Objective: To evaluate the refractive outcomes of 3-port lens-sparing vitrectomy (LSV) for subtotal retinal detachments owing to retinopathy of prematurity.

Methods: The study included 9 infants who had undergone complete ablative laser treatment for threshold retinopathy of prematurity in both eyes, subsequently developed stage 4A retinal detachment in 1 eye for which they underwent LSV, and maintained complete retinal attachment bilaterally. Eyes that underwent LSV were compared with fellow eyes. Cycloplegic refraction was performed, and corneal curvature, axial length, lens thickness, lens position, and anterior chamber depth were measured.

Results: Significantly less myopia was present in eyes that had undergone LSV compared with control eyes (mean spherical equivalent, −6.78 vs −10.33 diopter [D]; P < .001). The reduced myopia in LSV eyes was predominantly owing to increased anterior chamber depth (mean, 3.81 vs 2.96 mm; P < .001) and a more posterior position of the lens (mean, 5.58 vs 4.63 mm; P < .001). There was a minor contribution from reduced corneal power in LSV eyes (mean, 43.90 vs 44.20 D; P = .02). There was no significant difference in axial length, lens thickness, or lens power between LSV and control eyes.

Conclusions: Infant eyes undergoing 3-port LSV for stage 4A retinopathy of prematurity develop less myopia than fellow eyes treated with ablative laser alone. The difference is owing to posterior displacement of the lens, with a smaller contribution from reduced corneal power. The reduction in myopia may explain the excellent functional outcomes following 3-port LSV for stage 4A retinopathy of prematurity.


LENS-SPARING VITRECTOMY (LSV) for retinal detachment related to stage 4A retinopathy of prematurity (ROP) leads to anatomic success in 75% to 90% of eyes, while lens clarity is preserved in 81% to 100% of eyes. Although LSV was originally performed using 2 ports (with an infusing light pipe), it has been shown that a 3-port vitrectomy (using a 2.5-mm infusion) leads to similarly excellent anatomic outcomes, preservation of lens clarity, and improved visual outcomes while avoiding some of the difficulties encountered when switching hands and with sclerotomy closure using 2-port vitrectomy. The mean visual acuity is approximately 20/60 in eyes that have undergone successful LSV for retinal detachment related to stage 4A ROP in patients with 31/2 years of follow-up whose neurologic abnormalities did not preclude formal visual acuity testing.

Little is known about the refractive outcomes of LSV for ROP. The present study examines the refractive outcomes of LSV for retinal detachment related to stage 4A ROP.

METHODS

This was a retrospective case-control study of consecutive infants who underwent LSV by one of us (E.R.H.) at a single academic center who met the inclusion or exclusion criteria. Institutional review board approval was obtained, and the study complied with Health Insurance Portability and Accountability Act regulations.

The medical records of 102 patients who underwent LSV for ROP-related retinal detachment between February 1, 1998, and January 31, 2004, were reviewed. Study inclusion criteria were previous complete ablative laser treatment for threshold ROP in both eyes, subsequent LSV in 1 eye only for vascularly inactive stage 4A traction retinal detachment, and maintenance of complete retinal attachment bilaterally. The main outcome variables were cycloplegic refraction, keratometry, and A-scan values for axial length, lens thickness, lens position, anterior chamber depth, and anterior segment depth.

Eyes with subtotal macula-sparing detachment (stage 4A) were identified by indirect fun-
duscoppy before surgery by the surgeon (E.R.H.). Contralateral eyes were also examined to exclude retinal detachment. Primary standard 3-port LSV in eyes with stage 4A retinal detachment was performed in all patients by a single surgeon (E.R.H.).

