Retinal Point-Spread Function after Corneal Transplantation for Fuchs’ Dystrophy

Loren S. Seery, Jay W. McLaren, Katrina M. Kittleson, and Sanjay V. Patel

PURPOSE. To determine the effect of corneal transplantation for Fuchs’ dystrophy and of recipient age on the large- and small-angle domains of the retinal point-spread function.

METHODS. Retinal stray light (large-angle domain) and the full-width-at-half-maximum intensity of the point-spread function (50% width, small-angle domain) were measured in 40 pseudophakic eyes after keratoplasty (Descemet stripping with endothelial keratoplasty [DSEK], 30 eyes; penetrating keratoplasty [PK], 10 eyes) for Fuchs’ dystrophy and in 30 otherwise normal pseudophakic eyes. Correlations were assessed between the optical variables, high-contrast visual acuity (HCVA), and recipient age, and variables were compared between groups by using generalized estimating equation models.

RESULTS. The 50% width was higher in pseudophakic eyes after DSEK or PK compared with otherwise normal pseudophakic eyes ($P < 0.001$) but did not differ between DSEK and PK ($P = 0.36$). After DSEK, HCVA correlated with the 50% width ($r = 0.47, P < 0.001, n = 29$) and stray light ($r = 0.41, P = 0.01, n = 30$), whereas after PK, HCVA correlated with the 50% width ($r = 0.77, P = 0.003, n = 10$) but not with stray light ($r = 0.01, P = 0.98, n = 8$). Stray light correlated with recipient age after DSEK ($r = 0.67, P < 0.001, n = 30$), but not after PK ($r = 0.35, P = 0.39, n = 8$), and not with age of otherwise normal pseudophakic eyes ($r = 0.32, P = 0.18, n = 29$).

CONCLUSIONS. The degradation of the small-angle domain of the point-spread function after DSEK suggests that aberrations contribute to decreased visual acuity after DSEK. The poorer optical properties of the eye with older recipient age after DSEK can be attributed to the retained host cornea. (Invest Ophthalmol Vis Sci. 2011;52:1003–1008 DOI:10.1167/iovs.10-5375)

Endothelial keratoplasty has replaced penetrating keratoplasty (PK) as the preferred method of corneal transplantation for endothelial cell dysfunction, including Fuchs’ endothelial dystrophy, with Descemet-stripping endothelial keratoplasty (DSEK) being the prevalent endothelial keratoplasty technique. The advantages of endothelial keratoplasty over PK include more predictable postoperative refractive errors and better uncorrected visual acuity. Nevertheless, best-corrected visual acuity after endothelial keratoplasty frequently is <20/20, and some patients complain of postoperative glare and poor contrast, indicating that quality of vision after endothelial keratoplasty does not return to normal.

Quality of vision can be explained in part by the retinal point-spread function, which is the image on the retina of an infinitely small object. Any image formed on the retina is the convolution of the point-spread function and an ideal image and determines the quality of the sensorineural input. The intensity of the point-spread function is highest at its center and decreases quickly with distance from the center. Image quality is determined by the shape of the point-spread function, with the best optical properties from a point-spread function with a high-intensity narrow peak and degraded non-sharp optical images associated with a point-spread function with a broader, lower-intensity peak. The shape of the point-spread function is determined by the optical system of the eye, and in pseudophakic eyes with the same type of intraocular lens, abnormalities of the cornea largely explain variations in the shape of the point-spread function.

Optical abnormalities can affect two regions of the point-spread function, the small-angle domain (<1° of the central peak) and the large-angle domain (>1° of the central peak). If low-order aberrations are eliminated by the use of best sphero-cylindrical corrections, as in this study, the small-angle domain is affected primarily by high-order aberrations that degrade the sharpness of retinal images, whereas the large-angle domain is elevated mainly by forward light scatter, or retinal stray light, that degrades the contrast of the retinal images.

In this study, we investigated the effects of DSEK and PK in pseudophakic eyes transplanted for Fuchs’ dystrophy on the large- and small-angle domains of the point-spread function by comparing with that of age-matched, otherwise normal pseudophakic eyes, and to that of young, normal eyes. We assessed the relationships between visual acuity and the point-spread function and between the point-spread function and recipient age after transplantation for Fuchs’ dystrophy. We also determined the relationship between the large- and small-angle domains of the point-spread-function in eyes with a broad range of optical degradation caused by corneal disease, cataract, DSEK, and PK.

