جامعة المستقبل

كلية التقنيات الصحية والطبية

قسم تقنيات البصريات

Second Stage 2025-2026

REFRACTIVE ERRORS 3

Lecture Title

Astigmatism

Lecture Number: 3 / course 1

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OPTOMETRIST

Astigmatism

Management and Correction Options

The goal of astigmatism management is to align the principal meridians so that incident light converges at a single focal point on the retina, thereby restoring clear vision. Treatment selection depends on the type (regular versus irregular), magnitude, patient age, occupation, lifestyle, ocular surface health, and coexisting conditions.

1. Optical correction

- **Eyeglasses (Spectacles):** Cylindrical or sphero-cylindrical lenses remain the simplest and most widely used method for correcting regular astigmatism. They neutralize the difference in curvature between the principal meridians by introducing an equal and opposite toric power. Modern free-form lens technology enables the custom tailoring of lens power to the wearer's exact prescription and frame position, thereby improving peripheral optics and reducing aberrations. Progressive addition lenses can incorporate toric corrections for presbyopic patients, providing seamless distance, intermediate and near vision.
- **Soft toric contact lenses**: For patients who prefer contact lenses, soft toric lenses offer convenience and good comfort. These lenses employ prism ballast, periballast, dynamic stabilization or other designs to maintain rotational stability on the eye. Advances in silicone hydrogel materials have enhanced oxygen permeability, allowing for extended wear in suitable patients. However, soft toric lenses may be less effective for high degrees of astigmatism (>2.50 D) and can be susceptible to rotation, causing fluctuating vision.
- **Rigid gas-permeable (RGP) lenses**: RGP lenses provide a smooth refracting surface over the cornea, masking moderate corneal irregularities and delivering crisp optics. They are particularly advantageous for moderate to high astigmatism or when soft toric lenses yield inadequate visual quality.

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Specialty designs, such as bitoric and front-surface toric RGP lenses, are available for high corneal cylinder. Initial adaptation can be challenging, and lens awareness may limit tolerance.

- **Scleral and hybrid lenses**: When conventional contacts are insufficient, particularly in irregular astigmatism secondary to keratoconus, pellucid marginal degeneration, or post-surgical ectasia, large-diameter scleral lenses vault the cornea entirely and rest on the sclera. This design creates a fluid reservoir between the lens and cornea, neutralizing irregularities and providing stable optics. Hybrid lenses combine a rigid center with a soft skirt, offering improved comfort while maintaining the optical benefits of RGP lenses.
- **Orthokeratology (corneal reshaping therapy)**: Orthokeratology uses specially designed RGP lenses worn overnight to temporarily reshape the cornea by flattening the central area and steepening the periphery. Appropriately fitted, these lenses can correct low to moderate myopia with astigmatism of up to approximately 1.50 D, enabling unaided daytime vision. It is particularly appealing to active individuals and may slow myopia progression in children. Strict adherence to hygiene protocols and regular follow-up is crucial to minimizing the risk of microbial keratitis.

2. Laser and surgical interventions

- **Photorefractive keratectomy (PRK) and laser-assisted in situ keratomileusis (LASIK)**: Excimer laser ablation can sculpt the corneal stroma to correct both spherical and cylindrical components of refractive error. LASIK combines a lamellar flap with stromal ablation, whereas PRK removes the epithelium and ablates the anterior stroma. Wavefront-guided and topography-guided treatments enhance precision and reduce higher-order aberrations, particularly in irregular astigmatism. Candidates require adequate corneal thickness, a healthy ocular surface, and stable refraction.

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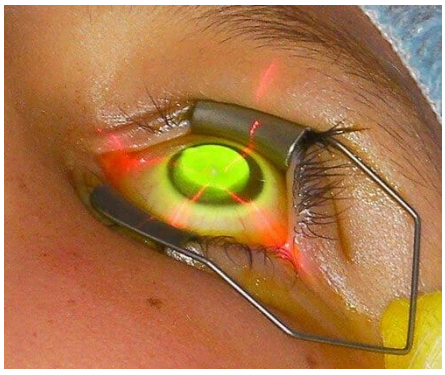
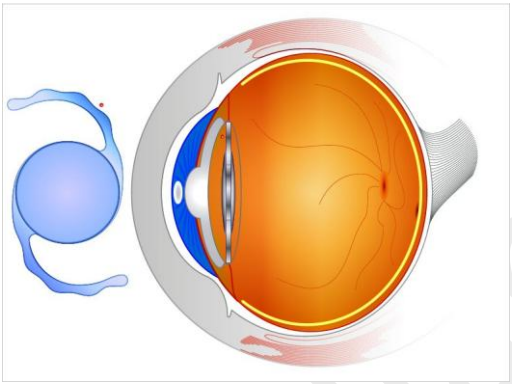
- **Small incision lenticule extraction (SMILE)**: SMILE uses a femtosecond laser to create and remove an intrastromal lenticule through a small incision, leaving the anterior stroma largely intact. It effectively treats moderate myopic astigmatism with minimal dry eye symptoms and rapid recovery. Nomogram adjustments account for surgical and healing factors to optimize astigmatic outcomes.
- **Arcuate keratotomy (AK) and intrastromal corneal ring segments (ICRS)**: Limbal relaxing incisions or femtosecond-laser arcuate cuts can reduce mild to moderate corneal astigmatism by weakening the steeper meridian. ICRS (e.g., Intacs) flattens the corneal curvature and regularizes the surface in keratoconus or post-LASIK ectasia. These techniques may be combined with cross-linking to halt progression.

