Excimer Laser Phototherapeutic Keratectomy for Corneal Diseases

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Abstract

The efficacy and safety of excimer laser phototherapeutic keratectomy (PTK) for treatment of various corneal pathologies were determined. The preoperative indications included lattice dystrophies (10 eyes), Reis-Bücklers dystrophies (4 eyes), macular dystrophies (2 eye), and corneal scarring secondary to trauma (1 eye). Mean follow-up time was 9.9 months (range 6-18 months). Uncorrected visual acuity postoperatively improved in 15 eyes (88.2%); not improved in 1 eye (5.9%) and decreased in 1 eye (5.9%). Corneal clarity improved in 14 of 17 eyes (82.4%) which corresponded to the improvement of uncorrected visual acuity. Ocular discomfort improved in 16 eyes (94.1%), decreased in 1 eye (5.9%) which subsequently developed double vision. The complications included delayed reepithelialization (> 7 days) in 6 eyes (35.3%) and corneal scarring 1 eye (5.9%). Sixty four per cent had increased significant hyperopia (>4 D) and 7.1 per cent had significant induced astigmatism (>2 D). One eye (5.9%) needed retreatment due to remaining corneal opacity. One eye (5.9%) had double vision due to irregular astigmatism. Excimer laser PTK is effective and safe for treatment of various corneal pathologies. It thus appears to be an alternative to penetrating keratoplasty in some patients.

Key word : Excimer Laser, Phototherapeutic Keratectomy (PTK)

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BACKGROUND

The excimer laser was introduced as a prospective tool in corneal surgery in 1983. High energy ultraviolet light is emitted by the excimer laser to ablate corneal tissue with submicron precision without significant injury to nonablated

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tissue. It can be used for reshaping the corneal curvature, for controlled removal of corneal tissue, or in reconstructive superficial keratectomy. In phototherapeutic keratectomy (PTK) the excimer laser is used to remove the anterior layers of the cornea. Excimer laser ablation has great potential to treat corneal opacities and to smooth corneal surface irregularities. The rationale of using the excimer laser to treat superficial corneal opacities and surface irregularities is to obviate more invasive procedures such as lamellar or penetrating keratectomy. The aim of this study was to determine whether the laser could be used to remove corneal opacities that interfere with vision, produce an optically smooth surface resulting in better vision, improve visual discomfort and finally to evaluate the safety of the procedures.

PATIENTS AND METHOD

The study included 6 female and 4 male patients; aged from 18 to 61 years. All patients had corneal pathology unresponsive to conventional therapy and were enrolled on the waiting list for corneal transplantation. Inclusion criteria were patients 18 years or older with corneal opacity or irregularity that impaired visual function. The surgical plan was to remove the corneal pathologies and retain at least 250 μm of the cornea after the procedure. The preoperative best corrected vision was no better than 20/40. Exclusion criteria included immunosuppression, uncontrolled uveitis, severe blepharitis, severe dry eyes, lagophthalmos, or any condition thought significantly adverse to affect corneal healing and conditions in which there was inability to comply with postoperative therapy.

Preoperative diagnoses included lattice dystrophy (10 eyes), Reis-Bücklers corneal dystrophy (4 eyes), macular dystrophy (2 eyes), and corneal scarring secondary to trauma (1 eye). Table 1 shows the demographic data of the patients treated with excimer laser PTK. Preoperative examinations included Snellen visual acuity (uncorrected and best spectacle corrected), refraction, intraocular pressure, slit-lamp examination and photography, and dilated fundus evaluations. Keratometry and computerized corneal topographic analyses were obtained, giving details of corneal irregularity. Ultrasonic pachymetry at central and in the area of pathology were performed on all eyes. Postoperatively, after complete reepithelialization, these measurements (except dilated fundus examination) were repeated at 1, 3, 6, 12 and 18 months. Corneal clarity was graded as follows; 0, clear; 0.5, barely detectable opacity; 1.0, mild opacity not affecting refraction; 1.5, opacity mildly affecting refraction; 2, moderate opacity interfering with refraction; 3, marked opacity that prevents refraction but allows clear view of the anterior chamber; 4, opacity that impairs view of the anterior chamber; and 5, opacity that prevents view of the anterior chamber. Corneal discomfort includes tearing, burning, reddish, and irritation was recorded preoperative and at each postoperative visits.

