Trends in the Indications for Penetrating Keratoplasty in the Midwestern United States

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Purpose. To examine the leading indications and identify the changing trends for penetrating keratoplasty (PKP) in the midwestern United States. Methods. The indications for PKPs at a single center tertiary care referral practice were tabulated to assess trends from 1982 to 1996. The data analysis was prospective after 1985. Age, gender, clinical indication for PKP, date of surgery, status of the lens at the time of surgery (phakic, aphakic, pseudophakic, cataract), and any secondary diagnoses were recorded. In pseudophakic eyes, the type of intraocular lens (IOL) present at the time of surgery was noted. Correlation analysis and linear regression were used in the SAS system, version 6.12, to test for the statistical significance in increasing or decreasing trends over the span of the study. Results. A total of 4,217 PKPs were performed on 3,263 patients. The leading indication for PKP was pseudophakic bullous keratopathy (31.5%), with 73% of these cases associated with an anterior chamber IOL, 21% associated with a posterior chamber IOL, and 6% associated with an iris-fixated IOL. Fuchs’ dystrophy (23.2%), keratoconus (11.4%), corneal scarring (11.2%), failed graft (8.9%), and aphakic bullous keratopathy (7.5%) followed pseudophakic bullous keratopathy in frequency. These six groups accounted for approximately 93% of all cases performed. There were significant increasing trends in the incidence of failed grafts (p = 0.0001) and corneal scarring (p = 0.0001), and decreasing trends in the incidence of aphakic bullous keratopathy (p = 0.0001). There was a significant decreasing trend in pseudophakic bullous keratopathy from 1989 to 1996 (p = 0.0031). Conclusions. Pseudophakic bullous keratopathy was the leading indication for PKP in our series. This is in agreement with the data reported in other similar studies done in North America. However, unlike most of these studies, our second leading indication was Fuchs’ dystrophy. This contrast may be secondary to different genetic demographics in the midwestern United States. Key Words: Penetrating keratoplasty—Bullous keratopathy—Fuchs’ dystrophy—Keratoconus—Corneal scarring—Failed graft.

Corneal transplants have become the most successful tissue transplant secondary to advances in ocular immunology, ocular pharmacology, surgical instrument technology, surgical techniques, corneal storage, and eye banking procedures.1 Over time, the leading indications for corneal transplants have changed. Before the mid-1970s, keratoconus and regrafts were the primary indications for corneal transplants.2,3 Since then, according to most North American studies, bullous keratopathy has become the leading cause for penetrating keratoplasty (PKP), with the advent of cataract extraction and placement of intraocular lenses (IOLs). However, with the advancements in surgical techniques for cataract surgery and (IOL) technology, the incidence of post-cataract surgery bullous keratopathy is decreasing and is actually no longer the primary indication for corneal transplantation in a few regions (Europe and Australia). The objective of this study was to examine the leading indications and identify the changing trends for PKP at a large referral center in the midwestern United States.

METHODS

From July 1982 through 1996, a total of 4,217 PKPs were performed at the Corneal Consultants of Indiana, in Indianapolis, IN, U.S.A. The Corneal Consultants of Indiana is a tertiary referral center for cornea, anterior segment, and refractive surgery. Patients are referred to this practice primarily from Indiana and surrounding midwestern states by both ophthalmologists and optometrists.

The data collection was retrospective from 1982 to 1985 and prospective from 1986 to 1996. The age, gender, clinical indication for PKP, date of surgery, status of the lens at the time of surgery (phakic, aphakic, pseudophakic, or cataract), and any secondary diagnoses were recorded. As well, in the pseudophakic eyes, the type of IOL present at the time of surgery was documented.

Indications for PKPs were divided into 28 categories. These were consolidated into six groups: bullous keratopathy (divided mainly into pseudophakic and aphakic); Fuchs’ dystrophy; keratoconus; corneal scarring; failed graft; and other, which consisted of corneal ulcer, herpes keratitis, interstitial keratitis, disciform keratitis, phakic bullous keratopathy, lattice dystrophy, granular dystrophy, macular dystrophy, posterior polymorphous dystrophy, iridocorneal endothelial syndrome, perforated cornea, wound dehiscence, corneal melt, keratoglobus, pellucid marginal degeneration, band keratopathy, aniridia, pemphigoid, lipid keratopathy, spheroidal degeneration, corneal blood staining, and iris tumor.

In most instances, only one clinical diagnosis was present. In situations in which there was a secondary diagnosis for cases that required a regraft, the diagnosis of failed graft was given. In situations in which the patient had the diagnosis of both bullous keratopathy and Fuchs’ dystrophy, bullous keratopathy was the primary diagnosis selected in pseudophakic patients and Fuchs’ dystrophy was the primary diagnosis selected in phakic patients.
Correlation analysis and linear regression were used in the SAS system, version 6.12, to test for the statistical significance in increasing or decreasing trends in the indications for PKP over the span of the study.

RESULTS

A total of 4,217 PKPs were performed on 3,263 patients. Table 1 categorizes these transplants by diagnosis and year performed. An average of 299 corneal transplants was performed each full year of the study, ranging from 36 in 1983, to 430 in 1990. The average age of all patients was 67. The mean age of the keratoconus patients was 41 years, which was significantly lower than the mean age in the other main groups. As seen in Table 2, of the 4,217 cases, 2,677 were female and 1,540 were male (ratio of 7:4). There were four times as many female Fuchs’ dystrophy patients requiring PKP than males (783 vs. 195). There were 188 female keratoconus patients who received PKP versus 293 males, giving a male preponderance, which is different than that observed in the majority of studies but similar to the ratio reported by Liu and Slomovic.

