STUDY OF CORNEAL OPACITIES INTERFERING WITH VISION IN EGYPT

THESIS

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BY

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بسم الله الرحمن الرحيم

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To My

Father and My Mother

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Review

STRUCTURE AND FUNCTION OF THE CORNEA

Gross Anatomy:

The cornea is a unique portion of the outer fibrous ocular tunic that is transparent and serves a refractive function while maintaining a mechanically tough and chemically impermeable barrier between the eye and the environment. Although the cornea is circular when viewed from the posterior surface, it is oval when viewed from the anterior surface. The major diameters of the cornea are 12.6 mm horizontally and 11.7 mm vertically. The central one third of the cornea is called the optical zone and is approximately spherical. The radius of curvature of the anterior surface centrally averages 7.8 mm [Klyce and Beuerman, 1988], that of the posterior surface is 7.0 mm [Last, 1968].

Microscopic Anatomy:

The cornea can be divided into five layers: the epithelium, Bowman's layer, stroma, Descemet's membrane and the endothelium. Although the pre-ocular tear film is not part of the cornea, it is intimately associated with the cornea anatomically and functionally.

Tear film:

The surface of the cornea must be kept moist to prevent damage to the epithelium, and this moisture must be evenly spread across the anterior membranes of the epithelial cell to prevent local drying. For the cornea to function as an optical lens, smoothing of the epithelial surface is needed because reticulations 0.5 µm high and 0.3 µm wide on the epithelial surface are a potential source of image degradation **[Kawabara, 1978]**. This moisture and smoothing are provided by the pre-ocular tear film, in conjunction with the spreading function of the eye lids during blinking. The tear film is 7 µm thick. There are two definable layers: a thin anterior lipid layer and a thick aqueous layer into which a mucin rich glycocalyx extends **[Klyce and Beuerman, 1988]**.

The plasma membrane of the epithelial cell is a typical unit membrane consisting of a lipid bilayer. This lipid surface is hydrophobic, as a result the aqueous tear film, left to its own devices would bead up on the corneal surface. However, the mucin spreads directly over the epithelial surface and decreases surface tension so that the aqueous component of the tears can spread over and adsorb to the epithelial surface and maintain an intact tear film for 20 to 30 seconds between blinks. Abnormalities of the mucin layer or epithelial surface will cause the tear film to break up rapidly into dry spots after the resurfacing effect of a blink **[Waring, 1984]**.

1. The epithelium:

The epithelium of the cornea consists of four to six layers of cells and represents 10% of the corneal thickness. It is divided morphologically into three layers; the superficial squamous cell layer, the middle or wing cell layer and the deep or basal cell layer. The basal cells are the only epithelial cells that undergo mitosis. The formed daughter cells are pushed anteriorly and change their shape to form the wing cells and more anteriorly they become the superficial cells after which they disintegrate and are shed into the tear film in a process known as desquamation **[Klyce and Beuerman, 1988]**.

Squamous cells:

Spread over the surface of the epithelium is a layer of glycoprotein. This protein-sugar complex is formed of mucin from the tear film that decreases surface tension and glycolipids and glycoproteins in the plasma membrane. These glycoproteins may play a role in the adhesive properties of the cell during wound healing and desquamation **[Waring, 1984]**. The thickened outer leaflet and the fine filaments that emerge into the tear film may also play a role in the mechanism of adherence of the tear film to the superficial cells **[Klyce and Beuerman, 1988]**. An important property of the superficial cell layer is the junctional complex formed with laterally adjacent cells. This complex consists of ribbon like tight junctions that surround the entire cell **[McLaughlin et al., 1985]**. This joining of adjacent superficial cells prevents the movement of substances from the tear film into the inter-cellular spaces of the epithelium **[Klyce and Beuerman, 1988]**.

Wing cells:

The wing cells consist of polyhedral cells whose rounded heads are directed anteriorly and whose concave bases fit over the heads of the basal cells and send processes between them. Each contains an oval nucleus whose long axis is parallel with the surface of the cornea **[Last, 1968]**.

The cells adhere with large numbers of desmosomal attachments. The inter-digitations and desmosomes produce tenacious adhesions that allow the epithelium to form bullae in corneal oedema. Fluid can accumulate in the epithelium both intracellularly and extracellularly. Intracellular fluid expands the cell into a small round vesicle, and extracellular fluid accumulates between the cells, which remain attached by the desmosomes. These little pockets of fluid produce a microcystic texture that acts as a diffraction grating to set up interference fringes that create the halos described by patients with epithelial oedema **[Waring, 1984]**.

