

Subjective refraction

OPTICS OF HUMAN EYE
& REFRACTIVE ERRORS

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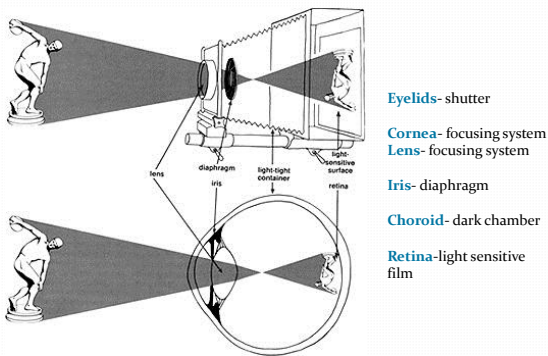
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Optics of human eye

- Eye as a camera
- Components
- Schematic eye and reduced eyes
- Axes and visual angles
- Optical aberrations

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Eye as a camera



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Components

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

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Cornea

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

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- 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)

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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

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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.

Average size:

- 2-4mm

Small pupil

- depth of focus increases
- Concept used as pin hole test in refraction

Large pupil

- Retinal image quality improves

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The crystalline lens

Thickness

- Birth 3.5 - 4 mm
- Adult life 4.75 - 5 mm

Radius of curvature

- Ant surface 10 mm
- Post surface 6 mm

Refractive index of lens

- Nucleus 1.41
- Pole 1.385
- Equator 1.375

Total power

- 15 -18 d.

Accommodative power

- At birth- 14-16 D
- At 25yrs- 7-8D
- At 50yrs- 1-2D

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- Lens accounts for about one third of the refraction of the eye.

ACCOMODATION

- Provides a mechanism of focusing at different distances.

OPTICAL CHANGES IN CATARACTOUS LENS

- Visual Acuity reduction.
- Myopic shift.
- Monocular diplopia.
- Glare.
- Color shift.

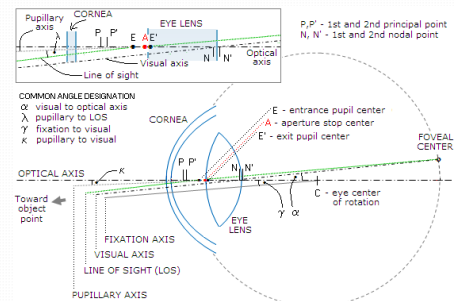
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Retina

- 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

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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

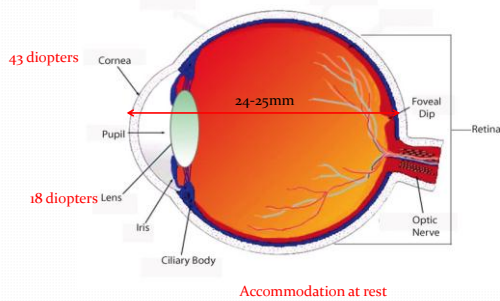
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Optical aberrations

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

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Emmetropia



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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

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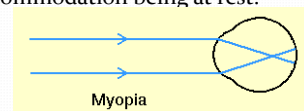
REFRACTIVE ERRORS

- **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

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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.



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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

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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

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Clinical features - Symptoms

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

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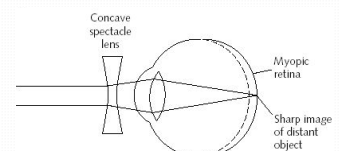
Signs

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

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Optical treatment

- Concave lenses
- (Minus lens)



- Contact lenses

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Optical treatment

- ✓ Adults:
 - ✓ <30years-full correction
 - ✓ >30years-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)

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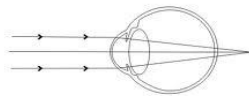
Surgical treatment

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

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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



Refraction in a hypermetropic eye.

