1 REFRACTION

1.1 Emmetropia

Emmetropia, or no refractive error

In a normal, emmetropic eye, parallel rays of light from a distant object focus directly on the retina. The total refractive power of the eye is about 63 diopters. The largest part of about 43 diopters is contributed by the cornea and the smaller amount, about 23 diopters, by the lens. The axial eye length of the normal eye is about 23.5 mm.

1.2 Ametropia

Ametropia, or refractive error of the eye

There are different ametropias, which can be present isolated or in combination. The spherical ametropias are Myopia, or near-sightedness, and hyperopia, or far-sightedness. Furthermore, there is astigmatism, which can be present in isolation or in combination with myopia or hyperopia. Lastly, presbyopia, or the decrease in accommodative ability.

1.2.1 Spherical Ametropias

We differentiate

- Axial ametropias, where the eye has a normal refractive power, but objects do not focus on the retina because the length of the eye is too long or short.

- Refractive ametropias, where the eye has a normal axial length, but objects do not focus on the retina because the refracting power (either of the cornea or lens) is too strong or weak.

1.2.1.1 Myopia

Myopia, or Nearsightedness is the most common ametropia

In myopia, parallel rays of light from a distant object are focused in front of the retina and therefore the image on the retina is blurred. In most cases the axial length of the eye is too long. The myop sees distant objects blurred. At which distance the myop can see clearly depends on the extent of the myopia. A myop with minus 2 diopters can see objects clearly at a 50 cm distance, at the far-point. Accommodation allows the myop to focus objects that are closer than the far-point. Concave lenses, or minus lenses, are used to bring the focal plane onto the retina.

1.2.1.1 Hyperopia

Hyperopia, or Farsightedness

In hyperopia, parallel rays of light from a distant object are focused in behind the retina and therefore the image on the retina is blurred. In hyperopia, the refractive problem can be compensated by the use of accommodation. By increasing the refractive power of the crystalline lens, the focal plane is shifted onto the retina, the patient sees clearly into the distance and at near, however, only with a constant accommodative effort. This effort may lead to symptoms such as tiredness when reading and a chronic headache. Hyperopia is corrected with convex or plus lenses.

1.2.2 Presbyopia

Presbyopia is a result of the loss in elasticity of the crystalline lens, causing a progressive weakness in accommodation. Once the accommodative amplitude is less than 3 diopters, which usually happens around the age of 50 years, reading is not possible at the normal reading distance. Spherical plus lenses are used to correct for presbyopia. Once the accommodative amplitude is zero, reading adds of plus 3 diopters are used which allow reading at a distance of about 33 cm.

1.2.3 Astigmatism

In the ideal case, the cornea is spherical so that light is refracted and focused equally in all meridians. Therefore a dot is seen as a dot. In the case of the surface of the cornea having a stronger curvature in one meridian than in the other main meridian, normal to it, a dot is seen as a line.

A regular astigmatism with the rule is present when the curvature of the vertical meridian is steeper than that of the horizontal meridian, as shown in the example. Horizontally oriented light rays are refracted normally, however, vertically oriented rays undergo stronger refraction. This results in 2 foci and between them the ‘interval of Sturm’. Exactly in the middle between both points of focus, or actually lines of focus, lies the circle of least confusion. The patient sees relatively best in this location.

Regular astigmatism is corrected with cylinder lenses. A segment is cut out of a glass cylinder. The axis of this plus-cylinder, a convex lens, is seen to be vertical, or at 90°, in this example. Therefore, horizontal rays of light are refracted, but vertical rays are not since they only hit plane surfaces. A cylinder lens in this position, neutralises an astigmatism with the rule. The back focus is pulled forward, resulting in one single focus, and therefore correcting the astigmatism.

A regular astigmatism against the rule is present when the curvature of the horizontal meridian is steeper than that of the vertical meridian, so just opposite to the previous example. Furthermore, the axis of astigmatism can also lie in between the vertical and horizontal axes, then called an oblique regular astigmatism.

An irregular astigmatism is caused by changing and irregular steepness of curvature along one meridian, often as a result of trauma. Such an irregular astigmatism can only be corrected with a contact lens.

1.3 Subjective Refraction

When evaluating subjective refraction the examiner assesses the degree of ametropia. During the examination the patient is given a trial frame, specially adapted for every individual to ensure a comfortable fit.

Next, one eye (in this case the left) is occluded. The patient is asked to read the smallest line on the reading chart still clearly visible to her.

In the collection of lenses one finds spherical lenses, plus (or convex) lenses in black, and minus (or concave) lenses in red. Additionally, there are cylindrical lenses in plus and minus, although we usually use plus cylinders.

