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RESEARCH ARTICLE

Evaluation of Mid-Term Results of Penetrating Keratoplasty

Penetran Keratoplastinin Orta-Dönem Sonuçlarının Değerlendirilmesi

Mustafa YILDIRIM[1,a], Fatma Tuğçe YAVUZ ÖZTÜRK[2]

[1]Atatürk Üniversitesi Tıp Fakültesi, Göz Hastalıkları Anabilim Dalı, Erzurum, Türkiye
[2]Mardin Eğitim ve Araştırma Hastanesi, Göz Hastalıkları Kliniği, Mardin, Türkiye

M.Y. 0000-0002-2706-3592, F.T.Y.Ö. 0009-006-4243-8731.

[a]Corresponding Author: Mustafa YILDIRIM (mustafa.yildirim@atauni.edu.tr)

ABSTRACT

Objective: This study aimed to evaluate the clinical and anatomical results of patients who underwent penetrating keratoplasty (PK).

Material and Method: Records of patients who underwent PK between 2019 and 2024 were retrospectively reviewed. Only those patients with at least six months of follow-up were included in the study. The data were evaluated based on the criteria of indication, allograft reaction, graft transparency, and final postoperative visual acuity.

Results: PK was performed on 130 eyes of 130 patients. Within the scope of the study, 62 female (47,69%) and 68 male (52,31%) patients were evaluated. The mean age was 36.4±18.2 (18-86) years. The cases were followed up for an average of 18 ± 2.6 (6-24) months. When the cases were analyzed in terms of indications, the most common diagnosis was keratoconus, with 45 (34.6%) patients. Keratoconus was followed by aphakic and pseudophakic bullous keratopathy in 30 (23.07%), vascularized leukoma in 25 (19.2%), viral keratitis in 13 (10%), traumatic scar in 11 (8.46%), corneal dystrophy and degeneration in 5 (3.84%), and keratoglobus in 1 (0.7%), respectively. Graft transparency was preserved in 102 (78.46%) eyes, while graft failure occurred in 28 (21.54%) eyes. Visual acuity of 0.2 and above was achieved in 82 eyes (63.07%).

Conclusion: In this study, the most common indication for PK over a 5-year period was keratoconus and representing the initial experiences of a surgeon who has recently started performing keratoplasty surgery, graft clarity was observed in 78.46% of eyes despite the presence of risk factors for postoperative graft survival.

Keywords: Penetrating Keratoplasty, Graft Survival, Visual Level.

ÖZET

Amaç: Bu çalışmanın amacı penetran keratoplasti (PK) geçiren hastaların klinik ve anatomik sonuçlarını değerlendirmektir.

Gereç ve Yöntem: 2019-2024 yılları arasında PK uygulanan hastaların kayıtları retrospektif olarak incelendi. Takip süresi en az altı ay olan hastalar çalışmaya dahil edildi. Veriler endikasyon, allogreft reaksiyonu, greft şeffaflığı ve postoperatif son görme keskinliği kriterlerine göre değerlendirildi.

Bulgular: Yüzotuz hastanın 130 gözüne PK uygulandı. Çalışma kapsamında 62 kadın (%47,69) ve 68 erkek (%52,31) hasta değerlendirildi. Ortalama yaş 36,4±18,2 (18-86) yıldı. Olgular ortalama 18 ± 2,6 (6-24) ay takip edildi. Olgular endikasyonlar açısından incelendiğinde en sık görülen tanı 45 (%34,6) hasta ile keratokonus idi. Keratokonusu sırasıyla 30 (%23,07) afakik ve psödofakik büllöz keratopati, 25 (%19,2) vaskülarize lökoma, 13 (%10) viral keratit, 11 (%8,46) travmatik skar, 5 (%3,84) kornea distrofisi ve dejenerasyonu ve 1 (%0,7) keratoglobus izledi. Greft şeffaflığı 102 (%78,46) gözde korunurken, 28 (%21,54) gözde greft başarısızlığı meydana geldi. Görme keskinliği 82 (%63,07) gözde 0,2 ve üzeri olarak elde edildi.

Sonuç: Çalışmada, 5 yıllık bir süre boyunca PK için en yaygın endikasyon keratokonustu. Keratoplasti ameliyatına yeni başlayan bir cerrahın ilk deneyimlerini içeren bu hasta serisinde, ameliyat sonrası greft sağ kalımı için risk faktörlerinin varlığına rağmen gözlerin %78,46'sında greft berraklığı gözlendi.

Anahtar Sözcükler: Penetran Keratoplasti, Greft Sağkalımı, Görme Seviyesi.

