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Phototherapeutic Keratectomy Results for the Treatment of Corneal Scarring After Pterygium Excision: A Retrospective Clinic Study

Pterjium Eksizyonu Sonrası Oluşan Ön Kornea Skarının Giderilmesi İçin Yapılan Fototerapötik Keratektomi Sonuçlarımız: Retrospektif Klinik Çalışma

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ABSTRACT Objective: To evaluate the post-treatment corneal changes by corneal topography in patients who underwent phototherapeutic keratectomy (PTK) to reduce anterior corneal irregularity and corneal scarring after pterygium excision. **Material and Methods:** One eye of 23 patients who underwent PTK was retrospectively analyzed. Corneal topography data of the patients collected after pterygium excision were compared with those obtained 1 year after PTK. **Results:** The mean time to PTK after pterygium excision was 5.93±1.39 months (4-9 months). No statistically significant difference was found in the topographic data of the patients at the 1st, 3rd and 6th postoperative months controls. In the 12th postoperative month results, the corrected distance visual acuity improved significantly from 0.55±0.28 logMAR (0.10-1.00 logMAR) to 0.46±0.32 logMAR (0.1-1.00 logMAR). While the K1 (flattest central keratometry) value was lower in 15 patients after PTK surgery, the difference was not statistically significant. (p=0.301). After PTK, K2 (steepest central keratometry), Kmax (maximum keratometry) and spherical equivalent values were lower than preoperative values, the difference was not statistically significant (respectively p=0.060, p=0.075, p=0.570). In 17 patients, the postoperative index of vertical asymmetry value was higher than before the operation, and the difference was statistically significant (p=0.014). Although index of surface variance, index of height asymmetry and index of height decentrization values were higher than before surgery, the differences were not statistically significant (respectively p=0.988, p=0.543, p=0.181). **Conclusion:** PTK improves corrected visual acuity by reducing corneal surface irregularity and spectacle-corrected astigmatism following pterygium excision.

Keywords: Pterygium; corneal topography; keratectomy; corneal laser surgery

ÖZET Amaç: Pterjium eksizyonu sonrası ön korneal düzensizliğini ve korneal skarını azaltmak için fototerapötik keratektomi [phototherapeutic keratectomy (PTK)] uygulanan hastalarda, tedavi sonrası korneal değişiklikleri kornea topografisi ile değerlendirmektir. **Gereç ve Yöntemler:** PTK uygulanan 23 hastanın bir gözü retrospektif olarak analiz edilmiştir. Hastaların pterjium cerrahisi sonrası toplanan kornea topografi verileri, PTK'den 1 yıl sonra elde edilen verilerle karşılaştırılmıştır. **Bulgular:** Pterjium eksizyonu sonrası PTK uygulanma süresi ortalama 5,93±1,39 ay (4-9 ay) idi. Ameliyat sonrası 1, 3 ve 6. ay kontrollerinde hastaların topografik verilerinde istatistiksel olarak anlamlı bir fark bulunmamıştır. Ameliyat sonrası 12. ay sonuçlarında ise düzeltilmiş uzak görme keskinliği, 0,55±0,28 logMAR (0,10-1,00 logMAR) değerinden 0,46±0,32 logMAR (0,1-1,00 logMAR) değerine anlamlı bir şekilde iyileşmiştir. On beş hastada K1 (düz merkezi keratometri) değeri daha düşük olmasına rağmen, fark istatistiksel olarak anlamlı değildi (p=0,301). Ameliyat sonrası K2 (dik merkezi keratometri), Kmax (maksimum keratometri) ve sferik eş değer değerleri ameliyat öncesi değerlere göre daha düşük olmakla birlikte, fark istatistiksel olarak anlamlı değildi (sırasıyla p=0,060, p=0,075, p=0,570). On yedi hastada ameliyat sonrası vertikal asimetri indeksi değeri ameliyat öncesine göre daha yüksek bulunmuş olup, fark istatistiksel olarak anlamlıydı (p=0,014). Yüzey varyans indeksi, yükseklik asimetrisi indeksi ve yükseklik desantralizasyon indeksi değerleri ameliyat öncesine göre yüksek olmasına rağmen fark istatistiksel olarak anlamlı değildi (sırasıyla p=0,988, p=0,543, p=0,181). **Sonuç:** PTK, pterjium eksizyonu sonrası korneal yüzey düzensizliğini ve gözlükle düzeltilebilir astigmatizmayı azaltarak düzeltilmiş görme keskinliğinin artmasını sağlar.

