Correction of Large Amblyopiogenic Refractive Errors in Children Using the Excimer Laser

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Purpose: We sought to determine whether laser subepithelial keratomileusis (LASEK) and photorefractive keratectomy (PRK) are effective methods for correcting amblyopiogenic refractive errors in children. Methods: Thirty-six eyes in 35 amblyopic children, who ranged in age from 4 to 16 years (mean, 8.4 years), received treatment for large magnitude ametropia. Seventy-two percent (25/35) of the children had a neurobehavioral disorder and/or were noncompliant with spectacle or contact lens wear. Myopia ranged from −3.25 to −24.25 D (mean, −11.48 D); one patient had hyperopia of +5.87 D. Correction was tailored to match the refractive error of the nonamblyopic eye. VISX Star S2/S3 excimer lasers were used in manual or auto-tracking modes, and corneal centration was achieved using brief, general anesthesia. Mean follow-up was 29.2 months (range, 4-42 months).

Results: Myopia correction averaged −8.95 ± 2.89 D (range, −3.25 to −15.50). Eighty-nine percent (31 children) were corrected to within ± 1.00 D of goal refraction and the remaining 11% to within 2.0 D of the goal (most were undercorrected). Acuity improved postoperatively in 97%; by 1 optotype line in 37% and by 2 or more in 60%. No child lost acuity. Binocularity improved in 69% (24/35) and remained the same in 31%. Corneal haze measured grade 0-1 in 78%, grade 2 in 14%, and grade 3-4 in 8%. Myopic regression exceeding 1.0 D/year (0.08 D/month) occurred in 50% (18/36) of eyes treated. No substantial differences were observed in PRK- (n = 18) versus LASEK- (n = 17) treated children. Conclusions: Laser refractive surgery is effective for correcting anisometropic myopia in amblyopic children. Recurrence of myopia is common. Further study is indicated to determine long-term stability and safety of the procedure in this population. (J AAPOS 2005;9:224-233)
are used to correct high ametropia in adults.\textsuperscript{15,16} The techniques also have been used to correct ametropia in a small number of pediatric case series.\textsuperscript{8-10} The purpose of this report is to communicate our experience using PRK and LASEK to correct ametropia in a sizable cohort of anisometropic children. A preliminary report of a portion of these data was published in 2002 as an ARVO abstract.

**PATIENTS AND METHODS**

Clinical outcome data displayed in Tables 1 and 2 were collated from a prospective study of 36 consecutive eyes in 35 ametropic children (17 boys, 18 girls). All surgery was performed at St. Louis Children’s Hospital between June 2000 and December 2002. Tables 1 and 2 divide the patients into 3 groups on the basis of the laser surgical technique used: combined phototherapeutic keratectomy (PTK) and PRK (patients 1-12), manual removal of epithelium and PRK (patients 13-18), or LASEK (patients 19-35). The mean age at surgery was 8.4 years; range 4-16 years. One third (39%, 14/36) of eyes treated were in patients 7 years of age or younger at the time of laser correction, and 72% (26/36) were age 10 years of age or younger. One child had follow-up for 3 months but did not return for longer follow-up and is therefore not listed in the Tables of 35 children (36 eyes) reported in our results. One child had sequential correction of high myopia in both eyes, and these results are reported (patient 22, age 5 years). Mean follow-up was 29.2 months (range, 4-42 months).
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<th>Postop VA</th>
<th>Preop binoc†</th>
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<th>Neurobehavioral status¶</th>
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<td>Down syn</td>
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Each child had a minimum of 2 office examinations performed preoperatively, as well as examination-under-anesthesia (EUA) at the laser procedure. The examinations included age-appropriate testing of visual acuity in each eye, pupillary examination with measurement of diameter, sensorimotor examination of eye alignment/eye movement/binocular function, a minimum of 2 manual and, when feasible, automated cycloplegic refractions performed within 1 week, slit lamp biomicroscope evaluation of the anterior segment and assessment of tear film, indirect ophthalmoscopy, and measurement of intraocular pressure with a Tonopen (Minter O&O, Norwell, MA). Automated photokeratoscopy mapping was performed before and after the surgery in cooperative children. Additional measurements obtained under anesthesia immediately before the laser procedure included pachymetry, keratometry, corneal diameters, biomicroscopy with gonioscopy, and A-scan ultrasonographic axial length measurement. The amount of desired correction was adjusted (unless otherwise noted) to conform to the refractive error of the fellow eye.

