Original Article

Visual and Refractive Outcomes after Topographic-Guided Customized Ablation Photorefractive Keratectomy in Keratoconic Eyes

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Abstract

Purpose: To investigate the visual and refractive outcomes of topographic-guided customized ablation treatment (T-CAT) photorefractive keratectomy (PRK) combined with iris registration and the use of mitomycin C among patients who have undergone corneal transplantation.
Patients and Methods: This cross-sectional study was conducted on 18 eyes of 14 patients with keratoconus over a 2-year period at Torfeh Eye Hospital, Tehran, Iran. Of these patients, 11 patients were male and 3 patients were female. All participants had previously undergone penetrating keratoplasty (PKP) or deep anterior lamellar keratoplasty (DALK) and subsequently underwent T-CAT PRK surgery with 0.02 % mitomycin C to correct residual refractive errors due to intolerance or reluctance to wear glasses or contact lenses. Pre- and post- T-CAT PRK surgery assessments included uncorrected visual acuity (UCVA), best-corrected visual acuity (BCVA), cylindrical and spherical lens measurements, spherical equivalent, and corneal opacity in the transplanted cornea.
Results: The mean postoperative spherical equivalent decreased from 4.27 ± 2.28 D to 1.48 ± 1.39 D, a statistically significant reduction (P = 0.001). The improvements in UCVA, BCVA, and spherocylinder levels were also statistically significant during the follow-up periods after PRK.
Conclusion: The present study suggest that T-CAT PRK combined with iris registration and the use of mitomycin C intraoperatively in keratoconus patients who have undergone corneal transplantation can effectively treat spherical astigmatism. This approach significantly reduced refractive errors and improved visual and refractive parameters.

Keywords: Keratoconus; Keratoplasty; Refractive Error; Topography; Photorefractive Keratectomy.

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Introduction

Keratoconus is a non-inflammatory disease characterized by the progressive thinning and protrusion of the central cornea, leading to refractive disorders such as myopia and irregular astigmatism [1]. The etiology of keratoconus remains unclear, although a positive family history suggests a genetic predisposition [2]. Contributing factors may include eye rubbing, atopic disease, sleep apnea, and floppy eyelid syndrome [3]. Pathological findings in the cornea include fractures in Bowman's layer, thinning of the stroma and epithelium, as well as scarring in the Descemet's layer [4].

The prevalence of keratoconus varies globally. In Russia, it is reported at 0.3 per 100,000 people [5], while studies in central India estimate it at up to 4 per 100,000 [6]. A study in Yazd province, Iran, estimated the prevalence of clinical cases to be as high as 40 per 1000 people, with a one-year incidence rate 22.3 per 100,000 populations [7]. These findings highlight the need for extensive clinical studies in Asia, where the prevalence appears higher, to understand the disease's causes and to explore effective treatment methods [7].

Initial treatments for keratoconus include glasses and contact lenses [8]. In advanced cases, treatments may involve intra-corneal rings (ICRS) [9] or anterior segment lens insertion (Toric ICL) [10]. Corneal transplantation, via penetrating keratoplasty (PKP) or deep anterior lamellar keratoplasty (DALK), might be necessary, though it may fail to fully correct refractive errors [11]. Patients may subsequently require refractive surgery, such as astigmatic keratotomy, anterior segmental lens insertion, photorefractive keratectomy (PRK), laser epithelial keratomileusis (LASEK), or laser-assisted in situ keratomileusis (LASIK) procedures, to address residual refractive errors [12].

One promising method for treating refractive errors in irregular corneas is topographic-guided customized ablation treatment (T-CAT) PRK with iris registration [13]. T-CAT, introduced a decade ago, targets high-order aberrations and corneal irregularities, aiming to create symmetry in the corneal center without correcting other optic disorders [14]. This method typically involves a lower ablation rate and depth but can significantly improve topographic shape and correct distance visual acuity.

In this study, we evaluated the visual and refractive effects of T-CAT PRK surgery on keratoconus patients who have previously undergone PKP or DALK surgery.

Patients and Methods

This study was conducted on 18 eyes of 14 patients over a 2-year period at Torfeh Eye Hospital, Tehran, Iran. The study protocol was approved by Shahid Beheshti University of Medical Sciences ethics committee and all participants gave written consent before entering the study.

All patients had undergone PKP or DALK surgery and were evaluated before and after PRK surgery using T-CAT method. Patients were included if at least three months had passed since complete corneal suture removal, with a maximum spherical residual refractive error of -8 diopters and astigmatism up to -6 diopters. Exclusion criteria included corneal opacity, vascularization, dry eye, and a residual corneal thickness of less than 380 microns post-PRK, regardless of epithelial thickness. PRK surgery was performed using the excimer Allegretto laser device, with an active tracking system and pupil centroid shift during ablation. Mitomycin C was applied to

prevent corneal opacities.

