Excimer Laser Photorefractive Keratectomy in Hyperopia

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Purpose: *To evaluate excimer laser photorefractive keratectomy for the treatment of different degrees of hyperopia.*
Patients and Methods: *Hyperopic photorefractive keratectomy was performed for 98 eyes of 52 patients at the Ophthalmology Centre, St. Petersburg, Russia. Patients were included in 1 of 4 groups according to initial refraction — group A (+ 1.00 D to + 2.75 D); group B (+ 3.00 D to + 4.75 D); group C (+ 5.00 D to + 5.75 D); and group D (≥ + 6.00 D). All eyes underwent photorefractive keratectomy using 5.5 mm ablation and 9.0 mm transition zones.*
Results: *12 months after photorefractive keratectomy, 100% of eyes in group A, 63.6% in group B, 41.7% in group C, and 40.0% in group D were within ± 1.00 diopters of emmetropia. Uncorrected visual acuity was 20/40 or better in 94.3%, 80.5%, 86.7%, and 62.6% of eyes for groups A, B, C, and D, respectively. No eyes in group A lost more than 1 line of best corrected visual acuity, although 8 eyes (22.9%) in group B, 7 (53.8%) in group C, and 6 (40.0%) in group D lost 2 or more lines of best corrected visual acuity.*
Conclusion: *Excimer laser photorefractive keratectomy was predictable and safe for the treatment of low and moderate hyperopia (1.00 - 4.00 diopters).*

Key Words: complications, hyperopia, management, photorefractive keratectomy, stability.

Asian Journal of Ophthalmology 2000;2(4):7-10.

Introduction

There are several surgical techniques for correction of hyperopia. These include holmium laser thermokeratoplasty, automated lamellar keratoplasty (ALK), LASIK, clear lens extraction, and posterior chamber phakic lens implantation. Laser correction of hyperopia involves change of the anterior corneal curvature by steepening the central optical zone. This is achieved by flattening the peripheral cornea through laser ablation.

The surgical correction of hyperopia remains a challenge. However, most of the published literature shows that hyperopic photorefraction keratectomy (H–PRK) is a relatively safe and effective treatment for the correction of low degrees of hyperopia up to 4.00 diopters (D).[1-6] This article reports our retrospective results of 98 eyes undergoing H-PRK.

Patients and Methods

Patient Selection

This study comprised 98 eyes of 52 patients undergoing PRK. 50.9% of patients were men, 49.1% were women, and the mean age was 48.6 ± 8.5 years. Patients who had herpes keratitis, superficial corneal pathology, significant refracting media alterations, keratoconus, or collagen diseases were excluded.

The risks and benefits of PRK and the therapeutic alternatives were explained to patients before their consent was obtained. For group D patients, the possibility of undercorrection was explained and agreed to since deeper ablation may cause unexpected side effects and full correction was not attempted for these patients.

Pre-operative Refraction and Intended Correction

Patients were divided into 4 groups according to the pre-operative spherical equivalent of hyperopia:

- group A — 1.00 D to 2.75 D (mean, 2.00 D; 35 eyes [35.7%])
- group B — 3.00 D to 4.75 D (mean, 3.70 D; 35 eyes [35.7%])
- group C — 5.00 D to 5.75 D (mean, 5.47 D; 15 eyes [15.3%])
- group D — ≥ 6.00 D (mean, 6.88 D; 13 eyes [13.3%]).

Ablation was performed according to the cycloplegic refraction, even if the difference between cycloplegic and manifest refractions exceeded 1.00 D. Usually, ablation did not exceed 6.00 D in patients with a high degree of hyperopia. Each patient was asked to evaluate his/her satisfaction on a scale of 1 to 5, 12 months after PRK.

Procedure and Postoperative Management

PRK was performed with the Excimer Laser Corneal System NIDEK EC 5000 (Nidek

Technologies Inc., Tokyo, Japan). After a 9 mm diameter section of the epithelium was removed with a spatula, ablation was performed at a repetition rate of 34 Hz, energy 180 mJ/cm^2, ablation depth 0.6 mm/pulse in the optical zone, and 0.4 mm/pulse in the transition zone. The 5.5 mm optical and 9.0 mm transition zones were used. Topical tobramycin 0.3%, naklof 0.1%, and solcoseril eye gel were prescribed 4 times a day for the epithelialisation period. Topical dexamethasone 0.1% was administered 3 to 4 times a day for 3 to 6 months with gradual dosage reduction, depending on the degree of hyperopia. The mean follow-up period was 8.9 months (range, 2 to 14 months). The first postoperative examination was performed after 4 days, and thereafter monthly for 6 to 12 months.

Visual Acuity and Refraction

Uncorrected and best corrected visual acuity (UCVA and BCVA) and manifest refraction were measured after 3 weeks and monthly thereafter.

