Therapeutic Flap Amputation for Atypical LASIK Flap and Interface Abnormalities

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ABSTRACT
PURPOSE: To describe LASIK flap amputation as a therapeutic option for patients with atypical refractory flap complications.

METHODS: Case series and literature review.

RESULTS: Seven eyes of 6 patients underwent flap amputation for various atypical indications, including non-infectious flap/interface opacity (3 patients), irregular astigmatism on the flap surface (3 patients), and chronic pain (concurrent in 2 patients with irregular astigmatism). In each case, conservative measures were ineffective. All patients had symptomatic improvement and improved corrected visual function after amputation; however, uncorrected distance visual acuity worsened in 2 patients, manifest refraction worsened in 3 patients, and irregular astigmatism increased in 2 patients.

CONCLUSIONS: Flap amputation is a reasonable alternative to improve corrected acuity in select cases with significant flap opacities or irregular astigmatism unresponsive to conservative measures, but uncorrected acuity and irregular astigmatism may worsen and should be discussed during the informed consent process.


LASIK has become the primary surgical method to correct ametropia due to its efficacy and rapid post-operative recovery, made possible through the creation of the anterior stromal flap. Although rare, LASIK has a unique subset of complications related to the creation of the LASIK flap and the resulting potential space. The LASIK interface, within the stromal bed, provides a novel site for infection, inflammation, and epithelial cell ingrowth.1

Limited wound healing occurs after the creation of the flap.2 This facilitates flap lift for re-treatments. The optical role of the LASIK flap remains controversial, with most studies finding minimal optical alterations specific to the flap3,4 and minimal differences in optical profiles between LASIK and surface ablation.5,6

Planned therapeutic flap amputation has been reported in cases of recalcitrant epithelial ingrowth or infectious keratitis not responding to conservative therapy.7-9 In most cases with flap or interface complications, concerted attempts are made to preserve the flap, even in cases of late dislocation. We are not aware of any reports of planned flap amputation for irregular astigmatism or flap-specific opacity.

We describe 6 patients who benefitted from planned therapeutic flap amputation for atypical LASIK complications, including induced irregular astigmatism and opacity not amenable to more conservative treatment, and discuss the potential utility of this treatment.

CASES
Table 1 provides an overview of patient demographics along with final acuities and refractive outcomes. In all cases,
the same basic surgical technique was performed: the flap was reflected using forceps, and a 15-blade was used to cut the hinge and remove the flap. The bed was smoothed and rinsed, and a therapeutic contact lens was placed (Video 1, available in the online version of this article).

### CASE 1: FLAP AMPUTATION FOR FLAP OPACITIES

A 32-year-old man developed an opacity involving both the flap undersurface and LASIK interface presumed due to an atypical presentation of adenovirus (Figures 1-2), which was initially diagnosed and managed at an outside facility. No culture results were available from this time. On presentation to our clinic, Emory University, the scar worsened despite aggressive topical steroids followed by flap lift/irrigation, resulting in irregular astigmatism and decreased acuity (Table 1). After flap amputation, topography improved (Figure A), the patient achieved 20/40 acuity uncorrected and 20/25 acuity with a contact lens, and he felt comfortable performing his daily and work activities without correction.

