LAMELLAR KERATOPLASTY

Essay

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Ophthalmology

By

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INTRODUCTION

Corneal transplantation is the most common transplant surgery. Traditionally, corneal transplants have been performed as a penetrating keratoplasty (PK), replacing all layers of the cornea regardless of the level of corneal pathology. Although successful for the most part, complications with penetrating keratoplasty include endothelial graft rejection, astigmatism, inadequate wound healing, and suture-related problems[1].

Lamellar keratoplasty (LK) is an operation in which diseased corneal tissue is removed and replaced by donor corneal material, the procedure is performed to provide structural support for the cornea or to improve vision. It is defined as removal and replacement of less than the total thickness of the cornea[2].

Lamellar keratoplasty surgery avoids the usual complications often associated with penetrating keratoplasty[3], especially wound dehiscence, high astigmatism, vascularization along the suture track, immune rejection, and infectious suture abscesses[4].

The history of lamellar keratoplasty surgery spans over 100yrs, and the advantages of lamellar surgery

have long been known. The surgery is usually used for tectonic purposes; however, new techniques and technology over the past 25yrs have expanded the applications of LK in optical rehabilitation. Materials and instrumentations such as viscoelastics, diamond knives, ultrasonic pachymetry, artificial anterior chambers, advanced microkeratomes, excimer laser, and more recent by femtosecond enabled keratoplasty (FSEK) have enhanced our ability to work more safely in the tedious microsurgical environment of the lamellar procedure[5].

There are different indications of lamellar keratoplasty either therapeutic to remove a certain corneal pathology or refractive to correct an error of refraction or tectonic in cases of corneal thinning disorders to restore corneal thickness and to maintain the integrity of the globe[6].

There are different types of lamellar keratoplasty which include:

I. Anterior Lamellar Keratoplasty

A surgical procedure in which the anterior layer of the cornea (epithelium and its basement membrane and superficial stroma) to a variable depth are replaced by donor tissue[7].

Indications: as post-infectious superficial scar, anterior hereditary corneal dystrophy[8].

Deep anterior lamellar keratoplasty (DALK) is a surgical procedure for removing the corneal stroma down to Descemet's membrane. Common indications for DALK include keratoconus and corneal deep scars[8].

II. Posterior Lamellar Keratoplasty (DLEK)

It is the type of lamellar keratoplasty in which the posterior portion of the cornea including the endothelium is replaced by the donor tissue bearing the advantage of having no sutures, thus reducing postoperative astigmatism[7].

Techniques of Deep lamellar endothelial keratoplasty either:

1. Air bubble technique is described by injecting air into the cornea by which a spontaneous cleavage at the level of descement membrane can be achieved[9].

2. Descement stripping endothelial keratoplasty is usually performed using a blunt reverse Sinskey hook to first gently break through Descemet's membrane, and then to score Descemet's (i.e., drag the Sinskey to create a descemetorhexis)

with the hook, following a previously marked template placed on the surface of the cornea. Once done, the tip of the hook is then used to peel Descemet's membrane from the posterior stromal surface like wallpaper off a wall. Both of these steps should be done with gentle pressure to avoid engaging the stroma[10].

Indication: as Fuchs endothelial dystrophy, Aphakic or pseudophakic bullous keratopathy, other endothelial disorders[10].

Advances in surgical techniques such as deep lamellar anterior keratoplasty and deep lamellar endothelial keratoplasty have expanded and the application of lamellar surgery achieved visual results approaching those of penetrating keratoplasty while reducing the rate of rejection and improving the long-term graft stability. As research continues, LK promises to be increasingly important option in the corneal surgery[5].

AIM OF THE WORK

To study the different types, techniques, indications, contraindications, complications, and recent advances in lamellar keratoplasty.

Chapter 1

ANATOMY OF THE CORNEA

The cornea is a transparent avascular tissue highly specialized to refract and transmit light with a smooth outer convex surface and an inner concave surface[11].