The examiner starts by using a plus 0.5 diopter spherical lens while asking the patient if the image worsens. The patient indicates that the image does worsen. This excludes hyperopia.

Now the patient is given a spherical lens of minus 0.5 diopter and asked whether her vision improves. She affirms. This prompts the use of another minus 0.5 diopter spherical lens. Once again the patient indicates that her vision improves and that it is possible for her to read the bottom line of the reading chart. The examiner now changes the two minus 0.5 diopter lenses for a minus 1.0 diopter lens.

Now he adds another minus 0.25 diopter. This leads to a small improvement in vision, after which both lenses are replaced by a single minus 1.25 diopter lens.

When the examiner adds another minus 0.25 diopter lens, vision does not improve and the image actually gets smaller. Therefore this lens is discarded and the best spherical lens for this myopic patient is minus 1.25 diopter.

To confirm the presence of astigmatism, the subjective cross cylinder test is performed. The cross cylinder, or Jackson cylinder, is used to determine the axis and the power of the astigmatism. Because plus cylinders are conventionally used here, the axis along the two white dots is relevant.

The examiner holds the cross cylinder horizontal with the axis along the white dots. Subsequently, he turns the cross cylinder so that the axis is oriented vertically. The patient prefers the vertical axis at 90°.

The patient is then given a cylinder of plus 0.5 diopter along the axis at 90°. To compensate for the spherical effects of this lens, the examiner adds a spherical lens with half the power of the cylinder and opposite sign Thus, for a plus 0.5 diopter cylinder, a spherical lens of minus 0.25 diopter.

Now the precise axis of the astigmatism should be found. This is done by turning the cross cylinder, while its handle is held along the cylinder axis.

The patient compares the possibilities the white spot at 135° and at 45°. The patient chooses the axis in the direction of 135°, after which the axis is changed by 20°, from 90° to 110°. Again the handle of the cross is held along the lens axis. This time the patient chooses the axis in direction 90°. The axis is then turned back 10° to 100°.

To assess the degree of astigmatism, the plus axis (white spots), and then the minus axis (red spots), are placed on the found axis of 100°. The patient confirms that she sees equally badly with both cross cylinder positions, which prompts the examiner to leave the cylindrical strength at 0.5 diopters.

The final refraction of the right eye is minus 1.5 diopters sphere with a plus cylinder of 0.5 diopters at 100°.

1.4 Objective Refraction

1.4.1 Retinoscopy

Retinoscopy is mainly used to determine the refraction in children. A light is shone though a light permeable mirror of the retinoscope onto the pupil. By moving the light, the movement of the shadow in the pupil can be observed.

1.4.2 Autorefractometer

The purpose of the autorefractometer is the objective, automated measurement of refraction. The patient fixates a distant object, presented in the instrument, while the examiner takes one or more measurements. Subsequently the other eye is measured. The result is then printed.

2 VISUAL ACUITY

Visual acuity is a measure of the ability of the visual system to resolve fine detail. It is defined as the ability to see 2 dots as separate objects. This optical resolution is also named the minimum separabile and is made possible by the cones in the fovea.

Distance visual acuity is tested at a distance of 5m. The opening of a ring, or the thickness of letters or numbers, is 1 minute of arc, therefore 1 / 60th of a degree. The light that is reflected from such an optotype hits the photoreceptors of the fovea. In order to read such an optotype, one non-activated receptor between two activated receptors is necessary. In the normal retina the distance between cones is 2.5 micrometers. The smallest angle between two points that allows their differentiation, is the limit of resolution. Visual acuity is given as the reciprocal of this angle.

Normal visual acuity is defined as 1.0 and equals an angle of 1 minute of arc. At a distance of 5 meters, as seen in our example, the opening of the ring would be about 1.5 mm. An optotype that is presented at a nearer distance would need to be smaller to keep the angle constant. Visual acuity can also be presented as a fraction, such as 6/6 or 20/20.

As seen in this example, a loss of photoreceptors decreases the resolution and also visual acuity. Only the opening of a larger ring can be detected.

2.1 Distance Visual Acuity

In the examination of the distance visual acuity, or uncorrected visual acuity, one eye is covered and the patient is asked to read the lines on the reading chart from top to bottom. The smallest line the patient is able to read correctly determines the visual acuity for distance, in this case 0.5 or 20/40. After successful refraction, the best corrected visual acuity is determined.

