
Photorefractive keratectomy for the treatment of purely refractive accommodative esotropia

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Purpose: To evaluate the results of photorefractive keratectomy (PRK) for the treatment of young adult patients with purely refractive accommodative esotropia.

Setting: Private practice and university hospital, Milan, Italy.

Methods: The medical records of consecutive patients who had PRK for hyperopia associated with purely refractive esotropia were reviewed retrospectively. Preoperative and postoperative visual acuity, alignment, and sensory data were recorded and analyzed. Surgical methods and complications were reviewed.

Results: Sixteen eyes of 8 patients were treated. The mean patient age at the time of treatment was 24.6 years (range 17 to 38 years). All patients were followed for 1 year. At the 1-year follow-up evaluation, the uncorrected visual acuity was 20/40 or better in all eyes. No patient lost a line of best spectacle-corrected visual acuity. The mean spherical equivalent was -3.7 diopters (D) preoperatively and -0.7 D postoperatively. All patients were within ± 0.37 D of emmetropia at the 1-year evaluation. Preoperatively, the mean esotropic deviation was 10.75 prism diopters. Postoperatively, all patients were orthophoric without correction. Stereopsis was unaffected by PRK in all patients. There were no intraoperative or postoperative complications.

Conclusion: Photorefractive keratectomy was an effective treatment for esotropia associated with mild to moderate hyperopia in young adults with purely refractive accommodative esotropia. These findings should not be widely applied to children with accommodative esotropia.

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Purely refractive accommodative esotropia is caused by insufficient divergence amplitudes to overcome the accommodative convergence associated with moderate to severe hyperopia.¹ In individuals with accommodative esotropia, the eyes are normally aligned when hyperopic correction is worn but manifest an esotropic deviation without correction. For decades, the accepted treatment has been to prescribe the full cycloplegic hyperopic correction.

Refractive surgery has become a common alternative to glasses and contact lenses for the correction of

refractive errors in adults and can be used to treat myopia, hyperopia, and astigmatism. There is interest in the application of refractive surgery to treat purely refractive accommodative esotropia since the technique, at least in theory, would provide definitive treatment for the ocular misalignment and the underlying cause, hyperopia. Many ophthalmologists have been asked by their patients or the patients' parents whether surgery to eliminate the patients' dependency on glasses could be performed.

Although refractive surgery is not approved for use in children, there are many young adults whose accommodative esotropia has persisted into adulthood.^{2,3} There are only a few reports of the treatment of accommodative esotropia with refractive surgery in such patients.^{4–6} This study evaluated the results of photore-

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fractive keratectomy (PRK) for the treatment of young adult patients with purely refractive accommodative esotropia.

Patients and Methods

Consecutive patients with hyperopia and purely refractive accommodative esotropia who had refractive surgery to eliminate their dependency on glasses were included in the study. Patients were not offered refractive surgery if they were found to have ocular pathology other than esotropia, hyperopia, or amblyopia in the preoperative evaluation. This evaluation included visual acuity determination, anterior and posterior segment examination, intraocular pressure measurement, orthoptic evaluation, topography of anterior and posterior corneal surfaces, evaluation of corneal endothelium with specular microscopy, and corneal pachymetry.

The preoperative and postoperative best spectacle-corrected (BSCVA) and uncorrected (UCVA) visual acuities were recorded. Cycloplegic retinoscopy and autorefractometry were used to determine the refractive error; total hyperopia (manifest and latent hyperopia) was determined by instilling 2 drops of cyclopentolate 1.0% 10 minutes apart and performing retinoscopy 30 minutes after instillation of the second drop. Subjective determination of the manifest hyperopia was also used. The target correction was the maximum spherical correction that could be given without decreasing visual acuity at distance when the patient was not cyclopleged (manifest hyperopia) and within ± 0.50 diopter (D) of the total hyperopia in all eyes. The alternate prism and cover test was used to determine the amount of esotropia present at distance and near without correction. All patients were orthophoric with correction in place. Since all patients had equal deviations at distance and near and since all stereopsis data were obtained at near only, sensory and motor data are reported for the near deviation. Stereopsis was measured with the Lang test with glasses or contact lenses before PRK and without correction afterward.