The surgical technique has been previously described in detail. Briefly, following standard conjunctival opening for a 3-port vitrectomy, a single sclerotomy is created 1 mm posterior to the limbus in the inferotemporal quadrant by inserting a 2.5-mm 20-gauge infusion cannula, secured with 7-0 polyglactin suture, and turned on to the anterior chamber being deeper by a mean of 0.85 mm in LSV eyes (P < .001); anterior chamber depth correlated strongly with cycloplegic refraction for LSV eyes and for fellow eyes (Figure 2). There was a small contribution (0.40 D) from significantly less steep corneal curvature in LSV eyes compared with fellow eyes (P = .02). Axial length, lens thickness, and lens power were not significantly different between LSV eyes and fellow eyes (P = .43, P = .46, and P = .46, respectively).

Minimum postoperative follow-up included at least 1 clinic visit per month for 6 months and then every 3 to 6 months thereafter. All eyes were examined by the surgeon at each postoperative visit. Before dilation, ocular biometric data (A-scan; Carl Zeiss Ltd, Welwyn Garden City, England) were obtained on both eyes of all patients. Cycloplegic refraction was obtained using streak retinoscopy 30 minutes following administration of 1% cyclopentolate hydrochloride ophthalmic solution.

Ours was a retrospective study with no prior data available for sample size estimation. The data were examined using the skewness and kurtosis test for normality described by D’Agostino and Berry and did not deviate from normality. We conservatively consider that use of paired t test is best reserved for successive measurements on the same eye; therefore, the unpaired t test was used. P < .05 was considered statistically significant.

## RESULTS

Nine patients (5 boys and 4 girls) met the study inclusion criteria. The mean age at biometric testing was 3.9 years (age range, 2.3-4.3 years). The right eye had been the operative eye in 5 of 9 patients. The mean cycloplegic retinoscopy and ocular biometric data are given in the Table. On average, eyes that had undergone LSV had approximately 3.50 diopter (D) (range, 2.50-5.25 D) less myopia than fellow eyes (P < .001) (Figure 1). This was predominantly owing to the anterior chamber being deeper by a mean of 0.85 mm in LSV eyes (P < .001); anterior chamber depth correlated strongly with cycloplegic refraction for LSV eyes and for fellow eyes (Figure 2). There was a small contribution (0.40 D) from significantly less steep corneal curvature in LSV eyes compared with fellow eyes (P = .02). Axial length, lens thickness, and lens power were not significantly different between LSV eyes and fellow eyes (P = .43, P = .46, and P = .46, respectively).

## COMMENT

Eyes of premature infants have shallower anterior chambers and steeper corneal curvatures than those of term infants, which offsets shorter axial lengths and leads to

<table>
<thead>
<tr>
<th>Table. Comparison of Clinical Outcomes for LSV Eyes and Fellow Eyes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mean (SD)</strong></td>
</tr>
<tr>
<td>------------------------</td>
</tr>
<tr>
<td>Cycloplegic refraction, D</td>
</tr>
<tr>
<td>Anterior chamber depth, mm</td>
</tr>
<tr>
<td>Lens thickness, mm</td>
</tr>
<tr>
<td>Lens power, D</td>
</tr>
<tr>
<td>Axial length, mm</td>
</tr>
<tr>
<td>Keratometry, D</td>
</tr>
<tr>
<td>Cycloplegic refraction, D</td>
</tr>
<tr>
<td>Anterior chamber depth, mm</td>
</tr>
<tr>
<td>Lens thickness, mm</td>
</tr>
<tr>
<td>Lens power, D</td>
</tr>
<tr>
<td>Axial length, mm</td>
</tr>
<tr>
<td>Keratometry, D</td>
</tr>
</tbody>
</table>

Abbreviations: D, diopter; LSV, lens-sparing vitrectomy.
myopic refractive errors. Retinopathy of prematurity confers additional risk for the development of myopia, with increasing ROP severity leading to greater incidence and degree of myopia. Evidence suggests that higher myopia associated with ROP is predominantly owing to increased lenticular power and thickness and decreased anterior chamber depth. Cryopexy or laser ablation may not increase the risk of myopia after controlling for the severity of ROP.

