Visual quality improvement in refractive surgery
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STRAYLIGHT MEASUREMENTS BEFORE AND AFTER REMOVAL OF EPITHELIAL INGROWTH
ABSTRACT

In 3 eyes with epithelial ingrowth after laser in situ keratomileusis, straylight was measured before and after the ingrowth was removed. In 2 eyes of 1 patient, epithelial ingrowth reached the pupillary axis. Straylight decreased (improved) significantly after ingrowth removal: a 3.6-fold decrease in the right eye and a 10-fold decrease in the left eye. The uncorrected distance visual acuity (UDVA) improved from 0.25 (20/80) in both eyes to 1.0 (20/20) and 0.8 (20/25), respectively. In 1 eye of another patient, from which epithelial ingrowth was removed to prevent flap melting and distortion, the pupillary opening was not obscured and no significant change in straylight was found. The UDVA improved from 0.32 (20/60) to 1.0 (20/20) after the ingrowth was removed. An increase in straylight can be a significant complication of epithelial ingrowth. After the interlamellar space is cleared, the improvement in straylight is several factors larger than the gain in UDVA.

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INTRODUCTION

Epithelial ingrowth is a well-known complication of lamellar corneal surgery. It occurs in 1% to 20% of laser in situ keratomileusis (LASIK) procedures.\(^1\,^2\) Most epithelial ingrowth is self-limited and has no or minimal consequences on visual acuity. In 1% to 1.7% of cases, it is more persistent and extensive and may reach the visual axis or lift the flap and cause irregular astigmatism and flap melting.\(^1\,^3\) Visual acuity is usually compromised in these cases. The ingrowth has to be surgically removed to preserve the corneal integrity and improve visual acuity.

Straylight corresponds to the light that enters the eye but does not reach the retina in a focused manner. It forms a veil of light that is scattered over the retina by intraocular structures such as the cornea, lens, iris, and other intraocular media.\(^4\) Straylight is a parameter of quality of vision. It describes disability glare from light sources. This parameter often correlates well with complaints about quality of vision after refractive surgery procedures, even if visual acuity is 1.0 (20/20) or better.\(^5\,^6\,^7\)

The C-Quant straylight meter (Oculus Optikgeräte GmbH) measures straylight in an objective but functional manner.\(^8\) It provides direct information about optical imperfections as the cause of glare disability. Glare disability is the reduction in visual performance caused by a glare source, which causes retinal contrast degradation secondary to intraocular straylight. The most common example is an oncoming headlight as a glare source, causing a contrast loss that leads to the patient not able to see an object (such as a car) in front of her or him. The C-Quant determines straylight according to the internationally accepted definition (Commission Internationale d’Eclairage [CIE]). Straylight is a functional measure of the effect of light spreading over the retina, introduced as the CIE definition for “disability glare.” The amount of straylight is expressed as straylight parameter \(s\). We studied the effect of removing intralamellar epithelial ingrowth on quality of vision as determined by straylight values.\(^4\,^6\,^9\,^12\)

![Figure 1](image1.png)  
**Figure 1.** Case 1, left eye: Preoperative image of the epithelial ingrowth shows encroachment on the pupil. The photograph is underexposed as the glare disability made it difficult for the patient to cooperate.

![Figure 2](image2.png)  
**Figure 2.** Case 1, left eye: At 6 months interface and flap edges are clean.
METHODS

In this prospective case series of 3 treated eyes, the tenets of the Helsinki Agreement were adhered to. After informed consent was given, the clinically significant epithelial ingrowth in post-LASIK eyes were treated. Topical anesthesia was applied using oxybupivacaine and tetracaine eyedrops 3 times at 5-minute intervals. The eyes were swabbed with povidone–iodine 5% solution, which was also instilled in the fornices for 2 minutes. The eyes and lashes were draped with tape. Using a blunt instrument, the epithelium was removed 2.0mm from the central and peripheral edge of the LASIK flap to 2.0mm beyond the edge of the ingrowth radially. The flap was then lifted with a blunt forceps. The epithelial ingrowth was removed in one movement from the stromal bed or the underside of the LASIK flap using a forceps. Remnants were identified and removed. Alcohol 20% was applied to the stromal interlamellar surface, which was then rinsed with balanced salt solution (BSS).

