Theme section

Biomicroscopic Lenses to Visualise Posterior Segment

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Abstract

Ophthalmology is a unique field allowing the clinician a non-invasive 'window' to the organ of interest as the eye and especially its posterior segment hide's information, not just about eye-related issues but also about the patient's general well-being.

Although newer technologies like Optical Coherence Tomography (OCT) and other retinal imaging modalities have revolutionised the diagnosis and management of posterior segment pathologies, they are still not a replacement for the easily available, affordable and portable hand-held lenses. By utilising the optics of these lenses, we are able to visualise the remote areas of the eye especially the fundus, in order to facilitate any therapeutic interventions. This article focuses on the various types of lenses used for posterior segment evaluation which are important tools in every ophthalmologists' arsenal.

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The optical system of the patient's eye - the cornea and lens, together provide so much convergence that ordinarily we cannot see the retina using a slit-lamp. At most, the slit lamp can view upto the anterior vitreous. So, auxiliary lenses for slit-lamp examination of the retina are required to nullify these intervening optical effects caused by the patient's eye.[1] During indirect ophthalmoscopy the divergent rays from the patients eye are focused between the hand held condensing lens placed just above the patient's eye.

Classification Of Lenses For Posterior Segment Examination

The various lenses used in clinical ophthalmology can be divided in to Diagnostic(figure 1) and therapeutic (figure 2) lenses

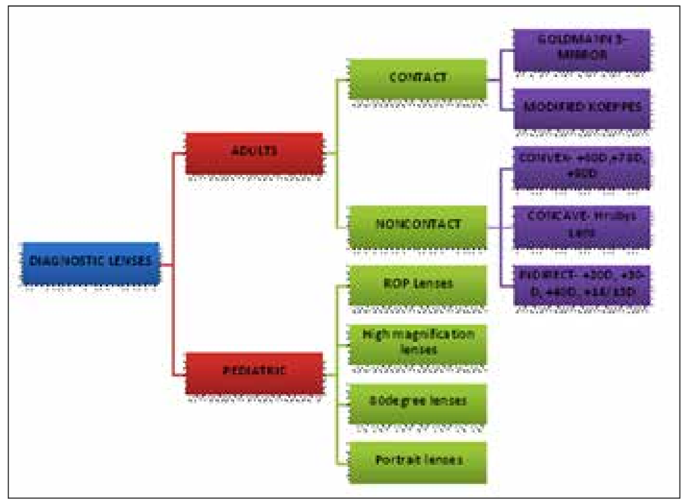

Figure 1: *Different categories of diagnostic lenses used in posterior segment evaluation*

