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Clinical Outcomes in Traumatic Penetrating Keratoplasty Graft Dehiscence

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Purpose: The purpose of this study was to report clinical characteristics and outcomes of surgical repair for patients with traumatic dehiscence of penetrating keratoplasty (PKP) grafts.

Methods: Retrospective, consecutive chart review of patients evaluated at Bascom Palmer Eye Institute between 2015 and 2020 with traumatic dehiscence of penetrating keratoplasty grafts.

Results: The study cohort consisted of 65 eyes of 65 patients. The mean age at presentation was 72 years (SD 18), with a male predominance (65%). The most common indications for PKP included keratoconus (42%), corneal scar (31%), and Fuchs corneal dystrophy (8%). Dehiscence occurred as a result of blunt trauma in 94% of cases, and the mean wound length was 6.4 clock hours (SD 2.4), with a predominance of inferior dehiscence. The mean presenting visual acuity (VA) was 2.45 logMAR (SD 0.41), and the mean final VA was 2.17 logMAR (SD 0.99). Graft failure occurred in 64% of patients, and 22% underwent repeat PKP. When stratified by indication for corneal transplantation (keratoconus vs. other), there was no significant difference in graft age at the time of rupture, final VA, rate of graft failure, or rate of repeat PKP.

Conclusions: Traumatic dehiscence of corneal grafts remains a rare but serious subtype of ocular trauma with generally poor visual prognoses. Presenting VA along with severity of trauma and posterior segment involvement tend to be the worst prognostic factors in final visual outcome.

Key Words: dehiscence, penetrating keratoplasty, trauma, corneal transplant, ruptured globe

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Traumatic dehiscence of a penetrating keratoplasty (PKP) graft is a relatively infrequent occurrence; however, given the severity of these injuries and the complications that can arise from dehiscence, it is important to understand the risk factors, outcomes, and prognostic variables. The incidence of traumatic globe rupture after PKP is as high as 0.6%–5.8%[1] and is attributed to the size and nature of healed corneal wounds post-PKP.

The susceptibility of the transplanted cornea to traumatic rupture is likely due to the avascular nature of corneal scars, which limits effective wound healing and remodeling, resulting in persistent weakness at the graft–host junction as compared with native tissue. In addition, the use of steroids to control immune/inflammatory responses post-PKP further delays/limits the wound healing process.[2] Thus, various factors should be considered when assessing candidacy and risk for complications from a PKP, including the indication for transplantation, the patient's occupation/lifestyle, and the presence of other ocular surgeries, as each of these can independently play a role in the likelihood of graft dehiscence. Understanding the risk factors and outcomes in graft dehiscence is important, as dehiscence can often lead to severe and permanent loss of vision.

A recent meta-analysis by Zheng et al[3] on wound dehiscence after PKP included 11 retrospective case series. There was significant variation in the number and demographics of patients across these studies. However, in general, visual outcomes were poor. The mean final visual acuity (VA) was 20/400 for phakic patients and 20/800 for aphakic patients. Larger case series are needed to identify additional risk factors and prognostic indicators.

In this study, we examined 65 eyes of 65 patients at a tertiary referral center (Bascom Palmer Eye Institute) who sustained traumatic wound dehiscence after penetrating keratoplasty.

MATERIALS AND METHODS

This study is a consecutive retrospective chart review of patients with traumatic dehiscence of penetrating keratoplasty

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The Institutional Review Board of the University of Miami approved the study protocol (IRB # 20201265), and the study was conducted in accordance with the Declarations of Helsinki.

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grafts that underwent surgical repair at the Bascom Palmer Eye Institute from January 2015 to October 2020. Exclusion criteria were age younger than 18 years, treatment with primary enucleation or evisceration, surgical closure at an outside institution, and less than 1 month of follow-up.

