Corneal Topographic Analysis by 3-Dimensional Anterior Segment Optical Coherence Tomography after Endothelial Keratoplasty

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PURPOSE. To investigate the characteristics of the corneal topography with three-dimensional (3-D) anterior segment optical coherence tomography (AS-OCT) following Descemet’s stripping automated endothelial keratoplasty (DSAEK).

METHODS. Thirty-four eyes of 33 patients following DSAEK were studied. In addition to conventional topographic maps, the elevation map of the intrastromal interface and pachymetric maps of the host and graft were obtained by corneal topographic analysis using 3-D AS-OCT. The coefficient of variation of the corneal power (CV-Pa, CV-Pp) and root mean squares of the corneal elevation (RMS-Ea, RMS-Ep) of the anterior and posterior corneal surfaces were determined. Based on the combination of the regularity and irregularity of the anterior and posterior surfaces, subjects were classified into four types: type 1, regular/regular; type 2, irregular/regular; type 3, regular/irregular; and type 4, irregular/irregular.

RESULTS. The average graft decentration was 0.59 ± 0.23 mm. The proportion of types 1, 2, 3, and 4 were 59%, 9%, 24%, and 9%, respectively. The CV-Pa (25.8 ± 8.9) and CV-Pp (−73.9 ± 18.0) of the type 1 corneas were significantly better than that of type 2 and type 3 corneas, respectively. The RMS-Ea (5.1 ± 1.3) and RMS-Ep (26.0 ± 7.5) of the type 1 corneas were significantly better than that of type 2 and type 3 corneas.

CONCLUSIONS. An OCT-based corneal topographer might be useful in determining the factors associated with optical quality of the cornea following DSAEK by analyzing the topographic characteristics of host and donor separately.


Corneal transplantation has evolved from conventional penetrating keratoplasty (PKP) to selective lamellar keratoplasty, such as deep anterior lamellar keratoplasty (DALK) and endothelial keratoplasty. Descemet’s stripping automated endothelial keratoplasty (DSAEK) consists of a selective replacement of a patient’s diseased or dysfunctional endothelium with a graft of the posterior stroma and endothelium from a donor cornea. DSAEK reduces the risk of traumatic wound dehiscence, endothelial rejection, postoperative refractive errors, and suture-related complications that can occur after PKP. It also has a faster recovery time.1-4

Various corneal topographers are available that can determine whether irregular astigmatism is present and can measure the corneal thickness during the preoperative period and even in the early postoperative period because they are noncontact instruments.5,6 Since corneal topographers became more common and color-coded topographic maps could be created, information about the entire corneal surfaces could be obtained at a glance and used for a qualitative analysis of the corneal shape.7 In addition, quantitative analyses of the corneal surfaces could also be obtained by using several parametric descriptors in the corneal topographers, and the information would be helpful for follow-up examinations.7,8

Placido ring-based corneal topographers and slit-scanning corneal topographers are conventional instruments used for analyzing the corneal shape, and they can examine only the anterior surface or the anterior and posterior surfaces of the cornea. However, assessing the degree of highly irregular corneas is not easy with these topographic instruments, as they are not able to analyze the topography of each intracorneal section (e.g., the host and donor parts) separately after lamellar corneal surgery.

Optical coherence tomography (OCT) was initially developed to obtain cross-sectional images of the retina noninvasively,9 and anterior segment OCT (AS-OCT) became available for imaging the anterior ocular segment later.10 Today, AS-OCT is used to obtain images of the anterior segment for diagnosing and following corneal diseases before and after treatments. Several studies have used the 1310-nm, time-domain (TD) OCT to assess the complications and evaluate the total or donor corneal thickness after lamellar keratoplasty.11-14 With the TD-OCT, the speed of the measurements is 2000 A-scans/second, and the vertical resolution is 18 μm. For corneal scans of the TD-OCT, up to four radial cross-sectional images are obtained and 512 A-scans/image are taken with a scan acquisition time of 0.25 seconds/image.12

Three-dimensional (3-D) AS-OCT, which is based on swept-source OCT technology, was recently introduced.15 With the 3-D AS-OCT instrument, higher-resolution cross-sectional images can be obtained at speeds higher than that of TD-OCT; and 3-D images of the anterior segment can be reconstructed from the individual images. An OCT-based corneal topographer with 3-D...
AS-OCT is available. It is believed that analyses of the anterior and posterior parts of the lamellar keratoplasty separately after DSAEK using the OCT-based corneal topographer have not been reported.

