Change in Corneal Sensitivity and Corneal Nerve after Cataract Surgery

Ji Hyun Kim, MD,*† Jae Lim Chung, MD, MBA,*† Sung Yong Kang, MD,*† Sun Woong Kim, MD,*† and Kyoung Yul Seo, MD, PhD*†

Purpose: To compare corneal sensitivity and recovery of corneal innervation between temporal and superior clear corneal incisions in cataract surgery.

Methods: We compared the change in corneal sensitivity in patients with cataract who had received phacoemulsification using either temporal clear corneal incisions (group 1) or superior clear corneal incisions (group 2). The changes were measured at 1 week, 1 month, and 3 months after surgery using the Cochet–Bonnet esthesiometer. For a different study population, changes of corneal sensitivity in 25 eyes of 20 patients and corneal nerve density with confocal microscopy in 20 eyes of 20 patients who had undergone cataract surgery were also assessed. All parameters were measured preoperatively and at 1 week, 1 month, and 3 months after surgery.

Results: There was a significant decrease in sensitivity at the incision site in both groups. At 3 months after surgery, corneal sensitivity mostly recovered to preoperative values. Although postoperative change in corneal sensitivity showed similar patterns in both groups, group 1 showed a larger decrease. At temporal clear corneal incision sites, there was significantly decreased sensitivity at 1 week and 1 month postoperatively. However, corneal sensitivity returned to the preoperative levels by 3 months. Confocal microscopy revealed that at 1 week, 1 month, and 3 months after cataract surgery, subbasal nerve density was significantly reduced to 4113 ± 1421, 3470 ± 1498, and 4198 ± 1239 μm²/mm², respectively.

Conclusions: Corneal sensitivity after cataract surgery returned to near preoperative levels by 3 months before complete restoration of normal corneal innervation. Regeneration of subbasal nerve fibers determined by confocal microscopy seems to require more time than the return of corneal sensation after cataract surgery.

Key Words: cataract surgery, confocal microscopy, corneal sensitivity, subbasal nerve density

(Cornea 2009;28(Suppl. 1):S20–S25)
corneal incision in cataract surgery. We also compared changes of corneal sensitivity in temporal and superior corneal incisions after cataract surgery.

**MATERIALS AND METHODS**

**Patients**

We measured and compared changes of corneal sensitivity in patients with senile cataract who had undergone cataract surgery using either temporal clear corneal incisions (group 1) or superior clear corneal incisions (group 2). The changes were measured at 1 week, 1 month, and 3 months after surgery by esthesiometer.

All patients had a complete ophthalmologic examination before surgery to assure a normal cornea and anterior segment. Patients with previous ocular surgery, topical ophthalmologic treatment, glaucoma, and diabetes were excluded. The study was approved by the Institutional Review Board of Yonsei University, Severance Hospital, and followed the principles of the Declaration of Helsinki for research involving human subjects. Appropriate informed consent was obtained from each patient.

**Surgical Procedures**

The same surgeon (K.Y.S.) performed all phacoemulsification and intraocular lens implantation procedures using topical anesthesia. A 3-mm clear corneal incision (temporal or superior, approximately 2.0 mm from the limbus, 300-μm depth) was made using a surgical knife. The surgical technique consisted of phacoemulsification and aspiration through a clear corneal incision followed by foldable intraocular lens (AR40e, Sensar; AMO, Santa Ana, CA or SI40NB, PhacoFlexII; AMO) implantation into the capsular bag. At the conclusion of surgery, the incision wound was sealed by stromal hydration without sutures. All procedures were performed without intraoperative and postoperative complications.

**Corneal Sensitivity**

Corneal sensitivity was measured preoperatively and at 1 week, 1 month, and 3 months postoperatively by Cochet–Bonnet esthesiometer (Luneau Ophthalmology, Chartres, France). The instrument consists of a nylon filament 6.0 cm long and 0.12 mm in diameter. The force exerted by the filament when it touches the cornea is inversely proportional to its length. Results are presented as centimeters of length of the nylon filament, with 6.0 cm being maximum sensitivity of the cornea and 0 cm corneal anesthesia at that point tested. To minimize bias, all measurements were taken by the same experienced examiner. Measurements were taken at 5 different locations of the cornea: the 4 quadrants of the cornea (superior, inferior, nasal −2 mm from the limbus, and temporal −1 mm from the temporal incision site) and at the corneal center. The filament was smoothly moved toward the cornea at a perpendicular angle. Contact was detected by slight bending in the filament. If there was no patient response to the first contact, the length of filament was decreased by 0.5 cm to increase its rigidity, and the procedure repeated until the patient reported feeling corneal contact. The filament was maintained perpendicular to the cornea at all times. The longest filament length at which a minimum of 3 stimulus applications produced a positive response from the patient was recorded; this was considered the corneal touch threshold.

