Wavefront aberrometry and refractive outcomes of flap amputation after laser in situ keratomileusis

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Laser in situ keratomileusis flap amputation was performed in 3 eyes of 2 patients because of flap melt and surface irregularity. In the first patient, a 34-year-old man, flaps were excised after a photorefractive keratectomy retreatment procedure on a previous LASIK flap had been done, secondary to steroid-induced interlamellar keratitis, progressive melt, and irregularity of the corneal surface. In the second patient, a 52-year-old man, the LASIK flap in the right eye was repeatedly treated for epithelial ingrowth. The patient developed herpetic keratitis and a flap melt, which had to be amputated. In all 3 eyes, amputation of the LASIK flap resulted in relatively good uncorrected distance visual acuity and corrected distance visual acuity.

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Although laser in situ keratomileusis (LASIK) is an effective and usually uneventful procedure to correct myopia, it may have vision-threatening complications. Many of these are related to the LASIK flap.1,2 Flap melt can cause scarring and opacification of the underlying corneal bed and result in corneal haze ectasia and surface irregularities with decreased corrected distance visual acuity (CDVA).3 Amputation of the LASIK flap remnant will allow epithelialization of the stromal bed with a smoothing effect on the surface and may solve some problems associated with irregularly melted LASIK flaps.3

Flap amputation has been reported relatively rarely in the literature and may be underreported. Only a few recent case reports are available.1–6 However, we have not found reports of the use of wavefront aberrometry after LASIK flap amputation.

In our case series, we add the wavefront aberrometry data to the previously published cases. McLeod et al.7 reported that the refractive and topographic outcomes after flap amputation indicate that there is a risk for refractive change and induction of irregular astigmatism.

CASE REPORTS

Case 1

A 34-year-old man was referred to our center with acute severe bilateral visual loss after photorefractive keratectomy (PRK) as a revision of a previous LASIK treatment in both eyes. The initial LASIK treatment for myopia of unknown magnitude had been done 4 months earlier. Soon after retreatment, the visual acuity decreased and was treated with antibiotics and steroids for what we presume to have been a steroid-induced interlamellar keratitis. About a week after initiation of the treatment, the patient was referred to our center. Previous data were incomplete, and we were unable to obtain more data from the treating ophthalmologist.

Examination of the right cornea showed epithelial edema and several epithelial islands. Diffuse opacification and thickening of the LASIK flap was seen; the central 2.5 mm
was elevated compared with the rest of the LASIK flap. There was also an opacity of 2.5 mm × 5.5 mm at the midperiphery of the flap.

The left cornea showed central necrosis of 4.3 mm × 5.5 mm. This was accompanied by displacement of the flap, severe flap edema, and corneal melting with thinning of the flap at the edges (Figure 1). In addition, the flap was almost entirely detached from the surface. It was decided to amputate the flap in the left eye, which was done 5 months after the initial LASIK procedure. After the amputation, honeycomb-like scarring of the anterior stroma was visible. This scarring is different from the haze seen after photorefractive procedures (Figure 2). Before flap amputation, the uncorrected distance visual acuity (UDVA) was 0.5/60 with a refraction of +1.50 –0.25 × 140.

Before flap amputation, the patient was treated with preservative-free dexamethasone 0.1% 3 times a day and ofloxacin 0.3% 4 times a day in both eyes and oral acetazolamide 125 mg 3 times a day. The dexamethasone was continued until 2 months postoperatively. After amputation, the refraction was +3.75 –6.50 × 105 with a UDVA of 0.25 and a CDVA of 0.63.

In the right eye, after 1 month of treatment, the UDVA was 0.25 and the CDVA was 0.8. As a result of the flap melt, the edge of the remaining part of the flap passed through the pupillary axis causing astigmatism and monocular diplopia.

Wavefront aberrometry (Zywave, Technolas Perfect Vision GmbH) after the flap amputations showed an increase in the total root mean square (RMS) compared with that in the healthy human eye. The total HOA values and the vertical and horizontal aberrations in both eyes are shown in Table 1. In the right eye, the total HOAs comprised primarily vertical and horizontal trefoil and horizontal coma aberrations. In the left eye, it comprised primarily horizontal coma.

**Case 2**

A 52-year-old man had uneventful bilateral LASIK performed elsewhere for myopia of +2.0 in the right eye and +3.0 in the left eye. Information available on the primary treatment, which took place several months earlier, stated that myopic LASIK treatment was done using the Hansatome keratome with a 160 µm footplate (Bausch & Lomb) for creation of the flap and the Bausch & Lomb 217 laser with the Keracor nomogram.

