THE USES OF FEMTOSECOND LASER IN REFRACTIVE SURGERY

Essay

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List of abbreviations

AC	Anterior chamber
ALK	Anterior lamellar keratoplasty
AK	Astigmatic keratotomy
BCVA	Best corrected visual acuity
D	Diopeter
DSEAK	Descemet’s stripping endothelial automated keratoplasty
DLEK	Deep lamellar endothelial keratoplasty
ECM	Extracellular matrix
FS	Femtosecond
FALK	Femtosecond assisted lamellar keratoplasty
FLE	Femtosecond lenticular extraction
FDA	Food and Drug Administration
HOA’s	Higher order aberrations
IEK	IntraLase-enabled keratoplasty
ICRS	Intrastromal corneal ring segments
LASIK	Laser in situ keratomileusis
LOA’s	Lower order aberrations
MKM	Myopic keratomileusis
Nd: YAG	Neodymium-doped yttrium aluminum garnet laser
NA	Numerical apperature
OCT	Optical coherence tomography
Po2	Partial oxygen pressure

PRK	Photorefractive keratectomy
PSF	Point spread function
PMMA	Poly methyl methacrylate
RK	Radial keratotomy
US	United States of America
WHO	World health organization

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Introduction

Uncorrected errors of refraction represent a major cause of visual impairment all over the world. Estimates made by world health organization (WHO) state that there are 98 million persons in the world with visual impairment due to uncorrected refractive error making it the largest cause of visual impairment globally***(Resnikoff*** **et al, 2002).**

Spectacles and contact lenses were the principal methods recommended by ophthalmologists and optometrists for managing this global problem.

Eye surgeons are able to correct ametropia by using different surgical techniques in a variety of anatomical locations. The refractive state of the eye is dependent chiefly on three main variables: the cornea, the lens, and the axial length. The refractive power of the eye can be modified by changing the curvature of the principal refractive surfaces (cornea and lens) ***(Linebarger et al, 2009).***

In 1983 Trokel demonstrated the precision and repeatability of the 193nm excimer laser in ablating corneal stromal tissue of bovine eyes with minimal thermal damage to surrounding corneal tissue. This led to ablative surgery.

The principle behind the excimer laser was a process called ablative photodecomposition. This concept of ablative photodecomposition forms the foundation of photorefractive keratectomy (PRK) and laser in situ keratomileusis (LASIK) procedure. (***Trokel et al, 1983)***

As of today, LASIK has become the mainstay techniques of refractive surgery, with more than 8 million procedures performed worldwide by 2006 ***(O'Connor et al, 2006).***

The United States of America Food and Drug Administration (FDA) approved the use of an ultrafast laser in 2000, which has revolutionized the creation of flaps for (LASIK) procedures. The FS laser is currently used for creating anterior corneal flaps in LASIK surgery, lamellar dissections in anterior lamellar keratoplasty (ALK), corneal pockets in Intacs insertion, donor tissue preparation in Descemet's stripping endothelial keratoplasty (DSEAK), and arcuate wedge-shaped resection in correction of high residual astigmatism. This technology is now able to create full-thickness corneal incisions with customized graft-edge profiles for both donor and recipient corneas to perform femtosecond laser-assisted keratoplasty (FLAK***) (Shahzad et al, 2007).***

Surgical procedures such as keratoplasty are technically challenging but laser-assisted surgery can allow precise creation of corneal resection planes, even in situations with limited optical clarity due to edema or scar tissue. Although the cost of the FS laser is considerable, improving patient outcomes and surgical efficiency will improve surgeon and patient access to this evolving technology ***(Mian and Shtein, 2007)***.

Aim of Work

This work focuses on recent advances in applying femtosecond laser technology to different procedures in refractive surgery to improve their outcome.

Anatomy of the cornea

The cornea is a transparent avascular tissue with a smooth, convex outer surface and a concave inner surface. The main function of the cornea is optical; it forms the principal refractive surface, accounting for 70 % [40-45 Diopeters (D)] of total refractive power of the eye. Refractive requirements are met by the regular anterior curvature of the cornea, which provides a protective layer and resists the intra ocular pressure by the collagenous component of the stroma. Transparency is achieved by the regularity and fineness of the collagen fibrils and the closeness and homogeneity of their packing ***(Bron et al, 1997).***

Surface zones of the cornea

The corneal surface can be divided into four anatomical zones. Central zone(optical zone) which is 2.4 mm in diameter and overlies the entrance of the pupil where it represents the most spherical area of the cornea. Para - central zone which is 6-8 mm in diameter. Peripheral zone which is7-11 mm in diameter. Limbal zone which is 11.5 - 12mm in diameter and forms the ring of the cornea about 0.5 mm wide that contain the capillary arcades and stem cells***(Bores et al, 1993).***

Dimensions

In front of the cornea appears elliptical, being 10.2-11.9 mm wide in the horizontal meridian and 9.6-11.00 mm in the vertical meridian in adults. The posterior surface of the cornea appears circular, about 11.7 mm in diameter. Thus, the front of the cornea forms part of what is almost a sphere, but it is usually more curved in the vertical than the horizontal meridian, giving rise to astigmatism (with the rule astigmatism). The natural and normal cornea is generally prolate, with steeper curvature centrally and relatively flatter periphery ***(Bron et al, 1997).***

Microscopic anatomy

1. Epithelium.
2. Bowman's layer.
3. Stroma.
4. Descemet's membrane.
5. Endothelium.

1. Epithelium

It's stratified squamous non-keratinized. It is continuous with that of the conjunctiva at the corneal limbus, but differs strikingly in containing no goblet cells. It’s 50-90micrometers (µm) thick and consists of five or six layers of nucleated cells (figure1) ***(Reinstein and Aslanides et al, 1994). (Thomas et al, 2003)***

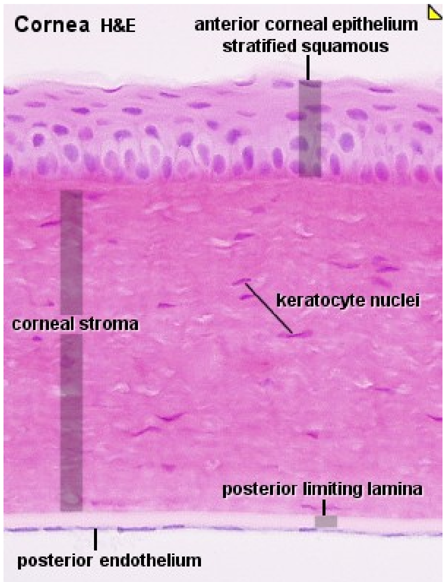

Figure: 1 – histology of the cornea. ***(Davison et al, 1997)***

Basal lamina

The basal lamina is secreted by the basal cells, which also synthesize the hemi desmosomal structures concerned in attachment of the epithelium to the lamina. The specific arrangement of fibrils within the lamina accounts for tight adherence of the basal epithelium to adjacent cornea **(*Gipson and Michaud, 1989).***

2) Bowman's layer (anterior limiting lamina)

Bowman's layer is a narrow, acellular homogenous zone, 8-14 μm thick, immediately adjacent to the basal