Anahtar Kelimeler: Pterjium; kornea topografisi; keratektomi; kornea lazer cerrahisi

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Pterygium is a very commonly seen disease. It is observed in the population at a rate of 1.9% to 9.84%.[1,2] Factors like ultraviolet radiation, heat, dust, wind and dry air contribute to the development of pterygium.[3] Pterygium can still recur even after surgical removal followed by conjunctival autograft transplantation with mitomycin C (MMC).[4-6]

In 1998, Talu et al, performed simple excision along with excimer phototherapeutic keratectomy (PTK) on recurrent pterygia.[6] After pterygium excision, excimer laser was applied, thus correcting the corneal surface and reducing the recurrence rate. PTK is used in the treatment of many corneal diseases, including corneal dystrophies and degenerations, recurrent epithelial erosions, corneal opacities, and various other corneal irregularities.[7] Scars in the superficial anterior stroma, which are avascular and less than 100 microns deep, can be effectively treated with PTK.[8] These scars may arise following trauma, infection, or after pterygium removal.[9,10] Recent research indicates that even with a successful pterygium removal, varying degrees of anterior corneal scarring are likely to remain.[11] PTK smooths the corneal surface and reduces corneal opacity.[12]

Corneal topography serves as an effective and valuable method for assessing refractive alterations induced by pterygium.[13] Additionally, keratometric readings and topographic indices provided by topography are essential for tracking corneal irregularities over time.

This retrospective study was conducted to assess the changes in the cornea after PTK in patients who underwent PTK due to corneal irregularity and scar tissue after pterygium excision through corneal topography.

MATERIAL AND METHODS

Between April 2021 and April 2023, one eye of 23 patients who underwent PTK due to irregularity and scarring of the anterior cornea after pterygium excision was enrolled in the study. Pterygium localized on the nasal side of the cornea, exceeded the cornea by 4 mm or more on slit lamp examination, underwent pterygium surgery for the first time, and developed corneal irregularities and scars in corneal topography performed during regular check-ups were enrolled in the study. Patients with keratoconus, dry eye, eyelid dysfunction and any congenital eye disease, patients with herpetic keratitis, and patients with systemic diseases that affect corneal healing such as diabetes, glaucoma and collagen vascular disease were excluded from the study. All patients included in the study underwent PTK 5.93±1.39 months after pterygium excision. Corneal topography was performed at 1, 3, and 6 months, as well as at 1 year. The data from the first year after PTK was compared with the pre-PTK values.

The study was carried out in accordance with the principles accepted in the Declaration of Helsinki, and approval was obtained from the Kayseri City Hospital Clinical Research Ethics Committee for the study (date: September 19, 2023, no: 917).

Corneal topography (Pentecam HR, Oculus, Germany) elevation data were measured in a standardized manner based on the reference best-fit sphere calculated in a fixed optical region of 8.0 mm. The image of Belin/Ambrósio improved ektasia was evaluated. With corneal topography, keratometric values such as flat keratometry (K1), steep keratometry (K2), maximum keratometry (Kmax), spherical equivalent (SE) and topometric indices such as index of surface variance (ISV), index of vertical asymmetry (IVA), index of height decentrization (IHD), index of height asymmetry (IHA) were evaluated.

PTERYGIUM EXCISION TECHNIQUE

After topical anaesthesia proparacaine hydrochloride 0.5%, [Alcaine® 0.5% (Alcon, TX, USA)], the pterygium head was removed from the cornea. Then the conjunctival and subconjunctival fibrovascular tissues were removed. Scarring on the cornea was bluntly cleaned. MMC 0.02% was administered for 1 minute and irrigated. The limbal conjonktival autogreft was sutured to cover the limbal deficient area with a 10-0 nylon suture (Alcon, USA). Topical moxifloxacin 0.5% were instilled four times a day for at least 3 weeks and artificial tear eye drops were given 3 times a day for 3 months after the surgery. Topical 0.1% fluorometholone was started 2 weeks after the surgery and continued for 3 months.

