INTRODUCTION

Laser in situ keratomileusis (LASIK) is a surgical procedure for correction of refractive errors and has a high level of safety and efficacy ***(Ahmadieh and Javadi, 2005).***

The range of available correction, the reliability and safety of the results, and the speed of visual recovery after the surgery have made the procedure the most revolutionary breakthrough in ophthalmology in the 1990s and the most frequent refractive surgical procedure worldwide. Technical development has made the microkeratome cut a safe procedure, which is followed by laser ablation of the cornea to achieve the refractive effect ***(Kohnen et al., 2003).***

Most reported LASIK complications are related to the refractive outcome or to corneal and anterior segment injury and wound healing ***(Loewenstein et al., 2002).***

Posterior segment complications after LASIK are rarely reported such as posterior vitreous detachement, choroidal neovascular membrane, retinal detachement, macular hole, cystoid macular oedema and optic nerve diseases. Although several hypotheses have been proposed to explain the effect of LASIK on the posterior segment, the rarity of these events makes it difficult to examine the exact incidence and risk factors of vitreoretinal complications. Several studies have attempted to investigate the effect of LASIK on vitreoretinal structures ***(Mirshahi et al., 2006).***

LASIK has become the procedure of choice for the surgical correction of myopia. With the increase in the number of LASIK procedures performed there have been reports of rhegmatogenous retinal detachment, postoperatively ***(Al-Rashaed and Al-Halafi, 2011)***.

Most reports on the complications of LASIK are published by refractive surgeons. As vitreoretinal disorders are usually managed by retinal subspecialists, refractive surgeons may not be as aware of posterior segment complications and their outcome, so posterior segment examination before LASIK is mandatory ***(Mirshahi and Baatz, 2009).***

Rapid development in new laser technology enables the application of ultrashort laser pulses in the femtosecond (fs) regime that marks advancement in conventional standard procedures of refractive surgery by eliminating the use of mechanical knives. With the fs-LASIK procedure, ultrashort laser pulses focus in the near-infrared spectral range and create a laser-induced breakdown (LIB) that disrupts the corneal tissue. During the cutting process not all of the pulse energy is deposited in the cornea. Approximately half the remaining energy is propagated through the eye and reaches the retina, as well as the strongly absorbing layers behind ***(Sander et al., 2008).***

AIM OF THE WORK

The aim of this work is to review the posterior segment complications associated with LASIK, possible pathogenetic mechanisms, risk factors, current management, and outcomes.

LASER IN SITU KERATOMILEUSIS (LASIK)

Laser in situ keratomileusis (LASIK), a surgical procedure for correction of refractive errors, has a high level of safety and efficacy. LASIK has become the most frequent refractive surgical procedure worldwide ***(Mirshahi and Baatz, 2009).***

The term "laser in situ keratomileusis" or **(LASIK)** describes a combination of lamellar refractive surgery and excimer laser photoablation of the cornea under a hinged corneal flap (corneal flap composed of whole epithelium and the outer part of the corneal stroma) ***(Dada et al., 2003).***

The principle of any surgical approach to move the focus point of the eye exactly into the fovea is to alter the refractive power of either the cornea or the lens which may be too high (myopia) or too low (hyperopia) or too inconsistent (astigmatism), depending on the nature of the refractive error (***Vossmerbaeumer, 2010).***

I. Basic principles of excimer laser:

The term ***excimer laser*** was first introduced by Stevens and Hutton in 1960. The word ***excimer*** is a contraction of the term ***excited dimer***, which describes the argon (Ar) fluoride (F) energized molecule. When the argon and fluoride molecules are in an excited state, they combine to create an ArF gas that is very unstable ***(Ayres and Rapuano, 2006).***

An Excimer laser is an excited dimmer which produces a laser beam of ultraviolet energy. An inert gas and a halide are used, specifically argon and fluoride. The Excimer lasers can produce ultraviolet light energy at various wavelengths depending upon the gas element utilized. If the ultraviolet energy released is of 248 µm, it results in potentially mutagenic behavior. If the ultraviolet energy is of 308 µm, it can lead to cataract formation. Thus, it was found that the ideal ultraviolet energy should be 193µm. This is really suitable for corneal ablation ***(Van Saarloos, 1997).***

Each Excimer laser ablates a different amount of stromal tissue per diopter of refractive correction due to differences in the ablation zone diameters, amount of pretreatment, and the ablation profile. The laser removes approximately 0.25 microns of corneal tissue with each pulse ***(Kumar et al., 2005)***.

