Risk Factors and Incidence of Ocular Hypertension After Penetrating Keratoplasty

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Purpose: Ocular hypertension is a potentially serious complication after penetrating keratoplasty (PKP). Our objective is to determine the risk factors, incidence, patient characteristics, response to pressure-lowering medical therapy, and graft outcome associated with elevation of intraocular pressure after PKP.

Methods: One hundred forty-six consecutive eyes that had PKP between June 2001 and June 2003 were operated and managed at Hadassah-Hebrew University Medical Center. Chart review was performed seeking preoperative and postoperative data on risk factors for ocular hypertension after PKP. Univariate and logistic regression analysis were performed to identify significant risk factors.

Results: After surgery, 70 eyes (47.9%) had at least 1 period of ocular hypertension, with a mean intraocular pressure (IOP) of 27.15 ± 5.66 mm Hg. Ocular hypertension appeared after a mean postoperative period of 70.3 ± 15.8 days, and continued for an average period of 15.6 ± 2.0 days. In 35 eyes (23.9%), a second episode of IOP elevation was noted 212.2 ± 46.8 days after the surgery. Logistic regression analysis revealed that preexisting glaucoma ($P = 0.009$) and an additional surgical procedure combined with PKP ($P = 0.007$) were the main factors predicting ocular hypertension after PKP. In 11 eyes (7.53%) the topical pressure-lowering therapy failed, and they required glaucoma filtering surgery.

Conclusions: The incidence of ocular hypertension after PKP is high, and at least 1 episode of high IOP was noted in almost half of our patients. A history of preexisting glaucoma and an additional surgical procedure combined with PKP were found to be significant factors predicting the occurrence of ocular hypertension.

Key Words: ocular hypertension, intraocular pressure, penetrating keratoplasty

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Ocular hypertension is a potentially serious complication after penetrating keratoplasty (PKP). High intraocular pressure (IOP) may cause increased loss of corneal endothelial cells and graft failure,[1–5] and can lead to irreversible optic nerve damage.[6] The high incidence, difficulties in diagnosing in proper monitoring, and the complex management of cases with refractory glaucoma, have turned postkeratoplasty glaucoma into a major problem which surgeons face after corneal transplantation surgery. Since computerized visual field examination and optic nerve visualization are often limited by corneal graft clarity and high refractive errors, the damage to the optic nerve is often difficult to assess in postkeratoplasty eyes. Pressure is also occasionally difficult to measure accurately. As evidence of optic nerve damage after keratoplasty is difficult to ascertain, the term "ocular hypertension" may be more appropriate than "glaucoma" in this context.

The reported incidence of ocular hypertension after PKP is highly variable, and ranges between 11% and 47%.[7,8] This incidence was associated with several risk factors. These include the indication for keratoplasty, the status of the lens, additional procedures at the time of keratoplasty, and preexisting glaucoma, as major risk factors.[9–13] The majority of these studies used basic statistical tools such as univariate analysis to identify risk factors. In addition—the distribution and time span of ocular hypertension after surgery were not reported.

This study presents the demographics, incidence, distribution and risk factors of postkeratoplasty ocular hypertension in a large cohort of patients in a single university medical center, using multivariate analysis to identify major risk factors leading to ocular hypertension after PKP.

PATIENTS AND METHODS

The hospital charts of all patients who underwent PKP at the Department of Ophthalmology, Hadassah University Medical Center, between June 2001 and May 2003 were reviewed. Medical charts were retrieved from the Medical Archives Department according to diagnosis codes that were assigned to summary letters after discharge. Information was further obtained from the operating room logbook, and cross-checked with the data from the Medical Archives Department. During this period a total of 174 PKP procedures were performed. Of these, 28 patients were excluded because of incomplete documentation, or lack of sufficient follow-up. Therefore, 146 patients met the above criteria and were included in this study. All patients signed an informed consent form before surgery.

The following data were collected for each patient: Age, sex, visual acuity, the presence of glaucoma before surgery, the number of pressure-lowering medications used before surgery, diagnosis underlying the need for corneal transplantation, previous ocular surgeries, preoperative IOP, preoperative lens status, graft and host trephination diameters, suturing method, additional procedures performed at the time of PKP, the dosage and duration of topical and systemic corticosteroids administered after surgery, time to postoperative epithelialization, intraoperative and postoperative complications, duration and

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timing of postoperative ocular hypertensive events, number of pressure-lowering medications which were used after surgery, and further surgical procedures. Uncorrected and best spectacle corrected visual acuity were measured by a Snellen acuity chart before surgery and at each postoperative visit. All Snellen visual acuity measurements were converted to logarithm of the minimum angle of resolution (logMAR) to allow statistical analysis.

