Corneal indices following photorefractive keratectomy in children at least 5 years after surgery

Radha Ram, MD,[a,b] Terry Kang, MD,[a,b] Mitchell P. Weikert, MD,[a] Lingkun Kong, MD, PhD,[b] David K. Coats, MD,[a,b] and Evelyn A. Paysse, MD[a,b]

PURPOSE To evaluate long-term corneal outcomes in pediatric patients who underwent photorefractive keratotomy (PRK) for the treatment of refractive amblyopia.

METHODS In this prospective interventional case series, children with refractive amblyopia underwent PRK between January 1, 2007, and December 31, 2011, at Texas Children's Hospital's Department of Ophthalmology, a single tertiary eye center, and were followed for at least 5 years after surgery. Main outcome measures were 5+ years postoperative indices of corneal thickness, keratometry, degree of corneal haze, and presence or absence of keratectasia.

RESULTS Twelve eyes of 8 subjects aged 3-9 years who underwent PRK and were followed for at least 5 years were included. The mean PRK treatment dose was 8.46 D for the myopic cohort and 4.49 D for the hyperopic cohort, which removed an average of 72 μm of corneal stromal tissue in addition to the 50 μm of corneal epithelium that was removed prior to laser ablation. The mean corneal thickness was 563 μm preoperatively, which decreased to 441 μm immediately following the PRK. The mean corneal thickness 5+ years after PRK was stable, at 498 μm, because of epithelial regrowth. None of the subjects developed visually significant corneal haze or topographic evidence of keratectasia.

CONCLUSIONS In this study cohort, there were no topographic signs of keratectasia or corneal haze in children treated with PRK for high refractive error 5 years or more after surgery. (J AAPOS 2019;23:149.e1-3)

Most children with refractive amblyopia can be treated safely and adequately with spectacles, contact lenses, patching, or pharmacologic penalization. When conventional therapy fails, alternative treatment options may be considered to prevent permanent visual impairment. Following the success of modern refractive surgery in adults, ophthalmologists began investigating the use of refractive surgery in children who were noncompliant or nonresponsive to traditional amblyopia therapy. There have been reports of improvement in vision in the near term and mid-term in this population. Laser in situ keratomileusis (LASIK), photorefractive keratectomy (PRK), and laser epithelial keratomileusis (LASEK) have shown promising near-term results.[1]

Author affiliations: [a]Department of Ophthalmology, Baylor College of Medicine, Houston, Texas; [b]Department of Ophthalmology, Texas Children's Hospital, Houston, Texas

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Correspondence: Evelyn A. Paysse, MD, 6701 Fannin, MD 610.25, Houston, TX 77030 (email: eapaysse@texaschildrens.org).

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We previously reported that PRK can reduce refractive error and improve visual acuity in children with high refractive error associated with moderate-to-severe amblyopia nonresponsive to standard therapy with follow-up of at least 3 years.[2] Although prior studies have discussed the long-term visual outcomes of pediatric PRK,[2-4] no study has investigated the long-term corneal outcomes after PRK in these children. The purpose of this study was to evaluate long-term corneal indices in children treated with PRK. Main outcome measures were postoperative indices of corneal thickness, keratometry, degree of corneal haze, and presence or absence of keratectasia at 5+ years.

Subjects and Methods

This prospective interventional case series investigating the long-term corneal outcomes following PRK in children with amblyopia and severe anisometropia or isoametropia at a single hospital was approved by the Institutional Review Board of Baylor College of Medicine. Written parental informed consent was obtained for all participants. Eight children aged 3-9 years were included. Inclusion criteria were as follows: (1) PRK at least 5 years previously for moderate to severe refractive amblyopia nonresponsive to standard therapy due to anisometropia of at least 3 D, severe

isoametropia and myopia in the amblyopic eye(s) of at least 6 D, or severe isoametropia and hyperopia in the amblyopic eye(s) of at least 4 D; and (2), the ability to participate in biometry assessments using the IOL Master 500 (Carl Zeiss Meditec Inc, Jena, Germany) and corneal topographic assessment using the Atlas 9000 (Carl Zeiss Meditec Inc). Children with corneal, lenticular, and macular abnormalities were excluded prior to having PRK.