The cornea forms part of what is almost a sphere, but is usually more curved in the vertical than the horizontal meridian-giving rise to physiological astigmatism with rule. The cornea forms the principle refractive surface of the eye and accounts for about 70% [40-45 diopters (D)] of the total refractive power of the eye. This is caused by the regular anterior curvature of the cornea and optically smooth nature of the overlying tear film. Most of the refraction of the eye occurs at the front surface of the cornea at the tear-air interface due to different in the refractive index[11].

The regularity of its collagen fibrils, closeness and homogeneity of their packing achieve the transparency of the corneal stroma. Water is constantly pumped out of the cornea by the endothelium which maintains the optical homogenecity of corneal layers and prevents their swelling and clouding[11].

Dimensions:

The axial thickness of the cornea is 0.52 millimeters (mm) centrally and 0.67 (mm) peripherally. The refractive index of the cornea is 1.4 compared to that of the air, which is 1.0. The front of the cornea appears elliptical, 11.7mm wide in the horizontal meridian and 10.6mm in the vertical meridian. On the other hand, the posterior surface is circular, 11.7mm in diameter. This difference is due to greater overlap of sclera and conjunctive above and below than laterally. The radius of curvature of the anterior surface is 7.8mm and of the posterior surface are 6.5mm in the central third[11].

Structures:

The cornea consists of 5 layers, which are the epithelium. The stroma which consists of Bowman's membrane (BM), lamellar stroma and descemet's membrane (DM) then the endothelium[12] (Fig. 1).

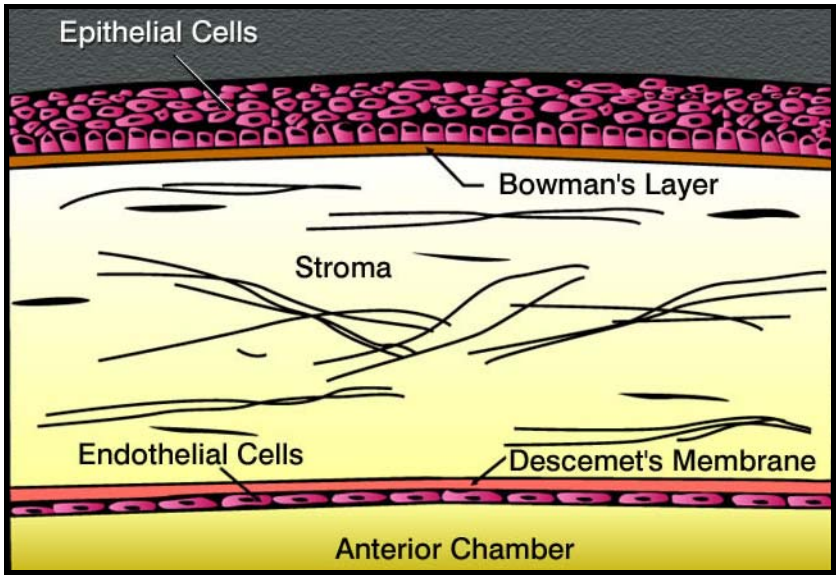

Fig. (1): Cornea cross-section, corneal layers, epithelium, bowman's, stroma, descemet's, endothelium[13].

A) Epithelium:

It is formed of stratified non-keratinized squamous epithelium. It is 5-7 cell layers, which is 50-52u thick. It is regular in thickness over the entire cornea and has an absolutely smooth, wet surface which acts as the major refractive surface of the eye. The cell layers of the epithelium include three to four outer flattened squamous cell "the superficial cell", 1-3 layers of mid epithelial cell "the wing cells" and a single layer of columnar cell "the basal cells"[12] (Fig. 2).

The superficial cells are flat with horizontal nuclei and are attached to one another by desmosomes. Electron microscopy of the outer surface of superficial

cells shows microvilli and microplicae that extend the superficial tear film. Some of the cells appear to be lighter and have many microvilli, while other darker cells have fewer microvilli and centrally located. The microvilli and microplicae of these surface cells assist in retaining the tear film thus keeping the cells moist.

