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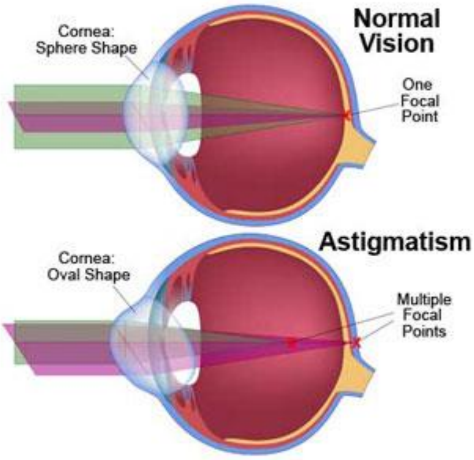
Theoretical part

Eye examinations

1. Astigmatism

Astigmatism is an optical defect in which vision is blurred due to the inability of the optics of the eye to focus a point object into a sharp focused image on the retina. Astigmatism can sometimes be asymptomatic, while higher degrees of astigmatism may cause symptoms such as blurry vision, squinting, eye strain, fatigue, or headaches.

Types



Regular astigmatism: Principal meridians are perpendicular.

- Simple astigmatism – the first focal line is on the retina, while the second is located behind the retina, or, the first focal line is in front of the retina, while the second is on the retina.
- Compound astigmatism – both focal lines are located behind or before the retina.
- Mixed astigmatism – focal lines are on both sides of the retina (straddling the retina).

Irregular astigmatism: Principal meridians are not perpendicular. This type cannot be corrected by a lens.

Tests

- Objective
  - Refractometer, autorefractometer
  - **Placido keratoscope** – A placido keratoscope consists of a handle and a circular part with a hole in the middle. The hole with a magnifying glass is viewed from a distance of 10–15 cm to the patients cornea. In the 200 mm wide circular portion there are concentric alternating black and white circles. They reflect the patient's cornea. In the event of astigmatism, a deformation appears at the corresponding location.
  - Sciascope
  - Ophthalmometry
- Subjective
  - **Fuchs figure** – This is a tool for evaluating astigmatism where examinee stands up against a pattern of circular shape (circular or striped rectangles) and fixes his/her gaze on the center of the pattern with one open eye. The examinee monitors himself/herself whether the image appears evenly or is somewhere distorted.

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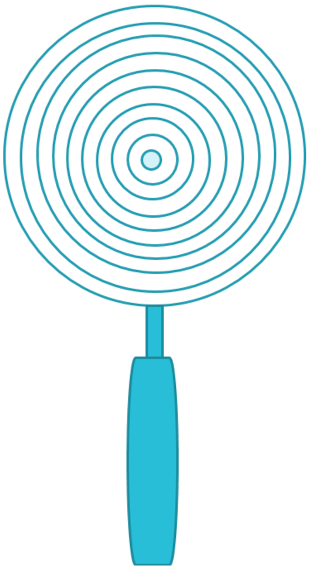
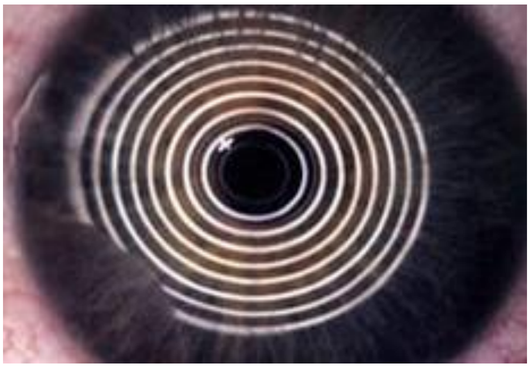
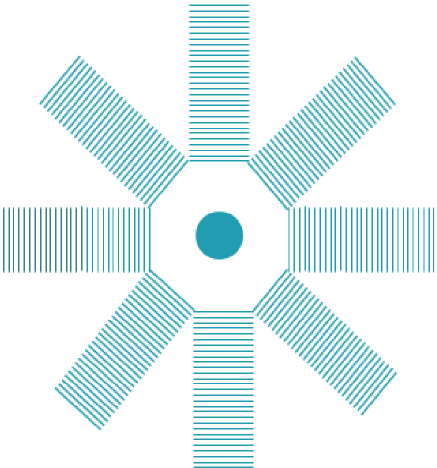




Placido keratoscope



Fuchs figure

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2. Color vision deficiency

The collective name for the inability to distinguish colors correctly is color blindness.

