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Phototherapeutic Keratectomy Outcomes in Superficial Corneal Opacities

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Abstract

Purpose: Compare the effectiveness of Phototherapeutic keratectomy (PTK) in treatment corneal dystrophies versus superficial corneal scars: visual outcomes, recurrence rate and safety profile.

Methods: PTK was performed in 51 eyes of 51 patients. Data regarding the indications for PTK, ablation depth, symptomatic relief, pre- and postoperative best spectacle-corrected visual acuity (BSCVA), spherical equivalent changes, recurrence and complications were analyzed. The indications for PTK in our study were classified into two categories – group A: patients with corneal dystrophies (n = 23) and the other group B (n = 28) with other indications.

Results: The average age of the patients was 47 years (± 16.4). The mean follow up period was 15.16 months (± 10.01 months). Post operatively, there were no significant complications. While the overall BSCVA in the patients improved from 20/41 (0.484) to 20/32 (0.645), group A showed improvement from 20/35 (0.561) to 20/29 (0.687), as compared to group B in which BSCVA improved from 20/47 (0.421) to 20/33 (0.611). The most common indication in group A was granular corneal dystrophy (n = 10) and the most common indication in group B was post traumatic/infectious corneal scar or opacity (n = 10). Eighty-six percent (n = 44) of all patients had alleviation of symptoms. Recurrence of symptoms was seen in 3 eyes of recurrent corneal erosions which required retreatment.

Conclusion: PTK is a safe and effective procedure. The outcome of this study suggests that PTK improves BSCVA. PTK appears to improve ocular surface health. Furthermore, PTK can be recommended to most patients with corneal dystrophies as a treatment modality prior to other more invasive procedure (viz. penetrating keratoplasty).

Keywords: phototherapeutic keratectomy, PTK, corneal opacities, keratoplasty, corneal dystrophy, recurrent corneal erosions

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Introduction

Phototherapeutic keratectomy (PTK) is an important excimer laser based surgical tool for the treatment of numerous corneal disorders. Dystrophies of the cornea, infectious and noninfectious scars, at the most common corneal causes of potentially reversible visual deterioration.¹ Apart from macular,¹ granular,¹ lattice,^{2,3} and map dot fingerprint⁴ dystrophies; other indications for which PTK has been reported to be an effective treatment include recurrent corneal erosion syndrome,⁵⁻⁷ stromal scar tissue such as post surgical scars and Salzmann nodular degeneration.⁸ We evaluate in this study the effectiveness of PTK in treatment of variable pathologies with anterior corneal opacities that carried out at a tertiary eye care center.

Subjects and Methods

All cases of corneal disease which had undergone PTK from January 2002 to December 2007 at the Cornea and Anterior Segment Service in a tertiary eye-care center in USA were retrospectively reviewed. The details of the cases were retrieved from the medical records. A thorough preoperative clinical evaluation was performed for all patients. The parameters evaluated were visual acuity, spherical equivalent, intraocular pressure, retinal evaluation, and detailed slit-lamp microscopy with particular attention to the corneal surface and the depth of the lesion. These parameters were assessed before, at three months and at the last follow up after the procedure. Tear film break up time (TFBUT) and Schirmers scores were assessed prior to the procedure and 3 months after the procedure. Informed consent was obtained from all patients. Ultrasonic pachymetry was used to obtain corneal thickness prior to the procedure. The PTK corneal ablations were performed under topical anesthesia with either proparacaine or tetracaine. A 6 to 6.5 mm treatment zone was used. VISX STAR S4 excimer laser (AMO, Irvine, California) was used in all cases, and included a 193-nm UVC beam at a fluence of 160 mJ/cm². A transition zone of 1 mm was set in 35 eyes. Transepithelial PTK was employed in all cases. Monitoring the pattern of epithelial fluorescence through the operating microscope determined the end point for completion of the transepithelial phase of the PTK. Because the epithelium is thinner over the elevations, the initial epithelial breakthrough, heralded by the loss of fluorescence, typically had the pattern