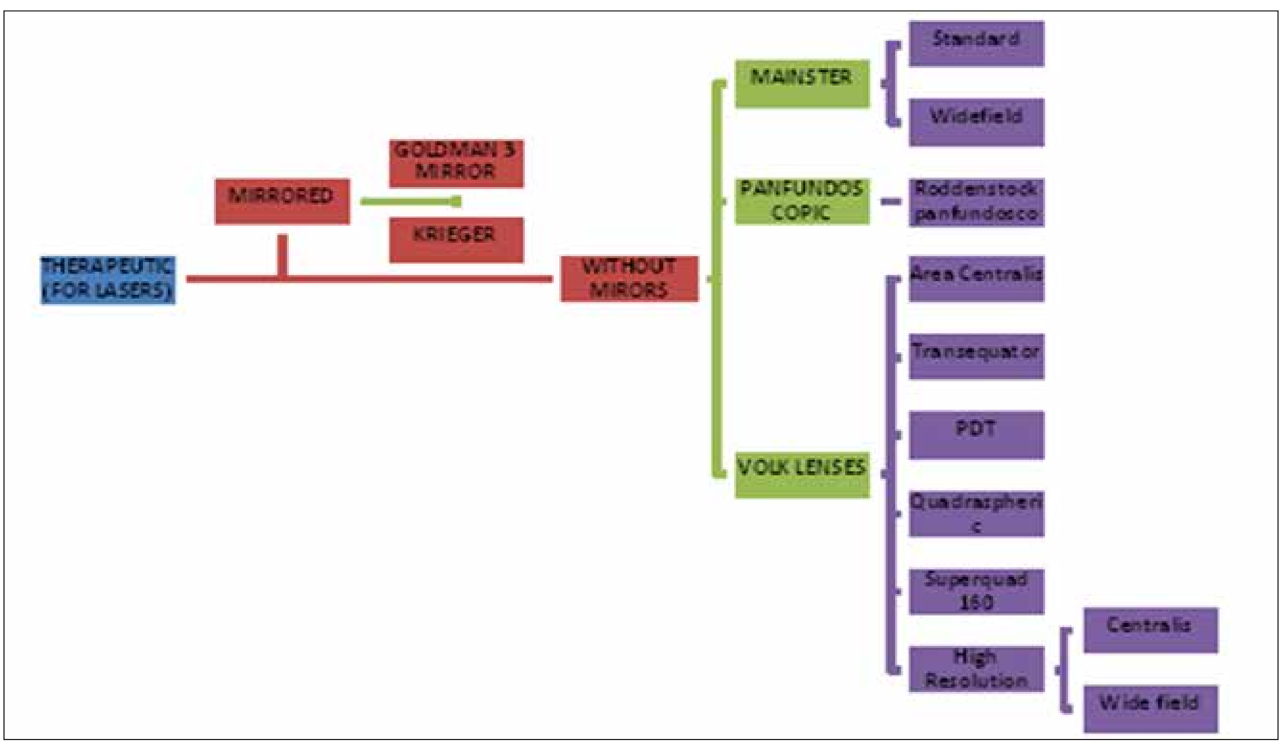

Figure 2: *Schematic representation of Therapeutic lenses used in posterior segment treatment*

1. Non-Contact Lenses

a. **Convex Lenses -** Examination of the retina using the slit-lamp with these lenses placed in front of the patient's eye, is called indirect slit-lamp double aspheric lenses bio microscopy. Typically, the +60D, +78D, and +90D(Figure 4) fundus lenses are used for comprehensive fundus evaluation.

These are double aspheric lenses (so it does not matter which side is held towards the patient), forming a real, inverted and laterally reversed aerial image of the fundus(Figure 3).

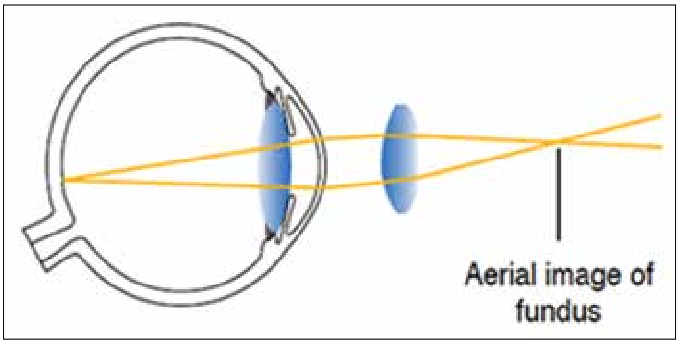

Figure 3: *Fig.3 High-power plus lenses for slit lamp indirect ophthalmoscopy (eg, 60 D and 90 D fundus lenses) held in front of the eye produce an inverted aerial image of the retina within the focal range of a slit-lamp biomicroscope.*[1]

POWER ∞ MAGNIFICATION∞ 1/FIELD OF VIEW

High powered lenses provide a large field of view but lesser magnification, e.g. the +90D lens provides a bigger field of view but lesser magnification than +78D lens.

Magnification is calculated under the assumption that the patient's eye is a +60D optical unit.

Field of view = (Dioptric Power of the lens x 2)
Magnification = Power of eye x magnification of slit lamp/ Power of the lens
Stereopsis = Magnification / 4.

Brief Technique: With the patient seated comfortably at the slit-lamp, the illumination and observation system kept co-axial, and magnification kept at 10X or 16X, the light beam (4mm wide with brightest light intensity) is focused on the patient's pupil. The condensing lens is then aligned at around 5-10 mm from the patient's cornea and the slit-lamp is pulled backward gradually towards the examiner until the fundus is visualized. To view the peripheral retina, the patient is asked to look into appropriate positions of gaze as with standard indirect ophthalmoscopy.

+60 D lens – Introduced by Volk Optical in the early 1980s.[4]
- High magnification views of the posterior pole for detailed optic disc and macula imaging. (Figure 4A)
- Ideal for optic nerve head examination as lens offers higher magnification near 1x.
- Diameter -31mm, facilitates easy handling.
- Working distance from the cornea - 11mm.

+78 D lens – Single lens providing an ideal balance between magnification and field of view (Figure 4B)
- Working distance from the cornea - 7mm.