Written informed consent was obtained from the parent(s). The consent document itemized the rationale for and potential risks of pediatric excimer laser surgery, the need for continuing amblyopia therapy, and the possible need for additional surgery. The protocol complied with the ARVO resolution on the use of human subjects in research and was approved by the Washington University Human Studies Committee.

### Indications and Contraindications

Indications for laser correction included (1) anisometropia greater than 4.00 D or bilateral ametropia greater than 5.00 D; (2) children noncompliant with spectacle wear or intolerant of or ill-suited for contact lens wear; (3) amblyopia in the candidate eye equivalent to 2-optotype-lines or worse; (4) absence of glaucoma, uveitis, recurrent conjunctivitis, tear film insufficiency, endothelial dysfunction/corneal dystrophy, corneal scarring, keratitis, or systemic inflammatory disease; (5) pachymetry exceeding 425 microns but less than 675 microns; and (5) good rapport with the child’s parent(s), who acknowledged the risks/alternatives and the importance of follow-up examinations.

### Outcome Measures

Principal outcome measures included postoperative best-corrected and/or uncorrected visual acuity, postoperative refractive error, refractive regression, postoperative binocularity, corneal haze, and complications. Binocularity was graded as lowest-to-highest using the following 3-tiered scale: presence of a fusional vergence response to a 2 diopter base-out prism; fusion of the Worth (Lombart Norfolk, VA), or Polaroid (Lombart Norfolk, VA) 4-dot test; and stereoscopic sensitivity scored by the Titmus
Stereotest (Titmus, Peterburg, VA). Postoperative corneal haze was graded on a scale of 0 to 4, with 0 representing no haze and grades 1-4 indicating increasing density of haze.

Outcome measures were those obtained at the most recent follow-up examination for refractive error, regression, haze, and complications. Outcome measures for visual acuity and binocularity were the lowest value or grade recorded in the interval of 1 month after surgery to the most recent follow-up examination. The postoperative acuities reported were best-corrected if the child wore refractive correction at home or in school, and uncorrected if the child would not permit spectacle wear because of a neurobehavioral disorder or chronic noncompliance with spectacle wear. These conservative conventions were adopted to deliberately bias outcomes in the direction of underestimating improvement. The convention (1) avoided ascribing to laser correction any improvements that could have resulted from on-going amblyopia therapy in children 10 years of age or younger, (2) incorporated any deficits that accrued because of progressive haze or refractive regression, and (3) provided the most realistic estimate of the visual gain achieved by laser correction for an individual child.

Surgical Procedure
All surgeries were performed under general anesthesia using standard pediatric techniques. Induction was conducted by mask inhalation of a volatile anesthetic mixture (nitrous oxide/sevoflurane/oxygen) followed by insertion of a laryngeal mask airway and conversion to total intravenous anesthesia (TIVA, using propofol). Ketorolac tromethamine was administered intravenously to reduce postoperative discomfort.

After the EUA, proparacaine drops were applied to the conjunctiva of the eye selected for treatment. The child’s pupil was undilated. Manifest and cycloplegic refraction with sphere, cylinder, and axis as well as the amount of desired refractive treatment, keratometry readings and vertex distance were programmed into the Visx Star S2 or S3 (VISX USA, Inc., Santa Clara, CA) laser. The depth of TIVA was adjusted if necessary to eliminate any tendency for globe rotation away from primary position in the orbit (ie, residual Bell's reflex). The child’s head was repositioned using a pneumatic beanbag so that the iris remained level in all planes. Betadine prep was applied to the eyelids and conjunctival cul-de-sac. The patient table was swiveled from the 12-o’clock position and smoothed into the 6 o’clock position, where it remained hinged (treatment zone diameter was 1.0 mm larger for the hyperopic correction).