TABLE 1. Demographics, Epidemiologic Features, and Characteristics of Patients With Traumatic Dehiscence of PKP Grafts

	Number (%)	SD
Cases	65	
Average follow-up	101 wk	
Average age	62 yrs	18.6 yrs
Men	42 (65)	
Women	23 (35)	
Eye		
Right	32 (49)	
Left	33 (51)	
Injury type		
Blunt	61 (94)	
Penetrating	4 (6)	
Graft age at the time of injury	13.6 yrs	11.52 yrs
Wound length	6.4 h	2.4 h
Suprachoroidal hemorrhage	19 (29)	
Zone of rupture		
I	63 (97)	
II	2 (3)	
Quadrants of dehiscence		
Superonasal	35 (52)	
Superotemporal	31 (46)	
Inferotemporal	51 (75)	
Inferonasal	55 (81)	
Initial BCVA*		
NLP	7 (11)	
LP	24 (37)	
HM-CF	30 (46)	
20/400 or better	3 (5)	
Mean	2.45 LogMAR	0.41
Final BCVA		
NLP	20 (31)	
LP	12 (18)	
HM	13 (20)	
CF	6 (9)	
20/200–20/50	6 (9)	
20/40 or better	8 (12)	
Mean	2.17 LogMAR	0.99
OTS*		
Category 1	6 (9)	
Category 2	27 (42)	
Category 3	30 (46)	
Category 4	1 (2)	
Follow-up duration	339 wk	84 wk

BCVA, best-corrected visual acuity; category 1 = 0 to 44 points, category 2 = 45 to 65 points, category 3 = 66 to 80 points, category 4 = 81 to 91 points, category 5 = 92 to 100 points.
*1 pt unable to measure.

The Institutional Review Board of the University of Miami approved the study protocol (IRB # 20201265), and the study was conducted in accordance with the Declarations of Helsinki. This study design was a retrospective review of medical records without contact with potential study subjects before acquisition of the requested data. As a result, the University of Miami approved a waiver of consent in accordance with US Code of Federal Regulations guidelines.

Preoperative data included age, sex, laterality of injured eye, date of injury, date and time of presentation, reason for penetrating keratoplasty, graft age at the time of rupture, sutures present at the time of rupture, quadrant of dehiscence, date of surgical repair, prior closure of open globe injury at outside hospital, primary enucleation, presenting VA, presence of afferent pupillary defect, wound dehiscence, lens expulsion, suprachoroidal hemorrhage, uveal prolapse, zone of wound,[4] length of wound (in clock hours), mechanism of injury, graft failure, and presence of retinal detachment. Ocular trauma score was calculated for each case.[5] Per the ocular trauma score (OTS) classification system, the OTS categories were as follows: Category 1: 0 to 44 points, Category 2: 45 to 65 points, Category 3: 66 to 80 points, Category 4: 81 to 91 points, and Category 5: 92 to 100 points.

Treatment data included use of topical antibiotics, tetanus–diphtheria–pertussis (Tdap) vaccine, systemic antibiotics, initial pars plana vitrectomy, intravitreal antibiotics, subconjunctival antibiotics, use of general anesthesia (GA) versus regional anesthesia with monitored anesthesia care (RA-MAC), procedure duration, and hospital admission. Outcome variables included VA at the last follow-up, whether enucleation was performed, and duration of follow-up.

Decisions regarding surgical management were made according to individual surgeon preference and did not follow a prospective protocol. The following logMAR assignments were utilized: counting fingers (CF) = 2.0, hand motion (HM) = 2.3, light perception (LP) = 2.7, and no light perception (NLP) = 3. VA and intraocular pressure "at the last follow-up" were determined only from patients with greater than 3 months of follow-up. The Student *t* test and Wilcoxon–Mann–Whitney *U* test were used for parametric and nonparametric data, respectively. The Fisher exact test was used for categorical data. Spearman rank order correlation was used for continuous data.

TABLE 2. Indication for PKP

	Number	Percentage (%)
Keratoconus	27	42
Fuchs corneal dystrophy	5	8
Other dystrophy	2	3
Corneal scar	20	31
Pseudophakic bullous keratopathy	3	5
Lipid keratopathy	1	2
Unknown	7	11
Total	65	100

RESULTS

The study included 65 eyes of 65 patients diagnosed with traumatic dehiscence of penetrating keratoplasty graft and open globe injury. The mean patient age was 72 years (SD 18), and 65% of patients were male (Table 1). Indications for penetrating keratoplasty (PKP) included keratoconus (42%), corneal scar (31%), Fuchs corneal dystrophy (8%), pseudophakic bullous keratopathy (5%), other dystrophy (3%), lipid keratopathy (2%), and unknown (11%) (Table 2). The average graft age at the time of injury was 13.6 years (SD 11.52) (Table 1).