Surgical Procedure

PKP trephination of the recipient bed was performed using a Barron vacuum trephine. Donor buttons were prepared 0.25 or 0.50 mm (in cases of aphakia) larger than the recipient bed, using a Barron vacuum trephine, and were cut from the endothelial side. The donor cornea was first anchored to the host bed by 4 cardinal 10-0 nylon sutures, and by then sutured with either running or interrupted sutures.

Excised buttons were sent to histologic evaluation and donor rims to microbiological evaluation. Gentamicin and cefazolin were injected subconjunctivaly at the end of surgery. Topical corticosteroids, antibiotics, and systemic corticosteroids were administered after surgery, at the discretion of the surgeons. Most patients received systemic corticosteroids until epithelialization of the corneal graft was complete. Topical corticosteroids were started at a dose of 6 to 8 times daily for the first 2 to 4 postoperative weeks and thereafter tapered down over the next 3 months to a frequency of 3 to 4 times daily, and maintained at this dosing during the first year. Thereafter, tapered to a frequency of 1 to 2 times daily.

Data Analysis

Postoperative elevation of IOP was the primary outcome in this study. Ocular hypertension was defined as IOP of 21 mm Hg or higher as measured with a Goldmann tonometer. IOP was measured postoperatively daily for 1 week, weekly for the first postoperative month, and then monthly for 6 months and during each subsequent examination after surgery. The occurrence of postkeratoplasty ocular hypertension was determined and associated with: age, sex, preoperative corneal diagnosis, previous ocular surgery, preexisting glaucoma, graft size, donor oversize, suturing type, lens status, and any associated surgeries combined with the PKP. The response to pressure-lowering medical therapy and graft outcome were also recorded.

Preoperative, surgical, and postoperative parameters were analyzed with SPSS (version 13; SPSS Inc., Chicago, IL). Independent risk factors for ocular hypertension after PKP, were identified using univariate and multivariate analyses. χ^2 and independent samples t test were calculated for the univariate analyses. Variables found to be significant in the univariate analysis were included in a multivariable logistic regression analysis with the presence of ocular hypertension as the dependent variable. A P-value of <0.05 was considered significant.

RESULTS

The mean age of the patients in this study was 45 ± 20.8 years (range, 15 to 88 y). There were 71 (48.6%) men and 75 (51.4%) women. The mean postoperative follow-up period was 24.4 ± 7.6 months (range, 12 to 42 mo). Demographic data and preoperative parameters are shown in Table 1.

TABLE 1. Patient Baseline Data

Patient Characteristics	
No. patients	146
Age (y)	
Mean ± SD	45 ± 20.8
Range	15-88
Sex	
Male	71 (48.6%)
Female	75 (51.4%)
Eyes	
Right	68 (46.6%)
Left	78 (53.4%)
Preoperative visual acuity (logMAR)	
Mean ± SD	1.58 ± 0.91
Range	0.16-3
Preoperative IOP (mm Hg)	
Mean ± SD	13.2 ± 3.7
Range	5-26
Preexisting glaucoma	33 (22.6%)
No. antiglaucoma medications;	
1 medication	23 (69.7%)
2 medications	7 (21.2%)
3 medications	3 (9.1%)

IOP indicates intraocular pressure.

Before surgery, the mean IOP was 13.2 ± 3.7 mm Hg (range, 5 to 26 mm Hg). Most glaucoma patients were controlled with medical or surgical treatment before surgery, and only 6 (4.1%) eyes had an IOP >20 mm Hg during the preoperative examination. Thirty-three eyes (22.6%) had a history of glaucoma and/or had used pressure-lowering medications. Of these 33 eyes, 23 eyes (69.7%) used 1 pressure-lowering medication, 7 eyes (21.2%) needed 2 medications, and 3 eyes (9.1%) needed 3 pressure-lowering medications in the period preceding the surgery. Eight patients had previously undergone trabeculectomy.