For PTK-mode removal of the epithelium, the microscope was adjusted and the aiming beam laser reticule was centered in the pupil, ablating the cornea over a diameter of 6.5 mm to a depth of 40 microns in a period of approximately 20 seconds. A Took knife (Storz Instruments, Bausch & Lomb, Rochester, NY) was scraped across the ablation zone to verify absence of epithelium. For manual removal, the Took knife alone was used. For LASEK, the trephine was removed and replaced with the 8.5-mm diameter well, which was filled with 20% alcohol diluted in sterile water, ensuring that the central epithelium was submerged fully. The alcohol was removed using a Merocel sponge after 30 seconds, followed by irrigation of the conjunctiva and cornea. The central 8 mm of epithelium was removed with the micro-hoe, scrolling the tissue in rolled-carpet fashion from the 6-o’clock to 12-o’clock position, where it remained hinged (treatment zone diameter was 1.0 mm larger for the hyperopic correction).

After de-epithelialization, the microscope was adjusted to 16X and the aiming reticule again centered in the pupil. A Merocel stick microsponge moistened with balanced salt solution was brushed across the corneal stroma to dull the reflex. Manual or autotracking PRK was completed using regular/blend treatment zones of 6.0/8.0 mm over a course of 60-90 seconds. After each 20-25 seconds of laser application, the treatment was interrupted and a microscope employed to wipe and barely moisten the ablation zone. In LASEK-treated children, the rolled carpet of epithelium was unscrolled from the 12-o’clock position and smoothed back over the stroma using a micro-spatula. Voltaren (Novartis Ophthalmics, Inc., Duluth, GA), Ciloxan (Alcon Laboratories, Fort Worth, TX), TobraDex (Alcon Laboratories, Fort Worth, TX), and additional proparacaine eye drops were applied, followed by a plano bandage contact lens and a Fox shield.

Postoperative Regimen and Medication Compliance
Printed instructions were discussed with and issued to the family at discharge, including discouragement of removal of the Fox shield or eye rubbing, and directions for instillation of eye drops to keep the eye moistened and reduce the risk of tight lens syndrome, infection, or inflammation. The parents also were instructed in the use of optional postoperative pain medications to include oral Percocet (Endo Pharmaceuticals, Chadds Ford, PA), or Tylenol with codeine elixir (Ortho-McNeil Pharmaceuticals, Raritan, NJ) and oral ketorolac. No anesthetic complications occurred in the study group, and all of the children were discharged from the same day surgery unit within 1 hour of the procedure. No restrictions were placed on activities.

Postoperative examinations were performed at 1 day and thereafter at 48-hour intervals until reepithelialization was complete and there was no evidence of corneal fluorescein staining. If the bandage contact lens was still in place it was removed. Follow-up examinations were performed at 1 month, 2-3 months, and then at 6-month
intervals, unless active amblyopia therapy warranted more frequent visits. Topical TobraDex and Voltaren drops were used q.i.d. during the first week after surgery. Thera-

after, Voxel (Alcon Laboratories, Fort Worth, TX), FML (Allergan, Inc., Irvine, CA), or prednisolone drops were to be substituted and used b.i.d. For the last 4 children reported in Tables 1 and 2 (patients 32-35), a standard chewable multivitamin containing 60 mg of vitamin C (ascorbic acid, 100% of the daily recommended value) was also prescribed each day for a minimum of 6 months in an attempt to minimize corneal haze.

The topical medication compliance data reported was estimated by having nonphysician members of the clinic staff query parents, asking them to recall the name or bottle color of the drop used, any difficulties with drop administration, and the need for any refills at each follow-up visit. The method was used to avoid embarrassing noncompliant parents/children while enhancing the chances of eliciting candid responses.