In all patients, PRK was performed using the Chiron Technolas[®] 217 excimer laser. The same surgeon (P.N.) performed all procedures. The instruments and laser parameters were the same as those used for correction of hyperopia in adult patients without accommodative esotropia and have been reported.^{7,8} Bilateral simultaneous procedures were performed in all patients because this minimized the disruption of binocularity, consolidated the recovery period, and was preferred over sequential unilateral procedures by the surgeon. All procedures were performed with the use of topical anesthesia consisting of ossibuprocaine or lidocaine 2%.

Postoperatively, patients wore a soft contact lens for 4 days and instilled tobramycin 0.3% solution twice daily for 5 days. Fluorometholone 0.1% eyedrops were instilled 3 times a day and were continued for up to 4 months, with the dosage

titrated based on the return of best corrected acuity to the preoperative baseline. Artificial tears were prescribed for use 3 to 4 times a day for 2 months. Patients took ibuprofen as needed for symptomatic relief of pain over the first 5 postoperative days.

Informed consent acknowledging that the intended result of treatment was to correct both hyperopia and esotropia was obtained from the patients (or, in the case of 1 minor child, the parents). Patients were fully aware that they were among the first to have refractive surgery for the correction of strabismus and that no long-term outcome data for such treatment were available. No institutional review board approval was required. All procedures were carried out in accordance with the Declaration of Helsinki.

Results

Eight patients (16 eyes) were included in the study. Five patients were women. The mean patient age was 24.6 years (range 17 to 38 years). Two patients were identified with amblyopia (defined as 2 or more lines of difference in Snellen visual acuity) preoperatively. All patients had 1 year of follow-up data.

Visual Acuity Outcome

The preoperative BSCVA was 20/40 or better in all eyes. Although a decrease in the BSCVA was observed at the 1-month examination in 11 of 16 eyes, the BSCVA returned to the preoperative level at the 1-year examination in all eyes (Table 1).

At the 1-year examination, the UCVA was 20/40 or better in all eyes. It improved in 11 of 16 eyes, remained the same in 3 eyes, and decreased in 2 eyes (due to postoperative myopia) (Table 1).

Refractive Outcome

The mean spherical equivalent (SE) was $+3.70$ D ± 0.67 (SD) (range $+2.50$ to $+4.25$ D) preoperatively, -0.88 ± 0.46 D (range -1.37 to -0.50 D) at 1 month, and -0.07 ± 0.13 D (range -0.37 D to plano) at 1 year. A mean hyperopic regression of 0.81 ± 0.54 D (range -0.75 to $+1.37$ D) was observed between the 1-month and 1-year follow-up evaluations. The mean cylinder was 0.52 ± 0.47 D (range 0 to 1.50 D) preoperatively, 0.20 ± 0.24 D (range 0 to 0.75 D) at 1 month, and 0.03 ± 0.12 D (0 to 0.50 D) at 1 year (Table 2).

Alignment Outcome

The mean preoperative esotropic deviation without correction at near was 10.75 prism diopters (range 8 to

Table 1. Preoperative and postoperative UCVA and BSCVA.

Patient/Eye	Preoperative		One Month Postoperative		One Year Postoperative	
	UCVA	BSCVA	UCVA	BSCVA	UCVA	BSCVA
1/OD	20/80	20/20	20/30	20/30	20/20	20/20
1/OS	20/80	20/20	20/30	20/30	20/20	20/20
2/OD	20/100	20/20	20/30	20/30	20/25	20/20
2/OS	20/25	20/20	20/25	20/30	20/25	20/20
3/OD	20/20	20/25	20/40	20/25	20/25	20/25
3/OS	20/40	20/20	20/20	20/30	20/20	20/20
4/OD	20/40	20/40	20/100	20/40	20/40	20/40
4/OS	20/40	20/20	20/20	20/30	20/25	20/20
5/OD	20/25	20/20	20/25	20/30	20/30	20/20
5/OS	20/80	20/20	20/40	20/30	20/30	20/20
6/OD	20/80	20/30	20/40	20/30	20/30	20/30
6/OS	20/80	20/25	20/40	20/25	20/25	20/25
7/OD	20/80	20/20	20/20	20/30	20/20	20/20
7/OS	20/80	20/30	20/40	20/30	20/30	20/30
8/OD	20/25	20/20	20/40	20/30	20/25	20/20
8/OS	20/80	20/40	20/100	20/80	20/40	20/40

UCVA = uncorrected visual acuity; BSCVA = best spectacle-corrected visual acuity; OD = right eye; OS = left eye

14 prism diopters). All patients were orthotropic without correction at the last follow-up examination.

