Effect of Scleral Shortening on Axial Length

Natsushi Nakagawa, MD; Jean-Marie Parel, PhD, Ing ETS-G; Timothy G. Murray, MD; Kenji Oshima, MD

Background: Partial thickness sclerectomy is the most commonly employed scleral shortening technique used in conjunction with pars plana vitrectomy in the repair of myopia-associated macular holes in patients with staphyloma. Recently, scleral shortening induced through scleral invagination has been advocated as an adjunct in retinal translocation surgery.

Objective: To determine whether a correlation exists between the amount of sclera infolding and the post-treatment reduction in axial length (AL) as a result of lamellar scleral resectioning or full-thickness scleral invagination.

Methods: Three groups of 10 eyes each underwent lamellar scleral resection with dissection of 6, 8, and 10 mm in height, and 1 group of 10 eyes underwent a 10-mm invagination. Presurgical and postsurgical external AL of globes with stabilized intraocular pressure was measured to ±0.022-mm precision.

Results: Average (±SD) AL shortening following lamellar resections for 6-, 8-, and 10-mm groups were 1.50±0.24, 2.10±0.13, and 2.65±0.24 mm, respectively, and 2.50±0.23 mm for the 10-mm invagination group. Differences in AL before and after scleral shortening were found to be significantly different between dissections of different heights (P<.05), and not significantly different between the 10-mm resection and invagination groups (P>.17). The AL of each group was shortened by approximately 25% of the resection-invagination height. The relation was quasilinear.

Conclusions: Lamellar scleral resection and nonresected scleral invagination reduce the ocular AL. The extent of the reduction significantly correlates to the amount of removed or invaginated sclera.

Clinical Relevance: Surgical shortening of the sclera is useful in the management of several retinal disorders, but causes significant changes in AL.

MATERIAL AND METHODS

Forty human eye bank eyes unsuitable for corneal transplantation with a postmortem time of less than 1 week and no history or gross sign of prior surgery were used. The eyes were divided into 3 groups of 10 eyes each that underwent partial-thickness sclerectomy and a group of 10 eyes that underwent full-thickness scleral invagination. The extent of the area of removed or folded sclera varied among the 4 groups.

Before surgery, the eyes underwent full conjunctival dissection. The intraocular pressure (IOP) was adjusted by insertion of a 20-gauge needle into the vitreous via the pars plana. The needle was connected to a piezoelectric pressure sensor linked to a custom-made IOP monitor and to an infusion bottle to establish a constant IOP of 16 mm Hg.

At this time, the external ALs of the eyes were measured with a digital micrometer (Digimatic Caliper model 500-351; Mitutoyo Corp, Tokyo, Japan; instrumental error, ±0.02; repeatability, 0.01 mm). The AL was defined as the longest length measured between the corneal apex and a point on the posterior sclera at the temporal side of the optic nerve insertion. Measurements performed 10 times on the same eye showed a clinical repeatability of ±0.022 mm.

Using the digital caliper, a crescent area was marked with a tattoo pen on the sclera, with the center of the crescent directly beneath the lateral rectus muscle and the points of the crescent reaching to the superior rectus and the inferior rectus muscles. The extent of the scleral crescent varied among the 4 groups with group 1 having a height of 6 mm; group 2, 8 mm; and groups 3 and 4, 10 mm.

For groups 1 through 3, the crescent outline was cut to a depth of half the scleral thickness with a razor blade fragment on a holder. At the superior rectus muscle, the point of the scleral crescent was grasped by forceps and peeled away from the intact sclera using the sharp edge of the razor (Figure 1, A).

In all eyes, 4 U-shaped, 6-0 silk mattress sutures were placed across the scleral indentation and separated by 3 mm (Figure 1, B). The sutures were tied by either single or double knots, and when needed, the edges of the scleral crescent were approximated by an additional interrupted 6-0 silk suture. Tightening of each suture was facilitated by continuously maintaining the IOP. After placing all the sutures, the postoperative AL of each eye, with stabilized IOP, was measured with the micrometer.

Values of AL were statistically analyzed by t test (2-tailed) and expressed as mean (SD).

In group 1, eyes with a 6-mm-high lamellar scleral resectioning, the external ALs before the procedure ranged from 23.45 to 24.95 mm, with an average of 24.38 mm. The postoperative external ALs ranged from 21.80 to 23.54 mm, with an average of 22.87 mm. The total reduction in AL ranged from 1.16 to 1.81 mm, with an average of 1.50 mm.

In group 2, eyes with an 8-mm-high lamellar scleral resectioning, the external ALs before the procedure ranged from 24.03 to 24.90 mm, with an average of 24.47 mm. The postoperative external ALs ranged from 22.02 to 22.87 mm, with an average of 22.38 mm. The total reduction in AL ranged from 2.00 to 2.43 mm, with an average of 2.10 mm.

In group 3, eyes with a 10-mm lamellar scleral resectioning, the external ALs before the procedure ranged from 23.95 to 25.13 mm, with an average of 24.57 mm. The postoperative external ALs ranged from 21.10 to 22.76 mm, with an average of 21.92 mm. The total reduction in AL ranged from 2.29 to 2.99 mm, with an average of 2.65 mm.

