

Lenses Technology

Prepared by

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توصيف مقرر دراسي

1- بيانات المقرر		
الرمز الكودي :	اسم المقرر : تكنولوجيا العدسات اللاصقة	الثانية الفرقة / المستوى :
التخصص : البصريات	عدد الوحدات الدراسية : 2 نظري 2 عملي	

2- هدف المقرر:		To provide training for the Ophthalmic Technician in Contact lenses, their different types, materials and the technology used in its manufacturing.
3- المستهدف من تدريس المقرر :		
أ. المعلومات والمفاهيم :	By the end of this course the trainee will be able to: <ul style="list-style-type: none"> Explain the design and concept of contact lenses. Identify different types and materials of contact lenses and recognize their different applications in ophthalmic practice. Know the precautions and complications of contact lens use and instruct the patients about them effectively. Demonstrate different manufacturing processes of CL and its use in CL practice. 	
الذهنية : ب- المهارات	By the end of this course the trainee will be able to: <ul style="list-style-type: none"> Apply the knowledge of contact lens design and material in clinical practice. Compare the different materials and designs of contact lens. Confirm the power and calculation of contact lenses and formulate their design to fit the patient's needs. 	
ج- المهارات المهنية الخاصة بالمقرر:	By the end of this course the trainee will be able to: <ul style="list-style-type: none"> Assess patients for contact lens wear and select the proper lens material and design to suit their needs. Perform fitting of contact lenses and insertion and removal techniques. Carry out proper contact lens care, evaluation, and disposal. Manage a contact lens dispensing office professionally. 	
د- المهارات العامة :	By the end of this course the trainee will be able to: <ul style="list-style-type: none"> Communicate the uses and precautions of contact lenses clearly and competently. Respond to patients' inquiries and frequent questions. Provide proper advice concerning contact lens wear and complications. 	

4- محتوى المقرر:	1. Introduction <ul style="list-style-type: none"> Contact lens (CL) development. Optics of CL Uses of Contact lenses (optical and non-optical). Preliminary evaluation of CL patient Role of the ophthalmic assistant and technician in CL practice 2. Rigid Gas-Permeable (RGP) contact lenses <ul style="list-style-type: none"> Introduction to RGP lenses Material of RGP lenses Design of RGP lens Fitting of RGP lens and adjustments Evaluation of RGP lens
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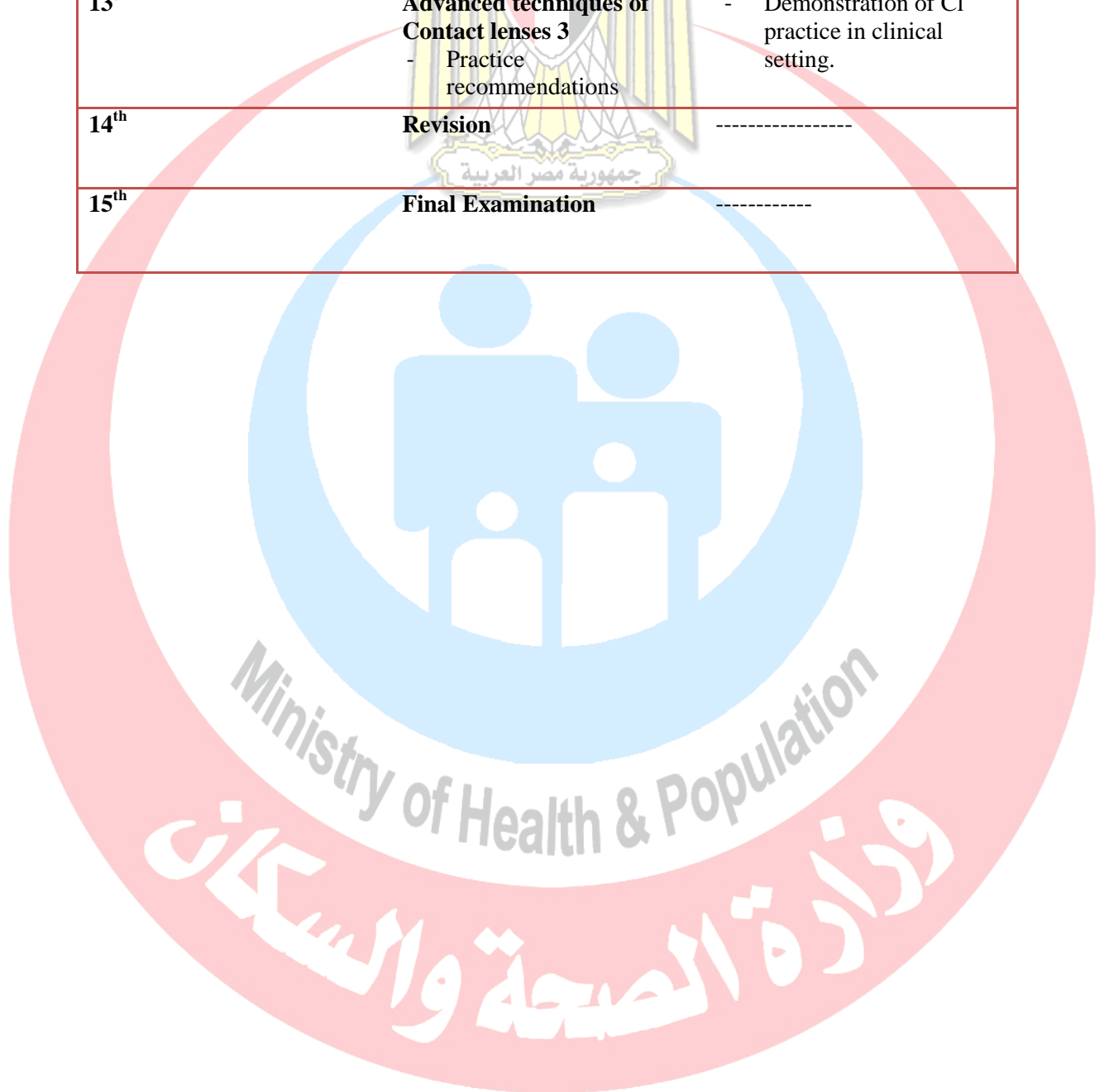
<ul style="list-style-type: none"> Insertion and removal of RGP lens RGP lens care and Patient education RGP lens complications and Problem solving. 	
3. Soft Contact lenses: <ul style="list-style-type: none"> Introduction to soft lenses. Material of soft lenses Manufacturing process of soft lenses Selection of soft lens and adjustments Inspection of soft lens Insertion and removal technique for soft lens Soft lens care and Patient education Soft lens complications and Problem solving. 	
4. Innovations and advanced techniques of Contact lenses <ul style="list-style-type: none"> Toric contact Lenses Presbyopia correction (Bifocal, Multifocal & diffractive CL) Tinted (colored) Contact lenses Manufacturing and modifications Practice recommendations 	

<ul style="list-style-type: none"> Academic Lectures. Assignments. Practical hands-on training. 	5- أساليب التعليم والتعلم
<ul style="list-style-type: none"> Extra tutoring hours. Small number training sessions. Supportive feed-back. Involve in projects and helpful assignments. Forming peer support groups. 	6- أساليب التعليم والتعلم للطلاب ذوى القدرات المحدودة
اختبارات نظرية اختبارات عملية	7- تقويم الطلاب :
Essay & MCQ (اختبارات نظرية) (Slide show) اختبار عملي على صور وسائط متعددة انتظام حضور التدريبات العملية على الاجهزة	أ- الأساليب المستخدمة
Mid-term assessment (MCQ) by 7 th week Final assessment (Essay, MCQ & Slide show) by 15 th week	ب- التوقيت
النهاية العظمى 100 درجة والصغرى 60 درجة 10 درجات اعمال سنة 10 درجات عملي اختبار تحريري 80 درجة	ج- توزيع الدرجات
<ul style="list-style-type: none"> Clinical Manual of Contact Lenses, 4th edition, ES. Bennett & VA. Henry, LWW, 2014, PA, USA. Contact lenses in Ophthalmic practice, MJ Mannis et al., Springer, 2004, NY, USA. Manual of Optics and Refraction, PK Mukherjee, Jaypee Bros., 2015, New Delhi. 	8- قائمة الكتب الدراسية والمراجع :
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<ul style="list-style-type: none"> Clinical Optics, 3rd edition, AR. Elkington et al., 1999, Blackwell Science, Tokyo, Japan. 	ج- كتب مقترحة
<ul style="list-style-type: none"> International Council of Ophthalmology website: www.icoph.org/resources.html American Academy of Ophthalmology website: https://www.aao.org/technicians-and-nurses American Academy of Optometry website and journal: www.aaopt.org 	د- دوريات علمية أو نشرات الخ

Week	Theory	Practice
1 st	Introduction 1 <ul style="list-style-type: none"> - Contact lens (CL) development. - Uses of Contact lenses (optical and non-optical). 	<ul style="list-style-type: none"> - Introduction to different types of CL in clinical setting
2 nd	Introduction 2 <ul style="list-style-type: none"> - Optics of CL 	<ul style="list-style-type: none"> - Introduction to CL design and calculations in clinical setting
3 rd	Introduction 3 <ul style="list-style-type: none"> - Preliminary evaluation of CL patient - Role of the ophthalmic assistant and technician in CL practice 	<ul style="list-style-type: none"> - Evaluation of CL patient
4 th	Rigid Gas-Permeable (RGP) contact lenses 1 <ul style="list-style-type: none"> - Introduction to RGP lenses - Material of RGP lenses - Design of RGP lens 	<ul style="list-style-type: none"> - Introduction to RGP lens design and materials
5 th	Rigid Gas-Permeable (RGP) contact lenses 2 <ul style="list-style-type: none"> - Fitting of RGP lens and adjustments - Evaluation of RGP lens 	<ul style="list-style-type: none"> - Fitting and evaluation of RGP lens
6 th	Rigid Gas-Permeable (RGP) contact lenses 3 <ul style="list-style-type: none"> - Insertion and removal of RGP lens - RGP lens care and Patient education - RGP lens complications and Problem solving. 	<ul style="list-style-type: none"> - Insertion and removal of RGP Contact lenses - RGP Lens care and patient education
7 th	Mid-term Assessment	-----
8 th	Soft Contact lenses 1 <ul style="list-style-type: none"> - Introduction to soft lenses. - Material of soft lenses - Manufacturing process of soft lenses 	<ul style="list-style-type: none"> - Introduction to different types of soft CL in clinical setting
9 th	Soft Contact lenses 2 <ul style="list-style-type: none"> - Selection of soft lens and adjustments - Inspection of soft lens - Insertion and removal technique for soft lens 	<ul style="list-style-type: none"> - Insertion and removal of soft Contact lenses
10 th	Soft Contact lenses 3 <ul style="list-style-type: none"> - Soft lens care and Patient education - Soft lens complications and Problem solving. 	<ul style="list-style-type: none"> - soft Lens care and patient education

11 th	Advanced techniques of Contact lenses 1 <ul style="list-style-type: none"> - Toric contact Lenses - Presbyopia correction (Bifocal, Multifocal & diffractive CL) - Tinted (colored) Contact lenses 	- Introduction to advanced types of soft CL in clinical setting
12 th	Advanced techniques of Contact lenses 2 <ul style="list-style-type: none"> - Manufacturing and modifications 	- Demonstration of CI manufacturing and modification technology
13 th	Advanced techniques of Contact lenses 3 <ul style="list-style-type: none"> - Practice recommendations 	- Demonstration of CI practice in clinical setting.
14 th	Revision	-----
15 th	Final Examination	-----



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حقوق النشر والتأليف لوزارة الصحة والسكان ويحذر بيعه

Course Description

This course aims to provide training for the Ophthalmic Technician in Contact lenses, their different types, materials and the technology used in its manufacturing.

Core Knowledge

By the end of this course, students should be able to:

- Explain the design and concept of contact lenses.
- Identify different types and materials of contact lenses and recognize their different applications in ophthalmic practice.
- Know the precautions and complications of contact lens use and instruct the patients about them effectively.
- Demonstrate different manufacturing processes of CL and its use in CL practice.

Core Skills

By the end of this course, students should be able to:

- Assess patients for contact lens wear and select the proper lens material and design to suit their needs.
- Perform fitting of contact lenses and insertion and removal techniques.
- Carry out proper contact lens care, evaluation, and disposal.
- Manage a contact lens dispensing office professionally.

Course Overview

ID	Topics	Methods of Teaching/Training with Number of Total Hours per Topic				
		Interactive Lecture	Field Work	Class Assignments	Research	Lab
1	Introduction	6	3			3
2	Rigid Gas Permeable Lenses	6	3			3
3	Soft Contact Lenses	6	3			3
4	Innovations and Advanced Techniques	6	3			3
TOTAL HOURS (48)		24	12			12

Chapter 1

Introduction

Objectives

- **Contact lens (CL) principle.**
- **Optics of CL**
- **Uses of Contact lenses (optical and non-optical).**
- **Preliminary evaluation of CL patient**
- **Role of the ophthalmic assistant and technician in CL practice**

Contact lens (CL) principle.

The contact lens places a new refractive surface (the contact lens) over the surface of the cornea (figure 1). The contact lens itself rests on a thin liquid cushion, the tear layer, and not on the eye. With rigid gas-permeable contact lenses, this fluid lying between the back surface of the contact lens and the front surface of the cornea fills out corneal irregularities (the amount and type depends on the contact lens material and design), converting the interface between the contact lens and the cornea into a smooth, spherical surface. In principle, the contact lens then alters the refractive power of the eye by providing a radius of curvature (the front of the contact lens) different from that of the cornea. This new front curvature is able to correct the optical error of the eye and allow light to focus on the retina, thereby correcting the patient's spherical and astigmatic refractive error to the extent possible by a given contact lens material.

