Introduction

Post Lasik keratectasia is a progressive corneal steepening, usually inferiorly, with an increase in myopia and astigmatism, loss of uncorrected visual acuity, and often loss of best-corrected visual acuity that can present days to years after LASIK (**Randleman et al.,2008)** .The actual incidence remains undetermined, and no good data supports firm predictions; previous estimates, however, have ranged from 0.04% to 0.2% to 0.6%. It is caused by biomechanical weakening or destabilization of the cornea due to excessive removal of tissue and disruption to the structure of the cornea **(Palikaris et al.,2001).**

In LASIK, a flap of tissue is created which, studies have shown, never again bonds to the tissue under the flap (called the residual stroma) strongly enough to contribute to its corneal stability. This means that the residual stroma alone will determine the strength and stability of the cornea **(Bryan et al., 2006).**

Currently identified risk factors include low residual stromal bed thickness from excessive ablation or thick flap creation, keratoconus, high myopia and defined topographic abnormalities such as forme fruste keratoconus . Ectasia rarely occurs in patients without currently identifiable risk factors **(Randleman et al, 2003).**

TREATMENT OPTIONS :

The refractive error caused by the ectatic cornea is initially managed with either spectacles or contact lenses. Rigid Gas Permeable (RGP) contact lenses are often the treatment of choice for moderate ectasia, but when it progresses to the point where contact lenses no longer provide useful vision, then surgical intervention may be considered **(Bryan et al., 2006).**

Penetrating keratoplasty is the most commonly performed surgical procedure for ectatic corneas, but is associated with complications including graft rejection, induced astigmatism, complications of intraocular surgery as well as the need for life-long follow-up **(Kwitko S. et al,2004).** Intralase Enabled Keratoplasty which is a new procedure modification for full PKP is the use of the femtosecond laser to prepare the recipient and harvest donor tissue. Intralase enabled keratoplasty (IEK), approved by the FDA in July 2005, uses shaped penetrating cuts to produce a better-fitting, tighter-adhering donor button (**Ronald et al.,2012).**

Deep anterior lamellar keratoplasty is a technique based on adding tissue to strengthen the cornea. Here, a host bed consisting of Descemet's membrane and endothelium is created into which a full-thickness corneal stroma and epithelial button is placed. The recovery time is faster and visual recovery is quicker than a penetrating keratoplasty. There is no risk of endothelial rejection **(Agrwal, 2006).**

Intacs, which were initially used to correct low myopia, have been shown to improve vision in post-LASIK ectasia. They are thin plastic, semi-circular rings inserted into the mid layer of the cornea. When inserted in the ectatic cornea they flatten the cornea, changing the shape and location of the cone. Without removing corneal tissue or invading the central optical zone **(Colin J. 2006).** They improve visual function and in some instances prevent the need for corneal transplantation also can be removed without permanent sequelae.

Another new and exciting development which will make this procedure safer and more commonly acceptable is the use of the femtosecond laser to create the channels to insert the

Intacs, This technology allows for accurate depth of inserting, improved outcomes and less complications due to superficial placement **(Rabinowitz. 2007).**

Ferrara intrastromal corneal rings Ferrara's ring segments differ from Intacs in 2 aspects: They have a 1.5 mm radius of curvature instead of the 3.5 mm radius of Intacs, and they have a triangular anterior shape instead of the flat anterior surface of Intacs. The triangular anterior shape and flat posterior shape of Ferrara ring segments might have a stronger effect on central corneal flattening in ecstatic corneas. Besides adding tissue to the corneal midperiphery, the tips of FICRS lift anteriorly after implantation, adding an extra flattening effect in the meridian opposite implantation. **(Kwitko and Severo, 2004).**

Collagen crosslinking by the photosensitizer riboflavin and ultraviolet A-light is an effective means for stabilizing the cornea in keratoconus. The treatment consists of applying riboflavin (vitamin B2) eye drops to the corneas and then exposing them to ultraviolet light to activate the riboflavin, allowing it to bind to the collagen in the cornea. The main aim of this treatment is to arrest progression of keratectasia, and thereby prevent further deterioration in vision and the need for corneal transplantation Biomechanical measurements have shown an impressive increase in corneal rigidity of 28.9% in human corneas after cross linking. **(Wollensak G., 2006)**. The addition of C3-R to the Intacs procedure resulted in greater improvements than Intacs insertion alone**. (Chan and Jurkunas, 2007).** ICRS implantation in the corneal periphery flattens the central corneal apex, while crosslinking induces additional covalent bonds between collagen molecules to increase corneal strength **(Kay et al.,2013).**

