Manuale di patologia degli organi di senso

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“Manuale di Patologia degli Organi di Senso”

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by Brad Bowling
Elsevier Ed.

by Peter K. Kaiser, Neil J. Friedman, Roberto Pineda
Elsevier Ed.
Optics and refractive errors

Prof. Leopoldo Spadea
Perception and recognition of objects
The interposition
Light: form of radiant energy. It makes visible the objects that surround.

Speed: 300,000 Km for second.

colori

- rosso
- arancione
- giallo
- verde
- blu
- violetto

<table>
<thead>
<tr>
<th>lunghezza d’onda in millimicron</th>
<th>colori</th>
</tr>
</thead>
<tbody>
<tr>
<td>700 - 610</td>
<td>rosso</td>
</tr>
<tr>
<td>610 - 590</td>
<td>arancione</td>
</tr>
<tr>
<td>590 - 570</td>
<td>giallo</td>
</tr>
<tr>
<td>570 - 500</td>
<td>verde</td>
</tr>
<tr>
<td>500 - 440</td>
<td>blu</td>
</tr>
<tr>
<td>440 - 400</td>
<td>violetto</td>
</tr>
</tbody>
</table>
The electromagnetic spectrum

Figure 8.9 The electromagnetic spectrum

Light is the visible portion of the electromagnetic spectrum. White light, separated according to wavelength with a prism, produces the spectrum of visible colors, extending from violet and blue at the short-wavelength end to red at the long-wavelength end.
The light propagates in a straight line

Light rays: ✓ Convergent
✓ Divergent
✓ Parallel

The point at which the rays diverge or converge is called FOCUS

VERGENCE: inverse of distance in meters

\[
\frac{1}{d} = D
\]
<table>
<thead>
<tr>
<th>Distanza in metri</th>
<th>Vergenza in diottrie</th>
<th>Distanza in metri</th>
<th>Vergenza in diottrie</th>
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<tbody>
<tr>
<td>∞</td>
<td>0,00</td>
<td>0,75</td>
<td>1,33</td>
</tr>
<tr>
<td>10,00</td>
<td>0,10</td>
<td>0,66</td>
<td>1,50</td>
</tr>
<tr>
<td>5,00</td>
<td>0,20</td>
<td>0,57</td>
<td>1,75</td>
</tr>
<tr>
<td>4,00</td>
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<td>0,50</td>
<td>2,00</td>
</tr>
<tr>
<td>3,00</td>
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<td>0,40</td>
<td>2,50</td>
</tr>
<tr>
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<td>0,40</td>
<td>0,33</td>
<td>3,00</td>
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<tr>
<td>1,50</td>
<td>0,66</td>
<td>0,20</td>
<td>5,00</td>
</tr>
<tr>
<td>1,33</td>
<td>0,75</td>
<td>0,17</td>
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</tr>
<tr>
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<tr>
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<td>1,10</td>
<td>0,10</td>
<td>10,00</td>
</tr>
<tr>
<td>0,80</td>
<td>1,25</td>
<td>0,05</td>
<td>20,00</td>
</tr>
</tbody>
</table>
Refraction index

\[
n (\text{medium}) = \frac{c}{v} \quad \text{(speed of light in vacuum)}
\]

\[
n = \frac{c}{v} \quad \text{(velocity of light in the medium)}
\]

\[\text{incident ray} \quad \text{angle of incidence} \quad i\]

\[\text{refracted ray} \quad \text{angle of refraction} \quad r\]

\[\text{normal}\]

\[\text{vacuum} \quad \text{medium}\]
Fig. 6. — Sezioni di vari tipi di lenti: A, biconvessa; B, biconcava; C, piano-convessa; D, piano-concava; E ed F, concavo-convessa.

+4 sf

\[ \begin{align*}
+2 & \quad +2 \\
\text{=} & \quad +4 \\
\text{=} & \quad +5.25 \\
\text{=} & \quad -1.25 \\
\text{=} & \quad +10 \\
\text{=} & \quad -6
\end{align*} \]

-4 sf

\[ \begin{align*}
-2 & \quad -2 \\
\text{=} & \quad 0 \\
\text{=} & \quad -4 \\
\text{=} & \quad +1.25 \\
\text{=} & \quad -5.25 \\
\text{=} & \quad +6 \\
\text{=} & \quad -10
\end{align*} \]
REFRACTIVE ERRORS

✓ MYOPIA
✓ HYPEROPIA
✓ ASTIGMATISM
✓ PRESBIOPIA
Distance Visual Acuity Test (E Game)
(Read in good light at 10 feet.)