The indications for PKP are presented in Table 2.

Surgical procedures before corneal transplantation were performed in 70 (47.9%) eyes (Table 3).

The median recipient bed size was 8.0 ± 0.3 mm (range, 7.0 to 9.0 mm) and the donor button was oversized by 0.25 mm in most of the patients (134 eyes, 92.4%). Interrupted sutures were used in 110 eyes (75.3%), and 4 interrupted sutures combined with a single continuous suture were used in 36 eyes (24.7%).

In 21 (14.4%) patients, PKP was combined with an additional procedure (Table 4).

The mean preoperative best corrected visual acuity improved from 0.90 ± 0.78 logMAR units (Snellen equivalent 20/160; range, 0.18 to 3.00 logMAR units) to 0.37 ± 0.51 logMAR units (Snellen equivalent 20/50; range, 0.0 to 3.00 logMAR units) at the final examination ($P < 0.001$). The mean postoperative best corrected visual acuity and the mean preoperative best corrected visual acuity did not significantly differ for both postkeratoplasty ocular hypertension patients ($P = 0.328$) and in patients who did not develop ocular hypertension ($P = 0.792$).

During a mean follow-up of 24.4 months, at least 1 consecutive period of high IOP (≥21 mm Hg) was documented in 70 eyes (47.7%) with a mean IOP of 27.1 ± 5.6 mm Hg (range, 21 to 49 mm Hg), starting after a mean postoperative period of 70.3 ± 15.8 days (1 to 720 d,

TABLE 2. Indications for Penetrating Keratoplasty

Diagnosis	No. Cases (%)
Keratoconus	60 (41.1)
Graft failure	30 (20.5)
BK	19 (13.0)
Corneal scar	12 (8.2)
Trauma	6 (4.1)
HSK	4 (2.7)
Fuch dystrophy	3 (2.1)
Other edema	3 (2.1)
Corneal dystrophies	3 (2.1)
Other	6 (4.1)
Total	146 (100)

BK indicates bullous keratopathy; HSK, herpes simplex keratitis.

95.7% in 360 d) and lasting for a period of 15.6 ± 2.0 days (1 to 90 d) (Fig. 1). Topical corticosteroids were used in 69 eyes and oral corticosteroids in 13 eyes of these 70 patients at the time of diagnosis of ocular hypertension. Topical corticosteroids were applied for 2 to 12 times a day (mean 6.0 ± 2.1 times daily), and oral prednisone was administered at a dose of 20 to 100 mg (mean 60.0 ± 18.2 mg daily). Generally the topical corticosteroid was tapered down, discontinued, or switched to a weaker one during the treatment period.

During the periods of pressure elevation, patients who had a history of preexisting glaucoma, when compared to patients without a history of preexisting glaucoma, tended to have a higher IOP (mean 29.7 ± 7.0 vs. 25.7 ± 4.2 mm Hg, respectively, $P = 0.02$), earlier manifestation of ocular hypertension (mean time 39.2 ± 57.4 vs. 87.6 ± 157.6 d, respectively, $P = 0.014$) and required a greater number of medications (number of medications: 1.5 ± 0.7 vs. 1.1 ± 0.36, $P = 0.001$). The number of medications was increased for patients with previous glaucoma (number of medications: 1.5 ± 0.7 vs. 1.3 ± 0.6, $P = 0.009$).

A second episode of postoperative ocular hypertension after control of first episode was observed in 35 of these 70 eyes. The mean IOP was 29.0 ± 6.7 mm Hg (range, 21 to 46 mm Hg) occurring 212.2 ± 46.8 days (range, 15 to 870 d) after the surgery (Fig. 1). Twenty-nine of them required new or additional pressure-lowering drugs. During the second period of ocular hypertension the IOP was no higher compared with the first period ($P = 0.403$), but the number of mean topical pressure-lowering drugs significantly increased this time ($P = 0.004$). The mean duration of the second period was 18.1 ± 2.9 days (range, 1 to 60 d). During the second period of ocular hypertension 30 eyes received topical corticosteroids with a mean dose of 4.6 ± 1.9 times a day (range, 2 to 10 times). Only 3 patients received oral corticosteroid treatment. Overall, 11 eyes did not respond to the topical pressure-lowering therapy, and all them required glaucoma filtering surgery to control the pressure.

