The Effects of Scleral Buckling on Young Rabbit Eyes

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Objective: To evaluate the effects of scleral buckling surgery on the developing eye in an animal model.

Methods: Eleven young rabbits underwent scleral buckling surgery in one eye. In 6 rabbits, a 2.5 × 0.6-mm solid silicone encircling band (240 style) with a Watzke sleeve was used, and in 5 rabbits, a 2.0-mm silicone encircling sponge (502 style) with its ends abutting, but not connected, was used. After 3 months, both eyes of each animal were enucleated. Six eyes of an additional 3 rabbits served as baseline controls for determining initial globe volumes.

Results: Of the eyes buckled with a 240 band, 4 of 6 developed glaucoma compared with 0 of 5 eyes buckled with a 502 sponge (P = .06). Migration of the element occurred in all eyes with a 240 band (3 anterior, 3 posterior), while none of the 502 sponges migrated. There was no significant difference in the mean final corneal diameter between eyes with a 240 band (P = .94) and untreated fellow eyes or between eyes with a 502 sponge and untreated fellow eyes (P = .25). The mean axial length of eyes with a 240 band and untreated fellow eyes was 19.57 mm and 16.83 mm, respectively (P = .009). The mean axial length of eyes with a 502 sponge and untreated fellow eyes was 16.67 mm and 16.50 mm, respectively (P = .67). When comparing eyes with a 240 band with eyes with a 502 sponge, a significant difference was observed in the mean axial length (P = .006) and mean volume (P = .006) between the 2 scleral buckle groups.

Conclusions: The use of a noninterrupted solid silicone encircling band appeared to have significant effects on the growth of young rabbit eyes. The use of an interrupted silicone sponge produced a buckling effect similar to the solid silicone band and did not migrate, adversely affect eye growth, or result in glaucoma.

Clinical Relevance: Noncontinuous encircling elements may prove to be as beneficial as continuous encircling elements in the treatment of tractional and rhegmatogenous retinal detachment in infant eyes without the potentially deleterious effects associated with a nondivided encircling band or the need for a second surgery to divide the encircling element.


ETINOPATHY OF PREMATURITY (ROP) is characterized by incomplete retinal vascularization and subsequent abnormal fibrovascular proliferation. In cases that progress to threshold ROP, laser photocoagulation or cryotherapy to the avascular retina greatly reduces the incidence of retinal detachment.1-8 However, despite timely treatment, some infants develop retinal detachment and require scleral buckling procedures to realign the retina in an attempt to restore or salvage useful vision.9,10 It is currently unknown what long-term effects such scleral buckling procedures have on the developing eye. Many surgeons believe that the scleral buckle could prevent growth of an infant’s eye and therefore advocate sectioning of the exoplant approximately 3 months after the initial surgery to allow the eye to grow.

Since the original oral presentation of our data,11 there has been only one other study documenting the effects of scleral buckling procedures on developing eyes.12 The purpose of this current study was to determine if placing an encircling silicone band around the eyes of young rabbits has deleterious effects on eye growth. The second goal was to determine if placing a silicone sponge for 360° (but not connected end-to-end) allows for normal eye growth and obviates the need for a second procedure to divide the element while still maintaining a good scleral buckle effect.

METHODS

ANIMAL MODEL

Fourteen young (aged 4-7 weeks) rabbits, weighing between 600 and 850 g, were used in this study. All animals in the study were treated in accordance with institutional guidelines and the Association for Research in Vision and Ophthalmology resolution on the use of animals in research.
Eleven of the rabbits were divided into 2 groups. In one group (n=6), each rabbit underwent scleral buckling surgery in the right eye, using a 2.5 x 0.6-mm silicone encircling band (240 style; Labtician Ophthalmics Inc, Oakville, Ontario) with a Watzke sleeve (Labtician Ophthalmics Inc). The left eyes in this group served as internal controls. In the second group (n=5), each rabbit underwent scleral buckling surgery in the right eye, using a 2.0-mm silicone encircling sponge (502 style; Labtician Ophthalmics Inc) with its ends abutting but not connected. The left eyes in this group also served as internal controls. A third group of rabbits (n=3) served as an additional set of control eyes for determining baseline globe volumes. Both eyes of the animals in this group were enucleated at the outset of the study to obtain this baseline measurement for comparison with globe volumes in buckled and control eyes 3 months later.