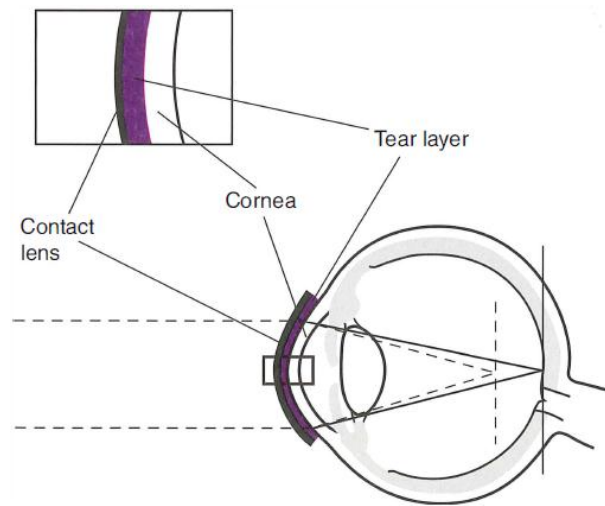


Figure 1: Principle of Contact Lenses.

Optics of CL

❖ Important terms and definitions:

➤ The following terms are important to know (Fig 2):

- **Base curve:** The curvature of the central posterior surface of the lens, which is adjacent to the cornea; it is measured by its radius of curvature (mm) or may be converted to diopters (D) by taking the reciprocal of the radius.
- **Diameter (chord diameter):** The width of the contact lens, which typically varies with the lens material; the diameter of soft contact lenses, for example, ranges from 13 mm to 15 mm, whereas that of rigid gas-permeable (RGP) lenses ranges from 9 mm to 10 mm.
- **Power:** Determined by lens shape and calculated indirectly by Snell's law: $D = [n_2 - n_1]/r$; for measurement of the posterior vertex power (as with spectacles), the lens (convex surface facing the observer) can be placed on a lensometer.
- **Dk:** The oxygen permeability of a lens material, where D is the diffusion coefficient for oxygen movement in the material and k is the solubility constant of oxygen in the material.
- **Dk/L:** A term describing the oxygen transmissibility of the lens; depends on the lens material and the central thickness (L).
- **Optic zone:** The area of the front surface of the contact lens that has the refractive power of the lens.
- **Peripheral curves:** Secondary curves just outside the base curve at the edge of a contact lens. They are typically flatter than the base curve to approximate the normal flattening

of the peripheral cornea. Typically, junctions between posterior curves (base curve and peripheral curve, for example) are smoothed or “blended” to enhance lens comfort.

- **Tear lens:** The optical lens formed by the tear-film layer between the posterior surface of a contact lens and the anterior surface of the cornea. In general, with soft lenses, the tear lens has plano power; with rigid lenses, the power varies, depending on the shape of the lens and the cornea.

❖ **The optical system of a contact lens:**

➤ *The resulted combined optical system consists of two lenses:*

(i) **The Tear (lacrima) lens:**

- **Surfaces:**
 - ◆ Anterior convex surface.
 - ◆ Posterior concave surface.
- **Importance:** It abolishes the refraction at the anterior surface of the cornea even if irregular.

(ii) **The contact lens:**

- **Surfaces:**
 - ◆ Anterior convex surface.
 - ◆ Posterior concave surface.
- **Importance:**
 - ◆ It determines the curvature of the anterior surface of the lacrimal lens.
 - ◆ Its anterior surface (the main refractive surface of the eye) can correct ametropia.

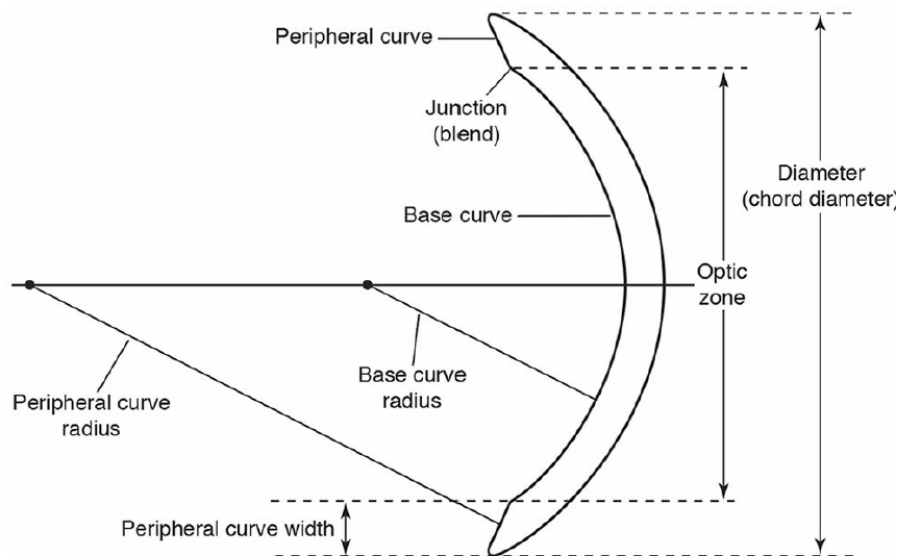


Figure 2: Parts of a contact lens.

❖ **Calculation of the power of a contact lens:**

➤ **Mathematical theory:**

- (i) *Determined by its shape:* $D = n_2 - n_1 / r$ (Snell's law)
- (ii) *From spectacle prescription:* $D_c = D_s / 1 - d D_s$

➤ **From special tables.**

❖ **Power rules:** Are applied as follows:

➤ **Lacrimal power change:**

- (i) **Soft contact lens:** Since the soft contact lens conform the shape of the cornea the curvature of anterior and posterior surface of intervening tear lens are identical thus the power of their fluid lens is always **plano**.
- (ii) **Hard contact lens:** In rigid contact lens the anterior and posterior surface of the fluid lens is not identical so The power of the tear lens is **0.25D** for every 0.05 mm difference in the radius of curvature between the base curve of contact lens and central curvature of the cornea (K) (Figure 3):
 - ◆ Tear lens created by rigid lens having a base curve **steeper than K** (figure 3-B) will have a plus power
 - ◆ Tear lens created by rigid lens having a base curve **flatter than K** (figure 3-B) will have a minus power, So

Steeper add minus (SAM) and flatter add plus (FAP).

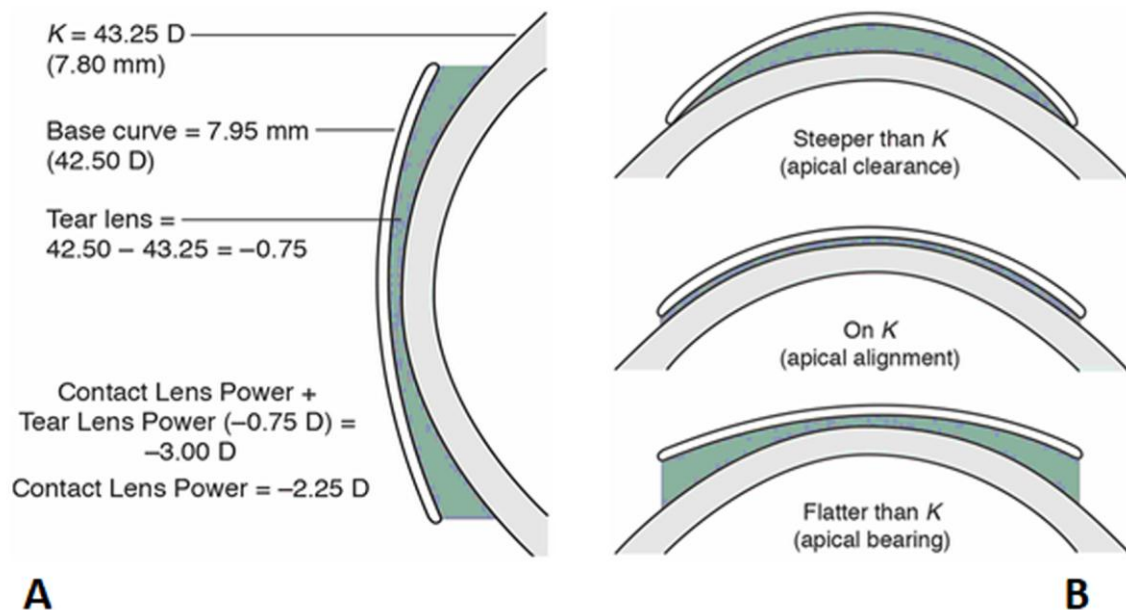


Figure 3: (A) Determining the power of a contact lens using the FAP-SAM rules. (B) A rigid contact lens creates a tear lens whose power is determined by the difference between the curvature of the cornea (K) and that of the base curve of the contact lens. (From AAO BCSC 3: Clinical optics, 2016-2017).

➤ **Vertex distance and closer add plus (CAP):**

- When refraction at the spectacle plane is $\pm 4\text{D}$ or more then the refraction at the corneal plane is determined by the addition of plus power.

Closer Add Plus (CAP)

❖ **Magnification of image by contact lenses:**

- **Positive contact lenses:** Smaller image than the spectacles which is:
 - (i) A disadvantage in moderate hypermetropia.
 - (ii) An advantage in anisometropia and in unilateral aphakia as the magnification is 10% only.
- **Negative contact lenses:** Larger image than the spectacles which is an advantage in myopia

❖ **Optical indications include:**

- Anisometropia (unequal refractive errors between both eyes)
- Unilateral aphakia,
- High myopia, However, Optically they can be used by every patient having refractive error for cosmetic purposes.
- Keratoconus and irregular astigmatism (Hard RGP lenses).

❖ **Advantages of contact lenses over spectacles:**

- (i) Contact lenses can correct irregular corneal astigmatism which is not possible to correct with glasses.
- (ii) Contact lenses provide normal field of vision.
- (iii) Aberrations associated with spectacles (such as peripheral aberrations and prismatic distortions) are eliminated.
- (iv) Binocular vision can be retained in high anisometropia (e.g., unilateral aphakia) owing to less magnification of the retinal image.
- (v) Rain and fog do not condense upon contact lenses as they do on spectacles.
- (vi) Cosmetically more acceptable especially by females and all patients with thick glasses in high refractive errors.

❖ **Therapeutic indications are as follows :**

- Corneal diseases e.g., non-healing corneal ulcers, bullous keratopathy, filamentary keratitis and recurrent corneal erosion syndrome.
- Diseases of iris such as aniridia, coloboma and albinism to avoid glare.
- In glaucoma as vehicle for drug delivery.
- In amblyopia, opaque contact lenses are used for occlusion.
- Bandage soft contact lenses are used following keratoplasty and in microcorneal perforation.

❖ **Preventive indications include**

- Prevention of symblepharon and restoration of fornices in chemical burns
- exposure keratitis
- trichiasis.

❖ **Diagnostic indications include use during**

- Goldmann's 3 mirror examination as Gonioscopy
- Electroretinography: Contact lens electrodes.
- Examination of fundus in the presence of irregular corneal astigmatism and fundus photography

❖ **Operative indications: Contact lenses are used during**

- Goniotomy operation for congenital glaucoma
- Vitrectomy
- Endocular photocoagulation.

❖ **Cosmetic indications include**

- unsightly corneal scars (colour contact lenses)
- Ptosis (haptic contact lens)
- Cosmetic scleral lenses in phthisis bulbi.

❖ **Occupational indications** include use by sportsmen, pilots and actors.

❖ **Contraindications for contact lens use:**

- Mental incompetence, and poor motivation;
- Chronic dacryocystitis
- Chronic blepharitis and recurrent styes
- Chronic conjunctivitis;
- Dry eye syndromes
- Corneal dystrophies and degenerations
- Recurrent diseases like episcleritis, scleritis and iridocyclitis.

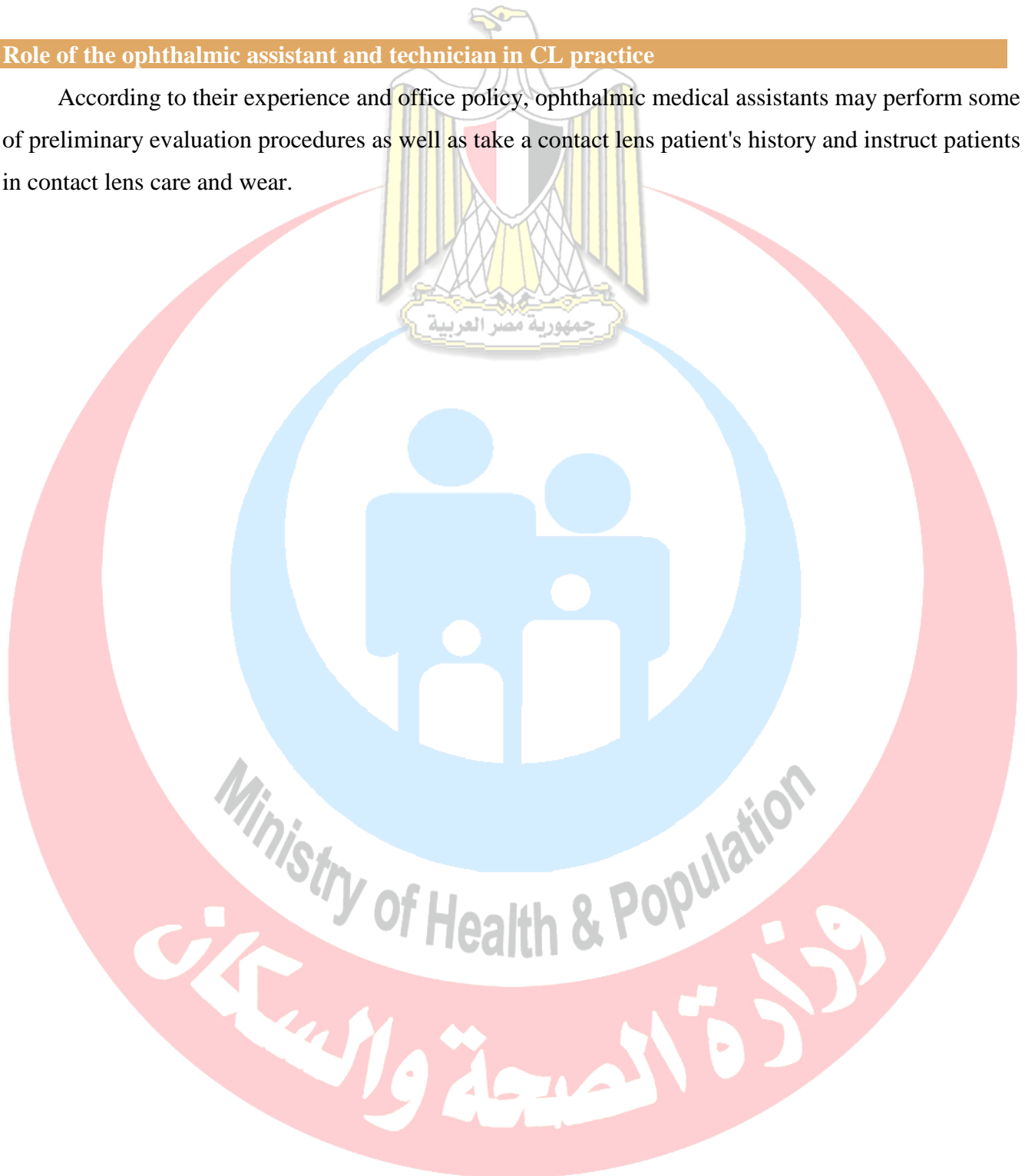
Preliminary evaluation of CL patient

- ❖ A complete medical and ocular history and ophthalmic eye examination must be performed in order to fit the most appropriate contact lens.
- ❖ The following procedures are specifically required to arrive at a contact lens prescription:
 - Determination of the refractive error (refraction/ autorefractometry)
 - Determination of the flattest and steepest corneal meridians and the axis (in degrees) in the central visual axis of the eye (keratometry) (In some cases a corneal topography test [detects aberrations of the corneal contour] may be desirable.)

