Lomb toric design has three laser marks that are each separated by 30° (5 minutes on a clock face). Others have 15 or 20° separations. Rotation can be estimated by observing the lens reference mark(s) with a slit-lamp.

  Where only one reference mark is present and none of the methods above are possible, reference to an analogue clock face is a last resort. The task may be little easier if the axes are only available in 10° increments. Where any axis can be ordered, estimation without the aid of some orientation measuring method is probably imprudent. A practitioner should acquire equipment for one of the methods detailed above.

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TORIC SCL
PREDICTING LENS ROTATION

- Average lens rotation is 5-10º nasal, however large individual variations exist:
  - anticlockwise for RE
  - clockwise for LE
- Lens affected by lens/eye relationship and lid anatomy
- Lens location affected by the lens thickness profile

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Predicting Lens Rotation

On average, toric soft contact lenses will tend to rotate nasally by about 5 to 10° (nasal rotation is rotation towards the nose with respect to the inferior aspect or base of the lens). However, the actual magnitude and direction of lens rotation is subject to *large* individual variations and depends on the following factors:

- Lid anatomy.

  This includes lid tension (tight lids, loose lids), lid location with respect to the cornea, and palpebral aperture size.

- Lens-eye relationship.

  Consider the fit of the contact lens on the eye. Large diameter *versus* small diameter, loose fit *versus* tight fit, etc.

- Lens thickness profile.

  This is determined by lens design and

14

PREDICTING LENS ROTATION

Based on lens thickness profile:

- Interactions with lids moves thinnest meridian towards vertical
- Upper lid is the dominant stabilizing component
- With respect to rotational influence, oblique is > WTR > ATR

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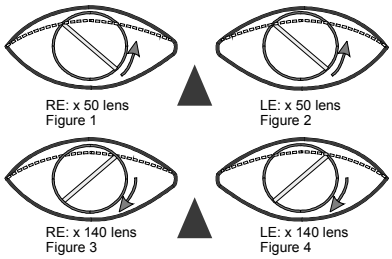
15

ROTATION OF LENS RELATIVE TO THICKER MERIDIAN



RE: x 50 lens Figure 1

LE: x 50 lens Figure 2

RE: x 140 lens Figure 3

LE: x 140 lens Figure 4

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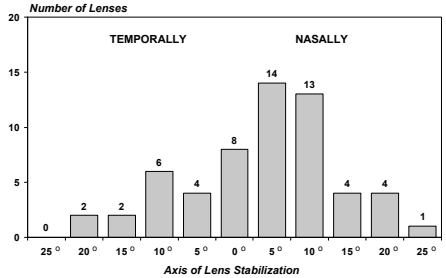
16

LENS STABILIZATION



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17

STABILISED SOFT TORIC LENS ORIENTATION*

Hanks, 1983

	Bausch & Lomb TORIC	CIBA TORISOFT®	Hydrocurve 45% TORIC	Hydron T	Salavatori Softform T
n	15	15	15	15	15
$\bar{x}$	10.0 Nas	12.5 Nas	15.1 Nas	9.2 Nas	4.2 Nas
s	± 14.3°	± 12.3°	± 14.9°	± 11.6°	± 15.1°

*Descriptive statistic for samples of patients fitted with these alternative toric soft lenses.

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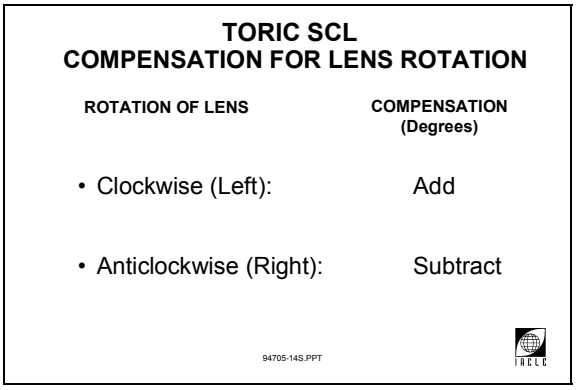
lens power, in particular the axis and magnitude of the astigmatic correction. Rotational influence is greatest for toric lenses with oblique axes (30 - 60° and 120 - 150°) followed by lenses that have with-the-rule axes (150 - 30°) and is least for lenses with against-the-rule axes (60 - 120°).

This is based on the tenet that one of the principal factors affecting lens rotation is the initial point of contact between the upper lid and the thicker meridian of the lens. The lens will always try to position itself so that the thinned zones are superior and inferior (i.e. thin under the lids, thick between the lids). For example, if a toric lens in the right eye has a cylinder axis of 50° (thickest meridian 140°) the lens thickness profile is most likely to lead to nasal (anticlockwise) rotation (slide 15, Figure 1). Conversely, the same lens in the left eye will probably rotate towards the temporal (but still an anticlockwise rotation) direction (slide 15, Figure 2). The same principle applies to clockwise rotation which would most likely be exhibited by a lens having a cylinder axis of 140° on both eyes (slide 15, Figures 3 and 4).

The results of a study conducted by Ivins (1984) on the performance of the Hydrocurve II 55 toric SCL showed that most lenses stabilized within 0 - 15° nasally (slide 16).

In another study by Hanks and Weisbarth (1983), similar results were demonstrated by various toric lens designs. Although a *large* standard deviation was shown, the lenses stabilized between 4 - 15° nasally (slide 17).

18



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Compensating for Lens Rotation

The final cylinder axis of the lens to be prescribed is determined by compensating the ocular *Rx* axis for the rotational behaviour of the trial lens. It is assumed that any subsequent lenses of the same design will exhibit behaviour identical to that of the trial lens. Regardless of orientation issues, a full astigmatic correction requires alignment of the principal meridians of both the prescribed toric lens and the ocular Rx.

If the reference marks of a lens (trial and prescribed) orient reliably and stably in some meridian other than the horizontal or vertical, depending on whether they have horizontal or vertical reference marks, a compensation must be made at manufacture to allow the principal meridians of the eye and lens *in situ,* to align. This compensation is only valid while the lens exhibits the *same* amount of mislocation originally allowed for. Such compensations should be considered a part of the 'prescription' since any deviation from it will induce residual astigmatism and reduce acuity.

In its simplest form compensation is based on the concept: **clockwise you add** i.e. if the trial lens reliably orients 10° clockwise, then compensation is required and 10° must be added to the ocular Rx axis. When the delivered lens also locates 10° clockwise the principal meridians of contact lens and eye will be aligned.

A useful rule is 'LARS', which stands for; Left Add , Right Subtract, i.e. when observing a lens *in situ* and the base rotates to the left (regardless of which eye is being considered), the degree of mislocation should be added to the ocular Rx axis to compensate for the clockwise rotation exhibited. When the lens rotates to the right, the mislocation is subtracted.

Example 1:

The ocular astigmatism axis is 140°. The trial lens when placed on the left eye rotates in a clockwise (nasal) direction by 20°. Therefore, the final cylinder axis of

the prescribed toric SCL will be 160°.

Example 2:

The ocular astigmatism axis is 15°. The trial lens when placed on the right eye rotates in a anticlockwise (nasal) direction by 10°. Therefore, the final cylinder axis of the prescribed toric SCL will be 5°.

II.C Fitting Procedures

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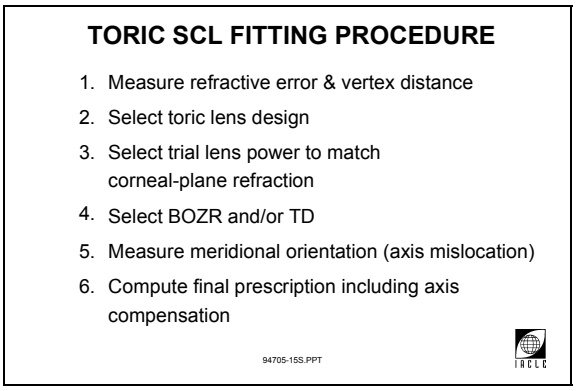

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Fitting Procedures

When fitting toric soft lenses, it is generally prudent to err on the large side when choosing a lens diameter as this will aid lens stabilization.

- Special spherical trial lenses (toric design).

  With the trial lens on the eye, perform a sphero-cylindrical refraction. Note that the cylinder and axis of the over-refraction may differ slightly from those of the ocular refraction (although they should be approximately the same).

  Determine the orientation of the trial lens. Compensate the ocular Rx axis for this orientation and record the allowance made (e.g. 10° clockwise). If the lens orientation at delivery is not what is expected, i.e. orientation of the delivered lens is different from that of the trial lens, but the delivered lens is stable at this new orientation, the next order should be based on this new orientation.

  Remember that changing the cylinder axis will alter the thickness profile and may affect the degree of rotation. If rotational stability is poor, alterations to the BOZR or the TD to achieve better lens stability may need to be considered. Often the simplest way of improving orientational stability is to increase the TD. This enhances lens-lid interaction thereby increasing the locating forces acting on the lens.

  If stability remains poor, consideration may need to be given to either another lens design or another form of astigmatic correction.

  If in doubt, wait until the first after-care visit before re-ordering (note the degree of lens rotation on the patient's record card). More than one attempt may be required to achieve a successful toric fit.

- Toric trial lens method.

  The trial lens is inserted and allowed to

settle. Its orientational behaviour is determined. The Rx to be incorporated is the corneal-plane refraction, compensated for any lens mislocation if required. Any compensation made should be recorded.

- Empirical method.

  Measure the spectacle Rx and vertex distance and derive the corneal-plane refraction (a close approximation to the true ocular Rx). Measure the corneal radii of curvature and HVID. Supply the data to the manufacturer. If any subsequent lenses are required, they should be based on the experiences with the first delivered lenses which assume the role of trial lenses.

- Spherical trial lens.

  Treat the lens as a conventional spherical soft lens and follow the manufacturer's instructions for finalizing a toric Rx from the best trial lens fit. Usually, this will involve determining the corneal-plane refraction. A routine inclusion of compensation for 'nasal' rotation may be made by some manufacturers. The basis of any subsequent lens orders should be the experiences with the first delivered lenses.

III Physiological and Refractive Considerations

20

TORIC SCL
PHYSIOLOGICAL CONSIDERATIONS

- Complications such as cornea oedema and corneal vascularization more likely due to the increased lens thickness
- If problems occur, use a high water content material (55% or greater)
- If problems persist, refit with RGP lenses

94705-16S.PPT

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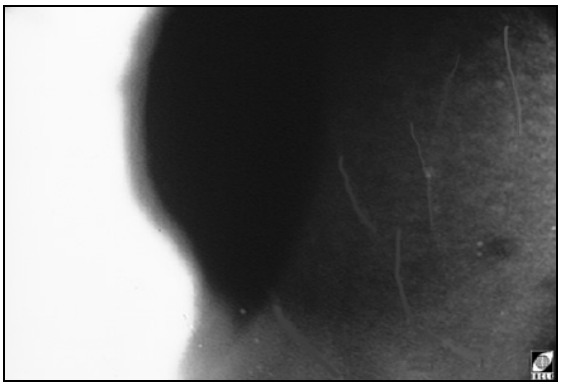
Physiological Considerations

Because of the thickness differentials created by its design and the incorporation of cylinder, a toric soft lens is significantly thicker (both centrally and peripherally) than an 'equivalent' spherical lens. Consequently, oxygen transmissibility is reduced and mechanical interactions increased, resulting in an increased likelihood of physiological compromises to both the cornea and the anterior eye in general.

Conditions which are more likely to occur with toric soft lenses include:

- Corneal oedema (slide 21), especially in eyes with hyperopic spherical components.
- Corneal vascularization (slide 22), usually inferior and superior, more so in myopic patients.
- Scleral or conjunctival indentation, especially with large, tight-fitting lenses.

21



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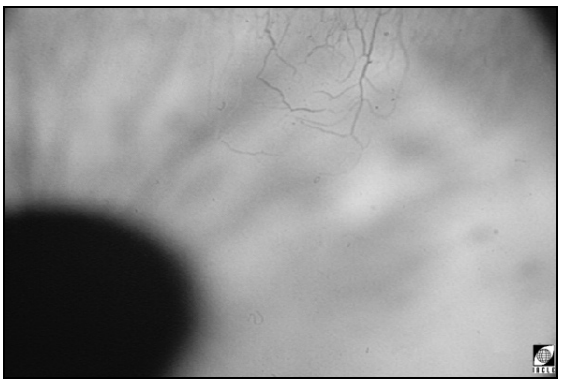
If any of these problems occur you may need to:

- Review the fit of the lens.
- Fit with a higher water content material (perhaps 55 or 60%). Note that toric lens stability decreases as water content increases, especially for the very high water content (>65%) materials.
- Refit with RGP lenses.
- Revert to spectacles.

22



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23

TORIC SCL
DIFFICULT CASES

- Low spherical components
  e.g +0.25 / -2.50 x 180
- Oblique cylinders
  e.g -2.00 / -2.00 x 45
- High cylinders
  e.g +4.00 / -6.00 x 80

94705-17S.PPT

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Difficult Cases

Patients who are less likely to be successful with toric soft lenses include those with:

- Low spherical components.
  e.g. +0.25 / -2.50 X 180

  Axis alignment is very critical to these patients because the astigmatism is the most significant component of their refractive error. In addition, the usual thickness differentials achieved are

reduced with small spherical components.

- Oblique cylinders.
  e.g. -2.00 / -2.00 X 45

  Will possibly have poor stability due to complex lid-lens interactions.
- High cylindrical components.
  e.g. +4.00 / -6.00 X 80

  Lens rotation becomes more significant optically as the degree of cylinder is increased. Therefore, larger cylinders necessitate greater accuracy when measuring lens mislocations. While not always possible, the accuracy normally afforded high-cylinder spectacle lenses should also be applied to contact lenses.

If difficulties are still being experienced when the BOZR and TD have been optimized for a particular wearer, the following issues may need to be considered:

- Avoid compensations for axis mislocation > 25° even if lens mislocation is stable.

  Compensations of 20° and more mean that the new lens incorporating such a compensation is quite different to that trailed and the outcome at delivery is unlikely to be as expected.
- If the cylinder is large (>2.00D) and the sphere low or plano, avoid compensating for mislocations > 20°.
- If the axis is WTR but not 180 and the sphere is low or plano, avoid compensating for mislocations > 20° especially if the cylinder is large as well.

24

TORIC SCL
PROBLEM SOLVING

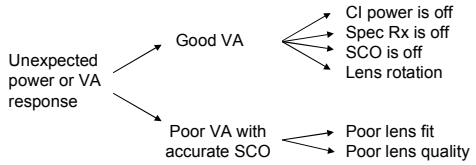
- Check accuracy of baseline data
  e.g ocular refraction, K readings
- Perform sphero-cylindrical over-refraction (SCO)

94705-18S.PPT

3L694705-18

25

INTERPRETING VISION THROUGH SPHEROCYLINDRICAL OVERREFRACTION



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26

ROUTINE FOR TORIC SCL ASSESSMENT

1. Case history (vision)
2. Measure visual acuity (VA)
3. Spherical over-refraction and VA
4. Sphero-cylindrical over-refraction and VA
5. Check meridonal orientation of lens (slit-lamp)
6. Check stability of fit
7. Get patient to move eyes and recheck meridonal orientation

94705-20S.PPT

3L694705-20

27

ROUTINE FOR TORIC SCL ASSESSMENT

8. For mislocating lens, rotate to intended position and check if vision improves
9. Use table of calculated angles of mislocation based on sphero-cylindrical over-refraction (Unit 3.3, Appendix B)
10. Measure power and axis of toric SCL
11. Check ocular refraction and keratometry for comparison with baseline

94705-21S.PPT

3L694705-21

Problem Solving

When the over-refraction is not as expected, a simple guide can be used to determine the possible cause, depending on the quality of the visual acuity achieved with the lenses (see slide 25). To use this chart simply move from left to right making a choice at each junction until the cause(s) is reached.

Alternatively, slides 26 and 27 provide a sequence for solving problems with over-refraction and mislocation. Based on the over-refraction, the angle of mislocation can be determined using suitable tables, see Unit 3.3, Appendix: B. The tables provide calculated angular mislocations of the contact lens cylinder axis relative to the ocular astigmatic axis based on Stoke's construction. Mislocation beyond 25° is usually indicative of the need to refit with a different toric lens design.

Practical 3.6

(2 Hours)

Toric Soft Contact Lens Fitting and Assessment

Purpose of Practical

The purpose of this exercise is to learn how to assess the fit and performance of toric soft lenses. The emphasis of this practical is the determination of the cylinder and axis correction of the toric soft lens.

Instructions: Students are to examine their partners by following the procedure outlined below and document their findings on the record form provided:

- Toric soft contact lens fitting and performance assessment is based on:
  - Centration
  - Movement
  - Tightness
  - Corneal coverage
  - Comfort (not necessarily related to fit)
  - Vision
- Spherical over-refraction (for toric powered trial lenses).
- Sphero-cylindrical over-refraction (for spherical powered trial lenses)
- Meridional orientation of lens (determining axis of the demarcation)
- Calculation of final toric Rx (difference between refractive astigmatism, axis and trial lens-axis orientation)

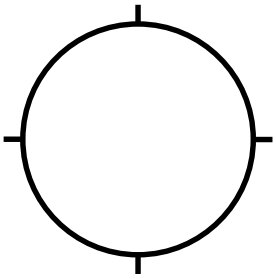
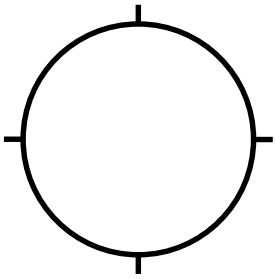
RECORD FORM

Name:_____ **Date:**_____

Partner:_____

ASSESSMENT VARIABLES		
Eye	Right	Left
Keratometry Reading Refractive Error	_____ D _____D@ _____ Low K radius _____ mm _____ DS ____ DCx____	_____ D _____D@ _____ Low K radius _____ mm _____ DS ____ DCx____
HVID	_____ mm	_____ mm
Baseline Eye Check _____Supervisor	☐clear ☐slightly red ☐irritated ☐staining	☐clear ☐slightly red ☐irritated ☐staining
Trial Lens: _____ Power	BOZR _____ mm Water content _____ Thickness _____ mm Lens diameter _ mm _____DS ____DCx _____	BOZR _____ mm Water content _____ Thickness _____ mm Lens diameter _ mm _____DS ____DCx _____
Lens Fit Assessment		
Centration	horizontal (N/T) _ mm vertical (S/I) _____ mm	horizontal (N/T) _ mm vertical (S/I) _____ mm
Corneal Coverage	☐complete ☐partial	☐complete ☐partial
Movement with Blink	Primary gaze mm Upgaze mm	Primary gaze mm Upgaze mm
Upgaze Lag	_____ mm	_____ mm
Horizontal Lag	_____ mm	_____ mm
Lens Tightness (push-up test)	_____ %	_____ %
Fit Classification	☐loose ☐tight ☐ optimal ☐accept☐reject	☐loose ☐tight ☐ optimal ☐accept☐reject
If rejected, what can be improved?		