II. Effects of excimer laser on corneal tissue :-

Laser effects on biological tissue can be grouped into three major categories: **thermal**, **ionizing** and **photochemical**. Excimer lasers affect changes in tissue by virtue of their photochemical interaction. When pulsed ultraviolet light, at wavelengths below 350 nm, is applied in the nanosecond (ns) range, it causes breaks in the intermolecular bonds of the polymer chains of corneal collagens, disintegrating the target tissue. This process is called ***photoablation***. This process does not involve a significant increase in the tissue temperature as the diffusion time for heat conduction into the surrounding tissue is much longer than the millisecond (ms) range pulse duration. The energy of the laser light is almost entirely absorbed at the surface of the treated tissue without producing relevant collateral effects within the stroma. **The depth** of ablation depends both on the excimer laser **wavelength** and **the energy density** of the pulse. The absorption maximum of the cornea at 193 nm makes the use of the excimer laser particularly suitable for corneal surgery. Irradiance at 193 nm leaves the immediate vicinity of the ablated stroma unchanged. The wavelength is crucial as the 193 nm pattern ablates creating **smooth** edges, whereas a comparable 249 nm pulse pattern leaves **jagged** tissue edges. With increasing wavelengths, the thermal effects and collateral damage of an excimer laser pulse increase (***Vossmerbaeumer, 2010).***

III. Instrumentation of LASIK :-

A- The Microkeratome :

The microkeratome is the basic instrument to make a corneal flap. It creates a uniform and homogenous flap of calculated diameter and thickness by cutting through the stromal corneal lamellae. The cutting action of the microkeratome is derived from a blade which is powered by an electromechanical system ***(Kumar et al., 2005).***

The cutting mechanism of the microkeratome may utilize a ***mechanical*** steel blade, the ***waterjet*** system or the ***IntraLase femtosecond laser (Burato and Brint, 2003).***

(1) **The mechanical microkeratome :**

The following components are included in an assembled microkeratome*:*

- **Head**: contains the thickness plate, blade holder and blade
- **Handle**: contains the motor.
- **Suction ring**: it stabilizes the globe and provides a stable platform for the microkeratome cutting head. It also raises the intraocular pressure (IOP) to a high level, which stiffens the cornea and prevents it from deforming away from the microkeratome blade when the flap is cut. The dimensions of the suction ring determine the diameter of the flap and the size of the stabilizing hinge. The suction ring is connected to a vacuum pump, which is controlled by an on-off foot pedal.
- **The motor**: either electrical or gas –driven turbine, oscillates the blade rapidly, ranging between 6,000 and 15,000 cycles per minute ***(Burato and Brint, 2003).***

There are a wide variety of microkeratomes in clinical use. These include :

- The **Hansatome** (Bausch & Lomb Surgical, Salt Lake City, UT, USA) **Fig (1-1)**,
- The **LSK-1**, the Carriazo-Barraquer (C-B) **Fig (1-2)**,
- the **Model 2 (M2)** (all by Moria SA, Antony, France) **Fig (1-3),**
- The **Chiron automated corneal shaper** (ACS; Bausch & Lomb),
- The **Summit Krumeich Barraquer** microkeratome (SKBM; Alcon Laboratories, Forth Worth, TX, USA),
- The **Nidek MK-2000** (Nidek, Gamagori, Japan) and
- The **Amadeus** (Advanced Medical Optics, Santa Ana, CA, USA) **Fig (1-4)**, ***(Huhtala et al., 2007).***

Fig (1-1): The Hansatome microkeratome; suction ring, head and motor ***(Burrato and Brint, 2003).***