+90 D lens – Relatively wide field of view with a good resolution.(Figure 4C)
- Posterior pole examination for general diagnosis and small pupil examination,.
- Diameter ring - 26mm, ideal for dynamic fundoscopy. ie dynamic observation of the fundus in all directions possible by moving the condensing lens, scleral indentation etc.
- Working distance from the cornea - 6.5mm.

Figure 4: *(A)+60 D lens (B)+78 D lens (C)+90 D lens*

Advantages

- Stereoscopic, view of the retina
- Better image achieved when viewing through media opacities like cataract.
- Ease of viewing independent of pupillary size/dilation status.
- Allows for magnification of image with the help of slit-lamp filters and magnification.
- Image size less affected by the patient's refractive error.
- "Up-close" look at the condition e.g. magnified view of the macular details and neuro-retinal rim tissue
- Non-Contact: avoids potential infection transmission.

Disadvantages

- Small field of view as compared to indirect ophthalmoscopy. Cannot visualise beyond the equator, hence not ideal for screening of peripheral lesions.
- Precise patient fixation required. Not ideal when patients cannot sit at the slit-lamp, in children and challenging situations like nystagmus.

b. **Indirect Ophthalmoscopic Lenses:** introduced by Nagel in 1864. The condensing lens used is aspheric with one surface less curved than the other which is kept facing the patient's eye (indicated by silver ring).(Figure 5)

Optical Principle

To make the eye highly myopic by placing a strong convex lens in front of the patient's eye so that the emergent rays from an area of the fundus are brought to focus as a real inverted aerial image between the lens and the observer's eye.

+30D lens – High Dioptric power lens with the least magnification of retina but the largest field of view.

- Least magnification – 60/30 = 2X
- Largest field of view – 30*2 = 60°
- Stereopsis is half that of normal, 2/4 = ½
- Used to obtain a panoramic view when detail and stereopsis are not as important. Can be used with a small pupil. (Figure 6a)

+20D lens (FIg 6)–

- Retinal magnification – 60/20 = 3X
- Field of view – 20*2 = 40°
- Stereopsis is 3/4th that of normal.
- Most widely used, since it provides an adequate field of view, stereopsis, and magnification.(Figure 6c)

+14/15D lens –

- Retinal magnification = 60/15 = 4X
- Field of view – 15*2 = 30°
- Stereopsis is full i.e. 4/4.
- Most useful for a detailed view of the macula or optic disc or for determining the elevation of the retina in shallow retinal detachment. (Figure 6b)

Advantages

- Large field with 3D stereoscopic view of the retina and considerable depth of focus
- Lesser distortion of the image of retina.
- Ease of examination especially if the patient's eye movements are present or if there are high spherical or astigmatic refractive errors.

