Assessment of Intra-operative and Early Post-operative Complications of Laser in–situ Keratomileusis

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Abstract

Several Laser in-situ keratomileusis (LASIK) complications have been identified over the years. Reporting complications of LASIK surgery will help refine the approach to their management. LASIK was introduced in the late 1980s with the development of the ophthalmic excimer laser [1, 2]. To avoid the disadvantages of photorefractive keratectomy (PRK), LASIK was introduced [3]. LASIK rapidly increased in popularity and became the predominant form of refractive surgery in the late 1990s and continues till today [4]. Correcting different refractive errors, including myopia, hyperopia, and astigmatism, is the main aim of all laser refractive procedures. LASIK has been used to treat many degrees of myopia with promising results, and there are great expectations for treating farsightedness. Compared to PRK, LASIK is advantageous in causing minimal postoperative discomfort, rapid restoration of visual clarity and stability of refractive changes, less frequent opacification, and better ability to correct high levels of myopia. Intraoperative complications, although infrequent, include Microkeratome-related flap complications (flap buttonhole, free cap, and incomplete, short, or irregular flaps), corneal perforation, corneal epithelial defect, conjunctival bleeding, subconjunctival hemorrhage, and interface debris [6]. Post-operative Complications include inaccurate correction, visual aberrations, flap striae (macrostriae -microstriae) [6], flap dislocation, dry eye, diffuse lamellar keratitis (DLK), pressure-induced stromal keratitis (PISK), infectious keratitis [7], and epithelial ingrowth [8].

Aim of the Study: To assess incidences, possible aetiology of the intra-operative, and early post-operative complications of LASIK.

Literature-based Methodology: The intra-operative complication rate, reported between 0.7% and 6.5% [6], is most commonly associated with flap-related issues, including mechanical or FS Laser complications.

Ethical Consideration: The study was approved by the Ethical Committee at the Faculty of Medicine, Assiut University (IRB No.17101184).

Intra-operative Complications:

1-Microkeratome-related Flap Complications:

In the past, the manual microkeratome was related to the more severe complications of LASIK. Recently, advances in microkeratome technology and the use of FS laser have decreased the incidence of severe, sometimes considered sight-threatening complications. A thin, irregular, or buttonhole flap is usually due to steep corneal curvature due to an uneven fit of the keratome suction device, putting it at risk of buttonhole formation. [9, 10, 11]

a- Flap Buttonhole:

Leaf defects or uneven motion of microkeratome through the cornea can produce buttonholes and irregular or thin flaps that lead to irregular astigmatism with affection for the best-corrected visual acuity outcome. [11]

If a thin or buttonhole flap occurs, ideally, the flap should not be lifted, and the procedure should be discontinued. Try another procedure after 3-6 months, allowing the flap to heal beforehand, which can prevent significant vision loss. [11]

b- Free Cap:

Occasionally, free caps are created instead of hinged flaps. It is crucial to replace the cap with the epithelial side up and use the previously placed radial markers to position it on the dry interstitial floor properly. This is an essential step before initiating the procedure using the microkeratome. A temporary suture (10-0 nylon) can be placed, but the endothelium's physiological dehydration of the interstitium mainly holds the cap in place. The contact lens helps keep the cap in place. [12]

c- Incomplete, Short or Irregular Flaps:

It is caused by insufficient aspiration or defects in the microkeratome. [6]

2 Corneal Perforation:

It is a rare, devastating complication. There are reports of older mechanical microkeratomes improperly assembled or improperly positioned depth plates [13][14]. It can also occur during ablation of very thin corneas. [15][16]

3 Corneal Epithelial Defect:

Diabetes mellitus, autoimmune disease, and epithelial basement membrane dystrophy (EBMD) are risk factors for epithelial erosion during LASIK. [7]

4 Limbal Bleeding:

It occurs in two cases: in case the suction ring is incorrectly sized or positioned and in case of corneal pannus formation, resulting in iatrogenic cutting of limbal or conjunctival vessels. [6]

5 Interface Debris:

An inflammatory response significantly indicates flap elevation, cleansing, and manual removal of debris and foreign bodies. Small amounts of lint and small metal particles from stainless steel surgical instruments are usually well tolerated. [7]

Post-operative Complications:

Undercorrection and Overcorrection

1- Undercorrection:

Undercorrection is common when treating severe refractive errors [7]. Occasionally, regression can be achieved with aggressive administration of topical corticosteroids. Once the refraction is stable, the patient can be re-treated 3 months after surgery. Surgeons should wait at least 6 to 12 months for significant corneal opacification to resolve spontaneously before repeating surface ablation.