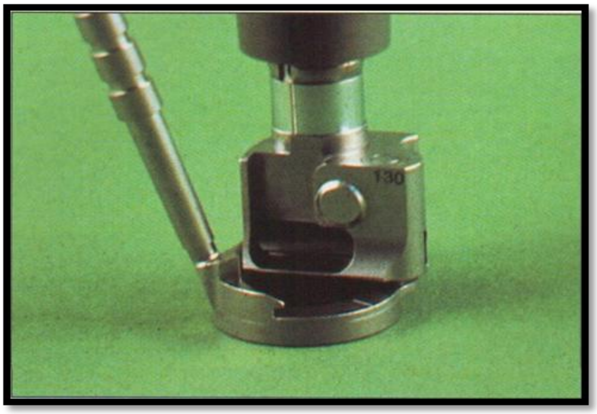

Fig (1-2): The Carriazo-Barraquer microkeratome
(Carmen et al., 2000).

Fig (1-3): Moria M2 Peripheral part of microkeratome; **sr**, suction ring; **h**, head; **du**, drive unit ***(Doctor and Shah, 2007).***

Fig (1-4): Amadeus™ II microkeratome (AMO) **(*left*)** Amadeus LCD display ***(right) (Pajic, 2007).***

(2) <u>Waterjet microkeratome</u>:

This keratome uses a Waterjet technology to create a *cleavage* in between the corneal lamellae. Because the cornea is a highly sectile tissue, cleavage rather than cutting is the best mechanism for tissue separation with minimal tissue damage. The **VisiJet HydroKeratome**™ uses a continuous beam of ultrahigh pressure saline that is only 36 microns in diameter, to cut a flap across the cornea ***(Kumar et al., 2005)***.

(3) <u>Intralase Femtosecond LASER</u> :

An ultrafast laser (femtosecond) has been introduced that allows <u>*the **non**-mechanical*</u> creation of corneal flaps for LASIK ***(Mian and Shtein, 2007).***

The femtosecond laser is the first alternative to mechanical microkeratomes, and the IntraLase femtosecond laser has been approved by the US Food and Drug Administration for lamellar corneal surgery. The IntraLase system relies on a low-pressure suction ring to align and stabilize the globe ***(Lim et al., 2006).***

The femtosecond laser is a solid-state laser used to create flaps laser in situ keratomileusis (LASIK). The laser uses a 1053 nm infrared wavelength neodymium:glass to deliver 3 um spots focused to a preset depth to photodisrupt tissue within the corneal stroma, creating cavitations bubbles of water and carbon dioxide ***(Nordan et al., 2003)***.

What is unique about the femtosecond laser is its ability to produce a cut within the corneal stroma, rendering the need for a microkeratome unnecessary. Femtosecond lasers have ultrashort laser pulses which means that the pulse energy is decreased and that there is a reduction in the amount of thermal and mechanical damage to the surrounding corneal and stromal tissue ***(*Dick *et al., 2010).***

B- **Excimer laser delivery systems:**

Each system has a specific ablation approach with advantages and disadvantages. **The three major delivary systems being used are:**

(1) ***Wide Field Ablation:***

This is the first generation laser delivery system. The principle feature of this system is the use of a stationary, ***broad*** and ***circular*** beam of the excimer laser for corneal tissue removal**.** The exact alignment of the eye and tracking systems are not necessary, because a broad system is used. Although the operating *time* is *short*, this system requires a *high energy* to achieve the required ablation and delivers a greater acoustic shock wave to the cornea. Limited ablation patterns are available and a higher incidence of central islands has also been reported with the wide field ablation system ***Fig (1-5, A) (Sharma et al. 2005).***

(2) ***Scanning Slit Ablation:***

This is the second generation photorefractive delivery system. It employs a rectangular ***slit shaped*** beam of light that scans across an aperture within the path of the beam and uniformly removes tissue with several successive pulses of laser. The amount of tissue removed varies depending on the amount of overlap between the pulses. It requires a complex scanning system with eye tracking facilities. The scanning slit ablation requires a *lower pulse energy* output and ensures an excellent beam uniformity and homogeneity because of the small area being ablated with each pulse. The small area ablation produces a smoother ablative surface also reduces the complication of central islands.

