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Penetrating Keratoplasty for Keratoconus

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Purpose. We performed a retrospective study of patients with keratoconus who underwent penetrating keratoplasty at the University of California, Davis, during the years 1983–1996 to analyze subsequent visual acuity and the need for optical correction. **Methods.** We reviewed 123 eyes of 94 patients and collected data including best corrected visual acuity (BCVA) and uncorrected visual acuity (UCVA), type of correction (contact lens vs. spectacles), incidence of rejection, and other complications. Data were obtained at 12 and 18 months postoperatively. **Results.** There was a significant improvement of the BCVA between 12 and 18 months ($p < 0.05$) and no significant improvement in UCVA between at the same times ($p = 0.222$). At 12 months postoperatively, 84%, and at 18 months, 87% of patients achieved 20/40 or better BCVA. At 18 months, 47% of eyes were fit with contact lenses, and 30%, with spectacles. Mean spherical refraction was –4.13 D ± 4.41 standard deviation (SD) at 12 months and –4.09 D ± 3.86 SD at 18 months, whereas mean cylinder was 2.52 D ± 2.45 SD and 2.67 D ± 2.04 SD, respectively. Of the eyes, 17.9% had at least one graft rejection, although rejection episodes did not significantly influence the incidence of 20/40 vision ($p = 0.084$). Combined nonrejection complications did not significantly influence incidence of 20/40 or better vision at 18 months ($p > 0.10$). **Conclusion.** This study reaffirms that the results for keratoplasty in keratoconus are very positive and emphasizes that ophthalmologists should counsel patients about the likelihood of the need for spectacle or contact lens correction. Our data demonstrate that the majority of patients require optical correction for functional visual acuity after keratoplasty.

Key Words: Keratoplasty—Keratoconus—Visual Acuity—Contact lenses—Spectacle correction.

Keratoconus is a progressive, noninflammatory corneal ectasia with central thinning, usually treated successfully with contact lenses. However, 10–20% of patients eventually require penetrating keratoplasty for scarring in the visual axis, insufficient visual acuity (VA) with contact lens correction, or contact lens intolerance.[1] Corneal ectasias and thinning disorders, as a group, are the third most common indication for penetrating keratoplasty in the United States.[2] Keratoplasty is generally recommended when the benefits that would result from surgical correction of functional visual impairment outweigh the risks of the procedure.

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Although most corneal surgeons provide their patients with broad guidelines for postsurgical expectations, this study was designed to demonstrate supportive data on which postoperative prognostications could be based. We performed a retrospective study of patients with keratoconus who underwent penetrating keratoplasty between 1983 and 1996. Our objectives were to determine postoperative VA, incidence of contact lens and spectacle use, as well as complication and rejection rates to provide accurate risk/benefit data to prospective transplant patients.

MATERIALS AND METHODS

All obtainable charts were reviewed retrospectively on patients who had undergone penetrating keratoplasty for keratoconus during the years 1983–1996 at the University of California, Davis Medical Center, Sacramento. There were 126 patients identified in the UCDMC Medical Records database with diagnosis codes for both keratoconus and perforating keratoplasty. Exclusion criteria included the presence of any corneal disorder other than keratoconus, the known presence of any ocular disease other than keratoconus that could affect VA, and lack of follow-up data around the target points of 12 and 18 months postoperatively. Thirty-two patients were excluded using these criteria. Surgeries on 123 eyes in 94 patients were performed by two experienced cornea surgeons and their fellows. Regrafts were treated identically to initial grafts for purposes of this analysis. Age at operation, gender, complications, and episodes of rejection or infection were recorded. Uncorrected and best corrected visual acuities (BCVAs) were recorded as the decimal equivalent of the Snellen chart ratio. For example, 20/40 vision was denoted 0.5, and no light perception was denoted 0. Most recent manifest refraction at time of visit was recorded. The presence or absence of sutures, either running or interrupted, was noted, and use of spectacles or contact lenses was recorded.

BCVA of 0.50 (20/40) or better was used as a successful end point. Paired t tests were used to evaluate VA and changes in manifest refraction between 12 and 18 months. The χ^2 test was used to determine whether incidence of success was independent of complications. Included in the χ^2 analysis were operative complications, as well as postoperative complications such as infections, wound leaks, increased intraocular pressure (IOP), corneal abrasions, epitheliopathies, cataracts, and displaced posterior chamber (PC) intraocular lenses (IOLs). Fisher's Exact test was used to determine whether there was a significant relationship between the incidence of rejection and 18-month VA of 20/40 or better.[3]

RESULTS

Patients

The charts of 94 patients were examined for a total of 123 penetrating keratoplasties. In 120 (97.6%) cases, this was the first graft; in two (1.6%) cases, the second graft; and in one (0.8%) case, the third graft. Two of the regrafts were in a single eye, and the other regrafted eye had a failed square-shaped graft placed in 1950. One patient died after the 12-month follow-up, one patient had 18-month but not 12-month follow-up, and two patients were lost to follow-up before their 18-month visit. There were 57 (61%) male and 37 female (39%) subjects with a mean age of 38.1 years (SD, 13.68) and a range of 12–74 years. Median age was 37 years.

