Objective: To assess lens clarity after 3-port lens-sparing vitrectomy for stages 4A and 4B tractional retinal detachment secondary to retinopathy of prematurity.

Methods: In a retrospective, interventional, consecutive clinical case series, 108 eyes of 102 patients who underwent lens-sparing vitrectomy for stages 4A and 4B tractional retinal detachment from February 1, 1998, through January 31, 2004, were reviewed. All procedures and follow-up examinations were performed by a single surgeon. Lens clarity was assessed at the final follow-up examination.

Results: Of the 108 eyes reviewed, 102 (94.4%) maintained clear lenses at the final follow-up examination, which ranged from 6 to 48 months (mean, 32 months) after the procedure. Thirty-two eyes had stage 4A detachments and 76 eyes had stage 4B.

Conclusions: Three-port lens-sparing vitrectomy may be performed with relatively low risk of cataract formation during the early postoperative period. Maintenance of a clear crystalline lens during the critical period of visual development may lead to better functional outcomes.

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LENS-SPARING VITRECTOMY (LSV) directly addresses tractional forces in retinopathy of prematurity (ROP) detachments and may improve visual rehabilitation after surgery by reducing the risks of aphakic deprivation or anisometric amblyopia after vitrectomy/lensectomy and scleral buckle procedures, respectively. Although aphakia management has improved considerably, amblyopia risks persist, and aphakia management remains a time-consuming task for the parents, patient, and pediatric ophthalmologist. Although scleral buckle procedures do not affect the crystalline lens, anisometric management is often required if only 1 eye undergoes the procedure, and a secondary dividing procedure is required as well. Also, some contend that scleral buckle procedures may not directly address tractional forces as well as LSV does. Maguire and Trese originally described the LSV technique as a 2-port, pars plicata approach wherein the instruments are inserted parallel to the visual axis, thus sparing the infantile crystalline lens. Ferrone et al reported an incidence of cataract formation of 15% in a series of eyes undergoing LSV that used that technique. In our series, we report the incidence of lens clarity using a 3-port LSV procedure specifically for stages 4A and 4B tractional retinal detachments (TRDs) secondary to ROP.

METHODS

Institutional review board approval to review patient data was obtained for this study. We retrospectively reviewed a consecutive case series of 108 eyes in 102 patients who underwent 3-port LSV performed by a single surgeon (E.R.H.) from February 1, 1998, to January 31, 2004, for stage 4A or 4B ROP-related TRD without lens-retina apposition that precluded anterior vitreous removal. The main outcome measure was lens clarity at the final follow-up visit.

PRESURGICAL EXAMINATION

Before vitreous surgery, both eyes of each infant were examined. Oftentimes, before surgery on the more involved eye (often advanced stage 4B or stage 5), the eye with the less severe but progressive TRD underwent vitrectomy.

Infants were examined either at the bedside or in the outpatient clinic. Eyes with progressive stage 4A or 4B TRD were identified. Stage 4A TRD was defined as detachment of the retina threatening, but not yet involving,
the macula. Stage 4B TRD was defined as detachment of the retina involving the macula. The zone of disease was determined according to examination results before the laser treatment and was defined according to the Multicenter Trial of Cryotherapy for Retinopathy of Prematurity. Examination with the patient under anesthesia and surgery were performed within 48 hours of the initial examination. At the time of the procedure, a dilated fundus examination was performed on both eyes in every case. All eyes that underwent surgery were vascularly fused. If retinal breaks were noted during the procedure, only balanced salt solution (BSS; Alcon Surgical, Fort Worth) was infused. If retinal breaks were noted during the procedure, only balanced salt solution (BSS; Alcon Surgical, Fort Worth) was infused.如果 retinal breaks were noted during the procedure, only balanced salt solution (BSS; Alcon Surgical, Fort Worth) was infused. Intraocular scissors were occasionally used, particularly to begin dissection of the anterior trough. Layers of sheetlike vitreous membranes were dissected sequentially approaching the retina. The posterior hyaloid face was often nondissolvable and could not be removed. The ridge often could be trimmed but not fully excised without creating retinal breaks. A thorough peripheral retinal examination with scleral depression was then performed. If no retinal breaks were noted during the procedure, only balanced salt solution (BSS; Alcon Surgical, Fort Worth) was infused. If retinal breaks were noted during the procedure, only balanced salt solution (BSS; Alcon Surgical, Fort Worth) was infused. 为确保手术的安全性，通常会使用梯度凝胶镜，这样可以放大视网膜的前部。如果气泡或14%全氟丙烷未用于保持气泡，则气体不会与视网膜后部接触。因此，特别是在视网膜切割前，必须确保短刀充分穿透 pars plana.