Penetrating keratoplasty (PK) is a surgical procedure over 100 years old that has become the most frequently performed type of transplant worldwide due to its efficacy and safety. Despite the development of new, less invasive, lamellar techniques, PK still accounts for approximately 70% of corneal

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transplants today (1). In addition, in treatment-resistant corneal diseases, removal of the pathological corneal section has benefits in reducing patient pain, preserving globe integrity and, rarely, cosmetically (2-5).

The reason why keratoplasty is more successful compared to other organ transplants is due to the cornea being avascular and immunologically privileged (6). Currently, in low-risk cases, the 5-year graft survival rate for keratoplasties is approximately 95% (6-10). In high-risk groups, the failure rate increases by three to four times (6, 8, 11). As follow-up durations increase, the transparency of the graft also decreases. Both the prolonged human lifespan and the continuous risk of endothelial cell loss and rejection throughout life affect the long-term outcomes of keratoplasty.

In this study, the data of patients who underwent penetrating keratoplasty (PK) were analyzed with the aim of presenting the clinical implications of the evaluations in the literature regarding PK (initial indications, graft survival, immunological graft rejection, visual outcomes, and factors affecting visual outcomes) (2, 12-14).

MATERIAL AND METHOD

The files of patients who underwent PK between December 2019 and April 2024 and had a follow-up period of more than 6 months were retrospectively reviewed. The study was conducted in accordance with the principles of the Declaration of Helsinki and was approved by the local ethics committee. Informed consent forms were obtained from the patients participating in the study. Data obtained from the records were evaluated according to the criteria of age, gender, follow-up period, indications for PK, graft rejection, graft transparency, final visual acuity and causes of decreased visual acuity. Since the study included the surgeon's early experience with the keratoplasty technique, only the penetrating keratoplasty technique was applied to the patients. Unilateral surgery was performed in all patients during the follow-up period, both to evaluate the surgical results and because the patients did not want to undergo a second surgery without complete relief in their operated eyes.

In all cases, donor corneas were collected within 8 hours after death and stored in Optisol GS solution (Chiron Ophthalmics, Irvine, CA) at +4°C. All patients received 300 IV mannitol preoperatively. The donor cornea was prepared by cutting it 0.25 mm larger than the recipient bed using a penetrating trephine (Moria Trephine, France) from the endothelial side, while the recipient bed was prepared using a vacuum trephine (Moria Cornea Vacuum Punch, France). Graft dimensions were set as standard recipient bed 7.50 mm, donor 7.75 mm. The graft was embedded in the recipient bed with 10.0 monofilament nylon sutures (Luxamid 10/0 nylon, Luxsutures, Luxembourg) 16 single or 8 single 16 continuous sutures. After the operation, the anterior chamber was created with balanced salt solution and subconjunctival gentamicin 20 mg (Türktıpsan Gentamisin Sulfate 20 mg/2 ml, Türktıpsan, Türkiye) and dexamethasone 8 mg (Deksamet 8 mg/ 2 ml, Osel, Türkiye) were applied after the operation.

In the postoperative period, topical dexamethasone sodium phosphate (Maxidex %0.1coll, Novartis, Spain) and topical moxifloxacin 6*1 coll (Vigamox %0.5coll, Alcon, USA), autologous serum 8*1 doses were started in all eyes. Steroid drops were continued with decreasing doses until the twelfth month. Systemic antimicrobial agents, antiglaucomatous agents and ocular lubricants were added to the treatment when necessary. Oral acyclovir, which was also started preoperatively in cases with herpetic keratitis, was used at a prophylactic dose (800 mg/day) for at least one year. The cases were followed up for an average of 18 ± 2.6 (6-24) months. Immune reaction was detected by the presence of new keratic precipitates, epithelial and endothelial rejection lines, subepi-thelial infiltrates and corneal edema (15).

Graft transparency and visual acuity were determined according to the final clinical examination findings. In cases where more than one keratoplasty was performed, final graft results were evaluated. Irreversible opacity development in the graft was considered as graft failure. Data analysis was performed using SPSS 11.0 (SPSS Inc., Chicago, IL) program.

RESULTS

PK was performed on 130 eyes of 130 patients. Within the scope of the study, 62 female (47,69%) and 68 male (52,31%) patients were evaluated. The mean age was 36.4±18.2 (18-86) years. The cases were followed up for an average of 18 ± 2.6 (min 6-max 24) months. When the cases were analyzed in terms of indications, the most common diagnosis was keratoconus, with 45 (34.6%) patients. Keratoconus was followed by aphakic and pseudophakic bullous keratopathy in 30 (23.07%), vascularized leukoma in 25 (19.2%), viral keratitis in 13 (10%), traumatic scar in 11 (8.46%), corneal dystrophy and degeneration in 5 (3.84%), and keratoglobus in 1 (0.7%), respectively. Medical indications are presented in table 1.

Table 1. Indications for penetrating keratoplasty.

