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Corneal Complications Of Laser-Assisted In-Situ Keratomileusis (LASIK)

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The purpose of this article is to discuss complications of refractive surgery. Marketing of refractive sur_eery rarely includes much discussion about complications. It is important to recognize that LASIK is a surgical procedure and can result in serious complications.

Although LASIK surgery technique is well established all over the world. we continue to recognize potential complications and their effective management. Preventive efforts and attention to detail I were never more crucial to success than in this micron-precision surgery. LASIK involves cutting a thin flap off of the surface of the cornea, ablating some of the central corneal stroma and then laying the 1-lap back in place.

The LASIK tissue components can be divided into the following 3 levels (Tiers):

Level I. Corneal section;
Level II. Interface; and
Level III. Ablation bed.

Complications involving these 3 levels are discussed below.

Complications of the Corneal Section (Level I)

The corneal section is the portion of the cornea that is prepared by the microkeratome. This is the flap we lay back to ablate the stroma. The corneal section can be divided into the 1-lap portion and the attached hinge portion that connects the flap with the undisturbed portion of cornea.

Complications that can occur in the flap are those of **1) SIZE** *(e.g., flap that is too small or too large);* **2) DEPTH** *(e.g., buttonhole, epithelial tear, and even anterior chamber penetration); or* **3) FORM AND APPEARANCE** *(e.g., wrinkling or edema).*

It is important to avoid complications by careful patient selection before surgery. If the cornea is unstable, the patient is not a good candidate. Patients wearing contact lenses may develop corneal instability. Corneal topography returns to normal after discontinuing contact lenses, however, and the surgery can proceed normally.

Irregularities in the corneal section induced by LASIK can create enough astigmatism to reduce the patient's visual acuity. Fortunately, such irregularities in form (e.g., wrinkles in the corneal flap) can readily be straightened out. The wrinkled flap in most cases can be raised (Gulani Lasik Revision Instruments: University of Pisa-Italy, 2000), hydrated and then flattened back in place.

Buttonholing is a significant complication that results when the corneal surface is buckled. The microkeratome hits the higher area of the cornea but the lower portions of the corneal epithelium are missed by the microkeratome. Even with adequate suction, the microkeratome may miss certain areas because of increased curvature of the cornea. Another complication, commonly occurring when inexperienced surgeons are still making themselves comfortable with LASIK, is construction of an incomplete flap. These over-anxious surgeons tend to release the footswitch too early and stop the cut midway.

Scarring on the cornea may be another reason for an incomplete flap. The microkeratome cannot completely traverse the area so that only a partial flap is constructed.

Improper sire of the corneal flap itself is another possible complication. The height and diameter of the suction ring and the suction pressure determine the amount of cornea exposed to the microkeratome. If these parameters arc incorrect, the corneal flap may be too small for ablation of the stromal bed. If this occurs, the surgeon can reposition the 1-lap, allow it to heal, and revisit the patient in about three months.

Complications of the Corneal Flap Hinge

One possible complication in construction of the hinge is the formation of a flap completely lacking the hinge. This situation is known as a full cap. Also, the laser may ablate the hinge. Accidental ablation of the hinge can be prevented by using covering instruments that are available to protect the hinge of the corneal flap from the laser beam when the flap is laid back. Special instruments like the Globe Stabilizer and Flap Restrainer as designed by the author can be used for this purpose.

Although a full cap may not have been the intended result, there is no reason to panic. Until recently, in fact, we deliberately constructed a full cap. It has been only within the past few years that we have devised the methods for making a hinge to facilitate reposition of the corneal flap. In extreme cases, if the full cap does not go back in place. it is possible to stitch it into position. I leave the stitches in for three days (Nonrefractive effect), and the results are very good.

Almost as soon as the speculum and drape are removed, patients want to blink and squeeze the eye. This can dislodge the flap or even separate the cap entirely. If the flap is dislodged, the cap can be replaced and sutured into place. If the cap is lost permanently, a homoplastic graft will restore the corneal anatomy.

Marking the cornea before beginning LASIK is absolutely essential so that when you replace the flap, it can be returned perfectly to the previous position. Misorientation of the corneal flap, when it is returned to its position, of course, can induce astigmatism. Furthermore, if the hinge is lost (full cap). it is very difficult for the surgeon to know which side of the flap is up and which side is down. The double ring marks on the cornea with the specially designed Lasik Marker make it virtually impossible to make a mistake about the orientation of the cap. In patients who have had previous incisional refractive surgery, the previous incisions can also serve as marks for alignment.

