LASIK in Children With Hyperopic Anisometropic Amblyopia

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ABSTRACT

PURPOSE: To evaluate the results of LASIK for hyperopia in pediatric eyes with amblyopia resulting from anisometropia.

METHODS: Thirty-two children with anisometropic amblyopia in whom conventional therapy was unsuccessful underwent unilateral LASIK between 1999 and 2005. Mean patient age was 10.3±3.1 years (range: 4 to 15 years), and mean follow-up was 20.1±15.1 months (range: 12 to 60 months). At the last follow-up examination, spherical equivalent refraction, uncorrected visual acuity (UCVA), best spectacle-corrected visual acuity (BSCVA), and complications were recorded.

RESULTS: Mean preoperative and postoperative manifest spherical equivalent refraction of the treated eyes was 5.17±1.65 and 1.39±1.21 diopters (D), respectively ($P<.01$). Mean UCVA was 0.06±0.09 (range: 0.01 to 0.5) preoperatively and 0.27±0.23 (range: 0.05 to 0.8) postoperatively ($P<.01$). Mean BSCVA was 0.20±0.17 (range: 0.01 to 0.8) preoperatively and 0.35±0.25 (range: 0.1 to 1.0) postoperatively ($P<.01$). Six eyes gained ≥4 lines of BSCVA, 4 eyes gained 2 to 3 lines, 12 eyes gained 1 line, and 9 eyes were unchanged; only 1 eye lost 1 line of BSCVA due to haze in the flap-stroma interface. None of the patients reported halos or glare. There were no intraoperative or postoperative flap complications.

CONCLUSIONS: LASIK seems to be an effective and safe procedure for the management of hyperopic anisometropic amblyopia in select cases. Visual acuity improved in the amblyopic eyes and was associated with decreased anisometropia. The refractive response to hyperopic LASIK in children appears to be similar to that of adults with comparable refractive errors. [*J Refract Surg.* 2008;24:464-472.]

There is no doubt that anisometropia is a cause of amblyopia. The exact mechanism of anisometropic amblyopia remains unclear, although it has been suggested there may be active inhibition of the fovea to overcome the interference caused by attempting to superimpose a focused image in one eye and a defocused image in the other.[1]

The traditional management of anisometropic amblyopia includes correction of the refractive error with spectacles or contact lenses combined with occlusion therapy; which can be difficult because of poor patient compliance.[2] Photorefractive keratectomy (PRK) and LASIK have been used to treat children with myopic anisometropic amblyopia, and promising results have been reported.[3-9] However, only a few studies have been conducted on the use of LASIK for hyperopic anisometropia in young children.[10-12]

This study evaluated the use of unilateral LASIK to create refractive balance between the two eyes in a case series of patients with hyperopic anisometropic amblyopia.

PATIENTS AND METHODS

Patient Selection

All patients with hyperopic anisometropic amblyopia who had completed treatment for amblyopia and could not tolerate spectacle or contact lens refractive correction were screened for participation in this study. Patients younger than 16 years who had anisometropia greater than 2.00 diopters (D) that had been stable for at least 2 years and wanted to undergo refractive surgery were included in the study. Exclusion criteria were eyes with thin corneas that would have residual stromal

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thickness less than 300 µm and eyes that would have keratometric power greater than 50.00 D. Other exclusion criteria included previous intraocular surgery; any posterior segment pathology; active ocular inflammation; infection; corneal scar; keratoconus, suspected keratoconus, or a family history of keratoconus; glaucoma; Schirmer's test less than 5 mm; and narrow palpebral distance.

The study was conducted in accordance with the tenets of the Declaration of Helsinki. All patients and parents received a detailed description of the procedure. All parents provided written informed consent in which the uncertain nature of the procedure, its risks, and the slight possibility of obtaining visual improvement or deterioration were clearly stated.

Ophthalmologic Examination

Preoperatively and postoperatively, all patients underwent a comprehensive ophthalmologic examination that included uncorrected visual acuity (UCVA), best spectacle-corrected visual acuity (BSCVA), manifest and cycloplegic refractions, keratometric power, corneal topography, central and peripheral corneal thickness, undilated pupil size, measurement of intraocular pressure using Goldmann applanation tonometry or Tono-Pen (Medtronic, Jacksonville, Fla), orthoptic examination, and funduscopy.

In children younger than 3 years, cycloplegia and mydriasis were obtained using three sets of cyclopentolate 0.5% and phenylephrine 2.5% drops administered approximately 5 minutes apart. In older children, the same dosage was used with cyclopentolate 1.0%. Refraction was performed at least 45 minutes after the last set of drops.

