Current indications and surgical approaches to corneal transplants at the University of Toronto: A clinical-pathological study

Ryan Le, HBSc,*,a Narain Yucel *,†,a Shireen Khattak HBSc,*,† Yeni H. Yucel, MD, PhD,*,†,‡,§ Gerald J. Prud’homme, MD,*‡ Neeru Gupta, MD, PhD, MBA*†,‡ ABSTRACT

Objective: To determine the most common reasons and surgical approaches for corneal graft surgery at the Kensington Eye Institute (KEI), University of Toronto.

Design: Retrospective cross-sectional study.

Participants: A total of 229 consecutive corneal transplants performed at the KEI.

Methods: Demographic, clinical, and pathological data on all 2012 and 2013 corneal transplants were collected.

Results: The mean age for corneal transplants was 65 ± 16 years; 39% were full-thickness penetrating keratoplasties (PK) and 61% were partial-thickness. Graft failure (30%), infection (18%), and keratoconus (17%) were the leading indications for PK. Fuchs’ dystrophy (40%) and bullous keratopathy (24%) were main causes for partial-thickness procedures. Among partial-thickness approaches, Descemet’s stripping automated endothelial keratoplasty (DSAEK), deep anterior lamellar keratoplasty (DALK), and Descemet’s membrane endothelial keratoplasty (DMEK) procedures accounted for 68%, 16%, and 16%, respectively. Fuchs’ dystrophy (40%) and bullous keratopathy (33%) were the most common indications for DSAEK. Keratoconus (57%) and corneal scarring (35%) were the most common indications for DALK, whereas Fuchs’ dystrophy (82%) accounted for most DMEK procedures. The most common reasons for all corneal grafts were Fuchs’ dystrophy (25%), bullous keratopathy (21%), graft failure (17%), and keratoconus (12%).

Conclusions: Almost two-thirds of all corneal transplant procedures at the University of Toronto are partial thickness procedures. A failed graft was found to be the most common indication for full-thickness transplants. Fuchs’ dystrophy was the most common indication for a partial-thickness approach, most often treated by DSAEK. Longitudinal data are needed to determine whether partial-thickness surgeries will improve graft survival and reduce the need for regraft.

Recent technological advances have led to the adoption of partial-thickness procedures as an alternative to full-thickness replacement of the cornea, with surgical choices guided by the location of the pathology. Selective replacement of the endothelium for diseases such as Fuchs’ dystrophy can be achieved by procedures such as Descemet’s stripping automated endothelial keratoplasty (DSAEK) and Descemet’s membrane endothelial keratoplasty (DMEK). The anterior stromal layers can be targeted as in deep anterior lamellar keratoplasty (DALK) for diseases such as keratoconus and corneal scarring. Many studies of corneal transplant surgery are derived from data spanning 2000–2010, a period of evolution and adoption of partial-thickness corneal transplants in addition to surgeon learning. During that period, significant increases in the number of partial-thickness corneal transplants were reported from Scotland,1 New Zealand,2 China,3 Colombia,4 the United Kingdom,5 Iran,6 and Canada.7–9 DSAEK leads in the treatment of corneal endothelial disease, as does DALK for anterior cornea opacity.

Although corneal procedures have matured over the years, information regarding current practice patterns from major academic centres in Canada regarding the type of and indications for corneal grafts are limited. Corneal transplant surgery at the University of Toronto was only recently centralized from major teaching hospitals in the city to the Kensington Eye Institute (KEI), an academic health centre providing ambulatory surgical care. This provided a unique opportunity to evaluate the types of procedures performed and their indications from multiple academic centres and faculty. Here we report mainly 2013 data on full- and partial-thickness corneal transplantation, their indications, and patient demographics from the largest single academic centre for corneal graft surgery in Canada.

METHODS

Institutional Research Ethics Board approval (REB No. 13-225) was obtained from St. Michael’s Hospital, Toronto, Canada, on October 30, 2013. This research

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adhered to the tenets of the Declaration of Helsinki. A retrospective review was conducted, and included clinical and pathological records of all adult corneal transplants performed at the KEI surgical center of the University of Toronto, from November 6, 2013 (date of first corneal transplant surgery at KEI), to December 31, 2013. Data were obtained from the University of Toronto Ophthalmic Pathology Laboratory and included the type of corneal surgery performed, clinical/pathological indication, and demographic information, including age and sex. All cases with confirmed clinical and pathological diagnoses were included. The data were categorized according to the type of procedure performed, separating full-thickness transplants from partial-thickness transplants.