For low vision assessment one examines the visual functions as follows:

The patient covers the eye that is not examined with her hand. The examiner then tests if the eye sees light. If it does, he has to check whether light projection in all for main directions (left, right, up and down) is present. Subsequently he determines whether the patient recognizes hand motion at a distance of 1 meter. Thereafter he checks if the patient can count fingers at a distance of 1 meter.

If the patient can recognize all the previous, then the so-called visual acuity at 1 meter can be determined. For example, if the patient can read the first line, which could normally be read from 30 m if the visual acuity were 1, the resulting visual acuity would be 1/30.

2.2 Near Visual Acuity

A reading chart is held 33 cm from the eye and the smallest readable text is determined.

3 EXTERNAL EYE

3.1 Inspection

An ocular examination starts with an inspection of the external eye. Using a penlight one can evaluate the lid, conjunctiva and cornea. When examining the conjunctiva one searches for a red discoloration, edematous thickening, the presence of secretion or the presence of any foreign body.

3.2 Intrapalpebral Fissure

The opening between the upper and lower lids has an oval shape and is measured with a ruler. 7-10 mm are a normal finding if the patient is looking straight ahead. The upper lid covers 1-2 mm of the cornea, while the lower lid is located 1-2 mm from the limbus. This patient has a ptosis of the right eye. This procedure is repeated with the patient looking down and up.

3.3 Lid Eversion

For the eversion of the upper lid the patient is asked to look down. With thumb and forefinger of the left hand, the examiner then takes the eyelashes, pulls the lid slightly downward and then, in a single quick movement, turns the lid around a cotton swab. The lid can be kept in this position for removing a foreign body.

The patient is asked to look upward while the lid is pulled downward with a cotton swab.

3.4 Lacrimal Irrigation

Basics
Physiologically, the tears flow through the upper and lower lacrimal punctae and into the upper and lower canaliculi, into the common canaliculus and into the lacrimal sac. From there the tears pass through the nasolacrimal duct that ends under the inferior nasal turbinate of the nose.

For lacrimal irrigation the punctae are dilated with a special dilator. A canula is held perpendicularly to the lid margin and inserted through the lacrimal punctum. After 1-2 mm the syringe is tilted by 90°, so that it is in a horizontal position. Carefully, the canula is pushed forward and the fluid is injected.

In case of a normal lacrimal system, the fluid runs into the throat.

Obstruction of the lacrimal system causes a reflux of the fluid, passing through the punctae into the lower fornix.

Video
Before irrigating the lacrimal system, the lacrimal punctae should be dilated. A canula is inserted into the lacrimal duct via the lacrimal punctae - first perpendicularly and then parallel to the lid. Then fluid is injected. If the lacrimal system is unblocked the fluid runs into the throat, which forces the patient to swallow.

3.5 Corneal Sensibility

Die Prüfung der Hornhautsensibilität erfolgt mittels eines ausgedrehten Zellstofftupfers. Von der Seite kommend, und ohne Berührung der Wimpern, wird die Hornhaut zentral berührt. Die Patientin wird gefragt, ob im Seitenvergleich zwischen den Augen ein Unterschied in der Empfindung besteht. Typischerweise findet man eine solche Hyposensibilität bei einer Herpeskeratitis.

3.6 Exophthalmometry

Basics
A Hertel exophthalmometer is used for assessment of the globe's position within the orbit. Two mirrors are fixed at 45°. One of the mirrors is movable on a scale. A millimeter scale is visible superimposed onto the corneal apex seen over the mirror. For measurements, the spurs are placed against the two

temporal orbital rims. The distance between the apex of the cornea and the temporal orbital rim can be read on the scale in millimeters.
The case shows an enophthalmus of the left eye where the globe is recessed several millimeters compared to the right eye.

Video

Before measurements are taken with the exophthalmometer, the patient is asked to look straight ahead. The examiner separates the two frames until the spurs touch the lateral orbit.
To ensure correct measurements and to avoid parallax errors, the examiner has to ensure that the red line of the scale lies at 18 mm. With the help of the mirror, the lower half of the corneal surface becomes visible. Above the mirror is a millimetre scale, where the corneal height can be read. In our example, using the left eye, we measure 15 mm.
The distance between the orbital margins, the so-called basic value, is read from the sliding scale.

4 ANTERIOR SEGMENT

4.1 Slit Lamp

Basics

The slit lamp consists of a binocular microscope and an illumination arm which are connected to a base. The examiner moves the base using a joystick.

This instrument permits a magnified examination of the transparent or translucent tissues of the eye in cross-section. By swinging the illumination arm from side to side, the various structures and their depth-localization in the eye can be assessed.
In this case the light beam is positioned at an angle of 45° from the left side. The cornea is the curved band of light which can be found left of the center, highlighted in red. The anterior lens surface can be seen right of the center, highlighted in blue. The anterior chamber is between the cornea and anterior lens surface, represented in green. The lens can be seen in its full thickness, represented in blue.

