EDITORIAL
Flap Complications of Lamellar Refractive Surgery
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OVER RECENT DECADES, REFRACTIVE SURGERY techniques have continued to evolve and now offer potential freedom from spectacle and contact lens correction for almost the entire spectrum of refractive errors. Use of lamellar corneal refractive techniques like keratomileusis, epikeratophakia, and automated lamellar keratoplasty is mostly obsolete. The incisional technique of radial keratotomy has, for the most part, been superseded by excimer laser ablative procedures. Astigmatic keratotomy is commonly performed in combination with cataract surgery and refractive lens extraction.

See also pp. 129–136.

However, even astigmatic keratotomy is being challenged by toric intraocular lenses and laser corneal surgery.

Photorefractive keratectomy has been shown to be safe and effective in correcting or reducing low to moderate degrees of myopia in tens of thousands of patients worldwide. However, with the marriage of automated lamellar keratoplasty and photorefractive keratectomy, excimer laser in situ keratomileusis is becoming the procedure of choice by surgeons and patients, particularly for hyperopia. Refractive lensectomy with intraocular lens implantation, including the use of combined soft and hard contact lenses for extreme hyperopia if necessary, or the implantation of toric or multifocal lenses, as well as phakic intraocular lens, are surgical alternatives in very high myopic or hyperopic corrections because of the surgical limitations of excimer laser corneal ablative procedures. Advances in technology, such as Intrastromal ring segments, may even diversify the options available in lower corrections.

Safety and efficacy address refractive outcomes and loss of best spectacle-corrected visual acuity. Quality of vision issues such as ghosting, halos, and night vision symptoms are more subtle and require patient questionnaires as well as other tests for subjective and objective evaluation.

Because refractive surgery is an elective procedure, patients must give fully informed consent after a careful consideration of all the risks and benefits. The most satisfied postoperative patients are those who preoperatively undergo a thorough discussion of their motivations, refractive expectations, surgical risks, and postoperative quality of vision issues. Vision quality issues must be considered, as well as the establishment of the safety and efficacy of each refractive surgery. The debate over photorefractive keratectomy vs laser in situ keratomileusis is currently of particular interest. All other considerations, such as ablation centration, beam profile, and fixation stability during ablation, aside, the quality of vision after photorefractive keratectomy relates primarily to haze and after laser in situ keratomileusis to flap complications.

Preservation of the Bowman membrane and rapid visual rehabilitation make laser in situ keratomileusis the choice of most surgeons and patients. However, these advantages must be balanced against potential flap complications that affect the quality of vision. Flap complications are usually thought of as microkeratome complications. However, striae in the flap, interface debris, inflammation, and epithelial ingrowth must all be included in any consideration of flap complications. Studies have shown that the incidence of laser in situ keratomileusis flap complications decreases as surgeons gain more experience with surgery, with the sharing of that experience through courses, publications, fellowship training, and mentoring. In addition, improvements in microkeratome design and technique modifications are reducing complications as well.

In this issue of THE JOURNAL, Drs Lin and Maloney report on flap complications associated with lamellar refractive surgery in 1,019 eyes, 490 consecutive automated lamellar keratoplasty and 529 consecutive laser in situ keratomileusis eyes by one surgeon (R.K.M.) using the automated corneal shaper. This study, like the two before it, describes a large series of laser in situ keratomileusis outcomes using the same microkeratome and reports: (1) a relatively low incidence of flap complications, (2) a decreasing rate of flap complications as the surgeon’s experience increases, and (3) no loss of best spectacle-corrected visual acuity with proper management of complications. However, these studies have not addressed the subjective assessment of quality of vision. Subtle changes like microstriae may affect the quality of vision without reducing the Snellen visual acuity.

Lin and Maloney report on 22 (2.2%) intraoperative flap complications of lamellar refractive surgery in 1,019 eyes.
flap complications, including three incomplete flaps; nine irregular flaps, including thin flaps and full-thickness holes; and 10 free caps. This compares similarly ($\chi^2 = 0.17, P = .68$) with 19 (1.9%) intraoperative flap complications reported in our series on the first 1,000 consecutive laser in situ keratomileusis surgeries by one surgeon (H.V.G.).

Interestingly, the nature of the flap complications was significantly different: three incomplete passes (R.K.M.) vs 12 (H.V.G.) and 10 free caps (R.K.M.) vs one (H.V.G.).

A common cause of incomplete passes is interference with the passes of the microkeratome by the lids, speculum, or drapes. Debris, a fold of conjunctiva between the suction ring tracks and the microkeratome gear, or obstruction by the drapes or the eyelids can also prevent the microkeratome from completing the pass. Other causes of microkeratome failure include damage in handling or transport, improper assembly or cleaning, and mineral deposits lodged in the housing or on the blade carrier that result in more than tolerable friction during the pass of the microkeratome through the suction ring slots. If Balanced Salt Solution (Alcon Laboratories, Fort Worth, Texas) is used intraoperatively, crystals may deposit in the motor spindle and cause friction. Nonsaline irrigation that is used before and during the microkeratome pass reduces this risk.

In a case where a partial pass occurs, the surgeon must decide whether to proceed with ablation. If the cut stops so that the reflected flap hinge barely lies over the zone of the planned ablation, the flap hinge can be shielded from ablation with a moist sponge. If the pass stops well within the planned ablation zone, and certainly if it stops within the central 5 to 6 mm of the cornea, the ablation is not done, and the flap is repositioned. A laser in situ keratomileusis recut can be performed after a 3-month waiting period using the same depth plate.