METHODS

Subjects

Subjects were either volunteers or were recruited from patients attending the department of ophthalmology at Mayo Clinic, Rochester, MN. We recruited subjects to different groups according to their age, and their corneal and lenticular status, to capture eyes with presumably a broad range of effects on the point-spread function (Table 1). The groups included young patients with normal eyes, older pseudophakic patients with otherwise normal eyes, pseudophakic patients with Fuchs’ endothelial dystrophy, pseudophakic patients after PK or DSEK for Fuchs’ dystrophy, and patients with nuclear sclerotic cataracts. Subjects were excluded if they were diabetic, had glaucoma, had significant vitreous floaters or asteroid hyalosis, or if their vision was impaired because of maculopathy, optic neuropathy, or amblyopia. All
pseudophakic eyes had the same style of acrylic, spherical intraocular lens, with the exception of the PK group (10 eyes), in which eight eyes had polymethylmethacrylate (PMMA) spherical intraocular lenses, and two eyes had acrylic spherical intraocular lenses. Pseudophakic eyes were excluded if they had posterior capsular haze, or if intraocular lenses contained glistenings. All eyes in the DSEK group had grafts prepared by a mechanical microkeratome and were examined at 6 months after surgery; and eyes in the PK group were examined at a median of 49 months (range, 33–200 months) after surgery. This study complied with the Health Insurance Portability and Accountability Act, was approved by the Mayo Clinic institutional review board, and adhered to the tenets of the Declaration of Helsinki. Informed consent was obtained from all subjects after explanation of the nature and possible consequences of the study.

Large-Angle Domain

Effects on the large-angle domain of the point-spread function were determined by measuring retinal stray light. All eyes were examined by using a stray light meter (C-Quant; Oculus, Lynwood, WA), which is noninvasive and uses a psychophysical compensation comparison method that requires subjects to decide which presented half-field, one with and one without counterphase compensation light, flickers more strongly. Subjects followed a two-alternative forced-choice protocol that was under computer control to derive a stray light parameter. Forward light scatter was proportional to the stray light parameter and was expressed as the logarithm of the stray light parameter; all analyzed data were reliable, as defined by an expected SD of <0.1 log units, which was reported with each test. Subjects were measured with best-spherical equivalent correction.

Small-Angle Domain

The small-angle domain of the point-spread function was determined in all eyes using a retinal image quality analysis system (OQAS [Optical Quality Analysis System]; Vissiometrics, Terrassa, Spain). This system measures from the center to 36° (arcminutes) of the point-spread function by using a double pass of the ocular media. The instrument calculates several metrics of the point-spread function, and here we examined the full width of the point-spread function at 50% of peak intensity (50% width). Narrower widths correspond to better optical quality. All eyes were examined with best sphero-cylindrical correction to eliminate degradation of the point-spread function by low-order aberrations. The effective pupil size was 2 mm on the entrance path (fixed by the instrument) and 4 mm on the exit path.

Other Outcome Measures

Best-spectacle corrected high-contrast visual acuity (HCVA) was measured by using the electronic Early Treatment of Diabetic Retinopathy Study (ETDRS) testing protocol. Best-spectacle corrected low-contrast visual acuity (LCVA) was measured by using a 10% contrast ETDRS chart (Sloan Chart; Precision Vision, La Salle, IL) under photopic (screen brightness, 139 cd/m²) conditions. Letter scores were converted to logarithm of the minimum angle of resolution (log MAR) and Snellen equivalent.