- **Corneal collagen cross-linking (CXL)**: Although not a refractive procedure per se, CXL stiffens the corneal stroma via riboflavin and ultraviolet-A exposure, stabilizing keratoconus and post-surgical ectasia. It is often combined with topography-guided PRK or ICRS to improve corneal regularity and reduce irregular astigmatism.



3. Intraocular lens solutions

- **Toric phakic intraocular lenses (IOLs)**: For patients with high degrees of myopic or hyperopic astigmatism who are unsuitable for corneal refractive surgery, toric phakic IOLs (e.g. implantable collamer lenses) provide predictable and reversible correction. Proper sizing and vaulting are critical to avoid complications such as cataract formation or glaucoma.



4. Management of irregular astigmatism

Irregular astigmatism, frequently due to ectatic disorders or corneal scars, demands a tailored approach:

- Rigid or scleral contact lenses remain the first-line treatment to provide a regular refractive surface.
- Topography-guided excimer ablation combined with CXL can normalize corneal shape and stabilize progression.
- Penetrating or deep anterior lamellar keratoplasty (PK/DALK): Advanced keratoconus or scars not correctable with contact lenses may necessitate corneal transplantation. Post-keratoplasty astigmatism can be significant; suture adjustment, selective suture removal, or secondary refractive procedures are often required.

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5. Patient counselling and follow-up

Successful management hinges on patient education, realistic expectations and diligent follow-up. Regular monitoring ensures timely detection of progression, complications, or changes in refractive status. For children, early screening and correction prevent amblyopia. For adults, lifestyle, occupational demands and ocular health guide the choice among spectacles, contact lenses and surgical options. Engaging patients in shared decision-making enhances satisfaction and compliance, ultimately leading to the best visual outcomes.

Diagnostic Instruments & Techniques

The core of astigmatism diagnosis is a comprehensive eye examination that assesses visual acuity, refractive status and corneal geometry. Modern optometry utilises several complementary tests:

Objective assessment tools include:

1. **Retinoscopy:** followed by subjective refraction with a phoropter or trial lenses, determines the spherical and cylindrical components.

2. **Keratometry**: measures curvature of the central anterior cornea by analysing reflections from mires. Manual keratometry is cost-effective but samples only a 3–4 mm zone and assumes orthogonal meridians; it fails to detect peripheral or lenticular astigmatism.

The device measures only the **central area of the cornea (~3 mm)**, since this zone is mainly responsible for vision (the optical zone).

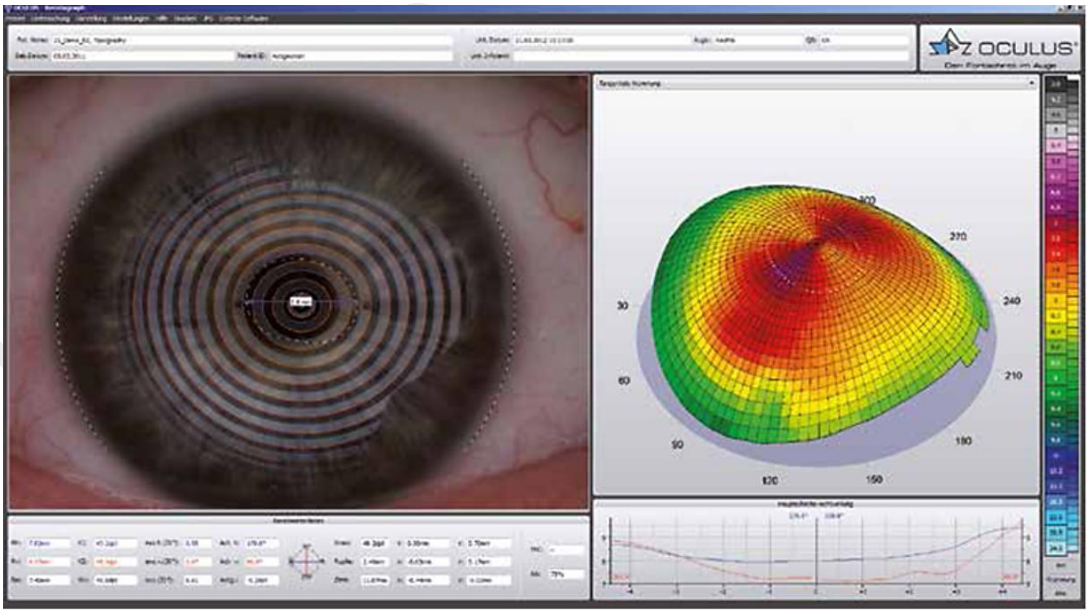
- It is very useful in diagnosing **regular astigmatism**.
- However, it is not sufficient to detect all **irregularities** of the cornea, such as early **keratoconus** or corneal scars, because these changes may appear in the peripheral regions that the keratometer does not measure.