- ❖ Choice of contact lens type based on the medical and ocular history, ocular examination, and patient's specific contact lens requirements The refractive state of the eye (the type of refractive error) and keratometry measurements provide a starting point from which to choose the type of contact lens as well as the appropriate base curve, the diameter, and the power of the contact lens.

Role of the ophthalmic assistant and technician in CL practice

According to their experience and office policy, ophthalmic medical assistants may perform some of preliminary evaluation procedures as well as take a contact lens patient's history and instruct patients in contact lens care and wear.



Chapter 2

Rigid Gas Permeable (RGP) Contact Lenses

Objectives

- Introduction to RGP lenses
- Material of RGP lenses
- Design of RGP lens
- Fitting and Evaluation of RGP lens and adjustments
- Insertion and removal of RGP lens
- RGP lens care and Patient education
- RGP lens complications and Problem solving.

Introduction to RGP Lens

Polymethylmethacrylate (PMMA) was the plastic material originally used in hard contact lenses and it was cut with a lathe (مخرطة). They are rigid, quite durable, easy to clean, may be stored wet or dry, and typically provide excellent correction of vision. However, they are basically gas non-permeable. The non-gas-permeable PMMA material allows oxygen to reach the cornea only by the pumping of oxygenated tears around and under the lens. This may lead to epithelial decompensation from lack of oxygen or what was called “the contact lens over-wear syndrome”. • This syndrome causes a patient to experience blur, redness, and severe pain for a short time after removal of the lenses. These symptoms are correlated with the degree of corneal swelling present at the time. Hence, PMMA polymers are rarely used today and have been replaced by rigid gas permeable polymers. RGP contact lenses, however, are made from materials that permit oxygen and carbon dioxide to diffuse through their semi-flexible plastic structure (Figure 4).

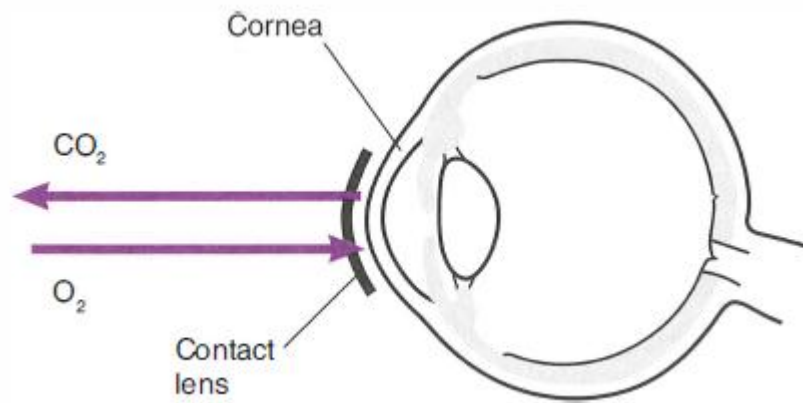


Figure 4: rigid gas-permeable contact lenses permit oxygen and carbon dioxide to diffuse through their semi-flexible plastic structure.

Material of RGP Lens

Technological advancements in contact lens material chemistry have continued to drive RGP lens usage for the past few decades. These materials exhibit varying degrees of oxygen permeability and interfere less with corneal epithelial metabolism than PMMA. These lenses are designed specifically to enhance gas transmissibility and limit protein and lipid deposits. Each of the RGP polymers has different properties suitable for different types of applications. Understanding the material properties is essential when fitting a lens to ensure the best visual acuity, patient comfort, and eye health.

❖ *Advantages of RGP material over PMMA:*

- Gas permeable with good oxygen transmission.
- Very thin (80- 120 mμ).
- Very small (7-9.5 mm diameter) and so the lens covers 2/5 of the cornea only.
- Flexible and increases the tear flow between it and the cornea.
- Easy to manipulate.
- The posterior surface and the edge of the lens are less annoying.

❖ Rigid (RGP) contact lens materials include:

- Cellulose acetate butyrate (CAB): first material developed.
- Silicone acrylates (S/A): Silicon material improved the oxygen permeability than the cellulose lenses.
- Fluoro-silicone acrylates (F-S/A) (Gold standard nowadays): less dryness than S/A material as Flourine coats the lens and prevents lipid deposits.

❖ Basic RGP material properties include gas permeability, wetting angle index of refraction, and lens tint.

- Gas permeability (D_k): is the measure of the material's ability to allow gasses, particularly oxygen, to pass through it.
 - PMMA plastic does not transmit any oxygen so it has a $D_k = 0$. Common RGP materials have a D_k between 15 and 90.
 - The thickness of the lens also affects the amount of oxygen transmitted to the eye (D_k/l). Given the same material, a lens with a thick center (i.e., high plus or biconvex), will transmit less oxygen than a lens with a thin center (i.e., high minus or biconcave).
- Wetting angle is the property that refers to how well the tear film spreads over the lens surface. The lower the wetting angle, the better the lens surface will wet. The wetting of the polymer is essential to ensure optimal comfort and proper lens optics.
- Index of refraction refers to ability of the material to refract light.
- Lens tint is typically a visibility tint. RGP color is not opaque and is not appropriate for changing the color of the eye. The purpose of tinting an RGP is to allow the patient to see the lens more readily (in the lens case or the sink).
- RGP materials may also be manufactured with UV protection, which is not detectable to the wearer but offers improved protection against UV light. This is particularly important in aphakic patients as the retina and posterior structures are vulnerable to UV rays in the absence of the crystalline lens.

Design of RGP lens

- Once a polymer is chosen, the RGP lens is manufactured with prescribed specifications. The lens parameters are custom made for each patient, thus providing a benefit over the limitations of soft lens parameters. The minimum required contact lens parameters include base curve, lens diameter, and lens power. Other parameters that are often specified or chosen by the lab are optic zone diameter, peripheral curve radii and width (Figure 5), center thickness, lenticulation, and special designs.

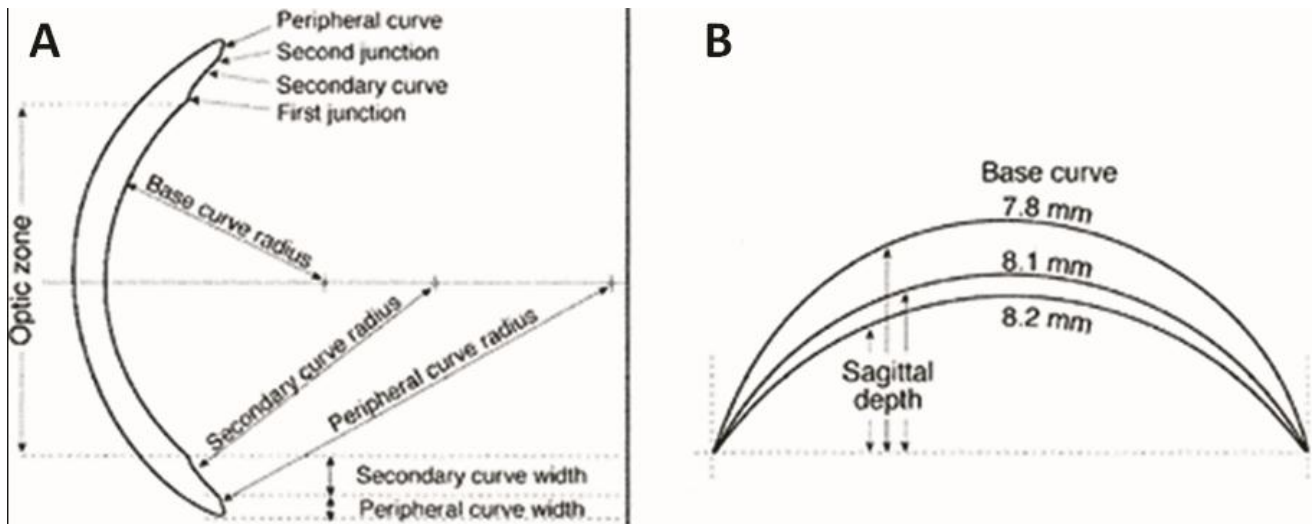


Figure 5: (A) The base curve and diameter of a lens are changed to achieve an optimum sagittal depth (sag). As the radius of curvature becomes smaller, the lens becomes steeper and the sag increases. A larger-diameter lens has greater sag than a smaller-diameter lens. The size of the sag helps to determine what the lens will look like on the eye. (B) The cross-section of a contact lens. Note that the peripheral curve radius is longer than the base curve radius. This allows for the gradual flattening of the lens into the periphery. (From Manual of ocular diagnosis and therapy Lippincott Williams & Wilkins, 2008)

- Different lens designs can be created with various factor adjustments and applied correctly once the factors necessary to manufacture an RGP lens are defined. Basically, RGP lenses are designed based on:
 - The corneal curvatures
 - amount of corneal astigmatism
 - manifest refraction
 - lid position
 - Palpebral aperture and the size of the eye.
- **The Base curve** (Figure 4-B):
 - The base curve defines the radius of curvature cut onto the posterior surface of the lens. The base curve selection ensures that the lens centers well and provides an adequate tear flow to the central corneal surface, thus providing a comfortable and healthy fit for the patient.
 - The base curve is measured in millimeters or diopters and is measured with an instrument called a radiuscope.
 - The typical base curve range is from 8.40 mm (40.25 D) to 7 mm (48.25 D).

➤ **The lens power:**

- It is generated by controlling the relationship between the front surface curvature of the lens to the base curve.
- Power is prescribed in diopters. Most powers range from -25 to +25 D. If a zero-power lens is desired, the power is referred to as plano.
- As a general rule, the higher the power of a plus lens, the steeper the front curve. The reverse is true for a minus lens; the higher the minus power, the flatter the front curve.
- Lens power is measured using a lensometer.
- When a lens is thick (power greater than +4.50 D), the power reading will be different when measuring the front surface verses the back surface. For this reason, the measurement direction must be specified. Power can be read as front vertex power or back vertex power.
- Lenses are most often referred to in terms of back vertex power.

➤ **Peripheral curves:**

- These are necessary to ensure a good-fitting lens and adequate tear exchange.
- Because the human cornea is not perfectly spherical, the edge of the back surface of the contact lens must be flattened slightly to sit comfortably on the eye.
- The peripheral curves are designed in order to allow tear flow under the lens at the flatter corneal periphery. The peripheral curve radii are always flatter (larger radius) than the base curve. Peripheral curve radii range between 8.40 and 13 mm.
- This is done by cutting a series of curves into the periphery of the lens.
- The peripheral curve width is measured in millimeters along the plane of the lens diameter. Each curve has a width measurement associated with it. These range from 0.10 to 0.45 mm.
- Most rigid corneal lenses used today are either bicurve or tricurve:
 - ◆ **A bicurve lens** has one base curve and one secondary curve (Figure 6).
 - A small lens is usually bicurve.
 - An intrapalpebral fit, is one that fits within the palpebral fissure limits, is bicurve.
 - This type of lens is small and steep, with narrow peripheral curves of 0.2mm and small diameters of 7.5–8.8mm.
 - ◆ **A tricurve lens** usually has a large diameter (Figure 7).
 - A contour lens is basically a tricurve lens with a narrow intermediate curve.
 - The blend is the point of transition between the radii of curvature from one curve to another.
 - The sharp junction is removed by making the zone of transition with a curved tool that has a radius value between the values of the two adjacent curves.

