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The effect of hyperopic laser *in situ* keratomileusis on refractive accommodative esotropia

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PURPOSE. *To evaluate the efficacy of laser in situ keratomileusis (LASIK) for discarding spectacles and simultaneously correcting ocular alignment in patients with refractive accommodative esotropia.*
METHODS. *LASIK was performed on 20 eyes of 10 patients (mean age, 24.3 years; range, 11 to 43 years) using a Technolas 217C excimer laser. The target refraction was emmetropia. Visual acuity (uncorrected and best-corrected), refractive error, and ocular alignment were recorded before and after LASIK. Minimum follow-up was 12 months.*
RESULTS. *The mean preoperative uncorrected and corrected angle of deviation was 37.1 prism diopters (PD) (range, 17 to 80; standard deviation (SD), 19.8)) and 14.74 PD (range, 0 to 50; SD, 12.9) of esotropia, respectively, which changed to 7.2 PD (range, 0 to 50; SD, 15.78) without correction postoperatively (p=0.005). Of 20 eyes, 15% lost one line of best-corrected visual acuity, 10% gained two lines, and 75% showed no change.*
CONCLUSIONS. *LASIK could be considered an alternative treatment for patients with refractive accommodative esotropia with intolerance to glasses and contact lenses. (Eur J Ophthalmol 2005; 15: 688-94)*

KEY WORDS. *Accommodative esotropia, Hyperopic LASIK*

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INTRODUCTION

Accommodative esotropia is one of the commonest forms of strabismus. It is caused by over-convergence in response to accommodation. In most cases, accommodative esotropia is associated with significant hyperopia of +2.00 diopters (D) or more (refractive accommodative esotropia). Prognosis is favorable if appropriate treatment is initiated promptly. Any approach to reducing hyperopia should relax accommodation and thus decrease accommodative convergence.

The final effect is decreasing or eliminating accommodative esotropia.

Conventional treatments include spectacles, contact lenses, and use of miotics. Some patients who cannot be weaned out of glasses are intolerant to spectacles and contact lenses as well. As discussed in several case reports (1-3) and series studies (4-9), this group would benefit from refractive surgery. The limited number of studies and their small number of patients, especially concerning LASIK for accommodative esotropia (4, 5, 8, 9), encouraged us to report our experience in this regard.

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PATIENTS AND METHODS

Ten patients with refractive accommodative esotropia were included in this noncomparative interventional case series study. The patients were admitted to Noor Vision Correction Center with a view to discarding their spectacles. All of them had esodeviation, which decreased with spectacles. Expecting surgical correction to have a similar effect, they underwent LASIK surgery to correct the refractive error and simultaneously improve ocular alignment.

For each patient an ocular history including previous treatments such as spectacle correction and strabismus surgery was recorded (Tab. I). Before LASIK, a complete ocular examination was performed, including measurement of uncorrected visual acuity (UCVA) and best-corrected visual acuity (BCVA); manifest refraction; cycloplegic refraction after instillation of cyclopentolate 1% eyedrops; and near and distant ocular alignment with and without spectacles, using the prism alternate cover test. In some patients there was a difference between distant and near deviation, but this did not exceed 10 prism diopters (PD). In these cases the averages of distant and near deviations were recorded. No patient had refractive astigmatism of more than 1.00 D, therefore the spherical equivalent refraction was recorded.

Corneal topography and pachymetry were performed on all patients and stereopsis was measured in the last five patients using the Titmus stereo test (Titmus Optical Company, Petersburg, VA).

This study was approved by the Noor Clinic Medical Ethics Committee. The nature of the procedure and its associated risks and complications were thoroughly explained to all patients and the 11-year-old patient's parents, and they signed an informed consent.

LASIK was performed under topical anesthesia with tetracaine 0.5% eyedrops. In all patients a Hansatome microkeratome (Bausch & Lomb, Inc., Rochester, NY) was used to create a 9.5-mm flap and laser ablation was performed with a Technolas 217C (Bausch & Lomb, Inc.) excimer laser. The cycloplegic refraction was used for surgery calculations and attempted correction, and the target refraction was emmetropia. Postoperative treatment consisted of a combination of antibiotic and steroid eyedrops.