Types:

- **Monochromacy** – color blindness
  - Rod monochromacy (achromatopsia) – an inability to distinguish any colors as a result of absent or nonfunctioning retinal cones
  - Cone monochromacy – the absence or nonfunctioning of at least two retinal cones

- **Dichromacy** (Daltonismus)
  - Protanopia – cones are less sensitive to red light
  - Deuteranopia – cones are less sensitive to green light
  - Tritanopia – cones are less sensitive to blue light
- **Anomalous trichromacy** – a common type of inherited color vision deficiency, occurring when one of the three cone pigments is altered in its spectral sensitivity.
  - Protanomaly – this is a mild color vision defect in which an altered spectral sensitivity of the red retinal receptors (closer to the green receptor response) results in poor discrimination of red–green hues.
  - Deuternomaly – caused by a similar shift in the green retinal receptors and by far the most common type of color vision deficiency.
  - Tritanomaly – a rare, hereditary color vision deficiency affecting blue–green and yellow–red/pink hue discrimination.

Tests

- **Anomalous trichromacy, dichromacy, monochromacy, decreased sensitivity to hue**
  - *Farnsworth – Munsel 100 hue test* – the test contains four distinct rows of similar color hues, each containing 25 distinct variations of each hue. Each color hue at the polar end of a row is fixed in position to serve as an anchor. Each hue tile between the anchors can be adjusted as the observer sees fit. The final arrangement of the hue tiles represents the visual system's ability to discern differences in color hue.
- **Monochomacy, Dichromacy, Anomalous trichromacy**
  - *Nagel anomaloscope* – this is based on a color match. Two different light sources must be matched to the same color. On one side you have a yellow color which can be adjusted in brightness. The other side consists of a red and a green light where the proportion of mixture is variable.
- **Dichromacy, Monochromacy**
  - *Ishihara test* – this test consists a number of colored plates. Each of them contains a circle of dots appearing randomized in color and size. Within the pattern are dots which form a number or shape clearly visible to those with normal color vision, and invisible, or difficult to see, to those with a red-green color vision defect, or the other way around.

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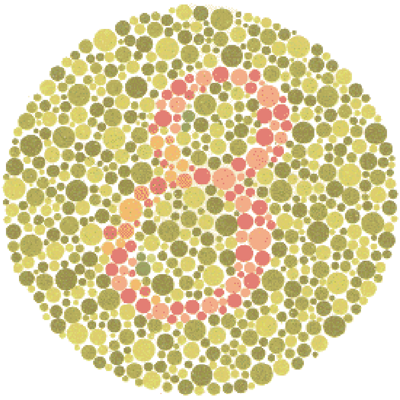
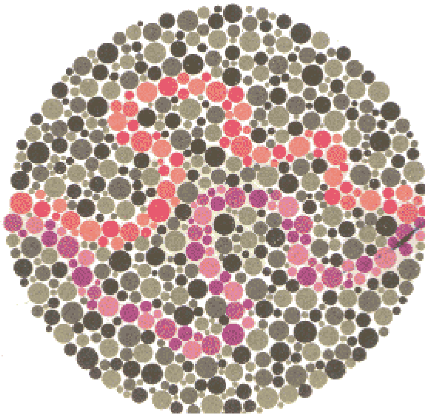
- *Holgrem test* –The patient must match one piece of wool to the samples in the box in this color blindness test. There are light and dark shades to confuse the patient. This helps to detect problems.



A trichromatic eye will see an “8”, while an eye with red-green blindness-protanopy, deuteranopy, protanomaly sees “3”. A monochromatic eye will not see any object.



Those with **normal** color vision should be able to trace along both the purple and red lines.
Those with **protanopia** (red colorblind) should be able to trace the purple line, while those with **protanomaly** (weak red vision) may be able to trace the red line, albeit with increased difficulty.
Those with **deuteranopia** (green colorblind) should be able to trace the red line, while those with **deuteranomaly** (weak green vision) may be able to trace the purple line, albeit with increased difficulty.

