Effects of Scleral Buckling Without Encircling Procedures on Retrobulbar Hemodynamics as Measured by Color Doppler Imaging

Yoshikazu Ito, MD; Mikio Sasoh, MD, PhD; Masashi Ido, MD; Shunsuke Osawa, MD; Yoshikatsu Wakitani, MD; Yukitaka Uji, MD, PhD

Objective: To study the effects of segmental scleral buckling without encircling procedures on retrobulbar hemodynamic conditions using color Doppler imaging.

Methods: In 65 consecutive eyes of 65 patients with unilateral rhegmatogenous retinal detachment repaired by scleral buckling, we prospectively measured the blood flow velocities in the ophthalmic artery, central retinal artery, and short posterior ciliary artery using color Doppler imaging before and 2, 12, and 24 weeks after surgery. Peak systolic velocity (PSV) and end diastolic velocity (EDV) (calculated in centimeters per second) were measured using color Doppler imaging.

Results: The PSV and EDV in the ophthalmic artery were not changed significantly during follow-up. The PSV and EDV in the central retinal artery were reduced temporarily at 2 weeks after surgery, but at 12 weeks after surgery had returned to presurgery levels. The PSV and EDV in the short posterior ciliary artery on both sides continued to decrease postoperatively, and the reductions became statistically significant by 24 weeks after surgery (buckled side: $P=.001$ for PSV and $P=.002$ for EDV; unbuckled side: $P<.001$ for PSV and $P=.004$ for EDV). The decreases of PSV and EDV in the short posterior ciliary artery on the buckled side were positively correlated with the subject's age ($R=0.40$, $P=.001$ for PSV; and $R=0.32$, $P=.004$ for EDV).

Conclusions: Scleral buckling procedures can cause subclinical disturbance of the choroidal circulation, even if encircling procedures are avoided. Aging is one of the risk factors for the disturbance.

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Scleral buckling procedures are the treatment of choice for most uncomplicated rhegmatogenous retinal detachments. Ischemia of the anterior segment of the eye is a rare complication of this surgery. Postoperative complications, such as anterior or posterior segment ischemia, are related to ocular circulatory disturbances. To determine ocular blood flow alterations after scleral buckling, many clinical studies using ocular pulse measurements, the bi-directional laser Doppler technique, the laser speckle method, or color Doppler imaging have been designed. In all of these studies, the surgery was performed using encircling procedures. On the other hand, many retinal detachments can be treated only with segmental buckling and cryopexy in the area of the breaks without use of the encircling procedure. This protocol aims to minimize surgical damage, and is called minimal surgery. Good anatomical and functional results have been achieved with minimal surgery. Color Doppler imaging is exclusively used for studying the retrobulbar circulation. This rapid noninvasive technique provides reproducible, qualitative, and quantitative hemodynamic information. In the present study, we used color Doppler imaging to study the influences of segmental scleral buckling without encircling procedures on the blood flow velocities in the retrobulbar vessels in patients with rhegmatogenous retinal detachment. To obtain more detailed information about the retrobulbar hemodynamic changes, not only the ophthalmic artery (OA) and central retinal artery (CRA) but also the short posterior ciliary artery (PCA) velocities were measured.

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Financial Disclosure: None.

METHODS

From October 1, 2000, to September 30, 2002, we prospecively enrolled 65 consecutive eyes of 65 patients (mean ± SD age, 48.7 ± 18.0 years) with unilateral rhegmatogenous retinal detachment repaired by scleral buckling. Informed consent was obtained from all subjects, and during the study process, all subjects were treated in accordance with the Declaration of Hel...
sinki for clinical research. Of the eyes, 37 were male and 28 were female. No patient had diabetes mellitus or cardiovascular or hematological disorders. Patients who underwent an encircling procedure or subsequent operation were excluded from the study. Retinal breaks were identified in all patients and were treated with transscleral cryotherapy. Segmental scleral buckling was performed using a silicon sponge exoplant (Mira No. 506, 507, or 509; Mira, Inc, Waltham, Mass). Neither scleral dissection nor extraocular muscle disinsertion was required for any patient. Subretinal fluid was drained externally when it was necessary. At the end of the surgery, we confirmed the absence of CRA pulsations and that the intraocular pressure was lower than 20 mm Hg. If those conditions could not be obtained, we performed paracentesis. The type, location, and length of the exoplants and the number of cryotherapies were diagrammed in the patient medical records after the operations. The best-corrected visual acuity was recorded before and 2, 12, and 24 weeks after surgery.