The newly introduced OCT-based corneal topographer is developing and has analysis programs that are not all automatic, but require manual operation for part of the analyses as discussed in detail later. Therefore, this is just a preliminary study. The purpose of this study was to investigate the characteristics of the corneal topography following DSAEK. To accomplish this, 3-D AS-OCT was used to analyze the anterior host part and the posterior graft part separately.

**Subjects and Methods**

Thirty-four eyes of 33 patients (10 men, 23 women; average age: 72.5 ± 7.8 years) who had undergone DSAEK in Osaka University Hospital’s Department of Ophthalmology were studied. The Institutional Review Board of Osaka University Hospital approved this study. The procedures used conformed to the tenets of the Declaration of Helsinki. An informed consent was obtained from all subjects after explanation of the nature and possible consequences of the study.

Of the 34 eyes, 11 eyes (32%) had pseudophakic bullous keratopathy; 11 eyes (32%) had bullous keratopathy following laser iridotomy; 5 eyes (15%) had Fuchs corneal endothelial dystrophy; 5 eyes (15%) had cytomegalovirus-induced corneal endothelitis; 1 eye (3%) had bullous keratopathy following trabeculectomy; and 1 eye (3%) had bullous keratopathy following keratouveitis.

Three experienced surgeons (YH, TI, NM) performed the DSAEK procedures as described. Surgery was performed under local anesthesia. The donor tissue was precut with a microkeratome equipped with a 500-μm (29 eyes) or 350-μm (5 eyes) head, and the precut donor tissue was cut with a 7.5- to 8.0-mm diameter punch. The host endothelium and the Descemet’s membrane were punched out corresponding to the corneal epithelial trephine mark. Then, the donor cornea was inserted into the anterior chamber using the taco technique (8 eyes) or the pull-through technique (26 eyes). Of the 26 eyes that used the pull-through technique, 21 eyes used a Busin glide and 5 used a Tan glide. Sutures with 10-0 nylon were used to close the 5.0-mm sclerocorneal incisions. Air was injected into the anterior chamber to press the donor tissue against the recipient cornea and corneal fenestrations were performed to drain the interface fluid. Finally, approximately one-half of the anterior chamber air was removed and replaced with balanced salt solution.

Thirty-eight eyes of 38 normal subjects (18 men, 20 women; 54.8 ± 9.9 years) without any ocular diseases or surgeries except for refractive errors were studied as controls.

**OCT-Based Corneal Topographer**

The OCT-based corneal topographic analyses were performed with a 3-D AS-OCT (SS-1000 CASIA; Tomey Corporation, Inc., Nagoya, Japan) that had a newly developed computer program embedded in the instrument. The AS-OCT was developed based on swept-source OCT, which is a subtype of the Fourier-domain OCT. The light source of the AS-OCT was a wavelength scanning laser with a center wavelength of 1310 nm. This longer wavelength enabled a greater penetration of the laser beam into the ocular tissue than the conventional 830-nm OCT. The measurement speed was 30,000 A-scans/second. This instrument had a 10-μm resolution for a vertical line and 30-μm resolution for a horizontal line. For the OCT-based corneal topographer to analyze the corneal configurations, 16 radial cross-sectional images through the central 10-mm diameter of the cornea were obtained in 0.34 seconds. Each cross-sectional image consisted of 512 telecentric A-scans.