Other combined methods for treatment of post lasik corneal ectasia have developed. Topography-Guided Partial Transepithelial PRK when immediately followed by CXL appeared to offer tomographic stability and symptomatically even after long-term follow-up **(Kanellopoulos and Binder,2011)**

Combined insertion of Intacs and Verisyse which proved to be safe and effective. The outcomes of the simultaneous implantation of the Intacs and Verisyse lens in one surgery were similar to the results achieved with sequential implantation using two surgeries **(Moshirfar et al.,2011).** It`s probably better than penetrating keratoplasty outcomes Considering the risk of graft rejection and the required intensive postoperative care, preserving their own corneas seems to be in the patients best interest.

THIS WORK AIMS TO:

Discussion of pathophysiology, early detection, risk factors, prevention and recent advances in management of cases of post LASIK ectasia that aim to enhance corneal rigidity.

Anatomy of The Cornea

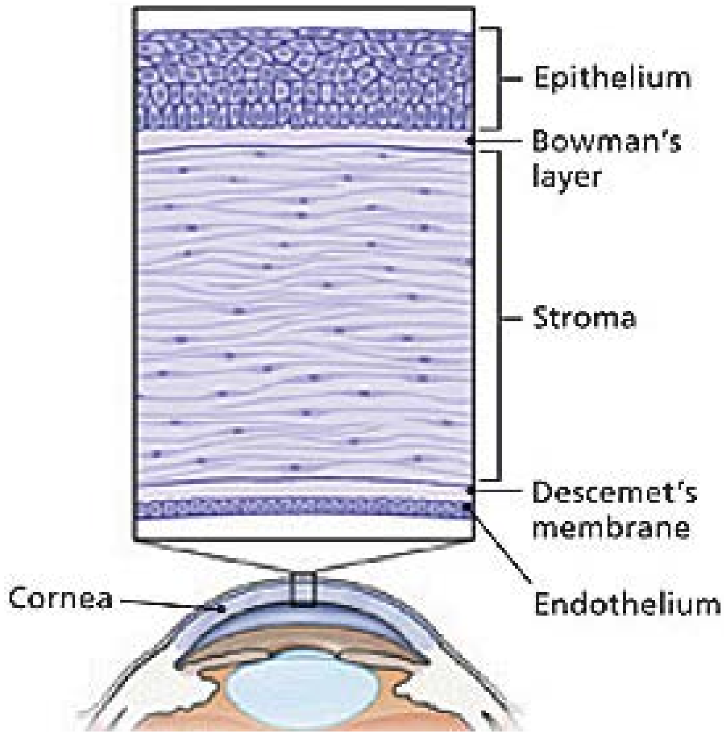

Fig (1) Anatomy of the cornea **(Stephen and Allen,2004)**

Gross anatomy:

The cornea is a clear dome-shaped window at the front of the eye (Figure 1), comprising one-fifth of the fibrous coat of the eyeball. It has no blood vessels **(Westrmoreland et al., 1998).**

The anterior surface of the cornea appears elliptical being 11.7mm wide horizontally and 10.6 vertically. Posteriorly, the cornea is concave and circular measuring about 11.7mm in diameter **(Born et al., 1997).**

It is thinner centrally, averaging about 580 um, whereas the periphery measures approximately 900-1000 um in thickness. The radius of curvature of anterior surface is about 7.7 and 6.9mm of the posterior surface **(Born et al., 1997).**

The cornea surface can be divided into four anatomical zones (Figure 2); **Central zone** (optical zone) 2-4mm in diameter, **Paracentral zone** 6-8mm in diameter**, Peripheral zone** 7-11 mm in diameter and the **Limbal zone**; it is 11.5-12mm in diameter **(Bores et al., 1993).**