### Table 1. Diagnoses of 135 Eyes of 92 Subjects

<table>
<thead>
<tr>
<th>Group</th>
<th>Number of Eyes (Subjects)</th>
<th>Age Range (y)</th>
<th>Cornea</th>
<th>Lens</th>
<th>Presumed Forward Scatter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>36 (18)</td>
<td>21–50</td>
<td>Normal</td>
<td>Phakic, normal</td>
<td>Lowest</td>
</tr>
<tr>
<td>Pseudophakia</td>
<td>30 (19)</td>
<td>55–83</td>
<td>Normal</td>
<td>IOL</td>
<td></td>
</tr>
<tr>
<td>PK</td>
<td>10 (9)</td>
<td>63–85</td>
<td>Clear graft</td>
<td>IOL</td>
<td></td>
</tr>
<tr>
<td>DSEK</td>
<td>30 (28)</td>
<td>42–85</td>
<td>Clear graft</td>
<td>IOL</td>
<td></td>
</tr>
<tr>
<td>Fuchs' dystrophy</td>
<td>16 (12)</td>
<td>61–85</td>
<td>Central guttae</td>
<td>IOL</td>
<td></td>
</tr>
<tr>
<td>Cataract</td>
<td>13 (9)</td>
<td>64–82</td>
<td>Normal</td>
<td>Nuclear sclerosis</td>
<td>Highest</td>
</tr>
</tbody>
</table>

### Table 2. Large- and Small-Angle Domains of the Point-Spread Function and Visual Acuity

<table>
<thead>
<tr>
<th>Group</th>
<th>Large-Angle Domain Stray Light Parameter (logarithm)*</th>
<th>Small-Angle Domain 50% Width (arcminutes)†</th>
<th>Visual Acuity (log MAR) [Snellen Equivalent]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>HCVA‡</td>
<td>LCVA‡</td>
<td></td>
</tr>
<tr>
<td>Normal, n = 36</td>
<td>1.06 ± 0.12</td>
<td>−4.4 ± 2.5</td>
<td>0.10 ± 0.05 [20/16] 0.15 ± 0.10 [20/28]</td>
</tr>
<tr>
<td>Pseudophakia, n = 30</td>
<td>1.28 ± 0.17†</td>
<td>−6.0 ± 2.9</td>
<td>0.09 ± 0.07 [20/18] 0.35 ± 0.22 [20/45]</td>
</tr>
<tr>
<td>PK, n = 10</td>
<td>1.53 ± 0.31†</td>
<td>−11.9 ± 4.6</td>
<td>0.10 ± 0.16 [20/25] 0.55 ± 0.18 [20/71]</td>
</tr>
<tr>
<td>DSEK, n = 30</td>
<td>1.40 ± 0.23</td>
<td>−12.5 ± 5.7†</td>
<td>0.24 ± 0.16 [20/35] 0.62 ± 0.20 [20/83]</td>
</tr>
</tbody>
</table>

All values are mean ± standard deviation. All variables were not significantly different between DSEK and PK, the minimum detectable difference for HCVA (P = 0.09) was 0.22 logMAR (α = 0.05/4, β = 0.20). HCVA, high-contrast visual acuity; LCVA, low-contrast visual acuity; log MAR, logarithm of the minimum angle of resolution.

* DSEK vs. pseudophakia, P = 0.02; PK vs. pseudophakia, P = 0.57; pseudophakia vs. normal, P < 0.001.
† DSEK vs. pseudophakia, P < 0.001; PK vs. pseudophakia, P < 0.001; pseudophakia vs. normal, P = 0.08 (minimum detectable difference was 2.5° (α = 0.05/4, β = 0.20).‡ DSEK vs. pseudophakia, P < 0.001; PK vs. pseudophakia, P < 0.001; pseudophakia vs. normal, P < 0.001.
§ n = 29 because the stray light measurement was unreliable in one eye.
|| n = 8 because the stray light measurement was unreliable in two eyes.
# n = 25 because the retinal image quality analysis system could not measure optical quality in five eyes after DSEK.

DSEK, Descemet stripping with endothelial keratoplasty; IOL, intraocular lens implant; PK, penetrating keratoplasty.
Statistical Analysis

The primary focus of this report was the differences in the point-spread function and visual acuity between normal, pseudophakic, PK, and DSEK eyes, and these were assessed by using generalized estimating equation (GEE) models to account for possible correlation between fellow eyes of the same subject. All P values were adjusted by the Bonferroni method for multiple comparisons, and P < 0.05 was considered statistically significant. Correlations between the point-spread function, visual acuity, and age were assessed by using Pearson correlation coefficients with significances calculated by using GEE models.

In addition, we determined the relationships between the large- and small-angle domains of the point-spread function by including data from all eyes to expand the range of optical degradation. We determined the repeatability of the large- and small-angle domain parameters by calculating the coefficient of variation (SD divided by the mean) of five measurements from 10 eyes; five eyes were normal and five eyes were abnormal (pseudophakic eyes with Fuchs’ endothelial dystrophy).

