Photorefractive Keratectomy Followed by Strabismus Surgery for the Treatment of Partly Accommodative Esotropia

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Purpose: To evaluate photorefractive keratectomy (PRK) followed by bilateral medial rectus muscle recessions (BMR) to treat adults with partly accommodative esotropia. ***Methods:*** We reviewed medical records of 10 consecutive patients with partly accommodative esotropia who underwent PRK to correct hyperopia followed 6 months later by BMR to treat the accommodative and nonaccommodative components of their esotropia, respectively. Visual acuity, spherical equivalent of refractive error, alignment, and sensory data were collected and analyzed. ***Results:*** Twenty eyes of 10 patients were treated and followed for 1 year. PRK was successful in treating the hyperopia (mean post-PRK spherical equivalent was 0.14 D (SD = 0.22)) and the accommodative portion of the esotropia (the mean percentage of the distance accommodative component eliminated by PRK was 101.67% and the mean percentage of the near accommodative component eliminated by PRK was 115%). However, subsequent BMR using standard surgical tables based on the distance deviation to treat the post-PRK residual (nonaccommodative) esotropia resulted in uniform undercorrection. ***Conclusion:*** PRK may be useful to treat the accommodative portion of partly accommodative esotropia. Bilateral medial rectus muscle recession can be used to treat the residual, nonaccommodative component; however, it may be necessary to base the surgical dosage on the near deviation. (J AAPOS 2004;8:555-559)

We have reported that photorefractive keratectomy (PRK) can be an effective treatment for esotropia associated with mild-to-moderate hyperopia in young adults with purely refractive accommodative esotropia.[1] The purpose of this study was to evaluate the use of PRK followed 6 months later by strabismus surgery to treat partly accommodative esotropia. PRK was used to treat the refractive accommodative component, and strabismus surgery was used to treat the residual, nonaccommodative esotropia.

METHODS

We retrospectively reviewed the medical records of all hyperopic patients with acquired, partly accommodative esotropia who underwent PRK between November 2001 and March 2002, followed approximately 6 months later by strabismus surgery to treat the refractive accommodative and nonaccommodative components of their esotropia. Patients were not offered refractive surgery if they were found to have any ocular pathology other than esotropia, refractive error, or amblyopia on their 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. Patients were excluded from the study if they had less than 1 year of follow-up after PRK, if they had undergone prior refractive or strabismus surgery, or if they had onset of their esotropia before 2 years of age.

We recorded the patient's best corrected and uncorrected visual acuities approximately 1 month (mean 29; range 26 to 34 days) before PRK and approximately 6 months (mean 6.2; range 5.8 to 6.9 months) after PRK. Cycloplegic retinoscopy and auto-refractometry were used to determine the refractive error. Total hyperopia (manifest and latent hyperopia) was determined by instilling two drops of cyclopentolate 1.0% 10 minutes apart and performing retinoscopy 30 minutes after instillation of the second drop. Subjective determination of manifest hyperopia was performed prior to cycloplegia.

The alternate prism and cover test was used to determine the amount of esotropia present at distance and near with and without correction, approximately 1 month (mean 29; range

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Table 1. PRK refractive data

PRK refractive data (by eye)	1 OD	1 OS	2 OD	2 OS	3 OD	3 OS	4 OD	4 OS	5 OD	5 OS	6 OD
Pre-op refractive error (SEQ)	2.50	2.25	2.75	2.25	3.00	4.00	3.25	4.25	3.25	3.25	3.50
6 month post-op refractive error (SEQ)	0.00	0.00	0.00	−0.25	0.00	0.00	0.00	−0.25	0.00	−0.25	0.00
1 year post-op refractive error (SEQ)	0.00	0.00	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

PRK refractive data (by eye)	6 OS	7 OD	7 OS	8 OD	8 OS	9 OD	9 OS	10 OD	10 OS	Mean	SD
Pre-op refractive error (SEQ)	3.75	2.75	3.75	3.00	4.00	3.50	4.00	2.75	3.25	3.25	0.60
6 month post-op refractive error (SEQ)	−0.25	0.00	0.50	0.00	0.50	0.00	−0.25	0.00	0.50	0.01	0.24
1 year post-op refractive error (SEQ)	0.00	0.25	0.50	0.25	0.50	0.00	0.00	0.25	0.75	0.14	0.22

SEQ, spherical equivalent. Preoperative and 1 year postoperative data were determined by cycloplegic retinoscopy.