Follow-up examinations were scheduled for 1 day, 1 week, and 1, 3, 6, 9, and 12 months after LASIK. Postoperative UCVA, BCVA, manifest and cycloplegic refraction, and alignment were recorded for all patients, and stereopsis for the last five patients, up to at least 12 months after surgery.

TABLE I - PATIENTS' AGE, SEX, PREVIOUS TREATMENT, AND SPECTACLE CORRECTION

Patient no.	Age at surgery, yr	Sex	Previous treatments	Previous spectacle correction (D), right/left
1	20	Male	Glasses	+6.50
				+6.00
2	30	Male	Glasses	+1.50-1.00x180
				+1.50-1.00x180
3	11	Female	Glasses	+5.75-1.00x180
				+4.00
4	30	Female	Glasses	+3.00
				+3.00
5	28	Female	Glasses + strabismus surgery twice	+2.50
				+2.75
6	22	Female	Glasses	+5.00
				+5.00
7	19	Female	Glasses	+3.25
				+2.50
8	43	Female	Glasses	+1.00-0.75x180
				+1.25-1.00x170
9	18	Female	Glasses	+3.75
				+3.75
10	22	Female	Glasses	+4.00
				+4.00

Two patients (numbers 1 and 3) had amblyopia and one patient (number 5) had already undergone eye muscle surgery for esotropia twice. These patients were not excluded: they had esotropia that decreased with spectacles and met our study criteria. The large angle of esotropia (80 PD) in Patient 1 resulted from a mixture of accommodative and sensory esotropia due to coincident amblyopia.

Statistical comparisons were performed using the Wilcoxon signed rank test.

RESULTS

The mean age of the patients was 24.3 years (range 11 to 43 years) and 80% of them were female (Tab. I). The mean follow-up time was 14 months (range 12 to 24 months). Measurements of UCVA, BCVA, spherical equivalent cycloplegic refraction, spherical equivalent manifest refraction, and alignment (average near and distant esodeviation) are given in Tables II, III, and IV.

The mean UCVA after LASIK significantly improved compared to preoperative levels (p=0.004). There was no significant difference in the mean BCVA before and after surgery (p=0.68). Three eyes (15%) lost one line of BCVA, 2 eyes (10%) gained two lines, and 15 eyes (75%) showed no change.

The mean spherical equivalent cycloplegic refraction changed from +5.03 D (range, +2.50 to +8.75 D; standard deviation [SD], 1.61) preoperatively to +1.06 D (range, -0.50 to +3.50 D; SD, 0.82) 1 month after LASIK and +1.68 D (range, -0.50 to +4.00 D; SD, 1.11) 12 months after LASIK. The mean spherical equivalent manifest refraction changed from +4.13 D (range, +1.50 to +7.25 D; SD, 1.56) to +0.20 D (range, -0.75 to +3.00 D; SD, 0.83) 1 month after LASIK and +0.80 D (range, -0.50 to +3.50 D; SD, 0.86) 12 months after LASIK. The differences between preoperative and postoperative refractions were statistically significant (p<0.001). A mean hyperopic (cycloplegic) regression of 0.62 D (range, 0.00 to +1.75 D; SD, 0.82) was observed between the 1 month and 12 month follow-up evaluations.

All 10 patients demonstrated a reduction in esodeviation with spectacle correction before LASIK surgery. The mean uncorrected esotropia was 37.1 PD (range, 17 to 80 PD; SD, 19.18) and the mean esotropia with spectacles was 12.9 PD (range, 0 to 50 PD; SD, 14.74) before LASIK. After LASIK, the mean uncorrected esotropia was 7.2 PD (range, 0 to 50 PD; SD, 15.78) and the change was statistically significant (p=0.005) (esophoria was considered equivalent to zero). The difference between postoperative uncorrected esotropia and the preoperative esotropia with spectacles was not significant (p=0.74). The alignment status was stable throughout the follow-up (Fig. 1). Patient 1 underwent eye muscle surgery due to significant residual esotropia (50 PD) 12 months after LASIK.

