Clinical Pearls in Postoperative LASIK Management

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More than 35 million LASIK procedures have been performed worldwide with reported improvement in outcomes and safety.[1] With proper preoperative screening and advanced technology, visual outcomes are excellent with a low complication rate. This paper reviews potential LASIK complications and treatment options. The majority of complications are minor and resolve with treatment without any adverse effects on visual acuity or quality of vision.

Over the past 30 years, there have been significant advances in excimer laser technology, which include improved nomograms, flying spot lasers to deliver smoother ablations, accurate trackers, larger optical zones, aspheric curves, and customized treatments that reduce not only refractive errors but other optical aberrations of the eye.

In North America, femtosecond lasers for creation of the corneal flap have generally replaced mechanical microkeratomes that require a blade. Advances in femtosecond technology have shown predictable flap thickness and the ability to customize the diameter, location, hinge, and edge profile of the LASIK flap. In the rare event of suction loss with a femtosecond laser, the suction ring can be reapplied, and the procedure completed. With suction loss using a mechanical microkeratome, the procedure is aborted, and the patient must return a few months later for PRK.

In a large LASIK clinical review (97 papers; 67 893 eyes) from 2008–2015, 90.8% of eyes achieved a distance uncorrected visual acuity (UCVA) ≥20/20 and 99.5% achieved ≥20/40.[2] The spherical equivalent refraction was within ±0.50 D of target in 90.9% of eyes and within ±1.00 D of target in 98.6%. These outcomes were superior to earlier reports, which reflect further advances in hardware and software of the lasers, surgical techniques, and improved patient selection. Loss of 2 or more lines of corrected distance visual acuity (CDVA) was 0.61%, less than one half the number of eyes that had an increase in CDVA of 2 lines or more (1.45%). The more advanced treatments (topography- and wavefront-guided or wavefront-optimized) allowed for an UDVA of nearly a full line better than in eyes with conventional treatments.

The most significant long-term complication of LASIK is corneal ectasia (incidence of 0.03%).[3] The risk has been lowered by improved preoperative detection of forme-fruste keratoconus, keratoconus, and pellucid marginal degeneration using elevation tomography that detects elevation abnormalities of both the anterior and posterior cornea.[4] Other factors accounting for improved LASIK outcomes include avoidance of surgery on thin corneas or those with high myopia, creation of thinner corneal flaps, and leaving a thicker residual bed underneath the flap.[5,6]

Further research in tracking devices, torsional alignment, the ideal centration of ablations, an understanding of the biomechanical properties of the cornea, and medications or adjunctive procedures to modulate wound healing will enhance our outcomes and patient safety for all laser vision correction procedures.

This review is on the recognition of postoperative LASIK complications and management is divided in to:

1. **Flap Issues**
2. **Interface Issues**
3. **Older Excimer Laser Technology**
4. **Mechanical Microkeratomes**
5. **Refractive Concerns**
6. **Other Complications**

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Flap Issues:

Microstriae, macrostriae, and epithelial defects are usually detected in the first 24 hours following LASIK. These complications can be easily managed with an excellent prognosis. (See Table 1)

Table I

Diagnosis	Symptoms	Signs	Treatment
Microstriae[7,8]	If located over the pupil, microstriae can interfere with visual acuity and/or quality of vision. If in the periphery, patient may be asymptomatic.	Fine superficial corneal folds seen on slitlamp exam can best be appreciated on retroillumination or with fluorescein dye and cobalt blue light. Potential causes include eye-rubbing, pressure on the eye while sleeping without a protective cover, lagophthalmos, and high myopic corrections (significant disparity between the curvature of the posterior surface of the flap and the bed after ablation).	Elevation of flap, stretching, and reposition. The earlier this is done postoperatively the better the chance of smoothing the flap. If minimal striae that are not interfering with vision, then treatment is not required.
Macrostriae[9,10]	Always associated with reduced visual acuity and quality of vision.	Large superficial corneal folds from significant flap displacement. May be secondary to trauma such as accidental rubbing of eye early postop. Flap edges are not aligned, and epithelium can be present on the bed.	Elevation of flap, stretching, and reposition. The earlier this is done postoperatively the better the chance of smoothing the flap. Epithelial regrowth on the bed or undersurface of the flap should be removed to reduce the risk of epithelial ingrowth.
Epithelial Defect[11,12]	Decreased vision if overlying the pupil and usually uncomfortable with pain and photophobia.	Epithelial defect may be on the central area of the flap, the flap edge, or in the peripheral cornea. May be secondary to epithelial basement membrane dystrophy or a toxic epitheliopathy and sloughing.	Bandage soft contact lens and antibiotic drop. If early postop, to continue NSAID and topical steroid. Increased risk of DLK, epithelial ingrowth, and regression secondary to wound healing. If central defect, vision recovery may be similar to PRK.