Sensory Outcome

The mean preoperative and postoperative stereoacuity was 80 seconds of arc (median 40 seconds of arc [range 40 to 200 seconds of arc]). The preoperative stereopsis measured 40 seconds of arc in 6 patients and 200 seconds of arc in 2 patients. No patient had a change in stereoacuity after surgery.

Complications

There were no intraoperative or postoperative complications. A transient, mild corneal haze was present in 2 patients and responded to topical steroids within 3 weeks in both cases. There were no infections, decentered ablations, or unexpected refractive outcomes.

Subjective Outcomes

Although patients' subjective response to the outcome of surgery was not solicited with a formal survey, all patients informally reported satisfaction with the functional and esthetic results.

Discussion

The results of this study show that in young adults, hyperopia and esotropia associated with purely refractive accommodative esotropia can be corrected with PRK. In theory, purely refractive accommodative esotropia would be an ideal indication for refractive surgery. The etiology of this form of strabismus is refractive. These patients have insufficient divergence amplitudes to overcome the convergence associated with the accommodation required to provide the retina with a clear image. Correcting the refractive error eliminates the need to accommodate and hence converge. Traditionally, patients have been offered spectacles or contact lenses to correct hyperopia, but these nonsurgical treatment options do not offer definitive treatment since the esotropia returns as soon as the refractive correction is removed.

Enthusiasm for surgical management of purely refractive accommodative esotropia is not new; however, in the "pre-laser in situ keratomileusis (LASIK)" era, proponents advocated the use of strabismus surgery.⁹⁻¹¹ This issue has been highly controversial. Advantages of

Table 2. Preoperative and postoperative manifest and cycloplegic refractions.

Patient/Eye	Preoperative (D)		Postoperative (D)*	
	Manifest	Cycloplegic	1 Month	1 Year
1/OD	+4.25 -0.50 × 180	+4.50 -0.50 × 180	-1.00 -0.50 (180)	Plano
1/OS	+4.00	+4.50	-0.75	Plano
2/OD	+3.75 -1.50 × 170	+4.00 -1.50 × 170	+0.75 -0.50 (170)	-0.25
2/OS	+4.00 -0.50 × 100	+4.50 -0.50 × 100	-1.25	Plano
3/OD	+3.25 -0.75 × 60	+3.50 -0.50 × 60	-0.75 -0.25 (60)	Plano
3/OS	+4.25 -0.50 × 120	+4.50 -0.50 × 120	-0.75 -0.25 (120)	Plano
4/OD	+2.25	+2.50	-1.00 -0.75 (180)	Plano
4/OS	+3.00 -0.75 × 180	+3.50 -0.75 × 180	-0.50 -0.25 (180)	Plano -0.50 (180)
5/OD	+3.50 -0.50 × 80	+3.75 -0.50 × 80	-0.50	-0.375
5/OS	+4.00	+4.50	-1.00	Plano
6/OD	+4.00 -1.00 × 95	+4.25 -1.00 × 95	-1.25	-0.25
6/OS	+3.75 -1.50 × 70	+4.00 -1.50 × 70	-1.25 -0.50 (70)	Plano
7/OD	+4.25 -0.50 × 45	+4.50 -0.50 × 45	-1.00 -0.25 (45)	Plano
7/OS	+4.25 -0.50 × 80	+4.50 -0.50 × 80	-1.25	Plano
8/OD	+2.25	+2.50	-1.00	Plano
8/OS	+3.00 -0.50 × 180	+3.50 -0.25 × 180	-0.50	Plano