Patient Comfort Rating	0 1 2 3 4 5	0 1 2 3 4 5

Over refraction	____ DS VA _____ ____ DS ____ DCx ____ VA _____	____ DS VA _____ ____ DS ____ DCx ____ VA _____
Toric Axis Assessment	Right	Left
Draw a schematic of the toric lens axis position in reference to the 6 o'clock position on the eye. Indicate the amount of mislocation in degrees and whether the axis mislocation is clockwise or anti-clockwise.	 6	 6 Mislocation: _____
The final toric lens Rx for the patient:	Lens Type: _____ BCOR: _____ _____mm Diameter: _____mm BVP: _____ DS _____ DCx _____	Lens Type: _____ BCOR: _____ _____mm Diameter: _____mm BVP: _____ DS _____ DCx ____

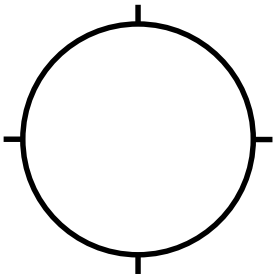
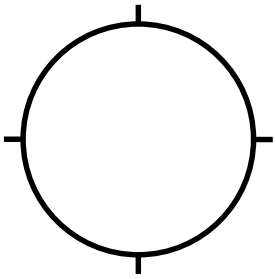
RECORD FORM

Name:_____ **Date:**_____

Partner:_____

ASSESSMENT VARIABLES		
Eye	Right	Left
Keratometry Reading Refractive Error	_____ D _____D@ _____ Low K radius _____ mm _____ DS ____ DCx____	_____ D _____D@ _____ Low K radius _____ mm _____ DS ____ DCx____
HVID	_____ mm	_____ mm
Baseline Eye Check _____Supervisor	☐clear ☐slightly red ☐irritated ☐staining	☐clear ☐slightly red ☐irritated ☐staining
Trial Lens: _____ Power	BOZR _____ mm Water content _____ Thickness _____ mm Lens diameter _ mm _____DS ____DCx _____	BOZR _____ mm Water content _____ Thickness _____ mm Lens diameter _ mm _____DS ____DCx _____
Lens Fit Assessment		
Centration	horizontal (N/T) _ mm vertical (S/I) _____ mm	horizontal (N/T) _ mm vertical (S/I) _____ mm
Corneal Coverage	☐complete ☐partial	☐complete ☐partial
Movement with Blink	Primary gaze mm Upgaze mm	Primary gaze mm Upgaze mm
Upgaze Lag	_____ mm	_____ mm
Horizontal Lag	_____ mm	_____ mm
Lens Tightness (push-up test)	_____ %	_____ %
Fit Classification	☐loose ☐tight ☐ optimal ☐accept☐reject	☐loose ☐tight ☐ optimal ☐accept☐reject
If rejected, what can be improved?		

Patient Comfort Rating	0 1 2 3 4 5	0 1 2 3 4 5

Over refraction	____ DS VA _____ ____ DS ____ DCx ____ VA _____	____ DS VA _____ ____ DS ____ DCx ____ VA _____
Toric Axis Assessment	Right	Left
Draw a schematic of the toric lens axis position in reference to the 6 o'clock position on the eye. Indicate the amount of mislocation in degrees and whether the axis mislocation is clockwise or anti-clockwise.	 6	 6 Mislocation: _____
The final toric lens Rx for the patient:	Lens Type: _____ BCOR: _____ _____mm Diameter: _____mm BVP: _____ DS _____ DCx _____	Lens Type: _____ BCOR: _____ _____mm Diameter: _____mm BVP: _____ DS _____ DCx ____

🕮 References

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Unit 3.7

(2 Hours)

Lecture 3.7: Toric RGP Contact Lens Types and Designs

Tutorial 3.7: Corneal Astigmatism and Toric RGP Contact Lens Parameters

Course Overview

Lecture 3.7: Toric RGP Contact Lens Types and Designs

I. Toric Lens Design
II. Principles of RGP Toric and Bitoric Contact Lenses Calculation
III. RGP Contact Lens Flexure and Correction of Astigmatism

Tutorial 3.7: Corneal Astigmatism and Toric RGP Contact Lenses

- Quiz
- Discussion

Lecture 3.7

(1 Hour)

Toric RGP Contact Lens Types and Designs

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III Back Surface Toric Lenses 302

IV Bitoric Lenses 304

V Peripheral Toric Lenses 305

VI Manufacturing Toric Lenses 307

I Toric Lens Design

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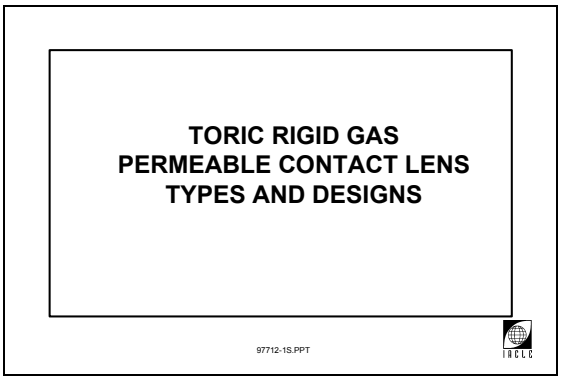

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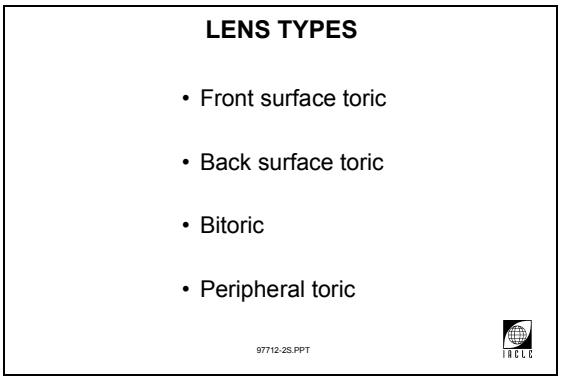

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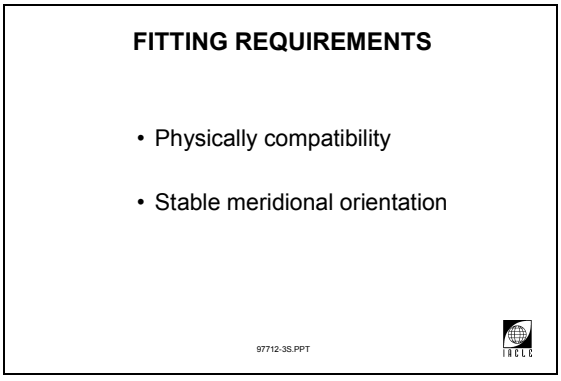

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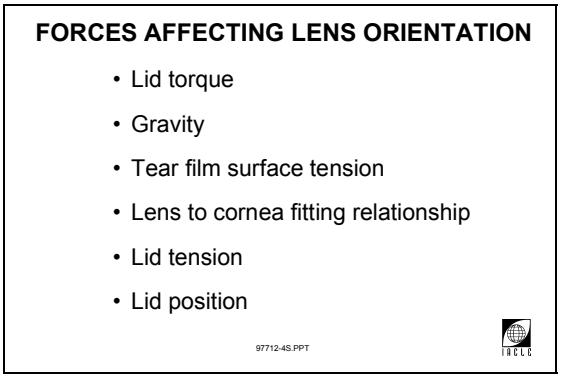
Fitting Requirements

A large part of successful spherical RGP lens fitting is the achievement of a compatible relationship between the front and back surface of the lens and the ocular surface and adnexa.

This compatibility is even more important when fitting toric RGP lenses due to factors such as greater lens thickness, increased lid forces and alterations in the static and dynamic fitting characteristics.

In many toric fittings, success is dependent upon achieving a stable meridional orientation of the lens on the cornea in order to correct the astigmatism. The degree of astigmatism may be dictated by the corneal topography, the internal astigmatism and/or the induced astigmatism from the toric back surface of the lens.

4



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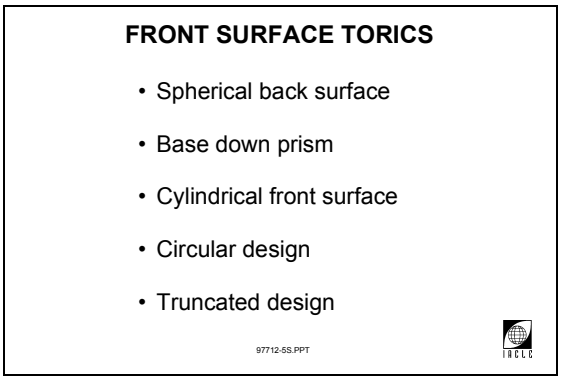
Forces Affecting Lens Orientation

A number of factors are involved in maintaining the position of the toric lens on the cornea. These include:

- **Lid torque**: The upper and, to a much lesser extent, lower lids can impart a significant rotational force to the RGP lens which is counter to the desired fitting characteristic of meridional stability. Some mechanism is usually required to resist or retard the rotational movement of the lens caused by this force.
- **Gravity**: The gravitational force acts to move the lens toward the inferior region of the cornea. In most toric lenses the increased thickness results in greater lens mass which is more likely to be affected by gravity. The dynamic fitting characteristics of the lens may be adversely influenced by the gravitational force.
- **Tear film surface tension:** The surface tension of the tear film will act to hold an RGP lens on the cornea as well as providing some force for centration and stability of the lens.
- **Lens to cornea fitting relationship:** The physical fitting relationship between the lens back surface and the cornea plays a major role in the success of RGP toric lenses. The relationship must ensure that a stable dynamic fitting is achieved if it is to provide the highest possible level of vision. Generally, a loose fitting RGP toric lens will not be successful.
- **Lid tension:** During a blink, the upper lid can exert a considerable force on the lens. This can result in a poor fitting due to misalignment of the cylindrical axis or unacceptable vision due to an unstable fitting.
- **Lid position:** The positions of both the upper and lower lids can exert considerable influence on the dynamic fitting of the lens. Care needs to be taken to select the most suitable type of toric lens for the patient requiring RGP lenses.

II Front Surface Toric Lenses

5



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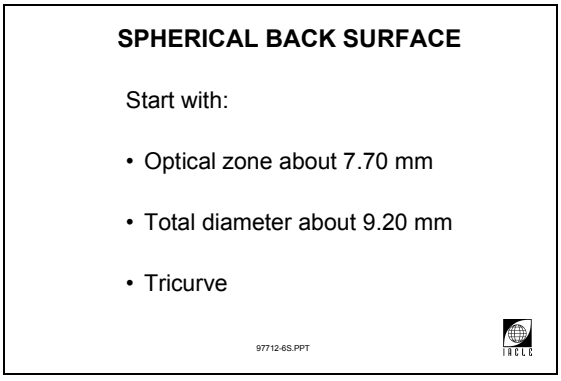
Front Surface Torics

The front surface toric lens has a number of very specific design features. These are intended to meet both the requirements for fitting a spherical lens and those that maintain the meridional orientation required to correct the patient's astigmatic error.

- **Spherical back surface.** The back surface design principles are similar to those employed for standard RGP lens fittings.
- **Base down prism.** This is the key factor in maintaining the lens in the proper meridional orientation to correct the astigmatism
- **Cylindrical front surface.** The visual quality is dictated by the correction of any residual astigmatism. This is achieved by inclusion of a cylindrical correction on the front surface of the lens.
- **Circular design.** The lens can be produced in a traditional circular design where the lens back surface is rotationally symmetrical about its central axis.
- **Truncated design.** When the prism is unable to maintain the orientation of the cylinder, the use of an inferior lens truncation may be employed to stabilize the lens by interacting with the lower lid margin.

6



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Spherical Back Surface

No single lens design is acceptable for all patients. Only a guide may be offered as to the design of the trial lens that the practitioner may use for an initial assessment of the toric RGP lens fitting.

A lens with an optical zone of 7.70 mm, a total diameter of 9.20 mm and manufactured in a tricurve back surface design is an ideal initial trial lens for the majority of patients.

7

BASE DOWN PRISMS

- Meridional orientation
- Requires 1 - 1.75 prism dioptres
- Provide thickness/weight differential
- Nasal offset by 10-15 degrees

97712-7S.PPT

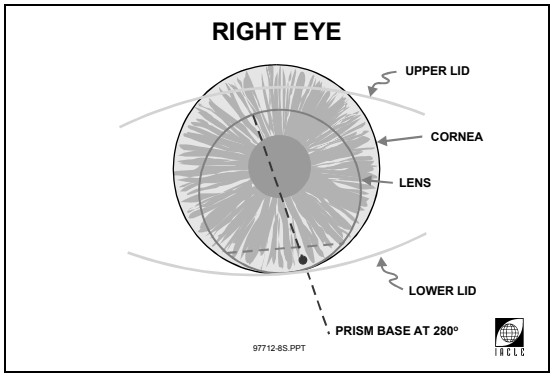
3L797112-7

Base Down Prism

Base down prism produces a thickness/weight differential between the top and bottom of the lens. This assists in preventing lens rotation with each blink and in maintaining the meridional orientation of the cylinder axis. The amount of base down prism can be controlled during the production of the lens front surface.

The appropriate amount of prism is defined by many variables such as the lens power, lens total diameter, and rotational force of the lids. In many cases it can only be determined by the on-eye clinical performance of the fitting.

8



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Excessive prism may cause the lens to ride too low on the cornea due to its greater weight and the influence of gravity. Insufficient prism may not prevent the lens from rotating with each blink.

The prism base is rarely found to be oriented in the vertical meridian. Typically, there is sufficient rotational force on the lens to move the prism base in a nasal direction for each eye. If the amount of rotation is consistent, this can be compensated for when ordering the cylinder axis to correct the patient's astigmatic requirements.

When using an empirical fitting technique, the amount of nasal rotation allowed for is generally in the order of 10-15 degrees. This is only a rule of thumb and does not apply in all cases.

9

BASE DOWN PRISM

- The tendency for the lens to rotate with a blink is counteracted by the thickness differential of the lens
- The heavier prism base helps to maintain meridional orientation of the cylindrical correction

97712-9S.PPT

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Base Down Prism

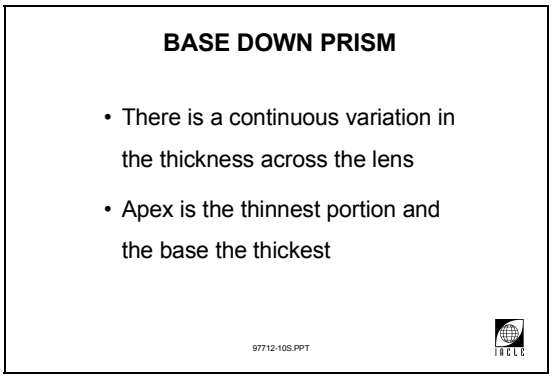
The thickness differential produced by the base down prism provides resistance to the rotational lid forces acting on the lens. Gravity may also play a role in maintaining the meridional orientation of an RGP toric lens. However it has been demonstrated that with a prism ballasted soft lens, the influence of gravity is minimal.

At the initiation of a blink, the thicker zone of the lens is positioned between

the lids where lid tonus and the normal locating forces centre and trap the lens. From this point, any lens rotation will attempt to position the thicker base of the lens under the lower lid. However, because the upper lid is moving from a thin to a thicker zone, the lid's mechanical and muscular properties oppose any rotational movement of the lens.

The opening of the lids also has a similar orienting/locating effect to that of the closing of the lids. Additional resistance to movement and rotation of the lens is provided by the viscoelastic properties of the post-lens tear film.

10



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Base Down Prism

The quality of the design of the upper and lower edge of a prism ballast toric lens is vitally important to adequate comfort during lens wear.

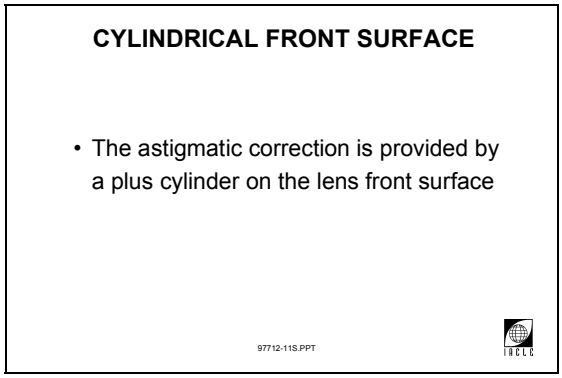
The apex of the lens should have an edge thickness and profile similar to that of a standard spherical RGP lens. Excessive edge thickness and/or an unsuitable profile may cause discomfort.

For greatest comfort, the edge should have a well rounded front and back surface meeting at the apex, which should be centrally or slightly posteriorly located.

The thicker base of the lens may cause some discomfort on the lower lid margin if the lens edge profile is not adequate. Careful attention therefore needs to be given to the finish of the prism base.

Excessive prism and edge thickness may prevent the upper lid from wetting the ocular surface during a blink, causing problems such as epithelial desiccation.

11



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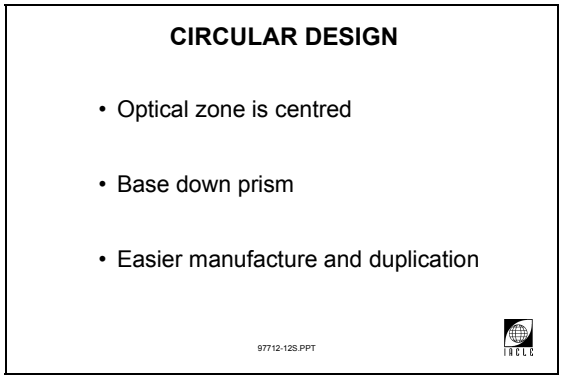
Cylindrical Front Surface

The most common method of producing a toric front surface on an RGP lens is to bend (flex) the spherical button of material by a specified amount. This process is called crimping. The flexed button, which is now a toric shape, is then mounted on a lathe and the front surface cut and then polished with a spherical curve. The pressure on the blank is then released. The front surface becomes toric after the release of the crimping pressure.