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Interface Inflammation

Several terms for interface inflammation are now in use (TI: Gulani AC, SOS: Maddox B & Hastis A, NSDIK: Slade S); but I believe that the different terms reflect a continuum of signs and symptoms associated with the same pathologic state. ***Toxic interfacitis*** (TU presents as a granular appearance, self-resolving condition. TI does not threaten vision. There is no need to treat it unless the patient's condition worsens. ***Sands of Sahara*** (SOS) is a more progressive and visually threatening pathologic condition that requires treatment with high doses of steroids. ***Nonspecific diffuse intralamellar keratitis*** (NSDIK) is a condition midway between TI and SOS in severity and need for intervention is based on clinical presentation.

The causes of interface inflammation are still being debated. Lipopolysaccharide (LPS) deposits from bacterial contamination (especially Gram-negative bacteria) is another potential cause of interface inflammation when instruments have been left wet and unsterile. Metallic deposits may also lodge in the stromal interface. These are difficult to clear. If they are not clinically significant to the patient, it is advisable not to operate to remove them. Finally, contamination of the interface with lint, lipid globules and blood *(especially in patients with contact lens induced pannus)* can also occur.

Interface infection with bacteria, virus and fungi have been noted. Minimal flap handling, limited fluidics, and interface cleansing *(Gulani Triple function Lasik Cannula)* can minimize most of these benign complications.

Complications Involving the Stromal Bed (Level III)

Stromal bed complications are generally Laser induced. With Excimer lasers at the forefront of refractive surgery, it has become mandatory to better understand their working principles and to perform a rigorous pre-surgical test series in order to conform to strict measures of predictable submicron precision laser refractive surgery.

Laser malfunctions can result in the following unwanted effects:

- Excessive ablation;
- Inadequate ablation;
- Decentration;
- Central island or irregular ablation;
- Potential personal injury; and
- Laser failure.

The potential causes of such laser problems are listed below:

- Incorrect laser calibration;
- Improper pulse energy;
- Malfunctioning optical or beam-delivery system;
- Inadequate nomograms;
- Uncooperative patient; and
- Improper patient selection.

These problems are prevented by paying strict attention to the following:

- Beam alignment and centration:
- Beam energy output and calibration;
- Beam profile and homogeneity;
- Nomogram-directed beam-shaping capacity; and
- Outcome analysis with feedback nomogram update.

Beam Alignment

At the discretion of the operator, and as a means of identifying problems with laser beam alignment, one must insure that the microscope has been centered prior to surgery or between surgical cases. First the electronically controlled precision patient chair is brought to a supine position. A piece of thermal FAX paper is placed on an adjustable stand, which is leveled parallel to the ground. This stand is brought to the same distance under the laser as would be the eye of the patient lying underneath it. A 3 mm diameter laser beam is then directed onto the FAX paper and checked using the projected reticle in the microscope ocular.

The ablation is checked for centration and for its relationship to the aiming diodes. During surgery, the position of the patient's iris plane should be checked by an assistant who would observe the patient's eye from the same horizontal level as the patient's head. The iris plane should be parallel to the floor and therefore perpendicular to the laser beam. Multi-function instruments like the Gulani globe stabilizer and Flap Restrainer can be used for controlled globe centration and simultaneous flap restraint for maximal stromal ablation.

Energy

The unit of measurement used is fluence, which is energy per unit area. The laser beam is fired on a center-sensitive diaphragm and the digital value is recorded in the operator's log each time the laser is fired. The energy measurements are checked between each surgical case and at the discretion of the laser operator or surgeon, but must always be taken after any adjustments of the energy output at the internal laser computer console or change in nitrogen flow in the system. Repeated need to increase the voltage may signal a decrease in the gas levels and need for refill. The laser room environment is also critical for optimal laser performance (temperature between 18˚ C and 24˚ C; relative humidity below 50%).

Beam Profile

The excimer laser energy beam profile indicates the overall distribution of energy density. This beam profile needs to be homogeneous in order to result in a reproducible clinical profile and, thus, consistent refractive predictability.

Analyzing the excimer beam can be performed using the ExACT film which comprises of a thin micron layer of foil covering a multilayered polymer adherent to a test plastic. The endpoint is a uniformly yellow ablation pattern.Wave patterns can be seen in profile around the impact zone of the beam and reveal beam profile in its own content ie. heterogenous or homogenous as well as beam displacement, i.e, decentration.

I refer to this appearance as Excimer Beam Profile Topography (Gulani AC. Excimer Beam Profile Topography. ECLSO meeting. Geneva, Switzerland, Sept.1999). since it represents the negative imprint of the final corneal topography post-lasik and is a direct correlate of the laser ablation pattern on the patient's cornea.

Other considerations in LASIK include:

1. Patient education
2. Trial runs if needed
3. Nomogram modification following feedback from outcome analysis
4. Accessory surgical tools to aid and enhance ablation effectiveness e.g., Globe stabilizers, Axes markers, etc.

Summary

In summary, periodic maintenance and preventive testing are critical if we are to minimize potential complications in the corneal section, interface, and ablation bed. The excimer laser requires continual maintenance and care in order to maintain consistently reproducible refractive outcomes. ■