When the light beam is positioned at an angle of 30° or 5° from the left or from the right, the view of the structures changes. Use the mouse to change the angle of the light beam. You may point at the anatomical structures in the photo or schematic drawing to highlight them and understand their affiliations.

Video

The slit lamp is the main instrument used in ophthalmology. It consists of a binocular microscope and a tilting light source, both of which are mounted on a mobile platform which can be moved over a joystick.
The patient places her chin on the support, which can be set at different heights, so that the eyes are level with the orientation mark.

Without adding extra lenses, one is able to directly evaluate the external eye (eyelids, conjunctiva), the anterior segment of the eye (cornea, anterior chamber, iris, lens) and the anterior part of the vitreous body. By twisting the joystick, the light beam can be lowered and elevated. By moving the light source of the lamp, it is possible to depict the different structures of the anterior eye segment properly. As seen here, when focusing on the cornea, the other structures (like the lens) are out of focus. To bring the lens into view, one has to bring the slit-lamp closer to the eye. This will cause the cornea to move out of focus.

To visualise the cornea and lens, which are both transparent tissues, one needs to produce a type of “optical cross section“. Furthermore the lightslit can be changed in width and in length. The lightslit can be rotated, exactly on the focal distance of the microscope being used. Because of the different angles, one is able to use, the exact, three-dimensional location of any structure to be ascertained. The viewing arm of the slit-lamp also contains a knob for adjusting magnification.

4.2 Tear Film

Basics

The tear film protects the eye against dryness. It covers cornea and conjunctiva and consists of three layers:

- the inner mucin layer, which is secreted by the conjunctival goblet cells,
- the middle aqueous layer, which is secreted by the lacrimal glands and makes up 98% of the tear film
- the outer lipid layer, which is secreted by the meibomian glands and the glands of Zeis. Its thickness is about 1 µm. The lipid layer retards evaporation of the aqueous layer of the tear film.

Nonetheless, the aqueous layer decreases continuously, until a local defect appears and the lipid layer is intermitted. A blink of the eyelids reconstitutes the tear film covering the cornea and conjunctiva.

Abnormalities in the tear film lead to dryness and defects in the corneal epithelium. Such corneal epithelial defects can be stained with fluorescein dye.

Video

4.2.1 Fluorescein Staining

To stain the tear film one asks the patient to look up and then one everts the lower lid carefully with a finger. The fluorescein dye is applied to the conjunctival sack using a small paper strip. Under cobalt blue light, the tear film turns yellow-green.

4.2.2 Schirmer Test

This test measures the aqueous components of the tear film. The patient is requested to look straight ahead, with a slightly elevated gaze. A filter paper strip is bent at right angles about 5 mm from the end and is hung into the fornix conjunctivae at the outer third of the lower lid. After 5 minutes the paper is removed and the length of the wet portion of the strip measured. Normally the result should be more than 10 mm.

4.3 Keratometry

Basics

The Javal keratometer enables the measurement of the curvature, or the radii of curvature, of the cornea. The keratometer consist of two “figures” fixated on a semi-circular arc: an orange, square and a green serrated image. These figures are projected onto the surface of the cornea and can be observed by the examiner’s ocular. By changing the distance between the two figures, both images can be brought into contact. By rotating the instrument, the two black lines which run through the images should be brought into one straight line. This axis is noted. Rotating the instrument by 90° may change the relative position of the images to one another. If the images don’t overlap, the corneal radii are practically equal and the cornea is a spherical curvature. If an overlap is seen, the two major radii are different. One step of the orange figure equals 1 diopter of corneal astigmatism. The axis of this astigmatism is along the black line.

In this case the orange image moves two steps into the green one. This can be seen in the vertical axis. A corneal astigmatism of plus 2 diopters at an axis of 90° - a regular astigmatism with the rule - can be diagnosed.

Distorted images of the figures indicate an irregular astigmatism. Irregular astigmatism cannot be corrected with cylindric lenses, but only with contact lenses.

Video

With the Javal keratometer one is able to measure the curvature of the cornea.

The keratometer projects an orange, square pattern as well as a green serrated image onto the surface of the cornea.

While the patient is looking at a central fixation light, the examiner has to bring the orange and green images together. Furthermore, he has to align the black lines in such a fashion that they become one single, straight line. Then the apparatus is turned 90° and the angles and radii can be read from the scale. When both radii are different, then astigmatism is present. In this example: plus 2 diopters at an axis of 75°.

