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# **RADIAL KERATOTOMY**

**ESSAY**

**PRESENTED IN PARTIAL FULFILLMENT**

**FOR THE**

**MASTER DEGREE OPHTHALMOLOGY**

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# ACKNOWLEDGMENT

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# INTRODUCTION

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Refractive surgery , which has to include not only contact lenses , but keratoprothetics and intraocular lenses . Actually the idea began in the 1700's with the suggestion by Tadini of replacing a cataractous lens with a crystalline lens . Mulier did scleral resection to shorten myopic eye ball on 1903

Refractive corneal surgery refers to operations on the cornea , which are intended to alter the refractive state of the eye . Radial keratotomy is a surgical procedure which flattens the central cornea by making deep partial thickness radial incisions in the peripheral cornea .

This operation , designed to eliminate or reduce myopia and astigmatism , has had a mixed reception in the ophthalmic community . A major reason for this controversy is the inability of current surgical techniques to produce accurate incisions of controlled depth

It was originally developed by Sato of Japan (1939) , then improved by Fyodorov of the USSR ( 1974 ) , and was introduced to USA by Boies ( 1978 ) .

By the end of 1979 Schachar et al . , ( 1980 ) constructed a physical model of radial keratotomy to obtain the greatest refractive effect with the least amount of surgery and to predict the outcome of the operation .

After a lot of work and experience Schachar and his associates presented a valuable summary about the number of incisions , the optical zone size , the length and depth of the incisions , and how to obtain the best results with modification of the previous data .

Excimer laser radial keratotomy presented itself since 1983 in an experimental stages , and the use of the excimer laser for cutting or removing tissue from the cornea present a significant hope ( Srinivasan et al . , 1983 ) .

# ANATOMY

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# CORNEAL ANATOMY

## TOPOGRAPHIC RELATIONS :

The cornea is a clear transparent tissue with a smooth and brilliant surface. It is curved in meniscus form, and fits with a bevelled margin into the anterior scleral foramen.

The cornea forms the anterior one sixth of the circumference of the eye. At its rim there is a transitional zone of varying width [1 to 1.5 mm] known as the limbus, where the corneal stroma is bonded to the sclera, its surface epithelium merges with conjunctival epithelium, and its endothelium joins the trabecular endothelium. The stromal lamellae of the transparent cornea and opaque sclera meet more posteriorly in midstroma than they do at the superficial and deep borders of the stroma. Clinically, the junction is difficult to discern because it is obscured by the overlying episcleral tissue and conjunctiva. It is broader superiorly and inferiorly than it is in the horizontal meridians. This causes the clear cornea to appear as a horizontally oriented eclipse (Spencer, 1966).

The adult cornea has an average diameter of approximately 10.5 mm vertically and 11.5 mm horizontally. The anterior and posterior surfaces are parallel to each other in the central 4 mm, spherically shaped "optical zone" where the cornea averages 0.52mm in thickness (Maurice, 1957). There is a slight flattening of the corneal curvature peripherally. In this area, the anterior and posterior corneal surfaces are no longer parallel, and the corneal thickness increases to an average of 0.65

**THE LAYERS :** The cornea is divisible into 5 distinct layers .

**EPITHELIUM :**

It is a layer of uniform thickness (50-100  $\mu$ ) and of great regularity , structurally continuous with the conjunctiva and easily detached from Bowman's membrane . It is of the stratified , pavement type , and consists of four layers of cells in the new born , multiplying to 5 or 6 layers at the age of 4 months ( Druault and Druault , 1946 ) The whole structure resting on a tenuous basal membrane ; the cells may be divided into 3 groups ( Virchow , 1910 )

a) **BASAL CELLS** , situated most deeply , arranged in a single layer , palisade like , on their basal membrane ; they stand on flat "bases" , have rounded " heads" , and approximate 18  $\mu$  in height by 10  $\mu$  in breadth ( Salzmänn , 1912 ) Some are larger than others and , assuming a club-shaped , appear to push into the next layer of cells . The nucleus is large and oval ( 5 X 7  $\mu$  ) , lying perpendicularly to the surface near the head - end of the cell

