Subjective refraction

OPTICS OF HUMAN EYE & REFRACTIVE ERRORS

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Eye as a camera

- Eyelids: shutter
- Cornea: focusing system
- Lens: focusing system
- Iris: diaphragm
- Choroid: dark chamber
- Retina: light sensitive film

Components

- The cornea
- The anterior chamber
- The iris and pupil
- The crystalline lens
- The retina

Cornea

- Reasons of refraction:
  - Curvature.
  - Significant difference in refractive indices of air and cornea.

- Vertical diameter slightly less than horizontal
- Front apical radius 7.5 - 7.7 mm
- Back apical radius 6.4 - 6.8 mm
- Actual refractive index cornea = 1.376
- Power of cornea +43D (2/3 of total eye power)
The anterior chamber
• Cavity between cornea and iris
• Filled with aqueous humor.
• Depth of AC – about 2.5-4.0 mm
• Change in AC depth change the total power. 1mm forward shift of lens- increase about 1.4D in power
• Refractive index of aqueous humor= 1.336

The crystalline lens

<table>
<thead>
<tr>
<th>Thickness</th>
<th>Birth 3.5 – 4 mm</th>
<th>Adult life 4.75 – 5 mm</th>
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<tbody>
<tr>
<td>Radius of curvature</td>
<td>Ant surface 10 mm</td>
<td>Post surface 6 mm</td>
</tr>
<tr>
<td>Refractive index of lens</td>
<td>Nucleus 1.41</td>
<td>Pole 1.385</td>
</tr>
<tr>
<td>Total power</td>
<td>15 -18 d.</td>
<td></td>
</tr>
<tr>
<td>Accommodative power</td>
<td>At birth- 14-16 D</td>
<td>At 25yrs- 7-8D</td>
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Iris and Pupil
• Regulate amount of light entering the eye
• At 2.4mm pupil size, best retinal image obtained, as aberration and diffraction are balanced.

<table>
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<tr>
<th>Average size:</th>
<th>2-4mm</th>
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<tbody>
<tr>
<td>Small pupil</td>
<td>• depth of focus increases</td>
</tr>
<tr>
<td></td>
<td>• Concept used as pin hole test in refraction</td>
</tr>
<tr>
<td>Large pupil</td>
<td>• Retinal image quality improves</td>
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Retina
• Maximum resolving power at fovea.
• A concave spherical surface with r = -12 mm.
• Advantages of curvature of retina over plane image forming surfaces of cameras and optical instruments:
  – The curved images formed by the optical system is brought in the right order.
  – A much wider field of view is covered by the steeply curved retina

Axes and visual angles
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OPTICAL AXIS: line passing through centre of cornea, lens and meets retina on nasal side of fovea

VISUAL AXIS: line joining fixation point, nodal point and fovea

FIXATION AXIS: line joining fixation point and centre of rotation

OPTICAL aberrations

- Diffraction of light
- Spherical aberrations
- Chromatic aberrations
- Decentering
- Oblique aberrations
- Coma

REFRACTIVE ERRORS

- Ametropia: a refractive error is present
- Myopia: Near sightedness
- Hyperopia (Hypermetropia): Far sightedness
- Presbyopia: Loss of accommodative ability of the lens resulting in difficulties with near tasks
- Astigmatism: the curvature of the cornea and/or lens is not spherical and therefore causes image blur on the retina

REFRACTIVE ERRORS

- Anisometropia: a refractive power difference between the 2 eyes (> 2D)
- Aniseikonia: a difference of image size between the 2 eyes as perceived by the patient
- Aphakia: (Phakos=lens), aphakia is no lens
- Pseudophakia: artificial lens in the eye

Myopia

A form of refractive error in which parallel rays of light entering the eye are focused in front of retina with accommodation being at rest.
Etiological types

- Axial (MC) - increased AP length of eyeball
- Curvatural - increased curvature of cornea, lens or both
- Index - increased refractive index of lens with nuclear sclerosis
- Positional - anterior placement of lens
- Myopia due to excessive accommodation