4.4 Gonioscopy

Basics

After topical anaesthesia the gonioscope is covered with contact gel. The goniolens is placed on the cornea. The lens contains a mirror that is tilted by 62°. It allows visualization the opposite anterior chamber angle. By rotating the goniolens, the complete 360° of the angle can be investigated with the slit-lamp at different magnifications. In the normal eye, various angle structures can be seen: the trabecular meshwork, with the Schwalbe line representing the peripheral termination of Descemet's membrane and the anterior border of the trabeculum, and the scleral spur, representing the posterior border of the trabeculum. Schlemm's canal is located behind the trabecular meshwork and cannot be seen.

In the case of a narrow or closed angle as seen in acute glaucoma, the trabecular meshwork cannot be seen because the iris is bulging forward or even in contact with it.

Video

After the contact surface of the gonioscope has been covered with contact gel, the gonioscope is placed on the previously anaesthetized cornea. The light source is directed at the gonioscope, which then reflects the light into the angle of the anterior chamber, enabling the examiner to visualize the various structures.

5 TONOMETRY

5.1 Applanation Tonometry

Basics

The Goldmann applanation tonometer consists of a tonometer tip, which is in connection with a torsion balance. The force applied onto the cornea can be changed by a force adjustment knob. After instillation of a topical anaesthetic and fluorescein dye the slit-lamp is moved towards the eye and the tonometer tip is brought into contact with the cornea. The flattened area can be seen through the transparent tonometer tip. A biprism divides the meniscus of dye into two semi-circles. The tonometer probe has to be centered, so that both semi-circles are of equal size. Using the force adjustment knob the variable force of the tonometer is increased until the inner margins of the semi-circles are in contact. Now, the applanated area of the cornea is 7.4 mm2, and the intraocular pressure can be read off the scale on the knob. In this case 25 mm of mercury.

Video

Before an applanation tonometry is performed a topical anesthetic and fluorescein dye are dropped into the patient's eye. Thereafter the measuring unit is swiveled into position. A cobalt blue light filter is put on. The previously disinfected tonometer tip, called a biprism, is slowly approximated, under slit lamp observation, to the cornea. As soon as the biprism touches the cornea, the examiner sees two displaced, yellow-green semicircles. Using the force adjustment knob, the applanation pressure is changed until the inner sides of the two semicircles touch. The value set on the force adjustment knob is equivalent to the intraocular pressure in millimeters of mercury.

5.2 Indentation Tonometry

Basics

After topical anaesthesia of the cornea, the Schiötz indentation tonometer is placed on the cornea. It consists of a perforated, cylindric sleeve. There is a small platform at the lower end for placing the tonometer onto the cornea. At the upper end there is a needle. The tonometer uses a preset amount of weight to gently press a plunger into the cornea, indenting it. The amount of corneal indentation, which is proportional to the intraocular pressure, is read off on a scale and is then converted into millimeters of mercury with the use of a table. In this case the intraocular pressure is zero, the plunger indents the cornea to a maximum and the needle moves to the right. In the second case the intraocular pressure is 60 mm of mercury, the plunger hardly indents the cornea, so that the needle only moves slightly.

Video

The indentation tonometry is performed on the supine patient. After topical anesthesia of the cornea, the Schiötz indentation tonometer is placed perpendicularly at the center of the cornea. By doing this, the cornea is indented by the plunger. The plunger is connected to an indicator needle, which in turn, shows the pressure reading on a scale. The lower the intraocular pressure, the deeper the plunger sinks and the greater the movement of the needle. By using the appropriate table, the measurement can be expressed in millimeters of mercury.

5.3 Palpatorical Assessment of Intraocular Pressure

Video

The intraocular pressure can also be palpatorically estimated. While the patient is looking down, the examiner places the tips of both index fingers on the upper lid. Light pressure is applied alternately to the eyeball. At normal intraocular pressure, the eye can be slightly indented. When the intraocular pressure is elevated (e.g. at 60), the eyeball becomes hard and inelastic.

6 RETINA

6.1 Ophthalmoscopy

6.1.1 Direct Ophthalmoscopy

Basics

For examination of the fundus using direct ophthalmology the patient is in a sitting position vis-à-vis the examiner. The direct ophthalmoloscope comprises a light source, a mirror and the so called Rekoss disc, a dioptric power wheel to compensate the patient’s and examiner’s refraction. The ophthalmoscope is held directly in front of the patient's eye, so that the light shines through the pupil onto the retina. The rays of light are reflected by a small area of retina and can be seen by the examiner as an upright and strongly magnified image, which can be brought into focus using the Rekoss disc.