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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

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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

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TOTAL HYPERMETROPIA

- It is the total amount of refractive error,estimated after complete cycloplegia with atropine
- Divided into latent & manifest

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LATENT HYPERMETROPIA

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

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MANIFEST HYPERMETROPIA

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

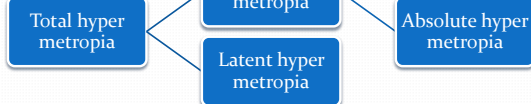
FACULTATIVE HYPERMETROPIA

- Corrected by patients accommodative effort

ABSOLUTE HYPERMETROPIA

- Residual part not corrected by patients accommodative effort

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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

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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)

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TREATMENT

BASIS FOR TREATMENT

- No Treatment
- ☐ Error is small
- ☐ Asymptomatic
- ☐ Visual acuity normal
- ☐ No muscular imbalance

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Young children (<6 or 7yrs)

- ❑ 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 months 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

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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

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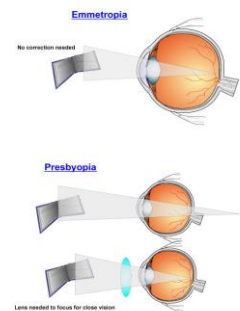
MODE OF TREATMENT

- SPECTACLES
- CONTACT LENS
- SURGICAL

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PRESBYOPIA

The physiologic loss of accommodation in the eyes in advancing age



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- 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

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SYMPTOMS

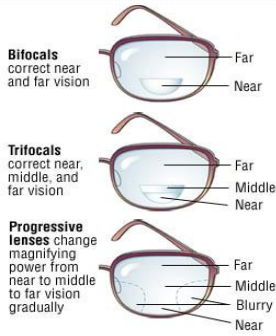
- The need to hold reading material at arm's length.
- Blurred near vision
- Headache
- Fatigue
- Symptoms worse in dim light.



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SPECTACLES

Plus lens
(or)
Convex lens



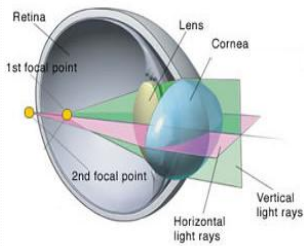
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Surgery

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

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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.

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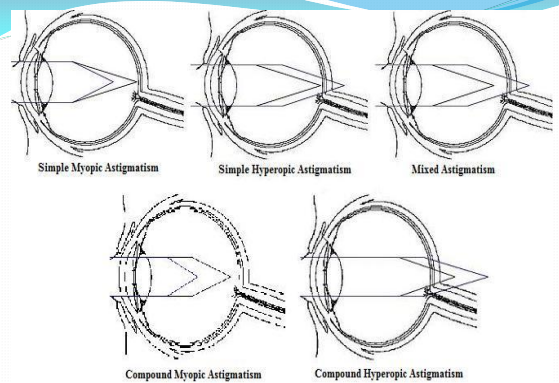
Types

- 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

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

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Regular Astigmatism :

- Correctable by Spherocylindrical lenses

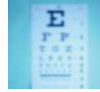
Etiology :

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

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• Symptoms :

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



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Investigations:

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

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Treatment

- Optical treatment
 - Spectacles
 - RGP contact lenses
 - Toric contact lenses
- Surgical correction

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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

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Irregular Astigmatism

• Etiology :

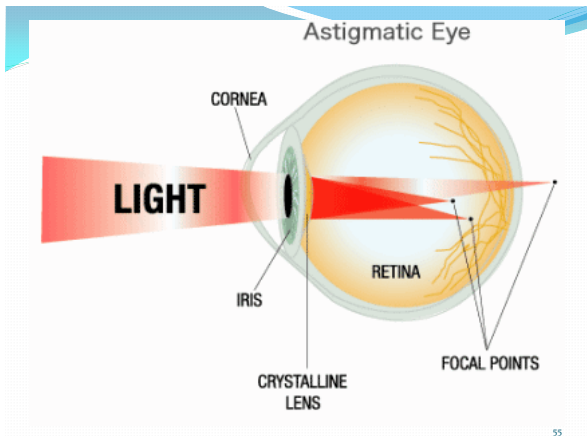
Corneal -[Scars , Keratoconus , flap complications, marginal degeneration]

Lenticular -[Cataract maturation]

Retinal-[scarring of macula,tumours of retina,choroid]



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Treatment :

- Optical treatment :
 - RGP contact lenses
 - Hybrid contact lenses
 - Scleral lenses
- Surgical treatment:
 - penetrating keratoplasty

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 Retinoscope 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

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How to ensure accommodation is relaxed?