### FLAP AMPUTATION FOR FLAP OPACITIES

**TABLE 1**

<table>
<thead>
<tr>
<th>Patient (Age/Gender/Eye)</th>
<th>Issue Necessitating Flap Amputation</th>
<th>Reason for Flap Amputation</th>
<th>Previous Treatment Methods</th>
<th>Pre UDVA</th>
<th>Pre MRx</th>
<th>Pre CDVA</th>
<th>Post UDVA</th>
<th>Post MRx</th>
<th>Post CDVA</th>
<th>Final Correction Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (32/M/OD)</td>
<td>Flap/interface opacity after presumed adenovirus</td>
<td>Flap/interface scar</td>
<td>Flap lift, topical antibiotics, topical steroids</td>
<td>20/50</td>
<td>-1.00 + 1.00 × 000</td>
<td>20/30</td>
<td>20/40</td>
<td>-1.50 + 0.75 × 080</td>
<td>20/25</td>
<td>RGP</td>
</tr>
<tr>
<td>2 (36/M/OU)</td>
<td>Granular dystrophy</td>
<td>Flap opacity (dystrophy excoriation)</td>
<td>None</td>
<td>20/70</td>
<td>-3.50 sphere</td>
<td>20/70</td>
<td>20/50</td>
<td>-2.25 + 0.25 × 180</td>
<td>20/30,</td>
<td>Glasses</td>
</tr>
<tr>
<td>3 (53/M/OD)</td>
<td>NSAID use for CME causing flap melt</td>
<td>Irregular astigmatism &amp; scar</td>
<td>Topical steroids, topical cyclosporine</td>
<td>CF</td>
<td>Unable to improvea</td>
<td>20/CF</td>
<td>20/100</td>
<td>-1.75 sphere</td>
<td>20/25</td>
<td>RGP</td>
</tr>
<tr>
<td>4 (55/F/OD)</td>
<td>PRK on flap × 1</td>
<td>Irregular astigmatism &amp; pain</td>
<td>Topical steroids</td>
<td>20/400</td>
<td>-3.00 + 0.25 × 007</td>
<td>20/70</td>
<td>20/400</td>
<td>-4.50 + 1.75 × 010</td>
<td>20/30</td>
<td>None</td>
</tr>
<tr>
<td>5 (62/M/OD)</td>
<td>PRK on flap (multiple)</td>
<td>Irregular astigmatism &amp; scar</td>
<td>Flap lift</td>
<td>20/100</td>
<td>Unable to improvea</td>
<td>20/100</td>
<td>20/25</td>
<td>-0.50 + 1.00 × 149</td>
<td>20/25</td>
<td>None</td>
</tr>
<tr>
<td>6 (57/F/OD)</td>
<td>Epithelial ingrowth with flap lift × 2</td>
<td>Irregular astigmatism</td>
<td>Flap lift</td>
<td>20/100</td>
<td>-1.50 + 0.50 × 175</td>
<td>20/60</td>
<td>20/70</td>
<td>plano + 2.00 × 160</td>
<td>20/40</td>
<td>Glasses</td>
</tr>
</tbody>
</table>

Pre = prior to flap amputation; UDVA = uncorrected distance visual acuity; MRx = manifest refraction; CDVA = corrected distance visual acuity; Post = after flap amputation; OD = right eye; RGP = rigid gas permeable contact lens; OU = both eyes; NSAID = nonsteroidal anti-inflammatory drug; CME = cystoid macular edema; CF = counting fingers; PRK = photorefractive keratectomy

aNo improvement with manifest refraction.
Case 2: Flap Opacity From Corneal Dystrophy Exacerbation After LASIK

A 36-year-old man presented with diffuse opacities concentrated where LASIK ablation had been performed at an outside facility (Figure 3). He had a significant history of phenotypic granular corneal dystrophy undiagnosed until approximately 2 years after LASIK. The patient underwent flap amputation in the left eye (Video 1 and Figure 4), with initial improvement but eventual regression 2 years later, at which time he underwent phototherapeutic keratectomy in the left eye and ultimately flap amputation in the right eye. On his most recent follow-up examination 5 years after presentation, corrected acuity was 20/30 and 20/40, respectively, topography showed a thin residual cornea with relatively normal curvature (Figure B, available in the online version of this article), and the patient was functional and satisfied with his acuity in spectacles.

Case 3: LASIK Flap Partial Melt With Opacity

A 53-year-old man was referred to the Emory University Cornea Service for management and presented with a partially melted LASIK flap (Figure 5) after prolonged topical nonsteroidal anti-inflammatory drug use (Acular 0.5%; Allergan, Inc., Irvine, CA) for recurrent cystoid macular edema following phacoemulsification with intraocular lens implantation. The patient also had pars plana vitrectomy for a rhegmatogenous retinal detachment in the right eye after cataract surgery. After stabilizing the ocular surface with nonsteroidal anti-inflammatory drug cessation, aggressive lubrication, and topical cyclosporine (Restasis; Allergan, Inc.), the opacity appeared primarily localized to the flap (Figure 6). Flap amputation was performed, after which the patient was fitted with a rigid gas permeable contact lens and achieved a corrected distance visual acuity of 20/25.

