

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

Lawrence Tychsens, MD, Eric Packwood, MD, and Gregg Berdy, MD

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 $\cong 1.0$ 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)

The management of large magnitude ametropia in children remains a challenge to pediatric ophthalmologists. Nonsurgical measures for correcting ametropia are spectacles and contact lenses. Patients with unilateral ametropia generally are suitable for spectacle correction, but this method of correcting high degrees of anisometropia causes lens-induced aniseikonia and, in eccentric gazes, disconjugate shifting of images caused by prismatic effects induced by thick lenses.^{1,2} Both of these factors produce binocular image decorrelation, impeding binocular fusion and the optimal correction of anisometropic amblyopia.³ Spectacle correction of high anisome-

tropia also may produce a degree of cosmetic disfigurement, subjecting school age children to social ridicule. Contact lens correction can circumvent these disadvantages but may not be tolerated or practical in many children, particularly those with neurobehavioral disorders.

Excimer laser correction of refractive errors has been shown to be effective and safe in adults,⁴⁻⁷ but the use of this method in children has been the subject of a limited number of case series.⁸⁻¹¹ In adults, the excimer laser technique most widely used (laser-assisted in situ keratomileusis, or LASIK) entails the creation of a corneal stromal flap using a mechanical blade or blade-equivalent laser methodology.⁷ After the reshaping of the corneal stroma to correct ametropia, the flap is repositioned and is held in place by initially tenuous, natural biomechanical bonds. After LASIK flap repositioning, manipulation of the eye must be avoided to reduce the risk of flap displacement, a potential sight-threatening complication.¹²⁻¹⁴ Creation of a LASIK flap also diminishes the magnitude of correction that may be achieved by laser ablation because a sufficient bed of nonablated stroma must remain to ensure long-term corneal integrity.

The surface-ablation procedures photorefractive keratectomy (PRK) and laser subepithelial keratomileusis (LASEK) circumvent these disadvantages because they do not require creation of a stromal flap. PRK/LASEK

From the Department of Ophthalmology and Visual Sciences, St. Louis Children's Hospital, at Washington University School of Medicine, St. Louis, Missouri.

Presented at the American Association for Pediatric Ophthalmology and Strabismus 30th Annual Meeting, Washington, DC, March 2004, and in part at The Association for Research in Vision & Ophthalmology Annual Meeting, Fort Lauderdale, Florida, May 2002.

Submitted March 9, 2004.

Revision accepted January 25, 2005.

Reprint requests: Lawrence Tychsens MD, St. Louis Children's Hospital at Washington University School of Medicine, One Children's Place, Suite 2S-89, St. Louis, MO 63110. E-mail: tychsens@vision.wustl.edu.

Copyright © 2005 by the American Association for Pediatric Ophthalmology and Strabismus.

1091-8531/2005/\$35.00 + 0

doi:10.1016/j.jaapos.2005.01.006

TABLE 1 Refractive goal, outcome, and regression in 35 PRK- or LASEK-treated children (36 eyes)