3. Accommodation

Accommodation is the process by which the vertebrate eye changes optical power to maintain a clear image or focus on an object as its distance varies.

Ability to focus is influenced by two factors:

- The ability of the lens to change its shape and the strength of the ciliary muscle.
- Actual physical deformation of the lens, which is measured in diopters, is called physical accommodation. Physiological accommodation expresses the contractile force of the ciliary muscle, which is necessary to change the refractive state of the eye of 1D.

Accommodation to the near point:

- In the process of accommodation to the near point, there is a contraction of the circular fibers of the ciliary muscle (Müller’s muscle) and relaxation of the zonulae, therefore lens with its own elasticity protrudes. The lens after releasing the contraction of the zonulae changes the radius of curvature of anterior and posterior refracting surface, due to its high elasticity.
- Innervation of the ciliary muscle to accommodation to the near point provides a parasympathetic pathway.

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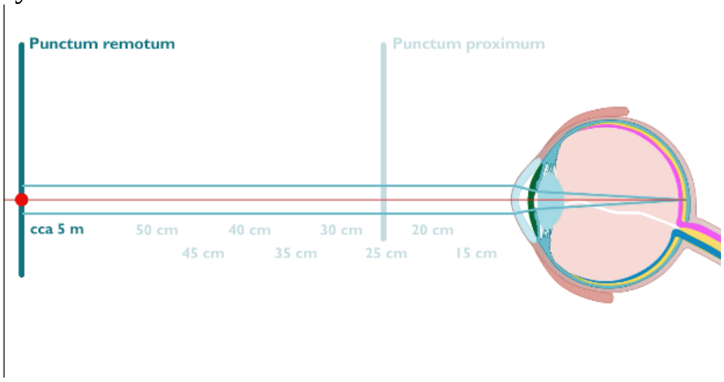
Accommodation to the distant point:

- Accommodation on a distant point is also active action. Meridional ciliary muscle fibers (Brücker's muscle) are contracting. The fibers are arranged so that by pulling on the lens toward the periphery, there is a flattening of the lens.
- Innervation of the meridional muscle to accommodation to the distant point provides a sympathetic pathway

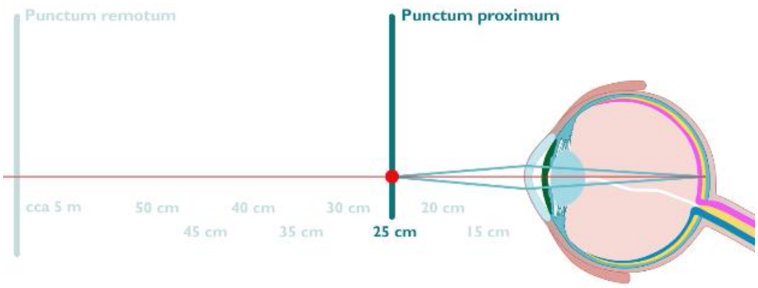
Far point R

The punctum remotum is a point lying on the optical axis that is displayed on the retina at the minimum accommodation. The far point of a healthy eye is at infinity. A hypermetropic eye has a far point at a finite distance behind the eye. Major hyperopia causes the far point to be moved closer to the final distance to the bulb of the eye. A myopic eye has a far point at a finite distance in front of the eye. The distance of the far point from the subject of the major plane of the eye is called aR and it is measured in meters. The reciprocal value of this distance is called axial refraction aR. Using this data, we can define the current refractive state of the eye.



Near point P

The punctum proximum is a point lying on the optical axis that appears on the retina at the maximum accommodation. The distance between the near point and the subject main plane of the eye is called the AP. AP is also measured in meters. The middle point is of fundamental importance in assessing the performance of the accommodation of the eye. Along with the distant point it encloses the accommodative area.