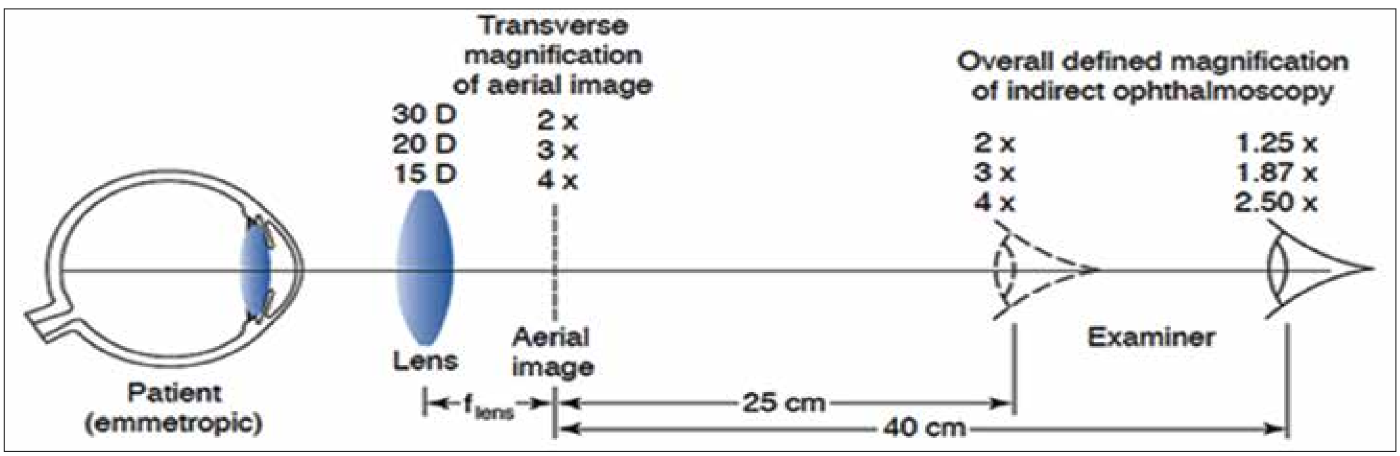

Figure 5: *Overall magnification of indirect ophthalmoscopy with different condensing lenses depends on the distance from which the aerial image is observed. From about 40 cm, from where it is usually observed, the overall magnification is about 1.87×, with the 20 D condensing lens.Image source:Brodie SE. Optical Instruments. In: Brodie SE, Mauger TF, Gupta PC. eds. Basic and Clinical Science Course – Clinical Optics. San Francisco: American Academy of Ophthalmology; 2020-21. p. 295-300*

Powerpatient's eye ÷ Powerfundus lens = Magnification.

Figure 6a: *30D Lens*

Figure 6b: *15D Lens*

Figure 6c: *Commonly used lenses for Indirect ophthalmoscopy*

- Easy visualization of retina anterior to equator, helpful in visualising retinal peripheral degenerations and breaks
- Useful in hazy media because of its bright light and optical property.

Disadvantages

- Relatively low magnification of 5x
- Visualization is difficult with very small pupils.
- Patient usually more uncomfortable with intense light of IO and scleral indentation.
- Steeper learning curve, requires extensive practice both in techniques and interpretation.

c. Concave Lens – Hruby Lens Biomicroscopy[5]

- Plano-concave high minus lens mounted on the slit-lamp for stability, with a dioptric power of -58.6D, which neutralizes the optical power of the eye (+ 60 D). (Fig 7)
- Placed 10-12 mm in front of the patient's cornea.
- Provides a high resolution, virtual, erect image of the fundus. Image is formed 18mm in front of the patient's retina.
- Small field of view with low magnification; cannot visualise the fundus beyond equator.

2. Contact Lenses = Combines stereopsis, high illumination and magnification with the advantages of slit beam[5]

a. Modified Koeppe's Lens – Posterior fundus contact lens used to examine the posterior segment. Image formed is virtual and erect .

Figure 7: *Hruby Lens [10]*

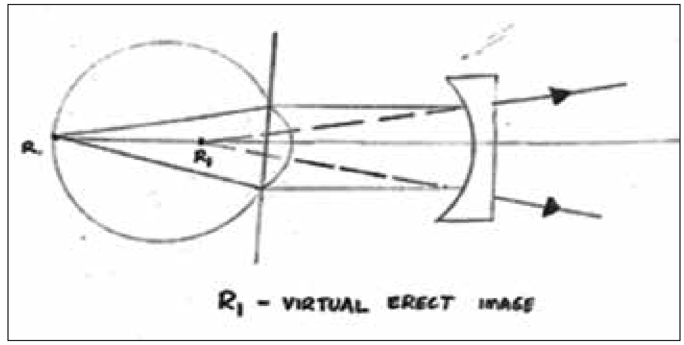

Figure 8: *Optics of Hruby Lens*

b. Goldmann's 3-mirror contact lens – Consists of a central contact lens with 3 mirrors placed in the cone, each with different angles of inclination (Figure 5).[5] Helps to visualise central as well as peripheral parts of the fundus, and even of the angle of the anterior chamber.

- Provides a virtual and erect image, located near posterior surface of crystalline lens.
- Can visualise the entire fundus by rotating the lens 360°. The 3 mirrors inclined at 59°, 67° and 73° gives view of the anterior peripheral retina (including ora serrata and pars plana), equatorial fundus and the area around the posterior pole, respectively. The central contact lens is used for posterior pole and vitreous.Figure 10a,b)
- Primarily used nowadays for therapeutic purposes like retinal photocoagulation

Disadvantages

Inconvenience to the patient (involves anaesthetising the cornea and direct contact). Limited field of view requiring rotation of the lens to visualize more than a small patch of the fundus.