Surgical Technique

In patients younger than 7 years, surgery was performed under sedative anesthesia with intravenous ketamine (2 to 3 mg/kg body weight). In patients older than 7 years, surgery was performed under topical anesthesia. All surgeries were performed by the same surgeon (H.C.).

For cases in which astigmatic correction was necessary, the horizontal meridian was marked preoperatively using a gentian-violet marker to avoid any effects of cyclotorsion of the eye when patients were in the supine position. After both eyes were prepared with povidone-iodine 10% solution, the amblyopic eye was draped and the contralateral eye was covered to eliminate cross-fixation. A pediatric lid speculum was placed, and the cornea was marked peripherally at two meridians using a gentian-violet marker to help align the flap at the end of the procedure.

In most cases, Moria CB and M2 (Moria, Antony, France) automated keratomes were used to create a superiorly hinged corneal flap with an intended thickness of 160 µm and a diameter of at least 9.5 mm. In two cases (patients 19 and 21), an IntraLase femtosecond laser (IntraLase Corp, Irvine, Calif) was used for superiorly hinged flap creation with an intended diameter of 9.2 to 9.3 mm and an intended depth of 95 to 100 µm.

Laser ablation was performed using the VISX S2 or S3 excimer laser system (VISX, Santa Clara, Calif). The VISX S3 has the ActiveTrak Eye Tracker. The standard optical zone with a 5-mm correction diameter and a 9-mm ablation diameter was selected for all patients.

In patients who could actively fixate, eye-tracker guided ablation was used. In patients who could not actively fixate or who were operated on under sedative anesthesia, the low-vacuum mode of the microkeratome was used and ablation was centered on the pupil center.

At the end of the procedure, the interface was gently irrigated with a balanced salt solution to remove debris. The flap was replaced in its original position, and a flush of air was injected onto the surface of the flap, allowing it to adhere to the stromal bed. One drop each of tobramycin 0.3% and prednisolone 1% were administered, and the lid speculum and drape were removed.

Postoperative treatment included topical tobramycin 0.3% and prednisolone 1% four times daily for 1 week and artificial tears at least 4 times daily for 6 months. Patients were required to wear clear glasses or sunglasses when awake and a shield when sleeping for 2 weeks. Patients and their parents were instructed to protect the operated eye very carefully. Follow-up examinations were performed 1 day, 1 week, and 1, 3, 6, 9, and 12 months postoperatively, and annually thereafter.

RESULTS

Fifty eyes of 50 pediatric patients with hyperopic anisometropia underwent surgery with LASIK at the Turkiye Hospital between 1999 and 2005. Thirty-two patients (17 boys and 15 girls) who had regular follow-up visits were included in this study. Mean patient age was 10.3±3.1 years (range: 4 to 15 years). There were 12 (37.5%) right and 20 (62.5%) left eyes. Three patients (patients 5, 11, and 22) had accommodative esotropia. One patient (patient 24) underwent surgery for esotropia at another clinic.

Mean follow-up was 20.1±15.1 months (range: 12 to 60 months). Patient demographics and pre- and postoperative data are shown in Tables 1-3. The data include patients' final follow-up visit. Postoperative corneal topography did not demonstrate laser ablation decentralization greater than 0.5 mm in any of the eyes

TABLE 1

Demographic and Preoperative Data of 32 Children With Hyperopic Anisometropic Amblyopia Who Underwent LASIK

