OPTICAL INSTRUMENTS

Lecture 14– Keratoscopy

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KERATOSCOPY

It is a general term to describe study of topographic abnormalities of corneal surface by direct observation of images of mires reflected from the surface of the cornea. *So keratoscopy is study of shape of corneal surface.*

Normal ranges

1- Corneal power is 43.0-44.0 diopters.

2- Anterior surface of the cornea is 7.8 mm

Keratoscopy

1. Placido disc
2. Photokeratoscopy
3. Videokeratoscopy

Based on the examination method:

- Reflection based: Placido disc technology
- Elevation based:

- Scanning slit technology
- Scheimpflug imaging
- Laser interferometry
- Wavefront technology

Uses .

1. it is used as preoperative evaluation of patients before corneal refractive surgery
2. Keratoconus screening and follow-up
3. Contact lens fitting and measurement

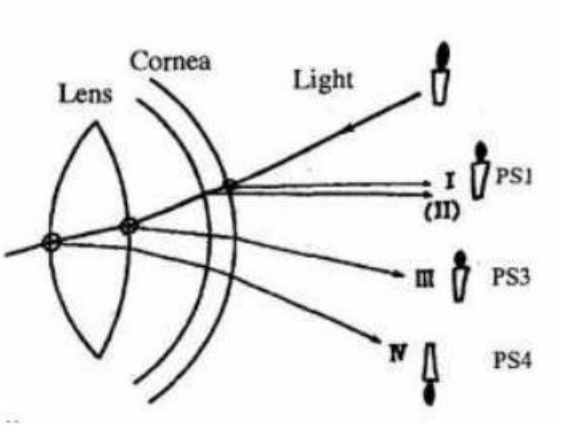
PLACIDO DISC

A Placido disc consists of a plate of alternating black and white rings placed around a convex viewing lens.

A Placido disc. A central 2 D lens aids focusing on the patient's cornea

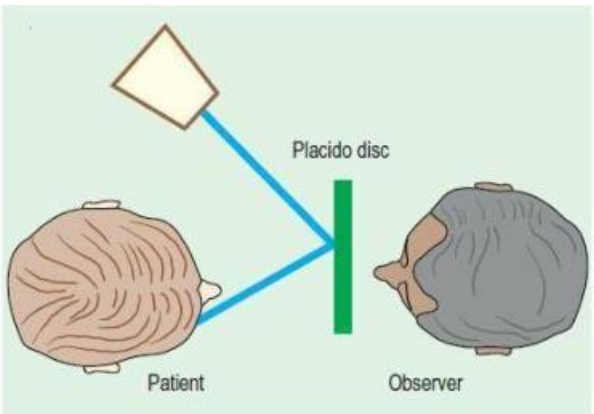
Principle of placido disc

It depends on the cornea as a convex mirror and study the shape of 1st Purkinje image (the image reflected from anterior corneal surface).

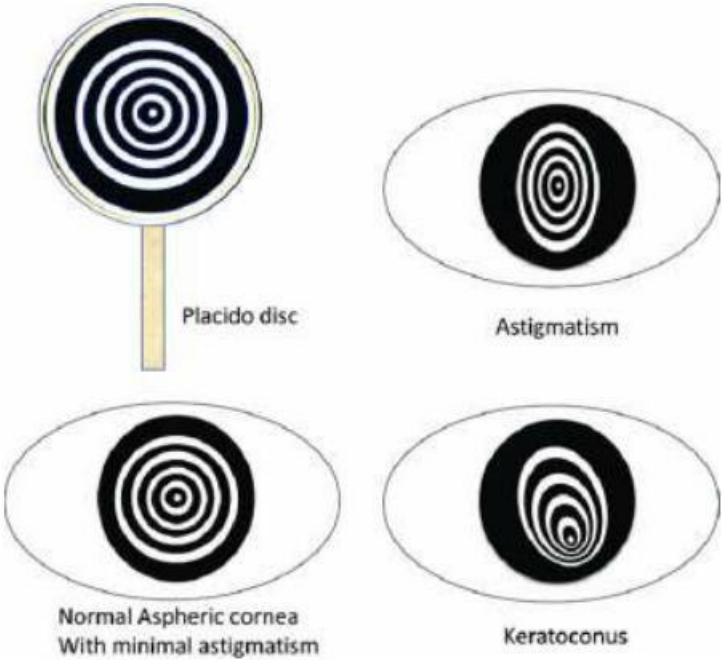


Purkinje Image

It enables a qualitative estimate of corneal shape to be made. The central lens allows close viewing of the reflection of the rings from the anterior corneal surface when the examiner sees through the placido disc. It is important to illuminate the disc from behind the patient so that a bright reflection is seen from the cornea. The reflected image will normally show regular rings, unless the cornea has an irregular shape when the reflection will appear distorted.