The 3-D AS-OCT measurements were made 1 to 29 months after the DSAEK (mean ± standard deviation; 10.1 ± 8.7 months). During the measurements, patients were instructed to keep both eyes open and to fixate the internal target. Each eye was scanned along the corneal vertex at least twice, and the better image was chosen by the examiner for the topographic analysis. Each scanned cross-sectional image was digitized automatically with respect to the location of the anterior and posterior corneal surfaces by the analysis program (Fig. 1 top, small green dotted line). However, the digitization of the corneal surface was frequently inaccurate around the edge of the graft because there was a discontinuity in the curvatures at the host-graft junction on the peripheral posterior cornea surface (Fig. 1 top, arrows). Therefore, only a part of the digitization of the peripheral posterior cornea surface was modified manually in all 16 cross-sectional images (Fig. 1 bottom, green crosses and yellow line). In addition, a line representing the interface between the host and graft was plotted manually (Fig. 1 bottom, blue crosses and yellow line) in all 16 cross-sectional images. The intervals between these two plotted points were connected automatically by curves with a cubic spline interpolation. For accurate analysis, more than 5 plots in the central 3-mm diameter and more than 11 plots in total of each corneal surface/image were used.

These processes were performed on all 16 cross-sectional images by the same operator (RH). The corneal configurations were reconstructed to produce the corneal topographic maps (i.e., elevation maps of the anterior, posterior, and interface surfaces), and the pachymetry maps of the anterior part, posterior part, and total corneal thickness were constructed. Based on the elevation information, the axial power maps of the anterior and posterior corneal surfaces were displayed. In the axial power maps, the corneal power was calculated by a circular approximation that fixed the center of curvature of the corneal vertex based on the data of each localized corneal shape. The Klyce/Wilson scale, extending from 28.0 to 65.5 diopeters (D) in 1.5-D intervals was used for the anterior axial power map, and a scale extending from 9.0 to 28.5 D in 1.5-D intervals was used for the posterior axial power map. The reference bodies for drawing the elevation maps were floated best-fit spheres with a 9-mm diameter. In
all elevation maps, the absolute scale was set at 10 μm intervals for the anterior, posterior, and interface.

For the pachymetry map, the corneal thickness in the direction perpendicular to the anterior corneal surface was determined. The absolute scale that extended from 340 to 840 μm in 20-μm steps was used for the pachymetry maps of the total and the host, and the graft scale was extended from 0 to 500 μm in 20-μm steps for the pachymetry map of the graft.

**Centration of Graft**

There was a distinct edge at the border of the peripheral posterior corneal surface at the host-graft junction after DSAEK. In the posterior elevation map, the points where the values changed from negative to positive (i.e., from blue to yellow in the scale color) were considered to be the margins of the graft. Using this map, the center of the graft was calculated by representing the portions of the graft margin at 0, 90, 180, and 270 degrees in polar coordinates.

Based on earlier reports, data from the left eyes were reversed at the median line and were vertical mirror images. As a result, positive “x” values were nasal and positive “y” values were superior for all eyes. In addition, the radial distances for each graft center from the vertex were calculated as the square root of (y² + x²).

**Classification of Corneas after DSAEK Based on Surface Regularity**

After DSAEK, the eyes were classified into four types based on the combination of the regularity of the anterior and posterior surfaces by two of the authors (RH and NM): type 1, regular/regular; type 2, irregular/regular; type 3, regular/irregular; and type 4, irregular/irregular (Fig. 2). The regularity of the surfaces was determined by the number of scale colors in the central 4 mm of the axial power map. Five colors or more for the anterior axial power map and four colors or more for the posterior axial power map were considered to be irregular in consideration of the control group that had four colors or less for the anterior axial color map and one color for the posterior axial color map. In addition, the causes for the irregularity of the axial power map of the anterior and/or posterior surfaces on types 2, 3, and 4 were determined.