Overall complications were observed in 30 eyes (20.5%) during the follow-up period. Corneal graft rejection appeared in 10 eyes, graft failure in 13 eyes, delayed epithelialization in 8 eyes, microbial keratitis in 5 eyes, and recurrent herpes simplex keratitis in 2 eyes. Graft failure occured after irreversible rejection episodes in 2 patients, infections in 2 patients, delayed epithelialization in 1 patient, and herpes simplex keratitis in 1 patient. The mean period to graft failure was 12.7 ± 9.5 months (range, 2 to 28.3 mo) after PKP. Nine of 13 failed grafts occurred in patients who had at least 1 postoperative episode of ocular hypertension. However, this higher rate did not reach statistical significance compared to graft failures in

TABLE 4. Additional Surgical Procedures With PKP (n = 21 eyes)

Additional Procedure	N (%)
Cataract extraction + IOL	8 (5.5)
Anterior vitrectomy + IOL exchange	6 (4.1)
Anterior vitrectomy	3 (2.1)
Anterior chamber IOL exchange	3 (2.1)
Anterior chamber IOL removal	1 (0.7)
Total	21 (14.4)

IOL indicates intraocular lens; PKP, penetrating keratoplasty.

TABLE 3. Previous Ocular Surgery (n = 70)

Previous Surgery	N (%)
Cataract extraction	22 (15.1)
PKP	20 (13.7)
Triple procedure	10 (6.8)
Trauma, perforation repair	3 (2.1)
Trabeculectomy + ECCE + PKP	3 (2.1)
Trabeculectomy + PKP	2 (1.4)
Trabeculectomy + ECCE	2 (1.4)
Stem cell transplantation + AMT	2 (1.4)
Trabeculectomy	1 (0.7)
Vitrectomy + ECCE + PKP	1 (0.7)
Retina detachment repair + vitrectomy	1 (0.7)
Retina detachment repair + cataract surgery	1 (0.7)
LKP	1 (0.7)
PRK	1 (0.7)
Total	70 (47.9)

AMT indicates amniotic membrane transplantation; ECCE, extracapsular cataract extraction; LKP, lamellar keratoplasty; PKP, penetrating keratoplasty; PRK, photorefractive keratectomy.

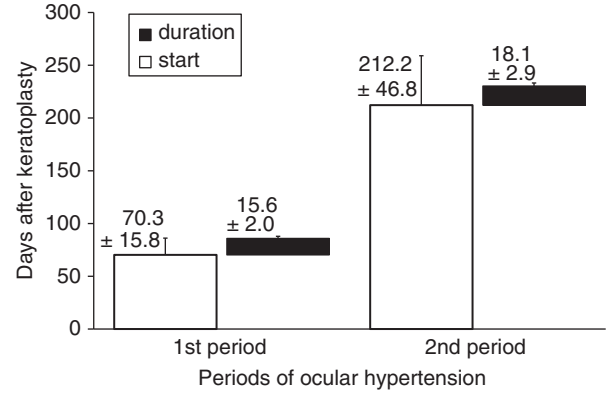

FIGURE 1. The mean starting time and mean length of periods with ocular hypertension after penetrating keratoplasty. Values are mean ± SE in days after surgery. Start—mean time from surgery until ocular hypertension was first noted; Duration—mean duration of period with ocular hypertension.

TABLE 5. Logistic Regression Analysis of Risk Factors

Variables	% With Postoperative Elevated IOP*	OR	95% CI for OR	*P*
Preexisting glaucoma				
No	37.1	1.00		
Yes	70.8	6.23	1.59-24.36	**0.009**
Previous ocular surgery				
No	35.4	1.00		
Yes	53.6	0.86	0.28-2.86	0.86
Donor over size (mm)				
0.25	41.1	1.00		
0.50	87.5	8.44	0.87-87.22	0.07
Additional procedures				
No	38.9	1.00		
Yes	84.6	13.08	2.04-83.91	**0.007**
Lens status				
Phakic	34.7	1.00		
Pseudophakic	55.8	0.65	0.17-2.41	0.52
Aphakic	75.0	0.99	0.50-20.12	0.99

Significant variables in the univariate analysis were included in the logistic regression analysis.

Bold values indicate statistically significant.

*Dependent variable: postkeratoplasty IOP elevation.