Most injuries were caused by blunt (94%) versus penetrating (6%) trauma. The mean wound length was 6.4 hours (SD 2.4). Most patients had inferonasal (85%) or inferotemporal (75%) quadrants dehisced versus superonasal (52%) and superotemporal (46%). Presenting VA was generally poor, with a mean logMAR VA of 2.45 (SD 0.41), corresponding to between HM and LP vision. The distribution of presenting VA was as follows: 11% NLP, 37% LP, 46% HM to CF, and 5% better than or equal to 20/400 (Table 1). Ocular trauma score was calculated for each case, with most patients falling into Category 2 or 3 (88%) (Table 1). The site of rupture was restricted to zone I (corneolimbal/graft–host junction) in 97% of cases, with 3% of cases having extension into zone II (limbus to 5 mm posterior to the limbus). On presentation, 37% of patients still had 1 or more sutures in their graft, while 40% did not have any sutures, and the presence of sutures for the remaining 23% was not known.

Regarding management, 92.3% of patients received topical antibiotics (typically both vancomycin and tobramycin), 91% received systemic antibiotics (typically an oral fluoroquinolone), and 85% received the tetanus–diphtheria–pertussis (Tdap) vaccine (Table 3). Intraoperatively, 59% of patients received intravitreal or intracameral antibiotics (usually vancomycin with ceftazidime ± voriconazole), and 95% received subconjunctival antibiotics. Initial pars plana vitrectomy was performed in only 3 cases (4.6%). Graft failure eventually occurred in 62% of patients (see Figure, Supplemental Digital Content 1, http://links.lww.com/ICO/B659), and repeat penetrating keratoplasty was performed in 22% of patients (Table 3). Endophthalmitis developed in 1 patient, and no patients underwent primary enucleation.

TABLE 3. Treatments for Patients With Traumatic Dehiscence of PKP Grafts

	Number (%)
Topical antibiotics	60 (92.3)
Systemic antibiotics	59 (91)
Tetanus–diphtheria–pertussis vaccine	55 (85)
Intravitreal/intracameral antibiotics	38 (59)
Subconjunctival antibiotics	62 (95)
Initial pars plana vitrectomy	3 (5)
Graft failure*	40 (62)
Repeat PKP	14 (22)

*Data missing for 2 pts.

The mean final VA was 2.17 logMAR (SD 0.99), corresponding to between CF and HM vision. However, 12% of patients did achieve 20/40 vision or better, and 9% between 20/50 and 20/200 vision (Table 1). The average duration of follow-up was 85 months (SD 21).

Variables associated with worse final VA included worse presenting VA ($P = 0.029$), the presence of a relative afferent pupillary defect on presentation ($P = 0.02$), suprachoroidal hemorrhage ($P = 0.006$), and more severe OTS score ($P = 0.033$). The only variable associated with better visual prognosis was repeat PKP. Several notable factors not associated with final visual outcome included age, wound length, presence of corneal sutures, lens expulsion, graft age at time of rupture, and surgical procedure duration. When stratified by initial indication for corneal transplantation (keratoconus vs. other), there was no significant difference in graft age at the time of rupture, final VA, rate of graft failure, or rate of repeat PKP (Table 4).

DISCUSSION

There have been multiple retrospective case series published on this traumatic dehiscence of PKP grafts, although few have greater than 50 patients.[2,6–19] A 2006 study also performed at Bascom Palmer Eye Institute by Renucci et al[19] included 51 eyes with a mean patient age of 69.5 years. The final VA was less than 20/200 in 53% of patients. A 2020 study by Bamashmus et al[2] in Yemen included 53 eyes with a mean patient age of 22.3 years and the final VA was less than 20/200 in only 36% of patients. As is evident when comparing these 2 studies, patient characteristics (such as age) likely play a critical role in final visual prognosis. A recent meta-analysis performed by Zheng et al[3] included 11 retrospective case series and found that the average final VA was 20/400 for phakic patients and 20/800 for aphakic patients. This study has a cohort with a mean age of 72 years (greater than all previous studies included in the meta-analysis), and 78% of patients had a final VA worse than 20/200. We suspect that as the American population continues to age, visual outcome after traumatic dehiscence will likely worsen due to patient factors such as impaired wound healing, tissue integrity, difficulties with self-care and medication administration, and increased severity of blunt trauma due to falls. It is important to note that some previous studies, such as Renucci et al, are not directly comparable because they also included atraumatic causes of dehiscence, such as suture-related complications and infectious keratitis.

