

## **The Vitreous**

Occupying 80% of the volume of the eye, the vitreous is a clear matrix composed of collagen, hyaluronic acid, and water. It is bounded anteriorly by the posterior lens capsule and posteriorly by the internal limiting membrane of the retina. The vitreous body is composed of two main portions: the central, or core, vitreous and the cortical vitreous.

The central vitreous has collagen fibers that insert in the vitreous base, a region where the vitreous fibers adhere firmly to the retina and pars plana. These fibers arch posteriorly. In between the collagen fibers are hyaluronate molecules, which bind water molecules. These hyaluronate molecules, with their associated water molecules, act as fillers and separators between the adjacent collagen fibers. The collagen fibers in the second part of the vitreous body, the cortical vitreous, are much more densely packed and course in a direction roughly parallel to the inner surface of the retina. The vitreous is most firmly attached to the vitreous base, but it is also firmly attached to retinal vessels, the optic nerve, and the macula. The attachment of the vitreous to the macula is arranged in 3 circumferential zones centered on the foveola. Focal traction on the retina may produce retinal tears or holes. The vitreous may also place traction over a somewhat larger area.

Because of the larger area, the resultant tensile force on the retina may be below that required to cause tears. This force may distort the retina or cause tractional elevation of the retina. One example of this process is the vitreomacular traction syndrome, a condition where the patient develops blurring and distortion of the central vision because of tractional elevation of the macula by the vitreous.

The *vitreous* cavity occupies four fifths of the volume of the globe. The transparent vitreous humor is important to the metabolism of the intraocular tissues because it provides a route for metabolites used by the lens, ciliary body, and retina. Its volume is close to 4.0 mL. Although it has a gel-like structure, the vitreous is 99% water. Its viscosity is approximately twice that of water, mainly because of the presence of the mucopolysaccharide the hyaluronic acid.

## **Retina**

is the part of the eye that is visible on ophthalmoscopy, including the retina and its vessels and the *optic nerve head* (or *optic disc*). The *macula*, 5-6 mm in diameter, lies between the temporal vascular arcades. At the macula's center lies the *fovea*, rich in cones and responsible for color vision and the highest visual acuity. In the far periphery, the *ora serrata* (the junction between the retina and the pars plana) can be seen by gonioscopy or indirect ophthalmoscopy. The reddish color of the fundus is due to the transmission of light reflected from the posterior sclera through the capillary bed of the choroid.

The *retina* is a thin, transparent structure that develops from the inner and outer layers of the optic cup. In cross section, from outer to inner retina, its layers are:

- .RPE and its basal lamina
- .Rod and cone inner and outer segments
- .External limiting membrane
- .Outer nuclear layer (nuclei of the photoreceptors)
- .Outer plexiform layer
- .Inner nuclear layer
- .Inner plexiform layer
- .Ganglion cell layer
- .Nerve fiber layer (axons of the ganglion cells)
- .Internal limiting membrane.

## **Retinal Pigment Epithelium:**

consists of a monolayer of hexagonal cells that extends anteriorly from the optic disc to the ora serrata, where it merges with the pigmented epithelium of the ciliary body. Its function includes:

- .vitamin A metabolism.
- .maintenance of the outer blood-retina barrier.
- .phagocytosis of the photoreceptor outer segments.
- .absorption of light (reduction of scatter).

- .heat exchange.
- .formation of the basal lamina.
- .production of the mucopolysaccharide matrix surrounding the outer segments.
- .active transport of materials in and out of the RPE.

## Neurosensory Retina

The *neurosensory retina* is composed of neuronal, glial, and vascular elements .

## Stratification of the Neurosensory Retina

The neurosensory retina can be subdivided into several layers .

The *external limiting membrane (ELM)* is formed by the attachment sites of adjacent photoreceptors and Muller cells. It along with the other glial elements, the *fibrous and protoplasmic astrocytes and microglia*, is therefore not a true membrane. In the peripheral retina, the ELM fuses with the pigment epithelium at the ora serrata. It is highly fenestrated.

The *outer plexiform layer (OPL)* is made up of the interconnections between the photoreceptor synaptic bodies and the horizontal and bipolar cells. The OPL is thicker and contains more fibers in the macular region, because the axons of the rods and cones become longer and more oblique as they deviate from the fovea. The OPL in this region is known as the *Henle fiber layer* . At the edge of the foveola, it lies almost parallel with the internal limiting membrane.

The *inner nuclear layer ONL*) contains nuclei of bipolar, Muller, horizontal, and amacrine cells.

The next region is formed by a zone of desmosome-like attachments in the region of the synaptic bodies of the photoreceptor cells. The retinal blood vessels ordinarily do not extend beyond this point.

The *inner plexiform layer (IPL)* consists of axons of the bipolar and amacrine cells and dendrites of the ganglion cells and their synapses.

The ***ganglion cell layer (GCL)*** is made up of the cell bodies of the ganglion cells that lie near the inner surface of the retina.