Statistical Analysis

Correlation coefficients were calculated for variables that included: the amount of laser correction, regression rate, corneal haze, age at surgery, and compliance with topical medication. Outcomes were compared between the three surgical technique groups by use of analysis of variance (ANOVA) for time to reepithelialization, corneal haze, and regression rate. Comparison of improvement in acuity across age group was performed using ANOVA. Differences between means of unpaired subgroups were measured using the t-test. Significance was defined as $P < 0.01$.

RESULTS

Ocular, Visuomotor, and Neurobehavioral Status

All of the 35 children reported in our results and listed in Tables 1 and 2 had amblyopia. Thirty-four (97%) had anisometropic amblyopia. Nine of these 34 children (26%) had superimposed strabismic or pattern-deprivation amblyopia. One child (3%, patient 22) had strabismic amblyopía and bilateral isometropic myopia. The preoperative acuities reported in Table 2 range from 20/40 (optotype fraction 0.5) to 1/200 (0.005) with a mean acuity of 0.23 (20/87). Patient 27 had acuity measured only as “fix/fol-

low up.” Owing to profound developmental delay/mental retardation. All of the children had a history of attempted amblyopia therapy, including spectacle wear, occlusion therapy, and/or atropine penalization before enrollment in the protocol. Continuing amblyopia therapy was recom-

mended in children 10 years of age or younger throughout the follow-up interval, but compliance with amblyopia therapy varied.

Twenty-one of the 35 children (60%) had strabismus (and a history of 1 or more strabismus surgeries), most commonly infantile onset, with primary esotropia exceed-

ing exotropia by a ratio of 1.7:1. An additional 11 children (31%) had evidence of primary monofixation syndrome. Nine of the 35 (26%) displayed conspicuous manifest latent nystagmus. Seven of 35 (20%) had a history of diode laser, cryotherapy-treated, or spontaneously regressed stage 3 retinopathy of prematurity. Three children (9%) had previous surgery for infantile cataract and intraocular lens implantation in the amblyopic eye (2 of these eyes also had mild microcornea). One child (patient 27) had bilateral iris colobomas with mild microcornea and a macula-

sparing chorioretinal coloboma in the treated eye.

Twenty-five of the 35 children (72%) had a neurobe-

havioral disorder, ranging from moderate to severe. Nine of these children (36%) had a history of prematurity with birth at gestational age of 30 weeks or less. An additional 5 children (14%) had no neurobehavioral disorder but were chronically noncompliant with spectacle wear. The remaining 5 children (14%) were normal, wore spectacles for anisometropia exceeding 6.0 D, and either contact-lens failures or unsuitable for contact lens wear because of family-related issues.

Initial Cornea Epithelium Healing

Reepithelialization of the cornea was complete by an average 3.6 ± 1.4 days. No substantial difference was noted in the rate of corneal reepithelialization between groups of children treated by PTK/PRK, manual scrape/PRK, or LASEK (analysis of variance [ANOVA], $P = 0.388$). Two of the 35 children (6%) required an oral analgesic for discomfort within 24 hours after the procedure but not thereafter. The other 94% (33/35 children) displayed no signs of substantial discomfort or change in behavior, other than photophobia, during the interval of reepithelial-

ization. Twenty-six percent (9/35) of the children (mainly but not exclusively those with severe neurobehavioral disorders) dislodged the eye shield, manipulated the eye, and lost the bandage contact lens within 12 hours of the surgery. Lens loss appeared to have no noteworthy effect on the rate of corneal healing or discomfort.

Patient 30 in Tables 1 and 2 had shedding of an adherent epithelial flap during attempted LASEK and the procedure was converted to manual scrape. The mishap did not impair corneal healing. Patient 35 had LASEK and normal postoperative healing, but experienced acute pain and photophobia in the operated eye 1 month after the procedure. He had a $\sim 2 \times 2$-mm region of loose epithe-

lum near the edge of the original flap, which was excised under brief anesthesia and treated with a bandage con-

tact lens. The cornea healed without scarring in 48 hours.

