Penetrating Keratoplasty Performed by Residents

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**Objective:** To report the results of penetrating keratoplasty performed by residents.

**Method:** A retrospective medical record review of all patients undergoing penetrating keratoplasty performed by residents at our institution from April 1998 to April 2002.

**Results:** Forty penetrating keratoplasty procedures were performed by 8 residents. The most common indication was keratoconus (17 eyes [43%]), followed by corneal scarring (14 eyes [35%]). Mean preoperative best-corrected visual acuity was 20/250. No intraoperative complications were reported. Mean follow-up time was 15 months. Postoperatively, mean best-corrected visual acuity was 20/40, mean postoperative astigmatism was 3.4±2.1 diopters, and graft survival was 92.5%. Postoperative complications included elevated intraocular pressure, wound dehiscence, and endophthalmitis.

**Main Outcome Measures:** Best-corrected visual acuity, postoperative astigmatism, graft survival, and intraoperative and postoperative complications.

**Conclusion:** Residents can be introduced to penetrating keratoplasty and achieve surgical success with intraoperative and postoperative complication rates similar to those previously published.

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RESULTS OF RESIDENT SURGERY are important to analyze. Using this data, residency programs can determine the effectiveness of their surgical teaching strategies and what modifications need to be made to improve outcomes. The results of cataract surgery performed by ophthalmology residents have been well described in the literature. Almost all of these publications have found that with proper supervision, residents can achieve results similar to experienced surgeons.1-5 This important information provides both confidence to the residents and surgical instructors and reassurance to the patients who will be cared for.

There is a limited amount of data regarding results of residents and cornea fellows performing penetrating keratoplasty (PK). A study from Duke University, Durham, NC, indicated that residents could be introduced to PK and achieve results comparable with those reported in the ophthalmic literature.6 Cornea fellows from the University of California, Davis, showed they could achieve rates of postoperative astigmatism following PK similar to experienced corneal surgeons.7 Our goal is to enlarge this pool of data by reporting results of PK performed by residents at our institution.

**METHODS**

The medical records of all patients undergoing PK from April 1998 to April 2002 performed by residents at California Pacific Medical Center (CPMC), San Francisco, were reviewed for the following data: patient demographics, ocular diagnoses, preoperative and postoperative complications, and postoperative clinical course.

All patients were examined and approved for surgery by a senior resident and a member of the corneal faculty. The informed consent process was performed by the senior resident, often in the presence of the supervising faculty surgeon. This included a lengthy discussion of the postoperative diligence required by the patient and surgeon following PK. All surgical procedures were performed using general anesthesia, sterile technique, standard trephination techniques, and 16 interrupted sutures.

Under the supervision of a corneal faculty member, residents performed all critical
Postoperative Visual Acuity

<table>
<thead>
<tr>
<th>Follow-up</th>
<th>No. of Eyes</th>
<th>Mean BCVA</th>
<th>20/15-20/40</th>
<th>20/50-20/70</th>
<th>20/70-20/100</th>
<th>&lt;20/200</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-3 mo</td>
<td>1</td>
<td>NLP</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>3-6 mo</td>
<td>0</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>6-12 mo</td>
<td>12</td>
<td>20/53</td>
<td>6</td>
<td>1</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>&gt;1 y</td>
<td>20</td>
<td>20/15</td>
<td>16</td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>All Eyes Measured</td>
<td>33</td>
<td>20/40</td>
<td>22</td>
<td>2</td>
<td>1</td>
<td>8</td>
</tr>
</tbody>
</table>

Abbreviations: BCVA, best-corrected visual acuity; NA, not applicable; NLP, no light perception.

The table summarizes postoperative visual acuity measurements for different follow-up periods. The results indicate a range of visual outcomes, with a notable number of eyes achieving 20/40 or better.

Forty PK procedures were performed on 35 patients at CPMC from April 1998 to April 2002. The mean patient age was 43 years (range, 4-86 years); 23 (66%) were men, and 12 (34%) were women. The most common indication for PK was keratoconus (17 eyes [43%]) followed by corneal scarring (14 eyes [35%]), failed PK (3 eyes [7%]), pseudophakic corneal edema (2 eyes [5%]), infectious keratitis (active) (2 eyes [5%]), Fuch endothelial dystrophy (1 eye [2.5%]), and Peters anomaly (1 eye [2.5%]).