**Corneal Nerve Density**

Cornea subbasal nerve density was estimated preoperatively and 1 week, 1 month, and 3 months postoperatively by NIDEK ConfoScan 4.0 confocal microscope (NIDEK Technologies Srl, Albignasego, Italy), equipped with an Acrophlan (Zeiss, Oberkochen, Germany) ×40 immersion objective lens, with a working distance of 1.98 mm and motorized focusing device. The patient was seated in front of the microscope while fixating on a bright blue target inside the instrument to minimize eye movement during examination. One drop of ViscoTears gel (0.2% acido poliacrilico; CIBA Ophthalmicus, Marcon, Italy) was applied onto the objective tip to serve as immersion fluid. Baseline macrometric alignment was made manually by the operator, who moved the x-ring adapter to temporal cornea (1 mm from the temporal incision). The focal plane is automatically moved to reach the anterior chamber and begins scanning and recording of corneal images. The instrument recorded video frames at 25 frames per second as the focal plane scanned from posterior to anterior through the cornea. The step distance between frames was 12 μm; scans were repeated until 350 frames were captured. Each cornea was scanned 3 times repeatedly. Subbasal nerves were defined as all visible nerve fiber bundles anterior to Bowman layer. One experienced investigator measured the total length of all visible subbasal nerves at each examination. Each nerve was measured only once; however, if its length extended across several images, the total length was measured as if it were projected onto 1 image. Subbasal nerve density was calculated as the total length of nerves (μm) divided by the area of the image (0.168 mm², 460 × 365 μm) and expressed as the total length of nerve fibers traced per image area (μm/mm²).

**Statistical Analysis**

Wilcoxon signed rank test was used to compare corneal sensitivity and corneal nerve density over time. P values <0.05 were considered statistically significant. All statistics were calculated with SPSS version 12.0 (SPSS, Inc, Chicago, IL).

**RESULTS**

In group 1, a total of 25 eyes of 20 patients (mean age, 67.2 ± 8.6 years) who had preoperative against-the-rule astigmatism or ≤1.25 diopters with-the-rule astigmatism underwent cataract surgery between October 2001 and March 2002 using temporal clear corneal incisions. In group 2, 25 eyes of 23 patients (mean age, 63.0 ± 6.7 years) who had preoperative >0.5 diopters with-the-rule astigmatism underwent cataract surgery between June and November 2003 using superior clear corneal incision.

Corneal sensitivity was measured in 25 eyes of 20 patients [mean age (range) 67.2 (55–81) years] who underwent cataract surgery between October 2001 and March 2002. We estimated the corneal subbasal nerve density using confocal microscopy from 20 eyes of 20 patients [mean age (range)
TABLE 1. Preoperative and Postoperative Corneal Sensitivity (Group 1, Temporal Incision)

<table>
<thead>
<tr>
<th>Location</th>
<th>Preoperative</th>
<th>1 wk</th>
<th>1 mo</th>
<th>3 mo</th>
</tr>
</thead>
<tbody>
<tr>
<td>Center</td>
<td>56.80 ± 3.50</td>
<td>55.80 ± 3.50</td>
<td>56.60 ± 3.45</td>
<td>56.80 ± 3.50</td>
</tr>
<tr>
<td>Superior</td>
<td>54.40 ± 3.63</td>
<td>54.00 ± 3.54</td>
<td>54.40 ± 3.63</td>
<td>54.40 ± 3.63</td>
</tr>
<tr>
<td>Temporal</td>
<td>56.40 ± 3.39</td>
<td>29.80 ± 2.69†</td>
<td>42.40 ± 4.36†</td>
<td>56.00 ± 2.89</td>
</tr>
<tr>
<td>Inferior</td>
<td>55.60 ± 4.16</td>
<td>55.60 ± 4.16</td>
<td>55.80 ± 4.00</td>
<td>55.80 ± 4.00</td>
</tr>
<tr>
<td>Nasal</td>
<td>56.60 ± 3.14</td>
<td>56.40 ± 3.39</td>
<td>56.60 ± 3.45</td>
<td>56.60 ± 3.14</td>
</tr>
</tbody>
</table>

*P = 0.057; †P < 0.05 versus preoperative value.