TABLE 4. Characteristics of Patients With Dehiscence of PKP Graft Grouped by Indication: Keratoconus Versus Nonkeratoconus

	Nonkeratoconus N = 38	Keratoconus N = 27
Graft age at the time of injury (yr)	13.9 (SD 10.9)	13.1 (SD 12.5)
Final VA (logMAR)	2.2 (SD 0.93)	2.1 (SD 1.08)
Graft failure	24 (67%)	16 (59%)
Repeat PKP	8 (21%)	6 (22%)

Corneal wounds usually do not regain the original strength of the natural cornea, even years after uneventful repair. Animal models suggest that only 6.5% of wound strength is regained in the first 7 days after a PKP.[6] In human limbal wounds, there is gradual fibrovascular tissue formation, and the integrity of the wound depends almost entirely on the corneal sutures for up to 14 days. Sutured limbal wounds take 6 months to gain just 70% of the original strength and can lose some of that strength upon suture removal.[6] According to previous studies, the first month is the highest risk period for dehiscence and the eye is especially vulnerable up to the first year.[3] This risk gradually declines over the next 18 months, with postsuture removal being the second major high-risk period for wound integrity weakening and graft dehiscence.[3] Our cohort is unique in that the mean age of graft at the time of dehiscence was more than a decade after transplantation. This may reflect a demographic shift in patients with traumatic dehiscence toward the elderly, which mirrors that of the United States in general.

Depending on the extent and mechanism of graft dehiscence, significant complications may include graft failure, iris prolapse, lens extrusion, vitreous loss, retinal detachment, and endophthalmitis. Grafts with a larger extent of dehiscence are generally associated with higher likelihood of posterior segment damage, graft failure, and worse final visual outcome.[7–10,20] This study found that factors significantly associated with poor visual outcome were worse presenting VA, presence of afferent pupillary defect, suprachoroidal hemorrhage, and more severe OTS score. Patients with more severe OTS score likely had more severe trauma with a higher likelihood of damage to the posterior segment. However, it should be noted that the OTS was originally described for globe injuries of unoperated eyes. Thus, while useful for comparing the severity of injury within a specific cohort, the numerical OTS scores are not generalizable to other types of globe injury.

This study also found that superotemporal dehiscence is associated with a worse visual outcome; this may be due to the fact that superotemporal dehiscence is relatively rarer (the least frequent quadrant in our study), and thus, a blunt trauma which affects the superotemporal quadrant may affect all other quadrants and/or the posterior segment as well.

In addition, repeat PKP was associated with improved visual outcomes in our study. This is likely reflective of selection bias as patients with favorable anatomy and normal posterior segment were selected to undergo repeat grafting. On the other hand, the presence of sutures did not portend an improved visual outcome in our study. This is likely due to lack of reporting of suture status as more than 20% of patients did not have this information reported in their charts.

Owing to the relatively higher rate of globe ruptures/injuries in PKP patients, lamellar keratoplasties may be preferred in patients who are at risk for blunt trauma[11] (among other variables to consider in the preoperative assessment for corneal transplantation). For example, in a study of 31 globe rupture patients with either deep anterior lamellar keratoplasty (DALK) or PKP, the presence of a DALK portended improved visual outcome in the setting of globe rupture.[11] Similarly, Descemet stripping endothelial keratoplasty (DSEK), which is nonpenetrating and thus avoids full-thickness corneal wounds, is less likely to result in open globe injury compared with PKP. As was suggested by Lee et al,[21] DSEK in the setting of trauma is more likely to result in graft dislocation rather than graft dehiscence, which is less likely to lead to irreversible vision loss.

Limitations of this study include its retrospective nature and the lack of a prospective treatment algorithm. However, compared with previous reports, this study has a relatively large sample size and includes a unique cohort of more elderly patients, reflective of a wider shift in the demographics of the United States. Providers should take special care to counsel their elderly patients about the dangers of trauma, especially in regards to fall precautions at home. Ultimately, graft dehiscence can be a devastating complication of penetrating keratoplasty. It is important for both physicians and patients to be aware of the various risk factors and prognostic indicators for graft dehiscence and ultimate visual outcome.

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