PTK TECHNIQUE

PTK was carried out under topical anesthesia with 0.5% proparacaine hydrochloride (Alcaine® 0.5%) sterile eye drops. After applying alcohol for 20 seconds, the corneal epithelium was removed using a hockey spatula. The laser device (VISX STAR S4 excimer laser, Abbott, Abbott Park, IL, USA) was focused on the scar area, with the 6.5 mm ablation diameter tailored to the scar size measured preoperatively under the microscope, and a 50µ ablation was carried out in PTK mode. The device's eye-tracking system was deactivated, and the laser procedure was conducted manually. After photoablation was completed, 0.02% MMC saturated sponch was kept on the corneal surface for approximately 30 seconds to prevent haze formation. Afterwards, the eye was washed abundantly with a balanced salt solution. Postoperatively, the bandage contact lens was kept on the surface of the eye until the epithelialization was completed. Postoperatively, fluoromethelone acetate 0.1%, moxifloxacin 0.5% and artificial tear eye drops were given 3 times a day for 1 month. After 1 month, fluoromethelone acetate 0.1% eye drop was decreased and contnued for 3 months and artificial tears were continued for 6 months. None of the patients had complications after PTK and pterygium excision. Patients were called for controls at 1st, 3rd, 6th months and at 1st year. Measured in the first year follow-up K1, K2, Kmax, corneal astigmatism, ISV, IVA IHD, IHA were evaluated. K1, K2, Kmax, corneal astigmatism, ISV, IVA, IHA and IHD values of all patients were compared with preoperative values.

STATISTICAL ANALYSIS

Statistical analysis was performed using SPSS 22.0 (SPSS Inc., Chicago, IL, USA) program. Descriptive statistics for numerical variables were expressed as mean±standard deviation, number and percentage for categorical variables. In the statistical evaluation of the data, normally distributed parameters were evaluated with paired sample-t test and abnormal parameters were evaluated with Wilcoxon signed rank test. The relationship between normally distributed parameters was determined by Pearson test. The results were accepted at the 95% confidence interval, with significance at $p<0.05$.

RESULTS

The analysis for the study involved 23 eyes from 23 individual patients. There were 16 males (69.6%) and 7 were females (30.4%) with a mean age of 57.09±11.96 years (23 - 81 years). The mean time to PTK after pterygium excision was 5.93±1.39 months (4-9 months), and the time to evaluation after PTK was 1 year. The demographic characteristics of the patients are shown in Table 1. The mean K1, K2, and Kmax values before PTK were 42.41±3.44 D, 46.56±3.50 D, and 44.32±3.29 D, respectively, and 41.27±3.04 D, 45.06±3.71 D, and 43.06±3.17 D after PTK, respectively. Although there was a significant decrease in K1, K2 and Kmax values between preoperative and postoperative measurements, the difference between K1, K2 and Kmax values was not statistically meaningfull (respectively p=0.301, p=0.060, p=0.075). Corneal astigmatism value decreased in 14 individuals, increased in 8 individuals and remained unchanged in 1 patient after PTK. Mean corneal astigmatism values were 3.86±2.19 before PTK and 3.80±2.44 after PTK, and no statistically significant difference was observed (p=0.570). While the corrected distance visual acuity (CDVA) before PTK did not change in one patient, it increased in 18 patients and decreased in 4 patients. Cataracts were observed to develop in these 4 patients whose vision decreased. The CDVA significantly improved from 0.55±0.28 logMAR (0.10-1.00 logMAR) to 0.46±0.32 logMAR (0.1-1.00 logMAR) after PTK. The difference is statistically significant (p=0.021). ISV value decreased in 13 patients and increased in 10 patients after PTK, and mean ISV was 69.13±42.03 before PTK and 73.43±45.13 after PTK. IHA value decreased in 11 patients and increased in 12 patients after PTK, and

TABLE 1: Demographic characteristics of patients..

Characteristics	n=23
Age (year), $\bar{X}$±SD	57.09±11.96
Gender, n (%) Female	7 (30.4)
Male	16 (69.6)
Time between pterygium excision and PTK (month), $\bar{X}$±SD	5.93±1.39
Follow-up time after PTK (year)	1 year

PTK: Phototherapeutic keratectomy; SD: Standard deviation.