	Manifest Refraction (D)					BSCVA		
Patient/ Age (y)	Right Eye	Left Eye	Cycloplegic Refraction Treated Eye (D)	Spherical Anisometropia (D)	UCVA Treated Eye	Treated Eye	Fellow Eye	Mean K Treated Eye (D)
1/8	0.00	+6.00 +1.00 × 110°	+7.50 +1.25 × 13°	+6.50	0.1	0.2	1.0	42.77
2/9	0.00	+5.50 +3.00 × 80°	+8.00 +3.00 × 80°	+7.00	0.01	0.05	1.0	39.87
3/13	0.00	+5.00	+7.00	+5.00	0.05	0.15	1.0	42.69
4/7	+2.50	+10.00	+9.00	+6.50	0.1	0.1	0.8	43.26
5/7	+5.00	+1.75	+5.75	+3.25	0.02	0.05	1.0	38.99
6/10	0.00	+5.50 +0.50 × 80°	+7.50 +1.00 × 80°	+5.75	0.01	0.02	1.0	42.44
7/8	+5.00	+2.25 –0.75 × 180°	+6.50	+3.13	0.1	0.2	0.8	42.72
8/10	0.00	+5.00 +2.50 × 80°	+5.50 +2.75 × 80°	+6.25	0.01	0.02	1.0	42.94
9/10	0.00	+4.50 +1.00 × 178°	+5.50 +1.00 × 178°	+5.00	0.05	0.3	1.0	42.44
10/9	+1.50 +3.50 × 110°	0.00	+1.75 +4.00 × 110°	+3.25	0.1	0.5	1.0	39.63
11/10	0.00	+5.00 –1.00 × 15°	+8.00 –1.50 × 15°	+4.50	0.01	0.05	0.7	45.16
12/9	+6.00 +1.00 × 180°	0.00	+8.00 +1.00 × 180°	+6.50	0.01	0.03	1.0	40.69
13/10	+6.00 –1.00 × 20°	+1.50	+7.00 –1.00 × 20°	+4.00	0.05	0.4	1.0	41.06
14/10	0.00	+6.50 –1.00 × 170°	+7.50 –1.00 × 170°	+6.00	0.05	0.2	1.0	39.10
15/8	+5.00 +2.00 × 100°	+1.25 +0.75 × 85°	+6.75 +3.00 × 112°	+6.63	0.02	0.1	1.0	38.44
16/5	+1.50	+5.00 +1.50 × 90°	+6.00 +2.00 × 85°	+5.50	0.02	0.1	1.0	43.19
17/7	+0.50 –1.00 × 75°	+2.50 –4.50 × 180°	+5.25 –4.50 × 5°	+3.00	0.05	0.3	1.0	43.25
18/15	+5.50 +1.50 × 120°	+2.00 +0.75 × 160°	+4.00 +1.50 × 120°	+3.88	0.1	0.3	1.0	43.55
19/13	+1.50	+4.50 +0.75 × 105°	+4.75 +0.75 × 105°	+3.38	0.05	0.1	1.0	41.56
20/8	+1.50	+5.00	+7.00	+3.50	0.05	0.3	0.9	42.12
21/10	+3.50 +4.75 × 80°	+2.00 +1.50 × 90°	+4.00 +4.50 × 90°	+3.13	0.02	0.3	0.9	42.56
22/4	+5.50 +0.75 × 70°	0.00	+7.00	+5.88	0.01	0.01	1.0	40.06
23/7	+2.25	+5.50 –0.50 × 5°	+6.50 –1.00 × 7°	+3.00	0.08	0.4	1.0	42.16
24/15	+1.00 –1.00 × 180°	+3.50 –1.50 × 175°	+4.50 –1.50 × 175°	+2.25	0.15	0.4	1.0	44.56
25/15	+0.25	+4.50 –0.50 × 170°	+6.00 –0.50 × 170°	+4.00	0.1	0.3	1.0	44.20
26/13	0.00	+1.00 +2.75 × 95°	+2.00 +2.75 × 95°	+2.38	0.05	0.2	1.0	41.50
27/14	+7.50	+1.00 –0.75 × 185°	+7.50 +1.25 × 90°	+6.88	0.01	0.2	1.0	44.56
28/13	+5.00 –1.75 × 175°	0.00	+5.75 –1.75 × 171°	+4.13	0.02	0.1	1.0	43.31
29/13	+0.50 +0.75 × 90°	+6.00	+7.00 +0.75 × 90°	+5.13	0.02	0.15	1.0	40.94
30/11	+6.00	+1.00	+6.50	+5.00	0.02	0.05	1.0	43.00
31/15	0.00	+3.00	+3.75 +0.75 × 90°	+3.00	0.5	0.8	1.0	41.87
32/15	0.00	+4.00	+5.50 +1.75 × 90°	+4.00	0.02	0.15	1.0	43.75
Mean	10.34±3.11			4.49±1.46	0.06±0.09	0.20±0.17	0.97±0.07	42.13±1.72
(Range)				(+2.25 to +7.00)	(0.01 to 0.5)	(0.01 to 0.8)	(0.7 to 1.0)	(38.44 to 45.16)

BSCVA = best spectacle-corrected visual acuity, UCVA = uncorrected visual acuity

TABLE 2
Postoperative Data of 32 Children With Hyperopic Anisometropic Amblyopia Who Underwent LASIK