RESULTS

Large-Angle Domain

Stray light was higher in pseudophakic eyes after DSEK than in otherwise normal pseudophakic eyes (P = 0.02) and higher in pseudophakic eyes than in young normal eyes (P < 0.001; Table 2). Stray light did not differ between pseudophakic eyes after PK and otherwise normal pseudophakic eyes (P = 0.57) or between eyes after DSEK and eyes after PK (P = 0.46). Stray light was higher in pseudophakic eyes after PK than in normal eyes (P < 0.001). The average coefficient of variation of the retinal stray light parameter was 7% (Table 3). The stray light meter was unable to measure stray light (tests were unreliable) in five eyes (PK, two eyes; cataract, two eyes; pseudophakia, one eye).

Small-Angle Domain

The 50%-width was higher in pseudophakic eyes after DSEK or PK than in otherwise normal pseudophakic eyes (P < 0.001). The 50% width did not differ between otherwise normal pseudophakic eyes and young normal eyes (P = 0.08, Table 2); the minimum detectable difference was 2.3' (α=0.05/4, β=0.20). The 50% width did not differ between DSEK and PK (P = 0.36; Table 2).

When all eyes were combined to encompass a broad range of optical degradation, the 50% width correlated with the stray-light parameter (r = 0.43, P < 0.001, n = 123, Fig. 1). The average coefficient of variation of the 50% width was 9% (Table 3). The retinal image quality analysis system was unable to measure the point-spread function in eight eyes (DSEK, five

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**Table 3.** Repeatability of Variables of the Large- and Small-Angle Domains of the Point-Spread Function

<table>
<thead>
<tr>
<th>Subject</th>
<th>Group</th>
<th>Large-Angle Domain</th>
<th>Small-Angle Domain</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Stray Light Parameter (logarithm)</td>
<td>50% Width</td>
</tr>
<tr>
<td>1</td>
<td>Normal</td>
<td>0.004</td>
<td>0.06</td>
</tr>
<tr>
<td>2</td>
<td>Normal</td>
<td>0.15</td>
<td>0.14</td>
</tr>
<tr>
<td>3</td>
<td>Normal</td>
<td>0.10</td>
<td>0.03</td>
</tr>
<tr>
<td>4</td>
<td>Normal</td>
<td>0.05</td>
<td>0.04</td>
</tr>
<tr>
<td>5</td>
<td>Normal</td>
<td>0.17</td>
<td>0.09</td>
</tr>
<tr>
<td>6</td>
<td>Fuchs'</td>
<td>0.04</td>
<td>0.08</td>
</tr>
<tr>
<td>7</td>
<td>Fuchs'</td>
<td>0.10</td>
<td>0.11</td>
</tr>
<tr>
<td>8</td>
<td>Fuchs'</td>
<td>0.08</td>
<td>0.08</td>
</tr>
<tr>
<td>9</td>
<td>Fuchs'</td>
<td>0.02</td>
<td>0.09</td>
</tr>
<tr>
<td>10</td>
<td>Fuchs'</td>
<td>0.02</td>
<td>0.14</td>
</tr>
<tr>
<td>Mean ± standard deviation</td>
<td>0.07 ± 0.06</td>
<td>0.09 ± 0.04</td>
<td></td>
</tr>
</tbody>
</table>

**Figure 1.** Correlation between 50% width and retinal stray light. For all eyes, the 50% width (full width at half maximum intensity) correlated with the stray light parameter (r = 0.43, P < 0.001, n = 123). The retinal image quality analysis system was unable to measure the point-spread function in eight eyes (DSEK, five eyes; Fuchs’ dystrophy, two eyes; cataract, one eye); and the stray light meter was unable to measure stray light (tests were unreliable) in five eyes (PK, two eyes; cataract, two eyes; pseudophakia, one eye).
eyes; Fuchs’ dystrophy, two eyes; cataract, one eye, which was also not measurable by the stray light meter).

**Visual Acuity**

High- and low-contrast visual acuity were poorer in pseudophakic eyes after DSEK or PK than in otherwise normal pseudophakic eyes ($P < 0.001$), and in otherwise normal pseudophakic eyes compared with young normal eyes ($P < 0.001$; Table 2). HCVA and LCVA did not differ between DSEK and PK ($P = 0.09$; Table 2); the minimum detectable difference was 0.22 log MAR ($\alpha = 0.05/4$, $\beta = 0.20$).