TABLE 2: Comparison of corneal topography values obtained 1 year after PTK surgery with the topographic data of patients who had undergone pterygium excision at least 4 months prior.

Parameters	Before PTK	After PTK	p value
K1 (D)	42.41±3.44	41.27±3.04	p=0.301
K2 (D)	46.56±3.50	45.06±3.71	p=0.060
Kmax (D)	44.32±3.29	43.06±3.17	p=0.075
Corneal astigmatism (D)	3.86±2.19	3.80±2.44	p=0.570
ISV	69.13±42.03	73.43±45.13	p=0.988
IVA (mm)	0.63±0.43	0.85±0.60	p=0.014
IHA (µm)	17.26±12.86	22.11±17.21	p=0.543
IHD (µm)	0.06±0.04	0.08±0.05	p=0.181
CDVA (logMAR)	0.55±0.28	0.46±0.32	p=0.021

Before PTK: PTK after pterygium excision; After PTK: One year after PTK; ISV: Index of surface variance; IVA: Index of vertical asymmetry; IHA: Index of height asymmetry; IHD: Index of height decantration; CDVA: Corrected distance visual acuity.

was 17.26±12.86 before PTK and 22.11±17.21 after PTK. IHD value decreased in 10 patients and increased in 13 patients, from 0.06±0.04 before PTK to 0.08±0.05 after PTK. There was no statistically significant difference between ISV, IHA and IHD values (respectively p=0.988, p=0.543, p=0.181). IVA values decreased in 5 patients, increased in 17 patients and remained the same in 1 patient after PTK, and the difference was statistically significant (p=0.014) (Table 2). A 32 years old male patient's imaging characteristics showing the reduction in corneal irregularity after pterygium exicion (A) and after 1 year PTK (B) are shown in Figure 1. There were possitive correlations between preoperative ISV-IVA (r=0.928, p<0.01), ISV-IHA (r=0.511, p<0.05), ISV-IHD (p=0.699, p<0.01), ISV-IHA (r=0.543, p<0.01), IVA-IHD (r=0.810, p<0.01) and IHA-IHD (r=0.707, p<0.01). Over the course of follow-up period, there was no delayed epithelial healing, intraocular pressure elevation, and no patients