Refractive Error and Laser Correction

Table 1 lists the preoperative refraction, goal refraction, and initial postoperative refraction for each of the treated children. Thirty-four of the 35 children were myopic, with the preoperative refractive error ranging from $-3.25$ to $-24.25$ D (spherical equivalent [SE], mean $-11.48$D).
Thirty-two of the 35 children (91%) also had astigmatism, ranging from 0.50 to 5.50 D (mean, 1.93 D). Treatment was tailored to match the spherical refractive error of the nonamblyopic eye and eliminate all astigmatism (in patient 22, who had bilateral high isometropic myopia, treatment in both eyes was targeted to plano). In 20/35 children (72%), the fellow eye was emmetropic or mildly hyperopic and thus the goal refraction was plano to + 1.00 D. In the other 15/35 (28%), the fellow eye was mild-to-moderately myopic and the goal refraction ranged from –0.50 to –8.00 D. One child (patient 26) had anisometropic hyperopia of +5.87 D, with a goal refraction of +1.00 D.

Myopic spherical correction (laser treatment achieved) averaged 8.95 ± 2.89 D (range, –3.25 to –15.50). Eighty-nine percent of children (31/35) were corrected to within ± 1.00D of spherical goal refraction. The remaining 11% (4/35) were corrected to within 2.0 D of the goal (3 of 4 undercorrected). Correction of astigmatism averaged 1.86 ± 1.34D, and the initial cylindric correction achieved was within 1.0D of plano in all 32 astigmatic children.

Visual Acuity Outcomes and Ablation Center Decentration

Acuity improved postoperatively in 34/35 children (97%) treated, but the gains were minor (the equivalent of 1 optotype line) in 13 of these 34 children (38%). Improvement of 2 optotype lines or more was achieved in 62% (21/34). Impressive gains in acuity (≥ 3 optotype lines) were achieved in patients 2, 5, 12, 19, 22, 24, 29, 31, and 35 (9/35 or 26%). One child (patient 7) had no change in acuity; no child lost visual acuity.

Mean gain in acuity (optotype fraction) for the study group was 0.20 ± 0.16. Gains in acuity were comparable for children younger than 7 years of age (mean improvement 0.18 ± 0.19), for children age 7-10 years (0.21 ± 0.15), and for children older than 10 years of age (0.18 ± 0.14; ANOVA; P = 0.421). None of the children complained of glare, haloes, or other subjective visual disturbances.18

Five children were able to cooperate reliably to compare awake pre- versus postoperative topographic corneal maps. The average decentration of the ablation center in this group was 0.67 mm (range, 0.41–0.98). No systematic trend was evident relating decentration to surgical technique used or visual acuity outcome.

Corneal Haze

Corneal haze observed during the follow-up interval ranged from zero to 4+, with a mean score of 0.77 ± 0.87 for the 36 eyes. Corneal haze measured grade 0-1 in 78%, grade 2 in 14%, and grade 3-4 in 8%. No systematic relationship between the surgical technique used and the subsequent occurrence of haze was found (ANOVA, P = 0.363). The severity of haze correlated weakly but significantly with the amount of laser correction (r = 0.157; P < 0.0001) and younger age at surgery (r = 0.115; P < 0.001).

To reduce the chance of developing haze, topical corticosteroid drops were prescribed for use twice a day for the first 6 months after surgery, but compliance after the first month was, on the whole, poor. Mean duration of drop compliance was 1.06 ± 1.08 months. Special efforts were made to achieve substantially longer intervals of good compliance (average 7.0 ± 2.0 months) with topical medication and oral Vitamin C in the last four children (patients 32-35) listed in Tables 1 and 2. Haze in this corticosteroid-plus-vitamin C group was significantly milder than that in the remaining LASEK group (unpaired t-test, P = 0.034), and 3 of the 4 experienced no myopic regression.

