

Comparison of phototherapeutic keratectomy and photorefractive keratectomy results in corneal opacities associated with adenoviral keratoconjunctivitis

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ABSTRACT

Purpose: To compare the visual and optical outcomes in patients undergoing phototherapeutic keratectomy (PTK) and photorefractive keratectomy (PRK) for corneal opacity associated with adenoviral keratoconjunctivitis.

Materials and Methods: Eighteen patients with a decision for treatment due to adenoviral corneal opacity were divided into two groups comprising a total of 23 eyes. Eleven eyes in the first group underwent only PTK, while 12 eyes in the second group underwent combined PTK+PRK treatments. Spherical equivalents (SE), best-corrected visual acuity (BCVA), and wavefront aberration values were compared within and between groups preoperatively and at 12 months postoperatively.

Results: The mean age was 32±17 years in Group 1 and 28±9 in Group 2 (p=0.9). The duration between infection onset and treatment was 13±2 months and 14±5 months, respectively (p=0.75). The ablation depths were 79±28 μ and 90±16 μ, respectively (p=0.16). Significant differences were observed in BCVA values between the groups at both preoperative and postoperative 12 months (p=0.013 and p=0.02). In both groups, there were significant differences in preoperative SE, BCVA, and spherical aberration (SA) values compared to postoperative 12 months (p values for Group 1 and Group 2, respectively: SE, 0.005 and 0.004; BCVA, 0.007 and 0.024; SA, 0.004 and 0.028). However, there was no significant difference in total wavefront aberration and higher-order aberration between preoperative and postoperative values in both groups.

Discussion: Both PTK and PTK+PRK treatments yield successful visual and refractive outcomes in adenoviral corneal opacities.

Keywords: Epidemic keratoconjunctivitis, Photorefractive Keratectomy, Phototherapeutic Keratectomy, Subepithelial Infiltrates.

INTRODUCTION

Adenoviruses are non-enveloped, double-stranded DNA viruses responsible for 75% of infectious conjunctivitis cases.¹ Adenovirus serotypes 8, 19, and 37 are the primary causes of epidemic keratoconjunctivitis (EKC) associated with ocular involvement. Highly contagious, transmission typically occurs via secretions, direct contact with hands or ophthalmologic instruments, and droplets.² Epidemic keratoconjunctivitis is an infectious process characterized by preauricular lymphadenopathy, punctate epithelial keratitis, and follicular conjunctivitis. Subsequently, it is marked by subepithelial infiltrates (SEI), thought to

result from a type IV delayed hypersensitivity mechanism, which may persist for an extended period. These small, round, usually bilateral, and asymmetric infiltrates are key features of the disease.³

Subepithelial infiltrates arise due to immune responses against adenoviral antigens in the stroma. Histopathological studies have shown that SEIs after EKC involve fibroblast and lymphocyte accumulation in the epithelium, Bowman's layer, and anterior stromal surfaces.⁴ They cause photophobia, light scattering, corneal surface irregularity, decreased visual acuity, astigmatism, and ocular aberrations. While SEIs and visual acuity can improve

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spontaneously over time, some cases require topical steroid or cyclosporine treatment. However, for certain patients, these infiltrates may progress to corneal scars despite medical treatment, leading to permanent visual acuity reduction.⁵ SEIs disrupt corneal smoothness, resulting in higher-order aberrations (HOA) and compromised optical quality.⁶

Phototherapeutic keratectomy (PTK) was approved by the FDA in 1995 for the treatment of recurrent epithelial erosions and corneal scars. It utilizes excimer lasers emitting 193 nm ultraviolet light to photochemically ablate pathological tissue in the cornea.⁷ Each laser pulse ablates approximately 0.25 μm of tissue.⁸ Photorefractive keratectomy (PRK), on the other hand, is primarily chosen for patients with refractive errors.⁷ Both methods, however, may result in hyperopic shifts post-ablation.⁹

This study aims to compare visual and optical outcomes in patients treated with PTK and PTK+PRK for SEI due to adenoviral keratoconjunctivitis.

MATERIALS AND METHODS

This study included 23 eyes of 18 patients with SEI caused by EKC and reduced visual acuity resistant to medical therapy between September 2016 and September 2022. Ethics approval was obtained from the Gülhane Training and Research Hospital (May 28, 2019, approval number: 10), and the study adhered to the Declaration of Helsinki. The study design was retrospective.

Patients were divided into two groups

- **Group 1:** 11 eyes treated with PTK
- **Group 2:** 12 eyes treated with PTK+PRK

Preoperative and 1-year postoperative evaluations included best-corrected visual acuity (BCVA), intraocular pressure (IOP) measured with Goldmann applanation tonometry, detailed slit-lamp and dilated funduscopy examinations, corneal topography, and wavefront analysis using the Pentacam HR (Oculus GmbH, Wetzlar, Germany). Measurements included keratometry, spherical aberration, and root mean square (RMS) values of total and higher-order aberrations (HOAs).