In group 4, eyes with a 10-mm lamellar scleral invagination, the external ALs before the procedure ranged from 23.35 to 25.67 mm, with an average of 24.48 mm. The postoperative external ALs ranged from 20.65 to 23.21 mm, with an average of 21.98 mm. The total reduction in AL ranged from 2.06 to 2.73 mm, with an average of 2.50 mm (Table).

Comparative analyses of all 4 groups, before and after surgery, are shown in Figure 3. Preoperatively, all eyes had approximately the same AL. (P>.2 in all 4 series). The eyes in group 1 had the least reduction in AL postoperatively. Eyes in group 2 had an AL shortening less than groups 3 and 4. The eyes in groups 3 and 4 showed the greatest overall shortening in AL postoperatively and displayed no statistically significant difference between the 2 treatment approaches to achieve a shortening of AL. A statistically significant difference was noted for AL shortening in each resection group at 6, 8, or 10 mm.

Figure 1. A, Marking the area of sclera to be excised or folded. B, Placement of the sutures along the scleral excision or folding area. The intracocular pressure was slightly reduced between each suture placement to facilitate closing the suture. RM indicates rectus muscle.
Scleral shortening is used to repair macular hole in patients with central retinal detachment and staphyloma resulting from high myopia.5-9 This procedure is thought to shorten the overall AL and, subsequently, reshape the staphyloma. It is postulated that scleral shortening collapses the staphyloma leading to retinal, choroidal, and scleral approximation leading to retinal reattachment. Retina translocation can be achieved through pars plana vitrectomy, retinal detachment, and intraocular gas tamponade coupled with scleral resection10-12 or scleral invagination,13 as it results in an alteration of the retina, choroidal, and scleral interface leading to a shift in retinal position with regard to underlying retinal pigment epithelium.

Matsumura and Ogino9 in a clinical surgical series examined the amount of sclera removed and overall shortening of AL, but could not find a statistically significant relation. Accurate in vivo measurements of AL, however, are difficult to obtain.5 In cases of macular hole with retinal detachment and myopia resulting from severe staphyloma, this error could be exacerbated. Echographic determination of AL using A-scan biometry is complex in these highly myopic, staphylomatous eyes secondary to poor ocular fixation and variability of the size of the posterior staphyloma.

Because the AL in human eye bank eyes can be measured directly, the AL error is greatly reduced. The eyes used in this study were regularly shaped, since eye bank eyes with staphyloma are difficult to obtain and were deliberately excluded from this study. As a result of the regular shape of the eyes, AL errors in measurements are even further reduced. It can be argued that results obtained with regularly shaped eyes may not fully correlate to the in vivo myopic, staphylomatous eyes reported by Matsumura and Ogino,9 but should correlate with nonstaphylomatous eyes undergoing retinal translocation. However, our study found that the total average AL in human eye bank eyes was shortened by approximately 25% of the area of the scleral dissection, which is similar to the results obtained from the in vivo study of Matsumura and Ogino.9

The preoperative AL of the eyes did not vary significantly between the 4 groups, providing a good homogeneous population for postoperative comparisons of AL. This study found a statistically significant relation

<table>
<thead>
<tr>
<th>Groups</th>
<th>Preoperative</th>
<th>Postoperative</th>
<th>Shortening</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>24.38 ± 0.46</td>
<td>22.87 ± 0.46</td>
<td>1.50 ± 0.24</td>
</tr>
<tr>
<td>2</td>
<td>24.47 ± 0.24</td>
<td>22.38 ± 0.22</td>
<td>2.10 ± 0.13</td>
</tr>
<tr>
<td>3</td>
<td>24.57 ± 0.42</td>
<td>21.92 ± 0.50</td>
<td>2.65 ± 0.24</td>
</tr>
<tr>
<td>4</td>
<td>24.48 ± 0.64</td>
<td>21.98 ± 0.67</td>
<td>2.50 ± 0.23</td>
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</tbody>
</table>

* All groups were composed of 10 human eye bank eyes and were measured using a digital micrometer (Digimatic Caliper model 500-351; Mitutoyo Corp, Tokyo, Japan). Groups 1 through 3 underwent the following lamellar scleral resectioning in height: group 1, 6 mm; group 2, 8 mm; and group 3, 10 mm. Group 4 underwent a 10-mm-height lamellar scleral invagination. Data are mean ± SD (in millimeters), unless otherwise indicated. The values of the ALs were statistically analyzed by 2-tailed t test with statistical significance at P < .05.
between the amount of sclera folded during the procedure and changes in the overall AL. A greater area of sclera folding resulted in a greater shortening in overall AL. Lamellar scleral resection and whole scleral invagination produced the same reduction in overall AL.

**CONCLUSIONS**

This study documents a significant correlation between the amount of sclera folded in lamellar scleral resectioning and whole scleral invagination procedures and the reduction in the overall AL of the eye. Defining this relation is important for more accurate correction of staphyloma and macular hole repair or repositioning. Documenting no difference between lamellar scleral resection and scleral invagination will allow the surgeon to select the surgical approach to reduction in AL based on clinical experience and an awareness of the potential benefits and risks of each procedure.

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Corresponding author: Jean-Marie Parel, PhD, Ing ETS-G, Ophthalmic Biophysics Center—Bascom Palmer Eye Institute, 1638 NW 10th Ave, Miami, FL 33136 (e-mail:jmparel@bpei.med.miami.edu).

**REFERENCES**