**Topographic Indices**

Eight quantitative indices were used to evaluate the corneal topography. The coefficients of variation of the corneal power (CV-
Statistical Analyses

One-way analysis of variance (ANOVA) was used to determine whether differences in the values of topographic indices among the four groups were significant. The Kruskal-Wallis one-way ANOVA on ranks was used if the data were non-parametric. A $P < 0.05$ was considered significant for all analyses.

RESULTS

The position of the center of the donor graft with respect to the corneal vertex is shown in Figure 3. The average position of the graft center was $0.39 \pm 0.28$ mm temporal and $0.29 \pm 0.31$ mm inferior to the vertex. The average radial distance for each donor graft center from the vertex was $0.59 \pm 0.23$ mm.

![Image](https://via.placeholder.com/150)

**Figure 3.** The position of the center of the donor graft with respect to the corneal vertex is shown in Figure 3. The average position of the graft center was $0.39 \pm 0.28$ mm temporal and $0.29 \pm 0.31$ mm inferior to the vertex. The average radial distance for each donor graft center from the vertex was $0.59 \pm 0.23$ mm.

**Figure 4.** Representative type 1 case. Case of Fuchs' corneal endothelial dystrophy 6 months after DSAEK. Top: Slit-lamp photograph. Bottom: Output from an optical coherence tomography-based corneal topographer. The uniform power distribution in the 4-mm diameter center of the anterior (first column, left) and posterior (first column, right) axial power maps can be seen. The elevation map of the surface of the interface between the host and graft shows uniform distribution (second column, center). Both the host (bottom column, left) and the graft (bottom column, right) corneas are uniformly thick.

### Table 2: Corneal Topographic Indices of Types after Descemet’s Stripping Automated Endothelial Keratoplasty and Control Group

<table>
<thead>
<tr>
<th>Type</th>
<th>CV-P Anterior Surface (CV-Pa)</th>
<th>RMS-E Anterior Surface (RME-Ea)</th>
<th>CV-P Posterior Surface (CV-Pp)</th>
<th>RMS-E Posterior Surface (RMS-Ep)</th>
<th>CV-P Interface (RMS-Ei)</th>
<th>RMS-E Interface (RMS-Ei)</th>
<th>CV-T Host Thickness (CV-Ta)</th>
<th>RMS-E Graft Thickness (CV-Tp)</th>
<th>CV-T Total Thickness (CV-Tt)</th>
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<tbody>
<tr>
<td>Type 1</td>
<td>25.8 ± 8.9</td>
<td>5.1 ± 1.3</td>
<td>−73.9 ± 18.0</td>
<td>26.0 ± 7.3</td>
<td>8.9 ± 2.5</td>
<td>40.3 ± 11.9</td>
<td>72.8 ± 29.1</td>
<td>39.4 ± 11.4</td>
<td>52.8 ± 44.1</td>
</tr>
<tr>
<td>Type 2</td>
<td>53.1 ± 9.5</td>
<td>9.9 ± 1.9</td>
<td>−90.8 ± 30.4</td>
<td>33.9 ± 3.5</td>
<td>11.6 ± 4.9</td>
<td>50.3 ± 9.9</td>
<td>58.2 ± 19.4</td>
<td>43.6 ± 18.1</td>
<td>59.4 ± 17.4</td>
</tr>
<tr>
<td>Type 3</td>
<td>30.0 ± 3.2</td>
<td>5.7 ± 1.1</td>
<td>−208.3 ± 194.4</td>
<td>40.7 ± 13.2</td>
<td>13.4 ± 4.6</td>
<td>54.6 ± 15.9</td>
<td>108.6 ± 40.3</td>
<td>59.4 ± 17.4</td>
<td>76.5 ± 17.8</td>
</tr>
<tr>
<td>Type 4</td>
<td>44.6 ± 8.0</td>
<td>9.9 ± 0.6</td>
<td>−136.3 ± 48.9</td>
<td>60.3 ± 26.8</td>
<td>13.6 ± 2.5</td>
<td>67.1 ± 6.8</td>
<td>140.2 ± 49.8</td>
<td>76.5 ± 17.8</td>
<td>22.0 ± 5.3</td>
</tr>
<tr>
<td>Control</td>
<td>13.5 ± 3.9</td>
<td>3.1 ± 0.7</td>
<td>−23.3 ± 5.9</td>
<td>5.8 ± 1.9</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>22.0 ± 5.3</td>
<td>22.0 ± 5.3</td>
</tr>
</tbody>
</table>