The LASIK flap was irrigated and replaced, and the flap edges were replaced using slight pressure from Weck-Cel spears (Medtronic Xomed, Inc.). The flap was allowed to adhere for 2 to 3 minutes while BSS drops were instilled on top of the flap. Fibrin glue was then applied at the flap edge, covering the central and peripheral flap edge. The glue was allowed to dry for several minutes. The extent of the glue was checked with a spear; where necessary, excess glue was removed with a Vannas scissors. A bandage soft contact lens soaked in gentamicin 0.4% was placed on the cornea.

Postoperatively, the patients received preservative-free chloramphenicol 0.4% and prednisolone 0.5% eyedrops hourly for the first 24 hours and an oral analgesic agent. The drops were tapered over subsequent days. The bandage contact lens was removed on postoperative day 7 in both cases.

Straylight was measured in undilated pupils with the C-Quant straylight meter as part of the perioperative protocol. Internal quality parameters of reliability expected standard deviation and quality had to be lower than 0.08 and higher than 0.5, respectively.

CASE REPORTS

Case 1
A 52-year-old woman presented with complaints of gradual visual loss and foreign-body sensation in both eyes. She had had LASIK for myopia in the Dominican Republic 3 years previously but could not provide the preoperative and postoperative refractions and visual acuity measurements.

Right Eye
At presentation, the uncorrected distance visual acuity (UDVA) was 0.25 (20/80) and the corrected distance visual acuity (CDVA) was 0.63 (20/30) with a refraction of plano —2.00 x 145. Slitlamp examination revealed epithelial ingrowth laterally in the flap with a communicating channel that was visible with fluorescein staining. Otherwise,
the ocular examination was normal. A decision to remove the epithelial ingrowth was made because of the complaint of visual loss and the communication with the interlamellar space, although this was not extensive. One procedure sufficed. The UDVA and CDVA gradually improved, with clear corneal flaps and no recurrence of the ingrowth after 10 weeks (Table 1). Straylight was very high at intake but improved after epithelial removal (Table 1); at 6 months, the improvement factor was 3.6. The 6-month value was slightly higher than normal levels for the patient's age.

Table 1: Case 1: Changes in visual acuity, refraction, and log (s) in both eyes from before epithelial ingrowth removal to 6 months postoperatively.

<table>
<thead>
<tr>
<th>Date</th>
<th>Right Eye</th>
<th>Left Eye</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>UDVA</td>
<td>CDVA</td>
</tr>
<tr>
<td>Intake</td>
<td>0.25</td>
<td>0.63</td>
</tr>
<tr>
<td>Postop (mo)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>0.8</td>
<td>0.8</td>
</tr>
<tr>
<td>6</td>
<td>1.0</td>
<td>1.0</td>
</tr>
</tbody>
</table>

CDVA = corrected distance visual acuity; UDVA = uncorrected distance visual acuity.

**Left Eye**

At presentation, the UDVA was 0.25 (20/80) and the CDVA was 0.63 (20/30) with a refraction of plano -3.00 x 60. Slitlamp examination showed a dense plaque of ingrowth in the interlamellar space of the LASIK flap. The ingrowth was dense and looked persistent, lacking the characteristic bubbly appearance of epithelial cysts. The ingrowth encroached on the visual axis (Figure 1). The extent and density of the ingrowth, which clearly caused the visual complaints, were the indications for removal. The ingrowth proved persistent. On postoperative day 3, the patient removed the bandage contact lens and rubbed her eye. This may have played a role in the recurrence that occurred subsequently. Two more procedures were needed to halt the process. Five months after the third procedure, the UDVA and CDVA had improved and the cornea was clear with a clear interface. At the interface, an “imprint” of where the ingrowth plaque had been could be discerned but no ingrowth was left (Figure 2). Straylight improved from preoperatively to 6 months, an improvement factor of 10. The 6-month value was within the normal range for this age.

**Case 2**

A 48-year-old woman presented with a residual refractive error after LASIK for myopia of -3.50 -1.00 x 130 in the right eye in 2002. Regression had stabilized at a UDVA of 0.4 (20/55) and a CDVA of 1.0 (20/20) with a correction of -1.25 -0.75 x 179. The flap in the right eye was lifted and an ablation performed for the above correction. One day postoperatively, the UDVA was 0.8 (20/25); at 1 week, it was 1.0 (20/20) and
the CDVA was 1.25 (20/15) with a correction of +0.75 -0.50 x 20. At 1 month, the patient complained of worse vision. The UDVA was 0.32 (20/60), and the CDVA was 1.3 (20/17) with a refraction of +1.75 sphere. Epithelial ingrowth up to 2.0 mm from the periphery of the flap and flap striae were seen at the inferior aspect of the flap. The epithelial ingrowth was removed because of progression, decreased UDVA, and the onset of flap melting peripherally. The pupillary axis and its overlying cornea were not affected. The surgical procedure was identical to that described.