12



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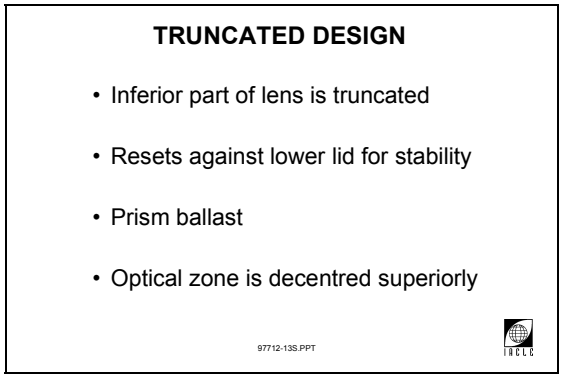
Circular Design

Compared with a truncated lens design, a circular front surface toric lens design provides the practitioner and the manufacturer with fewer variables with which to produce a successful lens for the patient.

The optical zone is centred. The amount of prism required for lens rotational stability is less than that needed for a truncated lens. This is because none of the prism base is removed in any secondary manufacturing steps.

An advantage for the manufacturer is that it is generally possible to reproduce the original lens design and thereby maintain successful lens wear if a replacement lens is required. A truncated lens is more difficult to reproduce.

13



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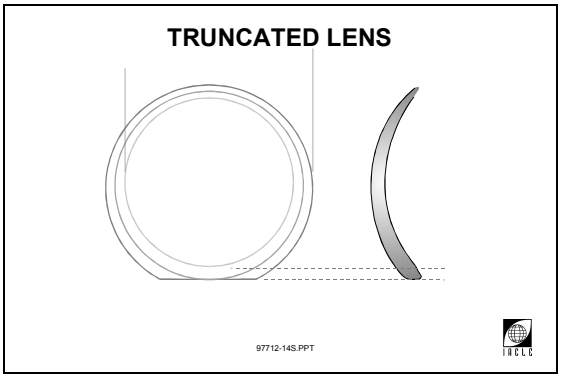
Truncated Design

A lens with an inferior truncation is used to minimize the rotational forces of the lids. This is achieved by shaping the base of the lens to match the contour and angular orientation of the lower lid.

Careful assessment of the lower lid margin is required to determine the likely effectiveness of using a truncation. If the lens rests too far from the lid, the interaction between lens and lid will be insufficient to stabilize the orientation of the cylinder axis.

14

14



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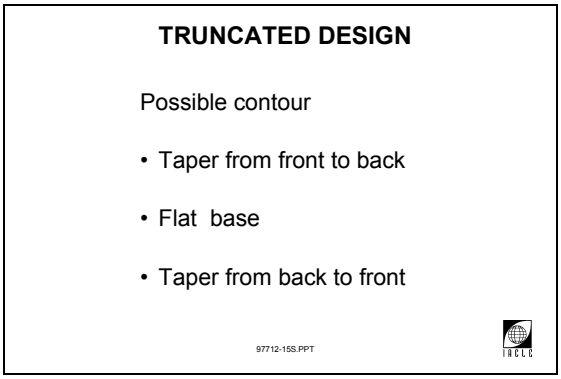
Prism ballast is also usually required in a truncated toric lens design. The amount of prism necessary will be influenced by the effectiveness of the truncation in resisting the rotational forces.

A truncated lens with prism ballast is intended to ride low on the cornea. To overcome the inferior decentration, the optical zone can be offset superiorly. This maximizes the pupil coverage and minimizes the risk of flare and other causes of degraded vision.

15



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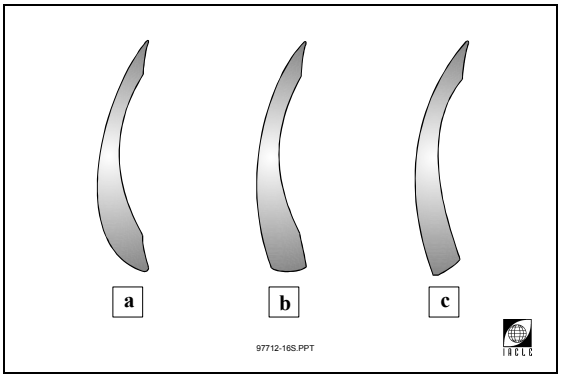

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Truncated Design

The contour at the prism base will control to some extent the dynamic fitting characteristics of the lens.

For maximum interaction between the prism base and the lower lid margin, the contour should be as flat as possible (lens b). This will assist in maintaining the meridional orientation of the lens. The edges must be rounded off to maximize comfort.

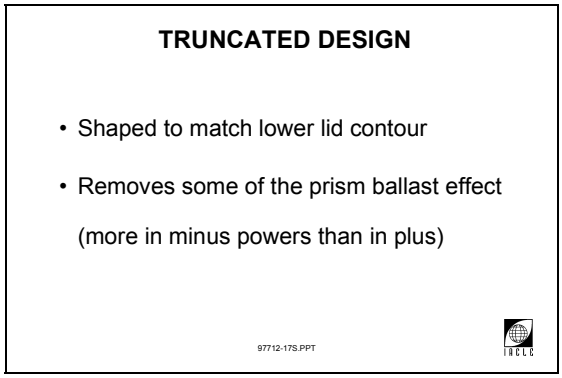
When the lens prism contour is tapered from the front to the back surface (lens a) the lens will:

- Have less interaction with the lower lid;
- Be able to slide behind the lid during the downward movement resulting from the upper lid force during a blink.

If the lens prism base is contoured so that the taper is from the back toward the front surface (lens c), the lens is likely to be very uncomfortable. This is due to the pressure exerted by the relatively small anterior portion of the lens base on the lower lid margin. An even distribution of the pressure is required for maximum comfort.

Any tapering of either the front or back surface will result in a decrease in the prism ballast effect. This may cause unstable meridional orientation.

17



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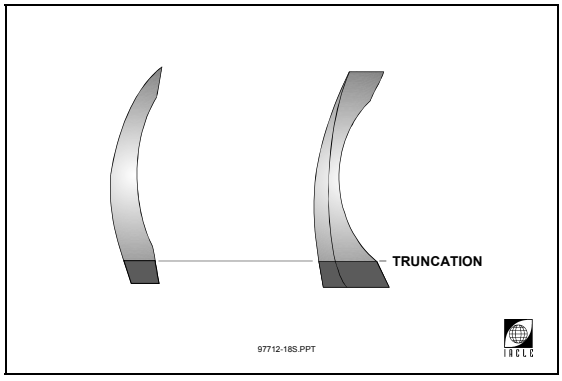
Truncated Design

The truncation must be aligned with the lower lid. As such, it will not necessarily be perpendicular to the base-apex meridian of the lens, due to the common base rotation in a nasal direction.

The truncation must be slightly rounded to maximize the comfort. If the edges of the truncation are not smoothed they will cause lower lid discomfort. This aspect of the design of a truncated lens is crucial for successful performance.

18



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The use of a truncation to promote lens stability by increasing the lens-lid interaction reduces the effectiveness of the prism ballast. This is because the lens thickness differential is also reduced. As a result, a truncated lens will require more prism ballast than a non-truncated lens, unless the truncation is able to resist the rotational forces.

This decrease in the effectiveness of the prism in a truncated design is most noticeable in higher minus powers because of the substantial loss of lens substance resulting from the rounding and chamfering of the lens edge along the truncation.

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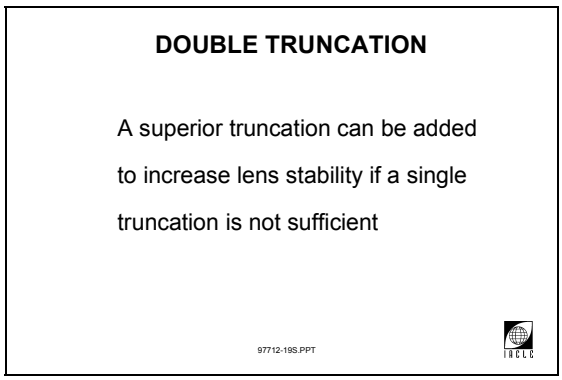

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Double Truncation

The use of an additional truncation in the superior part of the lens may help to increase the lens rotational stability. It may be useful when the patient has a very tight upper lid or when the palpebral aperture is small.

For maximum effect the upper lid margin has to be able to interact with the lens. The vertical lens total diameter is the key design feature.

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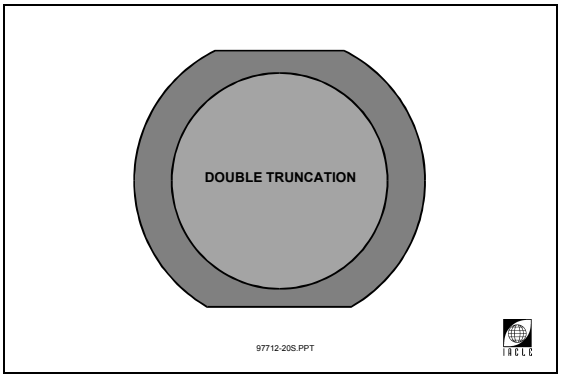

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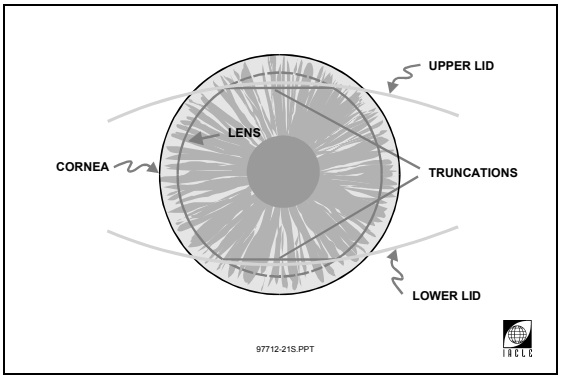

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III Back Surface Toric Lenses

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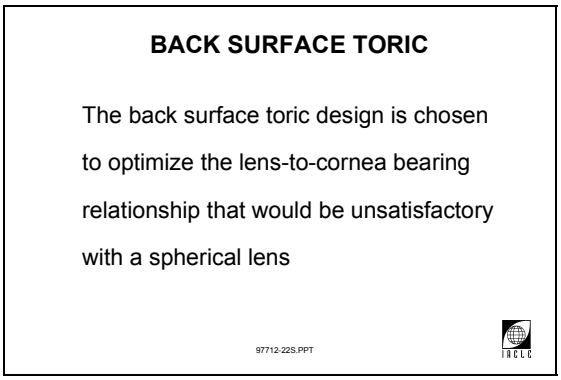

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Back Surface Toric

The decision to fit a cornea with a back surface toric RGP lens is based on the need to maintain an acceptable physical fitting relationship between the lens and the cornea. When a spherical back surface lens is fitted to a cornea with moderate to high toricity, areas of harsh bearing can be seen in the static fluorescein pattern. Such a fitting can cause significant optical, physical and physiological problems for the patient.

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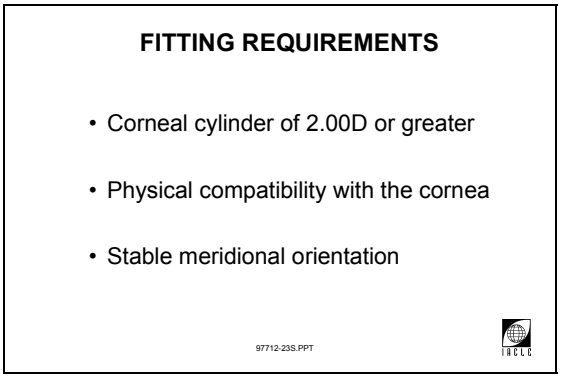

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Fitting Requirements

A significant amount of corneal toricity is necessary for a back surface toric lens to function reliably. At least two dioptres of corneal toricity is required to provide resistance to lens rotation. The correspondence between the back surface shape of the lens and the toricity of the cornea minimizes rotation.

Smaller amounts of corneal toricity make it difficult to locate the lens with the correct meridional orientation. If such a lens were to rotate on the cornea, the physical compatibility between the lens and the corneal surface would be poor, leading to discomfort and other problems for the wearer.

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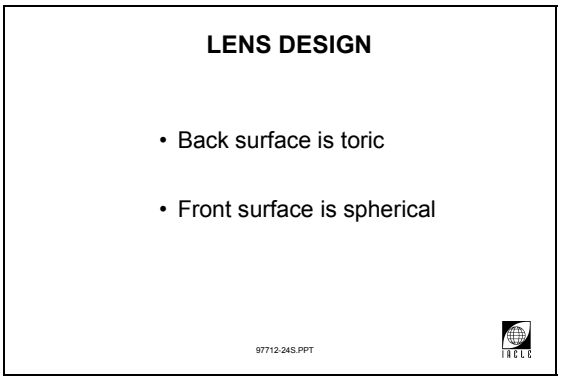

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Lens Design

In some cases the lens can be produced with a toric back surface and a spherical front surface. The toric back surface provides the correct physical fitting relationship with the cornea. As long as there is no significant residual astigmatism in the over- refraction, the spherical front surface curvature will provide a full correction. Sometimes a small adjustment to the radius of one back surface meridian is required to optimize the refractive correction.

This situation is rare, and in most cases, when a back surface toric lens is required for an optimal physical fitting, an astigmatism correcting cylinder must be cut on the front surface of the lens for

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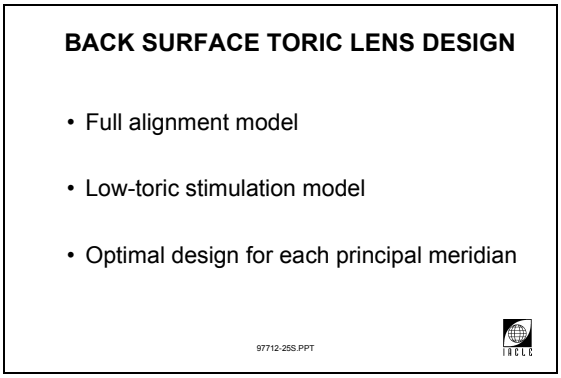

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maximum visual performance. In this case both the front and back surfaces are toric. Such a lens is referred to as a bitoric.

IV Bitoric Lenses

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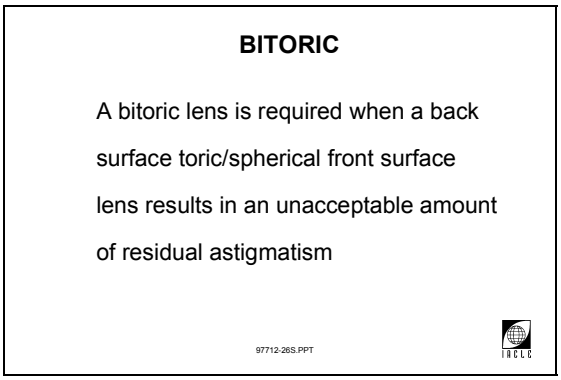

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Bitoric Lenses

A bitoric lens is required in many cases as a back surface toric/front surface sphere lens will result in an excessive amount of residual astigmatism. This can be corrected by producing a front surface cylinder.

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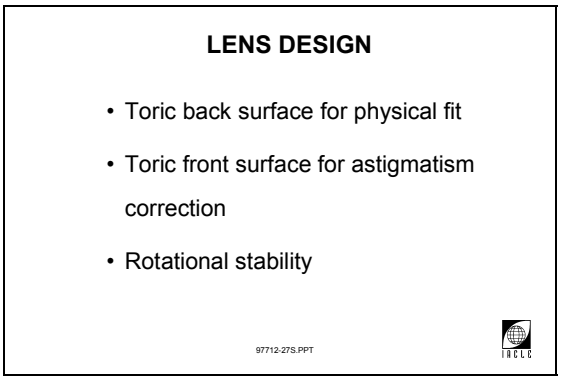

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Lens Design

To best understand the design and principles of a bitoric lens, the back surface should be thought of in terms of its ability to provide an acceptable physical fitting relationship with the cornea. The lens front surface design then has to provide the visual correction for both the spherical and cylindrical components.

Successful bitoric RGP lenses must maintain a stable orientation on the cornea to allow the front surface cylinder to provide an optimal visual correction. The rotational stability is usually achieved by a close physical fitting relationship between the lens back surface and the cornea. If adequate lens stability cannot be obtained in that manner, the addition of prism ballast is an option.

V Peripheral Toric Lenses

28

PERIPHERAL TORIC

- A toric periphery with a spherical back optic zone is designed to improve the fit on the cornea of moderate toricity

97712-28S.PPT

3L797112-28

Peripheral Toric

Peripheral toric RGP lenses are modified spherical designs. The BOZD of the lens is spherical and only the peripheral curves are manufactured with a toric design. This is a relatively simple lens to produce. The toric periphery has no effect on the visual correction. The lens can rotate on the cornea without compromising visual performance.

Physically, the lens will have a better peripheral fitting relationship with the cornea as long as it is rotationally stable.

29

PERIPHERAL TORIC

- A toric peripheral curve(s) design allows even bearing and/or clearance at the periphery, resulting in improved centration and comfort

97712-29S.PPT

3L797112-29

Peripheral Toric

The peripheral toric design may be employed in cases where:

- An acceptable central fitting pattern is observed.
- The peripheral axial edge clearance along the steeper corneal meridian is unacceptably large.

In such cases, the lens stability may be improved by more closely matching the peripheral corneal toricity with the peripheral curves of the lens.

The degree of peripheral corneal toricity is generally determined by trial lens fitting. However modern topographical corneal mapping systems may also be used as a guide.

30

LENS DESIGN

- Spherical back optic zone
- Toric back peripheral curves
- Spherical front optic zone and peripheral curves
- oval shaped optic zone

97712-30S.PPT

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Lens Design

By making the peripheral curves toric, the optical zone of the lens will be elliptical in shape. The smaller optical zone diameter will be oriented along the flatter principal meridian of the cornea.

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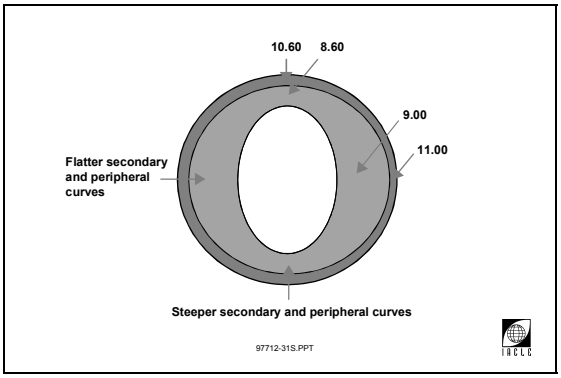

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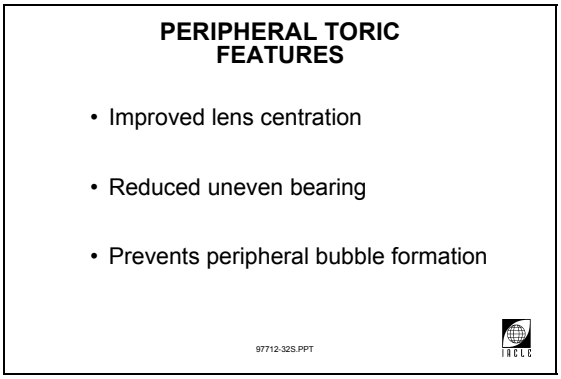

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Peripheral Toric Features

Toric peripheral curves are useful in cases where the peripheral corneal toricity is greater than that measured centrally.