Patient no.	Age at surgery/sex	Preop refraction	Eye/technique*	Goal refraction (diopters)	Init Postop refraction (diopters)	Final postop refraction	regression† (D/mo)
1	9 y/M	-16.00 sph	RE PTK/PRK	-5.50	-4.00	-5.50	-.075
2	7 y/M	-15.50 + 3.00 × 100	RE PTK/PRK	-3.50	-3.00	-2.50 + 0.50 × 13	+.150
3	9 y/F	-12.50 + 0.75 × 130	RE PTK/PRK	-2.25	-2.00	-2.00	0
4	13 y/F	-10.50 sph	LE PTK/PRK	Plano	-2.00	-3.00	-.066
5	10 y/M	-8.50 + 2.00 × 135	LE PTK/PRK	Plano	PL + 0.75 × 148	-3.50 + 1.00 × 135	-.090
6	5 y/M	-14.25 + 4.00 × 89	LE PTK/PRK	-4.00	-3.00	-9.00	-1.00
7	7 y/F	-24.25 + 1.50 × 100	LE PTK/PRK	-8.00	-10.00 + 1.00 × 45	-13.00 + 3.00 × 50	-.068
8	11 y/M	-18.00 + 1.75 × 66	RE PTK/PRK	-7.00	-7.75	-7.50 + 1.00 × 125	+.024
9	8 y/M	-7.50 + 2.25 × 004	LE PTK/PRK	Plano	0	PL + 2.00 × 180	+.048
10	8 y/M	-13.25 + 2.00 × 033	LE PTK/PRK	-6.25	-5.75 + 0.75 × 42	-8.00 + 1.00 × 20	-.111
11	16 y/F	-7.25 + 5.50 × 102	LE PTK/PRK	-1.00	-0.50 + 2.00 × 100	-1.50 + 0.75 × 005	-.107
12	10 y/M	-12.25 + 1.00 × 41	RE PTK/PRK	-2.00	-2.25 + 0.75 × 115	-2.50 + 0.50 × 137	-.025
13	14 y/F	-10.00 + 2.00 × 005	RE Man/PRK	-2.50	-2.50	-2.50 + 0.50 × 128	0
14	9 y/M	-12.25 + 2.00 × 100	LE Man/PRK	-5.00	-5.00	-9.00 + 2.00 × 88	-.125
15	10 y/F	-6.00 + 1.50 × 70	LE Man/PRK	-0.50	Plano	Plano	0
16	9 y/M	-10.00	LE Man/PRK	-1.25	-0.25	-5.50 + 0.75 × 105	-.196
17	10 y/F	-8.50 + 2.25 × 71	LE Man/PRK	-3.50	-2.75	-3.25 + 0.75 × 65	-.016
18	10 y/M	-11.00 + 0.75 × 167	LE Man/PRK	-1.00	-1.50	-4.00	-.104
19	10 y/M	-3.25 + 2.50 × 90	RE LASEK	Plano	Plano + 0.75 × 140	-0.75 + 1.50 × 102	-.020
20	14 y/F	-8.50 + 5.00 × 075	RE LASEK	Plano	-0.25	-2.50 + 2.00 × 65	-.044
21	7 y/M	-3.75 + 1.00 × 105	LE LASEK	Plano	Plano	Plano	0
22	5 y/F	-12.00 + 1.00 × 100	RE LASEK	Plano	Plano	-4.25 + 0.75 × 60	-.288
		-11.75 sph + 1.50 × 80	LE LASEK	Plano	-0.25	-4.50 + 1.50 × 65	-.156
23	7 y/F	-16.00 + 2.00 × 90	RE LASEK	Plano	-0.25 + 0.50 × 80	-6.00 + 1.00 × 90	-.423
24	7 y/M	-14.00 + 2.50 × 93	RE LASEK	Plano	-0.50	-7.00	-.309
25	7 y/F	-12.50 + 5.00 × 90	LE LASEK	Plano	-0.50	-7.00 + 4.00 × 70	-.250
26	16 y/F	+5.00 + 1.75 × 075	LE LASEK	+1.00	+2.00 + 1.00 × 55	+4.00 + 1.00 × 66	+.500
27	5 y/M	-6.50 sph	RE LASEK	+0.50	Plano	-1.25 + 1.00 × 90	-.066
28	14 y/F	-6.00 + 3.00 × 110	LE LASEK	Plano	1.00 + 2.00 × 82	-1.00 + 2.00 × 102	0
29	5 y/M	-10.00 + 0.50 × 90	LE LASEK	+1.00	+1.75 + 0.50 × 90	-0.50	-.192
30	11 y/F	-6.00 + 1.75 × 100	LE LASEK/ Man/PRK	Plano	-0.25 + 1.00 × 70	-1.50 + 1.00 × 70	-.096
31	5 y/F	-12.50 + 1.50 × 115	RE LASEK	Plano	Plano + 0.50 × 90	-4.50 + 1.00 × 70	-.307
32	15 y/F	-14.00 + 0.50 × 180	LE LASEK	Plano	-0.50	-2.25 + 0.50 × 120	-.125
33	6 y/F	-10.50 + 0.50 × 165	LE LASEK	+1.00	Plano	+0.50 + 0.50 × 68	+.083
34	7 y/F	-7.00 + 2.25 × 82	RE LASEK	+1.00	+0.50	+0.75 + 1.00 × 88	+.062
35	5 y/M	-6.00 + 2.75 × 105	RE LASEK	+1.00	+0.25	+0.50 + 1.00 × 90	+.045

*40 micron phototherapeutic keratomileusis (PTK)/photorefractive keratomileusis (PRK); Man: manual scrape.

†D/mo: average diopters per month.

are used to correct high ametropia in adults.^{15,16} The techniques also have been used to correct ametropia in a small number of pediatric case series.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).