CI indicates confidence interval; IOP, intraocular pressure; OR, odds ratio.

nonhypertensive patients ($P = 0.107$), perhaps because of limited power in this study. Preexisting glaucoma also did not show statistically significant effect on graft failure ($P = 0.152$).

Univariate analysis was performed to identify individual risk factors for postkeratoplasty ocular hypertension. In this analysis—age, sex, the indication for keratoplasty, the size of graft, and the type of suturing—were not found to be significant risk factors for postoperative ocular hypertension (χ^2 test, *P* values—0.07 to 0.579). In contrast, the following factors were found to be significant risk factors affecting ocular hypertension after PKP—preexisting glaucoma ($P < 0.001$), previous ocular surgery ($P < 0.014$), donor oversize of 0.50 mm ($P < 0.01$), additional surgical procedures at the time of keratoplasty ($P < 0.001$), pseudophakia or aphakia ($P < 0.006$; χ^2 test).

Risk factors identified by univariate analysis were subjected to multivariate logistic regression analysis. Using multivariate logistic regression analysis, only 2 risk factors were found to be associated with postoperative ocular hypertension: preexisting glaucoma [odds ratio (OR), 6.23; 95% confidence interval (CI),1.59-24.36; $P = 0.009$] and an additional intraocular surgical procedure at the time of keratoplasty (OR, 13.08; 95% CI, 2.04-83.91; $P = 0.007$; Table 5).

Since preexisting glaucoma was a major risk factor for postoperative ocular hypertension, a separate logistic regression analysis was performed for eyes without preexisting glaucoma and for eyes with preexisting glaucoma. Independent variables included previous ocular surgery, donor oversize of 0.50 mm, additional surgical procedures combined with keratoplasty, pseudophakia, and aphakia. For eyes without preexisting glaucoma, the only significant risk factor for the occurrence of postkeratoplasty ocular hypertension was an additional surgical procedure (OR, 14.85; 95% CI, 1.96-112.62; $P = 0.009$). Other factors were not found to be significant. For eyes that had a preexisting glaucoma, no other significant risk factors were identified for the development of raised IOP.

When the 70 eyes with postkeratoplasty ocular hypertension were divided to early-onset ocular hypertension [up to 1 mo, n = 43 (29.5%)] and late-onset [> 1 mo, n = 27 (18.5%)] no significant differences in the risk factors was noted between these 2 groups (*P* values = 0.162 to 0.667).

DISCUSSION

Glaucoma is a serious complication after PKP. This study evaluated the incidence and risk factors for postkeratoplasty ocular hypertension. Univariate analysis identified risk factors significant for this condition, including preexisting glaucoma, previous ocular surgery, donor oversize of 0.5 mm, additional surgical procedures combined with PKP, pseudophakia, and aphakia. Parameters including age, sex, laterality, indication for PKP, graft size, and type of suturing were not significantly related to postoperative IOP elevation in the univariate analysis. Multivariate analysis further showed that preexisting glaucoma and surgeries combined with PKP were the only 2 significant risk factors found for the occurrence of ocular hypertension after PKP.

The overall incidence of at least 1 consecutive period of ocular hypertension after PKP in our study was 47.7%. The reported incidence of glaucoma after PKP in previous reports ranges between 7.3% and 33.6%. Our higher incidence may be because of higher incidence of preoperative glaucoma in our patients (22.6%), the frequency of IOP measurements taken, and combined procedures with PKP (14.4%).

When patients with ocular hypertension in our study were subdivided according to the time of onset, the incidence was 29.5% in the early postoperative period (< 1 mo), and only 18.5% in the late (> 1 mo) postoperative period. Similarly, several studies have divided ocular hypertension into early and late onset and characterized the incidence and risk factors for these 2 periods. Irvine and Kaufman[14] found that during the first postoperative week, the majority of their patients suffered from ocular hypertension of ≥ 25 mm Hg. Karesh and Nirankari[9] noted an incidence of early ocular hypertension in 31%, and chronic IOP elevation in 29% of 80 eyes after keratoplasty. Goldberg et al[15] documented early and late ocular hypertension in 23% and 35%, respectively, of eyes after keratoplasty.