of the underlying irregularities. Phototherapeutic keratectomy was continued until epithelial fluorescence began to recede between the elevations and irregularities. A thin layer of sodium hyaluronate, 0.1%, was then applied with a lightly moistened surgical sponge and PTK resumed. One surgeon (RP) performed all surgeries. At the end of the procedure, moxifloxacin 0.5% or ofloxacin 0.3% eye drops were instilled. A bandage contact lens was placed in the eye and immediate slit lamp examination was conducted. Patients were then put on fluorometholone, 0.1% for one month in a tapering dose and antibiotic eye drops for one week. Patients were followed up at approximately 1 week, 1 month, 3 months, 6 months, and at 1-year intervals thereafter. During each visit, ophthalmologic examinations identical to those performed preoperatively were performed. Main outcome measures included indications for the procedure, BCVA, complications and recurrences (erosion and/or dystrophy signs). Ablation depth, symptomatic relief, Schirmer tests' values were compared using Student's *t*-test. A (*P* value) less than 0.05 was considered to be of statistically significant.

Results

Patient characteristics

51 eyes of 51 patients were operated upon. The average age of the patient was 46.9 years (± 16.4). 25 patients were female and 26 were males. 22 of the eyes were right eyes and 29 were left eyes. Three patients had undergone a previous PRK surgery (Photorefractive keratectomy).

Indications for PTK

All the patients were divided into two groups: group A included patients with corneal dystrophies ($n = 23$) while group B ($n = 28$) with other indications. The most common indication in group A was granular corneal dystrophy ($n = 10$), while in group B, it was corneal stromal scar due to trauma or ulcer ($n = 10$) (Table 1).

Ablation depth

Overall, mean ablation depth was 77.64 (± 26.33 μm), ranging from 50 to 200 μm . In group A (corneal dystrophy group), the mean ablation depth was 74.60 (± 20.92 μm), ranging from 50 to 125 μm ; whereas in group B (other pathologies), the mean ablation depth

**Table 1.** Indications for PTK – Frequency and percentage.

Indication	Number of eyes	Percentage
Granular corneal dystrophy	10	20%
Post trauma/ulcer scars	10	20%
Map dot fingerprint dystrophy with RCE	9	18%
RCE (post-traumatic)	7	14%
Graft Failure with edema	3	6%
Post PRK	3	6%
Salzmann's Nodule	2	4%
Lattice Dystrophy	2	4%
Bullous Keratopathy	1	2%
Post Chemical Burns	1	2%
Post Pterygium surgery	1	2%
Fuch's dystrophy	1	2%
Avellino Dystrophy	1	2%

Abbreviations: RCE, recurrent corneal erosions; PRK, Photo Refractive Keratectomy.

was 80.14 ($\pm 30.22 \mu\text{m}$), ranging from 55 to 200 μm with no statistically significant difference ($P = 0.08$).

Symptomatic relief and tear film assessment

The mean follow up period was 15.16 months (± 10.01 months). At the end of the procedure, an epithelial defect was present on the cornea. Complete epithelial closure was achieved after a mean of 3.6 ± 2 days. No delayed epithelialization was noted in any case. Minimal difference in symptomatic relief was found between the two groups ($P = 0.049$). In group A, 20 of the 23 patients reported alleviation of symptoms; three patients reported recurrence of symptoms. These patients had map dot fingerprint dystrophy with irritation on morning waking that recurred after three to four months. In group B, 24 of the 28 patients had symptomatic relief. Overall, 44 out of 51 patients (86%) experienced relief from symptoms post PTK. Mean tear film break up time (TFBUT) prior to PTK was 7 ± 2.2 seconds and following the procedure at three months follow up it improved to 11 ± 1.3 seconds. Greater improvement

was seen in group A compared to group B ($P = 0.014$). Mean Schirmers score before the procedure was 12 ± 4.6 and after the procedure was 14 ± 3.8 mm. Tear film break up time showed overall improvement after the procedure but Schirmers 1 remained the same after the procedure.