26 to 34 days) prior to PRK. The accommodative portion of the both the distance and the near esotropia was designated as the amount of esotropia eliminated by the distance hyperopic correction when the patient was measured while fixing at distance or near. The remaining esotropia was designated as the nonaccommodative portion. Distance and near alignment measurements were obtained with and without correction preoperatively, and without correction approximately 6 months (mean 6.2; range 5.8 to 6.9 months) after PRK and then approximately 6 months (mean 6.1; range 5.2 to 6.5 months) after bilateral medial rectus muscle recession (BMR).

PRK was performed using the method described in our previous report.[1] These are standard methods used to correct hyperopia in adult patients without esotropia and have been previously described.[2,3] The target correction was the maximum spherical correction that could be given without decreasing visual acuity at distance (manifest hyperopia) and was within 0.50 D of the total hyperopia (as determined by cycloplegic retinoscopy) in all eyes.

BMR was performed 6 months after PRK. We chose this interval to allow for expected post-PRK hyperopic regression. A standard approach was used, employing a fornix incision and measuring the millimeters of recession with a caliper. The recessed muscles were sutured in place using partial thickness scleral passes. No "hang-back" or adjustable sutures were used. Surgical dosages were based on the distance deviation measured without correction using a standard table[4] and are shown in Table 2. Recessions were augmented by 0.5 mm if the near deviation exceeded the distance deviation by ≥10 prism diopters (PD). One physician (P.N.) performed all examinations and surgical procedures.

Stereopsis was measured at near with the Lang stereotest (CB Medical, Via Dente Alighieri 23, I-20090 Cesano-Boscone) with glasses or contact lenses prior to PRK and without correction 6 months and 1 year after PRK.

We analyzed alignment outcomes 6 months after PRK and 6 months after BMR. We considered a successful alignment outcome after PRK to be total elimination of the accommodative component of the esotropia and thus expressed PRK alignment results as the percentage of the accommodative portion of the esotropia that was eliminated by the PRK. We considered a residual esodeviation of <10 PD, or a consecutive exodeviation of <10 PD at both distance and near, to be a successful outcome after BMR.

We obtained informed consent from the patients acknowledging that the intended result of the PRK procedure was to correct both hyperopia and esotropia and that additional strabismus surgery would be performed to correct residual esotropia. Patients were fully aware that they were among the first patients to undergo 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 because all examinations, surgical interventions, and data collection were performed in Italy. Data analysis was performed in Atlanta, GA with patients identified by numerical assignment only. All procedures were carried out in accordance with the Declaration of Helsinki.

RESULTS

Thirteen patients underwent PRK followed by BMR during the study interval. Three patients were excluded for having less than 1 year of follow-up data available, but will be reported in a subsequent paper. Ten patients (20 eyes) were included in the study. Four patients were male. The mean patient age at the time of PRK was 25.4 (range 20 to 31; SD = 3.37) years.

Visual Acuity Outcome

Preoperative best corrected visual acuity and uncorrected visual acuity were 20/30 and 20/40 or better, respectively, in all eyes. Although a decrease in best corrected visual acuity was observed at the 1-month follow-up examination in 2 of 20 eyes, best corrected visual acuity returned to the preoperative level at the 1-year postoperative examination in all eyes. At the 1-year postoperative examination, uncorrected visual acuity was 20/20 or better in all eyes. Uncorrected visual acuity improved in 10 eyes and remained the same in 10 eyes. All patients were wearing refractive correction prior to the PRK, and no patient required refractive correction following PRK.

Table 2. PRK strabismus data

PRK strabismus data (by patient)	1	2	3	4	5	6	7	8	9	10	MEAN	SD
Pre-PRK data												
Total distance deviation	20	25	25	30	30	25	30	35	25	35	28	4.83
Total near deviation	25	30	35	40	40	30	40	40	30	45	35.5	6.43
Distance accommodative component	5	10	10	15	15	10	10	10	10	15	11	3.12
Near accommodative component	5	5	15	15	15	5	10	10	10	15	10.5	4.38
6 Months post-PRK data												
6 mos post-PRK D deviation	15	15	15	20	15	15	20	20	15	20	17	2.60
6 mos post-PRK N deviation	20	20	25	30	30	20	30	25	20	30	25	4.71
% D accommodative component reduced	100%	100%	100%	67%	100%	100%	100%	150%	100%	100%	102%	20%
% N accommodative component reduced	100%	200%	67%	67%	67%	200%	100%	150%	100%	100%	115%	51%

D, distance; *N*, near.