For evaluating the retrolcular circulation, a color Doppler imaging unit (model LOGIQ 500; GE Yokogawa Medical Systems, Hino, Japan) was used. Patients were asked to lie in the supine position with closed eyes and to gaze straight ahead to restrict the ocular movements. The transducer was applied to the closed eyelids using sterile ophthalmic methylcellulose as a coupling gel, and ultrasonographic examinations were performed while keeping the gel space between the eyelid and probe on the display to prevent direct contact. Peak systolic velocity (PSV) and end diastolic velocity (EDV) were measured in the OA, CRA, and nasal and temporal PCA. In the present study, PCAs on the buckled and unbuckled sides were named as the buckled side PCA (BSP) and the unbuckled side PCA (UBSP), respectively. If the buckling procedure was performed mainly on the temporal side, the PCA on the temporal side was referred to as the BSP in that eye. These measurements were taken 1 day before and 2, 12, and 24 weeks after surgery in the eyes that underwent operation, and were taken 1 day before and 24 weeks after surgery in the fellow eyes as a control. However, we excluded 4 fellow eyes from the control group because of a history of ocular surgery and 24 weeks after surgery. In the present study, blood flow velocities in the OA were comparable to previously published data.18

RESULTS

No evidence of ocular complications related to the scleral buckling was observed in any of the 65 eyes. A postoperative visual acuity of 20/40 or better was obtained in 50 eyes (77%) (Figure). These visual acuity results were comparable to previously published data.18

There was a significant increase in intraocular pressure from before surgery to 12 and 24 weeks after surgery, but there were no significant changes noted in the mean blood pressure at any of the time points (Table 1). The PSV and EDV in the OA did not change significantly during follow-up. The PSV and EDV in the CRA were reduced temporarily at 2 weeks after surgery, but returned to presurgery levels 12 weeks after the surgery. The PSV and EDV in the BSP were significantly reduced at 12 weeks after surgery, and did not return to presurgery levels. The PSV in the UBSP was also significantly reduced at 12 weeks after surgery, and the EDV in the UBSP was significantly reduced only at 24 weeks after surgery (Table 2). In the fellow eyes, there was no significant change between values before surgery and 24 weeks after surgery for the PSV and EDV in the OA, CRA, BSP, and UBSP (Table 3).

Correlations were studied between the changes in blood flow velocities in the PCA and the subject’s age, the volume of the buckle, and the number of cryotherapies (Table 4). Significant correlations were observed between age and the changes in PSV in the BSP and between age and the changes in EDV in the BSP. For the UBSP, however, these correlations were not observed. The volume of the buckle, which was calculated with the type and length of the buckle, ranged from 105 to 949 arbitrary units. No significant correlations were detected between the change in blood flow velocities and the volume of the buckle or the number of cryotherapies.

COMMENT

In the present study, blood flow velocities in the OA were not changed significantly during the follow-up of 24 weeks. Blood flow velocities in the CRA were reduced temporarily at 2 weeks after surgery, and returned to preoperative levels at 12 and 24 weeks after surgery. From the previous color Doppler imaging studies, it is controversial whether blood flow velocities in the OA are changed after the scleral buckling procedure,9-12 and there is an agree-

Table 1. Intraocular Pressure and Blood Pressure of the 65 Subjects

<table>
<thead>
<tr>
<th>Time</th>
<th>Intraocular Pressure, mm Hg</th>
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</tr>
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<tbody>
<tr>
<td>Before surgery</td>
<td>12.3 ± 2.8</td>
<td>92.3 ± 14.1</td>
</tr>
<tr>
<td>After surgery, wk</td>
<td>2</td>
<td>13.3 ± 3.2 (.05)</td>
</tr>
<tr>
<td></td>
<td>12</td>
<td>13.6 ± 3.1 (.009)</td>
</tr>
<tr>
<td></td>
<td>24</td>
<td>13.4 ± 2.8 (.02)</td>
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*Data are given as mean ± SD. P values are given in parentheses, for comparisons before and after surgery (by the paired t test).

Figure. Scattergram for the 65 eyes, comparing visual acuity 24 weeks after surgery with visual acuity before surgery.