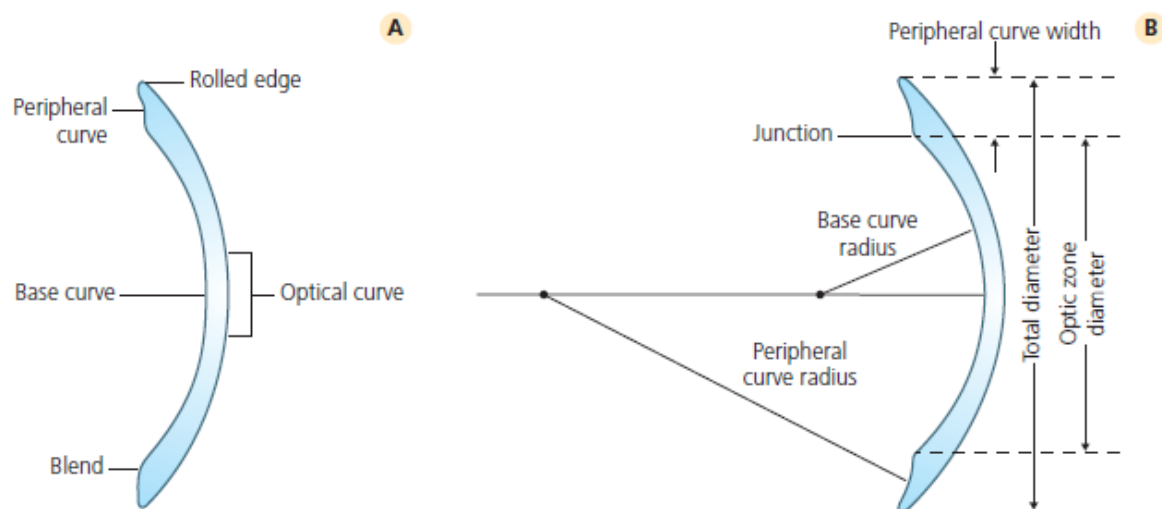


Figure 6: (A) Bicurve lens design indicating two curves, a primary base curve and a flatter peripheral curve with rolled edges to permit greater comfort. (B) Same bicurve lens indicating the diameter of the optic zone and the diameter of the peripheral curve. The combination of the two makes up the total diameter of the lens. (From *The Ophthalmic Assistant*, 9th Edition, H.A. Stein, R.M. Stein and M.I. Freeman, 2013, Elsevier Inc.)

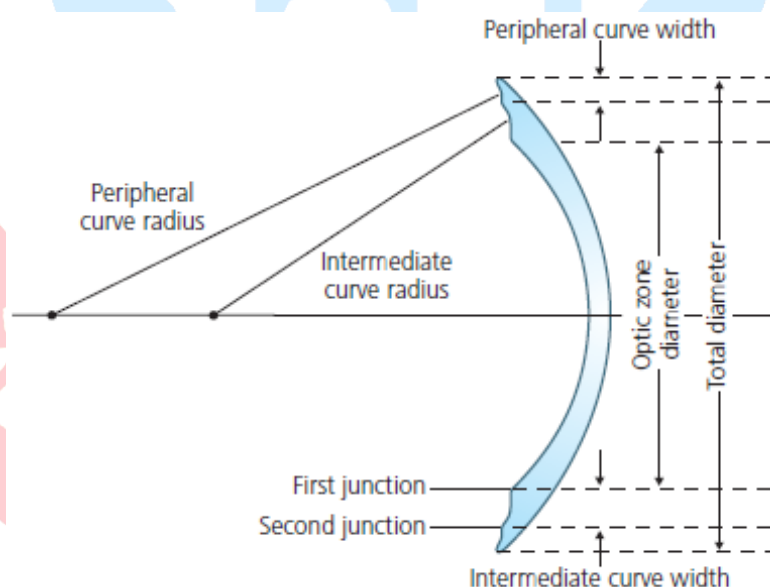


Figure 7: A tricurve lens has two peripheral curve radii. The intermediate curve may be very narrow, as found in contour lenses. These lenses have large diameters— 9.5mm or greater—with an optic zone of 6.5–7.5mm, which is just large enough to clear the maximum pupil diameter. The peripheral curves are slightly flatter than the base curves by 0.4–0.8 mm, with a width of 1.3mm. With a standard tricurve lens the intermediate curve is 1 mm flatter than the base curve. The peripheral curve is a standard 12.25 mm radius. (From *The Ophthalmic Assistant*, 9th Edition, H.A. Stein, R.M. Stein and M.I. Freeman, 2013, Elsevier Inc.)

➤ **The optic zone diameter:**

- This is the width of the curve produced by the base curve cut.
- The optical zone (also called the primary posterior curve or PPC) is the area through which the image will be focused and has the critical optical properties of the lens. It is determined by the difference of the lens diameter and the width of the peripheral curves, which are flatter than the base curve.
- The size of the optic zone ranges between 6 and 8.5 mm.
- The center thickness is the measure in millimeters of the lens thickness in the center of the optic zone.

➤ **Central thickness:**

- This is an important factor in contact lens comfort.
- The thickness is a function of the lens power and diameter; clinically, it is most desirable to have a lens with a center thickness of less than 0.10 mm, as this enhances patient comfort. The thinner the lens, the more comfortable but also the less stable is the lens and the more likely it is to warp and break.
- Also, the thinner the lens, the greater is the oxygen transmission through the plastic.

➤ **Lenticulation:**

- Lenticulation of the edge or center of a lens is used to reduce the mass of a lens or limit edge thickness.
- Lenses with high plus powers will be thick in the center, which will increase the lens mass.
- A minus lenticular can be ordered and material removed from the anterior center of the lens to reduce the weight of the lens and overall thickness. A plus lenticular is used on high minus lenses to remove material from the anterior edges, producing *a thinner edge design*.

➤ Lenses can be designed in spherical, back surface toric, front surface toric, and bitoric forms.

- **A spherical lens:**
 - It is the most common and is used to correct simple myopia and hyperopia.
 - A spherical lens has the same radius of curvature from one cross-sectional plane to another.
 - This applies to both the front and back surface of the lens.
 - One base curve radius and one power are used to define a spherical lens.

- **A back surface toric lens:**
 - It has two different base curves and one front curve. So, it is defined with two base curves and one power.
 - The angle between the two base curves is always 90 degrees.
- **A front surface toric lens :**
 - It has one toric curve found on the front surface of the lens and one base curve.
 - This lens is commonly used for patients with a small amount of corneal astigmatism (less than 1 D) and rather larger amounts of lenticular astigmatism.
- **A bitoric lens**
 - It has toric curves on the front and back surface of the lens.
 - A bitoric lens is defined by listing the two base curves for the back surface and the two power readings for the front surface.
 - This lens type is used for patients with large amounts of corneal astigmatism.

➤ **Diameter:**

- The contact lens can vary in diameter from 6 to 12mm. Most individuals wear lenses with diameter of 8–10mm. They are generally smaller than soft lenses.

➤ **Edge:**

- Edge design of a contact lens is important and is frequently the cause for patient rejection. The edge must be carefully designed, rounded and polished. If the edge is too thick, it will irritate the eyelid margin. If it is too thin, it will be too sharp (knife edge) and also irritate.

- Prism ballast can be included in a contact lens to give weight to the lens and consequently prevent rotation. Bifocals of varying design are also available (see chapter 4).

Fitting and Evaluation of RGP lens and adjustments

Appendix 1 gives the clinical protocol for fitting RGP lenses.

- ❖ Two general methods exist to fit RGP contact lenses and determine the parameters to be ordered:

➤ Lens parameters are chosen from **Pre-prepared nomograms**:

- Nomograms incorporate the corneal curvature obtained from keratometry or topography and measurements are made of the horizontal iris diameter, vertical palpebral aperture, and pupil diameter.
- The lens is ordered and should parallel the criteria of good fit (see later)

➤ **The diagnostic lens procedure:**

- This method involves a contact lens trial set.
- The earlier measurements are made first.
- Next, the appropriate lens is selected from the trial set, inserted on the patient's eye, and allowed to settle for a while (15–20 minutes) to allow for proper wetting of the lens and formation of tear lake.
- Then the position, movement, and relationship between the back surface of the contact lens and the front surface of the eye are evaluated.

❖ **Criteria for a good fit:**

- **Position:** two positions are acceptable
 - Superior position:
 - ◆ The most common type of RGP lens position with on-K lens fit.
 - ◆ The upper edge should be under the upper eyelid, but not over the superior limbus.
 - ◆ Advantages of this position:
 - Allows the lens to move with each blink
 - Enhances tear exchange
 - Decreases lens sensation because the eyelid will not strike the lens edge with each blink.
 - Central or Interpalpebral position:
 - ◆ The upper edge should be just below the upper eyelid, between the upper and lower eyelids.
 - ◆ Usually the diameter of the lens is smaller than with an On-K fit, the base curve is steeper than *K*, and the lens has a thin edge.
 - ◆ The lens here is given a steeper fit than *K* to minimize lens movement and keep the lens centered over the cornea.
 - ◆ This is best for patients who have any of:
 - very large interpalpebral opening,
 - astigmatism greater than approximately 1.75 D,
 - Against-the-rule astigmatism.
- **Centration:**
 - the lens should be centered horizontally
 - its lower edge should be at least 1–2 mm above the lower eyelid in the primary position

- **Movement with blinking:** the lens should move 1–2 mm, return to its original resting point, and remain there between blinks.
- **Fluorescein pattern evaluation:**
 - The primary force that holds a RGP lens against the cornea is the fluid attraction produced by the tear layer
 - The ability of the tear layer to maintain the lens on the eye is determined by two factors:
 - the physical characteristics of the tear layer
 - The geometric relationship between the back surface of the lens and the corneal surface which is evaluated using specific fluorescein patterns.
 - **Tear film patterns:**
 - ◆ This testing is done by placing a drop of fluorescein in the eye and examining the contact lens fluorescein tear exchange pattern.
 - ◆ These fluorescein patterns vary based on the lens and its fitting relationship with the cornea :
 - *Apical alignment or “On K” fit* (Figure 8): the lens base curve is the same radius as the flat meridian. A lens on K has a plano power lacrimal lens.
 - *Apical clearance or “Steeper than K” fit* (Figure 9): the lens base curve is steeper than the radius of the flat meridian. a steeper than K lens has a plus power lacrimal lens
 - *Apical bearing or “Flatter than K” fit* (Figure 10): the lens base curve is flatter than the radius of the flat meridian. a lens that is flatter than K has a minus power lacrimal lens.

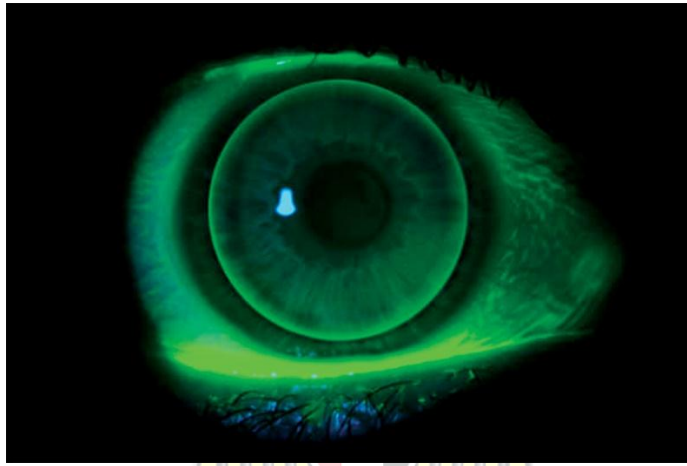


Figure 8: optimal Fit of RGP lens (On K). Produces a consistent fluorescein pattern under the central zone with approximate 0.5mm fluorescein band at periphery. Movement of 1-2mm on blinking is ideal.

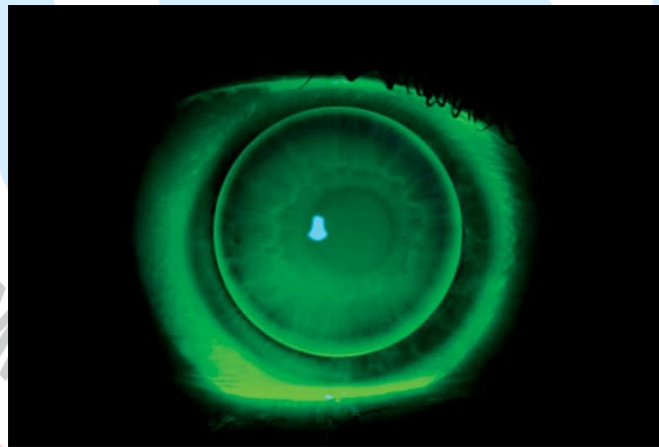


Figure 9: "Steeper than K" fit. Produces a fluorescein pooling under the lens center, inadequate peripheral standoff and reduced lens movement.

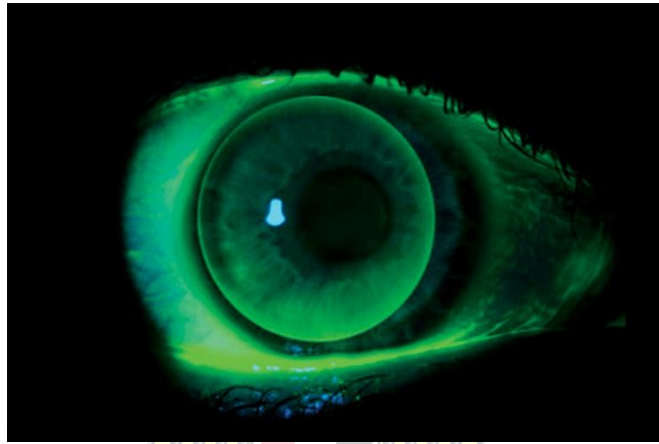


Figure 10: “Flatter than K” fit. Produces excessive movement and a fluorescein pattern with excessive peripheral standoff.

❖ **Edge evaluation:**

- An edge that turns away from the eye between blinks often indicates a flat lens.
- An edge that stands roughly against the cornea or bulbar conjunctiva often indicates a steep lens; also, using a slit lamp, blanching of the conjunctival vessels (conjunctival drag) may be seen with a steep lens (figure 11).



Figure 11: Conjunctival blanching with secondary peri-limbal irritation and injection from tight steep fit.