Line 1
20/200

Line 2
20/100

Line 3
20/40

Line 4
20/20

100 Millimeter Calibration Bar
Myopia is a refractive error, a visual defect of the system that focus the images.
EMMETROPIA
The parallel rays of light coming from infinity are focused on the retina with accommodation being at rest.
MYOPIA

A refractive error in which parallel rays of light entering the eye are focused in front of the retina with accommodation being at rest.
In Italy about 14 million people are myopes. In western countries 20% of population, in Asiatic countries 50-70%.
2010 U.S. Prevalent Cases
Myopia

- White: 80%
- Black: 5%
- Hispanic: 8%
- Other: 7%
2010
nearly 28% affected by Myopia

2050
nearly 50% affected by Myopia
Myopia Projections in United States

- 2010: 34,119,279
- 2030: 39,094,141
- 2050: 44,496,229

Source: Medscape
Figure 1: Myopia and high myopia are rapidly increasing worldwide.

- **2016**
  - No myopia: 77.1%
  - Low to moderate myopia: 20.2%
  - High myopia: 2.7%

- **2050**
  - No myopia: 50.7%
  - Low to moderate myopia: 39.5%
  - High myopia: 9.8%

Total population: 7 billion

Total population: 10 billion

Adapted from Holden et al. 2016
CLASSIFICATION OF MYOPIA
According to amount
Low (less -3.00 D)
Medium (-3.00 D to -6.00 D)
High (more -6.00 D).

In Italy:
• 10% with low myopia
• 70% with medium myopia
• 20% with high myopia
ETIOLOGICAL TYPES:

1. AXIAL: Increased ant/post length of eyeball
2. CURVATURE: Increased curvature of cornea, lens or both
3. INDEX: Increased refractive index of lens with nuclear sclerosis

The majority of myopia is due to an excessive length of the eyeball.
MYOPIA

NORMAL EYE

AXIAL MYOPIA

STEEP CORNEA MYOPIA

INDEX MYOPIA
There are two reasons why an eye may be longer than necessary.

1) excessive stimulus to the growth. During the period of puberty and adolescence all the body and the eye receive some stimulus to the growth. The eye responds stretching too much. Usually the eye growth end at the age of 20-25 years.
2) Yielding of the sclera’s structure.

Sclera is a rigid structure, but it is formed by collagen fibers that could be low resistance. The bulging is more visible in the central part of the retina and it is called myopic stafiloma.
✓ Stretching of eye ball
✓ Instability of vitreous

periphery retinal degeneration with retinal detachment risk.
Congenital and Acquired myopia

**Congenital myopia** is already present at birth.

**Acquired myopia** can be classified in:
- **simple myopia**: it arise in school children and increases in the period of body development.
- **degenerative**: it arise in children, around 2-3 years of age, increases in the next years up to (30D)
- **age related**: due to cataract (index myopia)
Myopic patients have good near visual acuity but haven’t a good distance acuity: this patients often squeeze eye to focus a far object.
Myopia is most commonly corrected through the use of corrective negative lenses, such as glasses or contact lenses.

This lenses have a negative optical power which compensates for the excessive positive power of the myopic eye.
Image focussed in front of retina

Lens diverges light rays

Image is refocussed on the retina
HYPEROPIA
FARSIGHTEDNESS

It is a refractive defect that occur in about 9 million people in Italy. In the normal eye the light ray that came from distant objects focus on retinal plan.
In the hyperopic eye the light ray focus behind the retinal plan: the patients receive a blurred image.
Normal eye

Hyperopia
Etiology of hyperopia:

1. short eyeball
2. cornea and/or lens less steep
3. lens refractive index changes
4. luxated lenses (it is not in the physiologic position)
5. aphakia (absence of lens)
occhio normale

il globo oculare è più corto della norma

la cornea è meno curva che di norma
1) The more frequent etiology is short eyeball

Every children have physiological hyperopia, with the growth it happens a gradual reduction of hyperopia. It disappeared with puberty. Patients with hyperopia have not a good far and near visual acuity
Hyperopia is most commonly corrected through the use of corrective positive lenses, such as glasses or contact lenses:

- ✓ low (< 2 D)
- ✓ moderate (< 4 D)
- ✓ high (> 4 D)
<table>
<thead>
<tr>
<th>LATENT (CYCLOPLEGIA)</th>
<th>MANIFESTS</th>
<th>ABSOLUTE</th>
</tr>
</thead>
</table>

- < 40 ys CYCLOPLEGIC REFRACTION
- > 40 ys MANIFEST REFRACTION (blurring technique)
LATENT HYPEROPIA

As long as the patient is young and mild hyperopia, the subject is able to compensate for this with the accommodation process, which is a physiological compensatory mechanism that permits changing the curvature of the lens to focus images on the retina. Therefore often hyperopic patient remains asymptomatic and hidden for long time.
MANIFEST HYPEROPIA

The accommodative effort is very tiring when protracted: hyperopes often do not complain to see bad for distance, but accuse fatigue i.e. when they study.