Patient	Spherical Treatment Attempted (D)	Follow-up (months)	Refraction Treated Eye	UCVA	BSCVA	Spherical Treatment Achieved (D)	Deviation From Attempted (D)
1	+6.75	12	+1.50 × 140°	0.2	0.3	+5.75	–1.00
2	+7.50	12	+2.00 +1.00 × 85°	0.05	0.1	+4.50	–3.00
3	+6.00	12	+1.00 × 90°	0.3	0.3	+4.50	–1.50
4	+6.00	12	+4.50	0.1	0.1	+4.50	–1.50
5	+5.50	12	–0.50	0.1	0.1	+5.50	0
6	+6.33	12	+2.00	0.1	0.1	+3.75	–2.58
7	+6.00	24	+1.00	0.3	0.3	+4.00	–2.00
8	+6.75	12	+0.50 +2.00 × 90°	0.1	0.1	+4.75	–2.00
9	+6.00	42	+1.50 +2.00 × 15°	0.5	0.7	+2.50	–3.50
10	+3.38	12	+1.50 × 110°	0.5	0.5	+2.50	–0.88
11	+4.25	24	+2.50 +1.00 × 45°	0.05	0.1	+1.50	–2.75
12	+6.50	12	+3.00	0.2	0.2	+3.50	–3.00
13	+5.25	24	+1.50 –0.50 × 20°	0.3	0.4	+4.25	–1.00
14	+5.00	60	+4.00 –3.00 × 110°	0.05	1.0	+3.50	–1.50
15	+6.50	12	+2.50 +1.00 × 120°	0.1	0.2	+3.00	–3.50
16	+6.75	12	+0.50 –2.00 × 160°	0.6	0.6	+6.25	–0.50
17	+2.13	60	–2.50 × 180°	0.7	0.7	+1.50	–0.63
18	+5.75	12	+2.00 × 135°	0.6	0.6	+5.25	–0.50
19	+5.50	12	+1.00 –1.00 × 10°	0.15	0.15	+4.38	–1.13
20	+6.00	12	+1.50	0.05	0.3	+3.50	–2.50
21	+6.75	12	+2.00 +1.00 × 70°	0.1	0.3	+3.38	–3.37
22	+6.00	36	+1.50	0.3	0.4	+4.38	–1.63
23	+6.50	36	+2.00 –1.00 × 5°	0.7	0.7	+4.25	–2.25
24	+1.50	12	+0.50 +1.00 × 5°	0.5	0.5	+1.75	+0.25
25	+4.25	24	+1.00	0.2	0.2	+3.25	–1.00
26	+3.38	60	+1.00 × 110°	0.4	0.6	+1.88	–1.50
27	+4.25	12	+1.00 +1.25 × 75°	0.1	0.2	+5.88	+1.63
28	+6.50	12	+2.75	0.1	0.1	+1.38	–5.12
29	+6.00	12	+2.00 × 90°	0.2	0.2	+5.00	–1.00
30	+6.00	12	+1.25	0.05	0.1	+4.75	–1.25
31	+3.25	24	0.00	0.8	0.8	+3.00	–0.25
32	+6.36	12	+1.00	0.1	0.15	+3.00	–3.36
Mean	5.46±1.44	20.06±15.06		0.27±0.23	0.35±0.25	3.77±1.34	–1.68±1.36
(Range)	(1.50 to 7.50)	(12 to 60)		(0.05 to 0.8)	(0.1 to 1.0)	(1.38 to 6.25)	(–5.12 to 1.63)