CV-P, coefficient of variation of the corneal power; RMS-E, root mean square of the corneal elevation; CV-T, coefficient of variation of corneal thickness; N/A, not available.
Five eyes had an anterior synechia between the graft and iris. The average decentration of the donor graft in these five eyes was $0.67 \pm 0.18$ mm, which tended to be higher than the overall average. However, there was no significant difference in the average decentration of the donor graft between the five eyes and others without an anterior synechia.

Representative cases of the four types of corneas based on the surface regularity are shown in Figures 4 through 7. There were 20 eyes with type 1 (59%); 3 eyes with type 2 (9%); 8 eyes with type 3 (24%); and 3 eyes with type 4 (9%) corneas. The central thicknesses of the total cornea and of the graft are shown in Table 1. The causes for the irregularity of the axial power map of the anterior surfaces in types 2 and 4 were corneal edema (2 eyes); inferosuperior asymmetry (2 eyes); chronic changes associated with longstanding bullous keratopathy including melting of the stroma or fibrosis (2 eyes); and the influence of a trabeculectomy bleb (1 eye). In type 3 and type 4 corneas with irregular posterior corneal surface, the irregularity of the posterior corneal surface was caused by a decentration of the graft (6 eyes); folds in the graft (4 eyes); asymmetrical cut of the graft (2 eyes); and/or localized distortion due to peripheral anterior synechia (2 eyes).

The mean and SDs of the CV-Pa, CV-Pp, RMS-Ea, RMS-Ep, RMS-Ei, CV-Ta, CV-Tp, and CV-Tt values for types 1, 2, 3, and 4 and the control group are shown in Table 2 and Figures 8 through 10.

The differences of the mean CV-Pa among the four types were significant ($P < 0.001$). The CV-Pa in type 1 cornea was significantly lower than that in type 2 ($P < 0.001$) and type 4 corneas ($P = 0.003$, Tukey’s test; Fig. 8). Similarly, the CV-Pa in type 3 corneas was significantly lower than that in type 2 ($P < 0.001$) and type 4 ($P = 0.049$, Tukey’s test) corneas (Fig. 8).

The differences of the mean CV-Pp among the four types were significant ($P < 0.001$). The CV-Pp in type 1 corneas was significantly lower than that in type 3 corneas ($P < 0.05$, Dunn’s method; Fig. 8).

The differences of the mean RMS-Ea among the four types of corneas were significant ($P < 0.001$). In addition, the differences in the mean RMS-Ea of type 1 and type 3 corneas were significantly lower than those in type 2 and type 4 corneas ($P < 0.001$, Tukey’s test; Fig. 9). The differences of the mean RMS-Ep among the four types of corneas were significant ($P = 0.004$). The RMS-Ep in type 1 corneas was significantly lower than that in type 3 and type 4 corneas ($P < 0.05$, Dunn’s method; Fig. 9). The differences in the mean RMS-Ei among the different types of corneas were not significant (Fig. 9).