Interface Issues:

Interface issues may require observation, aggressive topical steroids or antibiotics, or surgical intervention. (See Table 2)

Table 2

Diagnosis	Symptoms	Signs	Treatment
Diffuse Lamellar Keratitis (DLK)[13,14,15]	Usually asymptomatic or may have reduced vision in advanced stages. Pain and/or photophobia are usually not present with DLK in contrast to an infection.	White blood cell accumulation in the interface that appears as a fine punctate haze pattern. Referred in the past as 'Sands of Sahara'. May be in a focal area or diffuse. Usually present on the first postop day. Anterior chamber is quiet unlike with an active corneal infection.	Most cases are mild and can be treated aggressively with a topical steroid drop every 30 to 60 minutes during the day. In rare cases, in which DLK obscures iris details, intervention may require flap lift and irrigation with balanced saline. If steroid drops are prolonged, it is important to rule out elevated eye pressure secondary to the topical steroid.
Interface Debris[16]	Usually symptomatic.	May be meibomian gland secretions, mascara granules, lint, blood from limbal vessels, metal fragments from a blade used with a mechanical microkeratome, or other debris from tear film.	Typically, no treatment is required as inert particles do not result in inflammation. If there is a lint fragment extending from the flap edge, this should be removed. Usually there is no impact on vision.

Table 2 continued			
Diagnosis	**Symptoms**	**Signs**	**Treatment**
Epithelial Ingrowth[17]	Usually asymptomatic. If > 1.5 mm there is a greater risk of reduced visual acuity, induced astigmatism, and potential for an overlying flap melt. Reports of a lower incidence of epithelial ingrowth with femtosecond laser flap creation than mechanical microkeratome because of the geometry of the flap edge.	May have an overlying punctate keratitis, or topography with induced irregular astigmatism. Risk factors for ingrowth include epithelial defect at time of original LASIK procedure, flap displacement, epithelial basement membrane dystrophy, and LASIK enhancement especially at > 12 months.	If > 1.5 mm, induced astigmatism, or overlying flap issues, to consider a flap lift and interface debridement of both the bed and undersurface of the flap. If recurrence of significant ingrowth, may require repeat surgery with temporary sutures to decrease recurrence. Other modalities include fibrin glue, hydrogel sealant, and YAG laser.
Corneal Infection[18]	A rare complication associated with a decrease in vision, photophobia, and pain.	Whitish corneal infiltrate in the interface. Early onset (< 10 days) is typically caused by bacteria. Late onset (> 10 days) is usually caused by mycobacteria or fungi. A reaction is noted in the anterior chamber with cells and/or hypopyon.	Usually requires a flap lift and scraping for culture. Fortified antibiotic drops every 30 to 60 minutes. If not a satisfactory response to antibiotics, then corneal crosslinking may be helpful, which has been shown to kill micro-organisms.