Visual Acuity

Of 123 eyes, VA was obtainable on 122 eyes at 12 months and 120 eyes at 18 months (Table 1). BCVA of 0.50 or better was obtained in 103 (84%) of 122 eyes (84%) at 12 months with a mean VA of 0.68 (SD, 0.233) and a median of 0.67. At 18 months, successful VA was obtained in 104 (87%) of 120 eyes with a mean of 0.76 (SD, 0.250) and a median of 0.80. Mean BCVA significantly improved ($p < 0.0001$) over the 6-month period (patients without both 12- and 18-month follow-up were not included in the paired *t* test). Mean UCVA was 0.29 (SD, 0.268) at 12 months and 0.28 (SD, 0.281) at 18 months, showing no statistically significant difference between the two groups ($p < 0.222$).

Refraction and Mode of Correction

Mean spherical refraction was −4.134 D (SD, 4.408) at 12 months and −4.094 D (SD, 3.863) at 18 months, indicating no statistically significant change over 6 months. There was a significant difference ($p = 0.002$) in mean spherical refraction between eyes that had some sutures remaining at 18 months versus no sutures, with means of +2.10 D and −4.73 D, respectively. Mean cylindrical refraction was +2.52 D at 12 months and +2.67 D at 18 months, also showing no significant change. The mean cylindrical refraction with (+2.08 D) or without (+2.81 D) sutures at 18 months showed no significant difference ($p = 0.117$). The mean axis at 18 months was with the rule at 83 degrees. Separated into quadrants: at 18 months, 32% of axises centered around 180 degrees, 23% around 90 degrees, 21% around 45 degrees, and 23% around 135 degrees. Of the 120 eyes with follow-up at 18 months, 36 (30%) used spectacles, 56 (47%) used contact lenses, and 28 (23%) did not record using either mode of correction. Of the 28 patients without clear chart records of using either spectacles or contact lenses, 12 (43%) had *uncorrected* VA of ≥0.50. All but three of the remaining 16 eyes had vision correctable to ≥0.50, and either their mode of correction was not recorded, or they were choosing not to use spectacles or contact lenses secondary to continually evolving VA or personal preference.

TABLE 1. *Best corrected visual acuity (BCVA) at 12 and 18 months*

BCVA	≥0.50	Mean	Median
12 mo (*n* = 122)	103	0.68 ± 0.233	0.67
18 mo (*n* = 120)	103	0.75 ± 0.250	0.80

TABLE 2. *Complications*

Complication	No. of eyes
Preoperative	
Retinopathy of prematurity	1
Presumed ocular histoplasmosis with subretinal neovascularization	1
Operative	
Aphakic with anterior vitrectomy	1
Lens extrusion with vitreous loss	1
Triple procedure	1
Postoperative	
Rejection	22
Stitch abscess	9
Filamentary keratitis	9
Wound leak	6
Increased IOP	5
Subsequent cataract surgery	3
Corneal abrasion	2
Fungal keratitis	1
Endophthalmitis (9 mo postop)	1
Keratitis medicamentosa	1
Displaced PC IOL	1

Each eye may have more than one complication.

Sutures

At 12 months, 64.7% of eyes still had either interrupted or running sutures in place, compared with only 25.8% at 18 months.

Rejection and Complications

Incidence of at least one rejection episode was only 17.9% (Table 2). The only graft that was not clear at 18 months was in an eye that eventually required a regraft, which also failed at 25 months. The third graft stayed clear. All other graft rejections that occurred during the study period responded to treatment. Postoperative infections included nine stitch abscesses, one case of fungal keratitis, and one case of endophthalmitis at 9 months, diagnosed with vitrectomy. There were nine cases with filamentary keratitis, six cases with wound leaks, five cases with increased IOP, two corneal abrasions, and one case of postoperative keratitis medicamentosa. One patient was aphakic and underwent anterior vitrectomy at the time of operation, whereas another experienced lens extrusion and vitreous loss. There was one triple procedure, although three other patients underwent cataract surgery during the study period. Another patient had a displaced PC IOL with posterior capsule opacification. Two patients had posterior segment disease, although it is unclear whether the disease was appreciated before grafting. One patient had retinopathy of prematurity and a learning disability, whereas the other had presumed ocular histoplasmosis and subretinal neovascularization. Failure to achieve 0.50 VA was independent of the presence of nonrejection complications by the χ^2 test ($p > 0.10$)

DISCUSSION

This study analyzed postoperative BCVA, incidence of contact lens versus spectacle correction, and the influence of complications on BCVA after penetrating keratoplasty for keratoconus. Most patients were relatively young, with a mean age of 38 years that is consistent with previous reports,[4,5] and a median age of 37 years. Sharif and Casey (6) and Silbiger et al.[4] noted male preponderances of 68 and 64%, respectively, in patients undergoing

transplants, demonstrating results similar to the 61% found in our study. Considering that the incidence of keratoconus is equal between the genders at ~1 in 2,000,[1] one wonders whether the increased relatively frequency with which male subjects undergo transplantation is the result of more rapidly progressing disease in men or of an increased tendency to opt for surgical treatment compared with female subjects.