By producing toric peripheral curves on an RGP lens, the physical fitting relationship between the lens and the cornea will be improved.

Improved fitting characteristics include:

- Better and more stable centration.
- Reduced localized bearing on the corneal periphery.
- Reduced risk of bubble formation at the periphery which may occur due to excessive edge clearance.

VI Manufacturing Toric Lenses

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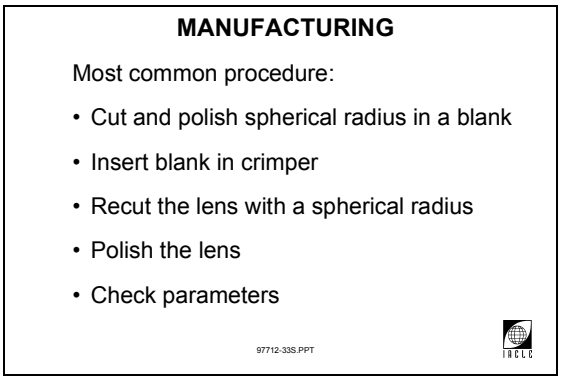

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Manufacturing: Most Common Procedure

The following manufacturing procedures are described in Bier and Lowther (1977).

The manufacturer cuts a spherical back surface on a button which is then placed in a crimper, or collar, which can apply pressure across the diameter. The pressure of the collar produces a toric surface which can be controlled by increasing the pressure until the desired amount of toricity is achieved.

The button, which is in the collar, is then placed on a lathe. A spherical surface is cut and then polished. When the pressure of the collar is relaxed the flexed button will return to its original state which will be toric.

The same technique can be applied to both the front and back surfaces of the lens and may therefore produce a back surface only toric, a front surface only toric or a bitoric lens.

Toric surfaces can also be ground by using toric tools or toric lens generators. The main disadvantage of the former technique is the large number of tools required to cover all the possible combinations of curves which are needed.

The disadvantage of toric generators is that they are usually limited to front surface designs and the complexity of the curves they can generate is limited.

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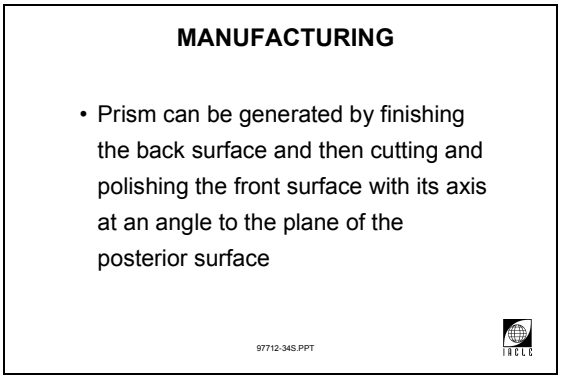

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Manufacturing

Prism ballast is created using a mounting tool whose angular relationship to the main axis of the tool is adjustable. By tilting the semi-finished lens button so that its front surface is no longer perpendicular to the lathe axis, prism is generated.

In practice, a series of fixed-tilt mounts may be employed where each mount offers a unique amount of prism. Alternatively, a continuously adjustable mount may be used.

Tutorial 3.7

(1 Hour)

Corneal Astigmatism and Toric RGP Contact Lenses

Slide Presentation

Name:_____ Date:_____

Instructions: The fluorescein patterns of various RGP lenses with spherical and toric BOZRs will be presented. Describe the fitting patterns and how they might be altered to improve the lens fit.

1. Fit description

_____

_____

_____

Recommended change of lens parameters

_____

_____

2. Fit description

_____

_____

_____

Recommended change of lens parameters

_____

_____

3. Fit description

_____

_____

_____

Recommended change of lens parameters

_____

_____

Case: A patient's refractive error is -4.0 DS/-3.0 DC X 180 with K readings of 42.00 DH/45.00 DCV. The patient requires a toric RGP lens.

Calculate:

1. The induced residual astigmatism of a toric back surface lens on the above eye.

   Result:

2. The back vertex power of a (thin) RGP toric lens (back surface or bitoric) and the lens surface powers that would correct the above refractive error (assume refractive index of tears is 1.337 and the RGP material is 1.48).

   Result:

🕮 References

Bier N, Lowther GE (1977). *Contact Lens Correction*. Butterworths, London.

Mandell RB (1988). *Contact Lens Practice*. 4th ed. Charles C Thomas Publisher, Springfield.

Phillips AJ, Stone J (Eds.) (1989). *Contact Lenses.* 3rd ed. Butterworth & Co (Publishers) Inc., London.

Ruben M, Guillon M (1994). *Contact Lens Practice*. Chapman and Hall Medical, London.

Unit 3.8

(5 Hours)

Lecture 3.8: Fitting Toric RGP Contact Lenses

Practical 3.8: Toric RGP Contact Lens Fitting and Assessment

Course Overview

Lecture 3.8: Fitting Toric RGP Contact Lenses

I. Lens Selection
II. Front Surface Toric Fitting and Stabilization
III. Back Surface Toric Fitting and Stabilization (prediction from calculation)
IV. Assessment of Fit
V. Final Lens Order

Practical 3.8: Toric RGP Contact Lens Fitting and Assessment

- Selection of Lens Type
- Assessment of Fit
- Deciding on Alterations to Lens Parameters

Lecture 3.8

(2 Hours)

Fitting Toric RGP Contact Lenses

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I.B Front Surface Toric Lenses 321
I.C Truncated Front Surface Toric Lenses 331
I.D Back Surface Toric Lenses 334
I.E Bitoric Lenses 343
I.F Peripheral Toric Lenses 348

I Fitting Toric RGP Contact Lenses

I.A Indications for Use

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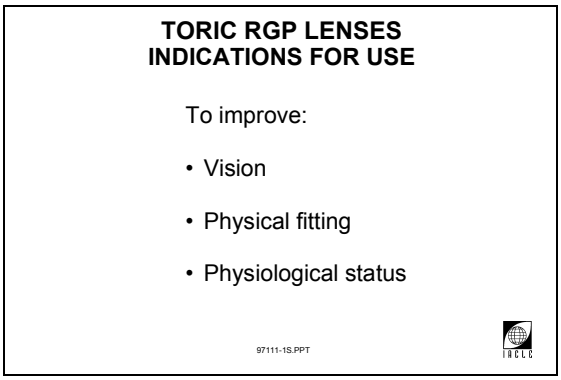

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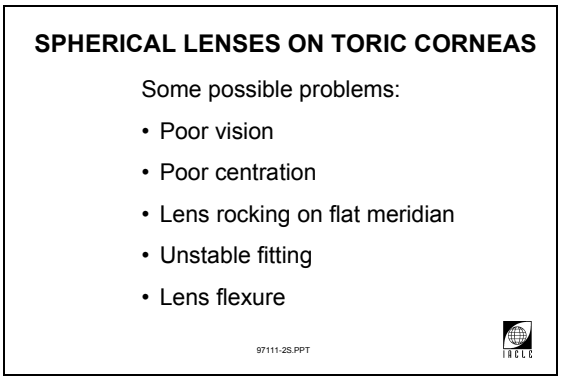

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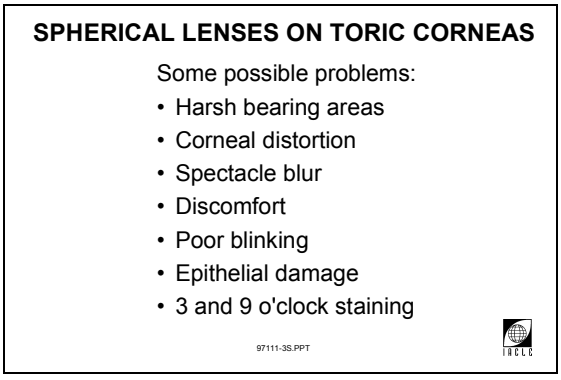

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Spherical Lenses on Toric Corneas

As refractive and/or corneal astigmatism increases, the likelihood of achieving an acceptable spherical RGP lens fitting diminishes. The problems that may be encountered are numerous and include the following:

- **Poor vision.** This may be due to residual astigmatism, unstable fitting characteristics and lens flexure.
- **Poor centration.** This may be due to the lack of physical compatibility between the lens and the cornea.
- **Lens rocking on flat meridian.** This can cause greater lens awareness and visual instability.
- **Unstable fitting.** Poor physical compatibility between the lens and the cornea will cause the lens to move excessively and to centre poorly.
- **Lens flexure.** As the cornea becomes more toric, a spherical RGP lens is more likely to flex to conform to the corneal shape. This can reduce the quality of vision.
- **Increased bearing pressure.** If the back of the RGP lens and the cornea are not physically compatible, areas of the cornea will be exposed to increased bearing pressure as the lens presses against the surface.
- **Corneal distortion.** Continuous pressure of an RGP lens against the

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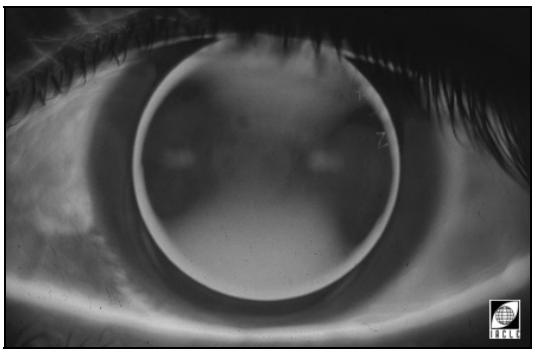

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cornea may cause the corneal shape to alter in either a regular or irregular manner.

- **Spectacle blur.** Any change in corneal shape may affect the refractive status of the eye. This may cause a visual problem when the patient transfers from contact lenses to spectacles.
- **Poor blinking due to discomfort.** If the lenses are uncomfortable, the patient is less likely to blink properly. This may affect the frequency of blinking and/or the completeness of each blink.
- **Epithelial damage.** Any significant degree of physical incompatibility between the lens and the cornea may cause damage to the epithelium due to the increased bearing that is produced.
- **3 and 9 o'clock staining.** Poor lens centration, movement and physical incompatibility with the cornea are likely to result in an increased level of 3 and 9 o'clock staining.

Slide 4 is an example of a spherical lens on a toric with-the-rule cornea, where the fluorescein pattern clearly shows excessive localized clearance and bearing - an unacceptable fitting pattern.

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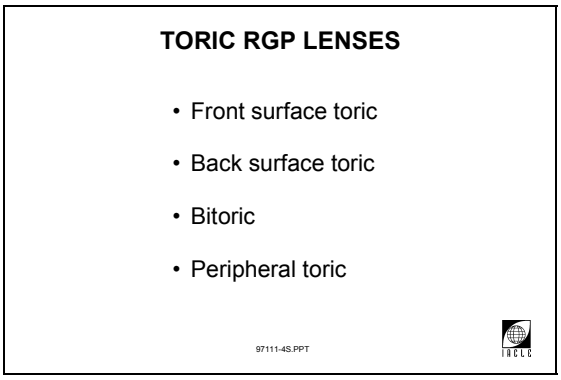

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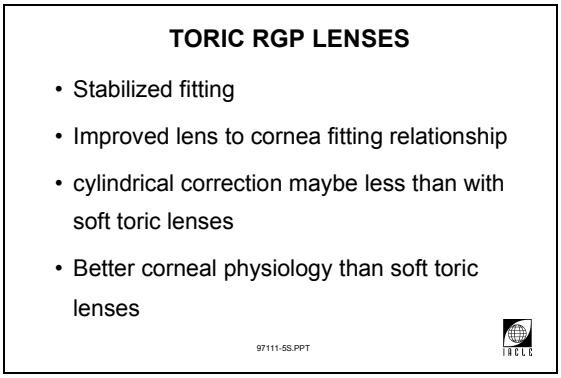

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Toric RGP Lenses

Advantages

The fitting of toric RGP lenses will, in many cases, provide the patient with significant advantages over soft toric lenses or inadequately fitting spherical RGP lenses.

As corneal astigmatism increases the fitting characteristics of a spherical RGP lens will become less stable.

An RGP lens can be readily manufactured to provide a suitable back surface shape to match that of the cornea. Physical compatibility between the lens and the cornea is important for successful long term wear.

The quality of vision is optimized by the rigidity of the material. The required astigmatic correction is often less with an RGP lens due to the effects of the tear lens.

The physiological benefits of RGP lenses over soft lenses are well known. These benefits result from the high level of oxygen that can be supplied to the cornea by the highly permeable materials and the significant tear exchange that occurs with each blink.

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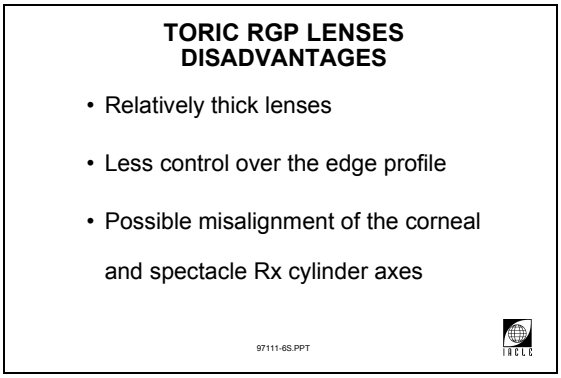

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Toric RGP Lenses

Disadvantages

Although the potential advantages of toric RGP lenses are considerable, disadvantages do exist and must be recognized.

Toric lenses are thicker than standard spherical lenses and can cause problems for some patients due to:

- Increased lens awareness.
- Increased levels of 3 and 9 o'clock staining.
- Reduced oxygen permeability.

An optimum lens edge profile is important for maximum comfort with any RGP lens. Lack of uniformity can cause a transient or persistent decrease in the level of comfort. In some cases the production of a toric lens makes it more difficult to ensure an

overall uniform edge profile.

Significant differences between the corneal and spectacle cylinder axes may cause a problem with the correction of any residual astigmatism when a front surface cylinder must be produced on the lens. In such cases the principal meridians on the back and front surfaces of the lens will be misaligned. This presents the manufacturer with a challenge to produce a lens of optimum quality.

I.B Front Surface Toric Lenses

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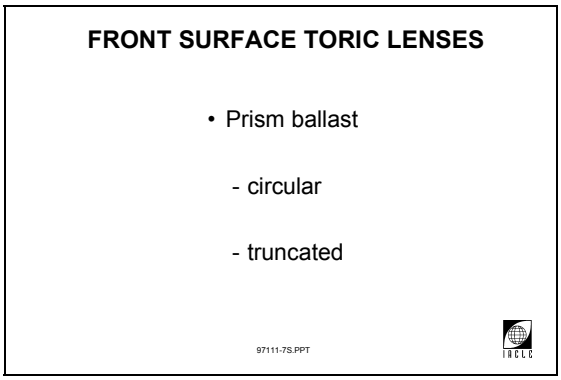

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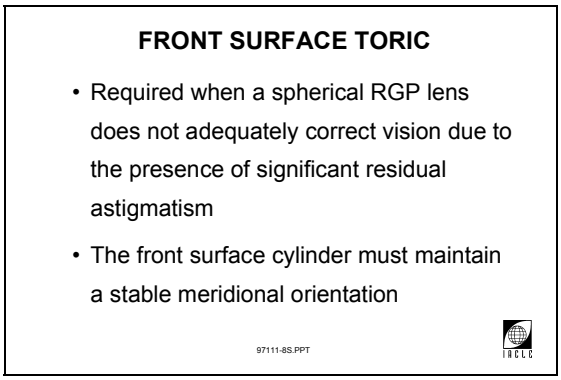

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Front Surface Toric

If other lens options have been considered and found to be unsatisfactory, the front surface toric RGP can be a simple solution to the problem of astigmatic correction.

In most cases the amount of residual cylinder that requires correction with a front surface toric RGP lens will be considerably less than with a toric soft lens. This is due to a partial correction of the refractive cylinder resulting from the neutralization of the corneal cylinder by the tear lens.

Since the residual cylinder axis does not change, the correcting cylinder on the front of the RGP toric lens must also remain oriented along a meridian to provide maximal visual correction.

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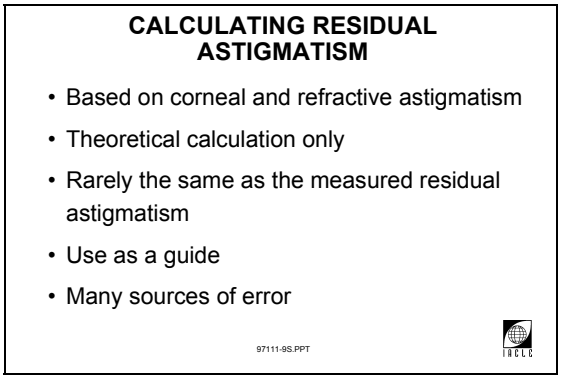

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Calculating Residual Astigmatism

When working with toric RGP lenses it is always worthwhile to calculate the expected residual cylinder that would be present if a non-flexing spherical lens were on the cornea.

The calculated residual astigmatism, total refractive astigmatism and corneal astigmatism are related to one another by the following formula:

$$CRA = TRA - CA$$

It is important to recognize that the formula will only give an approximate result which can be used as a guide to determining the best course of action when fitting the patient. It is advisable to apply a lens to the cornea to ascertain the sphero-cylindrical over- refraction data.

There are many sources of error in calculating the residual astigmatism. Some of these include:

- Inaccurate keratometry calibration and/or measurement.
- Inaccurate ocular refractive information.
- Significant misalignment of the axes of the refractive and corneal cylinders.

The measured residual astigmatism may also be significantly different from the calculated residual astigmatism due to the flexure of the RGP lens on the cornea.