Refractive Outcome (Table 1)

Mean preoperative spherical equivalent was +3.25 D (range +2.25 to 4.25; SD = 0.60), and mean postoperative spherical equivalent was +0.01 D (range −0.25 to +0.5; SD = 0.24) 6 months, and +0.14 (range 0 to 0.75; SD = 0.22) 1 year post-PRK.

Alignment Outcome After PRK (Table 2)

Before PRK, the mean uncorrected distance esotropic deviation was 28 PD (range 20 to 35; SD = 4.8) and the mean uncorrected near esotropic deviation was 35.5 PD (range 25 to 45; SD = 6.4). The mean distance accommodative component was 11 PD (range 5 to 15; SD = 3.2), and the mean near accommodative component was 10.5 PD (range 5 to 15; SD = 4.4). Six months after PRK, the mean percentage of the accommodative component corrected was 102% at distance and 115% at near. These data are presented in more detail in Table 2.

Complications of PRK

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

Alignment Outcome After BMR (Table 3)

Bilateral medial rectus muscle recessions were performed to correct the residual nonaccommodative esotropia after PRK had been used to correct the refractive accommodative component. The mean uncorrected distance esotropic deviation 6 months after PRK was 17 PD (range 15 to 20; SD = 2.6), and the mean near deviation was 25 PD (range 20 to 30; SD = 4.7). Surgical dosage was based on the distance deviation. In four of the patients, the near deviation was 10 PD greater than the distance deviation, and in one patient, the deviation was15 PD greater at near. In these patients, the surgical dosage was augmented by 0.5 mm. Six months after BMR, the mean distance and near esotropic deviations were 10.4 PD (range 5 to 15; SD = 3.5) and 16.5 PD (range 10 to 25; SD = 4.1), respectively. No patient was within 10 PD of orthophoria for both distance and near at the final evaluation.

Sensory Outcomes

No patient demonstrated any evidence of stereoacuity by the Lang stereoacuity test at any examination.

DISCUSSION

The results of this study show that, in young adults with mild hyperopia and partly accommodative esotropia, the hyperopia and the refractive accommodative component of the esotropia can potentially be corrected by PRK. However, standard medial rectus muscle recessions (based on the distance angle and augmented slightly when a distance near disparity is present) to treat the residual, nonaccommodative component of the esotropia tend to undercorrect the deviation. In light of these findings, discussion of both refractive surgery and strabismus surgery for esotropia is appropriate.

Refractive Surgery and Accommodative Esotropia

Several investigators[1,5-8] have evaluated the use of corneal refractive surgery to treat esotropia, and varying results have been reported. We[1] achieved good results in eight patients with a mean spherical equivalent of +3.7 D (range +2.5 to +4.2) of hyperopia who underwent PRK to treat their purely refractive accommodative esotropia. One year postoperatively, all patients were orthophoric at distance and near without correction; all patients were within ±0.37 D of emmetropia, and no patient lost any best corrected visual acuity.

Similarly, others have shown acceptable results using laser in situ keratomileusis (LASIK) to treat accommodative esotropia. Hoyos et al[7] treated nine patients with a

Table 3. BMR strabismus data

BMR strabismus data (by patient)	1	2	3	4	5	6	7	8	9	10	Mean	SD
Pre-BMR data												
Distance deviation	15	15	15	20	15	15	20	20	15	20	17	2.58
Near deviation	20	20	25	30	30	20	30	25	20	30	25	4.71
MR recession (mm per eye) performed	3	3	3.5	4	3.5	3	4	3.5	3	4		
6 months post-BMR data												
Distance deviation	10	10	5	10	8	8	15	15	8	15	10.4	3.50
Near deviation	15	15	10	15	15	15	20	20	15	25	16.5	4.11

BMR, bilateral medial rectus muscle recession.

mean spherical equivalent of +5.0 D (range +2.5 to +7.0). Postoperatively the mean spherical equivalent was −0.01 D (range −0.7 to +0.8) and all patients showed "orthophoria or the microtropia they showed with glasses before the surgery." The mean postoperative uncorrected visual acuity was 20/25, and no patient lost more than one line best corrected visual acuity. Nemet et al[6] reported six patients treated with LASIK. The mean preoperative spherical equivalent of these patients was +3.5 D (range +2.5 to +5.2). Three of these patients had purely refractive accommodative esotropia, and postoperatively, these patients were orthophoric without correction. The other three patients had partly accommodative esotropia, and LASIK eliminated the refractive portion of the esotropia but had no effect on the nonaccommodative portion. Postoperatively, the mean spherical equivalent was +0.4 D (range 0 to +0.75), and no patient lost any best corrected visual acuity. One patient developed flap striae after an enhancement, which were resolved by "ironing" the flap.