Older Excimer Technology:

Broad-beam excimer lasers have generally been replaced by flying-spot lasers in most countries around the world. The older broad-beam lasers can be associated with central islands, as the vortex plume interferes with the laser delivery. Modern software today allows for large optical and transition zones to enhance quality of vision during the day and night. Software many years ago was limited in the size of the optical and transition zone that resulted in a greater chance of halos and glare. Today, modern excimer lasers have sophisticated tracking devices to allow proper centration of the ablation. In the past, excimer laser centration was performed manually by the surgeon, which lead to a greater risk of a decentered ablation. (See Table 3)

Table 3			
Diagnosis	**Symptoms**	**Signs**	**Treatment**
Central Island[19]	Decreased distance vision with possible glare. Near vision may be improved as the central area of steepening can enhance close vision.	Computerized topography shows a small steep central area that is typically more than 1.5 mm in width and steepening of at least 3 D. Tomography shows this area to be elevated. Causes implicated include: inhomogeneity of the broad-beam laser ablation from blockage by the plume of ejected corneal tissue; inherent laser defects or degraded optics; and differential hydration of the stromal bed with less ablation centrally.	Typically, no treatment is required as smoothing occurs over time with epithelial remodelling on the surface of the flap. Rarely would a Topography-guided ablation with iris registration be required.
Small Optical Zone[19,20,21]	May have halos and glare. Uncommon complication today because of the use of large optical zones with transition zones using advanced excimer technology.	Computerized topography will demonstrate the size of the optical zone. Today most excimer treatments have an optical zone of 6.5 mm with transition to 9 mm. In the early days of excimer, the treatment zones were less than 6 mm.	Topography-guided ablation can enlarge the optical zone. This may be a 2 -step process with any residual prescription being treated in the future.
Decentered Ablation[19,20,22]	May have halos, glare, and reduced visual acuity. Uncommon complication today because of the use of sophisticated eye trackers.	Computerized topography will demonstrate a decentered ablation in relationship to the pupil.	Topography-guided ablation can smooth the corneal surface and improve the patient's symptoms. This will often result in needing a second procedure to correct any residual refractive error.

Mechanical Microkeratomes :

Mechanical microkeratomes use a blade and are primarily used in underdeveloped countries and at discount laser centres. An incomplete pass of the microkeratome can result in significant complications. These complications may be secondary to suction loss, power failure, interference by the eyelid, drape, or speculum, debris along the track, or from lack of blade sharpness. Although there are cost savings with this older technology, this method of flap creation has been generally replaced by femtosecond lasers, which allow improved safety and accuracy. (See Table 4)

Table 4

Diagnosis	Symptoms	Signs	Treatment
Irregular, Incomplete, or decentered flaps[23]	Incomplete pass with a mechanical microkeratome can result in significant flap complications with potential for loss of vision.	Best for the surgeon to abort the procedure and leave the flap in position. To wait 3 to 6 months for flap healing before further treatment.	Treatment with PRK after satisfactory flap adherence. These mechanical microkeratome complications can be totally avoided by the use of the femtosecond laser.
Free Cap[23]	No hinge present	If satisfactory width of the bed, the procedure can be completed.	The flap can be elevated, the excimer treatment performed, and the flap repositioned. More difficult for proper alignment with the absence of a hinge.
Corneal Perforation[23]	Rare event, which could occur with the original mechanical microkeratomes if the depth plate was not inserted properly.	Corneal perforation is a severe complication that requires urgent care. With a full thickness corneal cut, the anterior chamber collapses, there is a loss of aqueous fluid and usually prolapse of iris.	The procedure is aborted, and the patient is taken to a proper operating room for intraocular procedures. Corneal sutures are inserted, and any other repairs are performed. Fortunately, this type of microkeratome is no longer used today.
Thin flaps & Button-holes[23,24,25]	Can occur with mechanical microkeratomes on steep corneas, when suction loss occurs, or lack of blade sharpness.	Buttonholes are usually formed near the center of the corneal flap. Occasionally they can be subtle if a focal area of the centre of the flap consists of epithelium only without stroma.	Best to abort the procedure and perform PRK when the cornea is adequately healed. This is typically in 3 to 6 months.