Basal cells:

They rest on a basement membrane. They are columnar with rounded heads and flat bases, which present processes that spread out on the basement membrane **[Last, 1968]**. They represent the germinative layer of the epithelium and possess many cytoplasmic organelles than the anterior layers. The mitochondria are found in moderate numbers around the nuclei and in the posterior portion of the cells. Also, the Golgi complex is associated with the endoplasmic reticulum. The cytoplasm of the basal cell has large numbers of glycogen granules which represent a source of stored metabolic energy to be used in times of epithelial stress as wound healing. Also, actin filaments are found and may be important for cell migration in the healing of abrasions **[Klyce and Beuerman, 1988]**.

Epithelial basement membrane:

It is secreted by the basal epithelial cells. It has an amorphous appearance and forms the orderly scaffold on which the epithelium rests **[Waring, 1984]**, and it is a boundary that separates the epithelium from the stroma. The electron microscopic structure of the basal lamina consists of an anterior clear zone, the lamina lucida, and a posterior dense zone, the lamina densa. Clinically, various disease entities related to chronic epithelial defects are probably disorders of the basal lamina. The corneal epithelium may be present as a sheet, but does not adhere to the underlying stroma without basal lamina as an intermediary [**Klyce and Beuerman, 1988**].

During healing, the surface of the basement membrane contains glycoproteins, such as fibronectin and laminin, that play a role in the migration and adhesion of the epithelial cells [**Waring, 1984**].

2. Bowman's layer:

It is a thin homogenous sheet about 12 μ in thickness between the basement membrane and the substantia propria. Its anterior surface is absolutely parallel with the surface of the cornea [**Last, 1968**]. It is formed of randomly arrayed collagen fibrils that merge into the more organized anterior stroma. Bowman's layer is attached to the stroma by collagen fibrils inserted into Bowman's layer which then becomes part of the anterior stromal lamellae [**Klyce and Beuerman, 1988**]. This layer is probably produced by the basal epithelial cells, but it can not regenerate, so in diseases like keratoconus or corneal trauma breaks in Bowman's layer fill with cellular scar tissue that creates permanent opacities **[Waring, 1984]**.

3. Stroma:

It forms 90% of the thickness of the cornea. It is avascular, consisting of two elements, lamellae and cells. The lamellas are broad bands of interlacing collagenous fibrils extending over the entire width of the cornea, arranged parallel to its surface **[Hogan and Zimmerman, 1962]**. In the anterior stroma, the lamellae are not so discrete, since bundles of fibrils inter-digitate from one lamella to another. In the posterior stroma, the lamellae are more discrete. This can be observed biomicroscopically as the anterior third of the stroma will appear to have a slightly grayer appearance than the posterior two thirds **[Waring, 1984]**.

Collagen constitutes about 71% of the dry weight of the cornea and it is the structural macro-molecule providing tissue transparency and mechanical resistance to intra-ocular pressure. The collagen fibrils which are packed in parallel arrays comprise the 300 to 500 lamellae of the stroma. On electron microscopy, the fibrils appear to have uniform diameter that ranges from 22 to 32 nm. Also, they are surrounded by a polyanionic extracellular matrix which may be important in maintaining the constant separation distance of about 60 nm between the centers of the fibrils **[Klyce and Beuerman, 1988]**. This matrix is referred to as acid mucopolysaccharides or proteoglycans. Two types of glycosaminoglycans are present in normal cornea, keratin sulfate and chondroitin sulfate B. They play an important role in stromal hydration so that if more water enters the stroma as in endothelial dystrophy, the glycosaminoglycan molecules take up the water and swell. This swelling increases corneal thickness and displaces the collagen fibrils, disrupting their regular alignment and light transmission through the stroma, so that light is scattered and the stroma appears opaque **[Waring, 1984]**.

Keratocytes occupy 3-5% of the stromal volume. Their function is to maintain the collagen fibrils and extracellular matrix by a constant synthetic activity. Slender processes, which may taper to only one to several micra in cross section leave the nuclear region at all angles. Although these processes may penetrate into the collagen lamellae, they do not normally extend through them. However, the tips of the processes sometimes touch those of a neighbouring keratocyte and form a tight junction **[Klyce and Beuerman, 1988]**.