Shortly after the LASIK procedure, epithelial ingrowth developed in the right eye. Two attempts to remove the ingrowth by the referring surgeon were unsuccessful. Visual acuity was severely impaired because of visual axis obscuration by epithelial ingrowth.

The epithelial ingrowth was treated by us by removing the epithelium on and peripheral to the LASIK flap. In the same procedure, the flap was lifted and the ingrowth on the underside of the flap and the stromal bed was mechanically removed. A phototherapeutic keratectomy (PTK) was also performed, and the LASIK flap was replaced and glued using a fibrin sealant (Tisseeal, Baxter). A bandage contact lens was applied and removed 7 days postoperatively. Topical prednisolone acetate 0.5% and tobramycin 0.3% were instilled 4 times a day and tapered. The postoperative UDVA was 0.8.

One month after successful treatment of the epithelial ingrowth, the patient felt discomfort in the right eye and decided to treat himself with dexamethasone and tobramycin eyedrops that were left from one of the previous

### Table 1. Wavefront aberrometric data in the 3 eyes. Total RMS was increased in all eyes; a definite pattern of 1 predominant aberration could not be found.

| Measurement                      | Case 1 Right Eye | Case 1 Left Eye | Case 2 Right Eye |
|---------------------------------|-----------------|----------------|-----------------|
| WF diameter (mm)                | 8.20            | 8.19           | 6.32            |
| Total HOA (WF diameter 6.0 mm)  | 3.57            | 1.92           | 4.60            |
| Vertical trefoil                | –0.93           | 0.31           | –1.28           |
| Vertical coma                   | 0.33            | 0.27           | 1.76            |
| Horizontal coma                 | 0.48            | –0.74          | 0.56            |
| Horizontal trefoil              | 0.60            | –0.17          | 0.30            |

HOA = higher-order aberration; WF = wavefront

For this reason, 15 months after the LASIK procedure, it was decided to amputate the flap. A bandage lens was placed after flap amputation to promote the healing process and reduce discomfort until there was complete corneal epithelial closure. After amputation, the UDVA was 0.4 and the CDVA was 1.0. After 2 years of follow-up, the CDVA was 1.0 in the right eye and 0.7 in the left eye.

### Figure 1
Left cornea prior to the LASIK flap amputation. Edema and areas of corneal melting can be seen with lucent areas of the LASIK flap. The central cornea is highly irregular and opacified.

### Figure 2
Left cornea after amputation of LASIK flap. Honeycomb-like scarring of the anterior stroma is visible.
treatments. He experienced increased discomfort and pain as well as deterioration of his vision. When the patient returned to our center several days later, there was an evident geographic ulcer related to herpetic keratitis in the right eye and the inferior half of the flap had melted. The UDVA in the right eye was 0.1 and the CDVA was 0.5.

Oral valacyclovir 1000 mg 3 times a day was started, and the steroids were stopped. The herpetic keratitis resolved and left the patient with a linear scar through the pupillary axis (Figure 3). At that time, the UDVA was 0.4 and the CDVA was 0.8 with monocular diplopia.

As contact lens correction did not provide relief from the double vision due to the linear scar, it was decided to amputate the flap; this was 4 years after the initial LASIK procedure. After the amputation, the UDVA was 0.5 and the CDVA was 1.0.

Wavefront aberrometry after the flap amputation showed an increase in the total RMS compared with that in the healthy eye. The total HOA value is shown in Table 1. Most of the increases were seen in vertical trefoil and vertical and horizontal coma aberrations.

**DISCUSSION**

Flap amputations are rarely reported after LASIK. Reasons for scant reporting can only be surmised: possibly underreporting and its relatively rare occurrence.

Kymionis et al. presented a case report of a 23-year-old woman with post-LASIK keratitis due to atypical mycobacteria in the left eye. The reported CDVA in this eye was 3/60 (decimal 0.05) before treatment. Three months after corneal collagen crosslinking, flap amputation, and limited PTK, the UDVA was 20/35 (decimal 0.63).

Kamiya et al. reported a patient with infectious keratitis and subsequent lamellar flap necrosis after LASIK, which did not respond to antibiotic therapy.

The CDVA in the eye was 0.01. One month after excision of the flap and further treatment with antibiotics, the visual acuity improved to 0.7. However, a hyperopic shift of +3.0 diopters (D) remained.