The differences in the mean CV-Ta among the four types of corneas were significant ($P = 0.004$). The mean CV-Ta in type 1 corneas was significantly lower than that in type 4 corneas ($P =$
The differences in the mean CV-Tp among the four types of corneas were significant \( (P = 0.003) \). The CV-Tp values in type 1 and type 2 corneas were significantly lower than that in type 4 corneas \( (P = 0.025, P = 0.014, \text{respectively}; \text{Tukey’s test}; \text{Fig. 10}) \). The differences of the mean CV-Tt among the four types of corneas were significant \( (P < 0.001) \). The CV-Tt in type 1 corneas was significantly lower than that in type 3 and type 4 corneas \( (P = 0.009, P = 0.001, \text{Tukey’s test}) \), and the CV-Tt in type 2 corneas was significantly lower than that in type 4 corneas \( (P = 0.035, \text{Tukey’s test}; \text{Fig. 10}) \).

**DISCUSSION**

Tang et al. were the first to measure the corneal power by AS-OCT.\(^{24}\) When both corneal surfaces were measured to determine the corneal power by TD-OCT, the repeatability was poor mainly due to motion errors because of the relatively slow scan speeds.\(^{24}\) Thus, the scan speed is a key factor in the corneal topographic analysis using OCT. The SS-OCT corneal topographer improved the scan speed tenfold over TD-OCT; the TD-OCT required 0.25 seconds to obtain one radial cross-sectional image, while the SS-OCT could obtain 16 radial cross-sectional images in 0.34 seconds. The reduction in the time led to clearer and more precise images.

OCT-based corneal topographic analyses after corneal lamellar surgery can show not only the conventional corneal power maps of the anterior and posterior surfaces, elevation maps of anterior and posterior surfaces, and the total pachymetry map, but also the elevation maps of the interface and pachymetry maps of the donor and host corneas (see Figs. 4–7). With OCT, topographic analysis can be performed even in discontinuous areas such as at the donor margin after DSAEK or even in the area of a severe scar, which is difficult to analyze using the conventional Placido ring-based corneal topographers or slit-scanning corneal topographers. Additionally, with OCT-based corneal topographers, the host and donor parts of the selective lamellar keratoplasty can be analyzed separately. This may make it possible to evaluate the effects of the host and donor parts on the optical quality of the cornea.

The centration of the donor graft in DSAEK calculated is based on the posterior pachymetry map, and the calculations of this study are the first to show the centration of the graft following DSAEK. The average radial decentration of the donor graft was 0.59 ± 0.23 mm, and it tended to be displaced temporally and inferiorly. However, the displacement was within 1 mm of the center except in one eye. Because of the peripheral thickening of the graft in DSAEK, the decentration of the donor graft may increase the risk of developing an anterior synechia between the graft and iris.\(^{12}\) An anterior

![Image](image-url)
synechia was found between the graft and iris in five of the cases in this study, and all of these eyes had a shallow anterior chamber or peripheral anterior synechiae.

Most patients had a regular anterior surface (type 1 and type 3—i.e., total 83%). Considering that DSAEK mainly affects the posterior corneal surface, it is reasonable that the anterior corneal surface is regular in most of the cases. Terry and Ousley reported improvements in the irregularity that was due to bullae after the deep lamellar endothelial keratoplasty (DLEK). The anterior surface regularities also need to be examined to determine how they improve after long follow-up periods, because the optical properties of the anterior corneal surface are significantly correlated with the visual acuity following DSAEK. For this, the OCT-based corneal topographer has an advantage in that the evaluations can be made even in a scarred cornea in which conventional corneal topographers had difficulty obtaining accurate measurements.

Because the posterior corneal surface is recreated by the donor graft in DSAEK, the posterior corneal surface tended to be irregular because of the decentration and shape of the donor graft. Even if the edges of the donor graft protruded posteriorly in the early postoperative periods, the posterior axial power map had two colors at a maximum in the central 4-mm diameter when the centering of the donor graft was good, as shown in Figure 4. When both an asymmetric cut and decentration of the donor graft were present, the posterior corneal surfaces tended to be irregular, as shown in Figure 6. As reported, the difference in thickness between the center and periphery of the DSAEK graft induced a change in the posterior corneal curvature, resulting in a hyperopic shift that decreased with time due to the differential thinning rates of the donor graft as more thinning occurs in the peripheral tissue. Thus, the classifications could change because of the alterations of the posterior corneal curvature with time.