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

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How to achieve BVS?

- Highest positive spherical lens to give best VA

FOGGING

DUOC ROME

FOGGING TO ACHIEVE BVS

- Place enough PLUS lenses to FOG vision to ~6/12 line
- ROT: every line = -0.25 DS
- Slowly reduce the plus power until best VA is obtained
- Remember:
"Maximum plus power for best visual acuity"

USING DUOCHROME TEST TO ACHIEVE BVS



- Based on chromatic aberration
- ~~Place lens on the greatest line in the red darker or~~
- Green letters clearer = Add '+ 0.25DS'
- Red letters clearer = Add '- 0.25DS'
- End point is obtained when the letters on the reversal Red-

occurs.

JACKSON CROSS CYLINDER (JCC)

JCC used to find used to determine the cylindrical axis and the cylindrical power for the patient.



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STEP 2: JACKSON CROSS

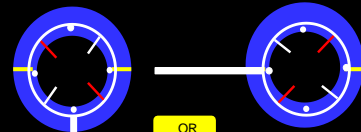
JCC CYLINDER

- JCC used to find used to determine the cylindrical axis and the cylindrical power for the patient.



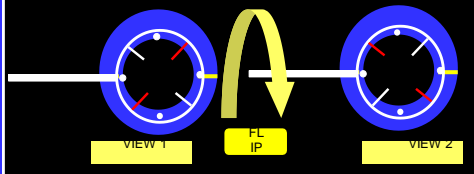
Determining Cylinder Axis

- Patient directed to observe a round target
- Align dots with trial lens axis ie: 180



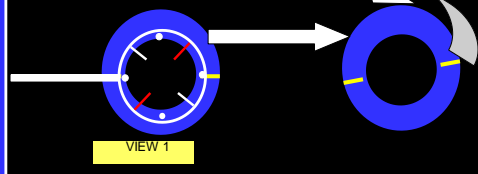
Determining Cylinder Axis

- JCC is flipped such that two views are shown
- Patient asked: "Is view one rounder, sharper, clearer or view two?"



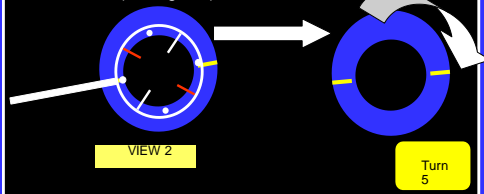
Refining the axis

- If view one is clearer turn trial lens' axis **turn 10 degrees TOWARDS red lines (-5-10 degrees)**



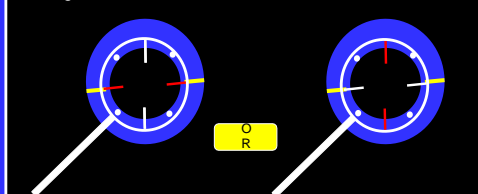
Refining the axis

- If view two is clearer turn trial lens' axis **TOWARDS red lines (-5 degrees)**



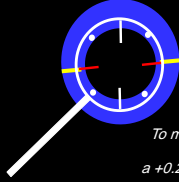
Determining Cylinder Power

- Patient directed to observe a round target
- Align red lines OR white lines to trial lens axis



Determining Cylinder Power

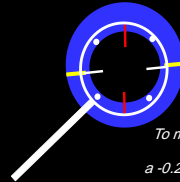
- If view one is clearer, ADD -0.25 DC



To maintain the circle of least confusion on the retina, a $+0.25$ DS is added for every -0.50 DC

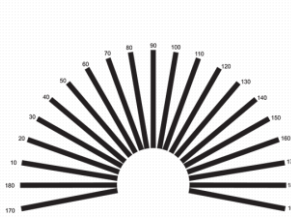
Determining Cylinder Power

- If view one is clearer, ADD $+0.25$ DC



To maintain the circle of least confusion on the retina, a -0.25 DS is added for every $+0.50$ DC

Another technique for measuring Astigmatism



The fan test



Clock dial test

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BINOCULAR BALANCING

- The technique is also known as "equalising".
- During the monocular refraction, a different state of relaxation of accommodation may occur because one eye was under test while the other was not.
- Thus, binocular balancing is performed to **balance accommodation between eyes**.