Indications	Eye	%
Keratoconus	45	34,6
Bullous keratopathy	30	23,07
Vascularized leukoma	25	19,2
Viral keratitis	13	10
Traumatic scar	11	8,46
Corneal dystrophy and degeneration	5	3,84
Keratoglobus	1	0,7
Total	130	100

Of the 130 grafts, 125 (96.15%) were made for visual purposes and 5 (3.85%) were made for therapeutic and/or tectonic purposes (5 spontaneous perforations).

At the end of the follow-up period, 19 (14.61%) patients developed allograft reactions, 9 of which were suppressed with medical treatment and graft transparency was preserved (7 keratoconus, 6 vascularized leukoma, 4 viral keratitis, 1 corneal dystrophy and 1 traumatic scar). 10 (21.53%) eyes lost graft transparency due to irreversible allograft reaction. Rekeratoplasty was not performed in these patients during the follow-up period. The development of allograft reaction is shown in table 2.

Table 2. Allograft reaction according to indications.

Diagnosis	Reversible allograft reaction	%	Irreversble allogreft reaction	%	Total	%
Keratoconus	6	66,7	1	10	7	36,84
Vascularized leukoma	1	11,1	5	50	6	31,57
Viral keratitis	1	11,1	3	30	4	21,05
Corneal dystrophy			1	10	1	5,26
Traumatic scar	1	11,1			1	5,26
Total	9	47,36	10	52,64	19	100

Graft transparency was preserved in 102 (78.46%) eyes, while graft failure occurred in 28 (21.54%) eyes. The most common cause of graft failure was allograft reaction in 10 (35.71%) eyes (5 vascularized leukoma, 3 viral keratitis, 1 keratoconus, 1 corneal dystrophy). Other causes were endothelial insufficiency in 5 (17.85%) eyes, ocular surface problems in 5 (17.85%) eyes, keratitis in 4 (14.28%) eyes, trauma in 3 (10.71%) eyes and phthisis bulbi in 1 (3.57%) eye. Reasons for graft failure are shown in table 3.

Table 3. Causes of graft failure.

Diagnosis	Eye	%
Allograft reaction	10	35,71
Endothelial failure	5	17,85
Ocular surface problems	5	17,85
Keratitis	4	14,28
Trauma	3	10,71
Phthisis bulbi	1	3,57
Total	**28**	**100**

Graft complications and outcomes are shown in figure 1.

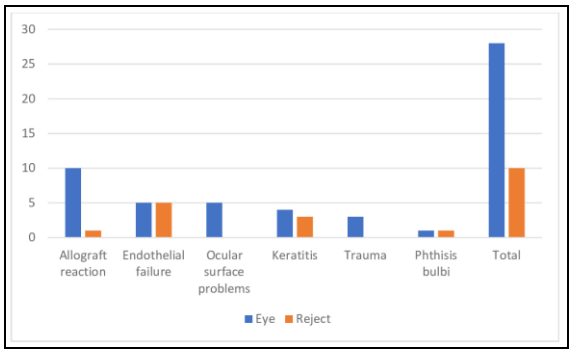

Figure 1. Graft complications and outcomes.

In 2 (1.5%) cases, although the graft was transparent, the degree of vision could not be measured because cooperation could not be achieved. Visual acuity of 0.2 and above was achieved in 82 eyes (63.07%). Visual acuity was less than 0.2 in 48 eyes (36.93%). The best corrected visual acuity values at the final clinical examination are presented in table 4.

Table 4. Final visual acuity.

Visual acuity	Eye	%
0,2≥	82	63,08
<0,2	46	35,38
Unevaluable	2	1,54
Total	**130**	**100**

The reasons for having a visual acuity of less than 0.2 despite a clear graft in 20 eyes are shown in table 5.

Table 5. Causes of low vision despite clear graft.

Diagnosis	Eye	%
Amblyopia	6	30
High astigmatism	5	25
Optic nerve damage due to glaucoma	4	20
Cystoid macular edema	2	10
Age-related macular degeneration	2	10
Degenerative myopia	1	5
Total	**20**	**100**