No optic zone limitations are present. However, the ablation takes a *longer time* to complete **Fig *(1-5, B) (Talamo and Krueger, 1997)***.

(3) *Scanning (Flying) Spot Ablation:*

It is the third generation flying spot laser. It performs scanning in ***multiple directions*** to remove a uniform layer of corneal tissue. It allows for a *custom designed* ablation and uses the *lowest energy* output. The number of optics in the machine are reduced. Large zone ablations with complex ablation patterns (including hyperopia) are possible. The main disadvantage is that it requires *the longest operating time* and therefore precise eye tracking systems are required **Fig *(1-5, C) (Fiore et al., 2001).***

IV. Operative Technique of LASIK:

- **Eye preparation and Anesthesia** :

An eyelid *speculum* is inserted in the operative eye, which has been anesthetized topically, and the fellow eye is covered. The cornea is marked to aid postoperative flap alignment. The patient should be instructed to look at the fixation light. *A* *suction ring* is placed to achieve an intraocular pressure (IOP) about 65 mmHg ***(Varley et al., 2004).***

(A)

(B)

(C)

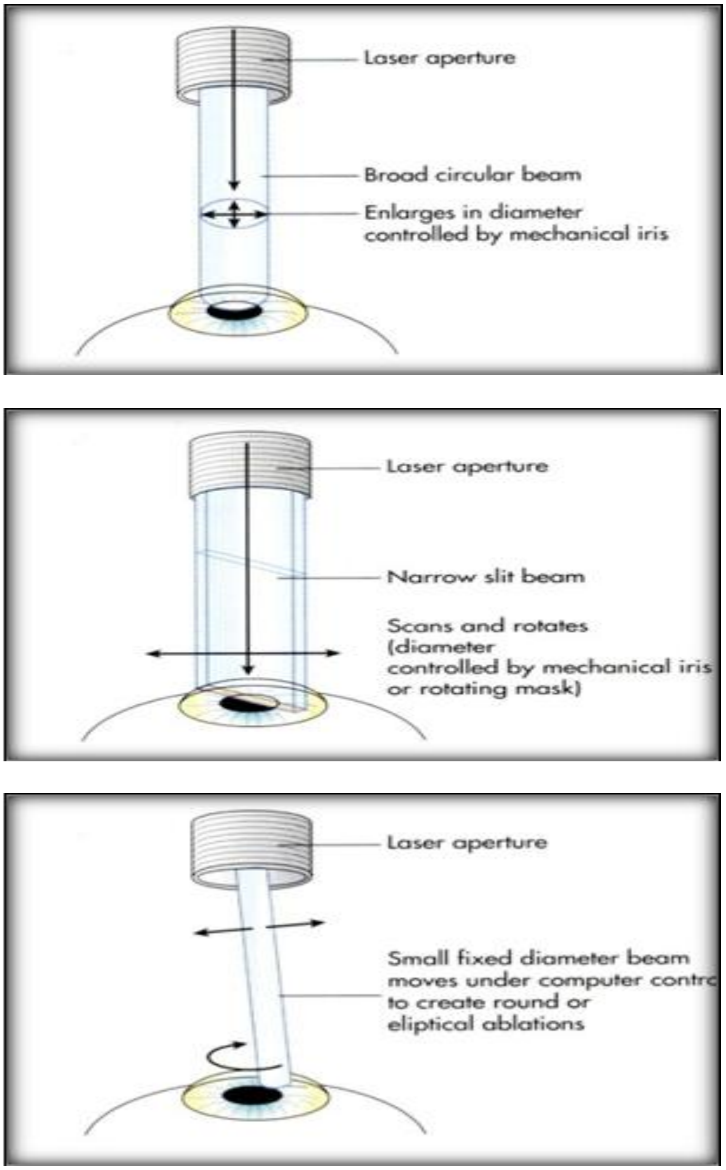

Fig. (1-5): The three approaches *to* excimer laser photoablation. (A) Broad beam. **(*B*)** Scanning slit. **(*C*)** Flying spot ***(Van Saarloos PP, 1997).***