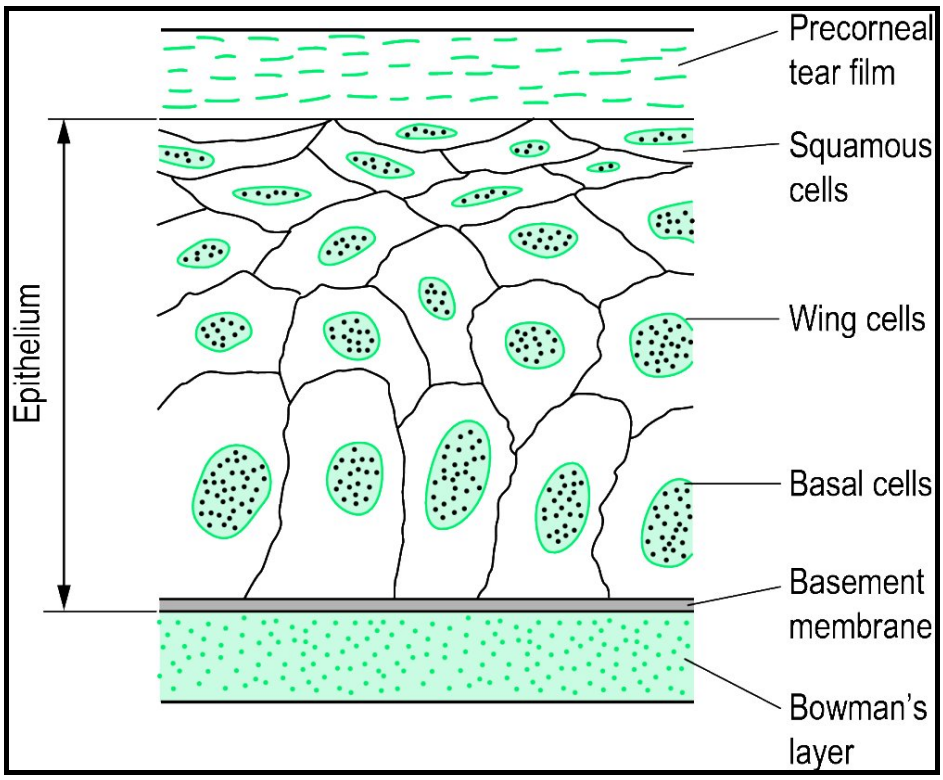

Fig. (2): Diagram showing the various layers of the corneal epithelium[14].

The wing cells are called so as they have lateral, thin, wing like extensions from a rounded cell body. They are polyhedral in shape with a convex anterior surface and a concave posterior surface.

Their nuclei are oval or rounded in shape. They are attached by desmosomes.

The deepest basal cells are tall, columnar cells attached by desmosomes.

Hemidesmosomes attach the basal plasma membrane to the basement membrane, which project into the Bowman's zone creating strong adhesions to this zone.

The major components of the cytoplasm of basal, wing and superficial cells are intermediate filaments composed of proteins known as keratin[12].

Actine filaments and microtubules are also present. There is sparse accumulation of cytoplasmic reticulum, and mitochondria to keep the epithelium transparent.The epithelium exists over an avascular connective tissue.

It acts as a barrier to fluid loss, pathogens entrance and resistance to abrasions that's why the cells of epithelium are tightly adherent to one another and to their underlying extracellular matrix.

The corneal epithelium like all stratified squamous epithelium is self-renewing and in the

cornea complete turnover occurs in 5-7 days. The basal cells are the mitotically active cells; they adhere to their basement membrane and to their underlying stroma through an adhesion complex[12].

B) Stroma:

The human corneal stroma is the middle connective tissue layer that is approximately 500 um thick and forms about 90% of the cornea. It is arranged in three clearly defined layers of extra cellular matrix which includes "Bowman's layer" next to the epithelium, a middle lamellar stroma which is the major portion and Descmet's membrane,the thickened membrane secreted by corneal endothelium[13] (Fig. 3).