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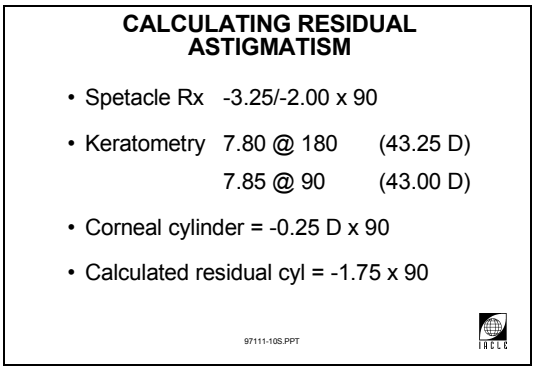

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Calculating Residual Astigmatism

In this example, a spherical RGP lens fitted to the cornea requires a –1.75 D cylinder at an axis of 90 degrees to provide the highest quality vision.

To correct the patient's refractive error with an RGP lens, the correcting cylinder can be applied to the front surface of the lens, which must maintain a stable meridional orientation to prevent visual fluctuation.

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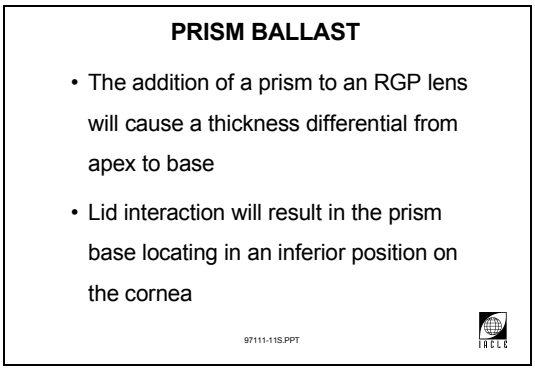

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Prism Ballast

Normal lid forces acting on a spherical RGP lens often cause the inferior lens edge to rotate in a nasal direction i.e. anticlockwise for the right eye and clockwise for the left eye.

To overcome normal rotational forces, the RGP lens must be designed so that its orientation on the cornea is more stable.

The most common method of ensuring stability is to manufacture the lens with a prism incorporated in the design.

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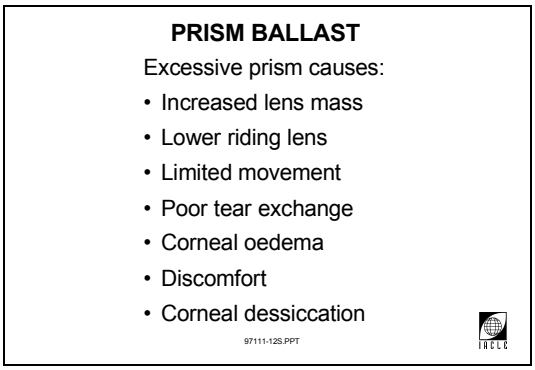

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Prism Ballast

When fitting prism ballast RGP toric lenses it is best to use the minimum amount of prism possible to maintain the meridional stability of the correcting cylinder.

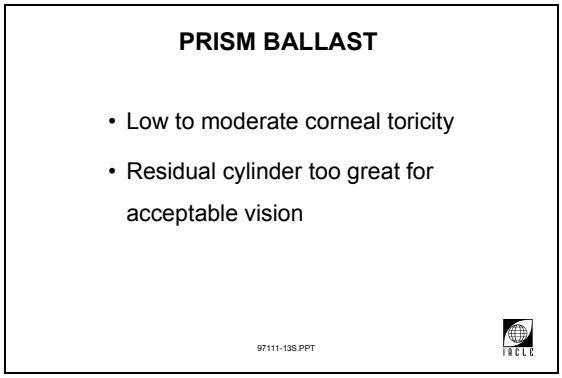
For some patients any amount of prism ballast will cause problems. Each case must be assessed individually. Excessive prism may cause the following problems:

- **Increased lens mass.** Any amount of

prism will increase the lens mass which may adversely effect the dynamic fitting characteristics.

- **Lower riding lens.** A well centred RGP lens is likely to ride lower on the cornea when the design incorporates prism. Excessive decentration may cause the lens to ride onto the inferior limbal region.
- **Limited movement.** The increased mass of the lens may retard the movement with and after a blink. It is vitally important to ensure that the lens design permits some post blink movement. If it does not, increased levels of 3 and 9 o'clock staining are highly probable.
- **Poor tear exchange and debris removal.** Any limitation in the amount of movement reduces the post-lens tear exchange and the ability of the tears to remove the build-up of debris that occurs with RGP lens wear.
- Corneal oedema; added lens thickness will decrease oxygen transmissibility, particularly in the inferior 1/3 of the lens. Reduced tear exchange due to reduced lens movement will also increase the risk of corneal oedema.
- Lid discomfort; increased lens-lid interaction, particularly inferiorly where the lower lid margin interacts with the prism base, can result in greater discomfort for the wearer.
- Corneal desiccation; the added lens thickness, reduced lens movement and any reduction in blink rate due to discomfort increase the risk of corneal desiccation, in particular 3 and 9 o'clock staining.

14



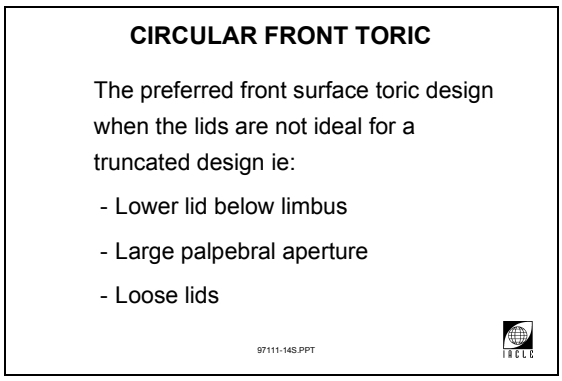
3L897111-13

Prism Ballast

Since the back surface of the lens is spherical, it is important to achieve an optimum physical fitting relationship to maximize the chance of success. As the degree of corneal toricity increases, the fitting characteristics become more compromised and some of the problems associated with front surface toric RGP lenses may be exacerbated.

Cases where a good fitting can be achieved with a spherical RGP lens but the quality of the vision is poor due to the level of residual astigmatism are ideal candidates for a front surface toric design.

15



3L897111-14

Circular Front Toric

The circular front surface toric lens is much more frequently prescribed than the truncated design. It is the lens of choice when the lids are not ideal for the interaction between lens and lower lid margin which accompanies the use of a truncation. A circular prism ballast lens is indicated when:

- The palpebral aperture is large.
- The lower lid margin lies below the inferior limbus
- The lids have very low level of tonus.

Compared with the truncated lens, the circular front toric lens is easier to design and manufacture and there are fewer considerations for the practitioner when prescribing them for the patient.

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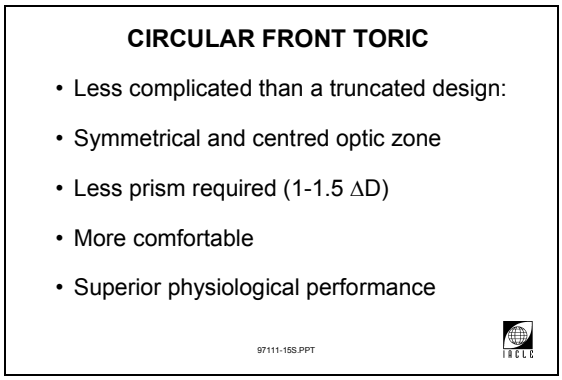

3L897111-15

Circular Front Toric

Since the circular front toric lens is easier to fit and design than the truncated lens, it is generally the lens of first choice. Compared with a truncated lens its advantages include:

- The back optic zone is symmetrical about the geometric centre of the lens. This makes manufacturing easier and reproducibility higher.
- Generally smaller amounts of prism are required to stabilize the cylinder axis.
- The reduced prism results in a thinner overall lens profile. This can contribute to greater comfort and better physiological performance.

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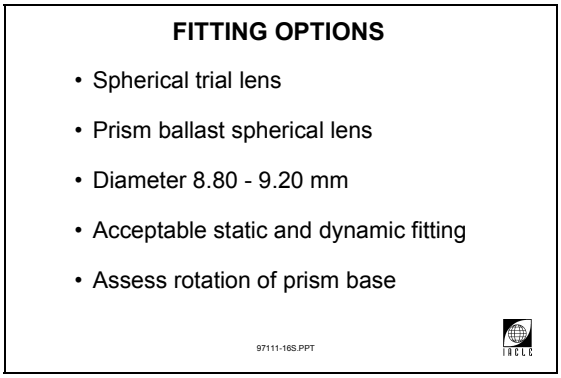


3L897111-16

Fitting Options

A number of options are available to the practitioner when electing to fit a patient with a circular prism ballast front surface toric RGP lens.

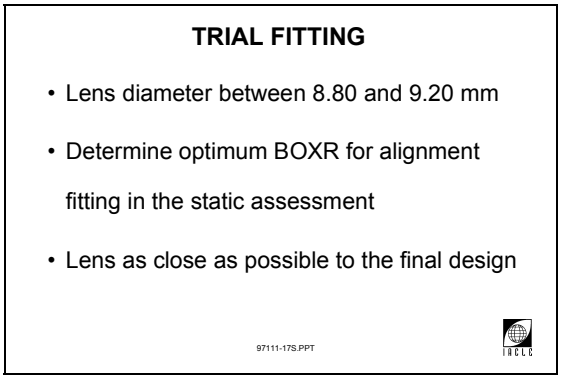
The desired outcome is:

- Stable fitting.
- Adequate dynamic and static characteristics.
- Correct meridional orientation for the cylindrical correction.

A spherical trial lens may be used to determine the static fitting characteristics as well as the final sphero-cylindrical refraction. However the use of a spherical lens will not provide an accurate assessment of the dynamic fitting characteristics including the amount of lens rotation due to lid influences.

To overcome the limitations of spherical trial lenses, the practitioner can use a trial set that is manufactured with a specified amount of prism incorporated into each lens. These lenses allow for determination of the degree of rotation due to lid influences. A more accurate meridional orientation of the cylinder axis will be obtained in the final lens order.

18



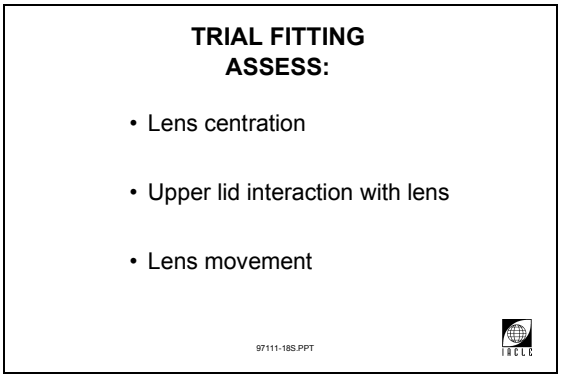
3L897111-17

Trial Fitting Use

When trial fitting, a lens that is as close as possible to the final design to be ordered should be used. One of the most important lens parameters to consider is lens total diameter. If a trial lens with an excessively large diameter is used, the final lens can have significantly different dynamic fitting characteristics when the prism is incorporated. This is due to the thickness differences and substantial weight increase that will occur with the incorporation of the prism ballast.

As a general rule, smaller (8.80 mm) diameter lenses are used for corneas with steeper than average curvatures and/or smaller diameters. Larger (9.20 mm) diameter lenses are more suitable for patients with flat corneal curvatures and/or larger corneal diameters.

19



3L897111-18

Trial Fitting

Assess

The trial fitting assessment should include all the dynamic and static lens fitting characteristics that are important for any RGP lens. Key factors for careful analysis include:

- **Centration.** The prism ballast lens will tend to ride low on the cornea. If a non-ballasted trial lens is used, ensure centration is acceptable, as problems such as riding excessively low will be accentuated once the prism is added to the design.
- **Lid interaction and lens movement.** If a prism ballast trial lens shows very little movement with each blink, the design needs to be altered to increase the movement. A thick, non-moving lens is likely to cause problems such as 3 and 9 o'clock staining.

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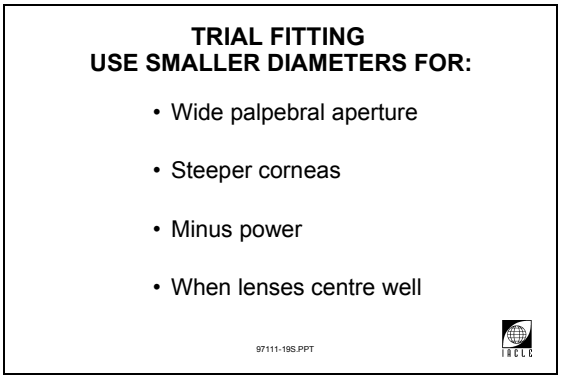


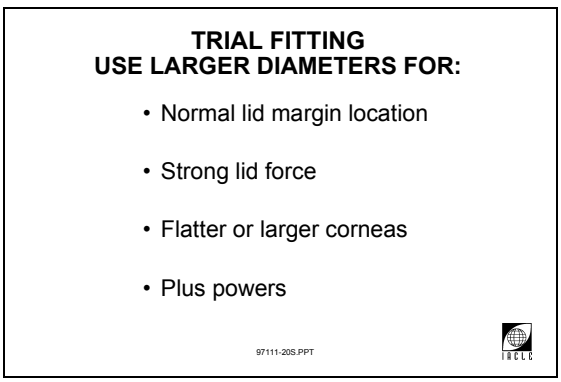
3L897111-19

Trial Fitting

When fitting front surface toric RGP lenses, it is best to use the smallest possible lens total diameter that provides acceptable dynamic performance characteristics. Features the practitioner must assess when determining the appropriate lens diameter include:

- Palpebral aperture size.
- Lid characteristics.
- Corneal topography.
- Lens power.
- Lens centration.

21



3L897111-20

22

LENS ROTATION

- Base of the lens will generally rotate nasally due to lid forces
- Allow for rotation when ordering (10 to 15 degrees by convention)
- Assess degree of rotation if using a prism ballast trial lens
- Compensate for rotation when ordering front surface cylinders

97111-21S.PPT

3L897111-21

Lens Rotation

The direction of the forces applied to a lens during blinking frequently result in the inferior (6 o'clock) edge of the lens rotating toward the nose. In the right eye this results in an anticlockwise rotation and in the left eye a clockwise rotation.

When ordering the lens on an empirical basis, or if using spherical trial lenses, the rotational effects must be allowed for by assuming that rotation will occur when the final prism ballast lens is fitted. The allowance is typically 10-15 degrees in the nasal direction. The lens manufacturer's advice should be sought when taking this fitting approach.

A more accurate assessment of the degree of rotation may be made if a prism ballast trial lens is used. The practitioner can directly measure the rotation and then order the appropriate cylindrical axis with greater confidence.

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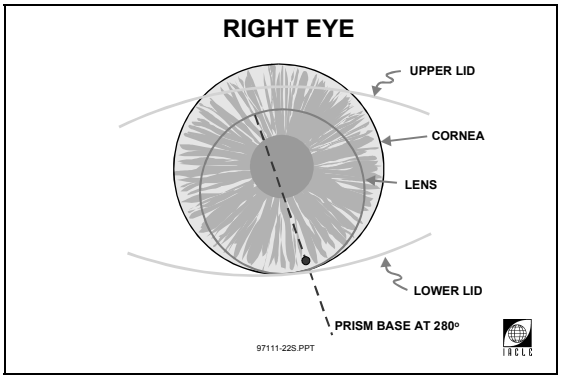

3L897111-22

24

ASSESSING ROTATION

- Use a prism ballast trial lens
- Align a narrow slit lamp beam with base-apex meridian and read from the scale
- Trial frame and cylindrical trial lens
- Estimate using clockface

97111-23S.PPT

3L897111-23

Assessing Rotation

An accurate assessment of lens rotation is the key to success with front surface toric lenses. A number of methods may be used by the practitioner to determine the correct cylindrical axis.

If the lens does not rotate, and the prism base remains at the 6 o'clock position, the contact lens and the refractive cylindrical axis will be coincident and no compensation is required. If the prism base does rotate from the vertical meridian, a compensation must be made when ordering the contact lens cylinder axis. This will enable the correct cylindrical alignment to be achieved.

The use of a prism ballast trial lens of suitable design will permit the practitioner to assess the rotation accurately.

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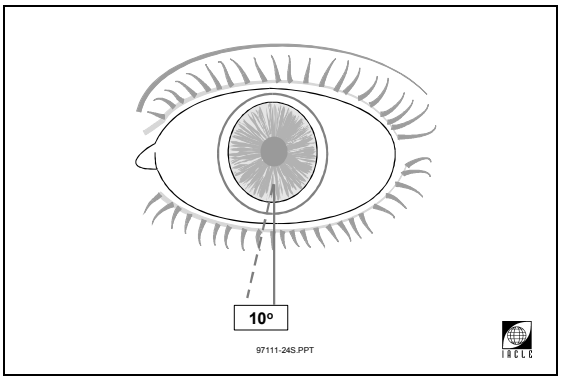
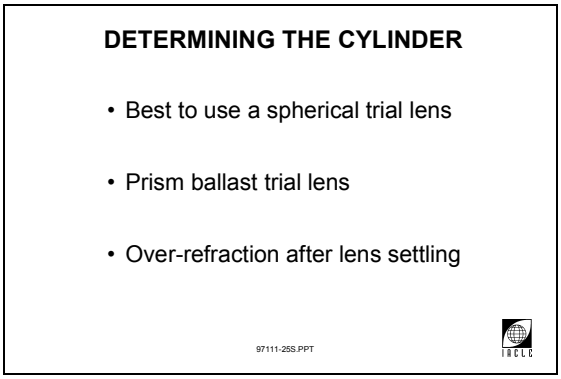


3L897112-24

One method of assessing the rotation is to align a narrow slit-lamp beam along the base - apex meridian and then read off the degrees of rotation from the scale on the slit-lamp's illumination system.
Another technique is to place a trial frame on the patient and use an engraved cylindrical lens which can be rotated to align with the base - apex meridian. The amount of rotation can then be read directly from the trial frame.
An experienced clinician may be able to accurately assess the rotation by observation. If the cornea is divided into a clock face, each hour represents 30 degrees. A further subdivision into 10 degree steps may be used to estimate the rotation of the base - apex meridian.