Penetrating keratoplasty is well known to be an effective treatment option for keratoconus. Our 18-month success rate (VA, >0.50) of 87% compares favorably with rates of 70–91% reported in the literature.[6–9] There is a steady, long-term progression in VA recovery after transplantation, with the most rapid improvement occurring during the first year.[5] Our data showed a significant improvement in BCVA between 12 and 18 months by paired *t* test analysis ($p < 0.0001$), with the mean improving from 0.68 to 0.76, and the median improving from 0.67 to 0.80.

Mean spherical and cylindrical correction did not significantly change between 12 and 18 months, although the size of the standard deviation decreased, indicating a stabilization of correction. This stabilization allows more effective and long-lasting corrective prescribing. The spherical correction of −4.09 D seen at 18 months is consistent with the tendency for myopia seen after graft in keratoconus patients.[7,10–13] The use of undersized grafts in keratoconus patients to compensate for this myopic tendency has been suggested, but is not generally used because of the increased technical difficulty of suturing same-sized grafts and greater difficulty in postoperative wound management.[7,12] Corneal button size was not analyzed in this study. Similarly, use of postoperative refractive procedures such as relaxing incisions was not addressed.

When to undergo keratoplasty for keratoconus is currently a more pressing question than whether keratoplasty is successful. Buzard and Bradley[14] suggested that with improved surgical and postoperative refractive options such as relaxing incisions and LASIK, keratoplasty should be considered a viable *primary* treatment option in keratoconic patients with a BSCVA to ≤20/40. Yet at this time, most corneal surgeons would agree that penetrating keratoplasty should be a secondary option after contact lens failure or apical scarring. Rabinowitz[1] and others[15,16] reported a 10–20% lifetime chance of needing a corneal transplant, and Kirkness et al.[7] reports that even though apical scarring is a common indication for penetrating keratoplasty, contact lens difficulties are the most common principal indication for the decision to undergo a transplant. Thus patient perception of discomfort relating to contact lens wear becomes a crucial factor in the decision process. When providing patients with information on the results of penetrating keratoplasty, it is, therefore, important to explain the conditions under which those results are obtained. In addition to the immediate operative risks and expense, patients must understand that life-long follow-up is necessary, and that the overwhelming majority will still need to wear spectacles or contact lenses. At 18 months, 30% of our patients used spectacles, and 47% wore contact lenses, compared with 10.6% contact lens wear at 18 months reported by Price et al.,[5] and 31% found by Silbiger et al..[4] In the study by Price et al.,[5] 45.5% of patients still had sutures in place at 18 months, and patients were fit with rigid contact lenses only, and only after suture removal. Patients must understand that there is a high probability that contact lenses will be required for functional visual correction after corneal transplant surgery.

Rejection rates are traditionally low in keratoconus patients. The graft rejection rate of 17.9% in this series compared favorably with previously reported rates ranging from 7.8 to 31%.[4,6–8,17,18] The incidence of successful VA (≥20/40) was not significantly associated with graft rejections. In fact, there was only one patient who had VA worse than 20/40 at 18 months and who had undergone an episode of rejection. Because our sample size was too small to use the χ^2 test, the Fisher Exact Probability Test was used to calculate the exact probability of finding one or fewer patients with rejection episodes and VA worse than 20/40, based on pure chance ($p = 0.084$). These findings may indicate that unless a rejection episode leads to graft failure, there is no adverse effect on VA that can be attributed to a rejection episode in the first 18 months. Graft-rejection episodes can occur many years after transplant, and longer follow-up studies may show an eventual adverse association with VA.

Complications other than graft rejection were not found to be significantly related to VA success at 18 months ($p > 0.10$). The patient with lens extrusion and vitreous loss had a BCVA of 0.80 at 18 months, yet this is a potentially tragic event, and steps should be made to avoid this complication in high-risk patients. Faktorovich and Rabinowitz[19] recently described a technique to prevent unopposed forward movement of the lens–iris diaphragm in patients with low scleral rigidity, in which the host cornea is incompletely excised and remains attached at 3 and 12 o'clock until three of the cardinal sutures are placed.

In conclusion, although our data affirm the generally accepted success of penetrating keratoplasty as an effective treatment option for keratoconic patients with contact lens intolerance or apical scarring, we conclude that all patients must be fully apprised of the high probability that they will require contact lens or spectacle correction postoperatively for functional vision. Because such a large percentage of patients require contact lenses postoperatively to obtain optimal vision, corneal surgeons must explore with their patients the likelihood that they may require contact lenses for the functional success of their transplants.

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