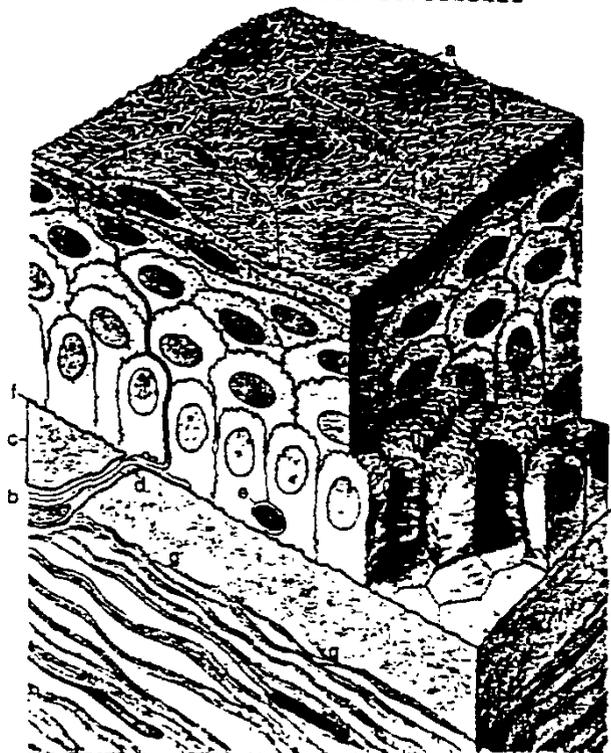
b) **WING CELLS** , of polyhedral shape , arranged in 3 layers . Their anterior surface is convex , the posterior concave fitting into the heads of the basal cells , and the edges taper off , slotting in between those of their neighbours in the shape of wings . Their oval nuclei lie parallel to the surface . The dimensions of these cells are practically equal in all directions , but those of the uppermost layer assume a flatter shape .

c) **SURFACE CELLS** , arranged in 2 layers superficially . They are flattened cells with a surface expanse extending to 46  $\mu$  ( Salzmänn , 1912 ) , while their greatest thickness is only 4  $\mu$  . Their nuclei are much flattened ( 2.5 X 12  $\mu$  , Salzmänn , 1912 ) , but project inwards leaving the surface perfectly smooth , a circumstance which accounts for its optical brilliance .

They never become keratinized as do the corresponding cells of the epidermis. According to Binder (1951), two types of cells are differentiated in the basal layer - relatively short, clear "matrix cells" which remain permanently in this layer, and others, taller, darker and club-shaped, which migrate toward the surface to renew those elements lost by normal exfoliation. The basal cells send fine denticulations into the underlying basement membrane which may reach Bowman's membrane (Virchow, 1910; Redslob, 1939 and Calmettes et al, 1956). Between the epithelial cells and particularly between the basal cells, polymorphous cellular elements are sometimes found with multiple processes running between the epithelial cells and penetrating Bowman's membrane to connect with similar structures in the stroma. These were originally interpreted as "wandering cells" (leucocytes) (Ranvier, 1881), but impregnation with silver shows that they are epithelial in nature corresponding to the cells of Langerhans (1868) in the skin (Fig 1)

Fig 1 *The corneal epithelium*

- a. Microvilli.
- b. Corneal nerve.
- c. Bowman's layer.
- d. Basement membrane.
- e. Lymphocyte.
- f. Basement membrane.
- g. Stroma.



### **BASEMENT MEMBRANE :**

As occurs in most epithelial layers the corneal epithelium rests upon a delicate basement membrane distinct from the membranes surrounding the basal cells. It is sometimes very tenuous appearing with the optical microscope merely as a contour but occasionally reaches a thickness of  $1/3$  that of Bowman's membrane, in either event it runs continuously, separating the basal cells of the epithelium from Bowman's membrane, extending beyond the limits of this structure through the limbus where it becomes thicker and is prolonged onwards into the bulbar conjunctiva ( Sebruyns, 1950 ). Like the corneal epithelium and unlike Bowman's membrane, the basal membrane is reproduced when it is destroyed since, like other basal membranes, it is presumably elaborated by the epithelial cells ( Redslob, 1949 )

### **BOWMAN'S LAYER :**

It is a uniformly thick ( 8 to 14 millimicrons ) , acellular structure that underlies the basement membrane of the epithelium, from which it is sharply defined. The posterior surface of the layer does not have a clear contour but merges with the superficial lamellae of the stroma, to which it is firmly attached. Bowman's layer is believed to represent a modified layer of the anterior stroma and is composed of randomly oriented, loosely packed, small collagen fibrils surrounded by mucoprotein ground substance. Numerous perforations or pores in the inner portion provide for the passage of the terminal branches of the corneal nerves. The peripheral margins of Bowman's layer demarcate the anterior boundary of the limbus ( Spencer, 1966 ), and it ends abruptly in a rounded border. The anterior limiting lamina ( Bowman's membrane ) is not truly elastic, nor does it regenerate when once it has been destroyed. It, however, shows a good deal of resistance to injury or infection.

## STROMA :

The substantia propria , or stroma , forms 90 per cent of the thickness of the cornea . It is avascular and consists of collagenous lamellae interspersed with cells (Keratocytes) and ground substance . The lamellae are broad bands of interlacing collagenous fibrils extending over the entire width of the cornea and are arranged almost parallel to each other and to its surface ( figures 2 and 3 ). The keratocytes are located mostly between the lamellae , but they occasionally extend into them .