SURGICAL PROCEDURE

Prior to surgery, all animals were anesthetized with an intramuscular injection of 50 mg/kg of ketamine hydrochloride and 3 mg/kg of xylazine hydrochloride. The animals were prepared and draped in the usual sterile fashion. After a 360° peritomy was made, dissection was performed, and the rectus muscles were isolated with +0 silk sutures. An encircling 240 band or 502 sponge was placed under the extraocular muscles in the equatorial plane in the right eye of each rabbit.

In the eyes with the 240 band, 8-0 nylon sutures were used to secure the element in all 4 quadrants. In the eyes with the 502 sponge, 8-0 nylon sutures were used to anchor the element to the sclera in all 4 quadrants. Although a 502 sponge was placed for 360°, its abutting ends were not sutured end-to-end. In both groups of rabbits, 7-0 polyglactin 910 (Vicryl) sutures were used to close the conjunctiva. All eyes with an encircling band or encircling sponge were given a similar amount of scleral indentation, estimated intraoperatively through the use of binocular indirect ophthalmoscopy.

An anterior chamber paracentesis was performed to normalize the intraocular pressure. All animals tolerated the procedure well, and there were no complications as a result of anesthesia. Immediately following euthanasia, enucleation was performed in the standard fashion in all eyes (control and experimental) 3 months after the start of the study. The globes were then analyzed for the variables of interest. The 3 animals used as controls for initial globe volume determination had both eyes enucleated at the outset of the study to obtain this baseline measurement for later comparison with experimental and fellow control eye volumes.

STATISTICAL ANALYSIS

Systat software (Systat, Cary, NC) was used to carry out the statistical calculations for this study. Prior to surgery, animal weight and corneal diameter data were recorded. At the time of enucleation, the following parameters were collected: animal weight, corneal diameter, axial length, eye volume, presence or absence of glaucoma, and presence or absence of element migration. For the 3 additional control animals, globe volume was assessed in each of the 6 eyes at the outset of the study.

Corneal Diameter

Mean preoperative corneal diameter measurements were compared with mean corneal diameter measurements at the time of enucleation in each eye, using the Wilcoxon signed rank test. The mean corneal diameter measurements at the time of enucleation in the experimental eyes and their fellow control eyes were compared against each other, also using the Wilcoxon signed rank test. The mean corneal diameter measurements at the time of enucleation in the eyes buckled with the 240 band and those buckled with the 502 band were compared using the Mann-Whitney test.

Axial Length

The Mann-Whitney test was used to compare mean axial length measurements for eyes with the 240 and 502 elements. The Wilcoxon signed rank test was used to compare the mean axial length measurements in the operated on vs the control eyes. The difference in mean axial length measurements between experimental eyes (eyes buckled with either the 240 band or the 502 sponge) and their fellow control eyes was compared using the Mann-Whitney test.

Volume

Globe volume determination was determined by measuring the displacement of water in a 10-mL graduated cylinder. For the experimental group of eyes, the Mann-Whitney test was used to compare the volume measurements between eyes with the 240 and 502 elements. This test was also employed to compare the difference in mean volume measurements between these 2 groups. The volume measurements from the 3 additional control animals (n=6 eyes) were compared separately with the volume measurements from the eyes with the 240 and 502 elements.

Glaucoma

Glaucoma was defined as an intraocular pressure greater than 21 mm Hg as measured by Tono-Pen (Mentor, Norwell, Mass) following topical instillation of tetracaine. Intraocular pressure was measured just prior to euthanasia. We used the chi² test to compare the association of glaucoma with either element (240 or 502).