Refractive Issues & Quality of Vision:

The effects of excimer laser surgery on the cornea are very different then simply reshaping a piece of plastic. Individual patient healing responses can occasionally result in less than the desired refractive outcome. Significant thickening of the corneal epithelial cells on the surface of a LASIK flap can result in regression requiring an enhancement. Halos and glare, which are uncommon today with the use of flying spot lasers and large optical and transition zones, can improve over time as the corneal epithelium undergoes maturation by thickening in valleys and thinning on peaks to improve the quality of vision. Rainbow glare is a very rare complication that is primarily of historical interest. (See Table 5)

Table 5

Diagnosis	Symptoms	Signs	Treatment
Regression[26,27]	Decreased vision occurring months or years later.	Refraction reveals nearsightedness, farsightedness, and/or astigmatism.	If no ectasia, and corneal thickness is satisfactory then a PRK enhancement is preferred if > 12 months since the original LASIK procedure. If patient desires both distance and near to consider monovision, which may result in no additional treatment.

Table 5 continued

Diagnosis	Symptoms	Signs	Treatment
Halos & Glare[28,29]	It is not uncommon during the first few month to have some halos and/or glare but these tend to return to baseline. If persistent symptoms, then there is usually a secondary cause.	Most common cause of persistent symptoms is a residual refractive error. Differential diagnosis includes a dry eye, decentered ablation, irregular ablation, and small optical zone.	Usually, an enhancement for a residual refractive error will help. A topography-guided ablation can reduce a decentered ablation, irregular ablation, or small optical zone. Treatment for a dry eye can improve symptoms.
Rainbow Glare[30]	A previous complication from older femtosecond flap creation. Light scattering from the back surface of the flap can create a spectral pattern whose visual impact is clinically inconsequential in the majority of patients.	The spectral pattern and visual angle correspond to an older raster spot separation when creating the LASIK flap. Eyes treated with the newer focusing optics have reduced the rainbow symptom. This is not seen today with advanced femtosecond lasers.	No treatment is required. Symptoms tend to resolve with healing.

Other Issues:

Subconjunctival hemorrhage secondary to suction during flap creation can be a frightening finding for patients but not serious and resolves without treatment. Although the flap interface never completely seals, traumatic subluxation is exceedingly a rare event and is usually secondary to a significant blow to the eye. Fortunately, this subluxation can be easily repaired. Some dryness after LASIK is common but tends to resolve with time returning to baseline levels. (See Table 6)

Table 6

Diagnosis	Symptoms	Signs	Treatment
Subconjunctival Hemorrhage[31]	Cosmetic presence of redness. No pain or inflammation. Common with flap creation and tearing of conjunctival or episcleral blood vessels and leakage in to the subconjunctival space.	Blood in the space between the conjunctiva and episclera. Typically related to suction application in creating the LASIK flap.	No treatment required. Artificial tears may enhance comfort if irritation or foreign body sensation.
Traumatic Flap Subluxation[32,33]	Early or late traumatic flap subluxation results in blurred vision and foreign body sensation.	Subluxation of flap is easily visualized. Fortunately, this is a rare event. Trauma, such as a deployed air bag during a car accident, a sports injury, or a domestic accident, can trigger flap dislocation at any time after surgery.	Surgical reposition of the flap. Important to be sure there is no epithelial ingrowth on the bed or undersurface of the flap.
Dry Eye[34,35]	Irritation, burning, and gritty sensation.	May have a superficial punctate keratitis, decrease tear volume on the ocular surface, and/or increased rate of tear evaporation. Reduced corneal sensation leads to reduction in tear secretion. As corneal nerves regenerate, symptoms and signs improve. A reduction of goblet cells of the conjunctiva from the suction ring has also been implicated. Another cause is change in the corneal curvature leading to abnormal tear distribution during blinking.	Preservative-free artificial tears are usually effective. Other options include gels, ointments, a humidifier, tear stimulants, autologous serum tears, and punctal occlusion. As the corneal nerves regenerate over 2 to 4 months the symptoms typically return to baseline. Meibomian gland dysfunction can also contribute to ocular surface discomfort and should be treated.
Neuropathic Pain[36,37,38]	Ocular pain without evidence of inflammation. Rare occurrence that potentially can occur with any type of eye surgery.	No typical signs. Pain is still present even after application of a topical anesthetic.	Autologous serum tears or platelet-rich plasma tears may be helpful. Other proposed treatments include oral Gabapentin and/or Naltrexone, and acupuncture.