Clinical types of myopia

- Congenital
- Simple or developmental
- Degenerative or pathological
- Acquired

Assignment:
- write an essay about clinical types of myopia discussing the difference between these types and mechanism of each type

Clinical features - Symptoms

- Distant blurred vision
- Half shutting of eyes
- Asthenopic symptoms
- Night blindness
- Divergent squint

Signs

- Prominent eyeballs
- Large cornea
- Anterior chamber is deep
- Large & sluggishly reacting pupil
- Fundus examination - changes seen only in pathological myopia

Optical treatment

- Concave lenses
- (Minus lens)
- Contact lenses
Optical treatment

Adults:
- <30 years - full correction
- >30 years - less than full correction with which patient is comfortable for near vision.

HIGH MYOPIA
- under correction is done to avoid near vision problem magnification of images contact lenses are better (to avoid image magnification)

Surgical treatment

- Radial keratotomy
- Lamellar corneal refractive procedures
- Laser based procedures
  - PRK
  - LASIK
  - LASEK
  - C-LASIK
  - E-LASIK

Hypermetropia

- It is the refractive state of eye where in parallel rays of light coming from infinity are focused behind the sensitive layer of retina with accommodation being at rest

Etiological types

- Axial (m.c) - decreased AP diameter of eyeball
- Curvatural flattening of cornea, lens or both
- Index - old age, diabetics under treatment
- Positional - posteriorly placed lens
- Absence of lens - aphakia

CLINICAL TYPES

- SIMPLE HYPERMETROPIA
- PATHOLOGICAL
- FUNCTIONAL HYPEROPIA

Assignment:
- write an essay about clinical types of hyperopia
- discussing the difference between these types and mechanism of each type

TOTAL HYPERMETROPIA

- It is the total amount of refractive error, estimated after complete cycloplegia with atropine
LATENT HYPERMETROPIA

- Corrected by inherent tone of ciliary muscle
- High in children
- Decreases with age
- Revealed after abolishing tone of ciliary muscle with atropine

MANIFEST HYPERMETROPIA

- Remaining part of total hypermetropia
- Correct by accommodation and convex lens
- Consists of facultative & absolute

FACULTATIVE HYPERMETROPIA

- Corrected by patients accommodative effort

ABSOLUTE HYPERMETROPIA

- Residual part not corrected by patients accommodative effort

NORMAL AGE VARIATION

- At birth +2+3D HM
  - Slightly increase in one year of life,
  - Gradually diminished by the age 5-10 years
- In old age after 50 year again tendency to HM
  - Tone of ciliary muscle decreases
  - Accommodative power decreases
  - Some amount of latent HM become manifest
  - More amount of facultative HM become absolute

SYMPTOMS

- Principal symptom is blurring of vision for close work
- Symptoms vary depending upon age of patient & degree of refractive error
- Asymptomatic
- Asthenopic symptoms
- Defective vision only (particularly near vision)

TREATMENT

BASIS FOR TREATMENT

- No Treatment
  - Error is small
  - Asymptomatic
  - Visual acuity normal
  - No muscular imbalance
**MODE OF TREATMENT**

- **SPECTACLES**
- **CONTACT LENS**
- **SURGICAL**

**PRESBYOPIA**

The physiologic loss of accommodation in the eyes in advancing age

- Physiologic loss of accommodation in advancing age
- deposit of insoluble proteins in lens in advancing age-->
  >elasticity of lens progressively decrease-->
  >decrease accommodation
- around 40 years of age, accommodation become less than 4.00 D, causing difficulty with reading fine print, headache, visual fatigue

**SYMPTOMS**

- The need to hold reading material at arm's length.
- Blurred near vision
- Headache
- Fatigue
- Symptoms worse in dim light.