Table 2. Postoperative Visual Acuity

<table>
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<th>Preoperative</th>
<th>Postoperative</th>
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<tbody>
<tr>
<td>2</td>
<td>20/200</td>
<td>20/200</td>
</tr>
<tr>
<td>12</td>
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Table 4. Correlation Coefficient Between Age and Changes in Blood Flow Velocities

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posterior ciliary artery.

The CRA results at 2 weeks after surgery in the present study showed that the encircling procedure is more harmful to ocular blood flow than segmental buckling, and may explain relatively the mild blood flow disturbance that was seen in the present study. The second reason may be due to the differences in the follow-up, which may influence the results, especially with regard to the CRA. In the previous studies, all follow-ups occurred within a week. However, in the present study, the follow-up was 24 weeks. The CRA results at 2 weeks after surgery in the present study are consistent with those found in the previous studies, although it is unknown whether the CRA blood flow velocities in the patients of the previous studies would have returned to preoperative levels if they could have been observed for up to 24 weeks. At any rate, it is reasonable to consider that this temporary decrease in the CRA blood flow velocity in the present study was related to the surgical procedure and postoperative periorcular edema, and that in the long run blood flow velocities in the OA and CRA are scarcely affected by segmental buckling performed without the encircling procedure.

In contrast to the OA or CRA, blood flow velocities in the PCA were progressively reduced in the buckled and unbuckled sides. To our knowledge, this is the first report to measure blood flow velocities in the PCA in eyes that have undergone the scleral buckling procedure. Reproducibility of the PCA measurements is also controversial. However, we believe that the blood flow velocity changes in the PCA in the operated on eyes are sufficiently reliable because the PCA blood flow velocities in the fellow eyes did not change (Table 3). In general, the CRA is responsible for the blood supply to the retina and the PCA is responsible for the blood supply to the choroid. Thus, segmental buckling without the encircling procedure may explain relatively the mild blood flow disturbance that was seen in the present study. The second reason may be due to the differences in the follow-up, which may influence the results, especially with regard to the CRA. In the previous studies, all follow-ups occurred within a week. However, in the present study, the follow-up was 24 weeks. The CRA results at 2 weeks after surgery in the present study are consistent with those found in the previous studies, although it is unknown whether the CRA blood flow velocities in the patients of the previous studies would have returned to preoperative levels if they could have been observed for up to 24 weeks. At any rate, it is reasonable to consider that this temporary decrease in the CRA blood flow velocity in the present study was related to the surgical procedure and postoperative periorcular edema, and that in the long run blood flow velocities in the OA and CRA are scarcely affected by segmental buckling performed without the encircling procedure.

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The structural and functional aging of the eyes, the more likely that the choroidal circulation will...buckling surgery but with the age of the patients. Therefore, these results suggest that the greater the age of the eyes, the more likely that the choroidal circulation will be affected by the surgery. Changes of the choroid due to aging have been previously reported clinically and anatomically. The structural and functional aging of the choroid may lead to vulnerability of the choroidal circulation to surgical intervention.

In the present study, the resistive index (RI) did not show significant change for any of the arteries during follow-up (OA, 0.759-0.776; CRA, 0.675-0.685; BSP, 0.627-0.636; and UBSP, 0.618-0.627). Hence, the present data for RI could not support the hypothesis that vascular resistance after surgery was actually increased and blood flow may have been actually decreased to some degree. Although it is unclear why RI showed a smaller change after surgery than was expected, one of the possible reasons may be due to the fact that RI does not necessarily correlate with vascular resistance. The RI is affected by 2 counteracting factors: vascular resistance and vascular compliance. And, if the vascular compliance is low, a lower numerical value will be calculated for RI, thus underestimating the vascular resistance. To our knowledge, there are no reports that have studied vascular compliance after scleral buckling. However, the decrease in the vascular bed after scleral buckling may lead to a decrease in vascular compliance. Therefore, provided that the vascular compliance is decreased after scleral buckling, the RI will be relatively low in appearance even in conditions of high vascular resistance.

Based on our present study, segmental scleral buckling surgical procedures without the encircling procedures seem to be more beneficial to ocular circulation than those that use the encircling procedure. However, even the segmental buckling can cause subclinical disturbance of the choroidal circulation. Because the disturbance can be gradual and progressive, it is still unclear when circulation conditions stabilize. Thus, further long-term follow-up studies are necessary to clarify the exact course of the changes that take place after these surgical procedures.

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REFERENCES