Eight senior residents performed the surgeries in this series. The average number of PK procedures performed by each resident was 5 (range, 3-7). The most common procedure was PK alone (28 eyes [70%]), followed by PK with extracapsular cataract extraction and posterior chamber intraocular lens placement (6 eyes [15%]), PK with anterior vitrectomy and sulcus-sutured posterior chamber intraocular lens placement (3 eyes [7.5%]), PK with intraocular lens exchange (1 eye [2.5%]), and PK with anterior vitrectomy (1 eye [2.5%]). A single case of PK with extracapsular cataract extraction, and planned anterior vitrectomy was performed on a 4-year-old boy with Peters anomaly. No intraoperative complications were reported.

Mean follow-up time was 15 months (range, 1 month to 3 years) with 24 patients (68%) having current follow-up at the time of data collection. One patient died secondary to a myocardial infarction 1 month following surgery.

Mean best-corrected visual acuity (BCVA) was calculated as described by Akpek et al. Mean preoperative BCVA was 20/250 (range, 20/70-light perception). Postoperative BCVA was available for 33 of 40 eyes and is summarized in the Table. Patients were grouped according to duration of follow-up. Seven eyes did not have a recording for postoperative BCVA. This was owing to death (1/7) or the absence of a manifest refraction at the time of data collection (6/7). Mean postoperative BCVA was 20/40 (range, 20/15-no light perception), with 22 eyes (67%) attaining a postoperative BCVA of 20/40 or better. Causes of postoperative BCVA < 20/200 (8 eyes) included graft failure (3), occlusion amblyopia (1), macular hole (1), persistent hyperplastic primary vitreous variant (1), undiagnosed preexisting retinal detachment (1), and endophthalmitis (1).

The most common postoperative complications were elevated intraocular pressure (IOP) (10 eyes [25%]) and wound dehiscence (4 eyes [10%]). Elevated IOP was defined as persistent IOP greater than 21 mm Hg requiring treatment. Elevated IOP was controlled with topical pressure-lowering agents in all eyes. Wound dehiscence was both traumatic (2/4) and spontaneous in the immediate postoperative period secondary to suture dehiscence (2/4). All cases were repaired without complication.

Allograft rejection (controlled) occurred in 3 eyes (7.5%) and was managed with topical steroids. Graft failure was defined as a totally opacified corneal graft secondary to corneal edema. This occurred in 3 (7.5%) of 40 eyes and in 3 (13%) of 23 eyes with more than 1 year of follow-up. Thus, when considering all grafts with at least 1 year of follow-up (n=23), 20 (87%) were clear.

Untolerated astigmatism occurred in 2 eyes (5%), and infectious suture abscess, shallow anterior chamber (grade 1), and choroidal detachment occurred in 1 eye (2.5%) each.

The most significant postoperative complication was acute postoperative endophthalmitis. After uncomplicated PK with extracapsular cataract extraction and posterior chamber intraocular lens placement, on postoperative day 4, the patient had a complete hypopyon. 30% graft dehiscence (secondary to tissue necrosis), and visual acuity of no light perception. Despite surgical repair of the dehiscence, vitrectomy, and intravitreal antibiotic injection, the vision did not improve. Vitreous cultures grew Pseudomonas aeruginosa. The patient eventually required enucleation for ocular discomfort.

Postoperative astigmatism measurements were available for 29 of 40 eyes. There were 11 eyes that did not have a recording for postoperative astigmatism. This was due to enucleation (1/11), graft failure (3/11), or lack of measurement in the immediate postoperative period (7/11). Two thirds of these measurements were recorded using manual keratometry and the other third, using manifest refraction. When both measurements were available, we used the larger of the 2 (always manual keratometry) for our data analysis. Mean±SD postoperative astigmatism for all eyes was 3.4±2.1 diopters (D) (range, 0.5-8.0 D); for eyes with 6 to 12 months’ follow-up, 3.2±2.4 D (range, 0.5-8.0 D); and for eyes with more than 1 year of follow-up, 3.5±2.0 D (range, 1.0-7.0 D).

Two cases of significant astigmatism required keratorefractive procedures for correction. The above quantification of astigmatism reflects the corneal measurements prior to these keratorefractive procedures.
Residents in our program have excellent exposure to PK, with each resident performing an average of 5 PK procedures during their training. A typical CPMC resident first performs PK during the second year of training, only after approximately 30 extracapsular cataract procedures, didactics regarding corneal surgery, assisting faculty and senior residents performing PK, and extensive practice with and without faculty supervision in a microsurgical wet lab.

The most common indication for PK in our series was keratoconus (17 patients [43%]). This is consistent with some series in the literature where keratoconus has surpassed pseudophakic corneal edema as the leading indication for PK.9,11 The number of patients requiring PK for pseudophakic corneal edema was low in our series.