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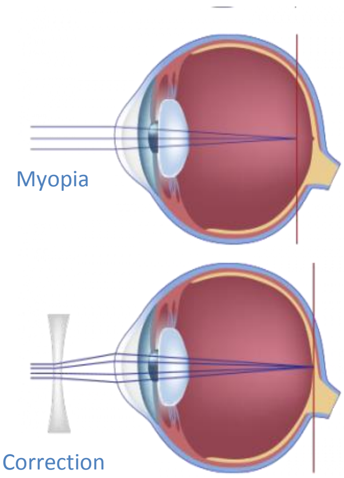
The **accommodative area** is the area between the far point and a near point. It therefore indicates the range in which we see the individual dots sharply. We measure it in meters.

Accommodation disorders

- **Myopia**

  Myopia is a condition of the eye where the light that comes in does not directly focus on the retina but in front of it, causing the image that one sees when looking at a distant object to be out of focus. It does not affect focus when looking at a nearby object. When used colloquially, myopia can also refer to a view on or way of thinking about something which is—by extension of the medical definition—hyper-focused and fails to include the larger context. Myopia is most commonly corrected through the use of corrective lenses, such as glasses or contact lenses. It may also be corrected by refractive surgery, though there are cases of associated side effects. Corrective lenses have a negative optical power (i.e. have a net concave effect) which compensates for the excessive ositive diopters of the myopic eye. Negative diopters are generally used to describe the severity of the myopia, as this is the value of the lens to correct the eye. High-degree myopia, or severe myopia, is defined as -6 diopters or worse.



- **Hyperopia**

  Commonly known as farsightedness, this is a defect of vision caused by an imperfection in the eye (often when the eyeball is too short or the lens cannot become round enough), causing the eye to not have enough power to see in the distance, causing the eye to have to accommodative, by having to make the lens of the eye more convex, or plus. For near objects, the eye has to accommodate even more. Symptoms vary depending on the amount of hyperopia and the age of the person which directly relates to the eye's accommodative ability. People with hyperopia can experience blue-red vision, asthenopia, accommodative dysfunction, binocular dysfunction, amblyopia, and strabismus, The causes of hyperopia are typically genetic and involve an eye that is too short or a cornea that is too flat, so that images focus at a point behind the retina.

- **Presbyopia**

  Presbyopia is a condition associated with aging in which the eye exhibits a progressively diminished ability to focus on near objects. Presbyopia's exact mechanisms are not fully understood; research evidence most strongly supports a loss of elasticity of the crystalline lens, although changes in the lens's curvature from continual growth and loss of power of the ciliary muscles (the muscles that bend and straighten the lens) have also been postulated as its cause.

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Experimental design

- The examinee looks through a thin window at a pin. At the maximum distance of 1 meter the examinee reports if he sees or does not see the pin out of focus. A healthy eye has the punctum remotum at 5 meters, while an unfocused pin at a distance of 1 meter is seen only by a myopic eye.
- The investigating person moves the pin progressively closer to the eye and the examinee reports if he/she sees a sharp pin or not.
- The punctum proximum in a healthy eye is about 25 cm. At this point, the healthy eye should not already see a sharp pin. For a hyperopic eye, this point – depending on the extent of the defect – is farther from the eye (30–35 cm) and a myopic eye – again depending on theextent of the defect – is punctum proximum closer to the eye (10-15 cm).

Scheiner's experiment

The aim of this experiment is to understand the connection between the refraction at the interface of two media (depending on the curvature of the lens) and the way the image is perceived. That is, it depends on the lens, which side of the retina will handle the beam and how the resulting image will appear. Scheiner's attempt is an essential part of a refractometer.

Basic theory:

While watching the two objects at different spatial depths (red and green pin) through the clips, one point will be seen two times and one point will be seen sharp. Due to clips with two holes only two incident rays fall to the retina. When looking at closer pin, the distant pin will be seen two times – eye accommodates at the near point (the beams converge rays from near point on the fovea centralis). Rays from distant point cross over before retina and distant point is seen two times.
Blurring of the pin depends on the imaging field of view – the right side of the retina processes the left side of the visual field and vice versa (regardless of whether one is dealing with the left eye or the right eye). This also means that if one beam falls from one place to the right side and the other onto the other side of the retina, the resulting image is composed of both sides of the retina and is blurred.