26

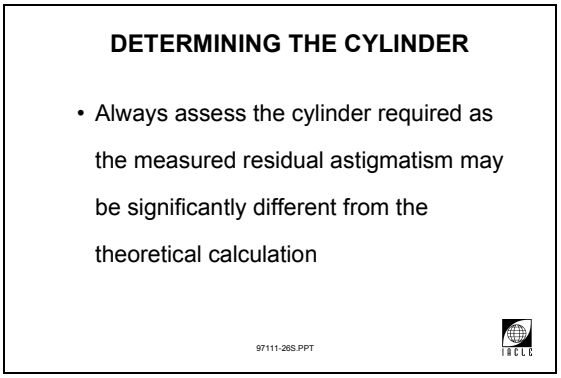


3L897111-25

Determining the Cylinder

An accurate over-refraction is important when determining the required cylindrical correction. It is best to use a spherical diagnostic lens for the assessment of the cylindrical power as the practitioner can be more confident of the final result.
A prism ballast trial lens that has only spherical power will also be suitable for the assessment of the cylinder.
To ensure accuracy, all assessments of lens stability, rotation and required sphero-cylindrical power must be undertaken after adequate lens settling time.

27



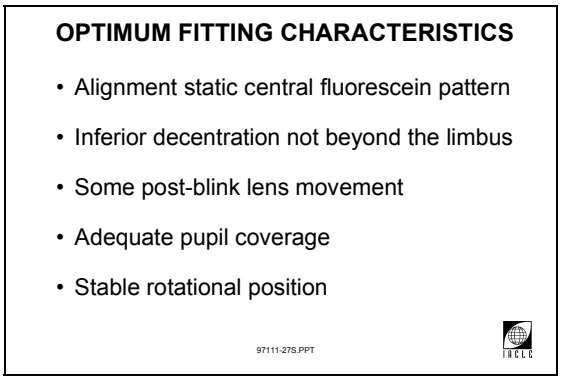
3L897111-26

Determining the Cylinder

Assessing the cylindrical power should be done in a careful and methodical manner. A subjective over-refraction with a suitable trial lens in place should provide the most accurate guide to the required cylindrical prescription.

Any theoretical calculations should be in close agreement with the subjective results. When significant differences occur, the reasons for the discrepancy need to be investigated.

28



3L897111-27

Optimum Fitting Characteristics

The following guidelines will help the practitioner provide the patient with a lens that performs satisfactorily:

- An alignment central fitting pattern is ideal as it gives the best chance of achieving stability and good movement.
- Most front surface toric lenses will decentre inferiorly. Excessive decentration beyond the limbus should be prevented as it is likely to result in discomfort and poor visual performance.
- Some movement (> 0.5 mm) is needed for successful performance. The weight of the front surface toric lens may result in reduced movement. An immobile lens will, in most cases, cause significant problems such as 3 and 9 o'clock staining.
- Since most front surface toric lenses decentre, the practitioner must give careful consideration to the degree of pupil coverage. Inadequate coverage will result in visual problems. These are most likely to be apparent at night when the pupil is dilated.
- For optimum vision, the front surface toric lens must be rotationally stable to ensure that the cylindrical correction is properly aligned. Variable rotation with each blink can result in substantial visual disturbance.

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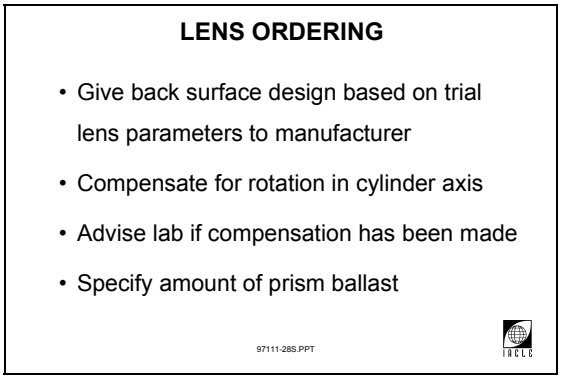


3L897111-28

Lens Ordering

Ensure that the design of the back surface of the trial lens and all other parameters are given to the manufacturer.

Any lens rotation that results in the base-apex meridian not being vertically oriented must be taken into consideration when ordering the final axis of the correcting cylinder. Failure to do so will result in a decrease in the quality of vision due to an off-axis cylindrical component.

30

VERIFYING FRONT SURFACE TORICS

- Focimeter
- Assess prism power
- With the prism base down measure the sphere, cylinder and axis
- Optics may be slightly distorted due to abberrations in the lens

97111-29S.PPT

3L897111-29

When specifying the prism ballast, use the least amount necessary to maintain rotational stability of the lens. Do not leave the decision on the amount of ballast to the manufacturer.

Verification of the parameters of a front surface toric lens is more difficult compared with a spherical lens. Despite the technical problems, the information obtained is useful for understanding the on-eye lens performance.

31

LENS ORDERING

- Give back surface design based on trial lens parameters to manufacturer
- Compensate for rotation in cylinder axis
- Advise lab if compensation has been made
- Specify amount of prism ballast

97111-28S.PPT

3L897111-30

Lens Ordering

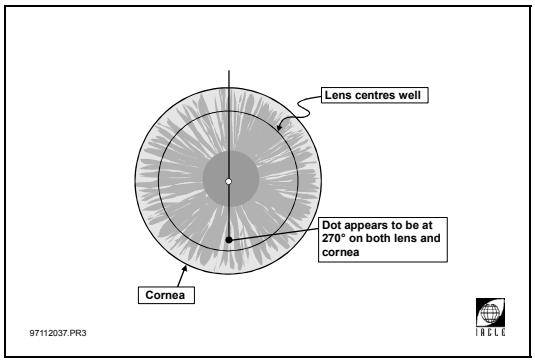
Before ordering a lens, the practitioner must ensure that the true rotational component has been evaluated.

An invalid assessment of the degree of rotation can occur if the horizontal decentration of the lens is not taken into account. The lens may have decentred in a nasal or temporal direction, but not necessarily rotated. In such cases the base-apex line maintains a vertical orientation.

Lens rotation should be assessed with the patient looking in the primary gaze position. The practitioner must consider the possibility that the rotation may be different in other directions of gaze.

As the amount of rotation can be unpredictable there is a need for careful assessment of lens movement and cylinder axis compensation.

32



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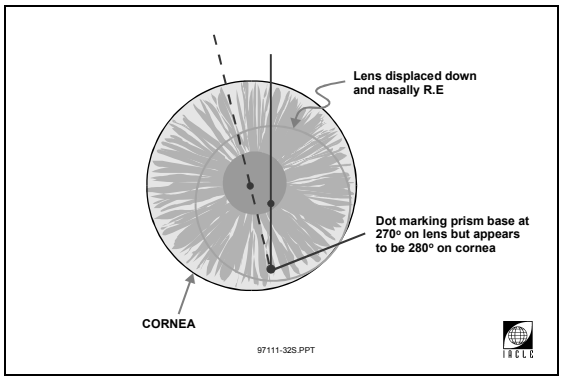

3L897111-32

I.C Truncated Front Surface Toric Lenses

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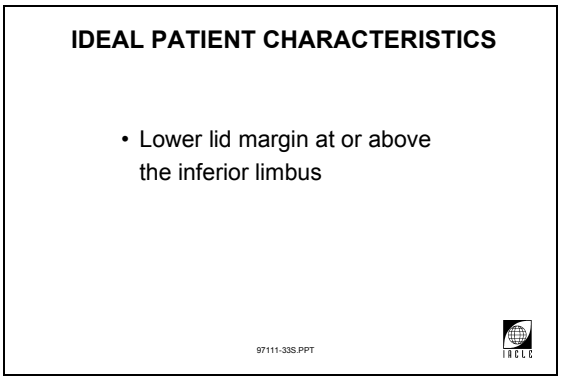

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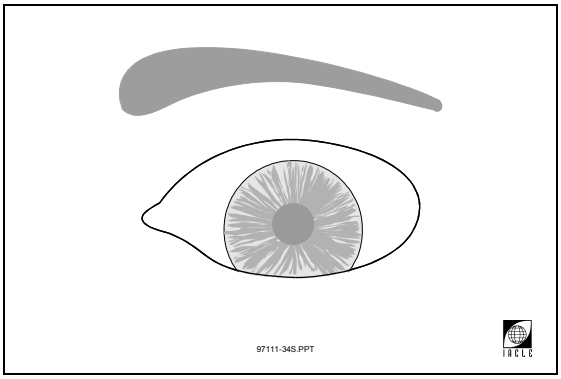


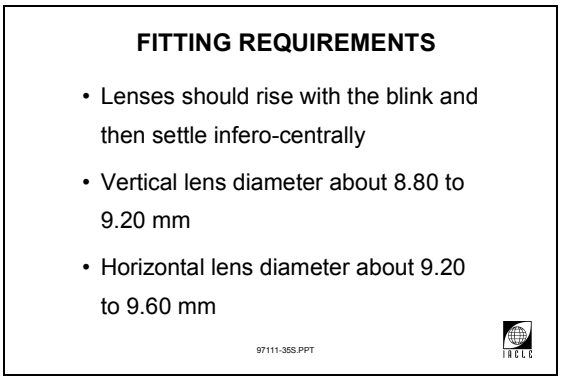
3L897111-34

Ideal Patient Characteristics

A lens truncation should be tried only when the lower lid position makes it possible to maximize the interaction with the base of the lens. If the lower lid margin is below the inferior limbus, the stabilizing interaction with the lens will be minimal.

The upper lid position is not as important. However it should be slightly higher than normal on the cornea and of moderate to loose tension. If the upper lid is lower on the cornea and/or tight, its influence on lens behaviour may counter the effect of the truncation.

36



3L897111-35

Fitting Requirements

The principal fitting consideration with a truncated lens is the quality of the interaction between the lens base and the lower lid margin. This must be optimized to maintain lens orientation and for adequate comfort.

Lens movement must be carefully assessed. Typically, truncated lenses move up with each blink and then reposition inferiorly to rest against the lower lid. Inadequate lens movement of 0.5 mm or less will often result in complications such as peripheral corneal desiccation.

37

LENS REQUIREMENTS

- Optic zone large enough for adequate pupil coverage in low illumination
- Upper lens edge well rounded and polished
- Truncation designed to match the lower lid contour
- Truncation should be square for maximum interaction with the lid margin
- No sharp junctions which cause discomfort

97111-36S.PPT

3L897111-36

38

LENS REQUIREMENTS

- Truncation temporal to the base-apex meridian by 10-15 degrees for maximum lid interaction
- More prism (1.25 to 1.75 ΔD) required in higher minus powers due to loss of ballast effect with truncation
- Offset the optical zone superiorly by 0.5 mm to maintain pupil coverage

97111-37S.PPT

3L897111-37

Lens Requirements

The design for a truncated RGP lens is more complicated than that for a circular lens.

A number of key features need to be considered to ensure optimal performance:

- The lens must ride low on the cornea to interact with the lid margin.
- If the optical zone is too small the coverage of the pupil may be inadequate in dim illumination.
- Careful consideration must be given to the BOZD required.
- For maximum comfort the upper, or apex, lens edge must be well rounded and polished. This is a key consideration since a low riding lens increases the chance of greater upper lid-lens interaction.

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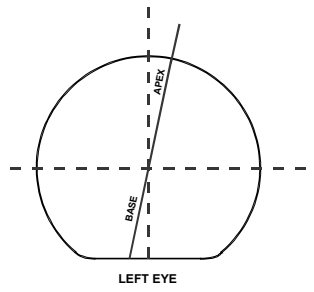

97111-38S.PPT

3L897111-38

Truncation Offset

To achieve the maximum degree of interaction between the lens truncation and the lower lid margin, it is important to have as much contact as possible between the two surfaces.

When the lens is in its resting position the truncation and the lid margin should be aligned. This will maximize the resistance to lens rotation.

In most cases the base-apex meridian will rotate nasally and, as such, the truncation will need to be made on the temporal side of the lens base. In some cases it may be useful to match the profile of the truncation to the contour of the lid.

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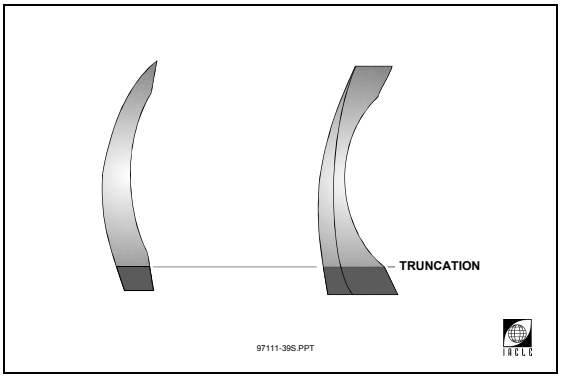


3L897111-39

Truncating Minus Lenses

Truncation of a lens involves the removal of a significant amount of material. This is particularly so when the lens BVP is –6.00D or greater.

The loss of material may adversely affect the stability of the fitting and result in an excessive amount of lens rotation. The dynamic fitting characteristics may be altered significantly from those observed with a circular prism ballast lens of the same BVP.

If a truncation is needed in such cases, a higher amount of prism ballast may be required to provide the stability needed for optimum visual performance.

Truncating Plus Lenses

When truncating a plus power lens, the amount of material removed is not as significant as it is with a high minus power. Generally it is not necessary to make any compensation in the amount of prism ballast used with high plus prescriptions.

I.D Back Surface Toric Lenses

41

BACK SURFACE TORICS

- In many cases a corneal cylinder of 2.50 D or less can be fitted with a spherical lens with appropriate parameters
- When a spherical lens is unable to provide a satisfactory physical and/or physiological fitting then a lens with toric back surface is required

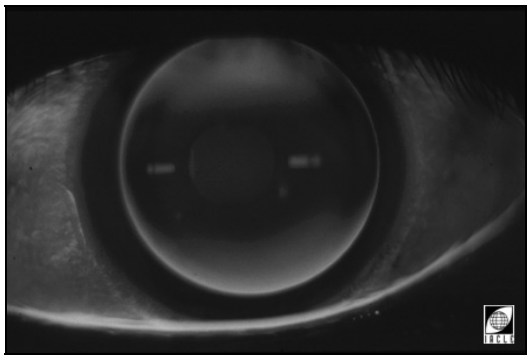
97111-40S.PPT

3L897111-40

Back Surface Torics

The decision to employ a back surface toric RGP design must be made on a case by case basis. Individual patient characteristics and requirements dictate whether a spherical or toric back surface will provide the optimum performance.

42



3L81741-93

43

OPTICS OF TORIC LENSES

- If a 3.00 D toric cornea is fitted with a toric back surface lens with a spherical front surface then the corneal cylinder will not be corrected fully
- A residual cylinder is INDUCED by the shape of the back surface of the lens

97111-41S.PPT

3L897111-41

Optics of Toric Lenses

If the lens back surface is made toric it will not correct all the corneal astigmatism.

For example, when a spherical, non-flexing RGP lens corrects 90% of the corneal astigmatism and the over-refraction shows just 10% of the original cylindrical component, it can be claimed that all the ocular astigmatism is corneal.

If, on the same cornea, the lens is fitted with a toric back surface design, the corneal astigmatism can not be as fully corrected as it was with a spherical back surface shape. An over-refraction will contain a cylindrical component which is not physiological in origin. The cylinder is induced by making the lens back surface toric.

44

OPTICS OF TORIC LENSES

- An astigmatism effect is created in the contact lens/tear fluid system by the toroidal back optic zone bounding two surfaces of different refractive index
- The amount of the induced cylinder is dictated by the refractive index of the lens plastic and the pre corneal fluid, and the amount of cylinder on the lens back surface

97111-42S.PPT

3L897111-42

45

OPTICS OF TORIC LENSES

- The cylindrical induced by any back surface toricity is always a minus cylinder of the same axis as the flatter principal meridian

97111-43S.PPT

3L897111-43

46

INDUCED CYLINDER POWER

Refractive index (n):

- Lens = 1.49 (PMMA)
- Air = 1.0
- Tears = 1.336
- Keratometer = 1.3375

97111-44S.PPT

3L897111-44

47

INDUCED CYLINDRICAL POWER

$$\frac{n\text{ (tears)} - n\text{ (lens)}}{n\text{ (air)} - n\text{ (keratometer)}}$$

$$\frac{1.336 - 1.49}{1.0 - 1.3375} = 0.456$$

Induced cyl = 0.456 x Δ K (CL)

For lens n of 1.47 = 0.397
1.43 = 0.279

97111-45S.PPT

3L897111-45

Induced Cylinder Power

The dioptric power of the induced cylinder can be calculated for any lens if the following values are known:

- Refractive index of the lens material.
- Radii of curvature of the principal meridians.

As the lens material refractive index approaches that of the tear film (1.336), the dioptric power of the induced cylinder decreases.

For any toric back surface/spherical front surface lens, the induced cylinder power may also be calculated from the lens cylinder power measured by the focimeter. The multiplier value is also reduced for materials with a lower refractive index.

48

INDUCED CYLINDRICAL POWER

$$\frac{n \text{ (tears)} - n \text{ (lens)}}{n \text{ (air)} - n \text{ (lens)}}$$

$$\frac{1.336 - 1.49}{1.0 - 1.49} = 0.314$$

Induced cyl = 0.314 x Focimeter cyl power (CL)

For lens n of 1.47 = 0.285
1.43 = 0.219

97111-46S.PPT

3L897111-46

49

INDUCED CYLINDRICAL POWER EXAMPLE

Keratometry 7.50 mm @ 180 (45.00 D)
6.89 mm @ 90 (49.00 D)

Lens BOZR 7.50/6.89 mm spherical front surface

Δ K (CL) = 4.00D

Induced cyl power = -(0.456 x 4) x 180
= -1.80 D x 180

97111-47S.PPT

3L897111-47

Induced Cylinder Power: Example

In this example, if a spherical lens is found to have a negligible over-refraction, a back surface toric/spherical front surface lens will have an over-refraction incorporating a 1.75 D cylinder.

The effect of the induced cylinder is, in most cases, reduced quality of vision. The goal in selecting a toric back surface is to achieve a more satisfactory physical fitting relationship between the lens and the cornea. If the vision is adversely affected by the induced cylinder, an appropriate correcting cylinder must be applied to the lens front surface. The front surface shape must correct all astigmata (induced, residual and/or physiological).

For this example, a +1.75 DC x 180 on the front surface will neutralize the induced cylinder. The addition of a toric surface on the front of the lens results in a BITORIC design. This will provide an acceptable physical fitting relationship on the cornea as well as correcting the vision satisfactorily.