Table 6 continued

Diagnosis	Symptoms	Signs	Treatment
Epithelial Toxic Keratopathy[39,40]	Topical medications especially with preservatives can result in a toxic keratopathy. Patients can have a decrease in vision secondary to a punctate keratopathy.	A diffuse superficial punctate keratopathy can be related to a toxic reaction to a topical medication or to a dry eye condition.	It is important to recognize the potential for topical drug toxicity and discontinue the medication. It may take a number of weeks to months for resolution.
Central Toxic Keratopathy (CTK)[41,42]	Decreased vision secondary to a central non-inflammatory toxic reaction. The cause is unknown. Thought to be a reaction from substances in the tear film with the excimer ablation that results in photoactivation. Appears similar to DLK in the early stages.	An uncommon complication characterized by central corneal opacification with associated stromal loss, striae, and hyperopic shift postoperatively.	Unlike with DLK, steroid drops are not effective. Unfortunately, it is difficult to differentiate from late stage DLK and therefore the general thinking is that it is best to give steroid drops so as not to miss DLK. CTK is self-limiting but takes 6 to 18 months for the cornea to clear, and the anterior corneal curvature to steepen secondary to epithelial thickening.
Ectasia[43,44]	With proper patient selection, ectasia is a rare complication after LASIK with an incidence of 0.03%. Patients may present with a decrease in vision or quality of vision. Patients may also be asymptomatic in the early stage.	Diagnosis is based on topographic or tomographic data. Atypical steepening of the anterior curvature and/or posterior elevation of the cornea are diagnostic signs. Most prevalent risk factors are thin cornea (≤ 500 µm), anterior topographic map irregularities, and low residual stromal bed (≤ 250 µm).	Treatment is with corneal crosslinking to prevent progressive steepening. If the degree of steepness is less than 10 D from the steep area to the flat area and there is satisfactory thickness, then Topography-guided PRK can be offered to improve best-corrected visual acuity.
Transient Light-Sensitivity Syndrome (TLSS)[45]	Delayed acute photophobia 2 to 8 weeks after femtosecond laser LASIK. No change in visual acuity.	Absence of clinical signs. Higher laser energy settings in the early days of femtosecond laser LASIK were associated with the higher incidence of TLSS. A reduction of the laser energy led to significant decrease of TLSS incidence.	Topical steroids result in resolution of symptoms suggestive of an inflammatory origin of the condition.
Irregular Ablation[46]	Decreased vision or quality of vision.	Computerized topography shows an irregular ablation pattern. This may occur if tears or blood, block the laser ablation.	Topography-guided PRK to smooth the corneal bed by steepening flat areas and flattening steep areas. May require a second procedure to correct a residual refractive error.

Summary

Although LASIK is one of the safest surgical procedures performed today on the human body, it is nevertheless important to understand and recognize any potential complications. Clinicians involved in postoperative LASIK care should be able to identify any abnormal symptoms and signs, and be prepared to initiate appropriate treatment or refer back to the surgeon for further management. In many cases, the complications are mild and do not interfere with visual acuity or quality of vision, and require either no treatment or that with artificial tears or steroid drops. In some cases, the patient needs to be referred back to the surgeon, which may be on an urgent or nonurgent basis. Fortunately, with advances in excimer laser technology, femtosecond lasers, and advanced surgical techniques, the incidence of significant complications is rare.

Clinical practice can be enriched by having satisfied patients that are enjoying life without the need for glasses or contact lenses. In some cases, this allows for career opportunities in professions that have vision requirements such as police force or firefighters, for others it may simply be able to function well with daily activities.

It is important to remind all postoperative patients of the need for regular ocular examinations to be sure their eyes are healthy. Patients need to be educated that although they may be seeing well after their LASIK procedure, they are still at risk for other ocular diseases such as glaucoma, cataracts, retinal tears, macular diseases, and optic nerve disorders

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