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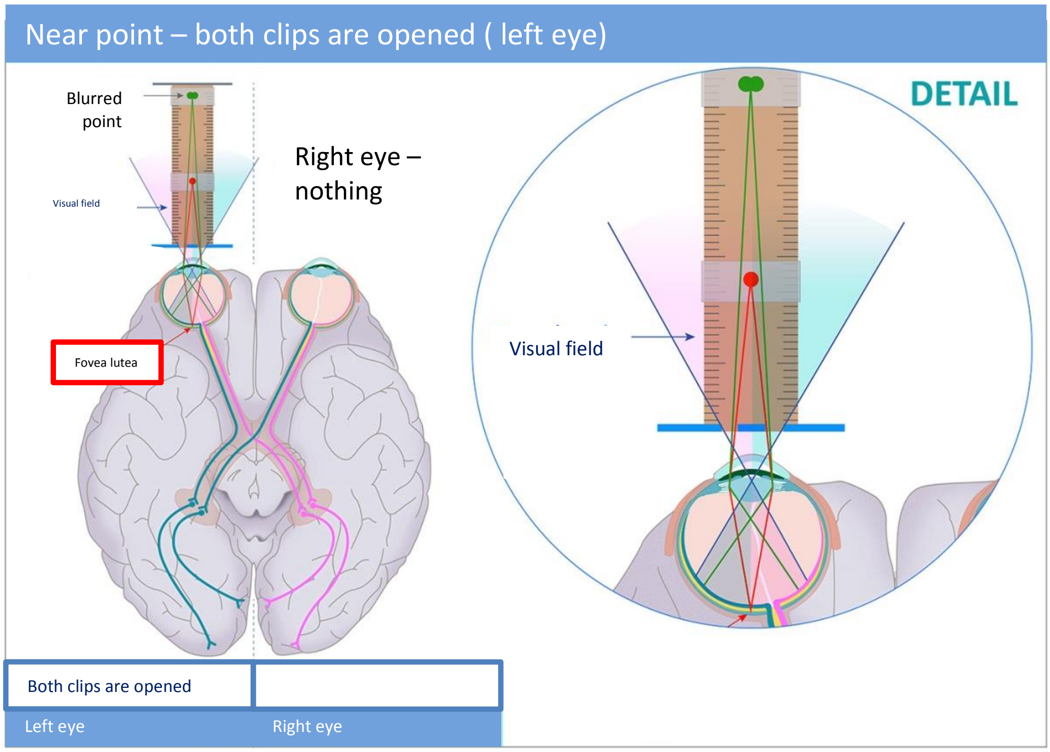