Element Migration

A chi² analysis was employed to characterize the association between the presence or absence of postoperative element migration and element type (240 or 502).

RESULTS

Table 1 presents the preoperative rabbit eye characteristics. The mean weight (849 g), corneal diameter (10.4 mm), axial length (13.7 mm), and globe volume (1.53

<table>
<thead>
<tr>
<th>Table 1. Baseline Characteristics of Rabbit Model*</th>
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<tbody>
<tr>
<td>Eyes Buckled With a 240 Silicone Band† (n = 6) Eyes Buckled With a 502 Silicone Sponge‡ (n = 5)</td>
</tr>
<tr>
<td>Mean weight, g‡</td>
</tr>
<tr>
<td>Mean corneal diameter of experimental eyes, mm</td>
</tr>
<tr>
<td>Mean corneal diameter of fellow control eyes, mm</td>
</tr>
</tbody>
</table>

*Data are given as mean ± SD.
†Labtician Ophthalmics Inc, Oakville, Ontario.
‡Indicates statistically significant difference.
mL) characteristics of the control group killed at baseline were recorded for initial volume determination. Table 2 presents pertinent findings determined at the time of postoperative enucleation.

WEIGHT

The 11 rabbits in the study had a mean weight of 701 g (range, 594-908 g) preoperatively and a mean weight of 3089 g (range, 2554-3715 g) at the time of euthanasia. The mean weight of the 3 control animals used to determine initial globe volume was 849 g (range, 820-886 g).

CORNEAL DIAMETER

There was a significant difference in the preoperative and postoperative corneal diameter measurements for both control (P = .003) and experimental (P = .003) eyes. The mean final corneal diameter for eyes with the 240 band was 13.01 mm compared with 12.81 mm for fellow control eyes (P = .94). The mean final corneal diameter for eyes with the 502 sponge was 12.19 mm compared with 12.31 mm for fellow eyes (P = .25). No significant difference in corneal diameter was found postoperatively between eyes with the 240 band and eyes with the 502 sponge (P = .07). Similarly, no significant difference in corneal diameter was noted between eyes with either 240 or 502 elements and their fellow control eyes, respectively (P = .26).

AXIAL LENGTH

A significant difference in axial length was found when 240 band eyes and 502 sponge eyes were compared postoperatively (P = .006). The mean axial length of eyes with the 240 band and untreated fellow eyes was 19.57 mm and 16.82 mm, respectively (P = .09). The mean axial length of eyes with the 502 sponge and untreated fellow eyes was 16.67 mm and 16.50 mm, respectively (P = .67).

VOLUME

A significant difference in the globe volume was found when we compared the eyes with the 240 band with those with the 502 sponge (P = .006). As Table 2 demonstrates, eyes buckled with a 240 band were an average of 0.42 mL larger than the fellow unbuckled eyes, and eyes buckled with a 502 sponge were an average of 0.11 mL smaller than the fellow unbuckled eyes. These mean differences in final globe volume between buckled eyes and their fellow control eyes were found to be statistically significant (P = .03).

GLAUCOMA

Of the eyes buckled with a 240 band, 4 of 6 developed glaucoma compared with 0 of 5 eyes buckled with a 502 sponge (P = .006).

ELEMENT MIGRATION

Element migration was noted in all 6 eyes with the 240 band (3 migrated anteriorly, and 3 migrated posteriorly).

Our findings support the widely held belief that the placement of an encircling band in a developing eye can have deleterious effects on ocular growth and physiology. Anterior and posterior migration of the element, high incidence of glaucoma, and negative influence on eye growth were all serious complications associated with the undivided 240 encircling band. Therefore, our original presentation of this data11 and a similar subsequent report12 support the notion that sectioning of the 240 band is recommended once adequate retinal apposition has been achieved to help prevent the described complications.