Device Description

An argon-fluoride excimer laser system (Nidek EC-5000) was used for all procedures. This excimer laser produces ultraviolet light with a wavelength of 193 nm. The laser delivers a fluence of 130 mJ/cm^2 at a frequency of 30 Hz. The laser unit was calibrated by the laser technician and surgeon before treating each patient as described by the manufacturer.

Surgical Techniques

Preoperative management began with topical administration of one drop of 0.5 per cent proparacaine, three times, 5 minutes apart. The patient was in the recline position under the operating microscope, and the eyelid speculum was inserted. The patients were asked to fixate on the coaxial fixation light while the nonablated eye was patched.

In each case, deepithelialization was performed mechanically or with laser scrape techniques individually, according to our determination whether the corneal epithelium was to be left intact.

Table 1. Demographic data of patients treated with PTK.

No. of patients	10
No. of eyes	17
Male:Female	4:6
Mean age (years)	35.5
Age range (years)	18-61
Mean follow-up (months)	9.9
Follow-up range (months)	6-18
Preoperative Diagnosis	
Lattice dystrophy (eyes)	10
Reis-Bücklers dystrophy (eyes)	4
Macular dystrophy (eyes)	2
Corneal scarring secondary to trauma (eye)	1

If smooth and regular, laser ablation proceeded without manipulating this layer (using laser-scrape technique). Where indicated, the epithelium was manually removed. This was performed with a no. 15 Bard-Parker blade. A masking fluid was then applied to the corneal surface (Tears Naturale; Alcon Pharmaceuticals, Ft Worth, TX, U.S.A, Cellufresh; Allergan, Refresh, Allergan, Irvine, California) to further smooth out the area. After deepithelialization, the laser was then centered over the entrance pupil. The laser was set to perform a therapeutic ablation with a depth ranging from 80 to 200 μm, according to the preoperative measurement of the thickness of the corneal opacity. The diameter of the treated surface was 6.0 mm except in cases of corneal scarring, the laser was centered over the scar area and the diameter was decreased to 3.0 mm. After ablating superficial stroma, the surgeon was able to evaluate the necessity of additional ablation, depending on the corneal clarity. A portable slit lamp was used intraoperatively to assess the completeness of excision of the superficial opacities as well as surface smoothness. In patients whose anterior surfaces were markedly irregular, sterile masking fluid was instilled on the surface in an attempt to smooth the cornea, and the ablation was continued. In order to minimize hyperopic shift, the midperiphery of the cornea was treated with modified tapering technique described previously by Stark(1).

Postoperatively, the patients received a drop of cyclopentolate hydrochloride, diclofenac, tobramycin 0.3 per cent, and were pressure patched. The patients were seen 24 hours postoperatively, and then at intervals of 48 hours until reepithelialization was complete. Initially, patients were maintained on topical tobramycin and fluorometholone 0.1 per cent (FML; Allergan Pharmaceuticals, Irvine, CA, U.S.A.) on a qid schedule. After complete reepithelialization, the antibiotics were discontinued, all patients received topical fluorometholone 0.1 per cent four times daily, with tapering of the dosage over a 12 week period.

RESULTS

The authors analyzed the visual outcome in terms of efficacy and safety; the refractive outcome; corneal clarity score; symptomatic improvement; and the complications in the patients treated with excimer laser PTK.

Visual outcome

Efficacy

We found that postoperative uncorrected visual acuity (UCVA) and best spectacle-corrected visual acuity (BCVA) were better than preoperative except eye No. 5 which had UCVA worse than preoperative; eye No. 7 showed no changes of UCVA. Table 2 details pre and postoperative refraction and visual acuity with and without correction. Postoperative UCVA improved in 15 eyes (88.2%); not improved in 1 eye, (eye No. 7) (5.9%); and decreased in 1 eye (eye No. 5) (5.9%) because of excessive stromal scarring. Four eyes (23.5%) had UCVA between 20/20 and 20/40, 11 eyes (64.7%) had UCVA between 20/50 and 20/100, 1 eye (5.9%) had UCVA of 20/200-20/400, and also one eye (5.9%) had UCVA of count finger. Best spectacle-corrected visual acuity (BCVA) improved in 12 eyes (70.6%); not improved in 5 eyes, (eye No. 2, 5, 7, 8 and 13) (29.4%). Table 3, 4 compare pre- *versus* postoperative UCVA and BCVA respectively.