❖ Other Indirect methods of evaluation:

- Keratometry, retinoscopy, and the subjective feedback about the vision.
- The goal is to obtain a fit that provides a clear, consistent mire, retinoscopy reflex, refraction, and vision.
 - A steep lens (too large a sag or vault) between blinks shows distorted or irregular keratometry mires, a central dark spot in the retinoscopy reflex, and blurred vision.
 - A flat lens (too small a sag or vault) between blinks theoretically shows slightly distorted keratometry mires, an inferior dark spot in the retinoscopy reflex, and fairly good vision.
- Poor keratometry mires, as well as poor retinoscopy reflex or vision, can result from a dry lens surface. The patient is asked to blink four or five times to help differentiate this condition from an improperly fitted lens.

- ❖ When fitting a RGP lenses, the practitioner must be aware of the variation from one RGP manufacturer to another. Not all labs manufacture lenses the same way. A lens produced at one lab may fit differently than the same-parameter lens ordered from a different lab. Even when reproducibility at a given lab is good, all lenses should be manually verified by the practitioner to ensure accuracy.

Insertion, Removal and care of RGP lens

The patient should be carefully instructed on how to insert, remove, and care for contact lenses. (See appendices 2-4 for details about lens care, insertion and removal).

Contact lens care and maintenance are the most crucial aspects of contact lens wear. It can influence the success of contact lens wear and patient's satisfaction. They can prevent potentially sight threatening infections.

The lens care and maintenance procedures have 4 steps (cleaning, rinsing, disinfecting, and storing the lenses).

➤ Cleaning

- The cleaning agents usually contain surfactants and are used to remove most loosely bound foreign bodies on the lens which includes cell debris, mucus, lipid, protein and micro-organisms. The mechanical action of rubbing reduces the amount of loose debris and also enhances the efficacy of the solutions surfactant properties.

➤ **Rinsing**

- After cleaning, the lenses should be rinsed. The rinsing procedure helps to remove the loosened deposits and some micro-organisms.

➤ **Disinfecting and storage**

- The process of disinfecting helps to kill or deactivate the microorganisms. There are two types of disinfecting systems.

- **Thermal disinfection:** The lenses are placed in the case with saline solution and heated to 70 - 80 degree c for 10-20 minutes.
- **Chemical disinfecting**
 - Hydrogen peroxide based solutions are used for chemical disinfection. This is reasonably effective within 10-15 minutes.
 - These disinfecting solutions are also used for storage. They function as a hydrating medium which helps to maintain the stability of contact lens parameters and physical parameters.
- **Multi-purpose solutions**
 - The modern lens care systems use one solution to perform the functions of a number of components. For ease of use and patients convenience, multipurpose solutions are formulated to allow cleaning, rinsing soaking and disinfecting functions to be combined.
 - To avoid lens contaminations, the lens case should be rinsed after every use and the lenses should be stored in fresh solution. For better lens care, change the lens case monthly.

The complications of contact lens wear

The complications of contact lens wear include:

- **Trauma related problems**
 - **Corneal abrasion:**
 - ◆ Linear or sharp-edged epithelial defect;
 - ◆ hyperemia
 - ◆ Caused by either foreign body under or deposits on lens, poor fit or insertion/removal trauma.
 - **Anterior stromal opacity:**
 - ◆ central superficial white stromal opacity
 - ◆ vision drops
 - ◆ Related to Long-term hard lens wear.

▪ **Metabolism (Hypoxia) related problems:**

- **Overwear syndrome (acute epithelial necrosis):**
 - ◆ Central punctate epithelial erosions or ulcer
 - ◆ with or without stromal edema
 - ◆ hyperemia
- **Tight lens syndrome:**
 - ◆ As above + ciliary injection & non-moving lens.
- **Decreased corneal sensation.**
- **Superficial and deep infiltrates.**
- **vascularization:**
 - ◆ Superficial and deep
 - ◆ Hypoxia-induced vessels
 - ◆ lipid keratopathy may occur with deep vessels
- **Superior limbal keratoconjunctivitis.**
- **Epithelial microcysts:**
 - ◆ Painful minierosions
 - ◆ Clear or opaque epithelial cysts,
 - ◆ More common in extended-wear soft contact lens wearers than RGP lens.

▪ **Allergy related problems:**

- **Lens related red eye:**
 - ◆ Hyperemia
 - ◆ punctate keratitis
 - ◆ papillae and follicles
- **Sterile infiltrates:**
 - ◆ Self-limited, Small (often non-staining) peripheral white infiltrates.
 - ◆ Discomfort
 - ◆ Hyperemia
- **Giant papillary conjunctivitis:**
 - ◆ Itching;
 - ◆ mucoid discharge
 - ◆ upper tarsal hyperemia
 - ◆ fine or cobblestone papillae

Chapter 3

Soft Contact Lenses

Objectives

- Introduction to soft lenses.
- Material of soft lenses
- Manufacturing process of soft lenses
- Insertion and removal technique for soft lens
- Soft lens care and Patient education.
- Soft lens complications.

Introduction to Soft Contact Lenses (CL)

The soft lenses match rigid lenses in their quality of vision and surpass them in the area of comfort and ease of adaptation. The two basic types of soft lenses used are the hydrogel (hydrophilic) lens, which has the ability to absorb and bind water to its structure, and the silicone lens, which retain intrinsic property of the rubbery material.

Material and types of soft lens

- ❖ Soft (hydrogel) lenses are made of polymers containing 2-hydroxyethyl methacrylate (HEMA) or related monomers. HEMA is hydrophilic because the free hydroxyl group bonds with water.
- ❖ Soft lens polymers have a dry phase and a hydrated phase. In the hydrated phase, water swells the polymer network, separating the molecular segments from each other. Hydrogel lenses have the unique characteristic of retaining a large volume of water in the hydrated phase.
- ❖ The water content, which may vary from 30% to 85% with different polymers, makes them relatively comfortable, easy to adapt to, and useful for intermittent wear.

❖ Materials used to manufacture contact lenses with hydration properties include:

- a) 55% to 80% (high water content) soft hydrogel lenses;
- b) fluorosilicone acrylate or CAB silicone copolymer rigid lenses;
- c) semisoft pure silicone lenses
- d) Silicone hydrogel lenses.

❖ **soft contact lens types include:**

➤ ***Conventional soft lenses:***

- These are replaced every 6 to 12 months.
- They are to be removed and cleaned with the strongest cleaning systems available, every night.
- A weekly enzyme treatment is necessary to remove proteinaceous deposits.
- They are available for the correction of high myopia, high hyperopia, and high amounts of astigmatism.
- High-powered custom lenses could be made but more expensive.

➤ ***Disposable soft lenses:***

- These are now worn by the majority of soft lens wearers.
- The lenses are to be worn for a given time period (one day, one to two weeks, or one month), cast-off, and replaced with a fresh lens.
- These lenses still must be removed and cleaned nightly or discarded.

➤ ***Moisture lenses for Dry eye:***

- In some of these designs hydrogel lenses are combined with silicone.
- While some patients find relief from dry eyes with these lenses, unfortunately, there are also patients who find that these lenses make their dry eye issues worse.
- These lenses build up lipid deposits quickly due to the lens material.
- They come in toric as well as spherical form.

➤ ***Extended-wear/Continuous-wear contact lenses:***

- Extended-wear lenses are worn for longer than 16 hours or more (typically overnight) on a continual basis.
- The manufacturing technology has produced thinner and thinner soft lenses that provide more comfort and more oxygen under the lens.
- In addition, lenses are now made with a high water content, which also provides more oxygen to the underlying cornea. It is well known that, if the thickness of a soft lens is halved, its oxygen transmission will be doubled.

- This method to wearing contact lenses originally developed in response to the needs of aphakic patients.

❖ **Advantages of Soft CL:**

- convenience,
- Initial comfort
- Decreased lens deposit buildup when discarded at proper timing.
- foreign body sensation is lesser in Soft lenses as they are larger and move less than rigid lenses
- Also, they are less likely to be displaced on the eye or to fall out.
- Disposable lenses reduced the incidence of giant papillary conjunctivitis and some forms of contact lens-related red-eye, including infection.
- The disposable soft lenses help to minimize problems with oxygenation, but they are more difficult to handle and are more fragile.

❖ **Disadvantages of soft contact lens use:**

- **Limited number of base curves.**
- **Increased incidence of dry eye:**
 - This may be due to the thin lens design which allows water to evaporate from the lens matrix.
 - The solution to this problem is to use the newer high-water content lenses designed for use in patients with dry eye problems.
- **They have no proven advantage in reducing the microbial keratitis risk:**
 - Soft lenses are more difficult to keep sterile and free of deposits than RGPs.
 - They must be meticulously cleaned daily.
- **Increased incidence of tight lens syndrome :**
 - In some patients, poor oxygenation or mechanical compression of the blood vessels at the corneo-scleral junction as the result of an improperly fitting soft lens (tight lens syndrome) results in congestion of the limbal vessels and a tendency to corneal vascularization.
 - This is solved by removing the lens and replacing it with a flatter one.
- Additional problems encountered with continuous-wear contact lenses include corneal edema and vascularization, eye infections, and iritis (see before in Chapter 2). All of these sequelae have been reported with continuous lens wear, often combined with tight lens syndrome. Although most of these changes are reversible, they do occur with sufficient rate and severity to cause concern.

❖ There are various methods of manufacturing soft lenses:

- 1) Spin casting
- 2) Lathe cutting with manual or automated lathes
- 3) Molding methods.

❖ The most common method today of manufacturing soft lenses is a combination of lathe cut and molded. Most steps today are relatively automated, quality control being performed by random sampling.

❖ Spin-cast lenses

- The spin-cast process produces a highly reproducible lens with a very smooth surface. This means that the lens is so standardized that all replacement lenses are duplicates of the original regardless of where in the world they are purchased.
- **Appendix 5** gives more details on the spin cast method.

❖ Lathe-cut lenses

- In the lathe-cut manufacturing process the lens, in the dehydrated state, behaves like a rigid lens. It is cut on a lathe to exact specifications similar to those of a rigid lens.
- The most important factor in this method is that one cannot use the usual polishing compounds that contain water; thus the whole process of grinding and polishing must be performed without any contamination by water.
- Automated lathes are currently in fashion and reduce labor.
- Lathed lenses are individually or custom made and a wide variety of parameters can be ground for a better fit.
- Lathe-cut lenses are produced for both stock and custom orders, with most using high-tech computer-controlled systems for excellent quality and reproducibility.
- **Appendix 6** gives more details on the lathe cut method.

❖ Molded lenses

- The cast-molding process uses precision injection molding of engineered thermoplastic resins to produce lens replica molds.
- These molds are used in a monomer-casting process to convert cross-linkable lens monomers directly into a finished contact lens form.
- This process produces an optically finished surface from the mold, thus ensuring accurate reproduction of the lenses.

Choice and Fitting of soft lens and adjustments

- ❖ Soft lenses may be fitted in one of two ways:
 - From an inventory of lenses, by selecting the lens that gives the best fit and the best visual acuity, or
 - From a trial set of standard diameters and base curves to obtain the proper fit. The fitter can then over-refract to obtain the correct power of the lens and order directly.
- ❖ Soft lenses fit must be much flatter than that of rigid lenses due to their larger overall diameter.
 - The average diameter of soft lenses used today is 13.8–14.5 mm, requiring that they be fitted 1.0–1.5 mm (5.00–7.00 diopters) flatter than K.
 - Lens diameter and base curve are inversely related. To attain basically the same fit, the base curve of the lens selected should be flattened as the lens diameter is increased; for example:
 - A 12–13 mm diameter lens is usually fitted approximately 2.00–3.00 diopters flatter than K.
 - A 14–15 mm diameter lens will have to be fitted approximately 3.00–5.00 diopters flatter than K.
- ❖ Lens selection may be based on one of three methods (3Ss):
 - Selection of soft lenses based on probable corneo-scleral profiles, in which the fitter may select a lens diameter based on the horizontal iris diameter and observe how the lens performs on a given eye.
 - Selection of soft lenses with a posterior curvature of radius based on K readings of the cornea, determined by actual measurement of the cornea.
 - Selection of soft lenses based on the sagittal value of the lenses, which requires the K reading of the cornea and takes into account not only the posterior radius of the lens curvature but also the diameter of the lens.
- ❖ The evaluation of a good fit (Figures 12 & 13) is determined by the positioning of the lens and its movement on the eye. The basic fitting idea is to fit the flattest, thinnest lens that will provide clear vision before and after the blink, comfortable wear, stable positioning, and minimum metabolic interference.

Appendix 7 discusses some basic guidelines for fitting all soft contact lenses.

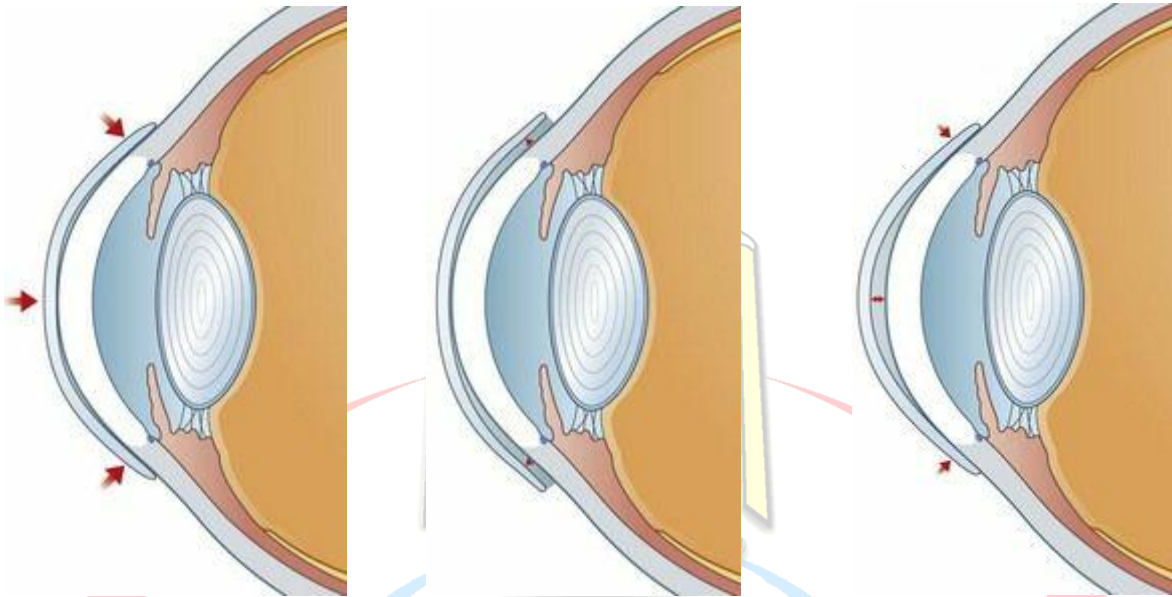


Figure 12: *Left:* A normally fitting soft lens will rest lightly at the apex and at the periphery of the cornea (Three-point touch). *Middle:* Cross-section showing a loose flat lens. *Right:* Cross-section showing a tight steep lens. (From Uotila M, Gassett AR: Fitting manual for Bausch & Lomb and Griffin lenses. In: Gassett AR, Kaufman HE, eds: Soft Contact Lens. St Louis: Mosby, 1972.).