Stereopsis was measured in the last five patients, and showed an improvement in three patients and no change in the other two.

TABLE II - VISUAL ACUITY (LOGMAR) BEFORE AND AFTER LASER *IN SITU* KERATOMILEUSIS (LASIK)

		Pre-LASIK		Post-LASIK	
Patient no.	**Eye**	**UCVA**	**BCVA**	**UCVA**	**BCVA**
1	OD	1	0.8	0.8	0.5
	OS	0.4	0.1	0.3	0.1
2	OD	0.2	0	0.2	0
	OS	0.2	0	0.1	0
3	OD	0.6	0.4	0.4	0.4
	OS	0.3	0.2	0.3	0.3
4	OD	0	0	0	0
	OS	0	0	0	0
5	OD	0.2	0	0	0
	OS	0.2	0	0	0
6	OD	0.2	0	0.1	0.1
	OS	0.1	0	0.1	0.1
7	OD	0	0	0	0
	OS	0.1	0	0	0
8	OD	0.1	0	0	0
	OS	0.2	0.2	0	0
9	OD	0.1	0	0.1	0
	OS	0.1	0	0.1	0
10	OD	0.1	0.1	0.1	0.1
	OS	0.1	0.1	0.1	0.1
Mean		0.21	0.09	0.13	0.08
SD		0.23	0.19	0.19	0.14

UCVA = Uncorrected visual acuity; BCVA = Best-corrected visual acuity; OD = Right eye; OS = Left eye

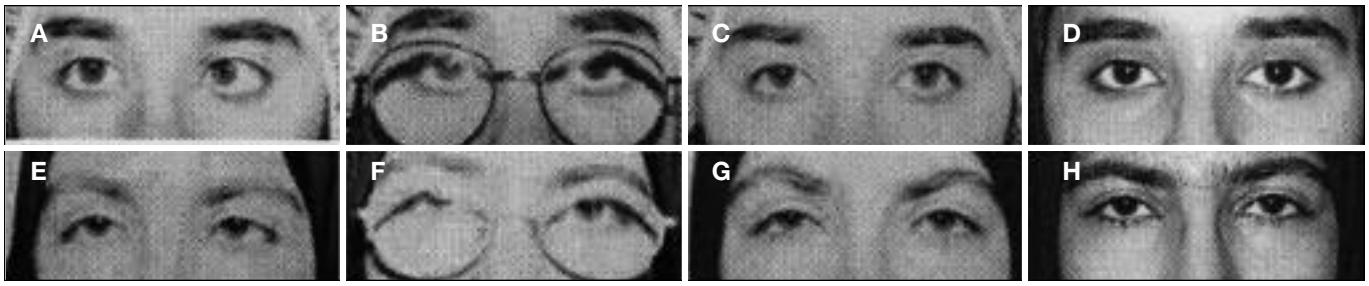

Fig. 1 - *Ocular alignment in two patients before laser* in situ *keratomileusis (LASIK) without correction (***A** *and* **E***), before LASIK with spectacle correction (***B** *and* **F***), immediately after LASIK (***C** *and* **G***), and 1 year after LASIK (***D** *and* **H***).*

No intraoperative complications were encountered in any of the 20 eyes. Postoperatively, there was a corneal epithelial defect in one eye, which healed after 2 weeks of wearing a therapeutic contact lens, though mild corneal opacity was induced and one line of BCVA was lost. Another patient lost one line of BCVA in both eyes due to irregular astigmatism.