TABLE 2 Visual acuity, binocular function, visuomotor findings, and neurobehavioral status of the 35 treated children (36 eyes)

Patient no.	Preop VA*	Postop VA	Preop binoc†	Postop binoc	Corneal haze‡	Ocular and visuomotor status§	Neurobehavioral status¶
1	20/200 (.10)	20/100 (.20)	+ fus vrg	+ stereo fly	0	Microesot; aniso amb	Normal/noncompliant
2	20/160 (.125)	20/50 (.40)	+ fus vrg	stereo 1/3	1–2+	aniso amb; monofix	ADHD/noncompliant
3	20/200 (.10)	20/100 (.20)	+ fus vrg	+ fus vrg	0–1+	Aniso amb + monofix	Normal
4	20/200 (.10)	20/100 (.20)	– fus vrg	+ fus vrg	2+	Aniso amb; monofix	30 wk prematur; DD
5	3/200 (.015)	20/80 (.25)	– fus vrg	+ fus vrg	0–1+	Inf ET surg × 2, MLN, Aniso amb, ROP cryo OS	25 wk prematur; DD
6	20/250 (.08)	20/125 (.16)	+ fus vrg	W4D fus	2–3+	Aniso amb + micro ET	Normal
7	20/50 (.40)	20/50 (.40)	+ fus vrg	+ fus vrg	1–2+	Aniso amb; micro ET; inf ET surg × 2	IUGR/DD
8	20/80 (.25)	20/40 (.50)	– fus vrg	+ fus vrg	0–1+	Aniso + strab amb; inf ET surg × 3	ADHD/DD
9	20/125 (.16)	20/70 (.28)	+ fus vrg	+ fus vrg	0	Aniso + strab amb; inf ET surg × 2; MLN regressed ROP, disc tilt + drag retina OU	ADHD/DD
10	20/100 (.20)	20/70 (.28)	– fus vrg	+ fus vrg	1+	Aniso amb + monofix	Shaken baby enceph/DD
11	20/60 (.33)	20/50 (.40)	stereo 1/3	stereo 1/3	0–1+	Aniso amb; monofix; cong ptosis surg OS	DD/autism
12	20/80 (.25)	20/40 (.50)	– fus vrg	+ W4D fus	0–1+	Aniso amb, monofix	DD/ADHD
13	20/100 (.20)	20/80 (.25)	+ fus vrg	+ W4D fus	0	Aniso amb, inf ET	Normal
14	20/40 (.50)	20/30 (.66)	– fus vrg	+ fus vrg	3–4+	Aniso + strab amb, MLN inf XT surg × 5	25 wk prematur, ADHD, DD/CP
15	20/100 (.20)	20/50 (.40)	+ fus vrg	+ stereo fly	0	Aniso amb, dev cat IOL surg age 3; microcornea	Normal/noncompliant
16	20/60 (.33)	20/30 (.66)	stereo 2/3	stereo 3/3	2+	Aniso amb, monofix	30 wk prematur, DD
17	20/40 (.50)	20/20 (1.0)	stereo 2/3	stereo 3/3	0–1+	Aniso amb, bilat IOL S/P dev cat/IOL surg age 3 RE age 4 LE	Normal
18	20/60 (.33)	20/50 (.40)	– fus vrg	+ fus vrg	0–1+	Inf XT surg × 6, MLN, aniso + strab amb, cryo OS ROP, cong ptosis rep OS	28 wk prematur, ADHD
19	20/100 (.20)	20/40 (.50)	W4D	stereo 3/3	0–1+	Aniso amb, monofix w/ micro ET	Noncompliant/ADHD
20	20/80 (.25)	20/70 (.28)	W4D	W4D	0–1+	Aniso + strab amb, MLN, DVD, inf ET surg × 2	Down syn
21	20/40 (.50)	20/20 (1.0)	stereo 3/3	stereo 9/9	0–1+	Aniso amb, micro XT monofix pre-op; phoric post PRK	Normal/noncompliant
22	20/400 Teller (.05) RE + LE	20/60 SSEP (.33) RE + LE	+ fus vrg	+ fus vrg	0-trace 0-trace	Inf XT surg × 1, MLN, strab amb LE	Marked DD, leukemia chemo rx
23	20/80 (.25)	20/70 (.28)	W4D	stereo 2/3	0–1+	Aniso amb, bilat cryo ROP	24 wk prematur DD
24	20/200 (0.10)	20/50 (.40)	W4D	stereo 2/3	2+	Aniso amb monofix	Normal/noncompliant
25	1/200 (0.005)	4/200 (.02)	– fus vrg	– fus vrg	2–3+	Pattern depr + aniso amb, neonatal vit hemorr LE, inf sens ET surg × 3, MLN	ADHD
26	20/40 (.50)	20/25 (.80)	stereo 1/3	stereo 3/3	1+	Aniso amb, monofix	Autism/PDD
27	FF	FF	– fus vrg	– fus vrg	0	Aniso amb; inf XT surg × 1; bilat Iris colob + microcornea; Inf retinal colob OD	Marked DD/MR
28	20/80 (.25)	20/70 (.28)	W4D	W4D	0–1+	Aniso amb; inf ET surg × 2; MLN	Down syn