DISCUSSION

PK is an important surgical procedure involved in the treatment of corneal diseases or in the rehabilitation of vision loss that occurs thereafter. In most cases, penetrating keratoplasty is performed for visual purposes (87-91%), while approximately 8-10% of cases are done for therapeutic and/or tectonic purposes. Cosmetic applications account for less than 1% of cases (14). In this study, 96.15% of the grafts were performed for visual purposes, while 3.85% were done for therapeutic and/or tectonic purposes. Numerous studies have been conducted in the literature regarding the indications for PK. Indications for PK vary depending on socioeconomic and geographic factors (14-18). In the early years, herpetic keratitis and regrafts were the leading indications, but with the advent of antiviral drugs, regrafts have moved to the top of the list, replacing herpetic keratitis as the primary indication. After the introduction of intraocular lenses in the 1970s, pseudophakic bullous keratopathy began to rise to the top of the list of indications (19-21). In a study conducted by Robin JB (20) and colleagues in 1979, pseudophakic bullous keratopathy was reported as the leading indication. Thanks to advancements in intraocular lenses, this rate has decreased in recent years. In a study by Kubaloglu (22) and colleagues conducted between 1987 and 1992, involving 142 cases, aphakic bullous keratopathy was the leading indication with 15.4%, while pseudophakic bullous keratopathy ranked second with 14.7%. In a series of 821 cases conducted by Doğanay (23, 24) and colleagues, the indications for penetrating keratoplasty were as follows: pseudophakic bullous keratopathy accounted for 11.4%, aphakic bullous keratopathy for 8.5%, and cases of keratoconus for 17.5%. Although a decrease in pseudophakic corneal edema has been observed since 1989 due to advancements in surgical techniques, viscoelastics, and IOL materials, it remains one of the leading indications today due to the prolonged human lifespan (2, 25, 26).

Keratoconus is a leading indication with a frequency ranging from 7-31% in many studies (14, 26-28). In this study, keratoconus was the most common indication with a frequency of 34.6%. Keratoconus was followed by aphakic and pseudophakic bullous keratopathy in 23.07%, vascularized leukoma in 19.2%, viral keratitis in 10%, traumatic scar in 8.46%, corneal dystrophy and degeneration in 3.84%, and keratoglobus in 0.7%, respectively.

The cases were followed up for an average of 18 ± 2.6 (6-24) months. After the follow-up period, 78.46% graft transparency was observed, while graft failure occurred in 21.54% of the eyes. When the results related to graft transparency after PK are examined in the literature, 89% graft transparency was found in the study conducted by Eren (29) et al. The graft transparency rate was reported as 74% in the study conducted by Nurözler (30) et al.

Factors affecting the survival rate of the graft are known to be the age of the recipient, graft size, graft endothelium number, degree of corneal vascularization, initial corneal disease, glaucoma, inflammation and perforation during keratoplasty (31). In vascular corneas, the immunological privilege of the cornea for tissue transplantation is lost and, like other vascular tissues, the probability of rejection increases (32). In the study, the number of patients with high risk of graft rejection such as vascularized leukoma and viral keratitis constituted approximately 30% of the cases. This situation reduces the success rate of the graft transparency. In their study, Doğanay (23) et al. found the graft transparency to be 74%, but in the same study, they found the graft transparency to be 94% only in patients with keratoconus and 42.3% in chemical burns. As the study period increases, the graft viability rate decreases due to progressive endothelial cell loss. The average follow-up period is within a time period that can be evaluated within the scope of medium term. According to the results reported in the literature, the most important reason for the lower graft transparency rate in the study may be the proportionally high number of patients with high risk of rejection.

The present study, the most common cause of graft failure was allograft reaction (35.71%). Allograft reaction occurred most frequently in eyes that underwent keratoplasty due to nonspecific vascularized leukoma and viral keratitis. In the study conducted by Nurözler (30) et al., the most common reasons for graft failure were reported as allograft reaction (42.1%) and endothelial insufficiency (24%). In the study, 47.36% of allograft rejection cases were treated and graft transparency was achieved. The best response to allograft reaction was obtained from cases that underwent PK due to keratoconus (85.71%). If rejection episodes are diagnosed early, they can be treated effectively. Teaching patients the symptoms of rejection and raising awareness is crucial for early diagnosis and treatment. However, in approximately 30% of cases, rejection is diagnosed during follow-up exams without the presence of rejection symptoms (33).

In conclusion, in this patient series, representing the initial experiences of a surgeon who has recently started performing keratoplasty surgery, graft clarity was observed in 78.46% of eyes despite the presen-

ce of risk factors for postoperative graft survival. PK is an important treatment method in the treatment of vision loss caused by corneal diseases. Despite advances in medical treatments and developments in lamellar keratoplasties, PK is still the first choice in many corneal pathologies. PK, which provides satisfactory results in appropriate patients and indications, will continue to be applied in the future as it has in the past years in response to new indications.

Limitations of the study

The main limitation of the study is the medium-term follow-up period. It should be taken into account that graft survival may decrease with increased follow-up periods in risky patient groups.

Ethical consent: The study was conducted in accordance with the principles of the Declaration of Helsinki and was approved by the Clinical Research Ethics Committee of Atatürk University Faculty of Medicine Health Practice and Research Hospital (Date:07.06.2024, Decision number:07, B.30.2.XXX.0.01.00/374).

Informed Consent: Written informed consent was obtained from the parents of the patients who partici pated in this study.

Peer-review: Externally peer-reviewed.

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