The refractive target for PRK was emmetropia or the highest refractive error reduction that could be achieved while maintaining adequate treatment safety. The details of the refractive surgical procedure and postoperative medications were reported previously.[5,6] Briefly, all children underwent PRK using the VISX Star S2 excimer laser (VISX Inc, Santa Clara, USA) under general anesthesia. Treatment safety was based on VISX FDA-approved limits in adults and a minimal residual corneal thickness of at least 375 μm. Of note, post PRK topical mitomycin C was not used in these subjects.

Postoperatively, the children were examined 5-7 days after the PRK. They were then examined 1 month postoperatively, every 3 months for 12 months, and then yearly for at least 5 years. Data that were analyzed included preoperative and postoperative (5+ years) best-corrected visual acuity, cycloplegic refraction, pachymetry, keratometry, axial length, presence and/or degree of corneal haze, and qualitative corneal shape. Postoperative subepithelial corneal haze was graded on a scale of 0 to 4+ (0, clear cornea; 1+, trace haze, only detectable with tangential illumination; 2+, mild, discrete haze visible by focal illumination; 3+, moderately dense opacity partially obscuring iris detail; 4+, dense opacity obscuring details of intraocular structures). Visual acuities were converted to a logMAR scale to facilitate data analysis. Statistical calculations were performed using SPSS statistical software (SPSS Inc) and Microsoft Excel.

Results

A total of 12 eyes of 8 subjects were included. Ten eyes had high myopia, and 2 had high hyperopic astigmatism. Mean age at surgery was 5.7 years (range, 3-9 years). Mean duration of follow-up was 6.5 ± 1.26 years (range, 5-9). Mean preoperative spherical equivalent refractive error was −10.26 D (range, −13.00 to −6.25 D) in the myopic group and +5.62 D (range, +5.25 to +6.00 D) in the hyperopic group. For the cumulative refractive data recorded from each patient's last examination, the mean postoperative spherical equivalent refractive error was −2.75 D (range, −8.38 to +1.25 D) in the myopic group and +2.50 D (range, +2.50 to +2.50) in the hyperopic group (Figure 1). Mean best-corrected visual acuity prior to PRK was logMAR 0.99 (about 20/200 Snellen); mean 5+ years postoperative best-corrected visual acuity was 0.628 (about 20/80 Snellen). Mean central corneal thickness for the myopic cohort was 557 μm (range, 521–609 μm) immediately before PRK and 479 μm (range, 404–540 μm) at final examination; for the hyperopic cohort, mean central corneal thickness was 582 μm (range, 581–583 μm) immediately before PRK and 586 μm (range, 563–610 μm) at final examination. The

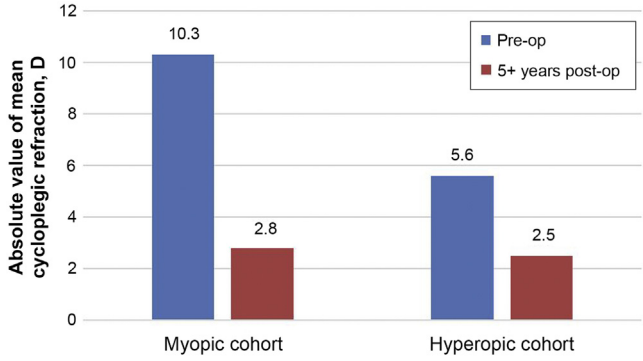

FIG 1. Change in mean cycloplegic refraction in the myopic and hyperopic cohorts.

average axial length was 24.30 mm preoperatively and 25.30 mm at the final examination (Table 1). None of the subjects had corneal haze or topographic evidence of keratectasia at final follow-up.

Discussion

This is the first report on the long-term effect of PRK on the corneas of pediatric patients. This study found that refractive error correction was sustained, corneal thickness remained stable, no corneal haze developed, and no keratectasia was encountered 5 or more years after PRK.

The literature regarding haze and keratectasia after refractive surgery in children is scarce. The incidence of keratectasia following PRK is rare in adults. Leccisotti[7] reported a 0.03% incidence when examining 6,453 myopic adults. Another study reported 0% after 15 years in 33 adults with high myopic treatments up to 10 D.[8] Each case of ectasia in Leccisotti's study[7] had at least one of the following predisposing factors: keratoconus, forme fruste keratoconus, low preoperative pachymetry, or deep ablation. Prognosis varied depending on severity.[7] Although many of our patients had deep ablations, none developed ectasia over the duration of the study. All the patients will continue to be monitored to determine the lifetime risk of ectasia in this cohort of patients.