Our results demonstrate that LSV eyes develop significantly less myopia (mean, 3.50 D) compared with fellow eyes, despite the more severe stage of ROP in LSV eyes. A similar result was incidentally presented in a 2004 case report of visual outcomes following LSV. An infant treated with diode laser for threshold ROP bilaterally subsequently underwent 2-port LSV for unilateral progressive 4A retinal detachment and had a refractive spherical equivalent of −6.25 D in the LSV-treated eye and −9.75 D in the fellow eye at 3 1/4 years of follow-up.

Furthermore, our data show that LSV eyes have less myopia predominantly because of increased anterior chamber depth owing to a more posterior position of the lens (mean, 5.58 vs 4.63 mm; P < .001), leading to less effective power. Fellow eyes in our study had anterior chamber depths (mean, 2.96 mm) similar to those in a previously published cohort of treated ROP eyes (mean, 2.80 mm). In contrast, our LSV-treated eyes had anterior chamber depths (mean, 3.81 mm) deeper than those previously published for a cohort of full-term infants (mean, 3.54 mm).

Our results can be explained by a direct mechanical effect of LSV. Removal of the infant vitreous may allow the lens to move posteriorly. Similarly, the observed corneal flattening may be owing to a lasting effect of the scleral sutures; comparison with eyes undergoing sutureless small-gauge LSV may support this hypothesis in the future. Alternatively, LSV may “unblock” anterior segment development that occurs with ROP and allow normal deepening of the anterior chamber and flattening of the cornea to proceed. Unblocking could result from allowing increased diffusion of factors to the anterior segment or simply by washing out a reservoir of signaling factors from the vitreous.

The favorable refractive outcomes may partially explain the excellent visual outcomes following LSV for stage 4A ROP beyond anatomic success, which can also be achieved with scleral buckling or vitrectomy-lensectomy. Scleral buckling for ROP results in high myopia (mean, −22 D in 1 series), which often improves by about 5 D following sectioning of the buckle. Such high myopia may lead to ametropic and anisometropic amblyopia. Vitrectomy-lensectomy, which is generally reserved for stage 4B (and selected stage 5) ROP leads to aphakia and commonly amblyopia, with documented worse visual outcomes than LSV for stage 4B ROP.

Our study has a few potential limitations. First, lacking randomized allocation to treatment, unknown confounders may have contributed to the apparent effect of treatment type; however, we would expect that worse ROP in the treatment eye would have led to greater myopia. Second, our sample size was limited; however, this information is unimportant because the results are statistically significant and increased sample size would not add strength to our statistical analysis. Third, measurements were obtained at a single time point in a child’s development. Additional time points and different ages would provide evidence as to whether the differences observed are maintained or change as children age and grow. Most ocular growth is complete by age 3 years, and the mean age at last follow-up was 32 months in this study, but biometrics may continue to change in the setting of ROP.

In conclusion, the data suggest that infant eyes undergoing 3-port LSV for stage 4A ROP develop less myopia than fellow eyes treated with ablative laser alone. This difference in refraction occurs mainly because of increased anterior chamber depth owing to a more posterior position of the lens in the LSV group.

Submitted for Publication: August 15, 2009; final revision received November 14, 2009; accepted November 25, 2009.

Correspondence: Eric R. Holz, MD, Retina and Vitreous of Texas, 2727 Gramercy St, Ste 200, Houston, TX 77025 (eric@retinanetexas.com).

Author Contributions: Drs Carvounis, Poll, Lakhanpal, and Holz had full access to all the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis.

Financial Disclosure: None reported.

Funding/Support: This study was supported by an unrestricted educational grant from Research to Prevent Blindness.

Previous Presentations: This study was presented at the Retina Congress 2009 New York; October 2, 2009; New York, New York.

Additional Information: The manuscript was based on a thesis prepared in partial fulfillment of the requirements for membership in the American Ophthalmological Society and published in Transactions of the American Ophthalmological Society in 2009. Dr Carvounis has worked as a consultant for Alcon Inc on issues not related to the subject of this study.

REFERENCES