Three children had corneal haze exceeding 2+ (patients 6, 14, and 25). Despite the haze (and myopic regression), the 3 children achieved minor improvement in visual acuity. One had PTK, 1 had manual scrape, and 1 had LASEK removal of the epithelium. Patients 6 and 25 had –10D SE and –8.25D SE laser correction, and the families did not instill eye drops after the first week. Patient 14 had –6.25 D SE laser correction and received TobraDex for 1 month, followed by prednisolone 0.125% for 1 year (he was also treated during the 32-month follow-up interval with courses of oral prednisone for asthma). The combined topical and oral corticosteroid treatment did not prevent the development of 3-4+ haze. Thirteen months after PRK, he was taken back to the operating room for scraping of the stromal surface and application of 0.02% mitomycin C.19,20 The haze cleared to 1-2+ and during a 3-month period myopic regression reversed by + 1.50D.

Myopic Regression

Myopic shift during the follow-up interval is reported in Table 1 as regression rate, expressed as SE dioptries per month. Twenty-four of the 35 children treated (69%) exhibited some evidence of regression. The average rate of regression was −0.088 ± 0.22 D/month, or −1.06 D/year. Myopic regression exceeding 1.0 D/year (0.08 D/month) occurred in 50% (18/36) of eyes treated. Regression rates were comparable in children treated by PTK/PRK (−0.110 ± 0.29 D/month), manual scrape/PRK (−0.074 ± 0.08 D/month), and LASEK (−0.079 ± 0.21 D/month; ANOVA, P = 0.818). The rate of myopic regression correlated with severity of haze (r = 0.356, P < 0.001) and younger age at surgery (r = 0.395, P < 0.0001).

As noted above, long-term compliance with drops and oral vitamin C was associated with less myopic regression. However, the use of topical corticosteroids did not prevent significant regression in all cases. Patient 14 received topical (and intermittently oral) corticosteroids but experienced substantial regression (with significant haze). Patient 32 was compliant with both drops and vitamin C for a duration of six months, but also experienced substantial regression (albeit with zero haze).
Improvement in Binocular Fusion

Binocular fusion (Table 2) improved postoperatively in 24/35 children (69%). Mild gains were measured in 19/24 (79%) of these cases, defined as an improvement in one grade of binocularity, eg from presence of fusional vergence to fusion of the four-dot test. Major gains in binocularity (defined as improvement of 2 grades) were measured in 5/24 (21%). No child had a deterioration of binocularity as a result of laser correction. Patients 5, 18, and 29 (33%, 3/9 with nystagmus) had manifest latent nystagmus damp to latent nystagmus as a benefit of the improvement in binocular fusion.

DISCUSSION

The purpose of this study was to review outcomes in a sizable series of children treated by a pediatric ophthalmologist using PRK or LASEK, with the goal of answering 2 major questions. Is excimer laser surgery, an effective way to correct high ametropia in children who, for one reason or another, are not suitable candidates for correction by other means? The answer to this question, based on the current study and earlier studies,8-11 is yes, when effectiveness is measured as improvement in acuity or ability to achieve a nearly emmetropic refraction. Visual acuity improved in 97% of the children in this study (substantially in 62%), and we were able to correct the ametropia to within 2.0 D of the target refraction in all eyes. The second, equally important, question we posed was whether correction using the excimer laser was safe. The answer to this question also is yes, when safety is gauged as a low prevalence of loss of vision and a low prevalence of sight-threatening complications. No children in our series lost vision, and none of the children suffered a devastating corneal complication. The negligible rate of complication is particularly noteworthy in light of the fact that many of the children treated in our study were highly uncooperative owing to neurobehavioral disorders. It is prudent to note that less serious complications may only appear after prolonged follow-up, and the average follow-up of the children in this series was two-and-one-half years.

The major drawback to excimer laser correction in children is the high prevalence of return of ametropia. Regression occurred in 69% of the children treated, with an average return of myopia at the rate of ~1 D/year. Regression also was apparent in the hyperopic child at a rate ~0.5 D/year. Keratocyte-mediated regrowth of the photoablated stroma and epithelial hyperplasia appear to be main causes of myopic regression.21,22 The development of haze is attributed to high numbers of wound healing keratocytes. Topical corticosteroids reduce regression and corneal haze in adult excimer laser patients.23-26 The use of systemic ascorbate (vitamin C) may also inhibit stromal collagenase, reducing both stromal haze and related regression.17,27,28 Three of the 4 children in our study who received both topical corticosteroid and systemic ascorbate for at least 6 months after surgery showed no regression and negligible haze. Further study in a larger group of children will be required to confirm the promising results obtained in this subgroup.