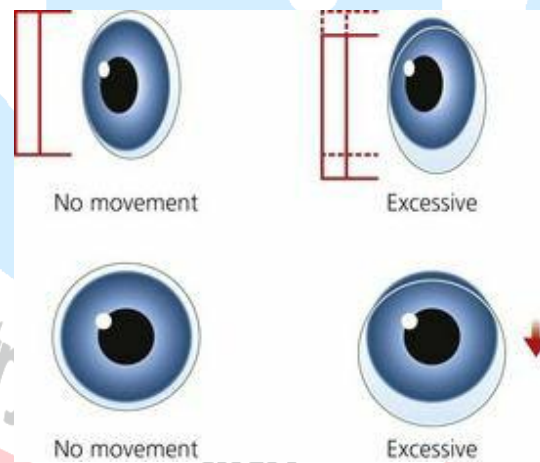


Figure 13: Movement of a soft lens may vary from nil (tight) to too much (loose). (The Ophthalmic Assistant, 9th Edition, H.A. Stein, R.M. Stein and M.I. Freeman, 2013, Elsevier Inc).

Insertion, Removal and care of RGP lens

Proper lens care and regular follow up are very essential to maintain a good ocular health. (See appendices 2-4 for details about lens care, insertion and removal).

The complications of Soft contact lenses are the same as RGP lenses discusses before (see chapter 2). However, Ulcerative keratitis has proved to be the most vision-threatening drawback to extended-wear soft contact lenses:

- The annual incidence of bacterial keratitis is approximately 20 in 10,000 persons using extended-wear lenses, as opposed to 4 in 10,000 persons using daily-wear lenses.
- The risk of developing ulcerative keratitis is 10 to 15 times greater in extended-wear lens users who chose to wear their lenses overnight.
- Caution should be employed in fitting extended-wear lenses. Patients on extended-wear CL require frequent follow-up exams and should be followed closely after starting continuous wear of these lenses.

Other problems faced with continuous-wear contact lenses are as discussed before in chapter 2. Many doctors are now recommending extended-wear contact lenses to be used on a daily-wear basis to benefit from the high oxygen lens permeability and reduce complications. The buildup of protein and lipid deposits on the surface of continuous wear lenses occurs with abundant frequency and requires regular lens substitution.

Chapter 4

Innovations and new trends in Contact lenses

Objectives

- Toric contact Lenses
- Presbyopia correction (Bifocal, Multifocal & diffractive CL)
- Tinted (colored) Contact lenses
- Manufacturing innovations and modifications

Introduction

Innovations are regularly appearing in the soft lens field, making old lenses and methods of cleaning and disinfecting outdated. Soft lenses have become thinner and more durable. Their manufacturing techniques have become more automated and more reproducible.

Toric Contact lenses

- ❖ Soft lenses mold to the surface of the cornea. so, astigmatism will persist with a spherical lens, and toric correction may need to be added to the contact. This remaining optical toricity is referred to as residual astigmatism.
- ❖ Toric soft lenses are used for the correction of astigmatism. These lenses require more advanced fitting techniques.
- ❖ Soft toric lenses work best for low to moderate degrees of astigmatism oriented with the rule (flat axis near the 180 degree meridian) or against the rule (flat axis near the 90 degree meridian.) Success with the correction of oblique astigmatism is more difficult.

- ❖ For adequate astigmatic correction, toric lens axis orientation and stability is crucial. All Toric lenses are designed to accurately orient the astigmatic correction, and prevent the axis from rotating on the cornea.
- ❖ Methods of axis stabilization include:
 - Prism ballast, that is, placing extra lens material on the bottom edge of the lens (Figure 14)
 - truncating or removing the bottom of the lens to form a straight edge that aligns with the lower eyelid (Figure 15)
 - Thin zones (or double slab-off) which involves making lenses with a thin zone on the top and bottom so that eyelid pressure can keep the lens in the appropriate position (figure 16).
- ❖ Most toric soft lenses use either prism ballast or thin zones to provide stabilization and comfort.

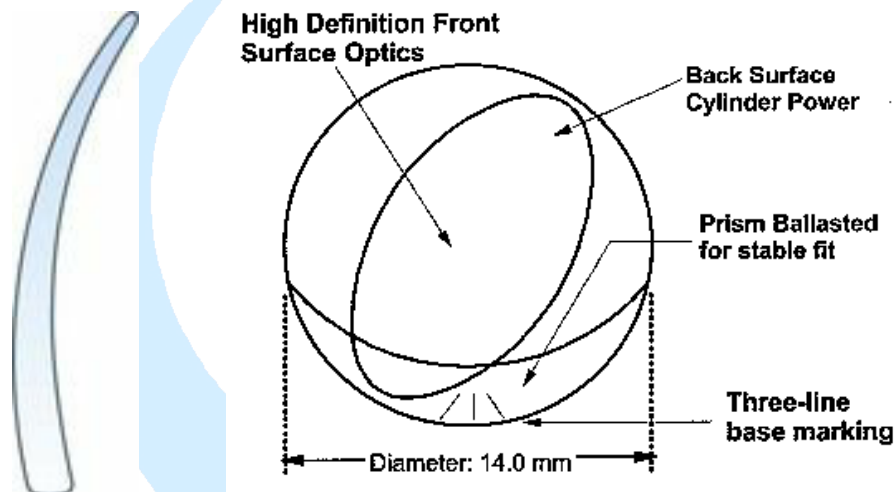


Figure 14: Prism ballast to provide weight and stop rotation of a lens.

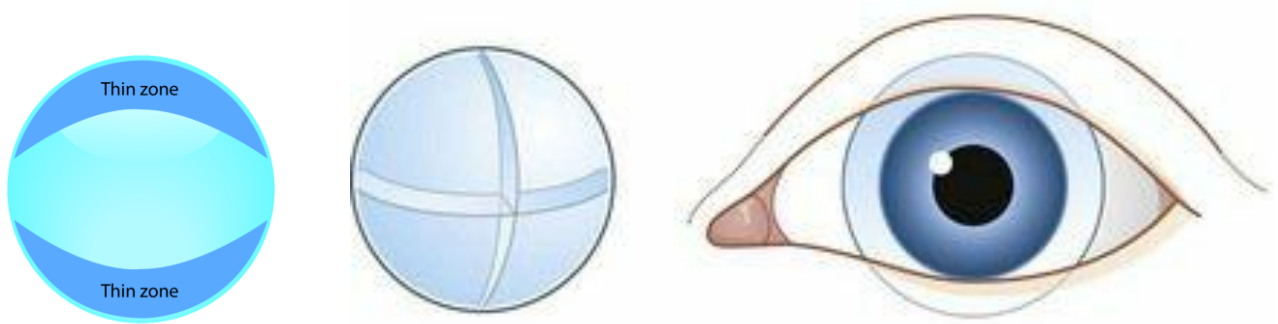


Figure 15: Thin zones design of CL. The lens is made thinner superiorly and inferiorly so that thinner portions tend to rotate and come to rest under the upper and lower eyelids. (From The Ophthalmic Assistant, 9th Edition, H.A. Stein, R.M. Stein and M.I. Freeman, 2013, Elsevier Inc.)

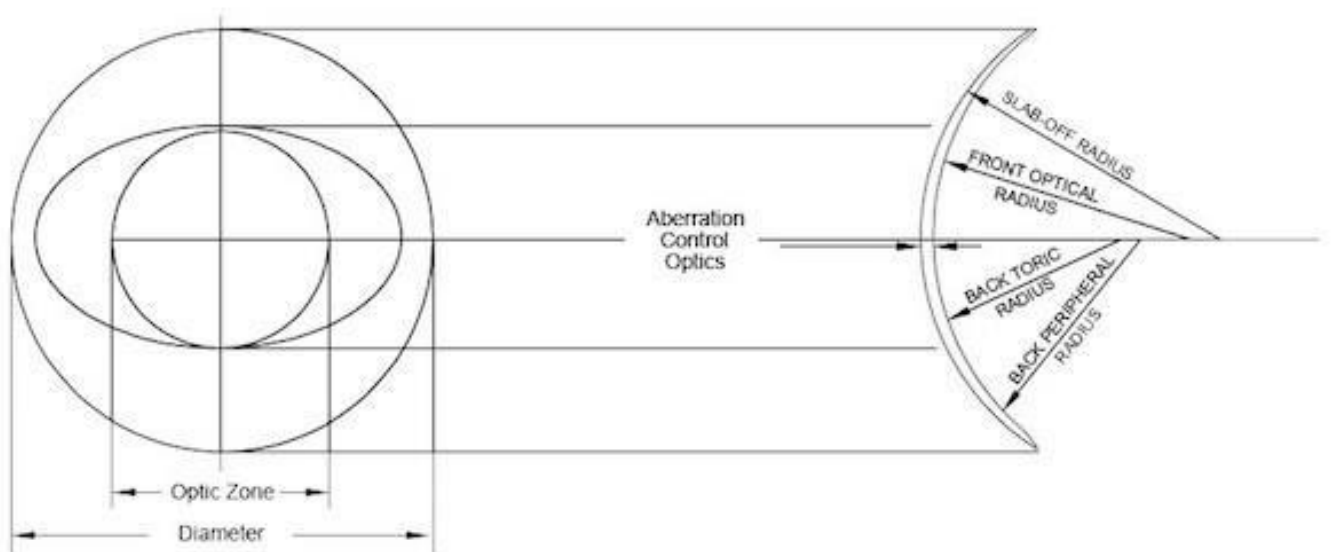


Figure 16: Design of Toric CL with double slab off (thin zones) stabilization technique.

- ❖ Fitting soft toric lenses is similar to fitting other soft lenses, except that lens rotation must also be evaluated.
 - Toric lenses typically have a mark to note the 6-o'clock position. If the lens fits properly, it is in the 6-o'clock position (figure 17).
 - The mark does not indicate the astigmatic axis; it is used only to determine proper fit.
 - If a slit-lamp examination shows that the lens mark is rotated away from the 6-o'clock axis, the amount of rotation should be noted, in degrees (1 clock-hour equals 30°) (Figure 18).
 - The rule for adjusting for lens rotation is **LARS** (*left add; right subtract*).
 - When ordering a lens, the clinician should use the adjusted axis (per LARS, adding or subtracting from the spectacle refraction axis), instead of the cylinder axis of the refraction).

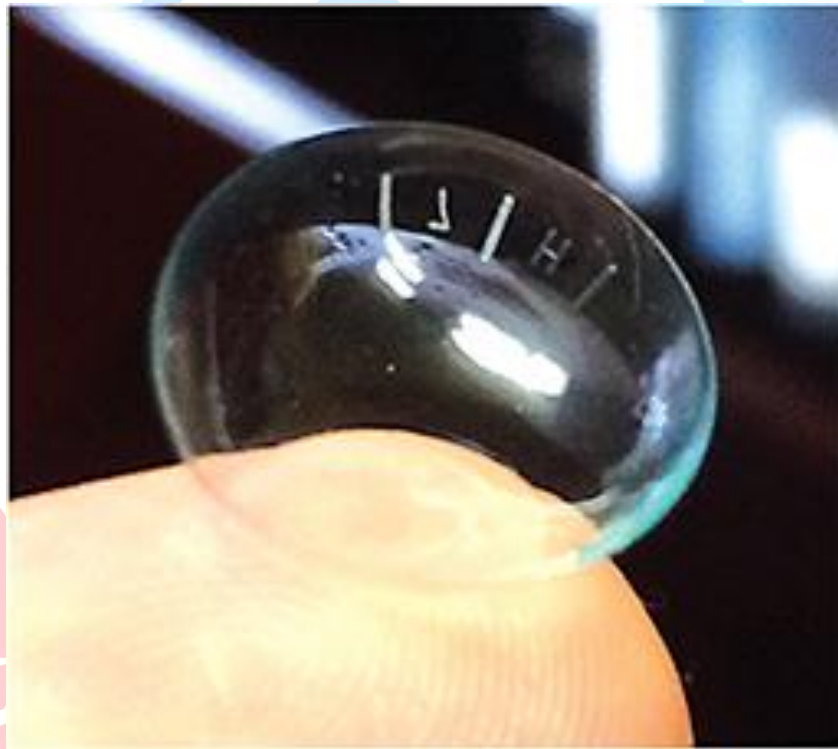
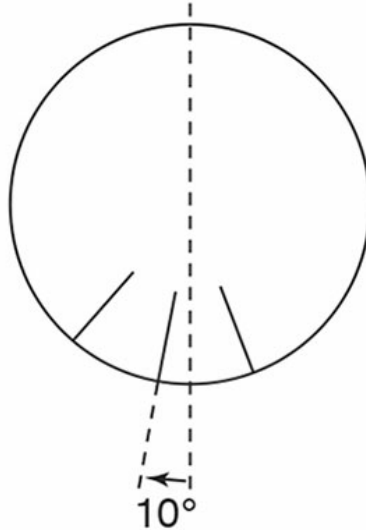


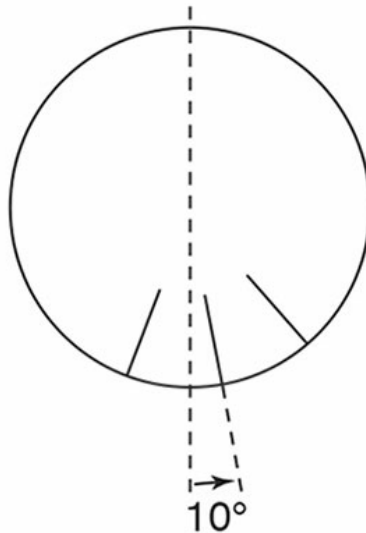
Figure 17: Markings on soft Toric CL.