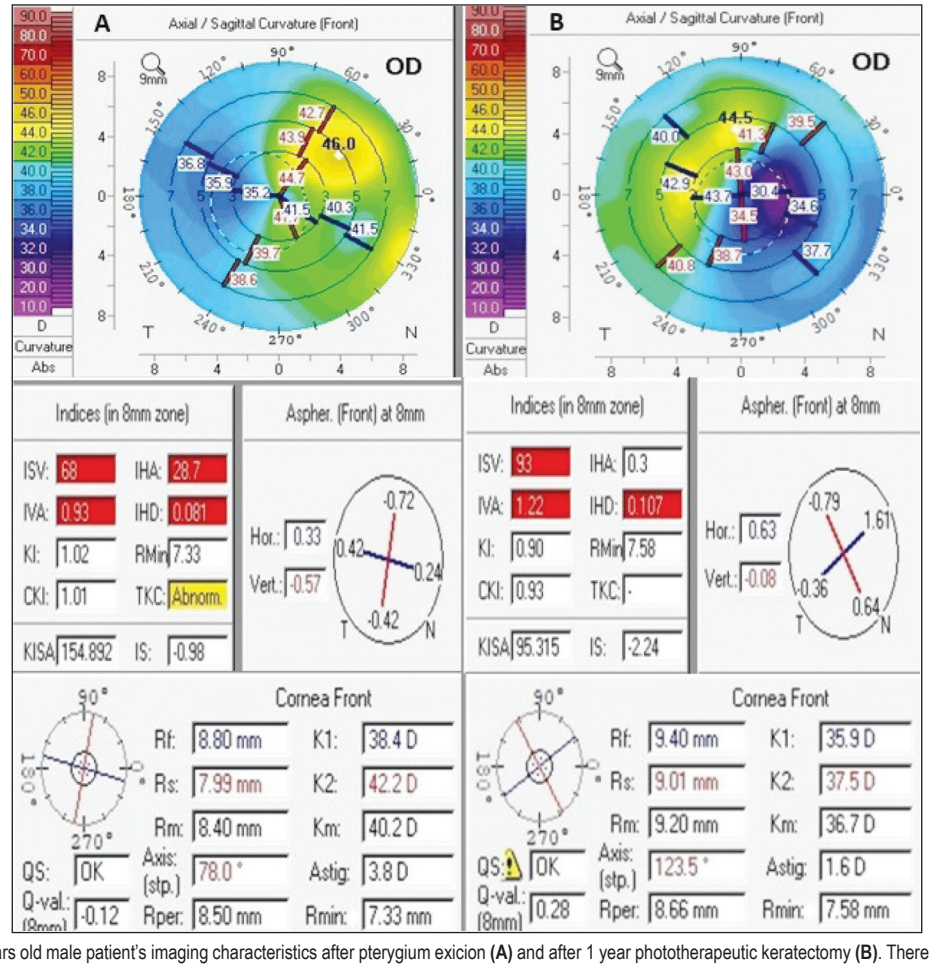

FIGURE 1: A 32 years old male patient's imaging characteristics after pterygium exicion **(A)** and after 1 year phototherapeutic keratectomy **(B)**. There is a reduction in corneal irregularity measured at the 12th month.

underwent keratoplasty or additional excimer laser therapy.

DISCUSSION

Pterygium is treated surgically. After excision, a pit in the stromal layer and remnants of fibrous tissue remain on the cornea, causing significant irregular astigmatism.[14] Corneal topography is a powerful tool for assessing pterygium-induced refractive changes.[13] Corneal asymmetry indices and corneal cylinder are significantly increased in pterygium patients.[14] Tomidokoro et al., evaluated the percentage of spread of pterygium over the cornea and observed that larger pterygia negatively impact corneal astigmatism, asymmetry, and irregularity.[15] Stern and Lin demonstrated a significant correlation between pterygium size and corneal astigmatism, noting that pterygium causes considerable astigmatism once it reaches a specific size.[16] Also they reported improvement in topographic indices in 16 eyes; corneal astigmatism to reduce from 5.93±2.46 D to 1.92±1.68 D. Yagmur et al., investicated the impact of pterygium removal in 30 eyes and found topographic astigmatism to reduce from 4.65±3.02 to 2.33±2.26 D.[13] In the present study, all topographic parameters showed significant improvement after pterygium removal. Errais et al. evaluated corneal spherical power, corneal shape, simulated keratometric astigmatism, surface regularity index (SRI), surface asymmetry index (SAI), and manifest refraction SE before and after surgery.[17] Significant differences were observed across all parameters following pterygium excision ($p<0.05$).

Even after successful pterygium excision, scar tissue and corneal irregularity may remain in the anterior cornea. Even though the optimal treatment for anterior corneal scarring remains uncertain, the ideal ablation protocol should both clear the corneal opacity and improve the irregularity of the cornea. Since 1995, PTK has been recommended by the U.S. Food and Drug Administration for the removal of corneal scars and the treatment of recurrent corneal erosions.[18] PTK can be used for treating anterior scars; smoothing the corneal surface; and removing redundant epithelial basement membrane in eyes experiencing recurrent corneal erosions. Therefore, PTK can efficiently address numerous conditions that might otherwise necessitate manual keratectomy or lamellar/full-thickness corneal transplantation.[19] Significant enhancement in visual performance can often be attained in many eyes without completely removing all stromal opacity in the cornea. Also, in many cases of stromal opacity there is also associated surface irregularity.[20]