Nevertheless, some investigators have described unpredictable results after refractive surgery for esotropia. Stidham et al[5] reported a series of 24 patients who underwent LASIK for fully accommodative, partly accommodative, and nonaccommodative estropia. The mean preoperative spherical equivalent in this group was +7.3 D (range +4.4 to +11), but the mean attempted correction was only 6.0 D (range +3.5 to +9.1), because the surgeons had to limit the amount of hyperopia they treated to avoid iatrogenic corneal ectasia. Postoperatively, these patients had more residual hyperopia (mean = +2.1 D; range −0.25 to +5.9) than reported in other series. Residual hyperopia was expected in this series because the targeted correction was less than the total hyperopia. What was not expected, however, was that postoperative alignment could not be predicted by preoperative accommodative status. In fact, three of the four patients who were classified preoperatively as "nonaccommodative" demonstrated a reduction in manifest esotropia of at least 15 PD. In contrast, 4 of 10 patients classified as "fully accommodative" showed no reduction in uncorrected esodeviation after LASIK. The authors stated that this finding could not be completely attributed to residual hyperopia since there was no statistically significant difference in the postoperative spherical equivalent among the three groups. In addition, complications were much more common in this series, with 25% of patients developing visually significant flap striae, 8% experiencing decentration, 4% developing diffuse lamellar keratitis, and 23% experiencing decreased best corrected visual acuity by one or two lines.

Strabismus Surgery and Accommodative Esotropia

The surgical management of esotropia is complex; however, there is a general agreement that augmentation of standard surgical dosages is appropriate for patients undergoing strabismus surgery for acquired esotropia, especially accommodative esotropia with a high AC/A ratio.[9] Prompted by a widely recognized undercorrection rate for acquired esotropia, the prism adaptation study[10] was carried out in the early 1990s to determine whether prism adaptation could be used to improve the success rate of strabismus surgery in acquired esotropia. The study showed significantly higher success rates in prism adaptation responders who underwent augmented surgery than those patients who did not undergo prism adaptation. The study also showed that prism responders had better results with augmented surgery than with conventional surgery. Although the prism adaptation study specifically excluded patients with a high AC/A ratio, Kutschke et al[11] claimed that prism adaptation for the near angle improves surgical outcomes in these patients as well. Kushner[12] questioned the validity of Kutschke et al's study and stated that the role of prism adaptation for the near angle in patients with high AC/A ratio, although "intuitively appealing," has yet to be determined.

Since prism adaptation requires substantial time and effort, and since its use is controversial in patients with a high AC/A ratio, a variety of alternative strategies have been proposed. Various formulas are available for calculating surgical dosages for acquired esotropia.[10,13-16] The end result of most of them is to augment the surgical dosage by 1 to 2 mm per muscle. If a high AC/A ratio is present, some advocate adding posterior fixation sutures or basing the surgical numbers on the near deviation.[12,17-20] Studies that have compared these two techniques favor the latter approach.[20,21]

In this study, we based our surgical dosage on the distance angle measured without correction 6 months after PRK. We chose this time interval so that the majority of hyperopic regression after PRK would have already occurred. We augmented our surgical dosages only in patients with a distance near disparity of more than 10 PD, in whom we increased the surgical dosage by 0.5 mm. This approach resulted in uniform undercorrection of our patients by the 6-month post-BMR follow-up examination. It may seem that a large undercorrection rate in our series could have been predicted by the findings of the studies cited above; however, our patients differ from those included in previous studies in that they are all adults and all had previously undergone refractive surgery to eliminate the refractive accommodative component of their esotropia. Thus, no truly comparative studies exist. Nevertheless, in the future, our approach will be to augment our BMR by basing our surgical dosage on the near deviation.

In conclusion, PRK may be useful in young adult patients to treat the accommodative portion of partly accommodative esotropia associated with low-to-moderate hyperopia. Standard BMR following PRK results in a high rate of undercorrection; therefore, augmented BMR may be needed to treat the residual, nonaccommodative component. This can be achieved by basing the surgical dosage on the near deviation.

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