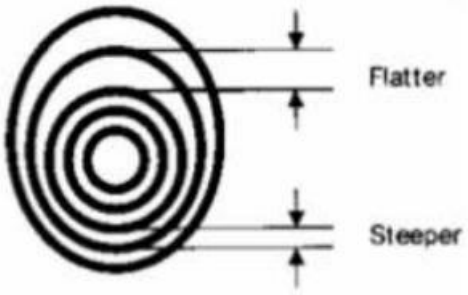
Illumination of placido disc



- Spherical cornea: circular rings and equally spaced
- Regular astigmatism: oval rings and equally spaced
- Irregular astigmatism,

Corneal scar, keratoconus: distorted or wavy ring image.

The space between the rings gives an idea about the curvature of the cornea.



- The closer the rings, the steeper the axis
- The wider the rings, the flatter the axis.

Disadvantages of placido disc

- Small degrees of abnormalities of corneal shape are not easily identified
- Small amount of corneal astigmatism may not be detected

So the placido disc keratoscope is used only as a gross method of qualitative assessment of the corneal surface.

PHOTOKERATOSCOPE

It is a qualitative reflection based instrument. When a camera is attached to a keratoscope, it is called photokeratosocpe.

The photokeratoscope can measure 12 mires over 70% of corneal surface.

Principle .

- It is reflection-based or Placido-based
- The Placido disk reflects a series of concentric rings, or mires, off the cornea. Each mire produces an upright virtual image in the anterior chamber of the subject's eye.
- The **distance between each mire to the corneal apex** is compared to the image's distance to the corneal apex. So the ratio of image distance to mire distance determines the anterior corneal curvature along any particular meridian.

Disadvantages …

1. It misses data from the central cornea
2. Limited data points
3. It measures the corneal curvature but not the height
4. It measures only the anterior surface of the cornea.

VIDEOKERATOSCOPE

When a video camera is attached to a keratoscope, it is called videokeratoscope.

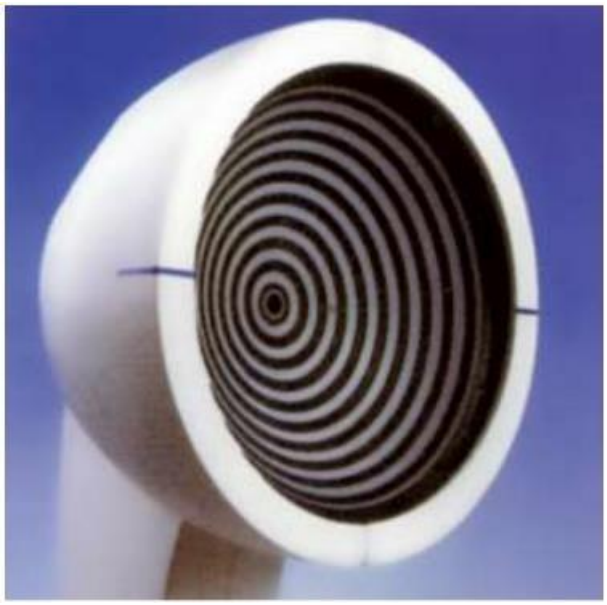
Computer Assisted Videokeratoscope

When computer is used to process data from videokeratoscope, it is called computer assisted videokeratoscope. It allows both qualitative and quantitative measurements about the cornea to be taken.

It can measure 18-38 mires over 95% of the corneal surface and has a theoretical range of 8-110 D.

Principle .

It is Placido-based or curvature based. Placido cone which project mires of concentric light rings and video camera captures the reflected rings from the tear film and a software to analyze the data. The computer evaluates the distance between the concentric rings. The shorter the distance, the higher the corneal power and vice versa.