Comparison With Other Pediatric Excimer Laser Studies

Although few studies have described longer-term outcomes of excimer laser surgery in children, the results of these studies are comparable with those reported here.8-11 Table 3 summarizes the results of recent reports for comparison with our findings (the list is representative but not

### Table 3: Representative pediatric excimer laser surgery studies for correction of anisometropic myopia

<table>
<thead>
<tr>
<th>Authors</th>
<th>Site</th>
<th>No. patients</th>
<th>Neurobehav disorders*</th>
<th>Age range</th>
<th>Average follow-up</th>
<th>Surgical technique</th>
<th>Anesthesia</th>
<th>Avg correction</th>
<th>Mean gain acuity†</th>
<th>Gain binoc fusion or vis function</th>
<th>Regression</th>
<th>Postop drops</th>
<th>Complications (major)</th>
<th>UK: United Kingdom; US: United States; yr: year; mo: month; PRK: photorefractive keratectomy; LASIK: laser-assisted in situ keratomileusis; LASEK: laser subepithelial keratomileusis.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nucci et al.</td>
<td>Italy</td>
<td>14</td>
<td>0%</td>
<td>9–14 yr</td>
<td>1.7 yr</td>
<td>PRK or LASIK</td>
<td>Topical</td>
<td>7.9 D</td>
<td>0.03</td>
<td>7%</td>
<td>0.28 D/yr</td>
<td>≤4 mo</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Drack et al.</td>
<td>Canada</td>
<td>27</td>
<td>33%</td>
<td>1–6 yr</td>
<td>1 yr</td>
<td>PRK</td>
<td>Gen</td>
<td>9.3 D</td>
<td>0.21</td>
<td>64%</td>
<td>1.36 D/yr</td>
<td>≤4 mo</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Astle et al.</td>
<td>Canada</td>
<td>27</td>
<td>0%</td>
<td>4–7 yr</td>
<td>2 yr</td>
<td>PRK or LASEK</td>
<td>Gen</td>
<td>6.6 D</td>
<td>0.55</td>
<td>78%</td>
<td>1.7 D/yr</td>
<td>≤6 mo</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Autrata et al.</td>
<td>Czech Republic</td>
<td>27</td>
<td>0%</td>
<td>2–12 yr</td>
<td>2 yr</td>
<td>LASIK</td>
<td>Gen</td>
<td>7.2 D</td>
<td>0.12</td>
<td>Not Reported</td>
<td>“none”</td>
<td>0.5 mo</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Rehurek et al.</td>
<td>Czech Republic</td>
<td>6</td>
<td>0%</td>
<td>4–16 yr</td>
<td>2.4 yr</td>
<td>PRK or LASEK</td>
<td>Gen</td>
<td>9.0 D</td>
<td>0.20</td>
<td>0%</td>
<td>1.06 D/yr</td>
<td>≤1.1 mo‡</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>O’Keefe et al.</td>
<td>UK</td>
<td>35</td>
<td>72%</td>
<td>4–16 yr</td>
<td>2.4 yr</td>
<td>PRK or LASEK</td>
<td>Gen</td>
<td>7.0 D</td>
<td>0.20</td>
<td>0%</td>
<td>1.06 D/yr</td>
<td>≤1.1 mo‡</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Nolan et al.</td>
<td>US</td>
<td>35</td>
<td>72%</td>
<td>4–16 yr</td>
<td>2.4 yr</td>
<td>PRK or LASEK</td>
<td>Gen</td>
<td>9.0 D</td>
<td>0.20</td>
<td>0%</td>
<td>1.06 D/yr</td>
<td>≤1.1 mo‡</td>
<td>0%</td>
<td>0%</td>
</tr>
</tbody>
</table>