Change in best spectacle corrected visual acuity (BSCVA) and spherical equivalent

In this study, only four of the patients in the study showed no improvement in the post operative BSCVA when compared with the pre operative BSCVA. These four patients belonged to group B (other pathologies). Group wise, the pre operative BSCVA in group A, improved from 20/35 (0.561) to 20/29 (0.687) after PTK; and in group B, the BSCVA improved more significantly from 20/47 (0.421) to 20/33 (0.611) after the surgery (Table 2). Refractive changes post-operatively were variable. Seventeen eyes showed a hyperopic shift (33%) and 8 eyes showed a myopic shift (16%). In the remaining eyes, including all cases of recurrent corneal erosions, mean spherical equivalent of manifest refraction remained constant with mean value of -0.45 ± 1.2 D preoperatively and 0.57 ± 1.4 D postoperatively.

Post operative complications

No major complications were reported. A mild stromal haze (Grade 1–2) was seen in 28 patients (55%). Three patients needed a repeat procedure, 10 months, 11 months and 14 months after the first surgery. These patients had Map dot finger print dystrophy with minor recurrence of recurrent erosion noted. All these recurrences occurred within the first year after the surgery.

Discussion

PTK has been used as an effective therapeutic tool in the management of corneal pathologies for over two decades now.⁹ It has several advantages such as precise

Table 2. Comparison between pre and post operative BSCVA in both groups.

Group	Pre operative BSCVA	Post operative BSCVA	P value
Overall	20/41 (0.48) \pm 0.28	20/31 (0.64) \pm 0.27	<0.05
Group A (corneal dystrophies)	20/35 (0.56) \pm 0.29	20/29 (0.68) \pm 0.28	>0.05
Group B (other pathologies)	20/47 (0.42) \pm 0.29	20/33 (0.61) \pm 0.28	<0.05



control of the depth of ablation, fast postoperative recovery, ease of use, creation of a smooth base for corneal re-epithelialization, and the ability to repeat treatment if required.

PTK is best suited for disorder in the anterior 10%–20% of the corneal stroma.^{1,2,7,8}

In our study, patients were classified depending on the indication, and formed 2 groups; group A had patients with corneal dystrophies and group B included all other pathologies; because PTK in corneal dystrophies benefit from both visual clarity as well as treat the associated recurrent corneal erosions, while other superficial corneal pathologies in group B benefit mainly from the visual results of PTK. Also, the patient. Also, group B is common to have associated dry eye either secondary to toxin in post-infectious corneal scars or associated keratitis medicamentosa. This is why we evaluate the effect of PTK on TFBUT and Schirmer's tests. In addition, Group A has more tendency to have recurrence of corneal dystrophy.

An interesting observation is the comparison between our study and a similar study involving a substantial number of subjects in India regarding the indications of phototherapeutic keratectomy. Sharma et al⁹ stated that in their study, bullous keratopathy accounted for 52.7% of the patients and a mere 0.15% of the patients had corneal dystrophies. This is in stark contrast to our study where 45% of the patients had corneal dystrophies and only 2% ($n = 1$) had bullous keratopathy. In the study by Sharma et al, patients were divided into two groups: those with bullous keratopathy and those with other corneal pathologies. The mean improvement of BSCVA seen was 20/222 (0.09) to 20/86 (0.23) in the corneal pathology group and 20/384 (0.05) to 20/202 (0.09) in the bullous keratopathy group. In our study, the mean BSCVA improved from 20/41 (0.48) to 20/31 (0.64). Their study reflects an unusually high frequency of bullous keratopathy patients that are referred in the advanced stages of the disease. These observations suggest that in developing countries, there is a paucity of institutionalized tertiary eye care and also limited availability of donor corneal tissue. This often means that patients wait for long periods, allowing further progression of the associated ocular pathology before a definitive treatment can be instituted.