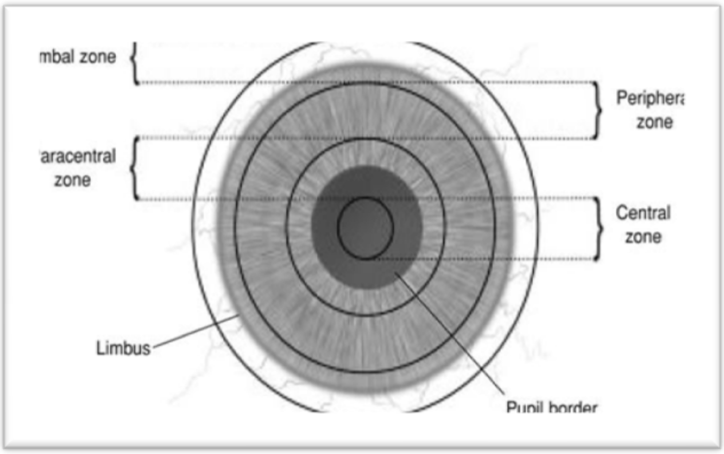

Figure (2): Zones of the human cornea: American academy of ophthalmology, 2003.

Microscopic anatomy:

It is made up of 5 distinct layers (Figure 1). Starting from the outer layer and moving inward, they are:

1-Epithelium:

The corneal epithelium is stratified squamous epithelium of uniform thickness (50 to 90 µm). It is consists of: basal zone which is formed of a single layer of columnar cells where mitosis only occurs.

The daughter cells move upward from the basal layer differentiating into wing cells of middle zone which is formed of two to three layers.

Finally the superficial zone formed of two to three layers **(Edelhauser et al., 1994).**

The cells adhere to one another via desmosomes. **(Born et al., 1997)** and the bottom layer attaches themselves to Bowman's layer by hemidesmosomes **(Krachmer et al., 1997).**

The basal lamina is an irregular zone (0.5-1 µm wide) of granuloamorphous and filamentary materials. A deep osmiophilic lamina densa and a superficial lamina lucida are distinguished ultrastructurally **(Snip et al., 1980).**

2-Bowman's Layer:

Bowman's layer is a narrow, acellular, homogenous zone 8-14 um thick, immediately subjacent to the basal lamina of the corneal epithelium. The anterior surface is smooth and parallel to that of the cornea; though sharply defined from the overlying epithelium anteriorly it is infiltrated by the lamina densa and merges into the stroma behind. It is now described as modified region of the anterior stroma **(Born et al., 1997).**

3- Stroma:

The stroma, which comprises over 90% of the thickness of the cornea, is a highly specialized connective tissue (Figure 3). The stromal matrix is made up of tightly packed orthogonal layers of collagen fibrils and abundant keratan and dermatan sulfate proteoglycans **(Kelly et al., 2001).**

Cells called keratocytes are dispersed in the stromal lamellae In transverse section of cornea they appear as long, thin ,flattened cells (maximally 2 um thick) running parallel to the corneal surface and viewed from either corneal surface as satellite cells with many processes in tangential sections **(Born et al., 1997).**

Collagens are believed to be essential for the strength of the cornea, and the interactions between collagen and proteoglycans contribute to the proper collagen spacing and in turn, to corneal transparency **(Kelly et al., 2001).**

In the posterior two thirds of the human cornea, lamellae lie in the plane of the cornea and run without interruption from limbus to limbus with a limited anteroposterior interweave. At the limbus, the collagen fibrils pursue a circular or pseudocircular course. Although the preferred direction of the posterior lamellae is in the inferior–superior and nasal–temporal directions, the lamellae of the anterior stroma have little preferred meridional arrangement. In the anterior stroma, there is an extensive anteroposterior interweave, and a proportion of the lamellae that arise in the limbus insert into the region of Bowman's layer. This arrangement is thought to be essential for the maintenance of corneal shape **(Keith et al., 2005).**

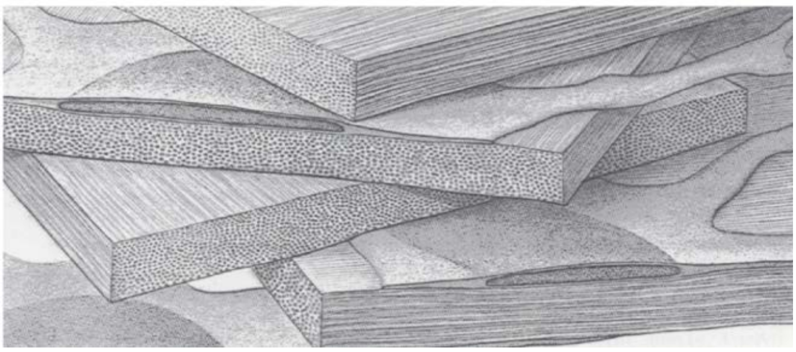

Figure (3): Schematic diagram of corneal stromal lamellae. Collagen fibrils within a lamella are parallel to each other and at right angles to each other **(Hogan et al., 1997).**