Inclusion criteria: Patients aged 18 years and older with symptomatic SEI for at least 6 months following adenoviral keratoconjunctivitis, BCVA of 5/10 or worse, complaints of photophobia or glare, minimal central corneal thickness (CCT) $\geq 450 \mu\text{m}$, residual stromal bed thickness $\geq 400 \mu\text{m}$, and maximum ablation depth $\leq 150 \mu\text{m}$.

Exclusion criteria: Use of immunosuppressant drugs, autoimmune disease, pregnancy, lactation, or ocular pathologies other than SEI due to adenoviral keratoconjunctivitis.

SURGICAL TECHNIQUE

All surgeries were performed by two experienced surgeons using the Nidek QUEST EC-5000CXIII excimer laser system. After sterilization with 10% povidone-iodine, 0.5% proparacaine hydrochloride was applied for topical anesthesia. Corneal epithelium was manually debrided after applying 20% ethanol for 15 seconds. Ablation was then performed using the excimer laser. Post-surgery, therapeutic bandage contact lenses were applied until corneal re-epithelialization was complete. Postoperative medications included topical antibiotic drops for 7 days and artificial tears for 3 months. Topical prednisolone sodium phosphate was tapered over 4 weeks after epithelial healing.

STATISTICAL ANALYSIS

Data were analyzed using SPSS 15.0. Normal distribution was assessed using the Kolmogorov-Smirnov test. Preoperative and 12-month postoperative comparisons of SE, BCVA, keratometry, and wavefront aberrations were conducted within and between groups using Wilcoxon and Mann-Whitney U tests, respectively.

RESULTS

The study included 23 eyes of 18 patients, with 11 eyes in Group 1 and 12 eyes in Group 2. There were no significant differences between the groups in terms of gender, age, or laterality (p-values: 0.59, 0.90, and 0.27, respectively) (Table 1). The interval between the onset of adenoviral keratoconjunctivitis and laser treatment was 13 ± 2 months in Group 1 and 14 ± 5 months in Group 2, with no statistically significant difference between the groups ($p=0.75$). All patients completed a 12-month follow-up period. Preoperative central corneal thickness (CCT) values ranged from 447 to 568 μm (Table 2).

Preoperative and postoperative 12-month spherical equivalent (SE), best-corrected visual acuity (BCVA), keratometry values, CCT, and higher-order aberration values, as well as their statistical comparisons, are shown in Table 2. There was a statistically significant difference in BCVA between the groups both preoperatively and at the 12-month postoperative follow-up ($p=0.013$ and $p=0.02$, respectively). For parameters other than BCVA, there were

	Group 1 (n=11)	Group 2 (n=12)	P
Gender (F/M)	5/6	5/7	0.59*
Eye (Right/Left)	6/5	4/8	0.27*
Age (years) ± SD (min-max)	32 ± 17 (13-64)	28 ± 9 (15-44)	0.90*
Duration Between Infection and Laser (months) (min-max)	13 ± 2 (10-18)	14 ± 5 (6-25)	0.75**
Ablation Depth (µm) (min-max)	79 ± 28 (25-120)	90 ± 16 (76-126)	0.16**

*Fisher's exact test, ** Man-Whitney U test, F: Female, M: Male, SD: Standard Deviation, max: maximum, min: minimum

	Group 1 (n=11) Mean ± SD (min/max)	Group 2 (n=12) Mean ± SD (min/max)	p*
Spherical Equivalent (diopters)			
Preop	-0.58 ± 1.64 (-4.75/1.75)	-1.33 ± 1.69 (-5.00/0.75)	0.17
Postop 12th month	0.42 ± 1.98 (-4.50/3.00)	0.37 ± 1.42 (-2.75/3.00)	0.81
p**	0.005	0.004	
BCVA (Snellen)			
Preop	0.60 ± 0.18 (0.30/0.80)	0.80 ± 0.18 (0.40/1.00)	0.013
Postop 12th month	0.87 ± 0.13 (0.60/1.00)	0.99 ± 0.03 (0.90/1.00)	0.02
p**	0.007	0.024	
K1 (diopters)			
Preop	43 ± 2 (40/47)	43 ± 2 (39/46)	0.26
Postop 12th month	41 ± 2 (37/43)	41 ± 2 (39/44)	0.57
p**	0.003	0.012	
K2 (diopters)			
Preop	43 ± 1 (42/46)	44 ± 2 (40/48)	0.26
Postop 12th month	42 ± 2 (39/44)	42 ± 2 (39/44)	0.57
p**	0.006	0.021	
Kmax (diopters)			
Preop	46 ± 3 (44/54)	46 ± 3 (43/53)	0.84
Postop 12th month	44 ± 1 (42/47)	45 ± 2 (42/48)	0.53
p**	0.062	0.015	
Central Corneal Thickness (µ)			
Preop	515 ± 29 (466/560)	516 ± 36 (447/568)	0.77
Postop 12th month	463 ± 33 (406/513)	440 ± 45 (360/513)	0.29
p**	0.003	0.008	
RMS Total			
Preop	3.7 ± 3.6 (1.12/12.94)	4.1 ± 2.3 (1.1/8.1)	0.49
Postop 12th month	3.3 ± 1.5 (1.04/6.1)	4.1 ± 2.06 (2.1/7.5)	0.53
p**	0.93	0.86	
RMS HO			
Preop	1.04 ± 0.61 (0.39/2.5)	1.1 ± 0.58 (0.34/2.0)	0.92
Postop 12th month	0.94 ± 0.35 (0.45/1.55)	1.1 ± 0.45 (0.57/2.00)	0.76
p**	0.86	0.21	
Spherical Aberration			
Preop	0.04 ± 0.49 (-1.22/0.66)	-0.03 ± 0.58 (-0.99/0.86)	0.82
Postop 12th month	0.33 ± 0.28 (-0.25/0.80)	0.15 ± 0.54 (-0.69/0.88)	0.62
p**	0.004	0.028	