Preexisting glaucoma and additional procedures combined with PKP were the leading risk factors for ocular hypertension, as identified in our study, using logistic regression analysis. Only 1 previous study had analyzed risk factors using multivariate logistic regression (Table 6). Chien et al[16] found preexisting glaucoma and additional procedures as risk factors using logistic regression analysis, but that study looked only at the immediate postoperative period (1 wk). Several other studies identified preexisting glaucoma as a risk factor for postkeratoplasty ocular hypertension (Table 6). Jonas et al[8] reported that on the first postoperative day the IOP was significantly higher than that before keratoplasty, the main predisposing factor being preexisting high IOP. Preexisting history of glaucoma was found to be responsible for higher graft failure.[3,5] On the day of admission for PKP only 6 (3.5%) eyes in our

TABLE 6. Previous Studies on Postkeratoplasty Ocular Hypertension

References	Incidence of Glaucoma	No. Patients	Significant Risk Factors	Follow-up (Range)
Franca et al[12]	21.5%	228	PBK Herpesvirus Trauma	17.14 ± 13.65 mo (4-60 mo)
Ing et al[5]	21%	351	PBK	10 y (8.1-11.3 y)
Jonas et al[8]	7.3% early	245	Preexisting glaucoma	30.4 ± 18.7 mo (12.1-111.6 mo)
Sihota et al[19]	10.6%	747	Leucoma Aphakia Combined surgery	23 ± 16.3 mo (6-48 mo)
Sekhar et al[17]	27.4%	190	Preexisting glaucoma Regrafting Aphakia	14.5 mo
Chien et al[16]	12% (>30 mm Hg) early (7 d)	155	Preexisting glaucoma Combined surgeries	7 d
Kirkness et al[13]	14%	1122	AC dysgenesis Combined surgeries PAS	—
Foulks et al[10]	18% (>25 mm Hg) chronic	502	Preexisting glaucoma Aphakia	3 y (6 mo-8 y)
Karesh et al[9]	31% early 29% late	80	Preexisting glaucoma Aphakia	22 mo (12-26 mo)
Simmons et al[7]	33.6% (≥24 mm Hg)	229	Preexisting glaucoma Aphakia	83.3 wk
Kirkness et al[20]	30%	305	IOL removal Aphakia Age Trauma Regraft	—
Goldberg et al[15]	23% early 35% late	137	Aphakia	7-30 mo
Wood et al[18]	15% (>25 mm)	423	Aphakia Combined surgeries	7-10 d
Karadag et al[21]	5.5% early	729	PAS Combined surgeries Preexisting glaucoma	—
This study	47.7%	146	Preexisting glaucoma Combined surgeries	24.4 ± 7.5 mo (12-41 mo)

AC indicates anterior chamber; BK, bullous keratopathy; IOL, intraocular lens; PAS, peripheral anterior synechia; PBK, pseudophakic bullous keratopathy.

study had IOP of ≥21 mm Hg, indicating that even when glaucoma was medically controlled, ocular hypertension could follow PKP if glaucoma preceded the surgery.

The second significant risk factor was the combination of PKP with another surgical procedure, usually cataract extraction with intraocular lens implantation. A combined procedure was performed in 14% of our patients at the time of PKP. Other studies have also reported combined procedures to be a major risk factor for postkeratoplasty ocular hypertension (Table 6).[13,16–19] Other reported risk factors for the development of postkeratoplasty ocular hypertension are aphakia, presence of anterior synechiae, and indications for keratoplasty such as trauma, regraft, and bullous keratopathy.[5,12,13,17,20,21] In the present study, previous ocular surgery, donor oversize of 0.50 mm, additional intraocular surgeries, pseudophakia, and aphakia were risk factors identified by univariate analysis. Most previous studies identified aphakia as a significant risk factor (Table 6). Olson and Kaufman[11] studied aphakic keratoplasty, and reported an incidence of IOP >35 mm Hg in the first postoperative week in 46% of 81 aphakic eyes. In our study aphakia was indeed a significant risk factor when analyzed separately, but was not found to be an independent predictor when multivariate regression analysis was performed.