BSCVA = best spectacle-corrected visual acuity, UCVA = uncorrected visual acuity

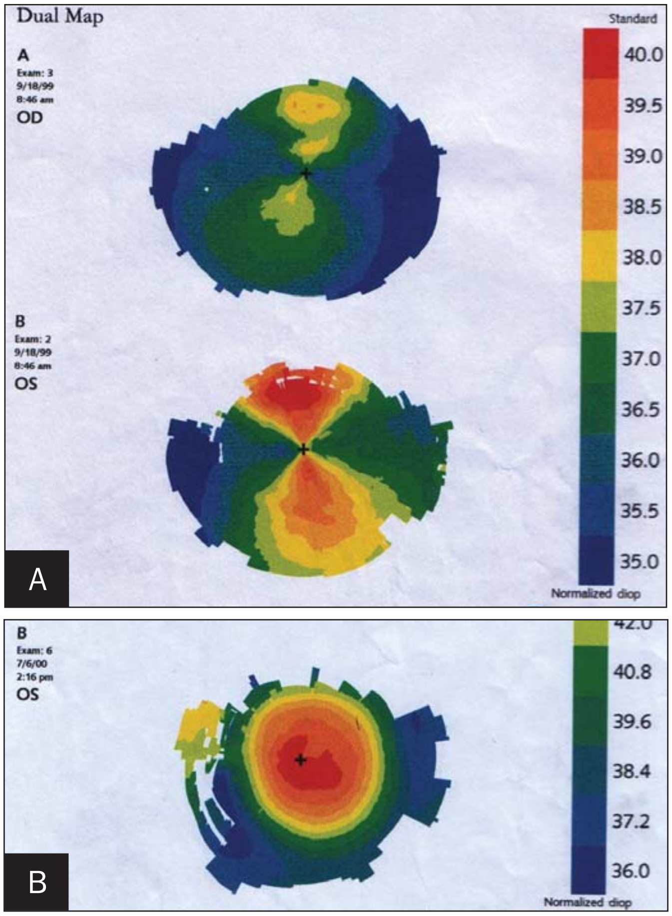

Figure 1. Axial computerized topography maps show **A)** preoperative with-the-rule astigmatism, and **B)** postoperative well centralized ablation pattern.

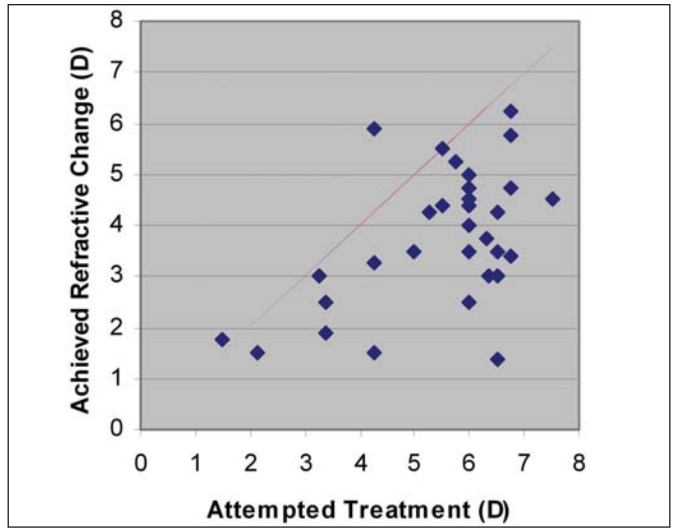

Figure 2. Scatterplot of the achieved refractive change at last postoperative follow-up examination compared with the attempted treatment.

(Fig 1). Postoperatively, spherical equivalent refraction was within ±0.50 D in 6 (18.8%) eyes, ±1.00 D in 15 (47%) eyes, ±2.00 D in 23 (72%) eyes, ±3.00 D in 31 (96.9%) eyes, and ±4.50 D in 32 (100%) eyes (Fig 2).

The percentage deviation was calculated with the following formula:

100% − [(treatment achieved/treatment attempted) × 100%].

At the last follow-up, overcorrection was observed in 2 (6.3%) eyes, undercorrection was observed in 29 (90.6%) eyes, and desired correction was achieved in 1 (3.1%) eye. The percentage deviation from attempted spherical correction ranged from −38.2% to 78.8%. Overcorrection ranged from 16.7% to 38.2% and undercorrection ranged from 7.4% to 78.8%. No patient required enhancement because either the undercorrection was less or the maximum amount of tolerable corneal steepening was achieved in eyes with large undercorrection.

Postoperatively, UCVA remained the same in 6 (18.8%) eyes. Eleven (34.4%) eyes gained 1 line, 7 (21.9%) eyes gained 2 to 3 lines, 5 (15.6%) eyes gained 4 to 5 lines, and 3 (9.4%) eyes gained 6 to 7 lines of UCVA; no eyes lost lines of UCVA (Fig 3). Postoperatively, BSCVA remained the same in 9 (28.1%) eyes. Twelve (37.5%) eyes gained 1 line, 4 (12.5%) eyes gained 2 to 3 lines, 5 (15.6%) eyes gained 4 to 5 lines, and 1 (3.1%) eye gained 8 lines of BSCVA; 1 (3.1%) eye lost 1 line of BSCVA due to haze in the flap-stroma interface (patient 25) (Fig 4). None of the patients reported the presence of halos or glare.

Accommodative strabismus in two patients (patients 5 and 11) resolved after LASIK. In one patient (patient 22), strabismus surgery was recommended for the non-accommodative part of his esotropia. All other patients maintained orthophoria after refractive surgery.

In this study, 10 patients were 4 to 8 years old, whereas 22 patients were 9 to 15 years old. The preoperative mean visual and refractive data for these two groups of patients were not statistically significant. There also were no statistically significant differences between the two groups in postoperative outcomes, induced improvements in visual acuities, or changes in refractive errors, including the percentage deviations (P>.05).