If lens rotation is 10° to the left (clockwise)



axis ordered is $180^\circ + 10^\circ = 190^\circ$

If lens rotation is 10° to the right (counterclockwise)



axis ordered is $180^\circ - 10^\circ = 170^\circ$

Figure 18: Evaluating lens rotation in fitting soft toric contact lenses using the LARS rule of thumb (left add; right subtract). The spectacle prescription in this example is $-2.00 -1.00 \times 180^\circ$. (from AAO BCSC 2016-2017 section 3: Clinical optics)

- ❖ Bifocal contact lenses are now available in both soft and RGP lens designs.
- ❖ Bifocal lens fittings require:
 - Careful choice of the patient
 - Realistic hopes from the patient
 - Detailed patient instruction.
- ❖ Bifocal contact lenses are based on one of two designs:
 - **Simultaneous-vision lenses (Figure 19):**
 - These designs provide the retina with light from both distance and near points in space at the same time, requiring the patient's brain to ignore the reduction in contrast. Usually, either the distance or near vision is compromised; the greater the add the greater the compromise.
 - They are available in soft and RGP types.
 - They are either diffractive (annular) or multifocal (aspheric) in design.
 - ***The multifocal aspheric CL (Figure 19-A):***
 - These provide simultaneous vision by allowing the wearer to select preferential rays from either distant objects or near ones.
 - The aspheric bifocal lens is similar to the progressive bifocal spectacle lens and is formed by altering the anterior and posterior curves to achieve a given power gradient.
 - Aspheric surfaces change in power from the center to the periphery: minus lenses decrease in power from the center to the periphery, whereas plus lenses increase.
 - ***Diffractive CL (Figure 19 – B):***
 - These lenses have concentric grooves on the back surfaces, such that the light rays are split into 2 focal arrays: near and far.
 - The diffractive surfaces reduce incoming light by 20% or more, thereby reducing vision in dim lighting.
 - They are less sensitive to pupil size than the aspheric multifocal designs, but they must be well centered for best vision.

➤ **The alternating vision lenses (Figure 20):**

- These are similar in function to bifocal spectacles in that there are separate areas for distance and near, and the retina receives light from only 1 image location at a time.

- ***The Segmented contact lenses (Figure 20-left A):***

- These have 2 areas, top and bottom, like bifocal spectacles.
- The position on the eye is critical and must change as the patient switches from distance to near viewing.
- The lower eyelid controls the lens position so that as a person looks down, the lens stays up and the visual axis moves into the reading portion of the lens (**Figure 20-Right**):.
- Maintenance of the proper lens position is crucial; hence, such lens designs do not work for all patients.

- ***The concentric (annular) contact lenses(Figure 20-left B):***

- These have 2 rings (or *tines*), one for far and one for near.
- The most commonly used annular design uses a central area to correct for near vision and a peripheral concentric area to correct distance vision.
- This design is based on the near miotic pupillary response and corresponding distance mydriasis.

➤ **The disadvantages of bifocal lenses:**

- Decreased contrast sensitivity,
- fluctuating vision
- Occasional halos or shadows.
- Higher cost than other lenses

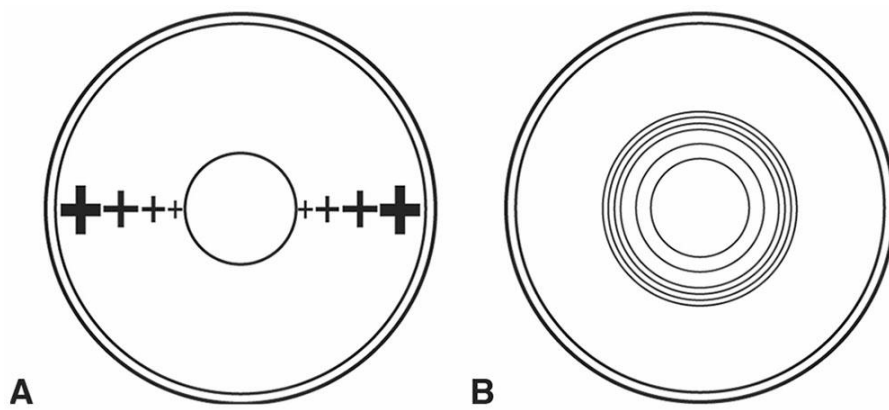


Figure 19: Simultaneous vision bifocal contact lenses. A, Aspheric, or multifocal lens. B, Diffractive lens. (from AAO BCSC 2016-2017 section 3: Clinical optics)

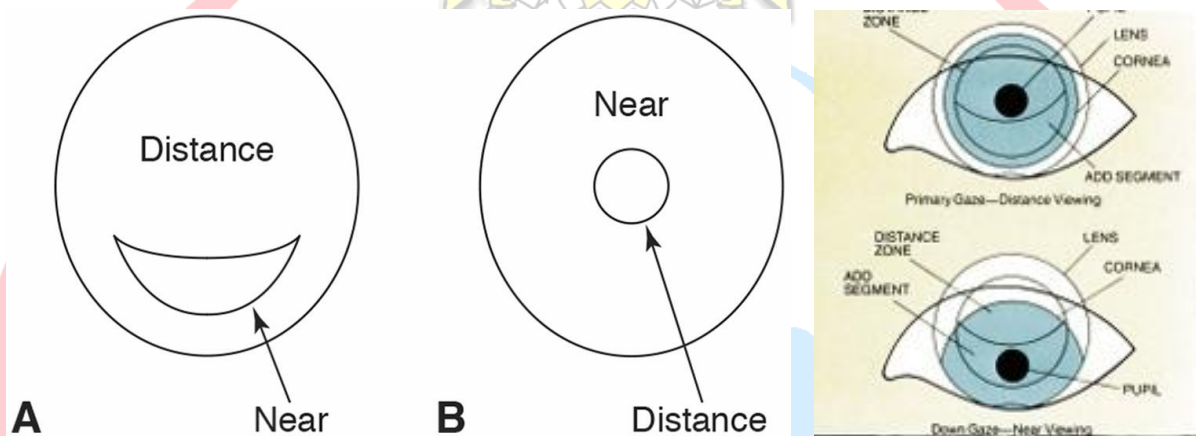


Figure 20: *Left:* Alternating vision bifocal contact lenses. A, Segmented lens. B, Concentric (annular) lens. *Right:* with segmented lens design, the lens moves on downgaze to correct near vision. (from AAO BCSC 2016-2017 section 3: Clinical optics)

MonoVision

Some presbyopic patients benefit from a more simple solution, known as monovision. With monovision, the dominant eye is corrected for distance vision and the non-dominant eye is corrected for near vision. A less common approach is termed modified monovision, in which one bifocal lens is used and one single-vision lens is used to enhance the intermediate range, a range of vision not corrected for by monovision.

Tinted (Colored) Contact lenses

- ❖ Tints may be used for therapeutic purposes, cosmetic purposes or to make the lens easier to locate.
- ❖ Therapeutic applications of tinted lenses include:
 - Scarred or opaque corneas,
 - Iris irregularities: iris coloboma, iridectomies, aniridia (absence of iris).
 - Dilated fixed pupil (Traumatic or 2ry to neurological disorders)
 - Photosensitivity resulting from albinism.
 - Amblyopia occlusion therapy.
- ❖ Handling tints were used in the lenses of for ease of identification.
- ❖ Cosmetic lenses are used alter the color of the eye. Color-changing lenses are also used for coloboma of the iris, where an opaque lens with a clear center can often give a very visually satisfying appearance.
- ❖ Colored CLs are manufactured using the iris print method. This consists of placing an iris image on a dome of clear HEMA, producing an opaque tint. A dot matrix is placed on the front surface of the contact lens to alter the iris color of the wearer.
- ❖ Tints are often affected by harmful vapors and chemical agents and they may also be affected by aging. In addition, some cleaning agents will bleach some lenses. Leak of the lens dye out of the lens may be a problem with continual wear. Some companies have minimized this effect by burying the material deep in the lens or directly into the buttons before cutting.

Manufacturing innovations and modifications Contact lenses

- ❖ Contact lens design, materials and manufacture are continually developing and pioneering new approaches are evolving to benefit more people every day.
- ❖ Some of the innovations that developed in the past few years include:
 - **Orthokeratology:**
 - Orthokeratology is a technique of fitting a RGP lens for the purpose of modifying the refractive error, principally in myopes.
 - A reverse geometry RGP lens (a lens with a base curve flatter than the secondary curve) is fitted in an attempt to induce a flattening effect of the cornea and thereby decrease the amount of myopia.

▪ ***Ortho-K lens (reverse-geometry) design:***

- The shape of the central zone (molding surface) of these lenses is intentionally made somewhat flatter than is needed for the cornea to correct the eye's myopia.
 - The intermediate zones are made steeper to provide a peripheral bearing platform
 - the peripheral zones are designed to create the necessary clearance and edge lift.
- Lens centration is key to the effectiveness of these lenses. It requires them to be supported by circumferential peripheral bearing at the junction of the intermediate and peripheral zones.
- Because the lenses are worn overnight, their oxygen transmissibility must be high; consequently, they are generally made of materials with very high oxygen permeability ($Dk \geq 100$).
- The amount of change that can be produced is limited. The procedure is approved for up to 5 to 6 D of myopia reduction, depending on the lens design.
- In orthokeratology, the myopia reduction effect is transient and merely reduces the spectacle correction without curing the myopia.
- Microbial keratitis related to the treatment has been reported. However, Risk can be minimized with proper compliance regarding lens care and wearing schedule.
- Orthokeratology is quite expensive for many reasons, such as cost of fitting and follow-up and the cost of the lens itself.
- It is not yet widely accepted as a routine procedure.

➤ **Scleral lenses for keratoconus and other corneal conditions:**

- Gas-permeable scleral lenses have 2 primary indications:
- Correcting abnormal regular and irregular astigmatism in eyes that cannot be fitted with rigid corneal contact lenses e.g. severe Keratoconus.
 - Ocular surface diseases that benefit from the constant presence of a protective, lubricating layer of oxygenated artificial tears.
- Advantages of scleral Lenses:
- These lenses are entirely supported by the sclera.
 - Their centration and positional stability are independent of distorted corneal topography.
 - They avoid contact with a damaged corneal surface.
 - These lenses create an artificial tear-filled space over the cornea, thereby providing a protective function for corneas suffering from ocular surface disease.
- Scleral lens design (figure 21) consists of a central optic that vaults the cornea and a peripheral haptic that rests on the scleral surface. The shape of the posterior optic surface is

chosen so as to minimize the volume of the fluid compartment while avoiding corneal contact after the lenses have settled. The posterior haptic surface is configured to minimize localized scleral compression; the transitional zone that joins the optic and haptic surfaces is designed to vault the limbus. Historically, these lenses were composed of oxygen-impermeable PMMA. Currently, scleral lenses are composed of highly oxygen-permeable polymers.

- The fitting method for these lenses uses a series of diagnostic lenses with known vaults, diameters, powers, and haptic design.

➤ **Rose “K” Lens for keratoconus:**

- The most current lens design of RGP lens for Keratoconus is the Rose ‘K’ design. The design provides a smaller central optic area to fit over the cone with rapid flattening of the mid-peripheral curvature. The peripheral lens design consists of a series of computer-controlled curves to form an aspheric edge (figure 22).

➤ **Hybrid lens designs:**

- These are large-diameter lenses that have a rigid gas permeable central zone, surrounded by a peripheral zone made of soft or silicone hydrogel material.
- The purpose of this design is to provide the visual clarity of GP lenses, combined with wearing comfort that is comparable to soft lenses.