Flap Amputation for Irregular Astigmatism

Case 4: Irregular Astigmatism After Photorefractive Keratectomy on Flap

A 55-year-old woman presented with bilateral eye pain and blurred vision. She initially underwent LASIK with successful monovision correction, followed years...
later by cataract extraction with Crystalens intraocular lens (Bausch & Lomb, Rochester, NY) implantation bilaterally at an outside facility. Due to an incorrect surgical plan, monovision was inadvertently reversed. She did not tolerate this, requested refractive correction, and underwent photorefractive keratectomy (PRK) re-treatment over both LASIK flaps (also at an outside facility). This resulted in pain and blurred vision bilaterally. On presentation to our clinic, she had moderate corneal haze, right eye worse than left, and topography showed central steepening with irregular astigmatism in the right eye (Figure 7) and regular astigmatism in the left eye. Anterior segment optical coherence tomography revealed an irregular flap that varied in thickness from 140 to 180 µm in the right eye, but was otherwise unremarkable. She was unsuccessful with rigid gas permeable contact lens trial and ultimately underwent flap amputation in the right eye. Despite increased myopia from increased central corneal steepening after amputation, her topographic steepening was more normalized (Figure 7), she felt her uncorrected near acuity had functionally improved, her pain had resolved, and she was satisfied with her outcome.

**CASE 5: IRREGULAR ASTIGMATISM AFTER PRK ON FLAP**

A 62-year-old man underwent hyperopic LASIK to treat approximately +6 diopters of sphere in the right eye and approximately +4.00 sphere in the left eye 2 years earlier, followed by hyperopic LASIK enhancement in the left eye 1 month later, two additional hyperopic PRK treatments in the right eye, and one PRK treatment in the left eye combined with limbal relaxing incisions (all at an outside facility). On presentation, he had dense superficial central corneal haze in the right eye and moderate haze in the left eye, with 2+ to 3+ nuclear sclerotic cataracts in both eyes. Anterior segment optical coherence tomography showed a residual stromal bed of 310 to 340 µm in the right eye and 330 µm in the left eye, with a notable midperipheral opacity in the right eye that appeared to extend through the flap to the anterior stromal surface (Figure 8). Corneal topography showed irregular astigmatism in both eyes (Figure 9). A flap amputation was performed in the right eye. During the case on lifting the flap it was noted that portions of the peripheral flap were absent, most likely due to surface ablation that had extended through the flap thickness (Video 2, available in the online version of this article). After flap amputation, the patient had significant improvement in visual acuity, significantly decreased central corneal haze, and improved regularity on topography (Figure 9). The patient subsequently underwent cataract extraction with toric IOL placement, which resulted in 20/25 final uncorrected acuity in the right eye.

**CASE 6: IRREGULAR ASTIGMATISM FROM MULTIPLE FLAP LIFTS**

A 57-year-old woman underwent bilateral LASIK complicated by recurrent epithelial ingrowth with several flap lifts and scrapes, all performed at an outside facility. On presentation, she had epithelial ingrowth present at the flap edge in both eyes, with visual axis involvement in the right eye, a significant nuclear sclerotic cataract in her right eye, and a posterior chamber intraocular lens in her left eye. Topography revealed...
irregular astigmatism with inferior steepening in the right eye, with the overall pattern consistent with hyperopic ablation (Figure 10).

An additional flap lift and scrape with suturing of the flap was performed on the right eye. After the procedure, there was no recurrence of epithelial ingrowth; however, irregular astigmatism increased and corrected distance visual acuity worsened to 20/80. The patient subsequently underwent flap amputation in the right eye. After amputation, topography exhibited increased central steepening compared to initial presentation (Figure 10); however, central corneal power was less irregular and the patient felt her acuity was slightly improved. The patient subsequently underwent cataract extraction and attained a final acuity of 20/40 with manifest refraction of plano +2.00 × 160 in the right eye.

**DISCUSSION**

These cases demonstrate the use of LASIK flap amputation for atypical flap complications, including flap opacities or induced irregular astigmatism, in highly selective situations that were not amenable to more conservative measures. The technique for LASIK flap amputation is easily performed and usually well tolerated. However, it does require close follow-up and monitoring for postoperative infection, haze, and astigmatism management.