When eyes from the normal, pseudophakic, DSEK and PK groups were combined, stray light and the 50% width were correlated with HCVA and LCVA (Fig. 2). After DSEK, HCVA correlated with the 50% width ($r = 0.48$, $P < 0.001$, $n = 25$) and with stray light ($r = 0.44$, $P = 0.01$, $n = 30$), whereas after PK, HCVA correlated with the 50% width ($r = 0.77$, $P = 0.003$, $n = 10$) but not with stray light ($r = 0.01$, $P = 0.98$, $n = 8$).

**Age and the Point-Spread Function**

The stray light parameter correlated with recipient age in subjects who had had DSEK ($r = 0.67$, $P < 0.001$, $n = 30$; Fig. 3), but not in subjects who had had PK ($r = 0.35$, $P = 0.39$, $n = 8$). Stray light did not correlate with age of the pseudophakic eyes ($r = 0.32$, $P = 0.18$, $n = 29$). There were no correlations between the 50% width and age in the DSEK, PK, or pseudophakia groups.

**DISCUSSION**

The first important finding from this study was that the small-angle domain of the retinal point-spread function was degraded after endothelial keratoplasty in addition to the large-angle domain. This suggests that, although the anterior surface of the cornea after DSEK is not disrupted as it is after PK, high-order aberrations are increased and might affect vision. The second important finding was that the optical properties of the eye correlated with recipient age after DSEK, suggesting that, in Fuchs’ dystrophy, there is an age-dependent effect of the retained host cornea on image quality.

**Large-Angle Domain after Keratoplasty**

Descemet stripping with endothelial keratoplasty has become the preferred method of corneal transplantation for Fuchs’ dystrophy, but vision after this procedure often does not return to normal. We previously found that forward scatter was increased after PK, DSEK, and deep lamellar endothelial keratoplasty (DLEK) compared with forward scatter in young normal (phakic) subjects. In the present study, we confirmed that forward scatter was higher than in otherwise normal pseudophakic eyes after DSEK, although not after PK. Increased forward scatter after endothelial keratoplasty for Fuchs’ dystrophy is unrelated to host, graft, or total corneal thickness and likely originates from structural changes in the retained host cornea in addition to irregularities at the lamellar graft-host interface.

**Small-Angle Domain after Keratoplasty**

Although increased forward scatter correlates with decreased visual acuity after DSEK, the association does not imply a causal relationship, and other factors are likely to degrade visual acuity. In the present study, the small-angle domain of the point-spread function was degraded in pseudophakic eyes...
after DSEK and PK compared with otherwise normal pseudophakic eyes, but there was no difference in the small-angle domain between DSEK and PK. We have assumed that PK increases high-order aberrations\textsuperscript{17,18} that affect the small-angle domain because of the irregular anterior corneal surface.\textsuperscript{19,20} In contrast, the anterior surface after DSEK (with a 5–6–mm limbal incision) should be similar to that of DLEK (with a 9–10–mm limbal incision), which is associated with lower corneal high-order aberrations than after PK.\textsuperscript{20} The degradation of the small-angle domain of the point-spread function suggests that high-order aberrations after DSEK are increased and could originate from surfaces other than the anterior surface of the cornea. The posterior surface of the graft is a possible source of high-order aberrations for DSEK.\textsuperscript{21}

**Visual Acuity after Keratoplasty**

High-contrast visual acuity after DSEK was weakly correlated with both the large- and small-angle domains of the point-spread function, whereas HCVA after PK was strongly correlated with only the small-angle domain. This suggests that HCVA after DSEK was affected by both high-order aberrations and, in extreme cases, forward scatter, whereas HCVA after PK was dominated by high-order aberrations and not by forward scatter. Although forward scatter was measured at a mean of 7° from the center of the point-spread function, forward scatter affects the entire point-spread function and can therefore degrade the small-angle domain and possibly visual acuity in extreme cases. Our data suggest that an increase in high-order aberrations after DSEK might also help explain the degradation of the small-angle domain and any associated effect on visual acuity.

