Holmium laser thermokeratoplasty for the reversal of hyperopia after myopic photorefractive keratectomy

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Abstract

***Background*—Overcorrection following myopic photorefractive keratectomy, with a target of emmetropia, leaving a spherical equivalent of more than 1.0 D of hyperopia is of the order of 1%. This study analyses the efficacy, safety, and 1 year stability of outcome of laser thermokeratoplasty (LTK) carried out on eyes with persistent symptomatic hyperopia following photorefractive keratectomy (PRK) for myopia.**

***Method*—11 consecutive eyes in 11 patients underwent LTK using the Technomed Holmium 25, contact holmium:YAG laser system. The mean spherical equivalent before LTK was +2.06 D (SD 1.02 D, range +1.00 D to +4.75 D) based on a non-cycloplegic refraction. Between four and 16 burns were used per eye, depending on the error to be corrected.**

***Results*—The mean spherical equivalent was +0.511 D (SD 0.551) at 1 year. Ten of the 11 eyes were seeing 6/12 or greater, unaided (91%) and nine were within 1.0 D of the target sphere equivalent (82%). Recovery of unaided acuity occurred during the first week in four cases and the first month in the rest. One eye lost greater than one line of best corrected vision (9%), going from 6/5 to 6/7.5 and one gained a line (9%), 6/12 to 6/7.5. No complications occurred during the follow up period.**

***Conclusions*—In this study of a small number of eyes with hyperopia induced by PRK, LTK appears safe, predictable, and stable for low errors followed for 1 year.**

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Laser thermokeratoplasty (LTK) is a technique to increase central corneal curvature for the correction of hyperopia and astigmatism. It is derived from work carried out initially by Lans at the end of the last century.[1] By heating the corneal stroma to approximately 60°C, collagen shrinkage can be induced[2 3] and placement of a ring of such burns about an appropriately chosen central optical zone can increase the curvature of the central cornea in a predictable manner while inducing peripheral flattening.[4] This can be achieved by the absorption of the infrared light (2100 nm wavelength) produced by the focused holmium:YAG laser beam in the corneal stroma.

Overcorrection following myopic photorefractive keratectomy (PRK), with a target of emmetropia, leaving a spherical equivalent of greater than 1.0 D of hyperopia occurs in approximately 1% of eyes treated.[5] Low hyperopic refractive errors are tolerated by younger patients, but less so by those approaching the age of symptomatic presbyopia. This study analysed the efficacy, safety, and 1 year stability of outcome of LTK carried out on 11 eyes with persistent symptomatic hyperopia following PRK for naturally occurring myopia.

Method

Eleven consecutive eyes in 11 patients (10 female, one male) aged between 25 and 69 years (mean 40 years) underwent LTK using the Technomed Holmium 25, contact holmium:YAG laser system between March and October 1995. This system produces a laser light in the infrared range (2100 nm wavelength) and has a pen-shaped handpiece delivery system that is applied to the cornea. The radiation is focused by a sapphire lens in the handpiece tip. Twenty five pulses were delivered, each of 1.0 ms duration, 20 mJ energy, and at a pulse frequency of 15 Hz, at each burn site. These settings were used in all cases. All 11 eyes had undergone PRK (three using the Summit ExciMed UV200 and eight using the Nidek EC5000) for naturally occurring myopia between 7 months and 3 years (mean 17 months) before undergoing LTK. The mean spherical equivalent before PRK was −6.08 D (SD 1.67 D) and all eyes were normal at this time. The preoperative best corrected and unaided Snellen acuities are shown in Table 1. The mean spherical equivalent before LTK was +2.06 D (SD 1.02 D, range +1.00 D to +4.75 D) based on a non-cycloplegic refraction since this most closely approximates the patient's day to day refractive error.

Four eyes each had an unsuccessful trial of epithelial debridement in the interval between PRK and LTK, leaving unaltered refractive errors.

The treatment was applied under topical anaesthetic using amethocaine 1% (tetracaine), centred on the visual axis using the fixation device in the Nidek EC5000 excimer laser delivery system. The target in all cases was emmetropia. The burn sites were marked on the corneal epithelium, the diameter of the optical zone being determined by the desired refractive result and the burns were all applied in a circular pattern. Four burns were applied

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Table 1 Refractive and visual outcome at 1 year

			Pre LTK				1 year	
Patient no	Pre PRK SE (D)	SE (D)	VA unaided	VA best corrected	No of burns	SE (D)	VA unaided	VA best corrected
1	−7.75	+4.75	6/36	6/5	16	+1.125	6/9	6/5
2	−6.5	+2.625	6/36	6/6	16	+1.50	6/12	6/6
3	−4.25	+2.25	6/12	6/6	8	−0.375	6/9	6/7.5
4	−8.25	+2.125	6/24	6/12	8	0	6/7.5	6/7.5
5	−5.5	+2.125	6/18	6/6	16	+0.25	6/6	6/6
6	−6.75	+2.00	6/7.5	6/5	8	+0.75	6/9	6/7.5
7	−7.00	+1.75	6/24	6/6	8	+0.875	6/18	6/6
8	−7.375	+1.50	6/18	6/5	8	+0.25	6/6	6/6
9	−3.625	+1.25	6/12	6/5	8	+0.75	6/9	6/6
10	−3.375	+1.25	6/12	6/4	8	0	6/5	6/5
11	−6.5	+1.00	6/9	6/5	4	+0.625	6/5	6/5

SE = sphere equivalent; PRK = photorefractive keratectomy; LTK = laser thermokeratoplasty.

to one eye with a +1.0 D error, eight burns to a further eight eyes with errors between +1.25 D and +2.25 D, and 16 burns to a further two eyes, one with a sphere equivalent of +2.625 D and a second with +4.75 D. One eye, initially receiving eight burns for a sphere equivalent of +2.125 D, had a further eight applied 2 months later because of an inadequate response to the first treatment. When four or eight burns were applied they were all placed equidistant from each other on the circumference of the circular 9 mm optical zone. If 16 burns were required, eight were placed at the 8 mm zone in one ring and the rest were placed at the 9 mm zone, each immediately peripheral to a burn in the inner ring—that is, in a radial pattern.