Video

While the patient looks over the examiner's shoulder, he approaches the patient temporally at an angle of 15°. When examining the left eye, the doctor uses his own left eye and the contralateral arm to guide the patient's head. This should enable him to visualize the optic disc. The Rekoss disc, which compensates for ametropies of both doctor and patient, can be used to focus the image.

In this case the pupil is not dilated during the examination. Firstly, the papilla is visualized at about 15° nasal. It is sharply demarcated, with good color tone and has a small, central excavation. The pulsation of the central vein is recognizable. By tilting the ophthalmoscope, the examiner can view other areas of the posterior pole of the eye. The retinal vessels are of normal size and slightly convoluted.

6.1.2 Indirect Ophthalmoscopy

Basics

For examination of the fundus using indirect ophthalmology the patient is in a sitting or supine position vis-à-vis the examiner. The examiner holds the magnifying lens in front of the patient's eye. The light source is between examiner and lens. The rays of light are reflected at the retina and can be seen by the examiner as an inverted and magnified image, which can be seen in the focal plane of the lens between lens and examiner. The examiner needs to accommodate at the focal plane. The advantage of indirect ophthalmoscopy is that the examiner can observe the retina binocularly so that he has a stereoscopic view. The section of retina seen with indirect ophthalmoscopy is larger than with direct ophthalmoscopy.

Video

The indirect ophthalmoscope, comprised of a light source and magnifying lenses, is worn on the examiner's head. During the examination, performed on the supine patient, the distance between examiner and patients is about an arms-length. The examiner takes the magnifying lens between thumb and forefinger and uses the other fingers to support himself. 7-10cm from the eye of the patient. To visualize different parts of the retina, the patient is asked to look in the different directions of gaze. Indirect ophthalmoscopy aims to visualize a relatively large area of the retina at low magnification. This is particularly useful when examining the periphery of the retina. However, the image is up side down and turned on its side.

6.1.3 Indirect Ophthalmoscopy with Volk 90

Video

Indirect ophthalmoscopy can also be performed with the slit lamp. A magnifying lens is placed between the slit lamp and the patient's eye. In primary gaze, the posterior pole with the optic disc and macula can be seen. To evaluate the rest of the retina, the patient is again asked to look in various directions.

6.1.4 Three Mirror Lens

Basics

After topical anaesthesia, the Goldmann three mirror lens is covered with contact gel. The lens is placed on the cornea. The central part provides a 30° view of the posterior pole as a virtual and upright image. Three mirrors are integrated in the lens. The first, equatorial mirror, is tilted by 60° and is the largest mirror. It enables visualization from 30° to the equator. The second, peripheral mirror, is tilted by 67°, intermediate in size and square shaped. It enables visualization between the equator and the ora serrata. The third, gonioscopic mirror, is tilted by 73°, is the smallest and is a dome shaped mirror. It enables visualization of the extreme periphery of the retina and the pars plana. By rotating the lens, the complete 360° of the retina can be observed.

Video

For this examination the patient's pupil needs to be dilated. After a topical anesthesia of the cornea and covering the mirror lens with a contact gel, it is placed on the cornea. When looking through the lens in the center of the three-mirror lens, one has a clear, direct and upright view of the retina. The middle mirror is used to view the intermediate periphery, whereas the outer mirrors are used to view the periphery of the retina. By rotating the lens, it is possible to view the entire 360° of the retina.

6.2 Angiography

Fluorescein angiography is a method used to investigate the blood circulation of the retina and choroid. After the patient has received a venous line, the patient is placed in front of a fundus camera. A set of photographs of the fundus is taken and digitally saved. All images can be shown on a monitor. Subsequently the fluorescent dye, usually sodium fluorescein or indocyanine green, is given intravenously. After the dye has reached the retina via the ophthalmic artery, three sets of images are recorded. The first during the early arterio-venous phase, the second during the late arterio-venous phase and the third during the late venous phase.

In this case an age-related macular degeneration is shown. The patient's visual acuity was 0.1. A retinal haemorrhage and hard exsudates can be found in this photo of the retina. In fluorescein angiography two-component lesion with two classical parts were indicated. Then photodynamic therapy was assessed. The visual acuity remained the same over years. In postinterventional angiography no lesions can be found anymore.

7 NEUROOPHTHALMOLOGY

7.1 Pupil

7.1.1 Direct and Consensual Reaction

Basics

For examination of the direct and consensual pupillary reaction both eyes are illuminated with a penlight one after the other. The pupillary reaction is observed on the illuminated pupil and contralateral one. Normally, the pupils, are round and equal in size, show a brisk reaction to direct light and an equal consensual reaction.