*Man-Whitney U, **Wilcoxon, SD: Standard Deviation, max: maximum, min: minimum, BCVA: Best Corrected Visual Acuity, RMS: Root mean square, HO: High order

no statistically significant differences between the groups either preoperatively or postoperatively at 12 months.

Postoperative SE, BCVA, K2, CCT, and SA values showed statistically significant improvements compared to preoperative values in both groups (Table 2). However, RMS Total and HO values did not show significant changes from preoperative levels in either group. No intraoperative or postoperative complications were observed in either group.

DISCUSSION

Adenoviral keratoconjunctivitis (AKC) is a self-limiting disease. Due to the absence of an effective antiviral treatment, no specific therapy has been established for subepithelial infiltrates (SEI). However, selecting the appropriate treatment method is crucial as SEI can reduce visual acuity and quality. Treatments such as cyclosporine, topical steroids, and tacrolimus are commonly used for SEI caused by viral keratoconjunctivitis, but in cases of unresponsiveness or insufficient response, surgical methods like PTK or PRK may be considered.^{9,10}

Various studies have demonstrated that PTK and PRK improve visual acuity in SEI associated with AKC.¹¹⁻¹³ However, stromal ablation performed in the presence of vision-impairing SEI has been reported to cause unexpected hyperopic shifts.⁸ Yamazaki et al. performed PTK on 32 eyes of 32 patients with SEI and observed an increase in BCVA compared to the preoperative period after 12 months of follow-up. Additionally, they reported a mean ablation depth of 65.4 μm , resulting in a hyperopic shift of 1.52 \pm 0.91 D.¹¹ In a study by Y. Yildirim et al., an average of 84 μm of ablation was performed using transepithelial PTK, resulting in a hyperopic shift of 0.62 \pm 0.28 D.¹⁴

In our study, BCVA improved at the end of the 12-month follow-up compared to preoperative values. The group treated with PTK received an average ablation depth of 79 \pm 28 μm , with a hyperopic shift of 0.42 \pm 1.98 D, while the PTK+PRK group received an average ablation depth of 90 \pm 16 μm , with a hyperopic shift of 0.37 \pm 1.42 D. However, there was no statistically significant difference between the groups.

Higher-order aberrations can reduce visual acuity and contrast sensitivity. Tzelikis et al. reported that a reduction in spherical aberrations improves visual acuity and contrast sensitivity.¹⁵ Kurna et al., in a study comparing patients with SEI and a control group, evaluated visual acuity and optical quality and found that irregular astigmatism, spherical aberration, and total RMS aberrations were higher in the

SEI group.⁶ Yıldız et al. reported that transepithelial PTK improved visual function and significantly reduced corneal higher-order aberrations over a 6-month follow-up period.¹⁶ Similarly, in our study, spherical aberrations decreased in both the PTK and PTK+PRK groups compared to preoperative values, with no significant difference between the groups.

In normal eyes, the mean central corneal thickness (CCT) is approximately 553 μm .¹⁷ In our study, the mean preoperative CCT was 515 μm in Group 1 and 516 μm in Group 2, which were lower than the values observed in the normal population. The lower CCT values in patients with SEI after AKC have been attributed to factors such as chronic inflammation due to SEI reactivation, prolonged corticosteroid use, tear film insufficiency, and ocular surface changes.¹¹ Dogru et al. reported that PTK had positive effects on the corneal epithelial surface and tear film layer.¹⁸

It has been shown that haze formation and SEI recurrence may occur after phototherapeutic keratectomy.¹⁹ However, in our study, no corneal haze or SEI recurrence was observed during long-term follow-up. We attribute this outcome to extended patient monitoring and medical treatment before PTK or PTK+PRK application.

The limitations of our study include its retrospective design, the small number of patients, and the lack of contrast sensitivity testing to evaluate the impact of both PTK and PTK+PRK on visual quality.

In conclusion, PTK and PTK+PRK are effective and reliable treatment options for improving visual acuity and reducing ocular aberrations in patients with SEI whose subjective and visual complaints persist despite medical treatment.

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