Very often in this accommodative effort it follows the appearance of eye strain. Sometimes also convergent strabismus.
Astigmatism is a refractive defect due to the shape of the cornea than in normal subjects has spherical symmetrical shape, while in astigmatic patients has asymmetrical shape, ellipsoidal, oval.
In the normal eye all meridians have the same refractive power while in astigmatic patients meridians have different refractive power. In other refractive errors a simple object, as a point of light is seen blurred but maintains the shape of a blurry dot. In astigmatism due to non-roundness of the diopter it is unable to identify more than the shape of the dot itself. Astigmatism is indeed a word that comes from the old Greek and means “vision with no dot”.
Normal eye

basketball shape

Astigmatic eye

football shape
Astigmatism is linked to an abnormality of curvature of the cornea, rarely the cause is an abnormality of curvature of the lens or even the shape of the sclera. It is a congenital abnormality that is detected early in life and that remains unchanged over the years.

Astigmatism can however also occur secondary to surgical procedures (cataract, corneal transplantation, retinal detachment, or after ocular trauma).

A minimum astigmatism, less than 0.5 diopter, is considered physiological, and generally does not require a correction.
Astigmatism can be:

✓ isolated (simple astigmatism)
✓ associated with myopia (compound myopic astigmatism)
✓ hyperopia (compound hyperopic astigmatism)
✓ both (mixed astigmatism)

This defect is corrected with cylindrical lens positive or negative depending on the case.
Classification of astigmatism

Regular Astigmatism

1. The two main meridians are perpendicular to each other (90°)
2. Power along each meridian remains constant

Otherwise

Irregular Astigmatism
Classification of astigmatism

With the rule astigmatism (WTR)
Against the rule astigmatism (ATR)
Oblique astigmatism (OBL)
ANISOMETROPIA

The anisometropia is a fairly frequent condition in which there is a difference in the refractive power of the two eyes.

Combinations:

✓ A normal eye and the other one myopic or hyperopic,
✓ both hyperopic,
✓ both myopic,
✓ one myopic and one hyperopic (antimetropia)
When the difference is more than 3-4 diopters, the different power of the lenses of the glasses produces the perception of images of different size of the two eyes in the brain causing problems in binocular vision. (aniseiconia)
The brain receives the images that come from the two eyes: one more confusing, less clear (from the eye with major defect) is deleted (suppression) to promote the perception of the sharp images provided by eye with lower refractive defect. In the long period time this mechanism do not utilizes the eye with worst images making it lazy.

**Amblyopia** Often the amblyopic eye, not used, is diverted (strabismus)
Children can tolerate lenses with different power on both eyes while adults can tolerate at most a difference correction between the two eyes of 2-3 diopters. Therefore is more indicated the correction by contact lenses.
Presbyopia is an accommodation disorder secondary to the physiological reduction of the ability to focus, with resulting difficulty in visual activities to close. The child emmetropic focuses to 7 centimeters. The young adult emmetrope than 10-14 cm. The subject of 60 years at 1 meter.
The accommodation is the main mechanism that allows to focus on the retina objects placed between the remote point and the near point.
The nervous reflex mechanism that allows the normal activation of this feature include:

**afferent way** (sensory fibers)

**efferent way** (parasympathetic)

**effectory muscle** (ciliary muscle "Rouget-Muller")
The accommodation is accompanied by two reflections dyskinetic:

✓ **Convergence**

✓ **Miosis**

---


**Age-related changes in static accommodation and accommodative miosis**

Hema Radhakrishnan and W. Neil Charman
The amplitude of accommodation (A) is measured in diopters and represents the difference between the near point (P) and the remote point (R):

\[ A = P - R \]
2 factors determine the accommodative amplitude:

- Refraction (remote point)
- Near point

If the eye is emmetropic the next point is equal to the accommodative amplitude.
The accommodative amplitude decreases with age:

✓ 10 years = 14D
✓ 65 years = 0
✓ 45 years = 4D near point close to 25 cm. At this age, for comfortable reading at 33 cm, the individual needs a lens +1 D, it is called presbyopic.
The speed of accommodation, about 0.5” from distance to near vision, decreases with age.
Pathology of accommodation

- Astenopy
- Accommodative deficiency
- Paralysis or paresis
- Spasm (hypertonic ciliary muscle)
- Presbyopia
The changes of accommodation can be linked to:

- disorders of innervation
- drug and toxic
- eye disorders (anterior uveitis)
- pathologies of lens or ciliary muscle
- refractive defects (anisometropia)
- environmental causes (lighting)
The dynamics of the accommodative function is still under investigation, as some phenomena alone do not justify all the events.
In the past many errors were made, such as the action of the extrinsic muscles, the change of curvature of the cornea, the elongation of the eyeball, the exclusive action of the pupillary miosis.
Helmholtz (1855) exposes the first thesis about accommodation explaining how the change of the radius of curvature of the lens is due to the relaxation of the zonule consequent to the contraction of the ciliary muscle.
Tshering (1898) opposing Helmholtz introduced the possibility of a traction zonular which results in an equatorial flattening and a central steepening
B

- Posterior Longitudinal Muscle
- Posterior Radial Muscle
- Anterior Radial Muscle Moves Toward the Sclera
- Anterior Longitudinal Muscle
- Collagen Fibers, Group 1
- Collagen Fibers, Group 2
- Collagen Fibers, Group 3
- Circular Muscle Moves Forward
- Pars Plana Moves Forward
- Trabecular Meshwork Opens
- Anterior Zonules Relax
- Iris Constricts
- Lens Equator Moves Toward the Sclera
- Posterior Zonules Relax
- Equatorial Zonules with Increased Tension
- Ciliary Processes Move Toward the Lens

Cornea
Accommodated Lens
Presbyopia is corrected by convergent (positive) lenses in subjects emmetropes.

In hyperopic correction amount for presbyopia is in addition to the value of the lens for distance;
in myopic patients presbyopia correction must be subtracted from the value of the lens used for far vision.
Follicular papillary hypertrophy

Corneal infiltrates from LAC
INDICATIONS

✓ Age >20 years

✓ Refractive stability at least 2 years

✓ Sphere-equivalent range
  8 -10D myopia
  3-5D hyperopia
absolute contraindications

✓ exophthalmos
✓ corneal diseases inflammatory / infectious
✓ ectatic disorders
REASON FOR CAUTION IN PRK/LASIK

✓ Autoimmune diseases (ex: Rheumatoid arthritis, Sjogrens syndrome, Lupus, scleroderma)
✓ Diabetes
✓ Immune deficiencies (ex: HIV/AIDS, history of an organ transplant, undergoing chemotherapy for cancer, taking oral corticosteroids)
✓ Personal or family history of corneal diseases, such as Keratoconus or Pellucid Marginal Degeneration
✓ History of Herpes Simplex or Zoster eye infections.
✓ History of other eye diseases (Glaucoma, Fuchs Dystrophy, Macular degeneration, Cataract, Amblyopia or lazy eye)
✓ Pregnancy or Nursing
✓ Certain medications: Accutane® (isotretinoin), Cordarone® (amiodarone)
✓ Dry Eyes
radial keratotomy (4 incisions)
Incisions in the cornea involves a modification of its curvature: the execution of each incision leads to the formation of an area of flattening.

Radial keratotomy (8 incisions)
Incisional surgery

Perioperative complications:
- micro-perforations (incidence: 2.3-7.4%)
- macro-perforations (incidence: 0.2%)

Refractive complications:
- hypo / hypercorrections
- regression
- decentrations
- small optic zones
EXCIMER LASER

1983: Trokel has realized that an intense laser light could be used not only for engraving on plastic materials, but also to create radial incisions on corneal stroma.

1986: Seiler used a prototype of the excimer laser by removing damaged tissue from the corneal surface.

1988: McDonald's has created the basis for what is known as PRK.
Basic Components of an Excimer Laser

- Laserhead
- Electronic Control
- Gas Supply System
- Beam Delivery and Shaping System
- Microscope
- Patient Bed
- Patient
Optical System of an Excimer Laser

- beam shaper
- lens
- prism
- output coupler
- containment window
- mirror
- energy control
- feed back line
- two channel energy measurement
- attenuator
- microscope
- sm 1
- sm 2
- output coupler
PRK
photorefractive keratectomy with excimer laser
Myopic Astigmatism
Myopia
Dati keratometrici: meridiani perpendicolari principali (d=3mm)

Ro: 38.6D
Rv: 39.3D
Ast.: -0.7D
Asse: 179.2°
Ecc.: -0.69

269.2° 89.2°
179.2° 359.2°
Hyperopia
Hyperopic Astigmatism
LASIK
laser in situ
keratomileusis assisted by excimer laser
In the world until 2015 were performed more than 40 million LASIK
USA

LASIK
In USA the percentage of medical-ophthalmologists who has undergone refractive surgery is higher than that of the general population.
LASIK
(Laser Assisted in Situ Keratomileusis)
Surgical technique with laser ablation on the corneal stroma after making a corneal flap (flap).
So it is a procedure based on the use of two tools:

MICROKERATOME

EXCIMER LASER
"... LASIK was created independently by Buratto and Pallikaris between 1989 and 1990 by the combination of keratomileusis and ablation with the excimer laser ..."

(Sekundo W, J Cat Refract Surg 2002)