3. **Autorefractometry:** automated devices quickly provide refractive measurements and are particularly useful in pediatric screenings.

4. **Placido keratoscope disc:** This test reflects irregularities on the corneal surface. The examiner looks through a hole in the center of the disc, with alternatingly painted black and white circles, at the corneal image reflected from a light behind the patient.

Figure 6. Placido disc ring patterns – normal vs astigmatic cornea

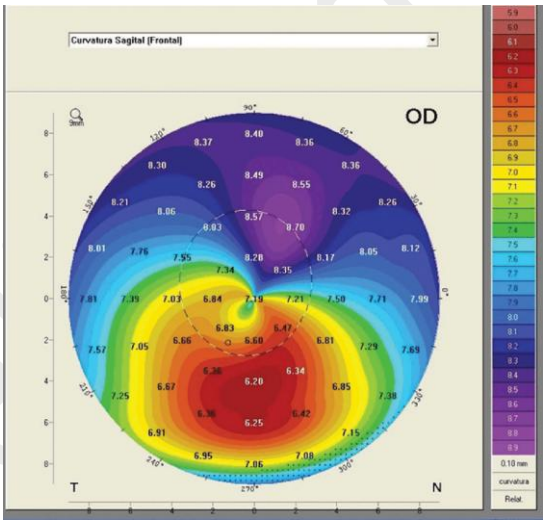
5. **Corneal topography:** generates a color-coded map of the entire cornea (anterior and posterior surfaces).



- Uses Placido disc reflections to map the anterior corneal surface only.
- Provides color-coded curvature maps (steep vs. flat areas).
- Limited: cannot image the posterior surface or corneal thickness.
- Accuracy affected by tear film quality.

6. **Scheimpflug Imaging (Pentacam):** assesses anterior and posterior corneal surfaces and pachymetry.

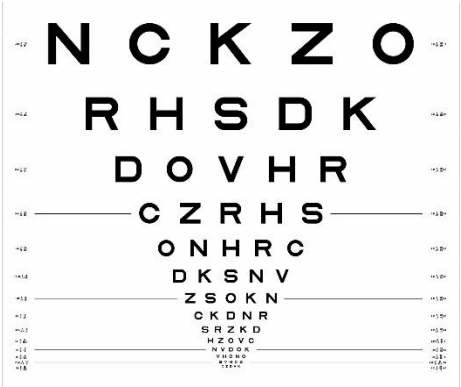
- Uses a rotating Scheimpflug camera to create a 3D model of the anterior eye.
- Measures anterior + posterior corneal surfaces and pachymetry.
- Provides curvature, elevation, and thickness maps.
- More accurate in detecting early keratoconus and ectasia.



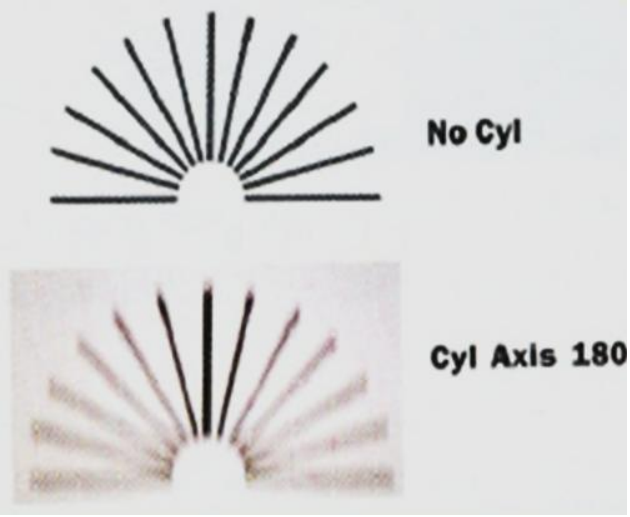
7. **Anterior-segment optical coherence tomography (AS-OCT):** high-resolution imaging that captures cross-sectional views of the anterior eye; it measures anterior and posterior corneal curvature, corneal thickness and lens position, and is useful for surgical planning.