50

FITTING BACK SURFACE TORIC RGP LENSES

97111-48S.PPT

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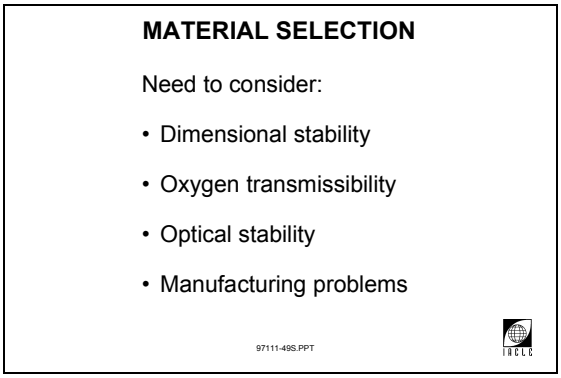

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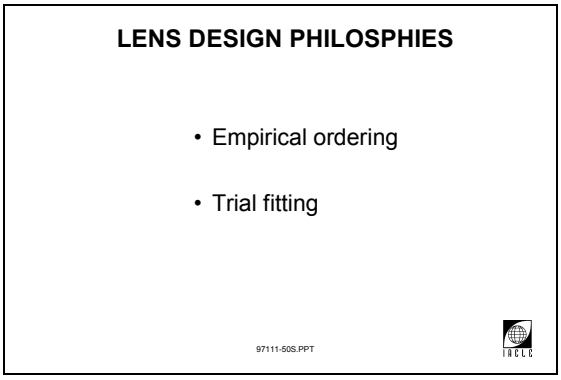
Material Selection

One of the most important factors in achieving a successful RGP back surface toric fitting is the selection of the lens material. The key issues are:

- **Dimensional stability.** The lens must maintain its shape to ensure physical compatibility between the back surface and the cornea is maintained. With some materials the degree of back surface toricity may vary over time and, as a result, the quality of vision may deteriorate with wear.
- **Oxygen transmissibility.** As toric lenses are thicker, the Dk/t is less than an equivalent spherical lens of similar power. Selection of a lens with moderate to high oxygen permeability is necessary to ensure that the cornea's physiological requirements are satisfied.
- **Optical stability**. A stable lens material minimises the risk of lens warpage. An irregular change in the shape of the lens would result in a degradation of the quality of vision.
- **Manufacturing problems.** Some RGP lens materials are difficult for the manufacturer to cut and polish. It is prudent to ask the lens supplier about the materials used in their laboratory and to ask them to suggest which materials best combine the requirements of strength and durability with ease of manufacturing.

52



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Lens Design Philosophies

When designing the shape of a back surface toric RGP lens the practitioner has the choice of using an empirical ordering technique or trial lens fitting. The latter will generally give more satisfactory results as the practitioner has greater control over the final outcome.

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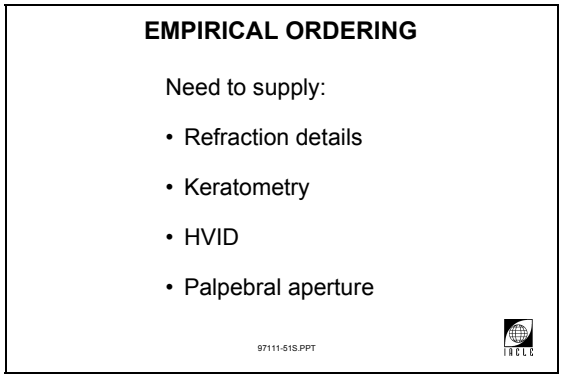

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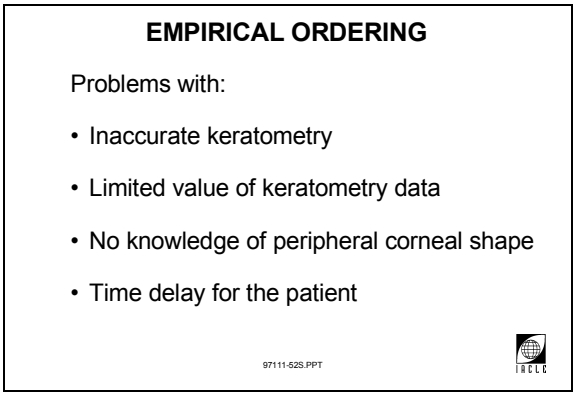

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Empirical Ordering

Fitting the lens empirically involves the manufacturer designing the lens based on refractive and keratometric data provided by the practitioner.

This technique is often successful. However the first lens fitted may fail to perform satisfactorily. This first lens therefore becomes the trial lens from which a second, improved lens design can be derived.

There are numerous reasons for the limited success of the empirical technique, including:

- **Inaccurate keratometry.** Errors that occur during the measurement will influence the selection of the toric lens radii of curvature. This may result in a poor physical fitting on the cornea.
- **Limited value of keratometry data.** As only the central corneal curvature is measured, there is very little useful information to help guide the selection of peripheral curves and the optic zone diameter.
- **No knowledge of peripheral corneal shape.** Significant variation in the corneal toricity can occur from the central to the peripheral zone.
- **Time delay for the patient.** If the first lens ordered by the empirical technique is unsatisfactory, a reorder is necessary. Greater success can be achieved by trial fitting the patient and basing the lens order on the results of a fitting assessment.

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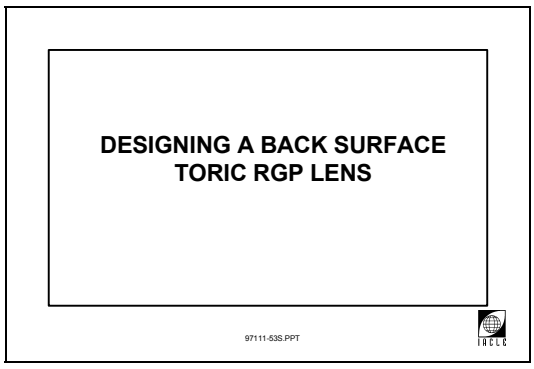

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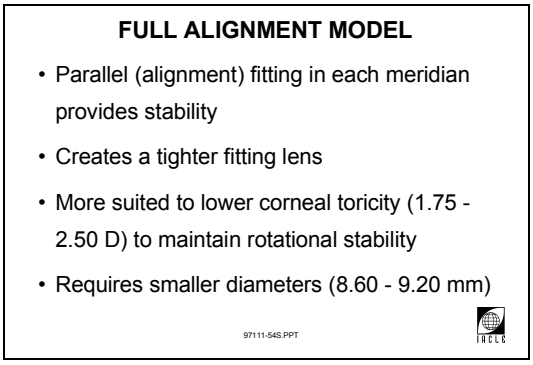


3L897111-54

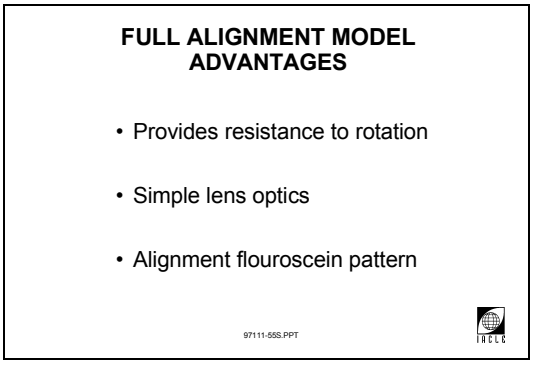
Full Alignment

A toric back surface RGP lens that is fitted with the BOZR in each principal meridian equal to the radii of curvature of the cornea will generally produce a stable, tight fitting.

This technique is best suited to cases where the corneal toricity is in the range 1.75D to 2.50D. When the toricity is low, the full alignment technique provides the maximum resistance to lens rotation.

The choice of the lens total diameter is also important in maintaining the stability of the fitting. A larger diameter will contribute towards increased stability.

57



3L897111-55

Full Alignment

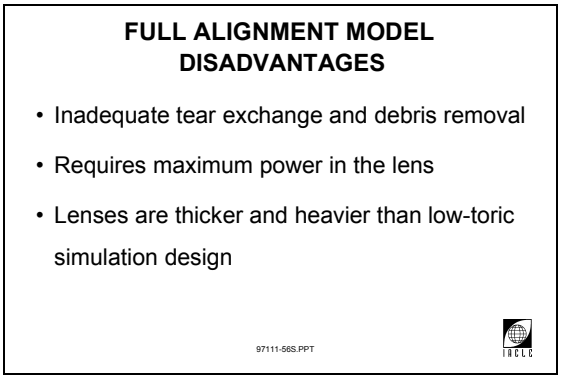
Advantages

When fitting a back surface toric RGP lens, the principal advantage of the full alignment technique is that the lens will generally maintain its meridional orientation on the cornea. There is an increased resistance to rotation when the toricity of the lens back surface closely matches that of the cornea.

When the principal meridians of the lens align with the cornea, a plano tear lens is created. Therefore, the BVP needed to correct each meridian will be equal to the spectacle refraction corrected to the corneal plane.

The fluorescein pattern should show broad alignment which is easily assessed by the practitioner.

58



3L897111-56

Full Alignment

Disadvantages

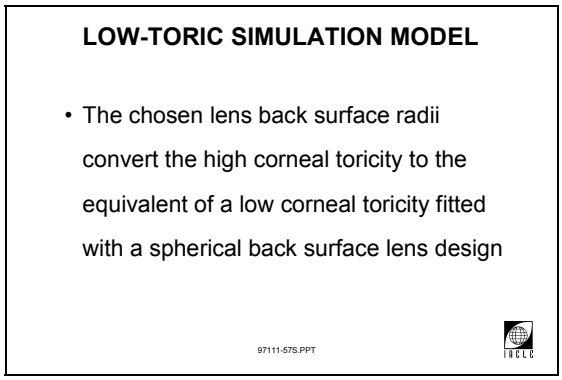
Even though the full alignment model will generally provide a stable fitting, some disadvantages exist:

- A tight, alignment fitting will reduce the free flow of tears under the lens. This may reduce the supply of oxygen to the cornea as well as limit the removal of metabolic debris from behind the lens. The build up of debris may result in an increase in

lens deposits as well as a reduction in the amount of lens movement with each blink.

- Fitting each meridian in alignment results in the absence of any tear lens power. Consequently, the BVP required in each meridian will be the full power as determined by refraction. This results in a lens design that is necessarily thicker and heavier than a low-toric simulation design, where a negative tear lens contributes some of the power required along one meridian.

59



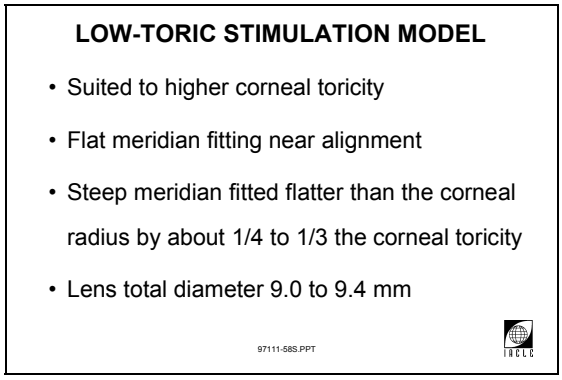
3L897111-57

Low-Toric Simulation

An alternative to fitting a patient with a full alignment design is to flatten one principal meridian. The final lens to cornea relationship will be similar to that achieved when fitting a spherical back surface RGP lens to a cornea with a low level of toricity where the flatter meridian is fitted close to alignment.

The low-toric simulation lens will be relatively flatter along the steeper corneal meridian, resulting in a fluorescein pattern typical of a cornea of low toricity as shown in slide 61.

60



3L897111-58

Low Toric Simulation

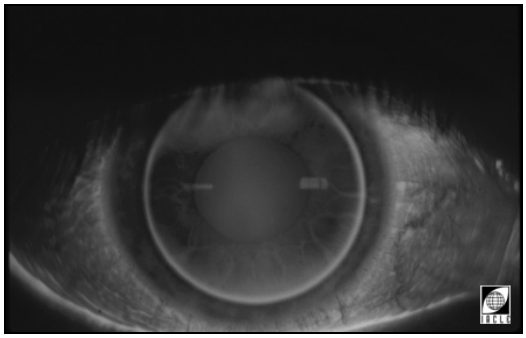
This technique of fitting a toric RGP lens is best suited to corneas with moderate to high levels of astigmatism.

A general approach to selecting the correct lens design is to fit the flatter corneal meridian close to alignment to achieve dynamic stability. The steeper meridian is fitted with a lens radius that is flatter than the corneal radius by approximately 1/4 to 1/3 the total corneal toricity.

The lens total diameter is in the range from 9.0 mm to 9.4 mm. Such a diameter will provide added stability to the lens fitting.

The following is an example of this approach:

61



3L82092-95

Keratometry 8.23 mm @ 180 (41.00 D)

7.67 mm @ 090 (44.00 D)

Corneal astigmatism 3.00 D

1st principal meridian =flat K

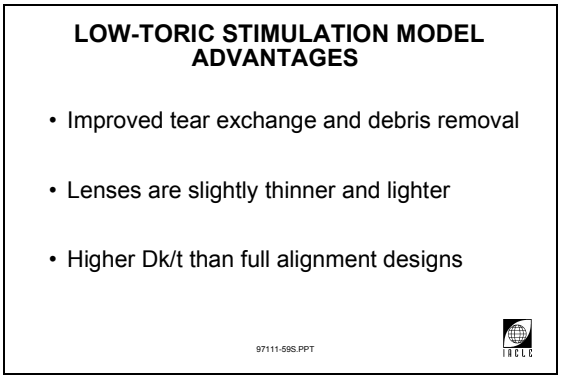
= 41.00 D (8.23 mm)

2nd principal meridian =1/3 of corneal toricity

= 1.00 D flatter

= 43.00 D (7.85 mm)

62



3L897111-59

Low-Toric Simulation

Advantages

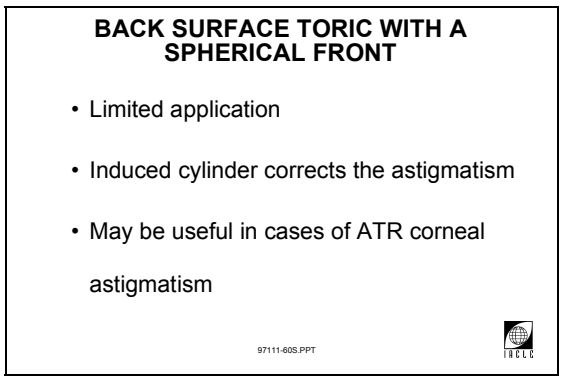
The low-toric simulation RGP fitting is the most commonly employed method. It offers some advantages over full alignment toric designs.

By having one meridian fitted flatter than the cornea, the exchange of tears during each blink is facilitated. The increased tear flow results in a somewhat greater supply of oxygen to the cornea as well as assisting in the removal of debris from behind the lens.

The BVP required in the steeper meridian for a low- toric simulation design is less than that needed for a full alignment back surface toric lens as some of the astigmatism is corrected by the tear layer. The lens will be thinner, lighter and provide a higher level of oxygen transmission.

The overall advantages of this type of design make it the lens of first choice for the majority of patients needing a back surface toric RGP correction.

63



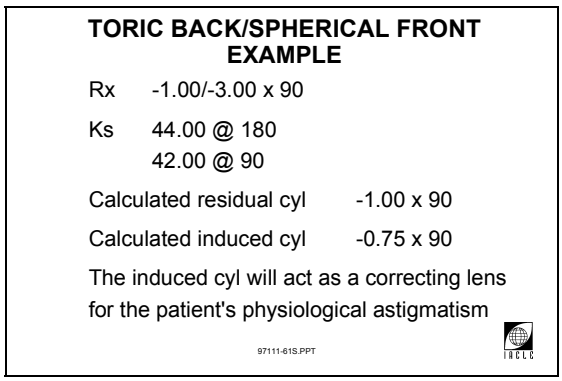
3L897111-60

Back Surface Toric With a Spherical Front

A lens with a toric back surface and a spherical front surface has only limited application. It can be applied when the induced cylinder can be used as the correcting power for the physiological residual astigmatism.

This occurs when the total refractive astigmatism is about 1/3 greater than the corneal astigmatism and both have the same axis. This situation is more likely to occur in cases of against the rule corneal astigmatism.

64



3L897111-61

Toric Back/Spherical Front

In this example, the calculation indicates that if a spherical RGP lens were fitted a residual cylinder of -1.00 D x 90 would be manifest in the over-refraction.

If a full alignment back surface toric RGP lens with a material refractive index of 1.47 was fitted, the induced cylinder could be determined from the following formula:

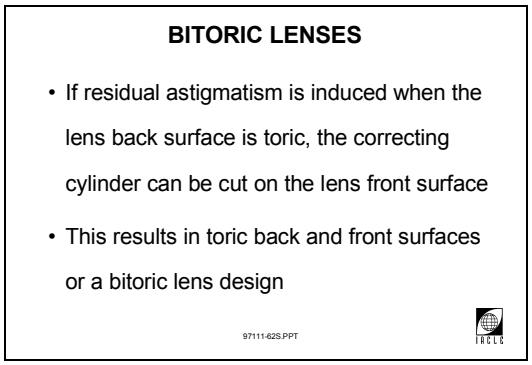
Induced cyl = 0.397 x 2.00

= 0.79 D

Therefore a negative cylinder of 0.75 D with an axis along the flatter meridian (90 degrees) is induced by the lens back surface toricity. This cylinder will, in this example, correct the physiological residual astigmatism.

I.E Bitoric Lenses

65



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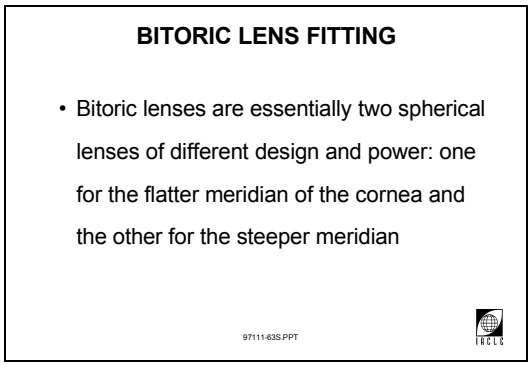
Bitoric Lenses

In most cases, the use of a back surface toric RGP lens to improve the physical fit will result in significant induced residual astigmatism which can be confirmed by over-refraction.

The patient's visual requirements can only be satisfied by manufacturing a lens with the appropriate correcting cylinder cut on the front surface.

66



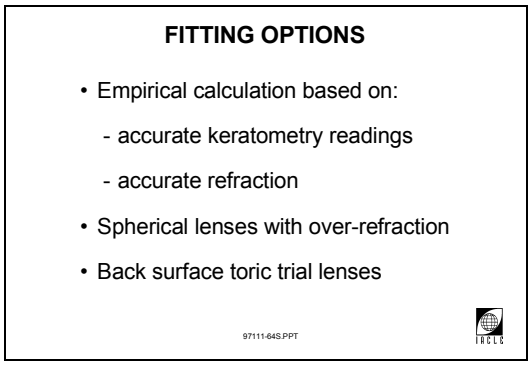
3L897111-63

Fitting Bitorics

The fitting of bitoric RGP lenses is not a complicated issue if the practitioner considers the lens in terms of two spherical lenses: one fitted to the flatter meridian and one to the steeper meridian.