The ***nerve fiber layer (NFL)*** is formed by axons of the ganglion cells. Normally, these axons do not become myelinated until after they pass through the lamina cribrosa of the optic nerve.

Like the ELM, the ***internal limiting membrane (ILM)*** is also not a true membrane. It is formed by the footplates of the Muller cells and attachments to the basal lamina.

## Physiology

The retina is the most complex of the ocular tissues. The eye performs as an optical instrument, a complex receptor, and an effective transducer. Rod and cone cells in the photoreceptor layer transform light stimuli into nerve impulses that are conducted through the visual pathways to the occipital visual cortex.

The photoreceptors are arranged such that there is an increased density of cones in the center of the macula (fovea), decreasing to the periphery, and a higher density of rods in the periphery. In the foveola, there is a nearly 1:1 relationship between each cone photoreceptor, its ganglion cell, and the emerging nerve fiber, whereas in the peripheral retina, many photoreceptors connect to the same ganglion cell. The fovea is responsible for good visual acuity and color vision, both requiring high ambient light (photopic vision) and being best at the foveola, while the remaining retina is utilized primarily for motion, contrast, and night (scotopic) vision.

The rod and cone photoreceptors are located in the avascular outermost layer of the sensory retina and are the site of the chemical reaction initiating the visual process. Each rod photoreceptor cell contains rhodopsin, a photosensitive visual pigment embedded in the double-membrane disks of the photoreceptor outer segment. It is made up of two components, an opsin protein combined with a chromophore. The opsin in rhodopsin is scotopsin, which is formed of seven transmembrane helices. It surrounds the chromophore, retinal, which is derived from vitamin A. When rhodopsin absorbs a photon of light, 11-cis retinal is isomerized to all-trans retinal

and eventually to all-trans retinol. The resulting configurational change initiates a secondary messenger cascade. Peak light absorption by rhodopsin occurs at approximately 500 nm, which is the blue-green region of the light spectrum. Spectral sensitivity studies of cone photopigments have shown peak wavelength absorption at 430, 540, and 575 nm for blue-, green-, and red-sensitive cones, respectively. The cone photopigments are composed of 11-cis retinal bound to other opsin proteins than scotopsin.

Scotopic vision is mediated entirely by rod photoreceptors. With this dark-adapted form of vision, varying shades of gray are seen, but colors cannot be distinguished. As the retina becomes fully light-adapted, the spectral sensitivity of the retina shifts from a rhodopsin-dominated peak of 500 nm to approximately 560 nm, and color sensation becomes evident. An object takes on color when it selectively reflects or transmits certain wavelengths of light within the visible spectrum (400–700 nm). Daylight (photopic) vision is mediated primarily by cone photoreceptors, twilight (mesopic) vision by a combination of cones and rods, and night (scotopic) vision by rod photoreceptors.

The photoreceptors are maintained by the retinal pigment epithelium, which plays an important role in the visual process. It is responsible for phagocytosis of the outer segments of the photoreceptors, transport of vitamins, and reduction of light scatter, as well as providing a selective barrier between the choroid and retina. The basement membrane of the retinal pigment epithelial cells forms the inner layer of Bruch's membrane, which is otherwise composed of a specialized extracellular matrix and the basement membrane of the choriocapillaris as its outer layer.

## **Retinal Detachment**

### **Definition**

Retinal detachment refers to the separation of the neurosensory retina from the underlying retinal pigment epithelium, to which normally it is loosely attached. This can be classified into four types:

1. Rhegmatogenous retinal detachment results from a tear, i.e., a break in the retina.
2. Tractional retinal detachment results from traction, i.e., from vitreous strands that exert tensile forces on the retina.
3. Exudative retinal detachment is caused by fluid. Blood, lipids, or serous fluid accumulates between the neurosensory retina and the retinal pigment epithelium. Coats' disease is a typical example.
4. Tumor-related retinal detachment.

**Epidemiology:** Although retinal detachments are relatively rarely encountered in ophthalmologic practice, they are clinically highly significant as they can lead to blindness if not treated immediately.

**Rhegmatogenous retinal detachment (most frequent form):** Approximately 7% of all adults have retinal breaks. The incidence of this finding increases with *advanced age*. The peak incidence is between the fifth and seventh decades of life. This indicates the significance of posterior vitreous detachment (separation of the vitreous body from inner surface of the retina; also age-related) as a cause of retinal detachment. The annual incidence of retinal detachment is one per 10 000 persons. There is a known familial disposition, and retinal detachment also occurs in conjunction with *myopia*. The prevalence of retinal detachment with emmetropia (normal vision) is 0.2 % compared with 7% in the presence of severe myopia exceeding minus 10 diopters.

Exudative, tractional, and tumor-related retinal detachments are encountered far less frequently.