OD = right eye; OS = left eye

*Values obtained with cycloplegia

surgical management include the elimination of dependency on glasses for alignment of the eyes, social benefits of not wearing glasses, the implicit compliance associated with surgical intervention, and avoidance of alteration in the emmetropization process that may occur when hyperopia is corrected with spectacles.¹² Conversely, others state that strabismus surgery for fully refractive accommodative esotropia is unnecessary and likely to result in asthenopia (which may require spectacles or miotics), a need for multiple surgeries, and diplopia (from consecutive exotropia) and may result in amblyopia by failing to correct highly hyperopic refractive errors.¹³ Spectacle compliance and treatment outcomes in patients with purely refractive accommodative esotropia are usually excellent^{3,14} and, finally, evidence that spectacle correction impairs normal emmetropization is speculative.¹⁴ Refractive surgery, although also “unnecessary,” would provide the benefit of a definitive treatment of esotropia and the elimination of dependency on glasses without the undesirable side effects of strabismus surgery and would circumvent the issues of emmetropization and compliance.

Although theoretically promising, there is limited experience with refractive surgery for the management of hyperopia associated with accommodative esotropia. Although 1 case report has been published,⁶ to our knowledge this is the first reported series of patients treated with PRK for accommodative esotropia. Previous series have reported results with LASIK for accommodative esotropia. Maldonado-Bas and Hoyos⁵ used LASIK to treat 6 patients with refractive accommodative esotropia. They did not provide refractive, sensory, or alignment data in their paper, but they stated that all patients achieved orthotropia and improvement in UCVA and that all cases achieved ± 1.0 D of emmetropia.

Stidham and coauthors⁴ report results in 24 patients (48 eyes) treated with LASIK for accommodative esotropia. Ten of the patients were classified as having purely refractive accommodative esotropia. Of these, only 2 became orthophoric after LASIK, 4 converted from an esotropia preoperatively to esophoria postoperatively, and 4 showed no reduction in the deviation. This contrasts with our results in which all patients became or-

thophoric postoperatively. There are several possible explanations for the disparity in our findings. In our study, the mean preoperative SE was +3.7 D with a mean attempted correction of +3.7 D. In the study by Stidham and coauthors, the mean preoperative SE was +7.36 D with a mean attempted correction of +6.00 D. None of our patients had residual hyperopia in contrast to Stidham and coauthors' population in which the postoperative SE averaged +2.1 D. Several patients in their study were orthophoric postoperatively despite a residual hyperopic refractive error greater than +2.0 D. Nevertheless, the patients in our study had substantially less hyperopia preoperatively and postoperatively than Stidham and coauthors' population, which may account for our higher success rate. Neither the study by Stidham and coauthors nor our study showed a change in the sensory status of any patient after refractive surgery.

Substantial complications were seen in eyes treated with LASIK that were not seen in those treated with PRK. In the series by Stidham and coauthors, visually significant flap striae were seen in 25% of eyes, decentered ablations were seen in 8%, and diffuse lamellar keratitis was treated in 4%. There were no complications observed in our series of eyes treated with PRK. In Stidham and coauthors' series, 23% of patients lost 1 or more lines of best corrected visual acuity. In contrast, none of our patients lost a line of BSCVA. Although these disparities are partly due to the smaller number of patients in our study, they are also undeniably a result of PRK not requiring a corneal flap.

As promising as the results of this study may be, it would be premature to use our findings to advocate PRK for the treatment of purely refractive accommodative esotropia in children. Several issues must be addressed. First, the refractive development in children with accommodative esotropia is not entirely predictable. Although most children with purely refractive accommodative esotropia will remain hyperopic as adults, a minority will lose the hyperopia.^{3,15,16} To date, no factors have been identified to help predict in which patients hyperopia will resolve; hence, routine correction of accommodative esotropia with refractive surgery would result in many patients developing undesired myopia in their late childhood or adolescence.