Safety

Postoperatively, 2 eyes (11.8%) gained 1 line; 3 eyes (17.6%) gained 2 lines; 2 eyes (11.8%) gained 3 lines and 4 eyes (23.5%) gained more than 3 Snellen lines of best spectacle-corrected visual acuity. Six eyes (35.3%) showed no change and there was no loss of 1 or more line. Table 5 shows number of eyes that gained or lost Snellen line of best spectacle-corrected visual acuity after PTK procedures.

Refractive outcome

When pre and postoperative refraction were compared, we found that all had hyperopic shift except eyes No. 7, 10, 17 on which refraction could not be done either pre- or postoperatively. Table 2 shows pre- and postoperative refraction.

Corneal clarity

The corneal clarity improved in 14 of 17 eyes (82.4%) as shown in Fig. 1, did not improve in 2 eyes (11.8%) and worsened in 1 eye (5.9%). Table 6, 7 details corneal clarity pre- and postoperative.

Patient's comfort level was assessed pre- and postoperatively with specific questions regarding pain, tearing, photophobia, redness, and foreign body sensation. Symptomatic improvement was noted in 16 of the 17 patients (94.1%); one eye

Table 2. Pre-*versus* postoperative refraction and visual acuity with and without correction.

No.	Diagnosis	Eye	Pre-op Visual Acuity		Preoperative Refraction (D)	Ablation depth (μm)
			UCVA	BCVA		
1	Lattice dystrophy	OD	20/200	20/100	Plano ≈ -4.00x120	120
2	Lattice dystrophy	OS	20/200	20/70	+0.25 ≈ -4.00x120	120
3	Lattice dystrophy	OD	20/70	20/50	+1.00 ≈ -7.00x170	150
4	Lattice dystrophy	OS	20/200	20/200	-1.50 ≈ -4.50x130	100
5	Lattice dystrophy	OD	20/100	20/70	-2.0 ≈ -2.50x45	168
6	Lattice dystrophy	OS	20/100	20/50	+2.50 ≈ -4.00x80	100
7	Lattice dystrophy	OD	20/100	20/50	+9.25 ≈ -2.75x170	200
8	Lattice dystrophy	OD	FC 3'	20/50	-4.00 ≈ -3.25x80	100
9	Lattice dystrophy	OS	FC 3'	20/100	-5.50 ≈ -1.50x90	80
10	Lattice dystrophy	OS	FC 1'	FC 1'	Can't be done	190
11	Reis-Bücklers dystrophy	OD	20/200	20/200	Plano ≈ -1.50x180	60
12	Reis-Bücklers dystrophy	OS	FC 3'	20/100	-1.25 ≈ -1.25x180	70
13	Reis-Bücklers dystrophy	OD	20/200	20/40	-6.00	80
14	Reis-Bücklers dystrophy	OS	FC 6'	20/40	-5.50 ≈ -1.00x170	90
15	Macular dystrophy	OD	20/100	20/100	-5.00 ≈ -4.00x80	85
16	Macular dystrophy	OS	20/100	20/100	-4.50 ≈ -4.00x20	85
17	Corneal scar	OS	FC 2'	FC 2'	Can't be done	116

No	Postoperative UCVA (mo.)					Postoperative BCVA (mo.)					Postoperative refraction (D)
	1	3	6	12	18	1	3	6	12	18	
1	20/100	20/70	20/100	20/50	20/50	20/70	20/30	20/30	20/50	20/50	+6.25 ≈ -6.50x120
2	20/100	20/70	20/100	20/70	20/70	20/70	20/50	20/50	20/70	20/70	+4.75 ≈ -4.25x60
3	20/70	20/70	20/30	20/30	20/30	20/30	20/30	20/25	20/20	20/20	+2.50 ≈ -3.25x180
4	20/100	20/70	20/200	20/30	20/30	20/50	20/30	20/70	20/20	20/20	+1.00 ≈ -2.50x130
5	20/100	20/200	20/200	20/200		20/70	20/70	20/70	20/70		+5.75 ≈ -4.00x150
6	20/50	20/70	20/50	20/50		20/30	20/30	20/30	20/30		+3.00 ≈ -0.50x180
7	20/200	20/100	20/100			20/70	20/50	20/50			Can't be done
8	20/100	20/50	20/50			20/100	20/50	20/50			+1.25 ≈ -2.00x130
9	20/100	20/50	20/40			20/50	20/30	20/30			+1.75 ≈ -0.50x140
10	20/200	FC 3'	FC 3'			20/100	FC 3'	FC 3'			Can't be done
11	20/40	20/50	20/50			20/30	20/30	20/30			Plano
12	20/100	20/70	20/50	20/70		20/50	20/30	20/30	20/30		+0.75 ≈ -1.00x180
13	20/70	20/50	20/50			20/50	20/40	20/40			+0.25 ≈ -2.00x180
14	20/70	20/30	20/30			20/30	20/30	20/30			+0.25 ≈ -1.25x20
15	20/70	20/70	20/70			20/50	20/50	20/50			+0.25 ≈ -3.75x10
16	20/100	20/70	20/70			20/70	20/70	20/70			+0.50 ≈ -3.00x100
17	20/200	20/100	20/100			20/70	20/70	20/70			-1.50