**Surgical Technique**

The surgical technique involved a standard conjunctival opening for a 3-port vitrectomy, followed by a single sclerotomy placed 1 mm posterior to the limbus in the inferotemporal quadrant. The microvitrectomy blade incision path was vertical and was advanced only until the widest portion of the blade cut the pars plicata epithelium to avoid damaging the retina immediately behind the sclerotomy. A 7-0 polyglactin 910 suture was then placed across the sclerotomy, followed by insertion and tying in place of a 2.5-mm, 20-gauge infusion cannula. Support

### Table 1. Demographic Characteristics of Eyes Undergoing 3-Port LSV for Stages 4A and 4B TRDs Secondary to ROP

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Total</th>
<th>Stage 4A</th>
<th>Stage 4B</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of eyes/No. of patients</td>
<td>108/102</td>
<td>32/31</td>
<td>76/71</td>
</tr>
<tr>
<td>Gestational age, mean (range), wk</td>
<td>26 (22-28)</td>
<td>26 (23-27)</td>
<td>25 (22-28)</td>
</tr>
<tr>
<td>Birth weight, mean (range), g</td>
<td>815 (485-1088)</td>
<td>885 (550-1088)</td>
<td>745 (485-1025)</td>
</tr>
<tr>
<td>Sex, No. of eyes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>62</td>
<td>21</td>
<td>41</td>
</tr>
<tr>
<td>Female</td>
<td>46</td>
<td>11</td>
<td>35</td>
</tr>
<tr>
<td>Age at surgery, mean (range), wk</td>
<td>40 (37-43)</td>
<td>39 (37-41)</td>
<td>40 (37-43)</td>
</tr>
<tr>
<td>Duration of follow-up, mean (range), mo</td>
<td>32 (6-48)</td>
<td>28 (6-42)</td>
<td>35 (9-48)</td>
</tr>
<tr>
<td>Zone of disease, No. of eyes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zone 1</td>
<td>20</td>
<td>6</td>
<td>14</td>
</tr>
<tr>
<td>Posterior zone 2</td>
<td>59</td>
<td>19</td>
<td>40</td>
</tr>
<tr>
<td>Anterior zone 1</td>
<td>29</td>
<td>7</td>
<td>22</td>
</tr>
<tr>
<td>Retinal tears-retinal detachments, No. (%) of eyes</td>
<td>5 (4.6)/2 (1.9)</td>
<td>1 (3)/0</td>
<td>4 (5)/2 (3)</td>
</tr>
<tr>
<td>Reoperation rate, No. (%) of eyes</td>
<td>3 (2.8)</td>
<td>0</td>
<td>3 (4)</td>
</tr>
</tbody>
</table>

*Abbreviations: LSV, lens-sparing vitrectomy; ROP, retinopathy of prematurity; TRDs, fractional retinal detachments.

*Stage 4A TRD indicates detachment of the retina threatening, but not yet involving, the macula; stage 4B TRD, detachment of the retina involving the macula.*

Three-port LSV was performed in all eyes. The patients’ demographic information is listed in Table 1. Three eyes (2.8%) underwent repeat LSV (all were stage 4B eyes), but only the first operation was counted for this study. All patients were followed up for a minimum of 6 months.
Table 2. Eyes That Developed Postoperative Cataracts

<table>
<thead>
<tr>
<th>Patient No.</th>
<th>Disease Stage</th>
<th>Time to First FU, wk</th>
<th>Preoperative Lens Status</th>
<th>Type of Cataract</th>
<th>Retina-Lens Apposition</th>
<th>Instrument-Lens Apposition</th>
<th>Lens Status of Fellow Eye</th>
<th>Tamponade Used</th>
<th>Lensectomy Performed</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4B</td>
<td>4</td>
<td>Clear</td>
<td>Cortical</td>
<td>N</td>
<td>Y</td>
<td>Clear</td>
<td>14% Perfluoropropane</td>
<td>Y</td>
</tr>
<tr>
<td>2</td>
<td>4B</td>
<td>8</td>
<td>Clear</td>
<td>Cortical</td>
<td>N</td>
<td>Y</td>
<td>Clear</td>
<td>SO</td>
<td>Y</td>
</tr>
<tr>
<td>3</td>
<td>4A</td>
<td>12</td>
<td>Clear</td>
<td>Cortical</td>
<td>Y</td>
<td>N</td>
<td>PL</td>
<td>14% Perfluoropropane</td>
<td>N</td>
</tr>
<tr>
<td>4</td>
<td>4B</td>
<td>12</td>
<td>Clear</td>
<td>PSC</td>
<td>N</td>
<td>Y</td>
<td>PL</td>
<td>None</td>
<td>Y</td>
</tr>
<tr>
<td>5</td>
<td>4B</td>
<td>96</td>
<td>Clear</td>
<td>Cortical</td>
<td>N</td>
<td>N</td>
<td>Clear</td>
<td>14% Perfluoropropane</td>
<td>N</td>
</tr>
<tr>
<td>6</td>
<td>4B</td>
<td>144</td>
<td>Clear</td>
<td>PSC</td>
<td>N</td>
<td>N</td>
<td>Clear</td>
<td>SO</td>
<td>Y</td>
</tr>
</tbody>
</table>

Abbreviations: FU, follow-up; N, no; PL, primary lensectomy; PSC, posterior subcapsular cataract; SO, silicone oil; Y, yes.