High-contrast visual acuity did not differ between the PK and DSEK groups in this study, although the smallest detectable difference with our sample sizes was 0.22 log MAR. These results should be interpreted with caution because the PK and DSEK groups were noncomparative series, and the two groups were examined at different times after surgery, DSEK at 6 months, and PK at a median of 4 years (with all sutures removed). In the shorter postoperative time, the DSEK eyes might not yet have attained their best HCVA. Nevertheless, in a randomized trial comparing DLEK and PK, there was no significant difference in HCVA at 1 year after surgery.\textsuperscript{4}

**Age-Dependence of Point-Spread Function after DSEK**

In this study, we confirmed the relationship between stray light and recipient age in pseudophakic eyes after DSEK for Fuchs’ dystrophy,\textsuperscript{3} whereas no such relationship was evident after PK, nor between stray light and age of otherwise normal pseudophakic eyes. Similarly, larger series have found weak, if any, correlations between stray light and age in pseudophakic eyes.\textsuperscript{10,22} The age-dependence of stray light after DSEK suggests that the age of the host cornea affects the postoperative optical properties of the eye, and we have hypothesized that increased forward scatter in older recipients might be a consequence of more advanced Fuchs’ dystrophy before DSEK, or to slower repair of the host ultrastructural changes in older corneas after DSEK.\textsuperscript{3} The exact nature of the ultrastructural changes in host corneas with Fuchs’ dystrophy that are responsible for optical degradation, and whether they are reversible with time, are unknown, but could include subepithelial fibrosis,\textsuperscript{25} extracellular matrix alterations,\textsuperscript{24} or anterior keratocyte depletion.\textsuperscript{25} Of interest is that visual acuity after DSEK is worse in older than in younger recipients for eyes without retinal or other causes of decreased vision,\textsuperscript{3,26} further suggesting increased optical degradation of older host corneas. Nevertheless, forward scatter does not affect visual acuity except in extreme cases, and in this study, we were unable to detect relationships between the established parameter of the small-angle domain (50% width), which is related to visual acuity, and recipient age.

Most of the subjects in this study were elderly, and one might argue that the relationship between stray light and age after DSEK might be attributed to age-related ability to successfully perform the test. However, this is unlikely to be the case because stray light measurement by the psychophysical technique is almost identical with that by optical techniques,\textsuperscript{10} and the reliability indices exclude tests with large variability\textsuperscript{10}; in addition, subjects with otherwise normal pseudophakic eyes were of similar age.

**Forward Light Scatter**

Light scattered toward the retina is termed forward light scatter and degrades retinal image quality. The retinal image quality analysis system also reports a parameter called the “objective scatter index” (OSI), which has been suggested to include only that portion of the point-spread function that is dominated by forward scatter and minimally affected by aberrations. We also evaluated this parameter, and in this study of eyes with a wide range of optical degradation, we found a weak predictive relationship between the OSI and stray light (r = 0.52, P < 0.001, n = 123), whereas we found strong relationships between the OSI and the 50% width (r = 0.91, P < 0.001, n = 127) and visual acuity. Thus, in our series, OSI was not a good measure of forward scatter, and because the derivation and interpretation of this parameter have not yet been established in the literature, published data for this parameter\textsuperscript{27–30} should be interpreted with caution.

The instruments used to determine the parameters of the large-angle (stray light meter) and small-angle (retinal image quality analysis system) domains were noninvasive and were
easily accommodated in the clinical setting. We found good repeatability for the 50% width, measured by the retinal image quality analysis system, and for the stray light parameter, measured by the stray light meter, making both instruments suitable for prospective studies. The stray light meter automatically indicates unreliable tests to maintain low variability of repeated results. Both instruments have been used to determine the large- and small-angle domains of the point-spread function in corneal disease and after keratorefractive and lenticular surgery.

**Summary**

In this study, we found that the small-angle domain of the retinal point-spread function was degraded by endothelial keratoplasty to a similar degree as by penetrating keratoplasty, suggesting that aberrations, in addition to forward scatter, contribute to poor vision after endothelial keratoplasty. Forward scatter after DSEK for Fuchs' dystrophy increases with distance and may be attributed to the retained host cornea, although this suggests that age-related degradation of the optical properties of the eye might explain poorer visual acuity in older recipients, such relationships have yet to be established.

**References**