TABLE 2 Continued

Patient no.	Preop VA*	Postop VA	Preop binoc†	Postop binoc	Corneal haze‡	Ocular and visuomotor status§	Neurobehavioral status¶
29	20/300 (.07)	20/160 (0.125)	– fus vrg	W4D	0–1+	Aniso amb; inf ET surg × 1, MLN, bilat optic atrophy	DD/schizencephaly
30	5/200 (.04)	20/400 (.05)	– fus vrg	– fus vrg	0	Aniso + pattern dep amb; cong cat surg age 2 mo; 2* IOL age 5; inf ET surg × 3; microcornea OS	Normal
31	20/400 (.05)	20/60 (.33)	+ fus vrg	+ fus vrg	0–1+	Aniso amb; inf XT, MLN	Marked DD
32	20/50 (.40)	20/30 (.66)	– fus vrg	+ fus vrg	0	Aniso amb; monofix	Normal; asthenopic HA + aniseikonic diplopia w/spec, noncompliant
33	20/70 (.28)	20/60 (.33)	+ fus vrg	W4D	0	Aniso + strab amb; L XT surg × 1; monofix; regressed stage 3 ROP	29 wk prematur, DD, ADHD
34	20/40 (.50)	20/30 (.66)	+ fus vrg	+ fly	0–1+	Aniso amb; inf XT surg × 2, MLN; bilat laser ROP	28 wk prematur, DD, cong hydroceph shunt age 1 mo
35	20/70 (.28)	20/25 (.80)	+ fus vrg	3/3	0	Aniso amb; regress stage 3 ROP, monofix	26 wk prematur w/IVH, DD, ADHD

*VA: visual acuity; Best corrected optotype (Snellen fraction) if tolerated spectacles, uncorrected otherwise; SSEP: spatial-sweep evoked potential.

†fus vrg: fusional vergence response to base-out prism; W4D: Worth four-dot test fusion; stereo-Titmus/Randot responses.

‡Haze at last f/u exam, except for retreated pt 14 (see text).

§ROP: retinopathy of prematurity; MLN: manifest latent nystagmus; ET: esotropia; XT: exotropia; IOL: intraocular lens

¶DD: developmental delay; ADHD: attention deficit hyperactivity disorder; CP: cerebral palsy; PDD: pervasive developmental disorder; MR: mental retardation.

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 photokeratometry 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 20 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.¹⁷

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 and locked in position under the microscope. Tegaderm (3M, St. Paul, MN) drapes were applied to the upper and lower eyelids. A lid speculum was inserted. A circular MeroceI (Medtronic Xomed Surgical Products, Inc., Jacksonville, FL) sponge soaked in 4% lidocaine was placed on the center of the cornea for 30 seconds and removed. The 8.0 mm diameter trephine was centered on the pupil and applied with gentle downward force to score the corneal epithelium.

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 MeroceI 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 MeroceI 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 microsponge 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. Thereafter, Vexol (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 anisometric amblyopia. Nine of these 34 children (26%) had superimposed strabismic or pattern-deprivation amblyopia. One child (3%, patient 22) had strabismic amblyopia and bilateral isometric 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/follow," 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 recommended 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 neurobehavioral 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 reepithelialization. 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 shredding 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 epithelium near the edge of the original flap, which was excised under brief anesthesia and retreated with a bandage contact 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 isometric 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 anisometric 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 ± 1.00 D 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 ± 1.34 D, and the initial cylindrical 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, halos, 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 diopters 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 $\cong 1.0$ 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).