PTK is chosen due to its lower invasiveness and greater effectiveness. In many studies conducted in the literature to improve corneal irregularity after corneal scarring, a significant improvement was observed in topographic parameters when preoperative and postoperative data were compared.[21] In a study conducted by Rush et al., PTK was performed on 22 patients with anterior corneal scars.[22] While corneal cylinder showed significant improvement ($p=0.0173$) after PTK, no improvement was observed in SAI ($p=0.0849$) or SRI ($p=0.0543$). In another study conducted by Rush et al., corneal cylinder, SAI and SRI were significantly improved in 64 eyes that underwent PTK due to corneal scarring ($p=0.0045$, $p=0.0054$, $p=0.0047$, respectively).[23] In the other study of Rush et al, all 11 eyes tolerated both the pterygium excision and transepithelial PTK (T-PTK) procedure, the topographic SAI, topographic SRI, and topographic projected visual acuity significantly improved after T-PTK ($p=0.0092$, $p=0.0022$, and $p=0.0002$, respectively).[24] In our series, K1, K2 and Kmax values have improved significantly. K1 value was 42.41 D preoperatively and 41.47 D postoperatively. There was a decrease in K2 value from 46.56 D to 45.06 D and in Kmax value from 44.32 D to 43.06 D ($p=0.301$, $p=0.06$ respectively). While there was a significant improvement in ISV, IHA and IHD values, the difference was not statistically significant. IVA is the difference between superior and inferior corneal curvature, and hence the value of curvature symmetry.[25,26] Our study revealed a statistically significant difference in IVA values between preoperative and postoperative measurements ($p=0.014$).

In a study conducted by Walkow et al., PTK was performed on 30 eyes that underwent pterygium excision, and astigmatism was significantly lower than the control group.[27] In our study, although the corneal astigmatism value decreased compared to the preop-

erative period, a statistically significant difference was not observed (p=0.570).

In our study there was an improvement in postoperative CDVA compared to preoperative CDVA from 0.55±0.28 logMAR to 0.46±0.32 logMAR in accordance with the literatüre.[28,29] PTK, can improve the visual acuity as well decrease the amount of irregular astigmatism and irregular corneal surface. This suggests that the gross amount of astigmatism may not change, but the astigmatism which is correctable with glasses can be markedly improved following PTK.

The limitations of our study include its retrospective design, absence of a control group, and a small patient sample. More reliable results can be obtained with studies in which more cases are followed. The fact that the corneal scar depth was not determined by optical coherence tomographyis the missing aspect of our study. Cornea irregularity resulting from pterygium excision affects both the central paracentral and peripheral cornea. Standard PTK treatment affects the central region with equal ablation in all layers of the stroma. Consequently, effective results may not always be achieved. In the literature, only a limited number of studies address the impact of PTK on topographic values for reducing corneal scarring following pterygium excision. Despite all its limitations, we found that the cornea was topographically flattened and the anterior stromal scar decreased after PTK consistent with other studies. In addition to other studies, we also found a significant improvement in IVA value topographically. Patients who underwent PTK had a more transparent and more regular cornea than before surgery. PTK is a safe, simple and effective procedure. It postpones the need for penetrating keratoplasty, along with its related complications and side effects.

CONCLUSION

PTK can reduce the corneal surface irregularity and the astigmatizm in a way that can be corrected with glasses and CDVA will be better.

Source of Finance

During this study, no financial or spiritual support was received neither from any pharmaceutical company that has a direct connection with the research subject, nor from a company that provides or produces medical instruments and materials which may negatively affect the evaluation process of this study.

Conflict of Interest

No conflicts of interest between the authors and / or family members of the scientific and medical committee members or members of the potential conflicts of interest, counseling, expertise, working conditions, share holding and similar situations in any firm.

Authorship Contributions

Idea/Concept: *Berrin Uzunovalı, Demet Mutlu, Mustafa Ataş;* ***Design:*** *Berrin Uzunovalı, Demet Mutlu;* ***Control/Supervision:*** *Berrin Uzunovalı, Demet Mutlu, Mustafa Ataş;* ***Data Collection and/or Processing:*** *Berrin Uzunovalı, Demet Mutlu;* ***Analysis and/or Interpretation:*** *Berrin Uzunovalı, Demet Mutlu;* ***Literature Review:*** *Berrin Uzunovalı, Demet Mutlu;* ***Writing the Article:*** *Berrin Uzunovalı, Demet Mutlu, Mustafa Ataş;* ***Critical Review:*** *Berrin Uzunovalı, Demet Mutlu, Mustafa Ataş;* ***References and Fundings:*** *Berrin Uzunovalı, Demet Mutlu;* ***Materials:*** *Berrin Uzunovalı, Demet Mutlu.*

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