The range of follow-up was 6 to 48 months (mean follow-up, 32 months) (Table 1). In the stage 4A group, mean follow-up was 28 months (range, 6-42 months). Of these, 25 (78%) of the 32 eyes were followed up for at least 1 year and 19 eyes (59%) were followed up for at least 2 years. In the stage 4B group, the mean follow-up was 35 months (range, 9-48 months). Of these, 59 (78%) of the 76 eyes were followed up for at least 1 year and 48 eyes (63%) were followed up for at least 2 years.

The 6 eyes that developed cataracts after vitrectomy are listed in Table 2. The range of time after surgery until significant cataract development was 4 to 144 weeks (mean, 46 weeks). Four of the cataracts developed in the stage 4B TRD group. Four of the cataracts were cortical and 2 were PSCs. Four of the 6 cataracts that developed after LSV (both of the PSCs and 2 of the cortical cataracts) were removed because they involved the visual axis. The remaining 2 eyes had peripheral cortical changes and did not undergo lensectomy. Five of the 6 eyes required tamponade after vitrectomy: 3 that required 14% perfluoropropane infusion and 2 that required silicone oil. All 5 developed cataracts after LSV. The eyes that were treated with 14% perfluoropropane all developed cortical changes and 1 eye required lensectomy. One eye infused with silicone oil developed cortical changes and the other developed a PSC, but both required lensectomy.

Retina–crystalline lens apposition at surgery was noted in 2 (6%) of the 32 eyes in the stage 4A group and 7 (9%) of the 76 eyes in the stage 4B group. Instrument-lens apposition was noted in 3 (6%) of the 32 eyes in the stage 4A group and 9 (12%) of the 76 stage 4B eyes. Two eyes in the stage 4A group developed cataracts without instrument-lens apposition; 1 of these also had retina-lens apposition. Four eyes with stage 4B TRDs developed cataracts. None had retina-lens apposition but 3 had instrument-lens apposition. The 2 eyes that developed cataract changes without any apparent retina-lens apposition, or less trauma, were both infused with long-acting tamponade (one with 14% perfluoropropane, one with silicone oil).

There are numerous possible reasons for this. First, because of intrinsic anatomic limitations in technique, some residual vitreous (anterior hyaloid face) remains as a protective barrier against the posterior lens surface. Because little to no liquefaction has occurred, the gel may be a mechanical buffer or a diffusion barrier that limits lens injury. Second, the lens epithelium in infantile lenses may be able to better withstand metabolic, hydrostatic, and mechanical insult than that in adult lenses. Third, adult eyes have sustained more metabolic and light-induced damage, and thus are probably more susceptible to cataractous changes after vitrectomy. In our study, only 6 eyes (5.6%) developed cataractous changes and only 4 (3.7%) necessitated lensectomy due to impairment of the visual axis. Although no eyes were noted to have nuclear sclerosis postoperatively, small amounts of nuclear sclerosis may have been overlooked because of our assessment technique.

In the past, vitreous surgery for ROP was performed via an open sky or a pars plicata approach with lensectomy. The rationale was that the position of the infant crystalline lens precluded adequate access to the vitreous. Also, the pars plana is not fully developed until a corrected age of approximately 6 to 12 months.27,28 With the advent of LSV,1 management of postequatorial disease without the added benefit of avoiding crossing the midline during vitrectomy and membrane dissection, thus potentially avoiding lens trauma. The potential avoidance of transient hypotony may also have minimal but important effects on the chamber stability and view of the posterior segment throughout the procedure. Finally, closure may be facilitated with a potential lower risk of hypotony by closing the infusion line last, thus often negating the need to reinject soft eyes after closure with 2 sclerotomy sites.

All postoperative cataracts in the study were secondary to a known pathogenic mechanism: 3 eyes had instrument-lens apposition, 1 eye had retina-lens apposition.

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tion, and in the remaining 2 eyes, long-acting tamponade was probably the cause of the cataract. In numerous instances, instrument-lens apposition and retina-lens apposition did not lead to cataractous changes following vitrectomy. This seems to further the belief that the infantile lens is somewhat resistant to metabolic and mechanical insult. Cataractogenesis was seen more frequently in the stage 4B group, probably because the procedure typically involves more extensive surgical dissection of vitreous membranes. Finally, hydrostatic forces from the infusion cannula appeared to have been well tolerated.

One of the weaknesses of our study may be that we did not incorporate a standardized cataract grading system, as has been used in adults.\(^{29,30}\) Another potential weakness may be that an indirect ophthalmoscope and 25-diopter lens were used for grading the anterior segment changes. Unfortunately, examination of an infant lens for every visit precludes slitlamp examination even under optimal circumstances. Earlier studies\(^{1,3}\) assessing lens clarity used a similar method of examination because of such limitations. The possibility of missing subtle changes by not using a slitlamp certainly exists. However, we are confident that visually significant lens opacities were detected with high sensitivity by our examination technique. These visually significant opacities have the most impact during the critical phase of visual development. Subtle nuclear changes that develop more slowly, although important, may have less impact on eventual functional outcome in these children. Additional follow-up studies on this cohort are warranted to look for late nuclear cataracts. Based on our results, our data suggest that 3-port LSV maintains lens clarity during the critical early stages of visual development for the vast majority of eyes with stages 4A and 4B detachments secondary to ROP.

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REFERENCES