Although perhaps not directly applicable to the treatment of infantile pediatric retinal detachments in humans, the results of the present animal study demonstrate clearly that a noncontinuous encircling element is better tolerated in a developing eye than a continuous, nondivided element. No eyes buckled with the 502 sponge had evidence of glaucoma or element migration. There was no significant difference in axial length between control eyes and eyes buckled with a 502 sponge at the end of 3 months.

We found no significant difference in corneal diameter between eyes buckled with a 240 band and those buckled with a 502 sponge.

Table 2. Postoperative Characteristics of Rabbit Eyes*

<table>
<thead>
<tr>
<th>Postoperative Variable</th>
<th>240 Silicone Band (n = 6)</th>
<th>502 Silicone Sponge (n = 5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean weight, g†</td>
<td>3350 ± 348</td>
<td>2778 ± 205</td>
</tr>
<tr>
<td>Mean corneal diameter, mm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Buckled eyes</td>
<td>12.8 ± 0.5</td>
<td>12.3 ± 0.1</td>
</tr>
<tr>
<td>Control eyes</td>
<td>12.8 ± 0.5</td>
<td>12.3 ± 0.1</td>
</tr>
<tr>
<td>Mean axial length, mm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Buckled eyes</td>
<td>19.6 ± 1.6</td>
<td>16.7 ± 0.3</td>
</tr>
<tr>
<td>Control eyes</td>
<td>16.8 ± 0.7</td>
<td>16.5 ± 0.5</td>
</tr>
<tr>
<td>Mean volume, mL</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Buckled eyes (corrected for scleral buckle volume)</td>
<td>3.17 ± 0.5</td>
<td>2.57 ± 0.2</td>
</tr>
<tr>
<td>Control eyes</td>
<td>2.47 ± 0.5</td>
<td>2.67 ± 0.8</td>
</tr>
<tr>
<td>Mean difference in volume (buckled − control), mL†</td>
<td>0.42 ± 0.4</td>
<td>-0.11 ± 0.1</td>
</tr>
<tr>
<td>Mean difference in axial length (buckled − control), mm†</td>
<td>2.73 ± 1.6</td>
<td>0.16 ± 0.3</td>
</tr>
<tr>
<td>Incidence of glaucoma, No. (%)</td>
<td>4 (67)</td>
<td>0</td>
</tr>
<tr>
<td>Incidence of migration, No. (%)</td>
<td>6 (100)</td>
<td>0</td>
</tr>
<tr>
<td>Anterior migration</td>
<td>3 (50), all with glaucoma</td>
<td>0</td>
</tr>
<tr>
<td>Posterior migration</td>
<td>3 (50), 1 with glaucoma</td>
<td>0</td>
</tr>
</tbody>
</table>

*Data are given as mean ± SD unless otherwise indicated.
† Indicates statistically significant difference.

All of the 240 bands that migrated anteriorly also demonstrated evidence of glaucoma (Figure 1A), while only 1 of the 3 bands that migrated posteriorly (Figure 1B) had secondary glaucoma. Of the 5 eyes implanted with the 502 sponge, none showed evidence of element migration (Figure 2). When comparing the element type with the incidence of migration, a significant difference was found (P = .004). Cheese-wiring of the scleral anchoring sutures through the sclera was seen with all of the encircling bands and with none of the 502 sponges.
led with a 502 sponge or between eyes buckled with a 240 band and fellow control eyes. This lack of a difference in corneal diameter despite the presence of a significant difference in axial length and globe volume calls into question the utility of corneal diameter measurements as a clinical indicator of ocular growth or restriction in buckled eyes. This is especially notable because when comparing the 2 buckling elements, we found a significant difference in axial length and globe volume measurement between eyes buckled with a 240 band and a 502 sponge.

Although this animal study was small, it stresses important points regarding the treatment approach to pediatric retinal detachments with scleral buckling surgery when lens sparing vitrectomy is not appropriate. This study offers surgeons an experimental basis for selecting a noncontinuous encircling element as an alternative to placing a continuous encircling element for the treatment of pediatric retinal detachments. A nondi-