ALTERNATE
OCCLUSION

HUMPHRIS
IMMEDIATE CONTRAST

BB: Alternate Occlusion

- Used only when VA is EQUAL in both eyes

- 1Fog both eyes with $+0.75$ DS
- 2Direct patient to view 3 lines above best VA
- 3Alternately occlude each eye for ~ 0.5 secs each while asking patient: "Which eye sees clearer/sharper"?
- 4Add $+0.25$ DS to the better eye
- 5Repeat step 3 and 4 until both eye's vision is equalised
- 6Slowly reduce fog until best VA is reached

BB: Humphriss immediate contrast

- Used when VA is EQUAL or UNEQUAL between both eyes

- 1Fog OS with $+0.75$ DS
- 2Direct patient to view OD's best VA line
- 3Perform BVS in OD
- 4Add $+0.25$ DS in OD \diamond VA same or better Add $+0.25$ DS, VA worse remove $+0.25$, until you achieve max plus min minus
- 5Repeat Step 1-3 to test OS

BINOCULAR BEST VISION SPHERE

- After binocular balancing, spherical lenses are added in front of the 2 eyes at the same time to determine the Binocular Best Sphere. The most plus/ least minus that would not reduce VA would be the end-point.
- Strongest positive spherical lens to give best VA
- 1. Direct patient to view best OU VA
- 2. ADD +0.25DS \diamond VA same= Add +0.25DS (Repeat with additional +0.25DS), VA worse= Remove 0.25+DS

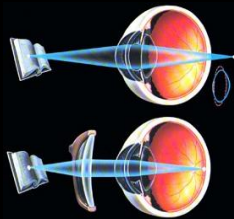
What about for reading?



"I can see clearly at distance, but I can't read my newspapers!"

Near Addition

- Presbyopic patients would require a near addition for their reading.



Finding the Near Addition

- Step 1: Estimation from patient's age

Age (in Years)	Estimated Add (in D)
40 - 45	+ 0.50 to + 1.00
46 - 50	+ 1.25 to + 1.75
51 - 55	+ 2.00 to + 2.50
56 - 60	+ 2.50 to + 2.75
61 - 65	+ 2.50 to + 2.75
66 - 70	+ 2.50 to + 2.75
70 +	+ 2.50 and Above

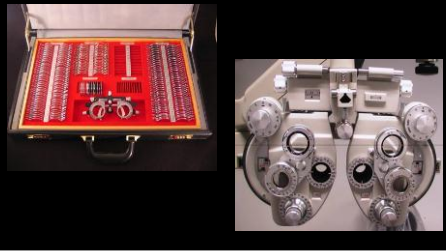
Finding the Near Addition

- Step 2: Place the estimated near addition on top of the distance prescription
- Step 3: Patients holds the near vision chart at habitual distance. The amount of near add is then adjusted to position the patient's habitual reading distance in the middle of the range of clear vision.

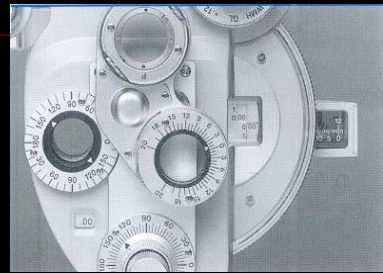
Instruments for Refraction

Trial lens set and frame
Phoropter

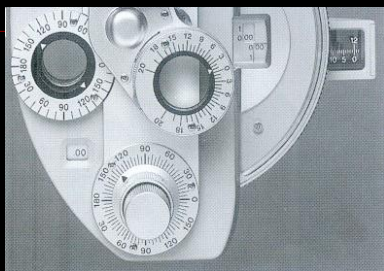
Two sets of commonly used instruments



Adjusting Sphere Powers



Adjusting Cylinder Powers and Axis



Cross Cylinder