DISCUSSION

The prevalence of amblyopia in children is estimated to range between 1% and 4%.[13] It has been reported that approximately 20% of the population with high refractive error develop legal blindness due to deep amblyopia.[14] Anisometropia is the etiologic factor in approximately 17% of the amblyopic cases,[13] in which a difference in refractive power greater than 2.00 D between fellow eyes suppresses binocular vision.[15]

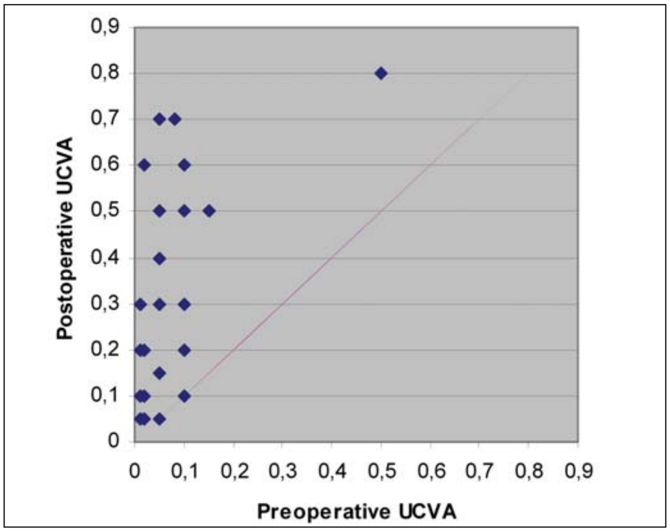

Figure 3. Scatterplot of postoperative versus preoperative uncorrected visual acuity (UCVA).

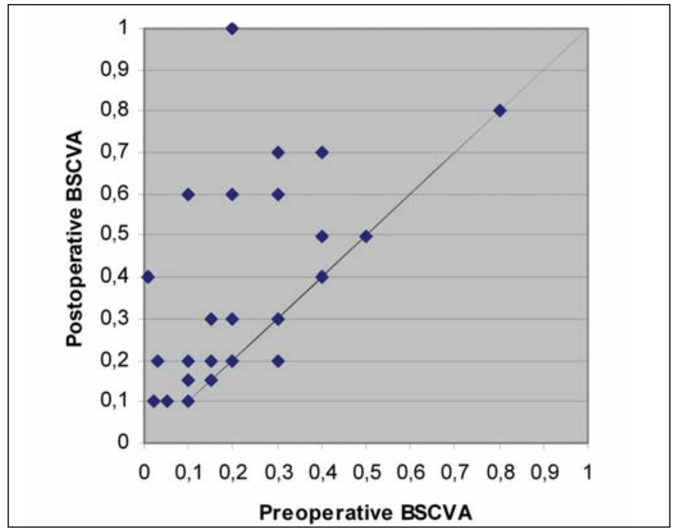

Figure 4. Scatterplot of postoperative versus preoperative best spectacle-corrected visual acuity (BSCVA).

Treatment modalities for anisometropic amblyopia include fitting the affected eye with spectacles or a contact lens, accompanied by patching or penalization of the sound eye. The success of the treatment depends on several factors, the most important of which are the amount of anisometropia, age and visual acuity level at the beginning of treatment, and patient compliance.

Refractive surgery in the pediatric and adolescent age groups has been used to correct primarily myopic anisometropia.[3-9] However, children with hyperopic anisometropia could be considered as candidates for refractive surgery because compliance with spectacles and contact lenses is often poor. One reason for this noncompliance could be that young hyperopic patients may not notice an improvement in visual acuity with correction unless the spherical equivalent refraction is at least +6.00 D, given their large accommodative response. Spectacles with lenses of different thicknesses induce changes in the image size and vertex distance of both eyes, and the differences of these in the fellow eyes lead to diplopia and optical aberrations. Additionally, social pressures hinder the acceptance of hyperopic spectacles by many children. Pediatric and adolescent patients often grow intolerant to contact lenses over time. Contact lenses also require frequent examinations, and if damaged or lost frequently, contact lens wear becomes expensive. Hyperopic anisometropic patients are more likely to develop deep amblyopia than myopic anisometropic patients, who have the advantage of effortless good near vision.

Hyperopic anisometropic children are likely to permanently maintain the hyperopic refractive difference between their two eyes.[16,17] Because hyperopia does not tend to progress through adolescence[17] and because even moderate amounts of hyperopia are well tolerated by children, the target refractive end point when treating hyperopes with excimer laser need not be emmetropia.[18] The goal of treatment is to achieve refractive symmetry to prevent the development of amblyopia and possibly reverse the condition.