Dilatation may be suspected in cases of delayed regression, especially in case of irregular astigmatism development, while in elderly patients, refractive shift may occur due to the development of cataracts. [7]

2- Overcorrection :

If excessive interstitial dehydration occurs before starting excimer treatment, overcorrection may occur as more stromal tissue is removed with each pulse. Controlling the temperature and humidity of the laser suite within recommended guidelines can reduce the variability of refraction results. [7]

Myopic or hyperopic surface ablation usually has some regressive component for at least 3-6 months. Generally, patients with high degrees of myopia and any degree of hyperopia need more time to stabilize their refraction. Various solutions are available to handle minor overcorrection [7]. Individuals with consecutive myopia or hyperopia may require less treatment to achieve emmetropia than individuals with previously untreated eyes. With conventional ablation, many surgeons reduce ablation by 20-25% in sequential treatment. [7]

3- Visual Aberrations:

Some patients may experience visual problems such as glare around lights, halo or

star patterns, haze, and reduced contrast sensitivity. Most cases of visual impairment stabilize 3-6 months after surgery. [7]

4- Flap Fold or Striae:

Striae can arise from size differences between the flap and the residual stromal bed, misalignment of the corneal flap, or post-operative flap movement. This size difference occurs even after generating flaps with femtosecond lasers, mainly when correcting large refractive errors (''tenting'' effect [17, 18]) [19]. The LASIK flap should be well positioned on the interstitial floor with uniform grooves around the flap to minimize the development of flap striae [20-22]. Leaf folds are classified into minor and major filaments. Imaging using AS-OCT demonstrated that the minor striatum appeared as grooves on the stromal surface and was regularly overlying the epithelium. In contrast, major striatum manifested as dome-shaped irregularities on the stromal surface with regular overlying epithelium [35]. Careful flap manipulation has been shown to reduce the incidence of striae. Stubborn striae may require additional treatment, such as suturing.

a- Macrostriae:

Macrostriae denotes stromal folds. These occur as a result of post-operative flap slippage or misalignment. [24]

The surgeon should pay attention to the development of striae after repositioning the flap. Oblique illumination should be used with an operating microscope to examine striae.

Macrostriae can occur when squeezer individuals close their eyelids when the speculum is being removed. [24]

To detect flap displacement, monitoring the patient immediately after surgery is essential. A plastic protective shield is usually used for the first 24 hours to prevent the patient from accidentally touching his/her eyelids.

b- Microstriae:

Microstriae are usually visually insignificant. These are fine creases in the Bowman layer, often caused by a mismatch between the flap and the new bed. [24]

5- Flap Dislocation:

Dislocations were reported in approximately 1.4% of eyes. Dislocation is seen on the first post-operative day. After the first day, re-epithelialization of the sulcus begins, and the flap becomes more stable. Within a few weeks, corneal cells renew collagen on the edge of the Bowman's layer incision, eventually forming a scar. [6]

Late traumatic dislocations have been documented for years after LASIK. This can be explained when shear forces exceed the strength of peripheral healing at Bowman's layer level. Dislocation requires prompt treatment to return the flap to its proper anatomical position. [6]

6- Dry Eye and Affection of Corneal Sensation:

Dry eye is one of the most common side effects of LASIK and is seen in approximately 70% of all patients with variable degrees of severity due to corneal denervation. Careful preoperative evaluation is needed to detect dry eye syndrome and treat it systemically with topical lubricants, cyclosporine A, and oral tetracycline. [24]

7- Diffuse lamellar keratitis (DLK):

The symptoms of DLK range from asymptomatic, mild interface opacification near the flap margins to marked, diffuse opacification with decreased BCVA. It is a nonspecific sterile inflammatory response to various mechanical and toxic causes. The potential space beneath the flap is the interface. Foreign material on the surface of the microkeratome blade, trapped meibomian gland secretions, marker inknd red blood cells (RBCs) on the surface are considered triggering factors. Inflammation generally resolves without sequelae with topical (anti-inflammatory) corticosteroid treatment alone. [25]

DLK is usually classified according to the following stages:

1. Peripheral mild leukocytes; rough appearance.
2. Central aggregates of leukocytes; rough appearance.
3. Dense aggregates of leukocytes in the middle of the visual axis.
4. Permanent scarring and/or melting of the stroma.