The indices used in this study tended to be correlated with the classification. In type 1 and type 3 corneas with regular anterior corneal surfaces, the values for CV-Pa and RMS-Ea, which represent the anterior surface, were significantly lower than those in type 2 and type 4 corneas. Similarly, the values for RMS-Ep in type 1 and type 2 corneas tended to be lower than those in type 3 and type 4 corneas. The values for RMS-Ei were not significantly different for the four types of corneas. It is generally believed that there are no changes in the configuration at the interface with Descemet's stripping or adhesion of the donor graft. If a similar study were performed on patients after DLEK or Pre-Descemet's DALK, it would be possible to determine how the partial removal of posterior corneal stroma or asymmetric residual stromal bed affects the shape at the interface.

The mean CV-Tp value was higher than the CV-Ta and CV-Tt values, possibly because of a decentration and a steeper change in thickness of the graft, which became thicker from the center.

**Figure 7.** Representative type 4 case. Patient with bullous keratopathy from keratouveitis. Data collected 1 month after DSAEK. Top: Slit-lamp photograph showing stromal scar in the host cornea. Bottom: Output of an OCT-based corneal topographer. Steepening of the superior area and flattening of inferior area can be seen in the anterior axial power map (first column, left) and steepening can be seen in the posterior axial power map (first column, right). Asymmetric thickness profile and decentration of the donor graft can be seen (bottom column, right).
toward the edge of the graft. The high CV-Tp value might be reduced with time in Descemet’s membrane endothelial keratoplasty.

This study has some limitations. First, because this was a preliminary study, the range of follow-up period was high. This period included the early postoperative period when the suitability of the methodology of this OCT-based corneal topography after DSAEK was investigated. The number of cases was also small. Future investigations should include temporal changes according to the follow-up period after DSAEK. The pathologies of the indication for DSAEK were also variable because of the lower incidence of Fuchs’ corneal endothelial dystrophy. In addition, because the interface between the host and graft was plotted manually, the reliability

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**Figure 8.** Variation in the corneal power on the anterior and posterior corneal surfaces. The averages and standard deviations of coefficients of variation of corneal power of the anterior (CV-Pa, left) and posterior (CV-Pp, right) cornea surface for 4-mm corneas are shown. Left: The CV-Pa of type 1 corneas is significantly lower than type 2 and type 4 corneas (*P < 0.001 and †P = 0.003, respectively, Tukey’s test). The CV-Pa of Type 3 cornea is significantly lower than type 2 and type 4 at the anterior surface (‡P < 0.001 and §P = 0.049, respectively, Tukey’s test). Right: The CV-Pp of type 1 is significantly lower than type 3 at the posterior surface (*P < 0.001; Kruskal-Wallis test).

**Figure 9.** Variations in the elevation of the anterior, posterior, and interface surfaces of the cornea. The averages and standard deviations of the root mean squares of the corneal elevation of the anterior (RMS-Ea, left), posterior (RMS-Ep, center), and stromal interface between the host and the graft (RMS-Ei, right) of 4-mm diameter. Left: The RMS-Ea of type 1 and type 3 corneas is significantly lower than that of type 2 and type 4 at the anterior surface (*P = < 0.001; Tukey’s test). Center: The RMS-Ep of type 1 corneas is significantly lower than type 3 and type 4 corneas at the posterior surface (*P = 0.004; Kruskal-Wallis test). Right: There are no significant differences among the four types at the interface.
of the topographic maps might be reduced compared with those that are computed automatically. In the future, it’s deemed desirable to analyze all topographic maps automatically to apply interface topography in a clinical setting. However, this is the first report of the analyses of interface topography and the improvement of the methodology is expected in future.

In spite of these limitations, the results of this preliminary study suggest that OCT-based corneal topography may provide important information about the corneal shape before and after DSAEK.

References