**Etiology:** Rhegmatogenous retinal detachment. This disorder develops from an *existing break in the retina*. Usually this break is in the peripheral retina, rarely in the macula . Two types of breaks are distinguished:

1. *Round breaks:* A portion of the retina has been completely torn out due to a posterior vitreous detachment.
2. *Horseshoe tears:* The retina is only slightly torn.

Not every retinal break leads to retinal detachment. This will occur only where the liquefied vitreous body separates, and vitreous humor penetrates beneath the retina

through the tear. The retinal detachment occurs when the forces of adhesion can no longer withstand this process. Tractional forces(tensile forces) of the vitreous body (usually vitreous strands) can also cause retinal detachment with or without synchysis. In this and every other type of retinal detachment, there is a *dynamic interplay of tractional and adhesive forces*. Whether the retina will detach depends on which of these forces is stronger.

**Tractional retinal detachment.** This develops from the tensile forces exerted on the retina by preretinal fibrovascular strands especially in proliferative retinal diseases such as diabetic retinopathy.

**Exudative retinal detachment.** The primary cause of this type is the breakdown of the inner or outer blood – retina barrier, usually as a result of a vascular disorder such as Coats' disease. Subretinal fluid with or without hard exudates accumulates between the neurosensory retina and the retinal pigment epithelium.

**Tumor-related retinal detachment.** Either the transudate from the tumor vasculature or the mass of the tumor separates the retina from its underlying tissue.

**Symptoms:** Retinal detachment can remain asymptomatic for a long time. In the stage of acute posterior vitreous detachment, the patient will notice flashes of light (photopsia) and floaters, black points that move with the patient's gaze. A posterior vitreous detachment that causes a retinal tear may also cause avulsion of a retinal vessel. Blood from this vessel will then enter the vitreous body. The patient will perceive this as "black rain," numerous slowly falling small black dots. Another symptom is a dark shadow in the visual field. This occurs when the retina detaches. The patient will perceive a falling curtain or a rising wall, depending on whether the detachment is superior or inferior. A break in the center of the retina will result in a sudden and significant loss of visual acuity, which will include metamorphopsia (image distortion) if the macula is involved.

**Diagnostic considerations:** The lesion is diagnosed by stereoscopic examination of the fundus with the pupil dilated. The detached retina will be white and edematous and will lose its transparency. Ophthalmoscopy will reveal a bullous retinal detachment; in rhegmatogenous retinal detachment, a bright red retinal break will also be visible .

The tears in rhegmatogenous retinal detachment usually occur in the superior half of the retina in a region of equatorial degeneration. In tractional retinal detachment, the bullous detachment will be accompanied by preretinal gray strands. In exudative retinal detachment, one will observe the typical picture of serous detachment; the exudative retinal detachment will generally be accompanied by massive fatty deposits and often by intraretinal bleeding.

The tumor-related retinal detachment (as can occur with a malignant melanoma) either leads to secondary retinal detachment over the tumor or at some distance from the tumor in the inferior peripheral retina. Ultrasound studies can help confirm the diagnosis where retinal findings are equivocal or a tumor is suspected.

An inferior retinal detachment at some distance from the tumor is a sign that the tumor is malignant.

**Treatment:** Retinal breaks with minimal circular retinal detachment can be treated with argon laser coagulation . The retina surrounding the break is fused to the underlying tissue whereas the break itself is left open. The scars resulting from argon laser therapy are sufficient to prevent any further retinal detachment. More extensive retinal detachments are usually treated with a retinal tamponade with an elastic silicone sponge that is sutured to the outer surface of the sclera. It can be sutured either in a radial position (perpendicular to the limbus) or parallel to the limbus. This indents the wall of the globe at the retinal break and brings the portion of the retina in which the break is located back into contact with the retinal pigment epithelium. The indentation also reduces the traction of the vitreous body on the retina. A scar is created to stabilize the restored contact between the neurosensory retina and retinal pigment epithelium. This is achieved with a cry probe. After a successful operation, this scar prevents recurring retinal detachment. Where there are several retinal breaks or the break cannot be located, a silicone cerclage is applied to the globe as a circumferential buckling procedure. The procedures described up until now apply to *uncomplicated retinal detachments*, i.e., without proliferative vitreoretinopathy. Suturing a retinal tamponade with silicone sponge may also be attempted initially in a *complicated retinal detachment* with proliferative vitreoretinopathy. If this treatment is unsuccessful, the vitreoretinal

proliferations are excised, and a vitrectomy is performed in which the vitreous body is replaced with Ringer's solution, gas, or silicone oil. These fluids tamponade the eye from within.

**Prophylaxis:** High-risk patients above the age of 40 with a positive family history and severe myopia should be regularly examined by an ophthalmologist, preferably once a year.

**Clinical course and prognosis:** About 95% of rhegmatogenous retinal detachments can be treated successfully with surgery. Where there has been macular involvement (i.e., the initial detachment included the macula), a loss of visual acuity will remain. The prognosis for the other forms of retinal detachment is usually poor, and they are often associated with significant loss of visual acuity.