Disadvantages

1. Data at the central zone have to be interpolated (although this unmeasured central zone is very small in some devices)
2. Quality of the tear film is critical, since the images are obtained from light rays reflected off the tear film.
3. It measures only the anterior corneal surface.

Scanning slit topography

Principle ..

It is a projection-based method that uses a series of slit-beam images to form a 3D model of the cornea. Projection based systems provide measurement of both anterior and posterior corneal surfaces and give pachymetric measurements.

1. Orbscan

Principle

A slit lamp projects a slit beam at 45 degrees onto the cornea.

20 slits are projected on the eye from the left side, and 20 slits from the right, for a total of 40 slits that produce 240 data points per slit.

This produces an elevation map of the cornea relative to a best-fit sphere.
This generates data regarding;

Anterior surface curvature.

- Posterior surface curvature.
- Pachymetery.

Therefore, the cornea is represented as a 3D structure.

2. Pentacam

It is an imaging technique where a series of cross-sectional images are merged to allow for a computer generated 3D reconstruction of the anterior segment.

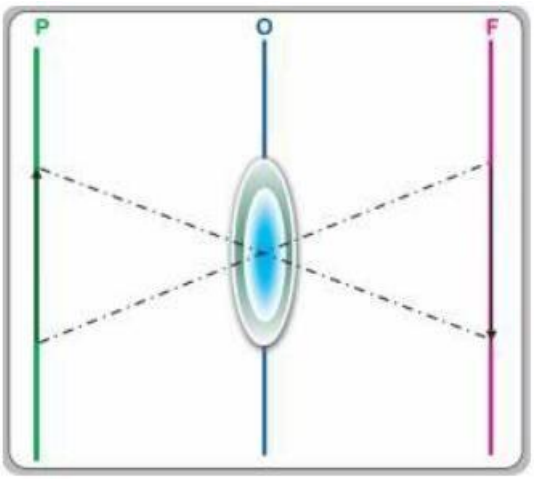
Principle ….

The traditional camera captures the view in an axial direction. The three planes (the picture plane, the objective plane and the film plane) are parallel. The Scheimpflug Camera captures the view laterally which depends on The Scheimpflug law which states:

To get a higher depth of focus→ the picture plane, the objective plane and film plane have to cut each other in one line or a point of intersection.

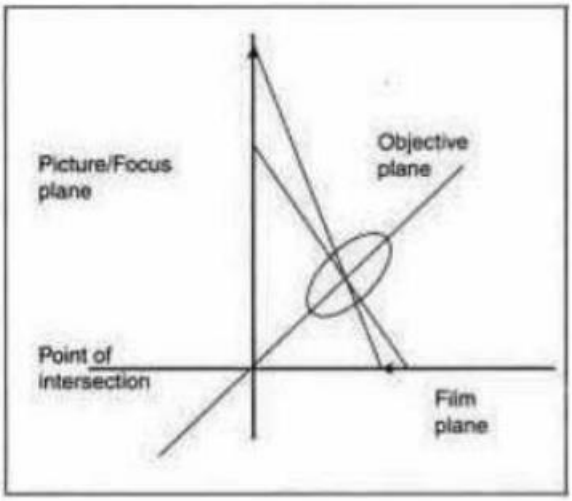
Principle of traditional camera

All planes are parallel



Principle of Scheimpflug based camera

The three planes intersect at one point



Scheimpflug image will get high depth of focus providing sharp images that include information from anterior corneal surface through to the posterior crystalline lens capsule.