The leading indications for PKP in our study in decreasing order were pseudophakic bullous keratopathy (31.5%), Fuchs’ dystrophy (23.2%), keratoconus (11.4%), corneal scarring (11.2%), failed graft (8.9%), and aphakic bullous keratopathy (7.5%). Table 1; Fig. 1). These six groups account for approximately 93% of all operations performed. Pseudophakic bullous keratopathy was the most common indication for PKP for 11 of the 15 years (Table 1; Fig. 2).

There was a significant decreasing trend in pseudophakic bul-

TABLE 1. PKP trends (total numbers)

<table>
<thead>
<tr>
<th>Year</th>
<th>PBK</th>
<th>Fuchs’</th>
<th>KCN</th>
<th>Corneal scar</th>
<th>Failed graft</th>
<th>ABK</th>
<th>Other</th>
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<td>56</td>
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<td>1989</td>
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<td>Totals</td>
<td>1,327</td>
<td>1,008</td>
<td>1,115</td>
<td>903</td>
<td>821</td>
<td>878</td>
<td>376</td>
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PBK indicates pseudophakic bullous keratopathy; KCN, keratoconus; ABK, aphakic bullous keratopathy.
further past the mid-1980s and with better anterior chamber IOL technology.

The fact that 27% of the cases had posterior chamber IOLs or iris-fixed IOLs reveals that the position of the IOL is not the only risk factor for developing pseudophakic bullous keratopathy. Other factors that have been shown to contribute are low endothelial cell count, corneal guttata, previous ocular surgery, chronic uveitis, intraoperative trauma, drug toxicity, peripheral anterior synechiae, and a shallow anterior chamber.4

What makes our study different from most of the other similar studies throughout the world is that our second most common indication for PKP was Fuchs’ dystrophy. Only the combined Wills Eye Hospital studies6,7 and a study from Denmark by Haammann et al.27 also had Fuchs’ dystrophy as the second indication. Most other studies had Fuchs’ dystrophy ranked fourth, fifth, or sixth. There was no observable trend in the incidence of Fuchs’ dystrophy over the span of the study. As mentioned earlier, there were four times as many female Fuchs’ patients requiring PKP as there were males (783 vs. 195), which is similar to what was previously reported.4 Because Fuchs’ dystrophy is a disease of the elderly, it was thought that age may be a significant factor in the disparity of the occurrence of Fuchs’ dystrophy in men and women, because, on average, women live longer. However, although our data show that the ratio of women to men who were diagnosed with Fuchs’ dystrophy under the age of 65 is less than the totals reported above, at three to one (177 vs. 59), there is still a significant difference, and thus age only partially contributes to this disparity.

Although keratoconus was the leading indication for PKP in a significant number of studies,9,15–23 it was third in our study. The reason for this discrepancy is unclear. Variations in success of contact lens fittings or contact lens intolerance secondary to climatic factors may have had an influence. The discrepancy may also be secondary to different genetic demographics. There was no significant trend in the frequency throughout our study.

Corneal scarring was our fourth most common indication, with a significant increasing trend throughout the study (p = 0.0001). Failed graft was our fifth most common indication, also with a significant increase in incidence throughout the study (p = 0.0001). Previous graft failure and young age are risk factors for corneal graft failure.28 The average age of patients in the corneal scarring group was 58, which is well below the average of all patients (67 years) in our study. Thus, as the corneal scarring and failed graft groups increase, this further contributes to the increasing trend of failed grafts. If these trends continue, regrafting could become one of the most significant indications in the future, as already reported by Sharif and Casey29 in England. Although significant improvements in surgical techniques, surgical instrumentation, eye banking, and tissue storage would suggest that there should be a decreasing trend in failed grafts, the increasing total number of patients who have had corneal transplants is the probable reason for this increasing trend.

Aphakic bullous keratopathy was our sixth most common indication. There was a significant decrease in incidence throughout the span of the study (p = 0.0001). This can be attributed to the vast improvements in cataract surgery techniques, resulting in many fewer aphakic states.

This is the only study of this kind performed in the midwestern United States. It is also one of the largest studies of this sort performed in the world. The leading indication for PKP in our study was pseudophakic bullous keratopathy, which is in agreement with a large number of other similar studies.1,5–7,10–14 There appears to be a significant association between pseudophakic bullous keratopathy and the use of anterior chamber IOLs. The main difference in our study, compared to most others, is that our second most common indication for PKP was Fuchs’ dystrophy. The reason for this discrepancy is unclear; however, it could be secondary to different genetic demographics in the midwestern United States.

As far as future trends go, failed grafts may become the leading indication for PKP because as technology and our surgical abilities improve, more and more transplants will be performed, leading to greater numbers of patients who could potentially have a graft failure. Also, as failed grafts continue to increase in incidence as an indication for PKP, this group will feed on itself and increase even further, because a history of graft failure is one of the most significant risk factors for developing a graft failure.28 Another group that may become a significant indication in the future is patients with refractive surgery complications. Improved technology and techniques in the refractive surgery industry have prompted greater surgical success and thus patient acceptance and willingness to have refractive surgery. Hence, there has been a dramatic increase in the number of refractive surgeries performed, and it is predicted that these numbers will continue to grow exponentially. However, this may also lead to a greater number of patients having complications secondary to refractive surgery. Thus, this group may potentially become an increasing source of patients requiring PKP.

![FIG. 1. Total number of PKPs by indication. PBK indicates pseudophakic bullous keratopathy; KCN, keratoconus; ABK, aphakic bullous keratopathy.](image-url)
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REFERENCES