TABLE 3 Representative pediatric excimer laser surgery studies for correction of anisometropic myopia

Authors	Nucci + Drack '01	Astle et al. '02	Autrata + Rehurek '04	O'Keefe + Nolan '04	Current study
Site	Italy	Canada	Czech Republic	UK	US
No. patients	14	27	27	6	35
Neurobehav disorders*	0%	33%	0%	0%	72%
Age range	9–14 yr	1–6 yr	4–7 yr	2–12 yr	4–16 yr
Average follow-up	1.7 yr	1 yr	2 yr	2 yr	2.4 yr
Surgical technique	PRK or LASIK	PRK	PRK or LASEK	LASIK	PRK or LASEK
Anesthesia	Topical	Gen	Gen	Gen	Gen
Avg correction	7.9 D	9.3 D	6.6 D	7.2 D	9.0 D
Mean gain acuity†	0.03	0.21	0.55	0.12	0.20
Gain binoc fusion or vis function	7%	64%	78%	Not Reported	69%
Regression	0.28 D/yr	1.36 D/yr	1.7 D/yr	"none"	1.06 D/yr
Postop drops	≤4 mo	≤4 mo	≤6 mo	0.5 mo	1.1 mo‡
Complications (major)	0%	0%	0%	0%	0%

UK: United Kingdom; US: United States; yr: year; mo: month; PRK: photorefractive keratectomy; LASIK: laser-assisted in situ keratomileusis; LASEK: laser subepithelial keratomileusis.

*Prevalence in cohort.

†Gain optotype fraction.

‡Medication compliance measured for each child.

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 negli-

ble 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

exhaustive). Three of the 5 studies were prospective: Astle et al,⁹ Aufrata and Rehurek,¹⁰ and ours (Table 3). The other 2 were retrospective. Aufrata and Rehurek reported a cohort of children in 2003 and 2004, and, therefore, the data of the more recent report are shown.^{10,29} The previous studies listed in the Table have taken place at sites outside of the United States.

Surgery was performed under brief general anesthesia in all studies involving younger children and/or those with neurobehavioral disorders. Follow-up ranged from 1 to 2.4 years, and the prevalence of sight-threatening or other major complications in all of the studies was zero. Similarly, the prevalence of haze exceeding 2+ was uniformly low. The 4 studies performed outside the United States noted 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 al³¹ 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 anisometric 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 Aufrata 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 studies^{9,10} (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 Aufrata 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

- Romano PE, About aniseikonia and refractive surgery. *Binocul Vis Strabismus Q* 2002;17:191
- Rubin ML. *Optics for clinicians*. Gainesville (FL): TRIAD Scientific Publishers; 1977.
- Tychsen L. Binocular vision. In: Hart WM, editor. *Adler's physiology of the eye: clinical applications*. St. Louis (MO): CV Mosby, 1992. p. 773-853.
- Krueger RR, Talamo JH, McDonald MB, Varnell RJ, Wagoner MD, McDonnell PJ. Clinical analysis of excimer laser photorefractive keratectomy using a multiple zone technique for severe myopia. *Am J Ophthalmol* 1995;119:263-74
- Kim JH, Kim MS, Hahn TW, Lee YC, Sah WJ, Park CK. Five year results of photorefractive keratectomy for myopia. *J Cataract Refract Surg* 1997;23:731-5.
- Hersh PS, Stulting RD, Steinert RF, et al. Results of phase III excimer laser photorefractive keratectomy for myopia. The Summit PRK Study Group. *Ophthalmology* 1997;104:1535-53.
- Lee YC, Hu FR, Wang IJ. Quality of vision after laser in situ keratomileusis: influence of dioptric correction and pupil size on visual function. *J Cataract Refract Surg* 2003;29:769-77.
- Nucci P, Drack AV. Refractive surgery for unilateral high myopia in children. *J Am Assoc Pediatr Ophthalmol Strabismus* 2001;5:348-51.
- Astle WF, Huang PT, Eells AL, Cox RG, Deschenes MC, Vibert HM. Photorefractive keratectomy in children. *J Cataract Refract Surg* 2002;28:932-41.
- Aufrata R, Rehurek J. Laser-assisted subepithelial keratectomy and photorefractive keratectomy versus conventional treatment of myopic anisometric amblyopia in children. *J Cataract Refract Surg* 2004;30:74-84.
- O'Keefe M, Nolan L. LASIK surgery in children. *Br J Ophthalmol* 2004;88:19-21.
- Melki SA, Talamo JH, Demetriades AM, et al. Late traumatic dislocation of laser in situ keratomileusis corneal flaps. *Ophthalmology* 2000;107:2136-9.
- Patel CK, Hanson R, McDonald B, Cox N. Late dislocation of a LASIK flap caused by a fingernail. *Arch Ophthalmol* 2002;119:447-448; correction 1565 and 2002;120:180.
- Heickell AG, Vesaluoma MH, Tervo TMT, Vannas A, Krootila K. Late traumatic dislocation of laser in situ keratomileusis flaps. *J Cataract Refract Surg* 2004;30:253-6.
- Lee JB, Seong JG, Lee JH, Seo KY, Kee YG, Kim EK. Comparison of laser epithelial keratomileusis and photorefractive keratectomy for low to moderate myopia. *J Cataract Refract Surg* 2001;27:565-70.
- Claringbold II TV. Laser-assisted subepithelial keratectomy for the correction of myopia. *J Cataract Refract Surg* 2002;28:17-22.
- Stojanovic A, Ringvold A, Nitter T. Ascorbate prophylaxis for corneal haze after photorefractive keratectomy. *J Refract Surg* 2003;19:338-43.