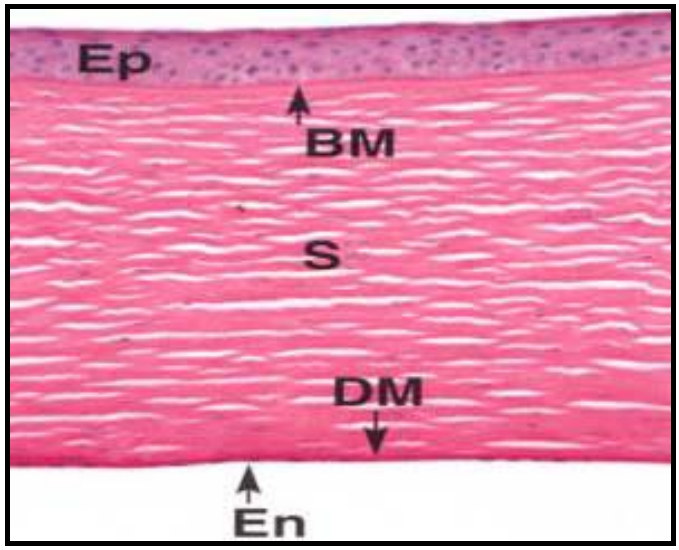

Fig. (3): Diagram showing the layers of the corneal stroma[13]; Ep, Epithelium; BM; Bowman's layer; S, Stroma; DM, Descemel's layer; En, Endothelial.

1. Bowman's membrane:

It is 8-10um thick and consists of collagen with associated proteoglycans and soluble glycoproteins. Its function is not clear; it may act as a smooth, rigid base for maintaining epithelial uniformity thus appropriate refractive power. Its presence is also necessary to prevent close contact between the epithelium and the stromal cells.

In minor abrasions this layer is left intact. If however trauma or infection structurally damages this layer,there may be poor adhesion to this membrane resulting in recurrent corneal erosion[13].

2. Lamellar stroma:

It is the major layer composed of collagen fibrils, a ground substance and keratocytes. It's 500 um thick. The collagen fibril lamellae are oriented in a parallel manner and are at right angle to one another. The lamellae act as a diffraction grating in which the light rays are separated from each other by less than one wavelength of light and interfere with scattered light by eliminating it by destructive interference. The lamellar stroma is highly organized and the most transparent of all connective tissue in the body. It acts as a window for light passage and also it meshes with the surrounding

scleral connective tissue to form a rigid framework to maintain intraocular pressure (IOP).

Individual fibrils have a diameter larger than of Bowman's membrane, it's secreted and maintained by stromal fibroblasts; the keratocytes. The collagen bundles are 200-300 centrally and 500 in the periphery. The bundles are separated from each other by mucopolysaccharides, the ground substance that is hydrophilic. The adsorption fluid keeps the bundles of collagen separated by a set distance which if changed by accumulation of fluid, the transparency is reduced.

The keratocytes are mesodermal in origin lying between the lamellae. They are very flat with many long attenuated processes extending from a central cell body in all direction. The tips of their processes touch the processes of the adjacent cells forming gap junctions. The cytoplasm of these cells is rich in rough endoplasmic reticulum and golgi apparatus keeping its function as synthesizer and maintenance of stromal lamellae[15].

3. Descemet's membrane:

It is the basement membrane of the endothelium by which it is synthesized. It appears first at the second month of gestation and continues throughout life, it is 2um at birth but it reaches up to 12um thick

by late adulthood and in between it reaches to 5um during childhood.

Although it appears homogenous under light microscopy, it has a laminated structure demonstrated by polarization, dark field and electron microscope. This reflects a structural difference between its foetal and postnatal components.

It is formed mainly by the protein type 1 collagen and it is a strong resistant sheet closely applied to the back of the corneal stroma. It is sharply defined from the stroma unlike Bowman's membrane. The plane of separation is used at lamellar keratoplasty. It thickens with age and degenerative conditions of the cornea. The peripheral rim of Descemet's membrane is the internal landmark of the limbus and marks the anterior limit of the drainage angle (Schwalbe's line)[15].

After traumatic interruption of DM and endothelium as in penetrating injures, stretching of the cornea in buphthalmos or rupture of hydrops in keratoconus; the endothelial layer will resurface the defect. This can be achieved by spread of its cells and synthesis of fresh basal lamina identical to normal DM, in contrast to Bowman's membrane where it is replaced by a scar[15].