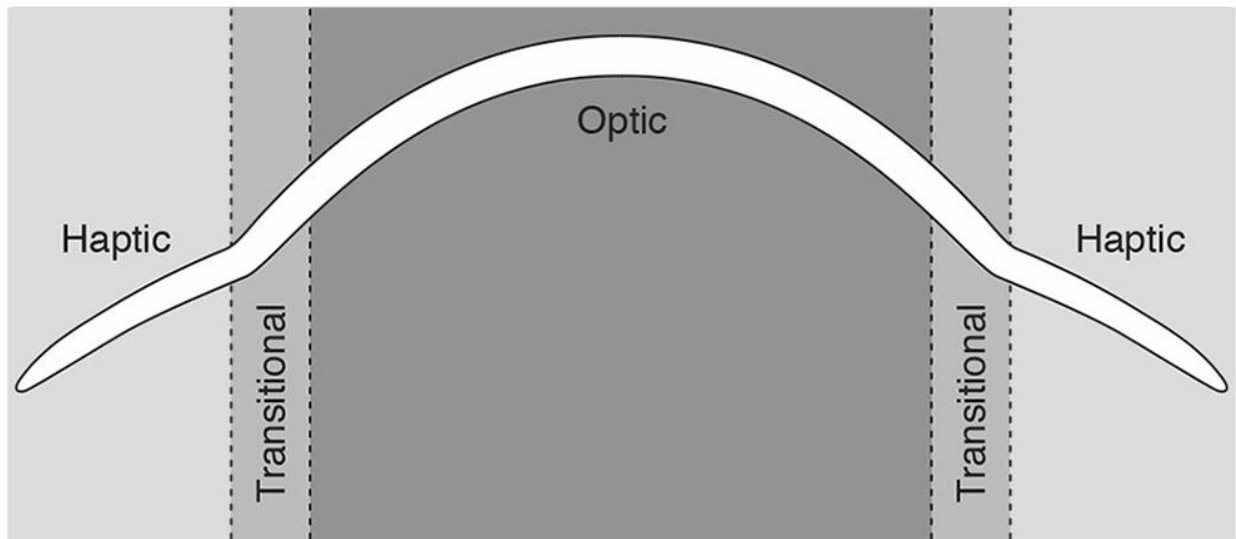


Figure 21: Scleral contact lens design. (from AAO BCSC 2016-2017 section 3: Clinical optics)

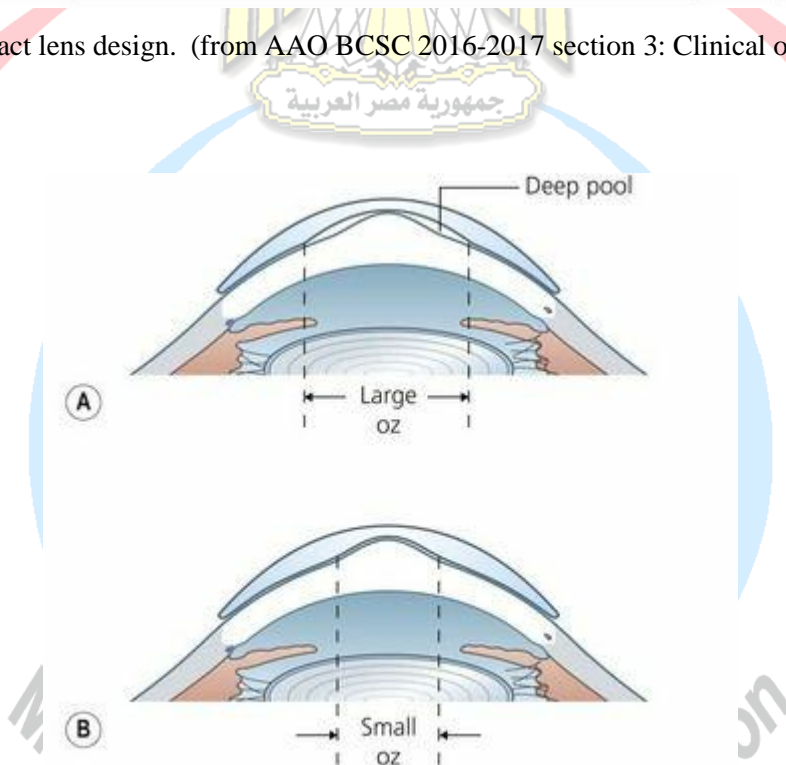


Figure 22: A, Standard lens design with large optic. B, Rose 'K' design. (From The Ophthalmic Assistant, 9th Edition, H.A. Stein, R.M. Stein and M.I. Freeman, 2013, Elsevier Inc.)

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APPENDICES

Appendix 1 - Clinical protocol: Steps for fitting RGP lens

1. Obtain an accurate refraction.
2. Convert to minus cylinder form and drop the minus cylinder (use spherical power only; the tears form a cylindrical “lens” between the cornea and the contact lens that will correct corneal astigmatism).
3. Calculate correction for zero vertex distance.
4. Evaluate the anterior segment with a slit lamp exam
 - a. Look for corneal edema, vascularization, staining; note contour.
 - b. Note tear film and the tear film breakup time (normally >15 seconds). Consider Schirmer testing.
 - c. Look for lid abnormalities, flip lid to check for papillae, note palpebral fissure.
 - d. Check for eccentric pupil.
5. Perform keratometry; compare results with spectacle refraction to detect lenticular astigmatism.
6. Discuss rigid vs. soft lenses with patient.
7. Fit RGP lens: Evaluate fluorescein patterns.

Appendix 2 – Clinical protocol: Instruction to the patient on contact lens use

1. The hands should be washed before the handling and insertion of contact lenses.
2. It is helpful to wet the finger before balancing a gas permeable lens on it. For soft lenses, a dry finger is preferred.
3. All make-up should be removed.
4. The eye should not be rubbed with the lens in place.
5. After removal, the lenses should be rinsed with saline or rinsing solution to remove secretions.

6. Storage of the lens is in contact lens solution. This permits the lens to be disinfected as well as lubricated on initial wearing. Follow the care instructions carefully for the specific disinfection solution being used in order to allow for effective disinfection.
7. Lenses should not be rinsed or placed in hot water, because the lenses may warp under extreme heat. Tap water use in general should be avoided, especially with soft contact lenses.
8. Tips on using cosmetics:
 - It is important to insert contact lenses before any cosmetic is applied to the lids.
 - A cosmetic with an oily base should be avoided, since any oily agent will gather on the lenses and cause distortion of vision.
 - Mascara should be used sparingly on the lashes and only the waterproofed brands are advisable. It should be placed on the very tips of the lashes only.
 - False eyelashes should be used sparingly or not at all. In many cases the adhesive breaks off and enters the eye, interposing between the cornea and the contact lens and causing irritation and abrasions.
 - Hair spray should be used with caution. The eyes should be closed when the hair spray is used and kept closed for several moments until the air clears.
 - Similarly, the eyes should be kept closed when the head is placed under a hot hair dryer because the dryer causes evaporation of tears and a dry eye, which in turn can result in a corneal abrasion.
9. The lens wearer should avoid swimming while wearing contact lenses. The lenses can possibly be washed out of the eye and pathogens present in the water could potentially attach to the lenses.
10. Body-contact sports such as hockey and football should be avoided with rigid gas-permeable lenses in place. Individuals involved in these sports may do best with soft lenses. Rigid contact lenses can be worn for activities such as golf, jogging, tennis, or badminton.

❖ **Insertion and Removal for soft contact lenses**

- Wash hands thoroughly with oil free soap and dry with lint - free towel
- Take the lens out of the case , clean and rinse it well
- Place the lens on the tip of the index finger
- Look up, and retract the lower lid with the middle finger and gently apply the lens to the lower part of the eye
- Remove the finger and then slowly release the lid
- Close the eye and gently massage the lids
- Cover the other eye and focus it to make the correct centration
- Repeat the same procedure for the other eye
- For removal, look upward and retract the lower lid with middle finger and place the index finger tip on the lower edge of the lens
- Slide the lens down to the white portion of the eye
- Compress the lens between the thumb and the index finger, so that the air breaks the suction under the lens
- Remove the lens for cleaning and sterilizing

❖ **Insertion for hard and RGP**

- Wash your hands thoroughly with oil free soap
- Take out the lens from the container
- Keep in your palm, clean it well with the prescribed solution
- Depress the lower lid with the middle finger while the index finger carrying the lens is gently applied on the cornea
- Slowly release the lids to avoid accident ejection of the lens. Release the lower lid first and then the upper

❖ **Removal for hard and RGP lenses**

- Look downward, open the lids wide so that the edge of the lid will engage the edge of the lens
- Draw the lid tight by a lateral pull of the index finger and blink
- The lid should dislodge the lens
- Cup the other hand under the eye to catch the lens
- **Scissors technique:** Hold the upper lid by the index finger and the lower lid by the middle finger. Apply lateral traction to the lids and squeeze the lens off with a scissors motion.

- Wash your hands with oil free soap before handling the contact lenses
- Before wearing the lens it should be cleaned thoroughly in cleaning solution and rinsed well.
- Place the lens which should look like a bowl on the tip of the index finger.
- After removing, the lens should be placed properly in the lens case with solution
- The lens should be placed in the center of the lens case; it should not be placed at the side because of chances of tearing.
- Solution should be changed daily. If the lens is not used daily; solution should be changed once in two days.
- The lens should not be kept without solution because it will get dried and the lens will be ruined.
- While wearing the lens avoid sitting under the fan or in windy places
- While traveling plain glass or sun glass should be worn
- The lens case should be washed weekly and should be changed once in three months
- Don't change the solution brand without the advice of the practitioner.
- Proper care and follow up is must.
- Lens should be changed according to the recommendations of the manufacturer
- If any complaints persist in the eye the lens should be removed and consult medical practitioner immediately.
- Alternative use of spectacles is advisable if any discomfort develops

Appendix 5 – The spin cast method of soft contact lens manufacturing

- The procedure is basically a kind of pressureless molding.
- It is derived from a revolving mold (frame) that spins the liquid plastic at high speed. The mold gives the lens its outside curvature.
- The inside curvature is formed as a result of the speed of rotation, the various surface tensions of the liquid, and the pre-calculated mathematic relationship between gravitation and rotation.
- The result is a parabola with an inside curvature that can shorten or lengthen, depending on the speed of rotation.
- Because the posterior surface of a spin-cast lens is aspheric, the traditional K readings and the posterior surface's relationship to the base curve do not apply with these lenses.
- The basic fitting system is based on measurement of the horizontal visible iris diameter and selection of a suitable diameter of lens with proper power.
- The numeric suffix on the label denotes the lens diameter. A label ending in 4 is a 14.5 mm diameter, a 3 is a 13.5 mm diameter, and the absence of a number is a 12.5 mm diameter.
- A combination of the spin-cast and lathing processes has been developed by Bausch & Lomb. Their design permits more variables in fitting while combining the high quality of the front surface for crisp optics. Other major soft contact lens manufacturers have developed their own advanced proprietary manufacturing methods.

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Appendix 6 – The lathe cut method of soft contact lens manufacturing

- ❖ In the lathe-cut manufacturing process the lens, Initially the back surface is ground with a diamond tool and then the front surface is polished and edged. In this method, peripheral curves, blends, and even intermediate curves can be cut for better lens design.
- ❖ The most important consideration in cutting soft lenses from a dry button that is later to be hydrated into a hydrogel lens is that the entire process of lathing must be performed under very strict climate control; too much humidity in the laboratory can cause variations in the finished product because the button can absorb moisture from the air.
- ❖ After completion of the grinding process in the hard inflexible state, the lens is placed for several hours in a water bath where it undergoes swelling and expands to its final state. This swell factor must be taken into account in the grinding of the lens in the hard state.
- ❖ When the finished lens in a dry state is hydrated for final wet inspection or quality control, the difference or swell factor is 20–40%, depending on the polymer material and water content.
- ❖ This factor makes it extremely important for the ‘dry state’ lens to be made to exact specifications. In years past, criticisms of lathe-cut lenses included their inconsistency and that reproducibility could be suspect. Today’s lathe-cut lenses, however, compare favorably in quality and reproducibility with those manufactured by any other process.

1. The hydrophilic lenses are fitted as large as or larger than the diameter of the cornea and range in size from 12 to 15 mm.
2. Small eyes will require smaller diameters and consequently steeper base curves, whereas larger eyes are fitted with larger lenses and flatter base curves.
3. Soft standard-thickness lenses generally are fitted flatter than the flattest K reading, usually about 2.00–3.00 diopters for the smaller lenses and 3.00–5.00 diopters for the larger lenses. The thinner soft lenses (0.06 mm and less) are fitted 4.00–7.00 diopters flatter than K because they tend to drape themselves over the corneal surface.
4. A normal-fitting lens should show 0.5–1 mm lag in the downward direction with each blink and provide good vision before and after blinking.
5. A soft lens that moves excessively (more than 1 mm with each blink) is too flat; a soft lens that moves less than 0.5 mm with each blink is too steep and will limit tear exchange.
6. A soft lens that decenters usually is too flat or too small. To correct this problem, a larger-diameter lens or a steeper lens should be selected.
7. The fitter may determine increased steepness or flatness from a table showing the relationship of the diameter to the radius (sagittal values). To loosen a lathe-cut lens, smaller diameters in 0.5 mm steps may be fitted or the radius increased in 0.2–0.3 mm steps.
8. The lower the water content of the lens, the more durable the lens becomes. The higher the water content, the more fragile is the lens.
9. The thinner the lens, the greater is the oxygen permeability to the cornea. However, a thin lens will tear easily and some optical quality may be lost by wrinkling.
10. Hazy vision caused by oxygen deprivation may occur either from wearing a lens that is too tight or from overwearing the lens.
11. Contact lens decentration can be caused by tight eyelids, large corneas, against-the-rule astigmatism, or asymmetric corneal topography.
12. Routine soft lenses do not correct large amounts of corneal astigmatism. In general, astigmatism over 1.0 diopter requires correction by toric soft lenses or rigid lenses.
13. With soft lenses, regular fluorescein cannot be used to study tear exchange because it permeates the lens. High-molecule fluorescein can be used, but it is no more effective than evaluating tear exchange by noting the movement of the lens. Fluorescein is helpful in highlighting and assessing corneal pathologic conditions.
14. Heavier lenses usually have to be fitted larger. The lens weight is influenced by its thickness

and water content. Polymers of high water content are usually weaker than those of lower water content and require lenses of greater thickness. The increased gravitational pull on a heavier lens has to be offset by use of a larger diameter.

15. The rigidity of a lens is a function of its thickness, its water content, and the unique properties of the polymer from which it is made.

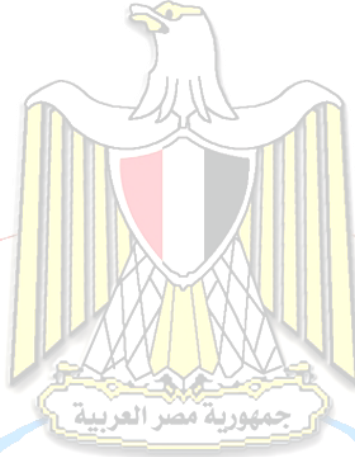
16. When fitting soft lenses, the fitter should aim at fitting the flattest possible lens that will provide good clear vision, center well, and have no effect on the corneal integrity.

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