Mechanisms explaining an IOP rise after PKP include the following: postoperative edema and inflammation compromising the trabecular meshwork, angle distortion, peripheral anterior synechiae, retained viscoelastics, and a steroid response. Olson and Kaufman,[22] using a mathematical model, identified several surgical variables that could potentially alter the anterior chamber angle and increase the IOP. According to this model, tight suturing, long suture bites, larger trephine sizes, same-sized donor-recipient trephination, and increased recipient peripheral corneal thickness were all related to iridocorneal angle compression and an IOP increase. Using same sized grafts may distort and collapse the angle thus causing decreased outflow and increased IOP. Zimmerman et al[23] observed a higher incidence of postkeratoplasty glaucoma in aphakic eyes or in combined procedures when same size donor buttons were used. The IOP was greater in larger corneas. Again, Zimmermann et al[24,25] showed that using same size donor buttons in aphakic keratoplasty resulted in a 37% reduction of outflow facility. This did not occur with 0.50-mm oversize donor button in phakic keratoplasty. Other studies, however, did not find a significant effect of graft oversizing by 0.5 mm on postkeratoplasty ocular hypertension.[26,27] Interestingly, oversizing the grafts by 0.50 mm

was one of the predisposing factors for ocular hypertension in our study, but only a small proportion of patients had this oversizing. This effect was most likely associated with aphakia, as 0.5-mm oversized donors were applied to aphakic patients. Having used multivariate analysis, both factors were eliminated as risk factors for postoperative glaucoma. Other possible explanations for the increased risk in 0.5 mm oversizing is that these grafts are usually larger. Larger donor buttons may affect the iridocorneal angle. Indeed, Panda et al,[28] noted an incidence of postoperative glaucoma of 37% in eyes with 10-mm grafts, versus 14% in eyes with 6 to 7.5-mm grafts. Steroids play an important role in the pathogenesis of glaucoma. Postoperative use of steroids controls inflammation and reduces the likelihood of peripheral anterior synechia, thus reducing the risk of IOP elevation. In contrast, topical steroids may induce steroid-induced ocular hypertension. Most of our patients were under treatment of steroids during the period of elevated IOP. The mean topical steroid application was 6 times a day. When high IOP was observed, steroids were tapered down, stopped, or switched to the weaker steroids. As almost all of our patients were maintained on topical corticosteroids postoperatively, it is difficult to assess the effect that steroids had on the incidence of postkeratoplasty ocular hypertension.

Preventive measures for postoperative glaucoma include control of preexisting glaucoma, use of oversized donor button,[23,29] goniosynechiolysis,[30] and removal of viscoelastic substance at the end of surgery.[31] Zimmerman et al[23] and Bourne et al[29] noted that use of 0.5-mm oversize donor button in aphakic patients reduced the postoperative incidence of glaucoma. Olson et al[32] recommended using a donor button 0.50 mm larger than the recipient bed in aphakic and combined procedures with PKP. Seitz et al[33] noted a lesser IOP after PKP with laser trephination.

Most eyes with high IOP were controlled medically, and only 3 eyes required surgical intervention. These included trabeculectomy or Ahmed valve implantation. Surgical procedures that were previously reported for refractory glaucoma include trabeculectomy with or without adjunctive antifibrotic agents, cyclodialysis, cyclodestructive procedures, and glaucoma drainage implants such as Baerveldt, Molteno, or Ahmed valve implants.[34–39] However, these procedures all increase the risk of graft failure.[34] Another option to control refractory glaucoma is by replacing topical corticosteroids with topical cyclosporine A (Perry et al[40,41]). This however may increase the risk of immune rejections.

The incidence of graft failures was higher, but didn't reach statistical significance, in patients with postkeratoplasty ocular hypertension. The higher risk of graft failure in preexisting or postkeratoplasty glaucoma was previously reported.[3–5] Rumelt et al[4] noted a higher incidence of graft failure in preexisting and postkeratoplasty glaucoma patients.

In conclusion, IOP elevation after keratoplasty was seen in nearly half of our patients during long-term follow-up. The elevation of IOP may occur in the immediate postoperative period, while half of these patients may experience a second period of ocular hypertension. Monitoring of IOP should be started in the early postoperative period. Preexisting glaucoma was found to be main risk factor for the development of postkeratoplasty ocular hypertension. Any patient with a history of preexisting glaucoma should be carefully evaluated before PKP, and carefully monitored after the procedure. Additional procedures during PKP increase the risk of postoperative ocular hypertension. Surgeons should probably consider the risk associated with combined procedures, and perhaps consider the possibility of staged procedures. The introduction of lamellar techniques for corneal transplantation may further decrease the incidence of postkeratoplasty ocular hypertension.

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