DISCUSSION

Refractive accommodative esotropia occurs in children with hyperopia, who accommodate in order to clarify blurred retinal images. It might also result from insufficient fusional divergence, which initiates the accommodative reflex and leads to excessive convergence resulting in esotropia. Some

TABLE III - SPHERICAL EQUIVALENT REFRACTIONS BEFORE AND AFTER LASER *IN SITU* KERATOMILEUSIS (LASIK)

		Pre-LASIK		Post-LASIK, 1 mo			Post-LASIK, 1 yr	
Patient no.	Eye	Cycloplegic refraction/ attempted correction	Manifest refraction	Cycloplegic refraction	Manifest refraction	Achieved correction	Cycloplegic refraction	Manifest refraction
1	OD	8.75	7.25	3.50	3.00	5.25	4	3.50
	OS	8.00	7.00	1.00	0.25	7.00	1.25	0.50
2	OD	3.50	2.50	0.75	-0.50	2.75	2.00	1.00
	OS	3.75	2.75	0.75	-0.25	3.00	2.00	0.75
3	OD	6.25	5.75	1.25	-0.25	5.00	2.25	1.38
	OS	5.75	5.25	1.25	-0.25	4.50	2.50	1.75
4	OD	3.88	3.00	1.25	-0.50	2.63	1.75	-0.25
	OS	4.12	3.00	1.50	-0.25	2.62	2.50	0.25
5	OD	3.75	3.25	1.25	0.50	2.50	1.50	0.75
	OS	4.00	3.50	1.25	0.50	2.75	1.50	0.75
6	OD	6.12	5.88	0.50	0.25	1.00	1.00	0.75
	OS	5.75	5.75	-0.25	-0.50	0.25	0.25	0.25
7	OD	5.00	4.00	1.00	0.75	4.00	1.50	1.00
	OS	4.88	3.88	1.75	1.25	3.13	1.75	1.25
8	OD	2.50	1.50	1.00	0.00	1.50	1.00	0.25
	OS	3.25	2.25	1.00	0.25	2.25	1.00	0.50
9	OD	4.25	4.00	-0.50	-0.75	4.75	-0.50	-0.50
	OS	4.50	4.25	0.00	-0.50	4.50	0.00	-0.25
10	OD	6.25	4.00	1.50	0.50	4.75	3.25	1.25
	OS	6.50	4.00	1.50	0.50	4.75	3.25	1.25
Mean		5.03	4.13	1.06	0.20	3.44	1.68	0.80
SD		1.61	1.56	0.82	0.83	1.64	1.11	0.86

OD=Right eye; OS=Left eye

of these patients could develop normal binocular vision, losing most of their hyperopia, if they wore correcting lenses early in life. According to the study by Wilson and coworkers (10), binocularity is important in helping accommodative esotropes maintain their ocular alignment.

In two studies, Hutcheson et al (11) and Lambert et al (12) have shown that 60% of children with accommodative esotropia were able to discontinue wearing spectacles after gradual weaning. In contrast, other studies (13, 14) have reported that most accommodative esotropes are unable to discontinue wearing spectacles after childhood because their hyperopia is unchanged and their fusional divergence amplitude develops inadequately. These patients require continuing hyperopic correction. All the patients of our study were in this category. In patients such as ours, who are intolerant to glasses or contact lenses, surgical correction of hyperopia could be a practical alternative treatment.

Surgical correction of hyperopia would be expected to improve ocular alignment. This occurred in our study: all patients showed reduced esodeviation after LASIK. Similar results have been reported by others (1-8) for surgical correction of hyperopia in refractive accommodative patients. An $11^1/_2$ -year-old girl with high hyperopia and accommodative esotropia was treated successfully with bilateral phakic hypermetropic epikeratoplasty (3). Control of esotropia was achieved in a patient with hyperopia and accommodative esotropia by means of hyperopic angle supported refractive implants (2). Photorefractive keratectomy (PRK) was performed on a 19-year-old refractive accommodative esotrope who became orthophoric after the treatment (1). In two studies by Hoyos et al (4, 5), orthophoria was achieved after LASIK in all of their patients with accommodative hyperopic esotropia. In a recent study by Phillips et al (8), accommodative esotropia was fully corrected by LASIK (initial surgery or surgical enhancement). The same result has been reported by Nucci et al (6) in patients with purely refractive accommodative esotropia after PRK. In another recently published study by Nucci et al (7), PRK was used to treat the accommodative portion of partly accommodative esotropia.