Topical fucidic acid 1% suspension (Fucithalmic) was applied for 48 hours postoperatively. The patients were allowed to use topical amethocaine 1%, as required for the first day, and the eyes were examined at 48 hours, 1 week, 1 month, 3 months, 6 months, and a year. No other medications were used. A non-cycloplegic refraction and unaided and best corrected acuities were recorded at each visit. No complications occurred during the treatments or in the follow up period.

Results

Table 1 contains the refractive and vision outcome for each eye at 1 year. The mean spherical equivalent was +0.511 D (SD 0.551 D) at that time. Ten of the 11 eyes were seeing 6/12 or greater, unaided (91%) and nine were within 1.0 D of the target sphere equivalent (82%). Recovery of unaided acuity occurred during the first week in four cases and the first month in the rest. The two eyes greater than 1.0 D from the target both demonstrated regression into substantial hyperopia and had the largest hyperopic errors before LTK. One eye lost greater than one line of best corrected vision (9%) going from 6/5 to 6/7.5 and one gained a line (9%), from 6/12 to 6/7.5.

Table 2 lists the refractive errors over the follow up period. It can be seen that the two eyes demonstrating the greatest regression (patients 1 and 2) regressed during the second 6 months after treatment. Comparison of the mean sphere equivalents for each follow up date demonstrates no significant difference between 3 and 6 months (p=0.909, Kruskal–Wallis test), 6 and 12 months (p=0.548, Kruskal–Wallis test), or 3 and 12 months (p=0.593, Kruskal–Wallis test).

No complications occurred during the follow up period and gradual resolution of the 'stress lines', seen running between laser burns in the peripheral cornea in the first few months after treatment, was noted, even in cases where the therapeutic effect was stable. The burns themselves became difficult to discern over the second 6 months.

Discussion

Significant overcorrection (greater than 1.0 D) following myopic PRK occurs in approximately 1% of eyes.[5] This can be symptomatic because of anisometropia with an untreated fellow eye or even a successfully treated fellow eye. In those patients of an age susceptible to symptomatic presbyopia, it can be particularly problematic. The mean age of the patients in this study was, not surprisingly, 40 years at the time of their treatment. By contrast, the mean age of myopic patients attending this institution for myopic PRK is 32 years.

Current keratorefractive techniques available for the correction of hyperopia include holmium:YAG laser thermal keratoplasty, hyperopic PRK,[6] hyperopic LASIK, and intrastromal refractive implants (Barrett GD, at the 1995 International Society of Refractive Keratoplasty meeting, San Francisco, CA, USA). All await long term analysis in the international literature. For those eyes with hyperopia following photorefractive keratectomy, simple removal of the corneal epithelium (with or without the use of a postoperative soft contact lens) was considered anecdotally among refractive surgeons as a possible method of stimulating wound healing to try and reduce overcorrection.[7] More formal study of this technique has been disappointing[8] showing no effect on hyperopic errors. Our limited experience of the technique, in this study, would tend to agree with this conclusion.

Holmium:YAG laser thermal keratoplasty has been studied for naturally occurring hyperopia with limited success. Regression of effect from 1 to 2 months, postoperatively, 'appears to be the rule'.[9] In this study of a small number of eyes with hyperopia induced by PRK, LTK

Table 2 Stability of refractive outcome

	Sphere equivalent (D)		
Patient no	At 3 months	At 6 months	At 1 year
1	+1.125	+0.125	+1.125
2	+0.375	0	+1.50
3	DNA*	+0.50	−0.375
4	0	+0.50	0
5	−0.125	−0.125	+0.25
6	+0.625	+0.625	+0.75
7	+0.75	+0.75	+0.875
8	+0.25	+0.125	+0.25
9	+0.125	+0.875	+0.75
10	+0.375	+0.625	0
11	DNA	+0.25	+0.625
Mean	+0.389	+0.386	+0.523
SD	0.392	0.328	0.553

*DNA = did not attend for follow up visit.

appears considerably more successful; 91% of eyes had 6/12 unaided visual acuity at one year and 82% were still within 1.0 D of the target refraction (emmetropia in all cases). Because of the relative rarity of this condition, the numbers of eyes available for study are small. Substantial regression occurred in those eyes with the largest pretreatment hyperopic errors (both greater than 2.5 D). Because the regression was in relatively few eyes and relatively mild (the greatest 1 year error being 1.5 D of hyperopia), comparison of the mean sphere equivalents at 3, 6, and 12 months showed no significant difference. These results compare favourably with those published for PRK for low to moderate myopia.[5] Furthermore, early recovery of unaided visual acuity occurs after this treatment (within the first month in all cases and in the first week in a third of cases).

Most regression of refractive effect in this study occurred in the second 6 months after treatment. This is in contrast with the early, vigorous regression seen in naturally occurring hyperopes, similarly treated. Perhaps the absence of Bowman's membrane after PRK alters the anterior corneal response to LTK.

LTK for hyperopia, persisting after PRK for myopia, appears on the basis of this small study, to be a useful, stable, and safe method of correcting low errors. The long term stability of the results will need to be observed further.

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