The assessments included uncorrected visual acuity, best-corrected visual acuity, cylindrical and spherical lens measurements, spherical equivalent, and corneal opacity in the grafted cornea. Patients were evaluated on the first and fifth days post-surgery for epithelial defect healing and absence of infiltration. Further evaluations were conducted at one month, three months, six months, 12 months, and 24 months post-surgery.

The results were analyzed using descriptive statistics, paired t-test, one-way ANOVA, and the Chi-Square test.

Results

The present study showed a statistically significant decrease in the mean spherical equivalent (SE), from -4.27 ± 2.28 D preoperatively to -1.48 ± 1.39 D (P = 0.001) 24 months postoperatively. The uncorrected visual acuity (UCVA) significantly improved following PRK surgery, increasing from a mean of +2.07 ± 1.63 preoperatively to +5.65 ± 2.65 postoperatively (P < 0.001), with 88 % of patients experiencing improvement.

During follow-up, 14 eyes (77.7 %) had no corneal opacity, 1 eye (5.5 %) had mild corneal opacity, and 2 patients (11.1 %) had moderate corneal opacity. One patient required repeat of corneal transplant due to a significant decrease in vision caused by refractive error after PRK surgery and underwent PKP one year later. Patients with corneal opacity were treated with betamethasone drops. It is important to note that all patients were evaluated by the same examiner using a slit lamp.

Postoperative BCVA did not show a significant difference compared to preoperative values (P = 0.408), though there was a significant correlation between preoperative and postoperative BCVA values (correlation coefficient = 0.621, P = 0.006).

When comparing the astigmatism axis before and after surgery, no significant difference was observed (P = 0.465). However, the cylinder showed a significant reduction postoperatively (P < 0.001). Additionally, the comparison of pre- and postoperative sphere revealed a significant decrease (P = 0.034). Table 1 compares the mean readings for axis, cylinder, and sphere before and after surgery.

Further analysis showed that the P values related to UCVA and cylinder changes were 0.001 and 0.003, respectively, in patients who had MMC applied for more than 60 seconds. In contrast, for patients with MMC duration of 60 seconds or less, the P values for UCVA and cylinder changes were 0.031 and 0.04, respectively.

Table 1: Comparison of the mean readings for axis, cylinder and sphere before and after surgery

Variable	Pre-operation	Post-operation	Mean difference	*P value
AXIS	92.7647	99.5294	6.76471	0.465
Cylinder	-3.6528	-1.5833	2.06944	<0.001
Sphere	-2.3235	-0.4412	1.88235	0.034

*Paired t-test

Discussion

Correction of refractive errors after corneal transplantation remains a significant challenge worldwide [15]. This study examined the outcomes of PRK surgery with T-CAT method and the use of mitomycin C in correcting refractive errors in keratoconus patients who had undergone corneal transplantation using PKP or DALK.

Our findings indicate that T-CAT PRK surgery significantly reduces the mean SE in these patients from - 4.27 ± 2.28 D preoperatively to - 1.48 ± 1.39 D postoperatively. These results are consistent with those reported by Forseto Ados et al., [16] where SE decreased from - 3.95 ± 4.11 D preoperatively to - 1.07 ± 1.45 D postoperatively in patients who had undergone corneal transplantation and PRK surgery.

During follow-up, 14 eyes (77.7 %) had no corneal opacity, 1 eye (5.5 %) had mild corneal opacity, and 2 eyes (11.1 %) had moderate corneal opacity. One patient required repeat of corneal transplant due to a significant decrease in vision caused by refractive error after PRK surgery and underwent PKP one year later. However, the study by Forseto Ados et al., [16] reported that 92 % of patients did not develop corneal opacity during the follow-up period, a better outcome compared to the present study. Nevertheless, a similar incidence of corneal opacity post-surgery, with 80 % of patients has been reported by Leccisotti et al., [9]. This is consistent with our study's results, which reported no opacity in 77.7 % of cases. It is worth noting that previous studies did not follow patients for 24 months post-PRK surgery, which might explain the lower incidence of corneal opacity in the study by Forseto Ados et al., [16] where follow-up was limited to 12 months post-surgery.

In our study, UCVA significantly improved post-PRK surgery, increasing from a mean of 2.07+ ± 1.63 to 5.43+ ± 2.65, with 88 % of patients experiencing improvement. Additionally, sphere and cylinder values also improved significantly after PRK surgery ($P = 0.034$ and $P < 0.001$, respectively), which aligns with findings from previous studies [9,16].

Conclusion

The present study suggest that T-CAT PRK combined with iris registration and the use of mitomycin C intraoperatively in keratoconus patients who have undergone corneal transplantation can effectively treat spherical astigmatism. This approach significantly reduced refractive errors and improved visual and refractive parameters.

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Footnotes and Financial Disclosures

Conflict of interest:

The authors have no conflict of interest with the subject matter of the present manuscript.