In the above studies, accommodative esotropia was eliminated in all patients after refractive surgery. However, Stidham et al (9) reported that 40% of their patients with accommodative esotropia showed no reduction in esodeviation after LASIK. They believed that one of the limitations of their study was residual hyperopia, which could serve as some accommodative stimulus.

In our study LASIK was effective in reducing the esodeviation in all patients, notwithstanding residual hyperopia in some of them. As Hoyos et al (5) have mentioned, the fusional divergence amplitude could explain the orthophoria achieved despite the undercorrection. Interestingly, 5 out of 10 of our patients (50%) had better ocular alignment without correction after LASIK compared to preoperative alignment with correction (this difference was not statistically significant). This improvement was seen even in the patient whose BCVA decreased one line (Patient 6). This change, which was better than our expectation, may be related to the greater achieved correc-

TABLE IV - ALIGNMENT BEFORE AND AFTER LASER *IN SITU* KERATOMILEUSIS (LASIK)

	Pre-LASIK	Post-LASIK	
Patient no.	**Without correction**	**With correction**	**Without correction**
1	80 ET	50 ET	50 ET
2	20 ET	10 ET	6 E(T)
3	30 E(T)	10 E(T)	7 E
4	55 E (T)	20 E(T)	0
5	35 ET	10 E(T)	0
6	45 ET	10 E	0
7	27 E(T)	10 E	8 E
8	17 E(T)	11 E(T)	0
9	40 E(T)	12 E(T)	12 E(T)
10	22 E(T)	7 E	5 E
Mean	37.1	12.9	7.2
SD	19.18	14.74	15.78

ET = Esotropia; E(T) = Intermittent esotropia; E = Esophoria

tion than the preoperative spectacle correction. In these cases, treatment was performed on cycloplegic refraction and preoperatively, the patients' total hyperopia (cycloplegic) was not fully corrected with spectacles. The change in vertex distance could also be a reason for the better ocular alignment; refractive surgery, similar to contact lenses, can eliminate the vertex distance. By reducing the vertex distance in hyperopes, the accommodative effort required to see an object is less (15). The final result is less accommodative convergence and reduction of accommodative esotropia.

Visual acuity without correction showed a significant improvement. Three eyes (15%) lost one line of BCVA and no eye lost two or more lines; these results are almost similar to the study reported by Hoyos et al (5). Some other studies (9, 16-21) of hyperopic LASIK have reported losses of two or more lines but the numbers of patients in these studies are greater than in our study.

In the current study a mean hyperopic regression of 0.62 D was observed, which did not cause any change in the postoperative alignment status. This regression was close to reported regressions in some other studies (17-19) with baseline hyperopia similar to that of our patients. It has been suggested that regression is more likely to occur in cases with higher hyperopia (16, 18-21), and instability of alignment following refractive surgery in higher hyperopic cases of accommodative esotropia would be expected, although not seen in our series. In addition, most studies concerning refractive surgery in accommodative esotropia have not documented regression; therefore its effect on ocular alignment has not yet been established.

Apart from the small sample size, one limitation of our study is that stereopsis was not recorded in all patients, therefore in spite of the significant improvement of stereopsis in three patients, we cannot discuss this result.

CONCLUSIONS

Based on the results of this study, we can consider LASIK an alternative treatment for patients with refractive accommodative esotropia. This procedure could be applied to patients with intolerance to glasses and contact lenses. However, further studies with larger sample sizes and longer follow-ups are needed to corroborate this conclusion and to evaluate the possible effect of regression on postoperative alignment.

The authors have no proprietary interest in any aspects of the article.