Stages 1 and 2 generally respond to topical treatment with corticosteroids. Stages 3 and 4 almost always require flap elevation and direct cleansing beneath the flap with intensive topical corticosteroid treatment. In severe cases, oral corticosteroids can be added. Vision recovery in DLK can be good when the condition is diagnosed and managed as early as possible. [25]

Raising the flaps removes inflammatory mediators from the interface and allows direct application of corticosteroids and non-steroidal anti-inflammatory drugs (NSAIDs) to reduce inflammation and necrosis. [25]

8- Pressure-Induced Interstitial Keratitis (PISK):

Elevated intraocular pressure (IOP) has been reported to occur in approximately 20% of cases after surface ablation. In some cases, IOPs can be very high. In one study, 2% of cases had a post-operative IOP higher than 42 mm Hg. Most cases of intraocular pressure elevation were reported with chronic topical corticosteroid use. [26-27]

Correspondingly, post-operative corticosteroid-induced IOP elevation is more likely to arise after surface ablation. Corticosteroid-induced intraocular pressure elevation occurs in approximately 2.0% with fluorometholone but up to 25% with dexamethasone. Increased eye pressure is usually controlled with topical eye pressure-lowering drugs and usually returns to normal when corticosteroid use is stopped or reduced. [28] Goldmann tonometry after myopic plane ablation and LASIK can be misleading due to changes in corneal parameters (including curvature and/or corneal thickness). Active contour tonometry is the only accurate technique after refractive ablation. Additionally, high intraocular pressure can cause fluid to pool under the valve, masking a dangerously high intraocular pressure. [29]

9- Infectious Keratitis:

Infection after LASIK usually accompanies decreased vision, redness, and photophobia. In addition, because the corneal nerve is cut during flap formation, the cornea may become numb, along with the pain that usually accompanies infection. Several features can distinguish DLK and infectious keratitis. [30]

In general, the DLK inflammatory response is diffuse but enclosed within the area of the flap interface. This is contrary to post-LASIK infectious keratitis, which usually begins 2 or 3 days after the operation and is associated with an inflammatory infiltrate unrelated to the lamellar interface and extends deep into the flap and beyond the edge of the flap. The anterior chamber response can distinguish between infectious and sterile processes. [30].In severe cases of infection within the interface, marked corneal scarring and flap melting can occur and may require corneal transplantation. The most common infections are with Gram-positive bacteria, followed by atypical mycobacteria. [31]

In general, the timing of symptom onset is a good indicator of the aetiology of infection. If the infection is resistant to treatment, a flap cut may be necessary to improve penetration of the antibiotic. Fourth-generation fluoroquinolones, such as moxifloxacin, show superior activity against the more common bacteria causing post-LASIK infections, including several atypical mycobacteria. [31]

10- Epithelial Ingrowth:

Epithelial ingrowth is a rare complication characterized by the growth of corneal epithelium at the interface between the flap and the stromal bed after LASIK. [32]

Due to the surgical risk of epithelialization, irregular astigmatism, and increased incidence of corneal flap tearing, there are some reports of conservative follow-up without intervention.

Surgical options range from manual ablation alone or the addition of lasers

(Phototherapeutic keratotomy [PTK]), mitomycin C, alcohol, suturing flaps, fibrin glue, or mechanical barriers such as amniotic membranes. In more severe cases, penetrating keratoplasty may be required. All these operations are invasive and do not guarantee recurrence prevention. [33]

Risk factors include poor adhesion of the flap margin, epithelial abrasion at the flap margin, loose cap, buttonhole flap, ablation at the stromal bed margin, and epithelial irregularity at the flap margin, Introduction of epithelial cells, minimal irrigation, and prior radial resection. Keratotomy (RK) and revision surgery. [34]

Epithelial ingrowth was classified into three grades, as proposed by Probst and Machat. Grade

1, ingrowth limited to within 2.0 mm of the flap edge with no associated visual affection; Grade2, with a thickness of ingrowth of at least 2.0 mm from the margin of the flap, but marginal anatomy is normal; and Grade 3, with marked ingrowth >2.0 mm from the flap margin, often with anatomical abnormalities in the margin itself. [35]

Conclusion:

Fortunately, literature-based studies show a statistically significant reduction in complication rates over time. In most cases, there were no intraoperative complications. In

most cases, no complications occurred during the first 3 months. However, with recent technological advances and improvements in surgical techniques, the complication rate for LASIK is still relatively rare.

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