Surgical success was evaluated by reviewing postoperative BCVA, postoperative astigmatism, and graft survival. The prognosis for surgical success depends on the preoperative indication for PK. While some diagnoses carry a favorable prognosis (keratoconus), others are quite the opposite (advanced surface disease with loss of limbal stem cells).13 The surgical success in any PK series is partially dependent on the percentage of different indications present in the series.

Mean postoperative BCVA was 20/40, with 22 eyes (67%) attaining a postoperative BCVA of 20/40 or better. This compares favorably with a range of 20/25 to 20/60 published by experienced corneal surgeons.13-17 The group of patients with more than 1 year of follow-up had better mean BCVA (20/33) than those in the 6- to 12-month follow-up group (20/53), which is consistent with previously published reports of BCVA stabilizing across time after PK.13

Mean ± SD postoperative cylinder was 3.4 ± 2.1 D. This also compares well with previously published data looking at postoperative astigmatism by cornea fellows (3.27-D change from preoperative astigmatism)7 and corneal specialists (2.0-5.4 D).15,16,18-22 We used manifest refraction for final postoperative astigmatism if manual keratometry was not performed (approximately one third of patients). Because these values tend to be lower than manual keratometry, our results may be lower than if manual keratometric values had been used in all patients. Postoperative astigmatism was similar between the group of patients with more than 1 year of follow-up and those with 6 to 12 months of follow-up.

When considering all grafts with at least 1 year of follow-up (n = 23), 20 (87%) were clear. Series with a similar length of follow-up have demonstrated graft clarity ranging from 70% to 95%.6,15 However, it is difficult to compare graft survival across a wide spectrum of preoperative diagnoses.

Our results for postoperative BCVA, postoperative astigmatism, and graft survival are comparable with those of the Duke University residents. However, while our most common indication was keratoconus, the Duke University residents cited previously failed grafts as their most common indication for PK. Many of their patients had fully vascularized corneas. The prognosis for surgical success is markedly different between these 2 groups.12

No intraoperative complications were reported. The most common postoperative complication was elevated IOP (25%). This compares favorably with an incidence of 18% published by Foukls.23 All patients were managed successfully with IOP-lowering agents (and/or reduction of topical steroids). Risk factors for post-PK elevated IOP are preoperative glaucoma, aphakia, anterior segment inflammation, vitrectomy, intraocular lens removal, and preoperative trauma.24-26 More than half (7/10) of our patients with postoperative elevated IOP had 1 of these risk factors. Surgeons should be particularly watchful for post-PK elevated IOP in patients with these risk factors.

The second most common complication was wound dehiscence occurring in 4 eyes (10%). This was both traumatic and spontaneous in the immediate postoperative period related to unstable sutures. One author (D.F.G.) buried all the resident-placed suture knots evaluating the tension and stability. The resident replaced sutures that were of inappropriate tension or that dehisced during this process. This technique seems to have eliminated postoperative suture instability and may help with postoperative astigmatism.

Weaknesses of this study are those that are inherent to a retrospective analysis. Also, it would have been useful to have BCVA and manifest refraction, manual, and topographic keratometry values for all 40 eyes. However, in the first few postoperative months, the emphasis for evaluating patients post-PK in our cornea clinic includes IOP, the health of the corneal graft, graft-host approximation as an origin of large amounts of irregular astigmatism, and detecting posterior segment pathologic features. Values for BCVA, manifest refraction, corneal topography, and manual keratometry are obtained for some, but not all, patients in the early postoperative period.

In summary, results of this series indicate that with excellent supervision residents can be safely introduced to PK and achieve surgical success and intraoperative and postoperative complication rates similar to those previously published. We attribute the postoperative results of PK by CPMC residents to appropriate selection of patients, proper preoperative patient counseling, resident and patient diligence, and excellent teaching and supervision by the corneal faculty at CPMC.
REFERENCES


Correction

Omission in Acknowledgments. In the Clinical Sciences article by Murphy et al titled “Neutralizing Tumor Necrosis Factor Activity Leads to Remission in Patients With Refractory Noninfectious Posterior Uveitis,” published in the June 2004 issue of the ARCHIVES (2004;122:845-851), an omission occurred in the Acknowledgments section on page 890. In that section, the following statement should have appeared as the second paragraph, immediately following the acceptance dates: “Drs Murphy and Greiner contributed equally to this study and stand as joint first authors.”