Photorefractive keratectomy has been used to treat children with myopic[3-6] and hyperopic anisometropia.[3,19,20] Photorefractive keratectomy or laser epithelial keratomileusis (LASEK) may be easier to perform in the pediatric age group and would avoid risk of potential keratome-related problems. However, in children, increased tissue reactivity and a more aggressive healing response, which could theoretically manifest itself as corneal haze, might result in more scarring or regression. Additionally, those children with contact lens intolerance would not be able to wear a bandage contact lens after surgery. Furthermore, the severe postoperative pain would be poorly tolerated by this patient population.

Because of the issues of corneal haze formation, induced astigmatism, and regression, LASIK rather than PRK and LASEK has been considered for these patients. The potential advantages of LASIK over PRK include quicker visual rehabilitation and better predictability and stability in higher refractive errors. In addition, there is the potential for less haze due to an intact Bowman's layer, with haze reported to occur in zero to 8.7% of adult eyes after LASIK compared with up to 90% after PRK.[21-23] In the pediatric studies, the rate of haze formation was reported to be unexpectedly low, with 20% to 30% having trace haze, 10% to 20%

TABLE 3

Comparison of Mean Preoperative and Postoperative Findings for 32 Children With Hyperopic Anisometropic Amblyopia Who Underwent LASIK

	Preoperative	Postoperative	*P* Value
UCVA	0.06±0.09	0.27±0.23	<.001
BSCVA	0.20±0.17	0.35±0.25	<.001
Spherical equivalent refraction	5.17±1.65	1.39±1.21	<.001
Intended spherical equivalent refraction	–0.29±1.20	1.39±1.21	<.001

UCVA = uncorrected visual acuity, BSCVA = best spectacle-corrected visual acuity

having mild haze, and 60% having no haze formation at 12 months postoperatively.[4,6,19] Nevertheless, Alio et al[5] and Astle et al[6] have reported severe haze formation in pediatric eyes with high myopia. Hyperopic LASIK has been shown to be safe and effective in adults; however, only a few reports discuss the use of LASIK in children.[7,8,24,25] In our case series, we observed haze formation in only 3.1% of patients after pediatric hyperopic LASIK.

Cobb et al[26] demonstrated the age at presentation for children with anisometropic amblyopia appears to have no significant effect on the final visual acuity; therefore, children with anisometropic amblyopia should be treated regardless of age. Given this information, we performed LASIK surgery in all patients in whom amblyopia treatment was unsuccessful or anisometropic refractive correction was intolerable. Although better management of amblyopia is expected in younger children, we did not find any difference in the refractive and visual improvements in patients older than 8 years compared with those who were younger.

The amount of anisometropia that should be present for refractive surgery has been defined as 1.50 to 6.00 D.[8,20,27,28] In our case series, we included all patients who had greater than 2.00-D difference between fellow eyes and were spectacle or contact lens intolerant because a 2.00-D difference is known to be a cause of anisometropic amblyopia.

Although LASIK was performed on 50 eyes of 50 pediatric patients with hyperopic anisometropia at our clinic, only 32 eyes with close follow-up were included in this study. The remaining 18 patients had been referred to our clinic from other cities and subsequently were lost to follow-up. They did not have any surgical or postoperative complications, or poorer outcomes. We believe this did not introduce a bias in the overall statistics of this study.

The excimer laser procedure has some differences in children compared to adults. Poor cooperation and inattention by pediatric patients during refractive surgery can lead to increased optical decentration. Eye-tracking systems can improve centration to a certain extent yet still require cooperation with fixation on the fixation target. Allowing the parents to enter the operating room and be in communication with children during surgery may be a helpful strategy in calming young patients and having them obey the surgeon's instructions.

In younger children who cannot fixate cooperatively, surgery must be performed under sedative anesthesia. However, cyclotorsion of the eye would change the efficacy of the astigmatic correction. The Paysse study group tried to overcome this problem by having the surgeon manually center the ablation zone on the entrance pupil and two side observers monitor the position of the eye throughout the laser procedure.[29] To avoid a decentered ablation, we used the low vacuum mode setting of the suction ring as described previously.[30] This enables the surgeon to maintain full control of the globe after the flap is created. With the low vacuum mode, intraocular pressure is raised only to 40 mmHg so the retinal vasculature is assumed to be uncompromised. Additionally, we marked the conjunctiva vessels preoperatively and used the markings for orienting the eye under the laser beam.