Data on partial-thickness transplants were further categorized as DSAEK, DMEK, or DALK. Each procedure type was assessed according to its disease indications and the age and sex of patients. Three cases of DALK were converted to penetrating keratoplasties (PK). Cases in which clinical indications were not provided and pathological results showed corneal endothelial cell loss without characteristic findings of Fuchs’ dystrophy were termed “non-Fuchs’ dystrophy,” and cases of congenital hereditary endothelial dystrophy were also included here. A category of “others” included least common indications: granular dystrophy, central cloudy dystrophy of Francois, lattice dystrophy, pterygium, thick Descemet’s membrane, irido-corneal endothelial syndrome, trauma, neurotrophic keratopathy, corneal ulcer, toxic anterior segment syndrome, and uveitis.

Results

Two hundred and twenty-nine corneal transplants were performed from November 2012 to December 2013 (patients’ mean age 65 ± 16 years). Of these, 89 (39%) were full-thickness corneal transplants, and 140 (61%) were partial-thickness corneal transplants (Fig. 1A). Patients undergoing full-thickness transplants (59 ± 17 years) were significantly younger compared with those who had partial-thickness transplants (68 ± 15 years) (p < 0.0001). Partial-thickness procedures performed were DSAEK (68%), DALK (16%), and DMEK (16%) (Fig. 1B). Of the partial-thickness patients, the average age was 73 ± 11 years for DSAEK, 47 ± 16 years for DALK, and 71 ± 11 years for DMEK (Table 1).

Full-thickness transplants were performed for most cases of infection (89%), graft failure (68%), other (see methods) (57%), keratoconus (54%), and corneal scarring (47%). Partial-thickness transplants were performed for most cases of non-Fuchs’ dystrophy (100%), Fuchs’ dystrophy (98%), bullous keratopathy (71%), and corneal scarring (53%) (Fig. 2).

The most common indication for full-thickness transplant was graft failure (30%), followed by infection (18%) and keratoconus (17%) (Fig. 3A). The most common indication for partial-thickness transplant was Fuchs’ dystrophy (40%), followed by bullous keratopathy (24%) and both keratoconus and graft failure (9%). Among the partial-thickness procedures, keratoconus (57%) and corneal scarring (35%) were the most common indications for DALK procedures (Fig. 3B). Fuchs’ dystrophy (40%) and bullous keratopathy (33%) were the most common indications for DSAEK (Fig. 3C). Most DMEK procedures (82%) were performed for Fuchs’ dystrophy (Fig. 3D).

The most common indications for all corneal graft surgery were Fuchs’ dystrophy (25%), bullous keratopathy

Table 1—Procedure frequency and demographics

<table>
<thead>
<tr>
<th>Type of Procedure</th>
<th>Percent Frequency (n)</th>
<th>Mean Age ± SD (years)</th>
<th>Male/Female Ratio</th>
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<tbody>
<tr>
<td>Penetrating keratoplasty</td>
<td>39 (89)</td>
<td>59 ± 16.6</td>
<td>1:1</td>
</tr>
<tr>
<td>Partial-thickness</td>
<td>61 (140)</td>
<td>68 ± 15.2</td>
<td>2:3</td>
</tr>
<tr>
<td>transplant</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DSAEK</td>
<td>41 (85)</td>
<td>73 ± 11.1</td>
<td>1:2</td>
</tr>
<tr>
<td>DALK</td>
<td>10 (23)</td>
<td>47 ± 16.0</td>
<td>2:1</td>
</tr>
<tr>
<td>DMEK</td>
<td>10 (22)</td>
<td>71 ± 11.4</td>
<td>1:2</td>
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</table>

DSAEK, Descemet’s stripping endothelial keratoplasty; DALK, deep anterior lamellar keratoplasty; DMEK, Descemet’s membrane endothelial keratoplasty.