In Group A, comprising of patients with corneal dystrophies, the improvement of BSCVA was

in accordance with other similar studies by Hafner et al¹ and Wagoner and Badr.¹¹ Hafner and co-authors reported temporary improvement in BSCVA in patients with macular dystrophy for limited time period in which 90% of cases had dystrophy recurrence and 60% did penetrating keratoplasty in a later date. This was probably due to diffuse corneal haze and the opacities persisting in the deeper layers of the cornea after PTK.¹ This explains the importance of having PTK in superficial corneal dystrophy to have the best visual results.¹¹

In the PTK literature for recurrent corneal erosions, the reported rate of success, regarding alleviation of symptoms and prevention of recurrence ranges between 74% and 100%.¹² In our study, we have the nearly the same percentage, with 80% of cases with recurrent corneal erosions were treated successfully. Our case series, had 7 post traumatic recurrent corneal erosions (RCE) patients and 9 patients with Map dot fingerprint dystrophy, who were treated with PTK. The mean follow up period for the RCE patients was 19.14 months (± 8.78 , range: 12–36 months) and of the 15 patients 3 needed a repeat procedure at 10, 11 and 14 months after the first procedure respectively. Furthermore, Barlya et al studied the efficiency of PTK for RCE. The mean follow up period was 17.4 months. They reported the recurrence rate of RCE to be 36%⁴ which is higher than our results (20%). All recurrences in the current study were in the first year after the procedure similar to the other studies in which most recurrences were noted in the first year. In a recent review of recurrent corneal erosion syndrome, PTK was found to be the most effective treatment modality.¹¹ This is partly explained by the observed histological findings that PTK increases the density of hemidesmosomes in the cornea.¹²

In our study, corneal haze was rare and the significant induced hyperopia was limited for cases with deeper PTK ablation. In our series, there was no significant change in the spherical equivalent post-PTK in the recurrent erosion patients secondary for the superficial stromal ablation (20 microns).

PTK is a safe and minimally invasive procedure for the treatment of superficial opacities and helps to gain a moderate increase of visual acuity. Patients with stromal corneal dystrophies also benefit from improved vision as demonstrated in our study.



Treatment in these cases when performed for reduced visual acuity is largely successful by clearing central corneal opacification and deposits. Mild transient superficial stromal haze developed in some (55%) eyes in this series, but visual improvement and rehabilitation was rapid in the majority of cases. A repeat PTK procedure can be performed for recurrence of dystrophies which is usually central and superficial may help maintain good visual acuity for a longer period of time. This reduces the strain on the supply of corneal buttons, especially in developing countries. Also a prior PTK procedure does not compromise the outcome of subsequent penetrating keratoplasty. Refractive changes following PTK are variable. Induced hyperopia does occur when deeper ablation is performed. A “hyperopic shift” was seen only in the 33% patients in the current study. A possible explanation for this could be a large ablation zone, the use of masking fluid, and the centration of the laser aperture over the mid periphery and not the apex of the cornea. A myopic shift was seen in 17% of subjects in this study possibly as a result from central steepening of the cornea with more peripheral ablations or due to central island formation. This can be confirmed by topographic studies. Unfortunately due to the retrospective study we could not assess this aspect on topography. Some of the other factors that may affect the refractive results include epithelial remodeling, associated nuclear sclerosis, or the inaccuracy of preoperative refraction due to corneal scarring.¹⁻¹⁰

In a study by Dogru et al, ocular surface improvement was noted after PTK. Improvements in corneal sensitivity, tear film break up time, lipid layer interference grades, and conjunctival squamous metaplasia grades was noted.¹³ They proposed that PTK has favorable effects on the ocular surface by improving the stability of the tear film and ocular surface through attainment of a regular corneal surface. We also found that patients with reduced tear film break up time showed an improvement after the procedure, reflecting an improvement of ocular surface health.

To conclude, our study shows that PTK is a safe, simple and effective procedure that helps achieve

symptom alleviation, increase visual acuity, and delays the need for penetrating keratoplasty, and its associated complications and side effects. PTK has minimal side effects and complications; given that proper patient selection is backed up with sound pre-operative counseling. PTK also successfully attains smooth regular ocular surface and improves the tear film.

Disclosure

This manuscript has been read and approved by all authors. This paper is unique and is not under consideration by any other publication and has not been published elsewhere. The authors and peer reviewers of this paper report no conflicts of interest. None of the authors have a financial interest or received any monetary grant. The authors confirm that they have permission to reproduce any copyrighted material.

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