We used Moria CB and M2 microkeratomes and the IntraLase femtosecond laser to create a flap with a large diameter (⩾9 mm) for peripheral ablation in the largest possible optical zone. Also, because pupils tend to be larger in children than in adults, larger optical zones may be preferred to avoid glare and halos. Still, with a relatively small optical zone of 5 mm without custom surgery, our patients did not complain of glare or halos. Additionally, a large-diameter flap with the edges close to the limbus would allow faster flap healing. Bandage contact lenses can help protect the flap in the early postoperative period but do not provide any guarantee if patients rub their eye or if any ocular trauma occurs. However, Drack et al[27] reported flap dislocation does not affect the refractive outcome as long as the child receives proper medical attention and readily has the flap repositioned.

No intraoperative complications were encountered in this study. In children who underwent LASIK, various flap and interface complications including epithelial ingrowth, Bowman wrinkles, diffuse lamellar keratitis, and haze have been reported postoperatively.[31] We encountered minimal flap striae in two eyes (patients 2 and 3), which were optically and visually insignificant. The low incidence of postoperative flap complications in the pediatric population has been explained by more stable corneal flaps as the result of a stronger endothelial pump mechanism.[30]

In the young patient population, haze formation and excessive inflammation as a result of the disruption of Bowman's layer is another concern, even in LASIK. However, because of the temporary elevation and subsequent replacement of Bowman's layer in LASIK, postoperative haze formation is not frequently seen. Agarwal et al[8] have reported pediatric cases with diffuse haze in the flap-stroma interface, which is not normally seen in adults, but not visually significant. We did see haze formation in 1 eye (patient 25); this eye lost 1 line of BSCVA.

The preoperative mean keratometric value ranged from 38.44 to 45.16 D. During excimer laser treatment, attention was paid so as not to increase the mean keratometric value greater than 50.00 D because steep keratometric values may be associated with increased optical aberrations and reduced visual quality. At the last follow-up, the mean keratometric value ranged from 41.05 to 48.69 D.

Laser in situ keratomileusis also has been considered for the management of accommodative hyperopic esotropia and unilateral myopic exotropia. It has been reported that the accommodative component should be treated and, with the resolution of ammetropia, orthophoria could be reached.[32,33] In our case series, one patient (patient 24) had undergone previous surgery for esotropia at another clinic and had mild exotropia (Hirschberg 30°) before LASIK. The laser correction of the hyperopic eye did not increase the exodeviation in his eye. Preoperatively, three patients had accommodative esotropia. Postoperatively, strabismus surgery was recommended for one of these patients (patient 22) for the nonaccommodative part of his esotropia; in the other two patients (patients 5 and 11), the accommodative esotropia was relieved.

The most important aspect of hyperopic pediatric LASIK seems to be the unpredictable nature of the result. In their high hyperopic case series of patients aged 9.1 to 18.8 years, Phillips et al[10] had no overcorrections but reported the mean undercorrection was 34%±17%. In our study, we observed overcorrections of 16.7% and 38.2% in 2 cases, whereas in 29 of the cases, mean undercorrection at last follow-up was 33.5%±17.6%. Inadequate cycloplegia provided by diluted cyclopentolate to avoid adverse physiologic effects in children could be considered a factor in undercorrection. According to our clinical observations, the undercorrections noted at the last follow-up examination were predominantly primary undercorrections because the corneal response to laser correction greater than +4.00 hyperopia seems to be unpredictable. Additionally, however, we observed approximately 20% of these cases developed refractive regression during follow-up.

The high variability inherent in high hyperopic LASIK has been described by Goker et al[34] in an adult population. This variability could be easily understood through the corneal reshaping physics in myopic and hyperopic LASIK techniques. Unlike myopic LASIK, which directly flattens the cornea, hyperopic LASIK is destined to create a flat blend zone to indirectly steepen the central cornea. The width of the epithelial gap and healing defect is more obvious in hyperopic LASIK, which demonstrates the inherent variability of the response of the hyperopic LASIK operation. The creation of nomograms designed specifically for children is desirable to improve the precision of pediatric refractive surgery. Additionally, possible alterations of the emmetropization by pediatric refractive laser surgery also should be taken into account.

Laser in situ keratomileusis appears to provide a safe method of refractive surgery in selected children with hyperopic anisometropia. Nevertheless, parents should be given detailed information about the unpredictable nature of the results due to the variability inherent to the hyperopic LASIK procedure. Longer term follow-up in a detailed study protocol is necessary to determine whether pediatric refractive surgery is safe over the life span.

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