Second, results with conventional treatment for purely refractive accommodative esotropia are too good

to justify the additional risks posed by refractive surgery. Several series have shown that 90% or more of patients with purely refractive accommodative esotropia will maintain alignment without strabismus surgery if they are treated before the deviation becomes constant.^{3,15} Visual acuity with conventional treatment is 20/40 or better in 85% to 88% of eyes,^{3,15} stereopsis is documented in 89% of cases,³ and good compliance with refractive correction is reported in 92% of cases.¹³ Complications of refractive surgery are well known, and taking such risks seems unjustified in patients who respond well to conventional nonsurgical treatment.

Finally, several unresolved issues must be better understood before refractive surgery can be considered safe in children. These include (but are not limited to) anesthesia considerations, how to best center the eye for treatment, the best technique to use in children (LASIK, laser-assisted subepithelial keratectomy, or PRK), whether adult nomograms are appropriate for children, and details about the response of the pediatric cornea to refractive surgery. Until these issues are clarified, routine use of refractive surgery to treat purely refractive accommodative esotropia is not justified, although its use may be considered in exceptional cases that do not respond to conventional treatment methods.

Conclusion

Our findings suggest that PRK is an effective treatment for esotropia associated with mild to moderate hyperopia in young adults with purely refractive accommodative esotropia. These findings should not be widely applied to children with accommodative esotropia.

References

1. von Noorden GK, Campos EC. *Binocular Vision and Ocular Motility; Theory and Management of Strabismus*, 6th ed. St Louis, MO, Mosby Inc, 2002; 314
2. Raab EL, Spierer A. Persisting accommodative esotropia. *Arch Ophthalmol* 1986; 104:1777-1779
3. Mulvihill A, MacCann A, Flitcroft I, O'Keefe M. Outcome in refractive accommodative esotropia. *Br J Ophthalmol* 2000; 84:746-749
4. 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; 109:1148-1153
5. Maldonado-Bas A, Hoyos J. Estrabismo: componente ac-

- comodativo tratado con LASIK. *Rev Bras Oftalmol* 1998; 57:757–760
6. Bilgihan K, Akata F, Or M, Hasanreisoglu B. Photorefractive keratectomy in refractive accommodative esotropia. *Eye* 1997; 11:409–410
 7. Vinciguerra P, Epstein D, Radice P, Azzolini M. Long-term results of photorefractive keratectomy for hyperopia and hyperopic astigmatism. *J Refract Surg* 1998; 14: S183–S185
 8. Pacella E, Abdolrahmizadeh S, Gabrieli CB. Eximer laser photorefractive keratectomy for hyperopia. *Ophthalmic Surg Lasers* 2001; 32:30–34
 9. Gobin MH. The surgical correction of accommodative esotropia. In: Tillson G, ed, *Trans VII International Orthoptic Congress; Advances in Amblyopia and Strabismus*. Nürnberg, Fahner Verlag, 1991; 105–109
 10. Moltano ACB, Kindon R. A comparative trial of Gobin's method versus conventional surgery for refractive/accommodative esotropia uncorrected by nonsurgical methods. *Binocular Vis Strabismus Q* 2000; 15:351–356
 11. Semmlow J, Putteman A, Vercher J-L, et al. Surgical modification of the AC/A ratio and the binocular alignment ("phoria") at distance; its influence on accommodative esotropia: a study of 21 cases. *Binocular Vis Strabismus Q* 2000; 15:121–130
 12. Surgery or not for fully accommodative esotropia. Solomonic solutions to the controversy [editor's reply]. *Binocular Vis Strabismus Q* 2000; 15:204–205
 13. Jampolsky A, von Noorden GK, Spiritus M. Unnecessary surgery in fully refractive accommodative esotropia. (Symposium Report). *Int Ophthalmol* 1992; 16:129–130
 14. Kushner BJ, Romano PE, Moltano ACB. Surgery or not for fully accommodative esotropia[letter]. *Binocular Vis Strabismus Q* 2000; 15:315–318
 15. Swan KC. Accommodative esotropia long range follow-up. *Ophthalmology* 1983; 90:1141–1145
 16. Raab EL. Hypermetropia in accommodative esodeviation. *J Pediatr Ophthalmol Strabismus* 1984; 21:194–197; discussion by MM Parks, 197–198

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