Postoperatively, visual acuity improved gradually (Table 2). The patient is satisfied with the result in the right eye. Although the myopic LASIK treatment in the left eye also regressed, she is happy with monovision. The refraction in the left eye is -1.25-0.5x 174 with a CDVA of 1.0 (20/20); the uncorrected near visual acuity is 1.0 (20/20). Straylight measurement was repeated once at each examination. Table 2 shows the log(s) values before retreatment of the residual myopia, immediately before epithelial ingrowth removal, and 6 weeks and 5 months after ingrowth removal.

Table 2: Case 2: Change in visual acuity, refraction, and log (s) from before the enhancement procedure to 5 months after epithelial ingrowth removal.

<table>
<thead>
<tr>
<th>Date</th>
<th>UDVA</th>
<th>CDVA</th>
<th>Refraction</th>
<th>Log(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before Enhancement</td>
<td>0.4</td>
<td>1.0</td>
<td>+1.25-0.75x180</td>
<td>0.85</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.92</td>
</tr>
<tr>
<td>Before Removal</td>
<td>0.32</td>
<td>1.3</td>
<td>+1.75</td>
<td>1.13</td>
</tr>
<tr>
<td>Postop:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6 weeks</td>
<td>0.9</td>
<td>-</td>
<td>-</td>
<td>1.13</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1.18</td>
</tr>
<tr>
<td>5 months</td>
<td>1.0</td>
<td>1.1</td>
<td>+0.75</td>
<td>1.09</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1.09</td>
</tr>
</tbody>
</table>

CDVA = corrected distance visual acuity; UDVA = uncorrected distance visual acuity

DISCUSSION

Epithelial ingrowth is a phenomenon encountered in 1% to 20% of LASIK procedures. Most lesions are self-limited and may disappear with time. Some need surgical intervention. The indications for surgical intervention are a communicating channel that persists (a fistula), melting of the LASIK flap, irregular astigmatism with loss of visual acuity, and obscuration of the visual axis. In the 3 eyes presented, removal of epithelial ingrowth improved UDVA significantly and CDVA to a small extent. Straylight behaved quite differently. In the 2 eyes with ingrowth reaching the pupillary axis (Case 1), straylight increased significantly. When it is compared with the normal values at 50 years of age of about log(s) =1.0, the increase is close to a factor of 10. This a very disabling level. Straylight was significantly reduced after the interface was cleaned by physically removing the epithelial ingrowth. The epithelial ingrowth with
its secondary local changes impedes the proper passage of light through the cornea and increases straylight. Clearing the media, in this case the cornea, contributed to a reduction (ie, improvement) in straylight that was greater than the improvement in Snellen visual acuity. This difference between straylight and visual acuity has also been reported for age-related changes in the crystalline lens. The opposite can also be observed in the aging crystalline lens. The relative independence of these 2 functional aspects of vision in relation to media changes can be partly understood on the basis of the underlying optics of the ocular media. Changes of a refractive nature (aberrations) influence visual acuity but not straylight. Small irregularities (order of magnitude in the micron range) influence straylight but not visual acuity.

The eye in Case 2 illustrates the opposite effect. We did not see much change in straylight with the onset or removal of the epithelial ingrowth, the plausible explanation being that the indication for removal of the ingrowth was keratolysis, melting of the flap edges. The central part of the cornea was not covered by ingrowth. Analysis and statistical testing (repeated measures analysis of variance) showed significant difference between the sessions (P=.003). However, the repeated measures standard deviation that can be calculated for this patient from the dataset is exceptionally good (0.03 log units) compared with published values (around 0.07 log units). Also, given the normal spreading within the population of 0.1 log units, the differences between the sessions are limited. This means the minimal changes in straylight are real and not significant.

Straylight is a parameter of visual quality. It is usually not increased after LASIK procedures. In this case series, we show that central epithelial ingrowth may increase straylight to highly disabling levels. Its removal decreases straylight values to values comparable to those in the rest of the population. The straylight values were reproducible with repeated measuring. In conclusion, straylight is an important functional measure to consider when evaluating epithelial ingrowth. More study is needed to delineate the cause and effect relationships between epithelial ingrowth, flap surface irregularity, and straylight. Currently, clearing the interface and a more normal adherent fit of the LASIK flap to the residual stromal bed seem to be effective in reducing straylight values.
REFERENCES