The preoperative corneal sensitivity of all locations found in this study was in the range of previously reported normal values; the central cornea was most sensitive. Mean corneal sensitivity of central cornea was 56.80 ± 3.50 mm, and of temporal cornea was 56.40 ± 3.39 mm. One week after surgery, there was a statistically significant reduction in corneal sensitivity on the temporal incision area in group 1 (Table 1; Fig. 1). The most depleted corneal sensitivity was found on the temporal area 1 week postoperatively. The reduction in corneal sensitivity persisted even after 1 month; thereafter, corneal sensitivity improved to baseline level 3 months after surgery. There was a slight reduction of corneal sensitivity in central cornea 1 week after surgery, although this was not significant compared with the preoperative level (P = 0.057), and recovered to the preoperative level at 1 month after surgery. There was no significant change of corneal sensitivity on other parts of the cornea.

Similarly, there was a statistically significant reduction of corneal sensitivity on the superior incision area 1 week postoperatively in group 2 (Table 2; Fig. 2). The most depleted corneal sensitivity was found on the superior area 1 week postoperatively. The reduction of corneal sensitivity persisted even after 1 month; corneal sensitivity improved to baseline levels 3 months after surgery. There was a reduction of corneal sensitivity on the central cornea 1 week after surgery (P = 0.043) but recovered to the preoperative level at 1 month after surgery. There was no significant change of corneal sensitivity on other parts of the cornea.

Comparison of percent change of corneal sensitivity between the 2 groups at different locations is summarized in Table 3. Although there was no difference between the 2 groups in central cornea, there was a significant difference at the incision area at 1 and 3 months after surgery (Fig. 3).

Subbasal nerve densities of 20 eyes around the temporal incision site before and after cataract surgery are shown in Figures 4 and 5. At 1 week, 1 month, and 3 months after cataract surgery, subbasal nerve density was significantly reduced by 77%, 67%, and 79%, respectively, when compared with preoperative values (P < 0.001, P < 0.001, and P = 0.038, respectively). Subbasal nerve density gradually decreased until 1 month postoperatively, then improved but did not recover to the preoperative level until 3 months after surgery. We detected a discrepancy between recovery of cornea sensitivity and time of corneal reinnervation, as shown in Figure 6.

**DISCUSSION**

Modern cataract surgical procedures require a corneal incision to enter the intraocular chamber and disrupt normal
TABLE 3. Percent Change of Corneal Sensitivity* in the 2 Groups

<table>
<thead>
<tr>
<th>Location</th>
<th>Group</th>
<th>1 wk</th>
<th>1 mo</th>
<th>3 mo</th>
</tr>
</thead>
<tbody>
<tr>
<td>Center</td>
<td>1</td>
<td>-1.72</td>
<td>0.03</td>
<td>-0.33</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>-1.50</td>
<td>-0.32</td>
<td>0</td>
</tr>
<tr>
<td>Incision site</td>
<td>1</td>
<td>-47.2t</td>
<td>-24.8t</td>
<td>-0.56</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>-39.5t</td>
<td>-19.2t</td>
<td>-0.72</td>
</tr>
</tbody>
</table>

*Defined as [(postoperative value - preoperative value)/(preoperative value)] × 100.
†P < 0.05 (group 1 vs group 2; paired t test).

Table 3 shows the percent change of corneal sensitivity in the 2 groups over different time periods. The values are calculated as the percentage difference between postoperative and preoperative sensitivity levels, normalized by the preoperative value.

The table indicates that the initial decrease in corneal sensitivity is more pronounced in the incision site group (group 1) compared to the superior incision group (group 2) at 1 and 3 months postoperatively. However, the postoperative change in corneal sensitivity showed similar patterns and recovered to preoperative levels 3 months after surgery in both groups.

FIGURE 3. Comparison of corneal sensitivity between group 1 and group 2.

Corneal sensitivity after cataract surgery can take >2 years to return to preoperative levels after extracapsular cataract surgery. Kohlhass et al.7 showed that there is a distinctive decrease in corneal sensitivity not only at the incision site but also in remote areas after superior scleral incisions. They emphasized that the circumcorneal network of nerve fibers may have an important role in recovery after surgery. Corneoscleral dissection may disturb the circumcorneal nerve network, in which bundles of nerves with myelin assemble before entering the cornea; this disruption may affect corneal sensitivity over a long time.