UCVA uncorrected visual acuity
BCVA best spectacle-corrected visual acuity

Table 3. Compare uncorrected Snellen visual acuity (UCVA) between preoperative and postoperative.

UCVA (n=17)	Preoperative	Postoperative
20/20-20/40	0 (0%)	4 (23.5%)
20/50-20/100	6 (35.3%)	11 (64.7%)
20/200-20/400	5 (29.4%)	1 (5.9%)
Counts fingers	6 (35.3%)	1 (5.9%)

Table 4. Compare best spectacle-corrected Snellen Visual Acuity (BCVA) between preoperative and postoperative.

BCVA (n=17)	Preoperative	Postoperative
20/20-20/40	2 (11.8%)	8 (47.0%)
20/50-20/100	11 (64.7%)	8 (47.0%)
20/200-20/400	2 (11.8%)	0 (0%)
Counts fingers	2 (11.8%)	1 (5.9%)

Table 5. Gain/Loss Snellen lines of best spectacle-corrected visual acuity (BCVA) after PTK.

Gain/Loss of Snellen Lines	BCVA	%
Gain > 3	4	23.5
Gain 3	2	11.8
Gain 2	3	17.6
Gain 1	2	11.8
No change	6	35.3
Loss 1	0	0
Loss 2	0	0
Loss 3	0	0
Loss >3	0	0

Table 6. Corneal clarity score pre- and postoperative.

No. of Eye	Corneal Clarity Grading	
	Preoperative	Postoperative
1	2	1
2	2	1
3	2	1
4	2	1.5
5	2	4
6	2	1.5
7	2	2
8	2	1.5
9	2	1.5
10	5	5
11	2	1.5
12	2	1.5
13	2	1.5
14	2	1.5
15	2	1.5
16	2	1.5
17	4	2

Table 7. Per cent of corneal clarity score pre- and postoperative.

	Corneal Clarity Score	
Grading	Preoperative	Postoperative
0	0 (0/17)	0 (0/17)
0.5	0 (0/17)	0 (0/17)
1.0	0 (0/17)	17.6 (3/17)
1.5	0 (0/17)	58.8 (10/17)
2	88.2 (15/17)	11.8 (2/17)
3	0 (0/17)	0 (0/17)
4	5.9 (1/17)	5.9 (1/17)
5	5.9 (1/17)	5.9 (1/17)

Table 8. Complications after PTK.

Postoperative Complications		
Optical complications (%)		
Hyperopic shift	100	(14/14)
Increased significant hyperopia (>4 D)	64.3	(9/14)
Significant induced astigmatism (>2 D)	7.1	(1/14)
Residual opacity	100	(17/17)
Repeated PTK	5.9	(1/17)
Diplopia	5.9	(1/17)
Medical complications (%)		
Delayed reepithelialization (>7 days)	35.3	(6/17)
Pain	23.5	(4/17)
Excessive stromal scarring	5.9	(1/17)