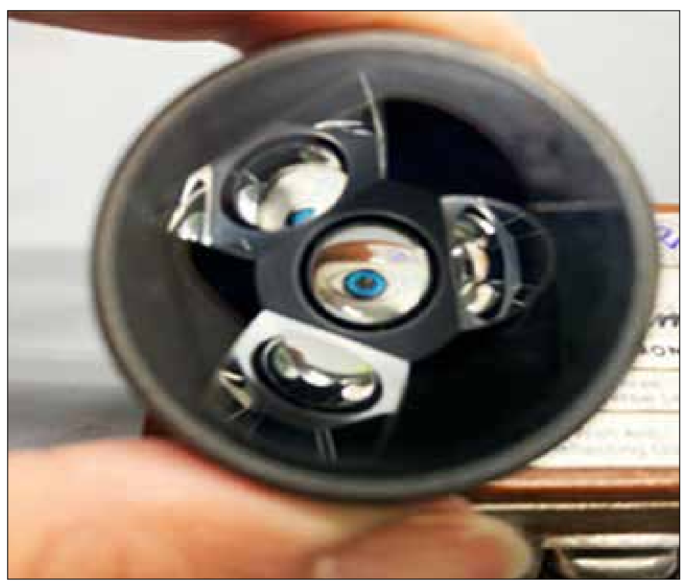

Figure 9: *Goldmann 3-mirror contact lens. The flat-front contact lens essentially nullifies the power of the eye and provides an upright view of the posterior pole. The mirrors at various angles inside enable alternative (inverted) views of different parts of the retina and the anterior chamber angle (gonioscopy).*

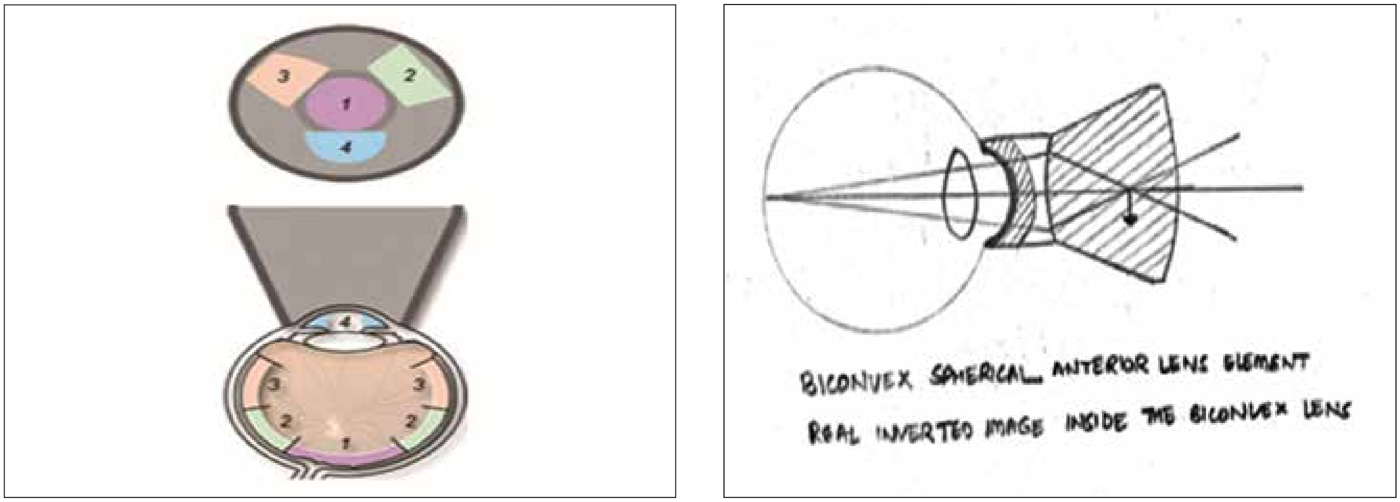

Figure 10: **(a)** *Goldmann three mirror contact lens[1] and* **(b)** *its optics of the area visualised*

c. **Wide-field Panfundoscopic Indirect Contact lens** – Field of view – upto 130°. Real and inverted image is produced. It is used for fundus examination and performing laser photocoagulation.

Figure 11: *Pan Fundoscopic Lens*

Therapeutic Purposes

Lenses used for Posterior Segment Lasers[6,7,8]

- Common Characteristics:

1. Concave posterior surface conforming to the corneal curvature and a flat or convex anterior surface
2. Planar mirrors allowing observation of the anterior chamber angle or peripheral retina.
3. A prism to allow visualization of the mid-periphery of the retina.
4. A flange to stabilize the lens and prevent blinking
5. Knurled edge to facilitate lens manipulation
6. Laser lenses generally consist of a conical PMMA or aluminium shell
7. Glass anterior surface, lenticular elements and mirrors.
8. Antireflection coatings applied to each optical surface reducing reflected white light (from the slit lamp source) that decreases contrast of image and laser light (from the treatment beam) that could pose a potential hazard to an observer standing behind the operator.