LASIK flap amputation has been described for cases of severe infectious keratitis, central flap necrosis, and persistent epithelial ingrowth. Kymionis et al. described a case of a 55-year-old woman who presented with flap melt and epithelial ingrowth, in which two attempts at flap lift and epithelial ingrowth removal were attempted and failed. Their patient eventually underwent flap amputation with phototherapeutic keratectomy and mitomycin C with a successful outcome.

For patients with corneal opacity in the central visual axis partially or fully confined to the LASIK flap, amputation may be of benefit in decreasing the overall opacity. In these cases (cases 1, 2, and 3) from our series, there were no major topographic irregularities induced after flap amputation. The etiology of opacity in case 1 remains unclear because it was an atypical presentation for any infectious organism. Patients with corneal stromal dystrophies (case 2) should not have LASIK because this often exacerbates their clinical course. It remains uncertain if the benefits of flap amputation...
will be transient or long lasting for this patient because the dystrophy is likely to recur to some degree.

For irregular astigmatism without opacity, the choice to amputate the flap is more challenging because irregular astigmatism may also arise from flap amputation. The LASIK flap is theoretically a refractively neutral entity; however, there is some controversy on this topic. Earlier generation microkeratomes were shown to induce higher-order aberrations distinct from excimer laser ablation.\(^3,4\) McLeod et al. found that irregular astigmatism after flap amputation may occur if the initial flap creation was irregular in depth, thus creating an irregular stromal bed curvature that was functionally masked by the same curvature on the undersurface of the flap but uncovered by amputation.\(^12\) Modern microkeratomes and femtosecond laser create more uniform, planar flaps\(^3,14\) and recent reports have found equivalent visual outcomes between surface ablation and LASIK\(^2\) and between wavefront-optimized or wavefront-guided LASIK for most patients.\(^15\) This suggests that these flaps have minimal optical impact and therefore may be more amenable to amputation when necessary. Results may vary more for older flaps or those created with older generation microkeratomes, and this should be taken into consideration when planning amputation.

In many instances of irregular astigmatism induced by flap healing/positioning, simple flap lift and repositional will often be sufficient. However, this was not adequate in case 6 and amputation was deemed necessary for corneal regularization prior to ultimate rehabilitation after cataract extraction. In cases 4 and 5, the irregularity was induced on the flap surface with PRK ablation; thus, flap lift alone was unlikely to improve surface regularity.

There are several modalities available to correct residual astigmatism (regular or irregular) after LASIK flap amputation, including further laser ablation.\(^16\) Corneal remodeling occurs for several months after the procedure\(^4\); therefore, an additional laser procedure, such as PRK, should not immediately follow the flap amputation.\(^9\) Phototherapeutic keratectomy may be performed to smooth corneal irregularities caused by variations in corneal thickness, which can improve refractive outcomes. The epithelium has a tremendous capacity to compensate for irregular curvature\(^7,18\); thus, direct epithelial measurements will benefit direct determination of stromal surface topography to guide optimal therapeutic ablations and may improve outcomes.\(^20\) Mitomycin C can reduce haze formation after surface ablations. Its role in therapeutic ablations is less clear.

Each of our patients had one or multiple attempts to correct the underlying flap issue prior to undergoing LASIK flap amputation. Most of our cases had decreased irregular astigmatism after flap amputation; however, in cases 4 and 6, increased steepening, increased irregular astigmatism, or both were present after amputation (Figures 7 and 10). Due to the potential for increasing irregularity in addition to complications related to epithelial defect formation, we recommend conservative treatment prior to proceeding with flap amputation in all non-infectious cases.

Flap amputation may be a viable option for select patients with LASIK flap complications refractory to more conservative measures. At this time, we do not advocate that flap amputation be used as the initial procedure of choice for LASIK flap complications; however, it can be useful for difficult cases not responding to other first-line treatments.

**REFERENCES**


Figure A. Case 1: Placido topography of the right cornea shows irregular astigmatism (A) after flap lift and irrigation prior to flap amputation, with a truncated bowtie with focal steepening centrally (B) after amputation topographic regularity improved. OD = right eye.

Figure B. Case 2: Scanning-slit image (Orbscan II; Bausch & Lomb, Tucson, AZ) showing a relatively normal anterior curvature (keratometric map, lower left corner) with significant corneal thinning (thickness map, lower right corner) after flap amputation. OD = right eye.