18. Probst LE. The problem with pupils. *J Cataract Refract Surg* 2004;30:2-3.
19. Vigo L, Scandola E, Carones F. Scraping and mitomycin C to treat haze and regression after photorefractive keratectomy for myopia. *J Refract Surg* 2003;19:449-54.
20. Carones F, Vigo L, Scandola E, Vacchini L. Evaluation of the prophylactic use of mitomycin-C to inhibit haze formation after photorefractive keratectomy. *J Cataract Refract Surg* 2002;28:2088-95.
21. Marshall J, Trokel SL, Rothery S, Krueger RR. Long-term healing of the central cornea after photorefractive keratectomy using an excimer laser. *Ophthalmology* 1988;95:1411-21.
22. Moller-Pedersen T, Cavanagh HD, Petroll WM, Jester JV. Stromal wound healing explains refractive instability and haze development after photorefractive keratectomy. *Ophthalmology*. 2000;107:1235-45.
23. Goggin M, Foley-Nolan A, Algawi K, O'Keefe M. Regression after photorefractive keratectomy for myopia. *J Cataract Refract Surg* 1996;22:194-6.
24. Phillips AF, Hayashi S, Seitz B, Wee WR, McDonnell PJ. Effect of diclofenac, ketorolac, and fluorometholone on arachidonic acid metabolites following excimer laser corneal surgery. *Arch Ophthalmol* 1996;114:1495-8.
25. Vetrugno M, Quaranta GM, Maino A, Cardia L. A randomized, comparative study of fluorometholone 0.2% and fluorometholone 0.1% acetate after photorefractive keratectomy. *Eur J Ophthalmol* 2000;10:39-45.
26. Vetrugno M, Maino A, Quaranta GM, Cardia L. The effect of early steroid treatment after PRK on clinical and refractive outcomes. *Acta Ophthalmol Scand* 2001;79:23-7.
27. Kasetsuwan N, Wu FM, Hsieh F, Sanchez D, McDonnell PJ. Effect of topical ascorbic acid on free radical tissue damage and inflammatory cell influx in the cornea after excimer laser corneal surgery. *Arch Ophthalmol* 1999;117:649-52.
28. Corbett MC, O'Brart DPS, Patmore AL, Marshall J. Effect of collagenase inhibitors on corneal haze after PRK. *Exp Eye Res*. 2001;72:253-9.
29. Autrata R, Rehurek J. Clinical results of excimer laser photorefractive keratectomy for high myopic anisometropia in children: four-year follow-up. *J Cataract Refract Surg* 2003;29:694-702.
30. Paysse EA, Hamill B, Koch DD, Hussein MAW, McCreery KMB, Coats DK. Epithelial healing and ocular discomfort after photorefractive keratectomy in children. *J Cataract Refract Surg* 2003;29:478-81.
31. Paysse EA, Hussein MAW, Koch DD, et al. Successful implementation of a protocol for photorefractive keratectomy in children requiring anesthesia. *J Cataract Refract Surg* 2003;29:1744-7.



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)