In the case of a Horner's syndrome, miosis is found on the abnormal side – in our case the right eye. In darkness, the anisocoria is more pronounced.

Video

Infrared pupillography detects infra red light reflected through the pupil in order to measure the width of the pupil. Both eyes are illuminated with a penlight one after the other.

7.1.2 Swinging Penlight Test

Basics

In the assessment of the swinging penlight test one eye is illuminated for a few seconds. The illumination is changed quickly to the other eye. The illumination of the first eye causes a constriction of both pupils. When quickly changing to the second eye, the constriction stays the same.

In the case of a relative afferent pupillary defect, both pupils dilate when moving the penlight from the healthy eye to the abnormal one. In the latter eye the perception for light is reduced. In this case a relative afferent pupillary defect of the right eye

Video

In a dark room, one eye is illuminated from below for about 3 seconds. This causes a binocular constriction of the pupils. The light is then quickly changed to the other eye. In a normal patient the width of both pupils stays constant.
At the end of the test the lamp is positioned close to the tip of the nose. Convergence and pupil constriction are seen in both eyes.

7.2 Motility

The patient is asked to look in all 9 main directions of gaze, to evaluate whether the eyes move in a synchronized fashion. To conclude the motility test, a fixation lamp is brought to the tip of the nose to test convergence.

7.2.1 3. Cranial Nerv

The oculomotor, or third cranial nerve, leaves the nuclear complex ventrally in the midbrain and is accompanied by parasympathetic fibers for innervation of the pupillary sphincter pupillae and ciliary muscle. The nerve reaches the orbit and innervates the superior rectus, the medial rectus, the inferior rectus and the inferior oblique muscle, as well as the levator muscle.

Here, you can see a third nerve palsy of the right side. The patient is asked to follow the penlight with his eyes. Besides the typical limitation in movement, a dilated pupil and a ptosis are associated with this third nerve palsy.

7.2.2 4. Cranial Nerv

The trochlear, or fourth cranial nerve, is the only cranial nerve to cross sides and to emerge from the dorsal aspect of the brain. It is a long and slender nerve, which makes it vulnerable to trauma. The fourth nerve innervates the superior oblique muscle.

7.2.3 6. Cranial Nerv

The abducens, or sixth cranial nerve, leaves its nucleus ventrally in the midpoint of the pons and reaches the orbit to innervate the lateral rectus muscle.

Here you can see a sixth nerve palsy of the right side. The patient is asked to follow the penlight with the eyes. The right eye shows a failure of abduction.

7.3 Strabismus

7.3.1 Hirschberg Test

The corneal light reflections are used to screen for manifest squints. The patient sits upright and both eyes are fixated upon a penlight at a distance of 1m. The deviation of the reflection from the center of the pupil is measured in mm and noted. If the patient’s eyes are in a straight position the reflected images are central in both eyes.

If a squint is present, the squinting eye has a deviation of the light reflection. This deviation is proportional to the squint angle – the larger the deviation, the larger the angle.

7.3.2 Cover Test

The patient is fixated upon a penlight. Both eyes are covered in turn. The presence of eye movements is noted. It is important to remember that only one eye is uncovered at any one time.

7.4 Visual Field

The field of vision is that portion of a subject's surroundings that is visible by one eye looking straight ahead.

The normal visual field extends about 50° nasally, 70° inferiorly, 100° temporally and 60° superiorly from fixation.

The borders of the visual field are defined by the anatomy. In the vertical plane the view is limited superiorly by the supraorbital margin and inferiorly by the maxilla. In the horizontal plane the view is limited nasally by the nose and temporally by the zygomatic bone. The point of fixation, a function of the fovea, defines the center of the visual field. The blind spot is located 15° temporal in the visual field and corresponds to the optic nerve head.

Perimetry is the assessment of the visual field, and is a representation of the way the patient sees. Therefore, the map of the visual field is always a mirror image of the retina and it is upside down.

In normal eyes, sensitivity to light differences is highest in the makula and declines progressively towards the periphery of the retina. The visual field can be expressed as a hill of light sensitivity, also called the hill of vision. In a three-dimensional plot, the x- and y-axes represent the map of the visual field and the z-axis represents the sensitivity for brightness, or luminance. Perimtery measures the surface contour of this hill.

In kinetic perimetry, a constant large, bright stimulus is moved from the periphery towards the center until it is seen by the patient. Then, a smaller or less bright stimulus is used, which will only be detected closer to the fovea.
In static perimetry, local light stimuli that change in brightness, but do not move, are used. The local threshold in a series of locations in the visual field is determined by reducing the brightness of the spot until the patient cannot see it any longer. A stimulus which is nearer to the fovea needs to be of less brightness than one that is shown in the peripheral visual field.