In this way the calculations for the lens back surface design and meridional BVP are made for toric corneas by considering them to consist of two independent meridians.

67



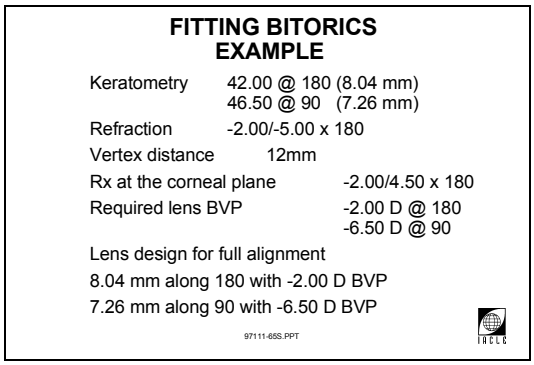
3L897111-64

Fitting Options

Empirical methods of fitting bitoric RGP lenses may be employed by the practitioner and the manufacturer. The limitations of the empirical approach were described previously. For bitoric lenses, the potential for error in the calculations is significant, even when great care is taken in measuring the refractive error and the corneal shape.

To increase the chance of a successful first fitting, trial lens assessment is recommended. By using back surface toric trial lenses, the practitioner can more accurately assess the lens to cornea relationship as well as determining the BVP needed along each meridian.

68



3L897111-65

Fitting Bitorics

An example of the empirical fitting technique for a bitoric RGP lens is given here.

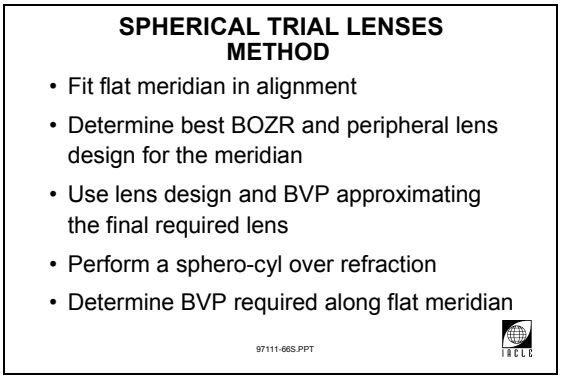
The cornea has 4.50 dioptres of cylinder and the lens is fitted, for ease of calculation, using the full alignment technique (the low-toric simulation technique is more likely in this case).

The first step is to calculate the refractive error along each meridian after allowing for the vertex distance. As can be seen in this example, the cylindrical power at the corneal plane is not the same as that found at the spectacle plane.

The meridional powers are -2.00 D along the 180 meridian and -6.50 D along 90. As the lens is fitted in alignment, there is no need to allow for any tear lens effects.

Providing the manufacturer with the details of the BOZR for each meridian as well as the BVP allows the required front surface toric curvature to be calculated.

69



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Spherical Trial Lenses

When using spherical trial lenses, begin by fitting the flattest meridian with a lens that has a BOZR equal to the corneal radius of curvature. Such an alignment fitting will provide the best assessment of the physical fitting relationship for that meridian. Most importantly, a careful analysis of the static fitting characteristics is made along that meridian. The trial lens can be altered to try to achieve an optimal meridional fitting.

The best fitting trial lens is then used to determine, by over-refraction, the BVP needed along the meridian. An allowance should be made for any tear lens effects if the BOZR of the final lens differs from that of the trial lens.

70

SPHERICAL TRIAL LENSES METHOD

- Fit steep meridian flatter than K by 25% to 33% the corneal toricity
- Perform a sphero-cyl over refraction
- Determine BVP required along steep meridian

97111-67S.PPT

3L897111-67

Spherical Trial Lenses

Using the method of low-toric simulation requires the steeper meridian of the lens to be fitted flatter than the corneal radius of curvature. The general rule is to make the lens radius flatter than the corneal radius by 25%-33% of the value of the corneal toricity (in mm).

For example, if the corneal radii of curvature are 7.20 mm and 8.00 mm, the steeper radius of curvature of the trial lens would be selected to be 7.40 mm and the flatter meridian would be 8.00 mm (i.e. 25% of the 0.8 mm toricity).

An over-refraction is performed to obtain the necessary BVP. An allowance must be made for the tear lens effect if the final lens BOZR differs from that of the trial lens.

71

SPHERICAL TRIAL LENSES METHOD

- Send the lens design details to the lab
- Provide BOZR and BVP required for each meridian

97111-68S.PPT

3L897111-68

Spherical Trial Lenses

The trial fitting technique allows the practitioner to determine the optimum back surface design for the flat meridian. It is important that the trial lenses have a BOZD that is close to the required size to allow for accurate determination of the optimal back surface design. A trial lens also allows for an accurate measurement of the BVP required along each meridian.

Once the design and BVP have been finalized, the information for each meridian is supplied to the manufacturer. The necessary front surface design is then calculated taking into account the material refractive index.

72

SPHERICAL TRIAL LENSES ADVANTAGES

- Can change each meridional lens design independently
- Meridional power calculation is based on an over-refraction
- Tear lens adjustments are generally of a low power

97111-69S.PPT

3L897111-69

Spherical Trial Lenses

There are a number of advantages in using a spherical trial lens when fitting the patient with bitoric RGP lenses. Each lens design used allows the static fitting pattern to be assessed. The practitioner can then determine the optimum back surface shape for each meridian.

The BVP needed for each meridian can be assessed by over-refraction with the best fitting trial lens on the eye. It is important that the over-refraction be performed carefully to ensure that the full refractive

error is determined.

An advantage of using trial lenses is that the effect of the tear lens is often very small. If the best trial lens is similar in design to that of the ordered lens, the adjustments to the BVP, as determined by the over-refraction, will be very low. A change in the BOZR of 0.05 mm is equivalent to an alteration to the BVP by 0.25 D.

73

SPHERICAL TRIAL LENSES

- If the over-refraction with a spherical lens on a toric cornea produces no minimal residual cylinder then only the induced cylinder (from making the back surface toric) will need correction

97111-70S.PPT

3L897111-70

Spherical Trial Lenses

Performing an over-refraction with a spherical trial lens on the cornea will provide the practitioner with very useful information.

If the result of an over-refraction suggests that a high level of vision can be obtained with a spherical power, then the only complicating factor might be the induced cylinder that results from making the lens back surface a toric shape.

The induced cylinder can be corrected by cutting a plus cylinder of the same power on the lens front surface.

Such a lens is described as a spherical power effect (SPE) design, as the lens may rotate on the cornea without compromising the quality of vision.

74

SPHERICAL TRIAL LENSES

- An equal plus cylinder, whose axis is the same as the induced cylinder, applied to the front surface of the lens will correct the residual (in this case induced cyl) cylinder power
- Such a lens has a SPHERICAL POWER EFFECT on the eye

97111-71S.PPT

3L897111-71

75

SPHERICAL POWER EFFECT

- As the back surface toricity is known, the magnitude of the induced cylinder can be calculated (eg. 0.456 x Δ K (CL) for PMMA lenses)
- The manufacturer can then cut a front surface cylinder to negate the induced cylinder power

97111-72S.PPT

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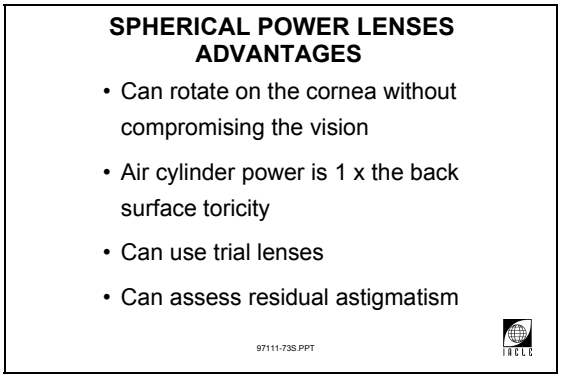
Spherical Power Effect

A more rigorous way of fitting bitoric RGP lenses is to use a set of bitoric trial lenses that have been manufactured with a spherical power effect design.

These lenses, which have toric back surfaces, provide the best opportunity for judging the suitability of the physical fitting relationship between the lens back surface and a toric cornea.

76



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Spherical Power Effect

The prime advantage of an SPE bitoric lens is that any rotation on the cornea will not adversely affect the visual performance. At any orientation, the front surface cylinder will neutralize the induced cylinder.

In air, when the lens is placed on the focimeter, the value of the measured cylinder power will be equal to the amount of the back surface cylinder (delta K) as measured by the keratometer.

An SPE trial set will allow for a very accurate determination of any residual astigmatism. If residual astigmatism is present, the manufacturer will produce a front surface on the lens that corrects the cylinder. Such a lens is described as a cylinder power effect (CPE) design.

I.F Peripheral Toric Lenses

77

PERIPHERAL TORIC

- In some cases a spherical lens may provide an adequate central and mid peripheral fir pattern. However, peripheral corneal tonicity may cause excessive edge clearance in the steep meridian.
- The peripheral fitting pattern can be improved by designing the lens with suitable toric peripheral curves

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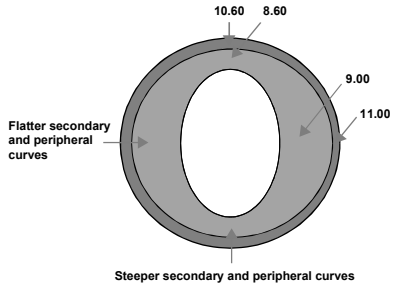

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Peripheral Toric

In some cases, the peripheral corneal toricity may be greater than expected based on the central measurements.

When this occurs, a spherical back surface lens may fit the central zone of the cornea adequately and provide an acceptable physical fitting relationship.

Due to the peripheral toricity, an excessive amount of clearance will occur between the lens back surface and the cornea along the steeper corneal meridian.

A large amount of clearance along one meridian of the cornea is likely to result in an unstable fitting, rocking of the lens about the flatter corneal curvature and possibly discomfort. By utilizing a toric peripheral design, the stability can be significantly improved. When the physical fitting characteristics of the lens are optimized the physiological integrity of the cornea will be better maintained.

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PERIPHERAL TORIC

Useful for:

- Low to moderate corneal toricity
- Corneas with more peripheral than central toricity
- Improves:
  - lens centration
  - lens stability
  - lens movement
  - tear exchange

97111-76S.PPT

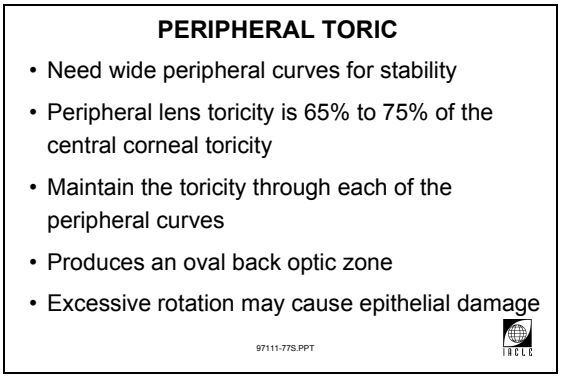
3L897111-76

Peripheral Toric

On a cornea with a moderate degree of peripheral toricity the peripheral toric design has a number of advantages over a spherical design.

The primary advantage is an improvement in the physical fitting characteristics including lens centration and stability. By using a peripheral toric design, the axial edge clearance will be more uniform over the circumference of the lens. This will result in smoother movement and permits the exchange of tears more freely without the risk of peripheral or central bubble formation.

80



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Peripheral Toric

For optimum peripheral toric lens performance, the secondary and subsequent curves should be sufficiently wide to enhance the lens to cornea fitting relationship. A width of 0.4 to 0.6 mm permits the manufacturer to control lens production accurately.

When designing a peripheral toric lens, the amount of toricity generated is based on the central corneal keratometry measurements. The value of the keratometry may underestimate or overestimate the peripheral toricity. As a general rule, the peripheral lens toricity is 65%-75% of the value of the central corneal toricity as measured by the keratometer.

The production of peripheral toric curves results in an elliptical optic zone shape. Care should be taken to ensure that the optic zone is large enough to prevent visual problems associated with decentration of the lens.

Because of the relatively small area of toricity on such a lens, it is more likely to rotate than a full back surface toric design.

If a peripheral toric lens rotates on the cornea, the steeper meridian of the lens periphery will impinge upon the flatter meridian of the cornea. This has the potential to cause localized corneal damage and discomfort for the wearer. Such rotation is most likely to occur if insufficient toricity is generated on the lens, or if an attempt is made to fit a cornea that has too little peripheral toricity.

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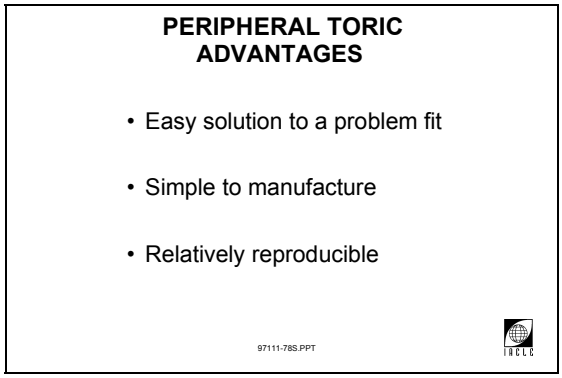

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Peripheral Toric: Advantages

The main advantage of a peripheral toric RGP lens design is that it is often the simplest solution to the problem of fitting an RGP lens to a toric cornea. In cases where a spherical lens can provide an acceptable central fitting, the addition of toric peripheral curves to the lens will increase the stability and quality of the fit.

A peripheral toric lens is relatively simple to manufacture and is more reproducible should a replacement lens be required.

Practical 3.8

(3 Hours)

Toric RGP Lens Fitting and Assessment

Purpose

The purpose of this exercise is to learn how to assess the fit of a toric RGP lens and to achieve a fluorescein pattern which would resemble that of a spherical BOZR lens on a spherical cornea.

Instructions: The students are to work in pairs. As most students are not rigid lens wearers the assessment of the lens performance should be done on anaesthetized and unanaesthetized eyes. This will allow students to observe the influence of lacrimation and lid activity on lens performance.

This practical requires patients (students) with corneal astigmatism of 2.00D or greater.

Use the fitting method (cornea/BOZR relationship for toric back surface RGP lenses) described in lecture 3.8 or one that is recommended by your supervisor.

Perform an over-refraction and record all the findings on the record form.

RECORD FORM

Name:_____ **Date:**_____

Partner:_____

ASSESSMENT VARIABLES		
Eye	☐Right	☐Left
Keratometry Reading	_____ D _____ D@ ____ Low K radius _____ _____ mm	_____ D _____ D@ ____ Low K radius _____ _____ mm
HVID	___ mm	___ mm
Baseline Eye Check _____Supervisor	☐clear ☐slightly red ☐irritated ☐staining	☐clear ☐slightly red ☐irritated ☐staining
Trial Lens: _____	BOZR: _____mm/_____ mm Lens material_____ Thickness_____ mm Lens diameter_____ Design_____	BOZR: _____mm/_____ mm Lens material_____ Thickness_____ mm Lens diameter_____ Design_____
Lens Fit Assessment		
Centration	horizontal (N/T) _ vertical (S/I) _____ mm	horizontal (N/T) _ vertical (S/I) _____ mm
Movement with Blink	_____ mm	_____ mm
Movement Type	☐smooth☐jerky ☐apical rotation	☐smooth☐jerky ☐apical rotation
Speed of Movement	☐fast ☐average ☐slow	☐fast ☐average ☐slow
Stability	☐yes ☐no If no, please explain _____	☐yes ☐no If no, please explain _____
Central Fluorescein Pattern	☐pooling☐alignment	☐pooling☐alignment

	☐touch	☐touch
Mid-peripheral Fluorescein Pattern	☐pooling ☐wide touch (alignment) ☐narrow touch	☐pooling ☐alignment ☐touch
Edge Width Horizontal (Nasal/Temporal) Vertical (Superior/Inferior)	_____ / __ mm _____ / __ mm	_____ / __ mm _____ / __ mm
Edge Clearance	☐low ☐average ☐high	☐low ☐average ☐high
Fit Classification	☐flat ☐steep ☐optimal ☐accept ☐reject	☐flat ☐steep ☐optimal ☐accept ☐reject
Over refraction	Sph _____D _____ VA _____DS ____DCx ____ VA	Sph _____D _____ VA _____DS ____DCx ____ VA
If rejected, what can be improved?		

RECORD FORM

Name:_____ **Date:**_____

Partner:_____

ASSESSMENT VARIABLES		
Eye	☐Right	☐Left
Keratometry Reading	_____ D _____ D@ ____ Low K radius _____ _____ mm	_____ D _____ D@ ____ Low K radius _____ _____ mm
HVID	___ mm	___ mm
Baseline Eye Check _____Supervisor	☐clear ☐slightly red ☐irritated ☐staining	☐clear ☐slightly red ☐irritated ☐staining
Trial Lens: _____	BOZR: _____mm/_____ mm Lens material_____ Thickness_____ mm Lens diameter_____ Design_____	BOZR: _____mm/_____ mm Lens material_____ Thickness_____ mm Lens diameter_____ Design_____
Lens Fit Assessment		
Centration	horizontal (N/T) _ vertical (S/I) _____ mm	horizontal (N/T) _ vertical (S/I) _____ mm
Movement with Blink	_____ mm	_____ mm
Movement Type	☐smooth☐jerky ☐apical rotation	☐smooth☐jerky ☐apical rotation
Speed of Movement	☐fast ☐average ☐slow	☐fast ☐average ☐slow
Stability	☐yes ☐no If no, please explain _____	☐yes ☐no If no, please explain _____
Central Fluorescein Pattern	☐pooling☐alignment	☐pooling☐alignment

	☐touch	☐touch
Mid-peripheral Fluorescein Pattern	☐pooling ☐wide touch (alignment) ☐narrow touch	☐pooling ☐alignment ☐touch
Edge Width Horizontal (Nasal/Temporal) Vertical (Superior/Inferior)	_____ / __ mm _____ / __ mm	_____ / __ mm _____ / __ mm
Edge Clearance	☐low ☐average ☐high	☐low ☐average ☐high
Fit Classification	☐flat ☐steep ☐optimal ☐accept ☐reject	☐flat ☐steep ☐optimal ☐accept ☐reject
Over refraction	Sph _____D _____ VA _____DS ____DCx ____ VA	Sph _____D _____ VA _____DS ____DCx ____ VA
If rejected, what can be improved?		

🕮 References

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