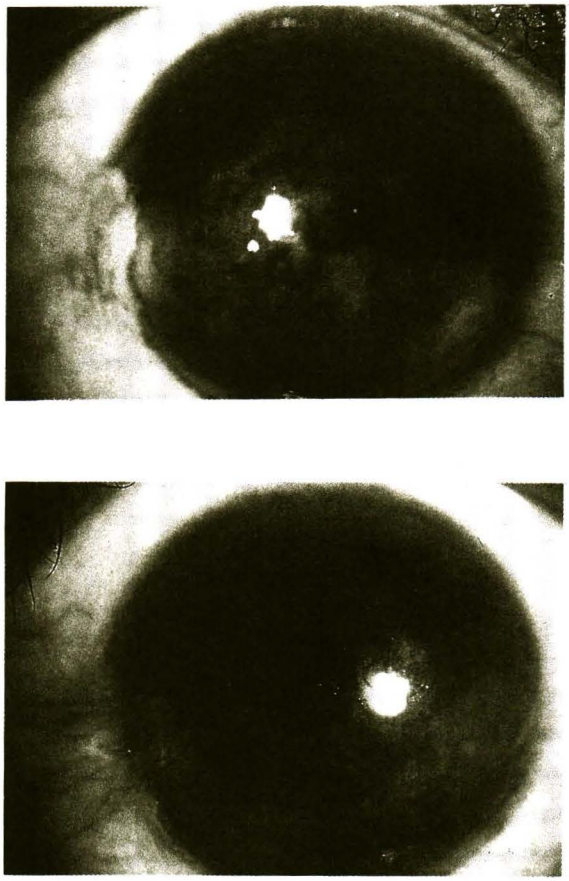

Fig. 1. Improvement of corneal clarity after PTK: compared between pre-operative (top) and postoperative (bottom).

(5.9%) (eye No.10) had ocular discomfort due to double vision.

Complications (Table 8)

For optical complications, hyperopic shift was found 100 per cent (14 of 14 eyes in which refraction was done) but significant hyperopia; i.e. more than 4 diopters was 64.3 per cent (9 out of 14 eyes). Increased significant astigmatism; i.e. more than 2 diopters was observed in 7.1 per cent (1 of 14 eyes). We found that all cases had residual opacity but only one case (eye No. 3); that is 5.9 per cent needed repeat PTK and visual acuity was finally improved. Also one case experienced diplopia (eye No. 10); this was due to irregular astigmatism which was confirmed by corneal topographic analysis. For medical complications, we found 35.3 per cent had delayed reepithelialization (i.e. >7 days), pain 4 eyes (23.5%), excessive corneal stromal scarring 1 eye (5.9 %) which caused no improvement in visual acuity.

DISCUSSION

We used the excimer laser to treat various corneal pathologies. Our work confirms that of others[1-8] in that excimer laser phototherapeutic keratectomy is an effective tool for the treatment of patients with superficial corneal opacities who would otherwise need penetrating keratoplasty.

Eye No. 5 had postoperative UCVA worse than preoperative, this was due to deep ablation (168 μm) that caused scar formation. Even though eye No. 10 had a little improvement in visual acuity (UCVA and BCVA) but experienced diplopia. This was also due to deep ablation (190 μm) that caused irregular astigmatism which was confirmed by computerized corneal topography. Eye No. 7 also had no improvement in visual acuity. Even though there was neither excessive stromal scarring nor irregular astigmatism as shown in eyes No. 5 and 10 respectively, this can be explained by deep ablation (200 μm) together with preoperative hyperopia. As we know, the resultant PTK profile usually causes hyperopia; the greater the ablation depth is, the higher the hyperopia. This may cause very high hyperopic shift that causes no improvement in visual acuity.

Table 3, 4 and Fig. 2 show the efficacy of PTK by comparing preoperative BCVA to postoperative UCVA. This means that the efficacy of PTK for corneal diseases was very good, especially for ablation depth of less than 120 μm. Eyes which had deep ablation (eyes No. 5, 7, 10) caused stromal scarring, irregular astigmatism and very high hyperopic shift, respectively.