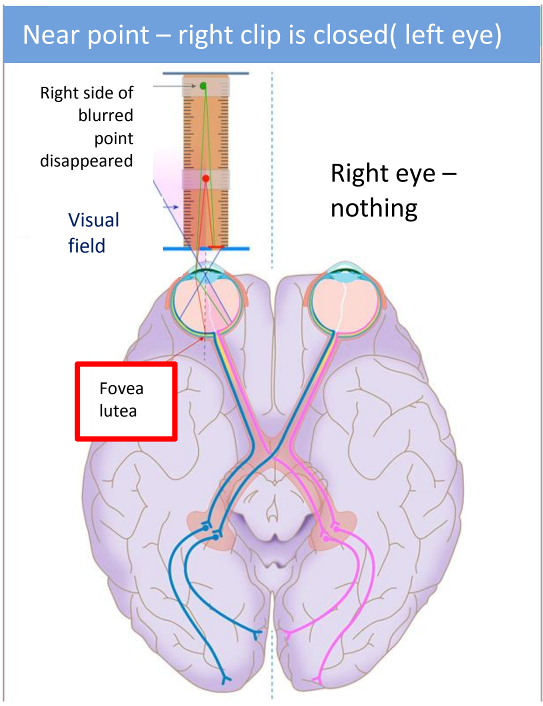

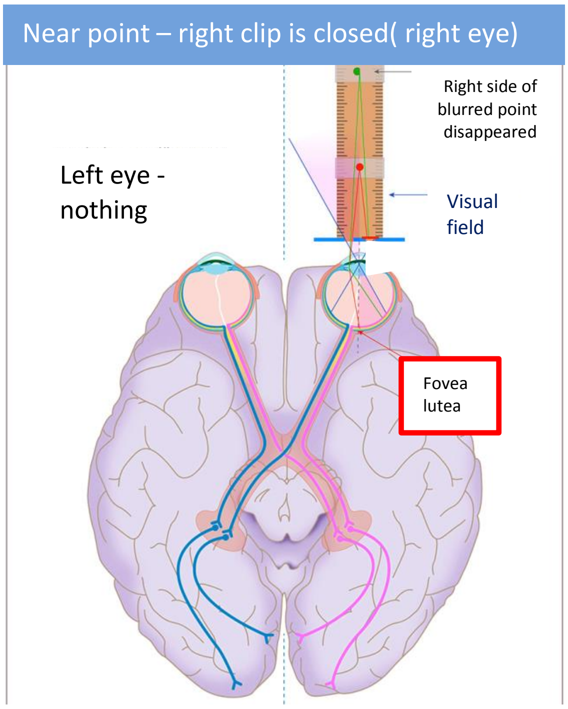

4. Visual field

The visual field is the entire area that can be seen when the eye is directed forward, including that area which is seen with the peripheral vision.

Perimetry

- Kinetic perimeter:

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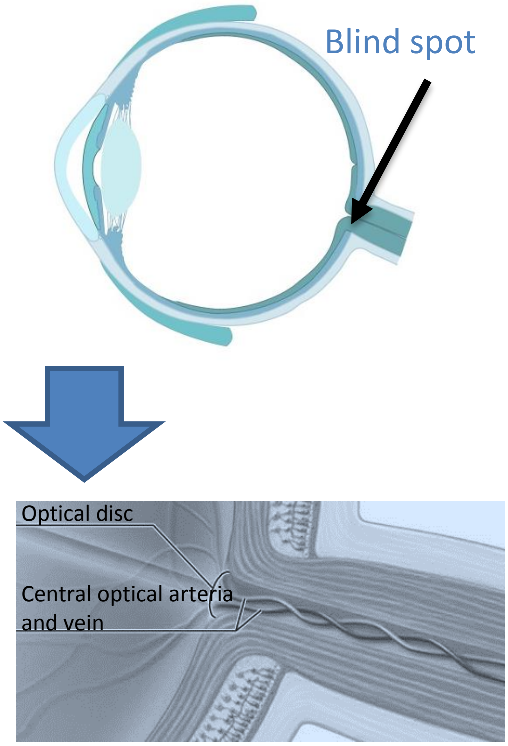
- The examination is performed on a rotating perimeter with moving targets. The task of the examinee is to report the changes in visibility of the target or color.
- The method is less accurate than static perimetry.

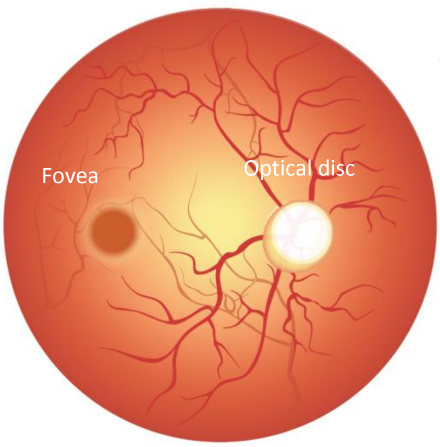
- Static perimeter:
  - The examinee focuses on a point located in the middle of a screen. Examinee presses button as soon as elsewhere light point is registered.
  - Static perimetry is more sensitive than kinetic.

Blind spot

This is a small area on the retina where the optic nerve protrudes. It is a space which does not contain sensitive cells, i.e. rods or cones.

- Ophthalmoscopic examination: An objective examination the ocular fundus, accurate measuring the size and changes on the background of the retina.
- Perimetry: Using perimetry physiological scotoma can be captured in the 18–20 °
- **Mariotte test:**
  - Evidence of blind spots – a basic subjective method for detecting blind spots using a Mariotte image (paper with a point on one side and a cross on the other). By fixing the eye on the point, saccadic movements are avoided, which allows the cross at some distance to be at such an angle that it enters into a blind spot.
  - The approximate shape and size of blind spots – based on the principle of proportional triangles and the principles of the Mariotte test – can be roughly displayed.





Examination the ocular fundus

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