Free caps may be the result of mechanical or anatomic features. In our experience, despite proper microkeratome assembly, free caps have occurred in large flat corneas of less than 41 diopters mean keratometry when the automated corneal shaper was used. A smaller area of the cornea may have been exposed to the microkeratome blade in these cases, resulting in a free cap.

When a free cap is encountered, it should be kept covered in the microkeratome or carefully placed in an antidesiccation chamber while ablation is performed. Careful preoperative corneal marking is essential to the proper replacement of a free cap. It is imperative to replace the cap with the stromal surface down. Some surgeons advocate the routine use of double-circle markings with different size circles to aid in the alignment if a free cap occurs.

The nine irregular flaps experienced by R.K.M. were similar to the six observed by H.V.G. ($\chi^2 = .38, P = .54$). Irregular flaps, including thin flaps or full-thickness holes, may result from inadequate suction, loss of suction, or anatomic features related to the keratome suction ring being used. Corneas that are large and steeper than average may be prone to buckling when excess tissue is compressed beyond applanation by the foot plate of the microkeratome. The microkeratome may perform a complete pass, but the resultant flap may have a central thinning or a full-thickness hole. In the event that a full-thickness hole is created, the ablation is not done; the flap is replaced, and a laser in situ keratomileusis recut is scheduled 3 months later. When recutting a flap after a full-thickness hole, a different depth plate may be used for a thicker cut. In the case of a thin flap that does not have a full-thickness hole but has faint ridges on the bed, an alternative approach is to proceed with the ablation if the ridges are outside of the 5-mm to 6-mm zone. Use of a poor quality blade or the presence of debris that interferes with the blade may create narrow ridges on the stromal bed.

Lin and Maloney reported postoperative flap-related complications, including 20 eyes with displaced flaps, 22 eyes with epithelial ingrowths that required surgical treatment, and 11 eyes with flap folds that required retreatment. These complications are similar to those of 41 eyes with postoperative flap complications in our series ($\chi^2 = 1.91, P = 1.665$). Shifted flaps usually occur in the first few hours after surgery. Wrinkling of only a small area at the edge of the flap may occur because of squeezing the lids or rubbing the eye. In such cases, repositioning is relatively straightforward. Wrinkles can usually be smoothed out if repositioning is done early, and if only the edge of the flap has shifted or curled, it can be stretched back in place with a dry sponge while the eye is held with a Thornton ring. If more than a few hours have elapsed, the section involved or the entire flap can be refloated into position. Although secondary epithelial wrinkles will not smooth out immediately, they will disappear after 6 to 12 hours.

Possible causes of epithelial ingrowth include poor flap edge apposition; epithelial abrasions at the flap edge; flap misalignments; full-thickness holes that go through the epithelium as well as the Bowman membrane; spillover of ablation at the bed margins, such as occurs in wide ablations or eccentric flaps; and epithelial tags at the bed margins on retreatment. Epithelial ingrowth problems can be minimized by meticulous attention to the epithelium in primary and retreatment surgeries, especially by careful assessment of all torn epithelium at the edges of the flap. Any epithelium, including tags and debris, should be cleared away from the stromal bed before flap repositioning. Large ablation and transitional zones on small-diameter beds should be avoided. Epithelial ingrowth that requires surgical treatment involves lifting a portion of or the entire flap. The stromal surface is debrided with a Paton spatula, as is the undersurface of the flap in the area of the ingrowth. The spatula is cleaned after each pass. Lin and Maloney report that with treatment, flap-related complications rarely lead to a permanent decrease in best spectacle-corrected visual acuity.

With laser in situ keratomileusis, decrease of vision quality is usually related to flap microwrinkles or surface
irregularities from interface inflammation. Photorefractive keratectomy haze, especially in an asymmetrical distribution, can cause symptoms related to the quality of vision. In both instances the quality symptoms may be present without the loss of best-corrected Snellen visual acuity. Subtle central islands can affect quality of vision in both procedures. Overall subjective patient satisfaction after excimer laser surgery for low to moderate myopia is very high. Glare and halos, loss of contrast sensitivity, and starbursts at night seem to constitute significant secondary effects that deserve further investigation in both photorefractive keratectomy and laser in situ keratomileusis. They correlate with pupil size, treatment zones, and surface abberations.

Evaluation of results of any refractive procedure now goes beyond Snellen visual acuity, refraction, and contrast sensitivity. Objective methods of evaluating surface quality through refinements in mapping instruments and their software programs, as well as confocal imaging and digital retroillumination imaging, are being applied to post–photorefractive keratectomy and post–laser in situ keratomileusis corneas. These objective evaluations must be correlated with a subjective patient evaluation of quality of vision. We are conducting a survey using the questionnaire Quality of Vision After Laser In Situ Keratomileusis, developed by Isabelle Brunette, MD, of the Quality of Vision Research Group, in Montreal, PQ, Canada. The survey aims to identify quality of vision issues in our laser in situ keratomileusis patients with and without any identified complications.

Because of the extreme variability of refractive errors, as well as variations in corneal diameter, pupil diameter, and corneal curvature, there is no single refractive technique that is most appropriate for every patient. For some patients a combination of techniques may be best. With the refinement of current techniques and the development of new refractive surgical techniques, refractive surgery can be expected to gain even more widespread acceptance by patients and surgeons, and it can be anticipated that the outcomes will improve and bring excellent quality of vision to most patients.

REFERENCES