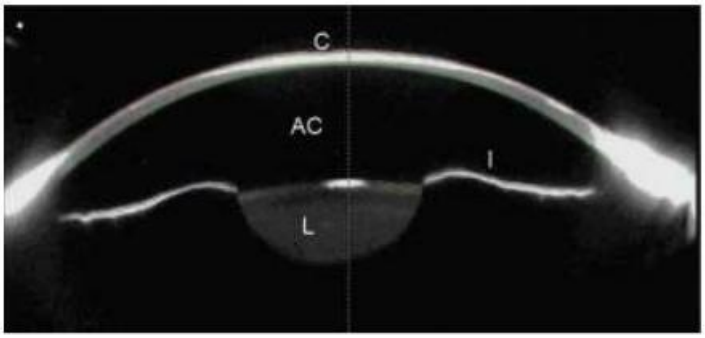
Scheimpflug image

C: cornea

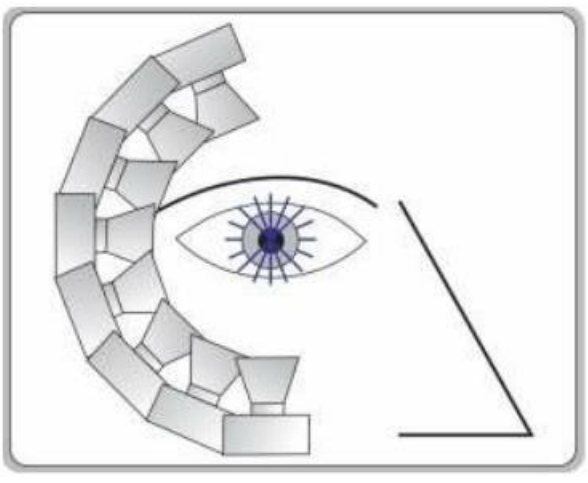
AC: anterior chamber

I: iris

L: lens



The Scheimpflug camera is a rotating camera that provides images in 3 dimensions 3D. The topography and pachymetry of the entire anterior and posterior corneal surfaces from limbus to limbus are calculated.



The rotating Scheimpflug camera

Components

- Slit illumination system: blue light to illuminate the eye.
- Rotating Scheimpflug camera to take images
- Processor for digital signal processing

Procedure

Pentacam scanning is non-contact procedure and takes less than 2 seconds to complete.

1. A thin layer within the eye is illuminated through the slit→ a sectional image is then photographed in side view by a camera
2. The camera is oriented according to the Scheimpflug principle so the image of the illuminated plane will appear completely sharp from the anterior surface of the cornea to the posterior surface of the crystalline lens.
3. Swiveling around the eye

The slit camera generates a series of radially oriented images of the anterior chamber.

It obtains 50 scans in 2 seconds with 500 true elevation points per scan surface (i.e. about

25,000 true elevation points are measured and analyzed).

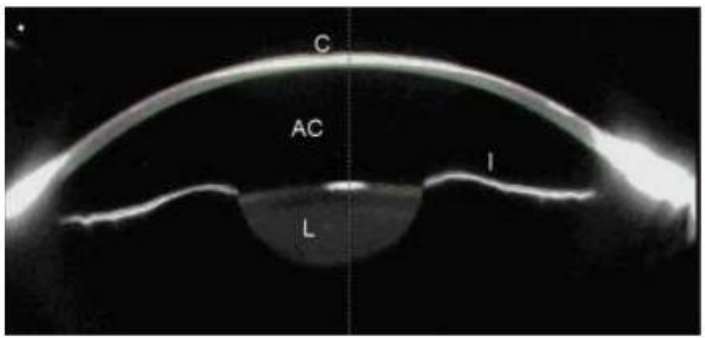
The sectional images are merged to create a 3D model of the entire anterior chamber of the eye.

Functions of the Pentacam …

Pentacam is a 5 in one device that generates the following outputs:

1. **Scheimpflug image**

It obtains a clear, sharp Scheimpflug image showing the entire anterior segment from the cornea to the posterior lens surface, including the angle area.



2. Corneal topography

It provides a topography map of the anterior and posterior surfaces of the cornea. The topographic analysis is based on the measurement of 25,000 true elevation. **Applications**

- Keratoconus detection
- Preoperative evaluation for patients want to have corneal refractive surgery
- Improved IOL power calculation for patients who previously had corneal refractive surgery e.g. LASIK.

3. Pachymetry

The thickness measurement of the entire cornea.

The most important points are displayed in values and location such as:

- Thickness in the pupil center
- Thickness in the apex
- Thinnest location
- corneal volume

Applications .

- Preoperative evaluation for patients who want to have corneal refractive surgery
- Keratoconus detection
- Measuring corneal thickness to adjust the measurement of intraocular pressure in evaluation of patients with glaucoma.

4. 3D anterior chamber analyzer

Colored map of the anterior chamber allowing evaluation for:

- Chamber angle
- Chamber volume

- Chamber depth
- Chamber height

Applications

- Preoperative planning for implanting aphakic lenses
- Glaucoma screening

5. Densitometry of the lens

This provides analysis of:

- Lens thickness
- Structural alterations like radial opacities
- Early and advanced calcification of the lens.