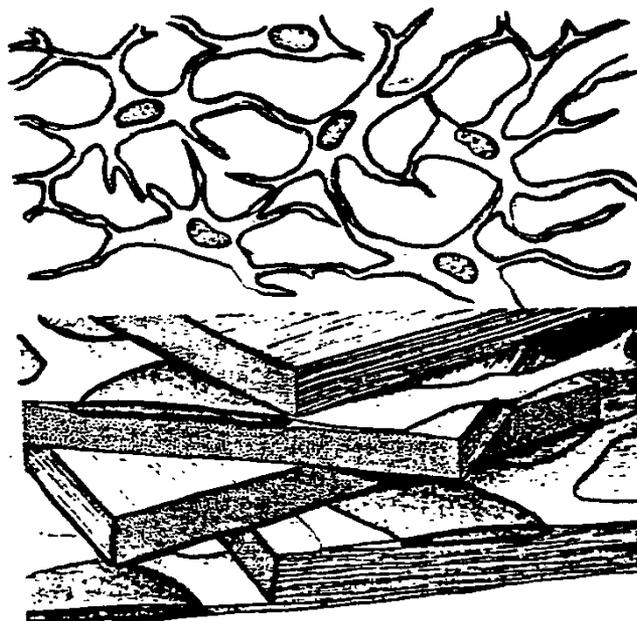
They show the electron microscopic characteristics of fibroblasts that have been flattened and somewhat compressed . They have thin nuclei , illdefined borders , and delicate cell membranes . They are present at all levels of the cornea . Wandering leucocytes , which are distorted into long spindle shapes , are also seen in the lamellar spaces . It is not known whether these are constituents of normal cornea

Fig 2

Corneal

Stromal

Keratocytes

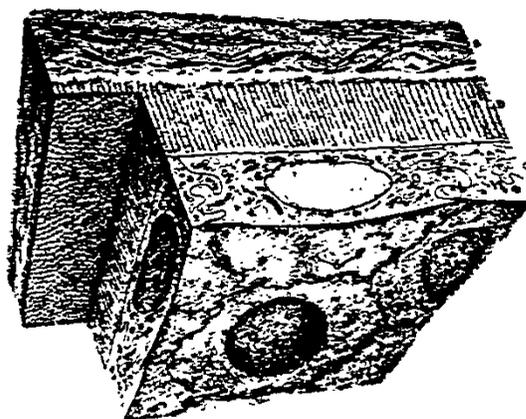


### DESCEMET'S MEMBRANE :

Descemet's membrane lies on the posterior aspect of the stroma . It is a true basement membrane , being formed by corneal endothelial cells . At its periphery , Descemet's membrane terminates at the junction between corneal and trabecular endothelium . Descemet's membrane is thicker in adults than in children . Hogan et al , (1971) found the thickness to be 3 to 4 microns at birth and 10 to 12 microns at age 50 years . Normally this increase in thickness is uniform , however , in pathologic states focal thickening may occur . Ultrastructural examination of Descemet's membrane has shown it to be composed of collagen - like filaments that tend to stratify into laminations , interspersed with interfilamentary ground substance ( Jakus , 1956 ) . Johnson and coworkers ( 1982 ) found the thickness of this banded layer to average approximately 3 microns at birth and to remain more or less unchanged in thickness throughout life . All postnatal laminations were found to have a nonbanded , finely granular appearance . In adults , Johnson and co-workers ( 1982 ) found an indistinct border between the anterior banded and the posterior nonbanded layers . The latter was found to continue to increase in thickness throughout life . It is not known why the endothelial cells secrete a banded type of basement membrane during gestation and a nonbanded type thereafter .

Fig 3

THE POSTERIOR  
PORTION OF  
THE CORNEA .



a. Stroma

b. Descemet's membrane

c. Endothelium

### **ENDOTHELIUM :**

The endothelium is a single layer of polygonal (5 to 6 sided ) cells extending over the inner surface of Descemet's membrane ( fig 3 ) . In cross sections , the cells appear rectangular , with a pale staining granular cytoplasm and a centrally located nucleus .

This layer , considered until recently to be of mesothelial origin , is now thought to be derived from the neural crest ( Johnston et al , 1973 , and Johnston et al , 1979 ) . As a single-layered structure , it bears a resemblance to true endothelium . Unlike the corneal epithelium , the endothelium rarely undergoes mitotic division in a normal eye .

### **NERVE SUPPLY :**

The cornea is richly supplied with unmyelinated nerves derived from the ciliary nerves , which are end branches of the ophthalmic division of the fifth cranial nerve . Branches from the long ciliary nerves enter the peripheral stroma in its middle third and extend radially toward the center of the cornea , dividing dichotomously .

The nerve fibers , up to 80 in number , are visible biomicroscopically as whitish threads crossing the limbus . The superficial branches emerge from the deeper stroma , pass through interstices in Bowman's layer , and terminate between the cells of the basal layer and the more superficial layers .

All the epithelial layers have been found to be surrounded by nerves , with the exception of the two surface layers .

The nerves are unmyelinated and wrapped by Schwann's cells in the stroma but not in the corneal epithelium .