Subepithelial Haze

Subepithelial haze formation was examined with a slit lamp and graded as follows:

- 0 — clear cornea
- 1+ — trace, barely perceptible haze
- 2+ — mild haze that does not affect refraction
- 3+ — moderate haze, refraction affected
- 4+ — anterior chamber easily viewed, opacity prevents refraction
- 5+ — totally opaque scar, anterior chamber not visible.

Intraocular Pressure

Intraocular pressure was measured pre- and postoperatively with non-contact tonometer NT-1000, (Nidek Technologies Inc., Tokyo, Japan).

Table 1. Time course of uncorrected and best corrected visual acuity (UCVA and BCVA) and correction

Hyperopia group	Mean ± SD			Number of eyes
	UCVA	BCVA	Correction (D)	
A (1.00 – 2.75 D)				
Pre-operative	0.24 ± 0.13	0.99 ± 0.06	2.00 ± 0.39	35
Postoperative:				
1 month	0.66 ± 0.27	0.94 ± 0.12	-0.43 ± 0.79	35
3 months	0.84 ± 0.21	0.97 ± 0.07	-0.18 ± 0.49	33
6 months	0.89 ± 0.17	0.99 ± 0.03	0.16 ± 0.59	17
12 months	0.94 ± 0.12	1.00 ± 0.06	0.31 ± 0.66	24
B (3.00 – 4.75 D)				
Pre-operative	0.13 ± 0.11	0.96 ± 0.11	3.70 ± 0.61	35
Postoperative:				
1 month	0.54 ± 0.26	0.77 ± 0.19	-0.56 ± 0.98	35
3 months	0.71 ± 0.26	0.90 ± 0.17	0.01 ± 0.80	32
6 months	0.67 ± 0.26	0.87 ± 0.19	0.56 ± 0.92	20
12 months	0.79 ± 0.25	0.91 ± 0.17	0.76 ± 0.88	18
C (5.00 – 5.75 D)				
Pre-operative	0.08 ± 0.05	0.90 ± 0.11	5.47 ± 0.66	15
Postoperative:				
1 month	0.44 ± 0.22	0.76 ± 0.16	-0.57 ± 1.59	15
3 months	0.67 ± 0.16	0.81 ± 0.16	0.31 ± 0.98	15
6 months	0.56 ± 0.21	0.79 ± 0.15	1.15 ± 1.20	10
12 months	0.44 ± 0.18	0.76 ± 0.18	1.19 ± 1.57	9
D (≥ 6.00 D)				
Pre-operative	0.05 ± 0.02	0.72 ± 0.35	6.88 ± 0.97	13
Postoperative:				
1 month	0.39 ± 0.18	0.54 ± 0.20	-0.45 ± 1.58	13
3 months	0.61 ± 0.24	0.64 ± 0.23	0.35 ± 1.26	13
6 months	0.43 ± 0.23	0.59 ± 0.25	1.08 ± 0.73	6
12 months	0.43 ± 0.15	0.55 ± 0.10	1.78 ± 1.19	4

Results

At the final examination, all patients had significant improvement in UCVA and stopped wearing glasses for long-distance. The overwhelming majority (96%) were satisfied with the operation results.

Visual Acuity

For patients in group A, UCVA of 20/40 was achieved for 33 of 35 eyes (94.3%) at 3 months, for 21 of 22 eyes (95.5%) at 7 to 9 months, and for 19 of 19 eyes (100%) at 1 year (table 1). For patients in group B, the same UCVA was achieved for 28 of 35 eyes (80%), in group C for 13 of 15 eyes (86.7%), and in group D for 8 of 13 eyes (61.5%). BCVA was maintained at 1 year for all group A eyes except for 1 eye that lost 1 line. At 12 months, there were no patients in group A who lost more than 1 line of BCVA. However, 8 patients (22.9%) in group B, 7 (53.8%) in group C, and 6 (40.0%) in group D lost 2 or more lines of BCVA. The most significant loss of BCVA was 4 lines determined for 3 eyes; 2 were in group C, and 1 in group D.

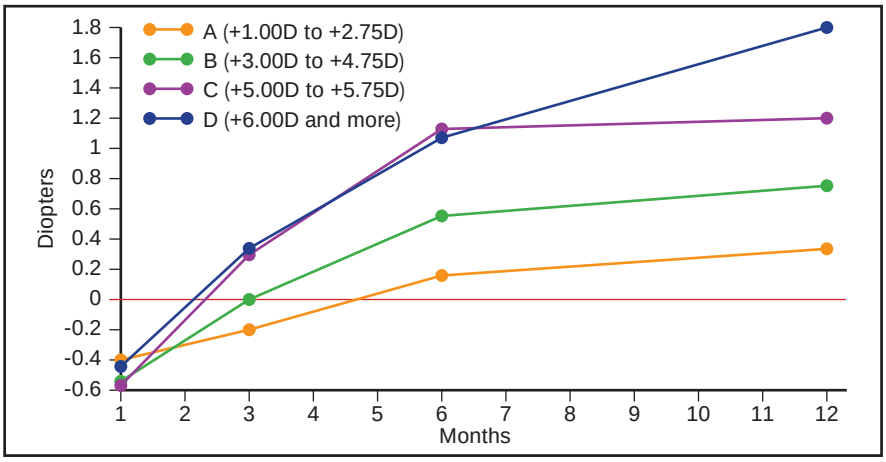
Predictability

The mean mild myopic refraction in all groups was revealed 1 month after surgery (figure 1), and there was a common tendency towards overcorrection. At 3 months, undercorrection was revealed in all groups except group A. 12 months after photorefractive keratectomy, 100% of patients in group A, 63.6% in group B, 41.7% in group C, and 40.0% in group D were within ± 1.00 diopters of emmetropia.