7.4.1 Confrontation Perimetry

The patient covers one eye with her hand and the other eye is fixated upon the examiner. Following the main meridians, the examiner proceeds to determine the outer borders of the visual field. It is important that the examiner uses both arms, so that the patient cannot guess the direction by watching the examiner's shoulders.

To uncover an incomplete hemianopsia a red test marker can be moved from the one half of the visual field to the other. The patient is asked if she notices any difference in the intensity of the color, once the midline has been crossed.

7.4.2 Kinetic Perimetry

The kinetic perimetry is conducted by using a Goldmann perimeter. One eye is covered as the patient places her head on the chin support. Her eye is fixated upon a central fixation lamp. The examiner can monitor and center the eye position through a viewing tube in the Goldmann globe. A light is then moved along meridians from the periphery towards the center. Once the patient notices the light, she presses a buzzer. The examiner repeats the procedure along different meridians from the periphery towards the center, marking the points at which the light was first noticed.

The examination can be repeated at various light intensities and with light points of different diameters. These results in a selection of concentric patterns, corresponding to the relevant peripheral border of the visual field, are called isopters.

7.4.3 Static Perimetry

The static perimetry is fully automated. Often called computer perimetry, the procedure starts with one eye being covered and the patient placing her head on the chin support before looking at a fixation light. The examiner then centers the eye on the monitor and starts the program. The patient is confronted with points of light that declines in light intensity until the lowest still recognizable intensity, called the regional threshold, is found. This method is the most common form of perimetry used today. The results are printed in various shades of gray.

7.4.4 Amsler Grid

The Amsler net is an effective screening tool to find small central scotomas. The patient holds the grid at normal reading distance. After one eye has been covered, the central point of the grid is fixated. Scotomas present themselves as missing parts of the reading grid. Metamorphopsia, or distorted vision caused by changes in the macula, brings about the curving of the straight lines.

8 OTHERS

8.1 History

When considering ocular history it is important to find out whether the problem is unilateral or bilateral. What has been the type and time span of onset: was it sudden or gradual? What is the severity: has the problem improved, worsened or remained the same?

How is vision disturbed?
Is vision blurred, is there glare, metamorphopsia, alterations of the visual field, floaters, photopsia or iridescent vision?

Is there any pain or discomfort?

Is it pulsating or continuous, deep or superficial, like a burning, maybe with a headache. Is there an association to an injury?

Take into account past ocular history, ask about past surgery, injuries and inflammation.

Take into account family history, ask about the presence of eye diseases in the patient's family, such as a glaucoma.

Taking into account general history maybe important. In the case of diabetes mellitus, hypertension, rheumatoid diseases or tumors and others a co-appearance of ophthalmologic problems may be seen.

8.2 Ultrasound

Before ultrasound examination of the eye, the eye has to be topically anesthetized. After having been disinfected and prepared with contact gel, the ultrasound probe is placed on the eyeball. By turning the probe, the whole eye can be depicted echographically.

Both A- and B-scans can be performed and recorded with the eyelid being open or closed.

In this B-scan image a cross-sectional display of the globe, the optic nerve and extraorbital muscles are shown.
In this A-scan image echographic peaks of the tissue interfaces along the measurement axis are shown: the corneal peaks, the peaks of the anterior and posterior lens surface, and retinal and scleral peaks.

8.3 Color Tests

8.3.1 Farnsworth Test

The Farnsworth Color Test contains 16 cups of small differences in color. The patient has to align the cups in the proper order. To check their correct alignment, the cups are numbered on the back. Thereafter the sequence is drawn into a circular diagram.

8.3.2 Ishihara Plates

The Ishihara plates are used to detect defects in the ability to separate red and green from each other. The plates are held at a distance of 75cm from the eye. Evaluation ensues by using the attached charts.

8.4 Dark Adaptation

In Dark Adaptation the increasing retinal sensitivity is tested with an adaptometer. The patient is placed in front of a globe. The procedure starts with exposure to a luminance of 1000 candela/m_ for 5 minutes. Immediately afterwards, for a period of approximately 30 minutes, the patient is presented with a test of decreasing luminance at predetermined intervals. In this case a striped pattern is used. In this way the threshold luminance can be found. Each value of every interval is stamped onto paper calibrated in millimeters.

At the end of the session, the dots are connected. For the first minutes the resulting curve shows a steep change, caused by the adaptation of the retinal cones until the adaptation of the retinal rods take over.