Fig. 1—Of corneal transplant surgeries performed at University of Toronto 2012–2013 (n = 229), 89 (39%) were full-thickness and 140 (61%) were partial-thickness (A). Most partial-thickness procedures were Descemet’s stripping automated endothelial keratoplasty (DSAEK) (68%), followed by deep anterior lamellar keratoplasty (DALK) (16%), and Descemet’s membrane endothelial keratoplasty (DMEK) (16%) (B).
Patients with Fuchs’ dystrophy (69.9 ± 9.4 years), bullous keratopathy (75.2 ± 8.5 years), graft failure (66.8 ± 16.6 years), infection (64.7 ± 14.1 years), and non-Fuchs’ dystrophy (63.8 ± 16.8 years) were older than those treated for keratoconus (42.0 ± 14.5 years) and corneal scarring (55.4 ± 14.0 years) (Table 2).

**DISCUSSION**

Recent centralization of corneal transplant surgery at the University of Toronto to the KEI provided an opportunity to evaluate types and indications of corneal graft surgery across multiple academic teaching hospitals and faculty. We found that approximately 61% of transplants performed in 2013 were partial-thickness grafts. Growing trends in Ontario from 2007 to 2010 have been reported, and advancements in partial-thickness procedures and outcomes, technology, and surgeon experience over the past decade likely play some role. Partial-thickness procedures have become attractive alternatives to full-thickness procedures with evidence of improved visual outcomes, earlier visual recovery, and comparable graft survival rates of 94% and 90% for partial-thickness and full-thickness, respectively.\(^{10-17}\) Full-thickness transplant recovery time is typically 1 year, whereas recovery rates for partial-thickness transplants may be 4–6 weeks.\(^ {11,18,19}\)

Among the partial-thickness procedures, a growing trend for the use of DSAEK in the surgical treatment of
Corneal endothelial disease has been reported. Our study showed that more DSAEK than DMEK procedures were performed for Fuchs’ dystrophy (67% vs 31%). As DMEK was relatively new at the time, it is possible that fewer surgeons were performing the procedure. Among the endothelial keratoplasty procedures (DSAEK and DMEK), DSAEK continues to be the more popular procedure. DMEK is known to be technically challenging with higher risk of the thin donor tissue dislocating or tearing.

Continuing improvements to the DMEK procedure may increase its frequency of use in treating corneal endothelial diseases.

In our patients with corneal scarring, 47% were treated with PK and 47% were treated with DALK. Similar proportions were found for keratoconus patients. For both of these conditions, PK was performed equally as or more often. Studies have reported increased frequency of DALK between 2001 and 2010. DALK has been found to have visual and refractive outcomes comparable to PK; however, data on long-term graft survival are variable. Use of one technique over the other is dependent on the disease severity and presence of risk factors, and experts agree that DALK is the preferred treatment for keratoconus unless other factors such as deep scarring are involved.

We found that more partial-thickness transplants, specifically DSAEK and DMEK, were performed in older patients compared with full-thickness transplants. Full-thickness transplants were performed for corneal scarring and infection, which may occur across a spectrum of ages. The increasing frequency of partial-thickness techniques performed for corneal endothelial diseases like Fuchs’ dystrophy helps to explain the older demographic, given that Fuchs’ dystrophy is not typically symptomatic until the sixth decade of life. Among partial-thickness transplant patients, DSAEK and DMEK patients had a higher age (70s) compared with DALK patients, with the average age found to be 47.4 ± 16 years (Table 2). DALK was indicated commonly to treat keratoconus and consistent with expected onset in the 20s, taking 10 to 20 years to progress to a surgical stage.

Although published data regarding current corneal transplant indications and types in major centres are limited, data from the 2000 to 2010 period from Scotland, New Zealand, Australia, the United Kingdom, Iran, and Germany found that keratoconus was a leading indication, and as high as 41% of total transplants. Hungary and Colombia reported bullous keratopathy to be the most common cause. In China, the leading cause was infectious keratitis, whereas in Canada, pseudophakic corneal edema was dominant from 2000 to 2009. These differences reflect diverse demographics and local pathologies and may change with future treatment advances.

Our study found Fuchs’ dystrophy as a leading indication for corneal transplant (25%), and Canadian data from 2010 to 2012 reported Fuchs’ dystrophy emerging as a major cause. Improvements in cataract surgical techniques have likely reduced the cases of pseudophakic corneal edema, coincident with the widespread adoption of partial-thickness procedures for Fuchs’ dystrophy.