*Prevalence in cohort.
†Gain optotype fraction.
‡Medication compliance measured for each child.
comfort. Paysse et al30 reported detailed information on surgery but did not quantify healing rate or level of discomfort. The 4 studies performed outside the United States indicated healing of the corneal surface within days after surgery but did not quantify healing rate or level of discomfort. Paysse et al30 reported detailed information on time to healing of the epithelium and level of discomfort after PRK. The level of discomfort was low in her study, and time-to-complete healing (mean 3.5 days) was similar to that which we report (mean 3.6 days). Paysse et al11 also have reported data on average error of ablation centration in pediatric PRK, which was minor, and equivalent to that in our patients.

With the exception of Nucci and Drack,8 each of the studies treated amblyopic children younger than 9 years of age. The average magnitude of anisometropic correction was large and comparable across studies, ranging from 6 to 9 D. Gains in acuity were noted in each study. Minimal gain was reported by Nucci and Drack, which they note was likely explained by correction at an age beyond which amblyopia is reversible. The amount of myopic correction (~9 D), and the mean gain in acuity (0.20) reported in the Canadian study of Astle et al. are remarkably similar to those we measured. The largest average gain in acuity is that reported from the Czech Republic by Autrata and Rehurek: 0.55 or twice that claimed in the 2 North American investigations. The reasons for the discrepancy are not entirely clear but could potentially be explained if adherence to spectacle wear and occlusion therapy were markedly better in the Czech study. (The study did not report compliance data but does appear to have excluded children with neurobehavioral disorders.)

Rates of myopic regression were generally similar across the 3 largest studies9,10 (ours included), ranging from 1.06 to 1.7 D/year. Given the importance of corticosteroids in reducing regression and haze in adult patients,23-26 we were surprised that no other study recorded compliance data for administration of drops (each of the five studies used fluorometholone as the drop of choice). Systemic ascorbate was not used in the previous pediatric studies.

Postoperative improvement in binocular function was reported by Autrata and Rehurek, with gains exceeding those which we found.10 Astle et al9 did not measure binocular fusion per se but did survey parents to assess gains in “functional vision,” which included balance, awareness of the environment, and coordination. A total of 64% of the children in the Astle et al study benefited from a functional vision improvement, with the most impressive improvements in children with neurobehavioral disorders.

We conclude that PRK and LASEK are effective and safe techniques for improving vision in children with myopic anisometropia or high bilateral myopia. Appropriate cautions should be taken when recommending this form of refractive correction. The main beneficiaries may prove to be the hard cases, that is, children with severe neurobehavioral disorders. The benefit of the surgery will be considerably enhanced if effective methods can be found to prevent myopic regression.

References

1. Romano PE, About aniseikonia and refractive surgery. Binocul Vis Strabismus Q 2002;17:191
An Eye on the Arts – The Arts on the Eye

It was one of those rare times when a bomb could have exploded beside me and I wouldn’t have noticed. I was absorbed in Jim, watching his expressions, listening to his words, enjoying the moment. I sat opposite him at a table next to the wall; a candle between us, its flame reflected in his eyes.

He noticed my eyes too. “You looked beautiful,” he told me recently, “but obviously I saw the scar near your eye.”

He said he wanted to reach over and touch my face near that scar, a sign of comfort or empathy, but he resisted. That would come later. “You were a person who might have died, a person who even if you had lived had no business sitting beside me having dinner, feeding yourself. So I knew right away you were a survivor.” He smiled. “There’s a sense of fragility about you, but scratch below the surface a little bit and you’ll find somebody who won’t be trifled with. I knew right away you were a person who wouldn’t break accidentally. You’d been through stuff I doubt I could have made it through. And though I still wanted to touch you and comfort you, I sensed you were stronger than me.

“The first thing I felt from you was your heart, your warmth,” Jim explained. “Maybe that’s what makes you so strong. Your ability to give your heart to others.”

—Trisha Meili (from I Am The Central Park Jogger, Simon & Schuster)