Garcia-Gonzalez et al. reported a case of diffuse lamellar keratitis (DLK) after LASIK retreatment in 1 eye. Prednisolone therapy and flap lifting with stromal bed irrigation did not resolve the problem. The UDVA was then 0.05. After flap amputation and, 4 months later, a customized transepithelial PRK, the UDVA improved to 0.8; there was no refractive error 3 months after the PRK.

In our 3 eyes in which LASIK flaps were therapeutically amputated, UDVA and CDVA were relatively preserved after amputation. Flap amputation might have smoothed the corneal surface and therefore enabled visual improvement. This improvement was sufficient as the patients were satisfied with their vision, notwithstanding residual refractive error and increased HOAs.

McLeod et al. report the topographical and refractive outcomes of flap amputation in 2 cases. The visual and topographic results in our cases are in concordance with the report of McLeod et al., ie, vision was relatively preserved despite the flap amputation. In addition, we obtained wavefront aberrometry data that showed highly aberrated eyes, with a possible trend toward increased coma and trefoil aberrations. No specific pathognomonic pattern could be discerned. The flap amputations were clinically and visually well tolerated. All 3 eyes had a residual cylinder of −1.75 to −2.5 D. The flap amputation appeared to cause an asymmetric biomechanical effect, leading to this kind of asymmetry. The anatomy of the normal cornea can be related to this phenomenon as normally the horizontal and vertical diameters in the cornea are different. The LASIK flap is a circular flap, so it is to be expected that there is a different effect in both meridians.

The rarity of this complication and the lack of registries or centralized treatment of severe complications make it hard to gather data and knowledge about occurrences such as we describe. A central registry has been available to refractive surgeons in Europe for only a few years. Actually until now, all data on refractive surgery complications have come from case reports and review articles, not from registries. It is impossible to know the true incidence of flap amputations, but the rarity of peer-reviewed reports supports the notion that flap amputations are a rare event, which may be clinically tolerated better than expected.

In conclusion, LASIK flap amputations may be necessary after flap melts secondary to steroid-induced interlamellar keratitis, DLK, or flap infections.
The results of such amputations show a small hyperopic shift with myopic astigmatism in some cases, with relatively preserved uncorrected and corrected visual acuity. In the 3 eyes we report, a hyperopic shift was expected to occur but was not detected. Flap amputation seems to have a more benign visual effect than expected. However, paucity of data make a definite conclusion impossible.

REFERENCES
1. Gimbel HV, Anderson-Penno EE, Van Westenbrugge JA, Ferensowicz M, Furlong MT. Incidence and management of intraoperative and early postoperative complications in 1000 consecutive laser in situ keratomileusis cases. Ophthalmology 1998;105:1839–1847; discussion by TE Clinch, 1847–1848
2. Stulting RD, Carr JD, Thompson KP, Waring GO III, Wiley WM, Walker JG. Complications of laser in situ keratomileusis for the correction of myopia. Ophthalmology 1999;106:13–20
3. McLeod SD, Holsclaw D, Lee S. Refractive, topographic, and visual effects of flap amputation following laser in situ keratomileusis. Arch Ophthalmol 2002;120:1213–1217. Available at: http://archopht.jamanetwork.com/data/Journals/OPHTH/6826/ECR0902.pdf. Accessed November 27, 2013
4. Kymionis GD, Kankariya VP, Kontadakis GA. Combined treatment with flap amputation, phototherapeutic keratectomy, and collagen crosslinking in severe intractable post-LASIK atypical mycobacterial infection with corneal melt. J Cataract Refract Surg 2012;38:713–715
5. Kamiya K, Kasahara M, Shimizu K. A case of intractable infectious keratitis and subsequent flap necrosis after laser in situ keratomileusis. Clin Ophthalmol 2009;3:523–525. Available at: http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2754083/pdf/opth-3-523.pdf. Accessed November 27, 2013
6. Garcia-Gonzalez M, Gil-Cazorla R, Teus MA. Surgical flap amputation for central flap necrosis after laser in situ keratomileusis. J Cataract Refract Surg 2009;35:2018–2021
7. Dawson DG, Ubels JL, Edelhauser HF. Cornea and sclera. In: Levin LA, Nilsson SFE, Ver Hoeve J, Wu SM, eds, Adler’s Physiology of the Eye, 11th ed. Edinburgh, Scotland, Saunders/Elsevier, 2011;73

OTHER CITED MATERIAL
A. European Registry of Quality Outcomes for Cataract and Refractive Surgery. Available at: http://www.eure quo.org. Accessed November 27, 2013