Mirror Lenses

a. Goldmann's 3-mirror lenses (Figure 10)

b. Yannuzzi fundus lens (Krieger lens) - Has better optics than a simple Goldmann fundus lens. Image produced is erect, virtual and located in the anterior vitreous. It is used for macular photocoagulation. (Figure 12)

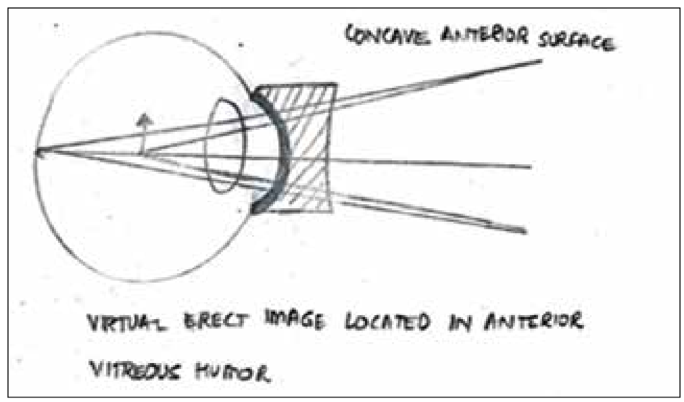

Figure 12: *Krieger lens with a concave anterior surface forms a virtual erect image in the anterior vitreous*

Lenses without mirror

a. Mainster: Introduced in 1986, this lens has more field of view (58% greater than Goldmann) and a greater magnification. It has a biconvex aspheric anterior lens element which produces a real and inverted image.

- Mainster Standard Lens: For focal and grid laser, from posterior pole to mid-periphery.
  Field of view = 90°/121°. Image magnification = 0.96X. Laser spot magnification = 1.05X.
- Mainster Wide Field Lens: Used for panretinal photocoagulation in proliferative diabetic retinopathy. Field of View = 118°/127°. Image magnification = 0.68X. Laser spot magnification = 1.50X.
- Mainster Ultra Field PRP Lens:(Figure 13)

  Widest field of view = 165°/180°. Image magnification = 0.51X. Laser spot magnification = 1.96X.
- Mainster Focal Grid laser Lens:
  Used for Focal macular or grid lasers. (Figure 14,15)

b. Rodenstock Panfudoscopic Lens: Introduced in 1969 by Schlegen Schlegel. Provides panoramic view and produces a real and inverted image. Used for PRP from the posterior pole to beyond the equator without the use of mirrors.

c. Volk Lenses: Following are used as tabulated below (Table 1).

Figure 13: *Mainster wide field PRP Lens*

Figure 14: *Mainster PRP 165 Lens*

Figure 15: *Focal / Grid Laser Lens*

In conclusion, the myriad condensing lenses remain vital to everyday ophthalmological practice. Selecting an appropriate lens for a particular diagnostic or therapeutic posterior segment modality depends on the ophthalmologist's experience with lens, its optics and the knowledge about new technological developments of lens designs and therapeutic strategies.

Table 1 : Summary of features of the Lenses used for lasers

Type of lens	Image Magnification	Laser Spot Magnification
Volk Area centralis(FIg 16 A)	1.06x	0.94x
Volk PDT Lens(Fig 16 B)	0.67x	1.5x
Volk Transequator (Fig 16 C)	0.70x	1.44x
Volk Quadraspheric (Fig 16 D)	0.51x	1.97x
Volk Super Quad 160	0.50x	2.00x
Mainster standard	0.96x	1.05x
Mainster wide field (fig 13)	0.68x	1.50x
Mainster ultra field PRP (fig14)	0.51x	1.96x

Table 2 : The table below enumerates the paediatric high index corneal contact lenses used along-with their field of view: (Figure 17)

High index corneal contact lenses [5]		
Lens	Use	Field of View
1. ROP lens	Premature infants	130 degrees
2. Standard children	Paediatric to young adult	120 degrees
3. High magnification lenses	Fine details	30 degrees
4. Portrait lens	For external imaging	

Figure 16: *(A to D): Volk Therapeutic Lenses [10]*

Figure 17: *Pediatric high index corneal contact lenses Image Source:Khurana AK, Khurana AK, Khurana B. Optical Instruments and Techniques. In: Khurana AK, 4th ed. India: Elsevier; 2018. p. 460-8*

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