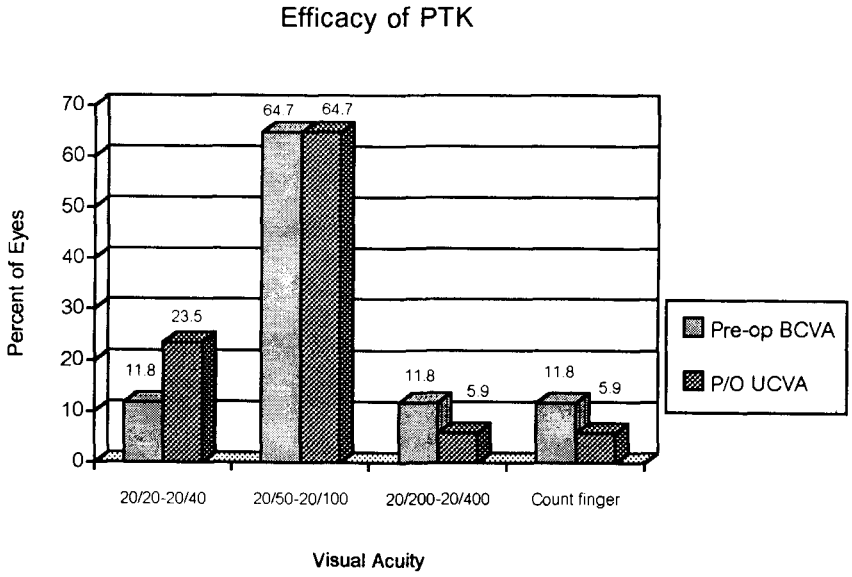

Fig. 2. Efficacy of PTK.

Patient No. 17 who had corneal scar secondary from trauma had marked improvement in visual acuity and ocular discomfort. Our results are contradictory to the study of McDonnell and colleagues[9] which found that there was no improvement of visual acuity in the case of deep corneal scarring when the laser ablation rate may be changed in different corneal densities causing no ablation and finally needing penetrating keratoplasty. The improvement of vision in this case can be explained by the decrease of forward light scattering. Dense corneal scarring, causing back light scattering, results in decreased image resolution. Marked irregular corneal surface caused forward light scattering, resulting in diplopia, glare, decreased sharpening of vision and also decrease in image resolution[10]. After PTK, there is much improvement in smoothness of the corneal surface. This may cause decrease in forward light scattering resulting in improvement of both vision and ocular discomfort. Table 5 and Fig. 3 show the safety of PTK. Per cent of gained Snellen lines was apparent postoperatively and there was no loss of BCVA in one or more line after surgery. We found that postoperative corneal clarity was improved in 82.4 per cent (14 of 17 eyes). Fig. 4 shows the improvement of corneal clarity postoperative.

Excision of superficial corneal opacities with excimer laser has been demonstrated in either obviate or delay, the need for penetrating keratoplasty in a large percentage of patients. Our results confirm this finding, not only for superficial corneal opacities but also in cases of deep focal corneal opacity as shown in eye No. 17. Thailand encounters the problem of the small number of eye donors. All patients in this study had already been enrolled on the waiting lists for corneal transplant, but the low number of donors as mentioned above delayed the procedure. Usually patients on the waiting lists have to wait at least 4 to 6 years which may sometimes cause increaseed opacity. The patient's quality of life may be reduced in terms of decreased vision and ocular discomfort. We found that the donor demands were decreased since 15 of 17 eyes obviated corneal transplant surgery. The patients were satisfied with the results of both visual outcome and ocular comfort. Moreover, PTK involves surgery of only the superficial cornea, causing less operative risk than conventional keratoplasty.

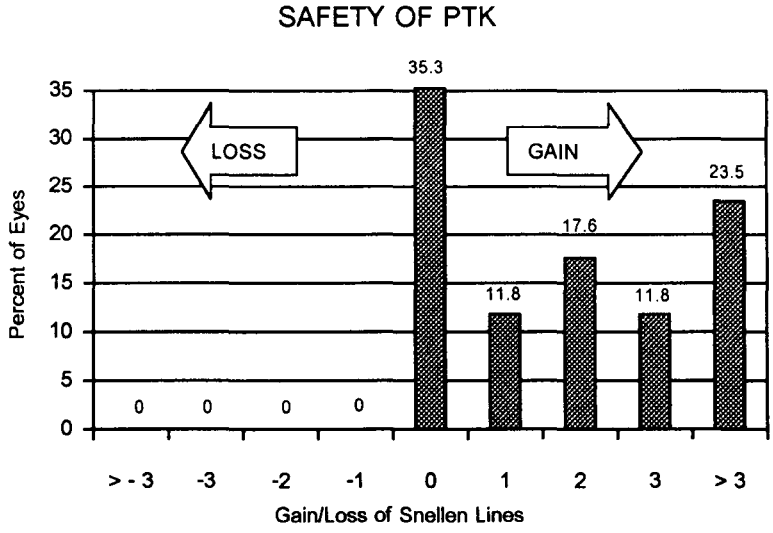

Fig. 3. Safety of PTK.