Higher excimer laser treatment doses have been associated with greater risk of keratectasia and more severe corneal haze.[9] The risk of keratectasia is much higher with LASIK than PRK.[10] PRK, on the other hand, is associated with a higher risk of corneal haze than LASIK.[11] Children who need refractive surgery typically have very high refractive errors and need large treatment doses. Due to risks associated with LASIK flaps in children including flap dislocation, striae, diffuse lamellar keratitis, as well as the increased risk of keratectasia associated with LASIK, PRK was the chosen treatment modality for our group, despite its increased risk of corneal haze. None of the children in our cohort showed any corneal haze or topographic evidence of keratectasia at their final follow-up examination at 5+ years.

Table 1. Baseline and long-term refractive and corneal indices of subjects who underwent PRK

		Age		Spherical equivalent		Visual acuity		Axial length[a]		Pachymetry[a]		Topography[a]			
												Pre-op		5+ years post-op	
Subject	Surgical eye	At surgery	At last follow −up	Pre-op	5+ years post-op	Pre-op	5+ years post-op	Pre-op	5+ years post-op	Pre-op	5+ years post-op	K1	K2	K1	K2
1	L	9	15	−12.63	−5.00	0.80	0.30	27.13	27.82	609	510	44.50	46.00	39.85	40.08
2	R	8	14	−13.00	−6.00	1.53	1.11	26.64	28.52	588	—	42.75	44.50	36.1	37.01
3	R	6	14	+5.25	+2.50	F/F	F/F	—	20.61	581	610	—	—	—	—
	L			+6.00	+2.50	F/F	F/F	—	—	583	563	—	—	45.61	48.49
4	R	5	11	−9.75	+1.25	0.67	0.30	24.44	24.70	571	473	44.50	47.00	36.41	38.18
	L			−7.25	+0.50	0.50	0.10	23.92	24.21	559	475	44.50	47.00	37.79	38.79
5	L	3	10	−13.00	−8.38	F/F	F/F	20.40	21.74	538	540	43.00	47.25	—	—
6	R	3	7	−6.25	−3.25	1.68	0.80	21.79	23.00	554	510	46.25	50.25	42.08	43.89
	L			−7.00	−2.50	1.68	0.00	21.81	23.00	558	519	46.25	50.25	40.71	42.67
7	R	7	12	−11.50	−1.88	F/F	0.40	24.34	26.41	521	404	47.75	50.75	43.21	44.18
	L			−10.50	−1.88	F/F	0.48	25.24	25.61	523	437	47.75	50.75	42.51	44.94
8	L	7	14	−11.75	−0.63	F/F	1.24	28.64	29.90	546	440	40.50	43.00	37.20	35.74

F/F, fix and follow.
[a]A dash indicates that data was unobtainable.

As would be expected in growing, children's eyes, axial lengths increased in all eyes over the 5+ years of follow-up. This likely contributed to some of the myopia recurrence. Another factor contributing to the residual myopia was that myopia was not completely corrected due to higher refractive error and corneal thickness limitations. Also, there might have been some true regression.[6] The residual hyperopia in the hyperopic patients is also unsurprising, because the aim was to reduce the refractive error while maintaining adequate treatment safety. Because centration can be challenging with excimer laser procedures performed under general anesthesia, slight decentration of the laser may have contributed to the residual hyperopia and may explain the increase in the central corneal thickness in patient 3 (Table 1) as well.

This study is limited by the small sample size. Patients had to be able to undergo biometry and corneal topography at 5+ years after PRK, and both tests require a high degree of cooperation to obtain accurate results. Although we had many patients who underwent PRK at least 5 years before the current study was undertaken, many were unable to cooperate for both tests and had to be excluded. The inability of the child to cooperate for testing typically was related to the child's neurologic status: many children we have treated also have neurodevelopmental disorders and cognitive disabilities. Despite the limitations, our results suggest that corneal thickness, corneal topography, and keratometry remain stable in the long term in children after PRK and that the risk of keratectasia following PRK in appropriately selected children is extremely low.

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