4- Descemet's Membrane:

Is a strong resistant sheet formed of type I collagen. It is closely applied to the back of the corneal stroma, from which, unlike Bowmen's layer, it is sharply defined **(Born et al., 1997).**

Although it appears homogeneous under light microscopy it has a laminated structure which may be demonstrated by polarization or electron microscopy **(Wulle, 1972)**.

It first appears at the second month of gestation. Its synthesis continues throughout adult life, so that while it is only 3-4 um thick at birth it is 5 um in childhood and reaches a thickness of 10-12 um in adult. The anterior third of the adult Descemet's membrane corresponds to that part produced in fetal life and is therefore oldest. The posterior two-thirds of the membrane are formed after birth, and consist of a homogeneous fibrillgranular material. The zone adjoining the endothelium is the most recently formed **(Born et al., 1997).**

5-Endothelium:

It is a single layer of hexagonal, cuboidal cells applied to the posterior surface of Descemet's membrane. Endothelial cell have a limited regenerative ability. Cell loss results in enlargement and spread of neighboring cells cover the defective area.

The cells decrease in number and become thinner and more attenuated with age. Endothelial cell density is 6000/mm at birth and falls 26% in the first year, and a further 26% over the next 11 years. They decrease constantly henceforth. They actively pump water out of the cornea keeping it transparent **(Gipson et al., 2000).**

The lateral borders of the cells are markedly convoluted to produce a complex interdigitation with neighboring cells. The anterior (basal) and the posterior(apical) cell membranes are relatively flat , however the surface of the posterior cell membrane shows 20-30 microvilli per cell which increases the absorptive surface area . The anterior cell membrane is in contact with Descemet's membrane, and attached to it by modified hemidesmosomes **(Ottersen et al., 1977).**

Nerves of the cornea:

The cornea is supplied by the ophthalmic division of the trigeminal nerve via the anterior ciliary nerves and those of the surrounding conjunctiva. There is also a supply from the cervical sympathetic providing adrenergic fibers to the limbus **(Born et al., 1997).**

The nerves pass into the cornea as 60-80 flattened mainly myelinated branches about 8 um wide and surrounded by perineurium. After about 1-2 mm they usually lose their myelin sheaths and divide into two groups anterior and posterior. The anterior nerves (40-50) pass through the substance of the corneal stroma and from a plexus subjacent to the anterior limiting membrane. The posterior group of nerves (40 or50) passes to the posterior part of the cornea to innervate the posterior stroma excluding Descemet's membrane **(Born et al., 1997).**

Functions of tear film:

The tear film serves several purposes: it keeps the eye moist, creates a smooth surface for light to pass through the eye, nourishes the front of the eye, and provides protection from injury and infection. Any disturbance of tear film markedly affects topography image. **(Behrens, et al, 2006).**

Post Lasik Keratectasia

Keratectasia remains one of the most troublesome complications that can arise after laser in situ keratomileusis (LASIK). Since the first reports by **Seiler and colleagues in 1998**, fewer than 150 cases have been reported in the ophthalmic literature **(Amoils, et al., 2000)**, although this number is likely an underrepresentation of the actual incidence. Thus, while rare, post-LASIK ectasia can have dramatic consequences and in some instances require corneal transplantation for visual rehabilitation.

Clinically it presents as the initial appearance of low myopia that progress over time to high myopia and irregular astigmatism, resulting in loss of uncorrected distance visual acuity (UDVA) and corrected distance visual acuity (CDVA) **(Randleman, et al., 2003).** Two major risk factors are thought to be responsible for this complication: operating on corneas with preexisting disposition to corneal ectasia, and removing too much corneal tissue **(Flanagan and Binder, 2003)**. After LASIK, the cornea is structurally weakened not only by the laser central stromal ablation (depending on the attempted correction), but also by the creation of the flap itself