Improvements in cataract surgery techniques over recent decades have made it possible to decrease the size of the incision. These techniques have resulted in improved prognosis for visual acuity, less risk for surgically induced astigmatism, reduced incidence of postoperative inflammation, faster wound healing, and shorter postoperative rehabilitation.22-24 Small-incision procedures such as phacoemulsification would be expected to cause less reduction in corneal sensitivity in comparison with refractive surgeries and extracapsular cataract extraction. However, it is also possible that corneal incision may cut the base of the corneal nerve and worsen corneal sensitivity because the subbasal nerve encounters the cornea from the limbal side—mainly from the temporal and nasal quadrants. Kadonosono et al21 reported profoundly reduced corneal sensitivity after corneal incision compared with scleral incision. More recently, Sitompul et al.9 showed that temporal corneal incision significantly decreased corneal sensitivity compared with manual SICS.

Despite minimal corneal involvement, reduction of corneal sensitivity was seen postoperatively in this study. We observed that clear corneal incision reduced corneal sensitivity confined to the surgical area until 1 month postoperatively, and corneal sensitivity recovered to preoperative levels 3 months after surgery.

We also observed that there is a difference in the change of corneal sensitivity at the incision area according to the incision site. Reduction of corneal sensitivity at the incision area was larger in the temporal incision group (group 1) than in the superior incision group (group 2) at 1 and 3 months postoperatively. However, the postoperative change in corneal sensitivity showed similar patterns and recovered to preoperative levels 3 months after surgery in both groups.

Muller et al12 reported that large nerve fibers run in the 9- to 3-o'clock direction and bifurcate several times in such a way that homogeneous distribution of nerve endings over the central and paracentral cornea is achieved. Therefore, nerve damage in the temporal or nasal quadrants may disturb corneal sensitivity of the central cornea. However, there was no significant reduction of corneal sensitivity on the central cornea in our study.

Erie et al15 found that corneal subbasal nerve density does not recover to near preoperative densities until 5 years after LASIK and 2 years after PRK, demonstrating that the corneal nerves that are lost during refractive surgeries very slowly regenerate over a long time.

Our investigation demonstrated that, after cataract surgery, nerve density of the surgical incision site, as it appeared in confocal microscopy, recovers slowly; the
subbasal nerve layer did not completely recover to the preoperative level by 3 months, although it slightly improved from 1 month postoperatively. In our study, at 3 months after cataract surgery, corneal sensation was recovered to near normal level, whereas subbasal nerve density did not recover to the preoperative level. This discrepancy suggests that morphological recovery of corneal innervation may take a longer time than recovery of corneal sensation.

Previous studies by Bragheeth and Dua identified that lamellar cutting of the cornea during LASIK impairs corneal sensitivity, and the return of corneal sensations does not directly correlate with regeneration of nerve fibers as determined by confocal imaging. Sensations may return to normal values before complete restoration of normal innervation; this is consistent with our finding. Another possible explanation is that partial recovery of nerves to the central cornea may be sufficient to show normal corneal sensitivity by Cochet–Bonnet esthesiometer. Furthermore, although fine epithelial nerves from subbasal nerve plexus have important roles in actual corneal sensation, they are unreliably imaged by confocal microscopy because of their fine structure.

Tervo et al reported that intraepithelial nerve terminals for the central cornea in the rabbit eye regenerated 3 months after PRK. This finding supports the possibility that intraepithelial nerves may recover to a density that is adequate to normalize Cochet–Bonnet esthesiometry at a time when subbasal nerve recovery is still incomplete.

Our study suggests that special concern for wound healing after cataract surgery is crucial for all patients—especially those with abnormal corneal sensation. Wound care should be started immediately after surgery for ≥3 months. Smaller incisions should be considered for patients with decreased corneal sensations. Monitoring and adjustments of corneal toxic eyedrops are needed, and autoserum eyedrops can be used in some patients.

Our study also suggests that 3 months of care would not be enough for recovery of corneal sensation. It is possible that the Cochet–Bonnet testing method may lack sensitivity to detect complete neural recovery. Most normal subjects respond to the lowest stimulus provided by Cochet–Bonnet esthesiometer. If the lowest stimulus from this device is above the normal threshold, then a positive response to this stimulus may not truly represent complete neural recovery.

This study had some limitations, including the short time of assessment and small sample size. Furthermore, the 2 study groups were independent of each other, and we could not evaluate the correlation between corneal sensitivity and nerve density.

In conclusion, our study found that corneal sensitivity after cataract surgery returned to near preoperative levels by...
3 months before complete restoration of normal corneal innervation. Therefore, regeneration of subbasal nerve fibers as determined by confocal microscopy requires more time than the return of corneal sensation after cataract surgery. Further studies are needed to show the correlation between recovery of corneal sensitivity and reinnervation after cataract surgery.

REFERENCES