Subjective

1. **Visual acuity testing**: Snellen or ETDRS charts evaluate uncorrected and corrected acuities. Pinhole testing helps differentiate refractive from ocular pathology



2. **Astigmatic fan:** It is used to measure the strength of the cylindrical lens and its axis. The endpoint of cylindrical lens correction is achieved when the outline of the whole fan becomes equally clear and sharp. The axis of the cylinder is perpendicular to the line that was initially most clearly defined.



3. **Stenopaeic slit test**

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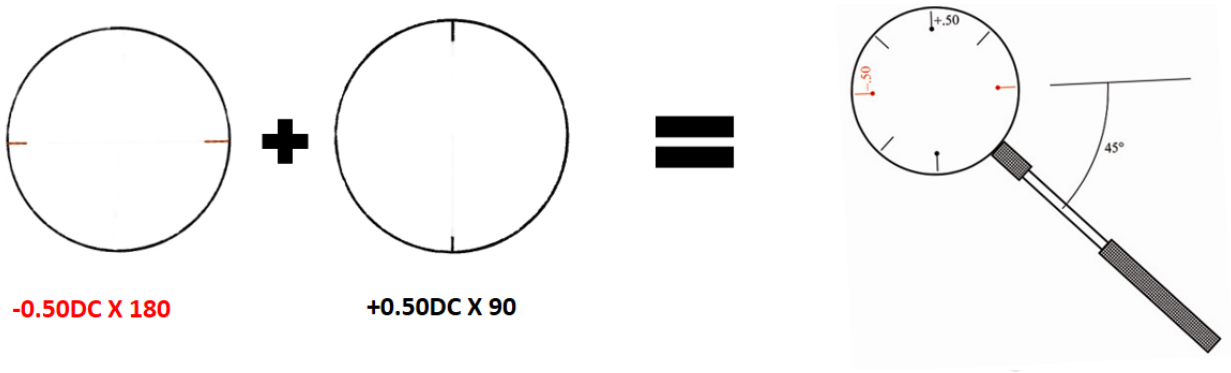
4. **Jackson's cross cylinder test (JCC test)**



Astigmatism in Pediatrics

- **Threshold of concern:**
  - ✓ Astigmatism greater than 1.5 D in children requires early correction to prevent amblyopia.
- **Meridional amblyopia:**
  - ✓ Caused by unequal stimulation of retinal neurons.
  - ✓ Results from blurred images confined to a specific meridian.
- **Management:**
  - ✓ Spectacles: first-line correction for most children.
  - ✓ Contact lenses: recommended for older children or when spectacles are poorly tolerated.
- **Public health importance:**
  - ✓ School vision screening programs are essential for early detection and timely correction of refractive errors.

Impact on Quality of Life

- Uncorrected astigmatism impairs reading and learning ability.
- Night vision difficulties: glare, halos.
- Workplace performance is reduced due to visual fatigue.
- Quality of life measured by VFQ-25 shows lower scores in high astigmatism.

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Complications of Uncorrected Astigmatism

If left untreated, astigmatism may lead to:

- Meridional amblyopia in children.
- Reduced academic and work performance.
- Chronic asthenopia and headaches.
- Night vision difficulties leading to increased driving hazards.

Case Example

Case: A 22-year-old student presents with blurred vision and headaches during study.

Uncorrected VA: 6/18.

Refraction: -1.25 DS / -2.00 DC × 180 → 6/6.

Topography shows with-the-rule astigmatism.

Management: spectacles first, toric contact lenses for daily wear. If irregular astigmatism is present, scleral lenses provide superior outcomes.

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HOME WORK

Questions

1. What is the main goal of astigmatism management, and which factors influence the choice of treatment?
2. Explain how cylindrical or sphero-cylindrical eyeglass lenses correct astigmatism.
3. Compare soft toric contact lenses and rigid gas-permeable (RGP) lenses in terms of effectiveness, advantages, and limitations.
4. In which clinical situations are scleral or hybrid lenses preferred, and why?
5. Describe how orthokeratology works and mention two benefits and one risk associated with its use.
6. Briefly explain the differences between PRK, LASIK, and SMILE laser procedures for correcting astigmatism.
7. What role does corneal collagen cross-linking (CXL) play in managing irregular astigmatism, and why is it often combined with other treatments?
8. When are toric phakic intraocular lenses (IOLs) indicated, and what are two key considerations before implantation?
9. Name two main treatment options for advanced or irregular astigmatism that cannot be corrected with contact lenses, and explain their purpose.
10. Why is patient counselling and regular follow-up essential in the long-term management of astigmatism?

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