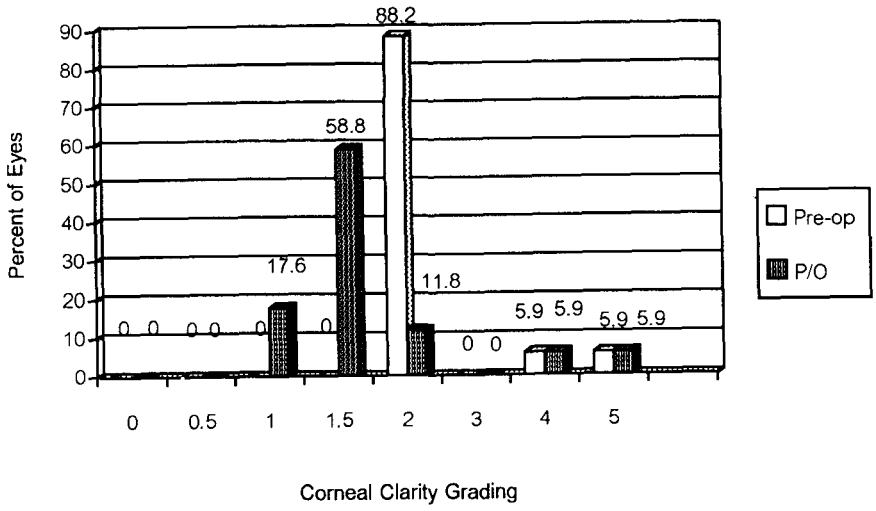

Fig. 4. Per cent of corneal clarity grading pre- and post PTK.

In conclusion, we found that excimer laser phototherapeutic keratectomy or PTK was effective and safe for treatment of various corneal pathologies. It significantly improved visual acuity in patients with visual loss from corneal opacities or irregularities. This procedure appears to be an alternative to corneal transplantation in some patients.

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การใช้เอ็กไซม์เมอร์เลเซอร์รักษาโรคของกระจกตา

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การศึกษาผลการรักษาโรคของกระจกตาโดยเอ็กไซม์เมอร์เลเซอร์ ในแง่ประสิทธิภาพ และความปลอดภัยในจำนวน 17 ตา ซึ่งได้รับการวินิจฉัยว่าเป็นกระจกตาเสื่อมชนิดแลททิสต์ 10 ตา ชนิดไรส-บุคเคลอร์ 4 ตา ชนิดแมกคูลาร์ 2 ตา และแผลเป็นที่กระจกตาจากอุบัติเหตุ 1 ตา โดยมีระยะเวลาของการติดตามผลเฉลี่ย 9.9 เดือน ผลการรักษาพบว่าระดับสายตาโดยไม่ต้องใช้แว่นช่วยเพิ่มขึ้น 15 ตา (88.2%) ไม่เปลี่ยนแปลง 1 ตา (5.9%) และลดลง 1 ตา (5.9%) ความใสของกระจกตาเพิ่มขึ้น 14 ตา (82.4%) ความสบายตาเพิ่มขึ้น 16 ตา (94.1%) ลดลง 1 ตา (5.9%) ซึ่งเป็นผลมาจากเกิดภาพซ้อนขึ้น ผลแทรกซ้อนของการรักษาพบดังนี้ การสมานของผิวกระจกตาช้าเกินกว่า 7 วันพบ 6 ตา (35.3%) เกิดแผลเป็นขึ้น 1 ตา (5.9%) ก่อให้เกิดสายตายาว (> 4 D) 9 ตา (64.3%) สายตาเอียง (> 2 D) 1 ตา (7.1%) พบ 1 ตา (5.9%) ต้องได้รับการฉายเลเซอร์ซ้ำเนื่องจากยังคงเหลือความขุ่นของกระจกตา และพบเกิดภาพซ้อน 1 ตา (5.9%) จึงสรุปได้ว่าการใช้เอ็กไซม์เมอร์เลเซอร์ในการรักษาโรคกระจกตาให้ผลการรักษาที่สูงและปลอดภัย นอกจากนี้วิธีนี้ยังอาจเป็นทางเลือกอีกทางหนึ่งนอกเหนือจากการเปลี่ยนกระจก ตาในผู้ป่วยบางรายอีกด้วย

คำสำคัญ : เอ็กไซม์เมอร์เลเซอร์, กระจกตา

งามจิตต์ เกษตรสุวรรณ และคณะ
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