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REFERENCES

1. Bilgihan K, Akafa F, Or M, Hassanreisoglu B. Photorefractive keratectomy in refractive accommodative esotropia. Eye 1997; 11: 409-10.
2. Galin MA, Gould HL, Hirschman H, Hofmann I. Angle-supported refractive implantation in stable adult accommodative esotropia. Strabismus 2000; 8: 153-6.
3. Hiles DA, Cheng KP. Bilateral phakic hypermetropic epikeratoplasty for accommodative esotropia. J Cataract Refract Surg 1990; 16: 361-6.
4. Hoyos JE, Cigales M, Maldonado-Bas A, et al. Hyperopic LASIK may work well in refractive accommodative esotropia. Ocular Surgery News 1998; 16: 93-4.
5. Hoyos JE, Cigales M, Hoyos-Chacon J, Ferrer J, Maldonado-Bas A. Hyperopic laser *in situ* keratomileusis for refractive accommodative esotropia. J Cataract Refract Surg 2002; 28: 1522-9.
6. Nucci P, Serafino M, Hutchinson AK. Photorefractive keratectomy for the treatment of purely refractive accommodative esotropia. J Cataract Refract Surg 2003; 29: 889-94.
7. Nucci P, Serafino M, Hutchinson AK. Photorefractive keratectomy followed by strabismus surgery for the treatment of partly accommodative esotropia. J AAPOS 2004; 8: 555-9.
8. Phillips CB, Prager TC, McClellan G, Mintz-Hittner HA. Laser *in situ* keratomileusis for high hyperopia in awake, autofixating pediatric and adolescent patients with fully or partially accommodative esotropia. J Cataract Refract Surg 2004; 30: 2124-9.
9. Stidham DB, Borissova O, Borissov V, Prager TC. Effect of hyperopic laser *in situ* keratomileusis on ocular alignment and stereopsis in patients with accommodative esotropia. Ophthalmology 2002; 109: 1148-53.
10. Wilson ME, Bluestein EC, Parks MM. Binocularity in accommodative esotropia. J Pediatr Ophthalmol Strabismus 1993; 30: 233-6.

11. Hutcheson KA, Ellish NJ, Lambert SR. Weaning children with accommodative esotropia out of spectacles: a pilot study. Br J Ophthalmol 2003; 87: 4-7.
12. Lambert SR, Lynn M, Sramek J, Hutcheson KA. Clinical features predictive of successfully weaning from spectacles those children with accommodative esotropia. J AAPOS 2003; 7: 7-13.
13. Mulvihill A, MacCann A, Flitcroft I, O'Keefe M. Outcome in refractive accommodative esotropia. Br J Ophthalmol 2000; 84: 746-9.
14. Swan KC. Accommodative esotropia long range follow-up. Ophthalmology 1983; 90: 1141-5.
15. Michales DD. Accommodation: clinical aspects. Focal points: Clinical modules for ophthalmologists, Vol 5, Module 10. San Francisco: American Academy of Ophthalmology; 1987.
16. Cobo-Soriano R, Llovet F, Gonzalez-Lopez F, Domingo B, Gomez-Sanz F, Baviera J. Factors that influence outcomes of hyperopic laser *in situ* keratomileusis. J Cataract Refract Surg 2002; 28: 1530-8.
17. Ditzen K, Huschka H, Pieger S. Laser *in situ* keratomileusis for hyperopia. J Cataract Refract Surg 1998; 24: 42-7.
18. Ditzen K, Fiedler J, Pieger S. Laser *in situ* keratomileusis for hyperopia and hyperopic astigmatism using the Meditec MEL 70 Spot Scanner. J Refract Surg 2002; 18: 430-4.
19. Esquenazi S, Mendoza A. Two-year follow-up of laser *in situ* keratomileusis for hyperopia. J Refract Surg 1999; 15: 648-52.
20. Esquenazi S. Five-year follow-up of laser *in situ* keratomileusis for hyperopia using the Technolas Keracor 117C excimer laser. J Refract Surg 2004; 20: 356-63.
21. Lian J, Ye W, Zhou D, Wang K. Laser *in situ* keratomileusis for correction of hyperopia and hyperopic astigmatism with the Technolas 117C. J Refract Surg 2002; 18: 435-8.