Bullous keratopathy (21%), graft failure (17%), and keratoconus (12%) were all important indications for corneal grafts. Most graft failures were treated with PK (68%). The cause of graft failure is an important consideration in patients undergoing surgery, and as endothelial cell loss is a common reason for graft failure, partial-thickness procedures may be more beneficial. Studies have shown that after an initial failed PK, repeat PK and

<table>
<thead>
<tr>
<th>Clinical Indication</th>
<th>Percent of All Transplants (n)</th>
<th>Mean Age ± SD (years)</th>
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<tbody>
<tr>
<td>Fuch’s dystrophy</td>
<td>24.9 (57)</td>
<td>69.9 ± 9.4</td>
</tr>
<tr>
<td>Bullous keratopathy</td>
<td>20.9 (48)</td>
<td>75.2 ± 8.5</td>
</tr>
<tr>
<td>Graft failure</td>
<td>17.4 (40)</td>
<td>66.8 ± 16.6</td>
</tr>
<tr>
<td>Keratoconus</td>
<td>12.2 (28)</td>
<td>42.0 ± 14.5</td>
</tr>
<tr>
<td>Infection</td>
<td>7.9 (18)</td>
<td>64.7 ± 14.1</td>
</tr>
<tr>
<td>Corneal scarring</td>
<td>7.4 (17)</td>
<td>55.4 ± 14.0</td>
</tr>
<tr>
<td>Other</td>
<td>6.1 (14)</td>
<td>71.3 ± 16.0</td>
</tr>
<tr>
<td>Non-Fuch’s Dystrophy</td>
<td>3.1 (7)</td>
<td>63.8 ± 16.8</td>
</tr>
</tbody>
</table>

Table 2—Diseases and demographics

Fig. 4—Procedures performed for Fuchs’ dystrophy (A), bullous keratopathy (B), and graft failure (C). Descemet’s stripping automated endothelial keratoplasty (DSAEK) was the most common procedure in Fuchs’ dystrophy and bullous keratopathy, whereas penetrating keratoplasty (PK) was the most common for graft failure.
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DSAEEK have similar graft survival rates and visual outcomes.31–34 DSAEK has been shown to result in less endothelial cell loss compared with PK.11 Long-term graft survival data show that endothelial keratoplasty procedures may be superior in regrafts, with 5-year survival rates of 86% for endothelial keratoplasty and 51% for PK.30,32

Attempts to reduce graft failure rates by increasing graft size may reduce endothelial cell loss but lead to irregularity of graft surface, among other problems.35 In cases of graft failure due to neovascularization, inflammation, or infection, many layers may be affected. For these challenging patients, partial-thickness procedures are less likely to be sufficient. Despite PK as the treatment choice for these graft failure patients, a high-risk graft bed contributes to high rates of failure in subsequent transplant procedures.36 Future improved ability to categorize the graft bed by risk and medical interventions may help address cases at higher risk of failure.37,38 Long-term survival studies of partial-thickness procedures are needed to determine whether this approach will affect the need for regrafting.

Current practice at the KEI, University of Toronto, indicates that almost two-thirds of all corneal transplants performed are partial-thickness transplants. Fuchs’ dystrophy, bullous keratopathy, and graft failure are the most common reasons for corneal transplantation. Most Fuchs’ dystrophy and bullous keratopathy are treated with partial-thickness procedures. Full-thickness transplants remain the preferred choice for graft failure. Longitudinal data and further research are needed to determine whether longer graft survival and higher success rates with partial-thickness transplants will reduce the demand for corneal transplants due to graft failure.

References


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From the *Keenan Research Centre for Biomedical Science at the Li Ka Shing Knowledge Institute of St. Michael’s Hospital, Toronto, Ont; †Ophthalmology & Vision Sciences, St. Michael’s Hospital, University of Toronto, Toronto, Ont; ‡Laboratory Medicine & Pathobiology, St. Michael’s Hospital, University of Toronto, Toronto, Ont; §Ophthalmic Pathology Laboratory, University of Toronto, Toronto, Ont.*

*Ryan Le and Narain Yucel contributed equally to this work and should be considered joint first authors.*


Correspondence to Neeru Gupta, MD, PhD, MBA, St. Michael’s Hospital, 30 Bond Street, Cardinal Carter Wing, 8-072, Toronto, Ont. M5B 1W8; guptan@smh.ca