Stability

On average, a low degree of overcorrection for group A and a low degree of undercorrection in groups B, C, and D were revealed 3 months after surgery. Manifest and cycloplegic refraction was stable 4 months after surgery for group A, and at

Figure 1. Evolution of refraction after photorefraction keratectomy over time



7 to 8 months for group B. In groups C and D, there were no stable results and the regression was appreciable.

Complications

Decentration

Tangential topographic maps were used after excimer laser photorefractive keratectomy to evaluate treatment displacement and movement during treatment (drift). Decentration (area of the central steepening shifting more than 1.0 mm in relation to the optical axis) occurred in 4 eyes (4.1%). Three were from group D, and one was from group C and all were complicated with a ring-shaped subepithelial haze. Decentered treatments generally led to loss of lines of BCVA. Three eyes lost 3 lines and 1 lost 4 lines. Thus, topographic maps showed a typical 'keyhole' pattern.

Irregular Astigmatism

Irregular astigmatism was caused by decentration of the treatment. However, both eyes of 1 patient from group D had irregular astigmatism caused by an apical nodular subepithelial corneal scar, which developed within the first month after H-PRK and did not resolve spontaneously over time. This patient lost 3 and 4 lines of BCVA in the right and left eyes, respectively.

Subepithelial Haze

Generally, the ring-shaped subepithelial haze had a diameter of 5.5 to 6.0 mm. Subepithelial haze formation was verified in 20 of 55 eyes (36.3%) examined 12 months after surgery and was less than 2+ in all except 4 eyes. Two from group C and 2 from group D had a 3+ haze. One eye from group C had 2+ haze formation.

Re-epithelialisation

Re-epithelialisation was complete within 4 days of surgery in 83 eyes (84.7%) — 31 eyes (88.6%) in group A, 29 (82.9%) in group B, 14 (93.3%) in group C, and 9 (69.2%) in group D. In these eyes, postoperative erosion was not revealed after 1 week.

Intraocular Pressure

Intraocular pressure increased in 24 eyes of 16 patients (24.5%). After topical steroid was discontinued, intraocular pressure decreased to normal levels. For some patients with a moderate or high degree of hyperopia, β-blockers were administered when steroids could not be withdrawn.

Patient Satisfaction

Overall, 96.7% of patients were happy that they had undergone this operation. The majority (76.7%) were very happy and rated the procedure 5/5. There was only 1 patient with a severe hyperopia who felt unhappy with the final outcome of the procedure and rated it 3/5. This patient had an apical nodular subepithelial corneal scar. After PRK, he had a final unaided vision of 0.3 and had lost 3 lines of BCVA in both eyes. Thus, the average score was 4.8.

Discussion

Hyperopia is the most frequent refractive error. However, hyperopic patients rarely turn to refractive centres for help. The main reason is that people with mild and moderate hyperopia consider short distance deterioration of vision to be a normal age-related process. Another reason is that the affected population has not recognised a predictable and safe method of correcting hyperopia. Numerous methods have been used to treat hyperopia, but their results have been variable and not always satisfactory.

Thermokeratoplasty is recognised as a procedure with a high regression rate and the achieved correction is relatively mild. Other methods such as clear lens extraction with intraocular lens implantation and ALK carry significant complications.

In this research, of the 53 patients examined 6 months after PRK, 83.7% had refraction within ± 1.00 D and 68.4% within ± 0.50 D. During the first 2 to 4 months after surgery, there was typical overcorrection, although refraction moved towards emmetropia and undercorrection. The most significant range in postoperative refraction was in groups C and D, in whom refraction remained unstable up to 1 year after surgery. It is interesting that there was noticeable improvement in refraction after an additional steroid course was prescribed.

Conclusion

PRK is a predictable and safe method for correction of hyperopia of less than 4.00 D.[1,2,5,6] Of 11 eyes in group B, 5 lost 1 or

more Snellen lines, all of whom had preoperative refraction of > 4.00 D. Groups C and D had the highest incidence of decreased BCVA. The main reason was irregular astigmatism caused by decentration of the treatment and different subepithelial formations.[7,8]

This study demonstrates a very high level of patient satisfaction after PRK. The vast majority of patients were satisfied with the procedure (96.7%); only 1 of 9 patients (15.0%) with decreased BCVA had any complaint.

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