**Young children (<6 or 7 yrs)**

- Some degree of hypermetropia is physiological so no correction
- Treatment required if error is high or strabismus is present
- Working in school small error may require correction
- In children error tends normally to diminish with growth so refraction should be carried out every six month and if necessary the correction should be reduced, otherwise a lens which is overcorrecting their error may induce an artificial myopia
- No deduction of tonus allowance in strabismus

**Adults**

- If symptoms of eye-strain are marked, we correct as much of the total hypermetropia as possible, trying as far as we can to relieve the accommodation
- When there is spasm of accommodation we correct the whole of the error
- Some patients with hypermetropia do not initially tolerate the full correction indicated by manifest refraction so we under correct them
SPECTACLES

- Plus lens (or)
- Convex lens

Surgery

- Monovision LASIK
- Monovision & CK
- IntraCor
- Refractive lens exchange
- Corneal Inlays & Onlays

ASTIGMATISM

A defect of an optical system causing light rays from a point source to fail to meet in a focal point resulting in a blurred and imperfect image.

- Types of regular astigmatism
- Simple astigmatism
  - Simple hyperopic astigmatism
  - Simple myopic astigmatism
- Compound astigmatism
  - Compound hyperopic astigmatism
  - Compound myopic astigmatism
- Mixed astigmatism

Types

- Regular astigmatism – change in refractive power is uniform from one meridian to another
  - With-the-rule astigmatism
  - Against-the-rule astigmatism
  - Oblique astigmatism
  - Bi-oblique astigmatism
- Irregular astigmatism – Irregular change of refractive power in different meridians
Regular Astigmatism:
- Correctable by Spherocylindrical lenses

Etiology:
1. Corneal - abnormalities of curvature [common]
2. Lenticular is rare. It may be:
   i. Curvartural - abnormalities of curvature of lens as seen in lenticulan.
   ii. Positional - tilting or oblique placement of lens, subluxation.
3. Retinal - oblique placement of macula [rare]

Symptoms:
- Blurring of vision
- Asthenopic symptoms
- Tilting of head
- Squinting [Half closure of eyelid]

Investigations:
- Retinoscopy
- Keratometry
- Computerized corneal Tomography
- Astigmatic fan test
- Jackson cross cylinder

Guidelines for optical treatment:
- Small astigmatism: treatment is required
  - In presence of asthenopic symptoms
  - Decreased vision
- High astigmatism: full correction
- Better to avoid new astigmatic correction in adults because of intolerable distraction

Irregular Astigmatism:

Etiology:
- Corneal: [Scars, Keratoconus, flap complications, marginal degeneration]
- Lenticular: [Cataract maturation]
- Retinal: [scarring of macula, tumors of retina, choroid]
Anisometropia

- Difference in refractive power between eyes
- Refractive correction often leads to different image sizes on the retinas (aniseikonia)
- Aniseikonia depend on degree of refractive anomaly and type of correction

Anisometropia

- Glasses: magnified or minified 2% per 1 D
- Contact lens: change less than glasses
- Tolerate aniseikonia ~ 5-8%
- Symptoms: usually congenital and often asymptomatic
- Treatment
  - Anisometropia > 3-4 D-> contact lens
  - Unilateral aphakia-> contact lens or intraocular lens

What is Refraction?

It is Determination of the refractive status (prescription) of the eye.

- Refraction could be performed Objectively (using Retinoscopy or Autorefractometer) or subjectively.

Subjective Refraction

To determine by subjective means the combination of spherical and cylindrical lenses necessary to provide best visual acuity. (with accommodation relaxed)
Principles of Refraction

• 1. Accommodation-relaxed state
• 2. Maximum PLUS, minimum minus
• 3. Always trial frame before prescribing
• 4. Take into account vertex distance especially for high prescription individuals

How to ensure accommodation is relaxed?

• Use PLUS lens to FOG
• Ensure image is located infront of retina
• This causes image / VA to become worse if eye attempts to accommodate (Image point becomes further away from the fovea)