Surgical Procedure Joining the Lateral Rectus and Superior Rectus Muscles With or Without Medial Rectus Recession for the Treatment of Strabismus Associated With High Myopia

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ABSTRACT

Purpose: To evaluate the outcomes of a surgical procedure involving the muscle union of the superior rectus (SR) and lateral rectus (LR) muscles with or without medial rectus (MR) recession for the treatment of strabismus associated with high myopia and the anatomic changes from before and after surgery.

Methods: Thirty-five eyes of 20 patients who had undergone a muscle union of the SR and LR muscles with or without MR recession for treatment of acquired strabismus associated with an inferior displacement of the LR and nasal displacement of the SR in magnetic resonance imaging of the orbit due to axial high myopia were observed prospectively. Main outcome measures were the angles of the dislocation of the globe, angles of horizontal or vertical deviations, abductions, and supraductions. The angles of the dislocation of the globe were analyzed using magnetic resonance imaging (1.5 Tesla Magnet; Siemens Symphonia, Munich, Germany).

Results: The axial lengths ranged from 26 to 36 mm (mean: 30.6 ± 2.8 mm). The angle of dislocation of the globe changed from 178º ± 10º to 101º ± 6º, the angle of esotropia changed from 58.6 ± 2.5 to 6.8 ± 1.4 prism diopters (PD); and the angle of hypotropia changed from 12.5 ± 1.3 to 3.3 ± 1.1 PD postoperatively. Abduction and supraduction improved significantly after surgery. At the 4-year follow-up, the postoperative outcomes were stable.

Conclusions: In the treatment of strabismus caused by high myopia, the surgical procedure involving the muscle union of the SR and LR muscles with or without MR recession was effective on both the restoration of the dislocated globe into the muscle cone and the improvement of ocular motility.

INTRODUCTION

Adult patients with unilateral or bilateral high axial myopia may acquire a typical restrictive motility disorder associated with obvious esodeviation and hypodeviation named strabismus fixus convergens.1-4 The exact mechanism is not well understood, but several studies have noted a superotemporal herniation of the elongated eyeball beyond the muscle cone in the orbit.2,3 Surgical management of myopic strabismus fixus is complex.4 Conventional maneuvers are resection-recession procedures that mainly affect muscle forces.5,6 Modified procedures include transposition techniques that alter the muscle paths.4,7-10 Yokoyama et
al.\textsuperscript{8} and Yamaguchi et al.\textsuperscript{11} described a surgical procedure involving the muscle union of the superior rectus (SR) and lateral rectus (LR) muscles to restore the dislocated globe back to the muscle cone.

The purpose of this study was to evaluate the outcomes of a surgical procedure involving the muscle union of the SR and LR muscles with or without medial rectus (MR) recession for the treatment of strabismus associated with high myopia and the anatomic changes from before and after surgery.

**PATIENTS AND METHODS**

This was a single-center, prospective, consecutive cohort study. Approval from the Ethics Committee and the Institutional Review Board at the Prof. Dr. N. Resat Belger Beyoglu Education and Research Eye Hospital, Istanbul, Turkey, was obtained. Informed consent was obtained from each participant. The study and data collection conformed to all local laws and was compliant with the tenets of the Declaration of Helsinki.

The study population consisted of patients who underwent surgery to unite the muscle bellies of the LR and SR muscles with or without MR recession for treatment of acquired progressive esotropia-hypotropia associated with high myopia. All procedures were performed at Prof. Dr. N. Resat Belger Beyoglu Education and Research Eye Hospital between July 2005 and January 2009. Patients fulfilling the following criteria were included in the study: axial high myopia (axial length longer than 27 mm), acquired strabismus (esotropia-hypotropia) associated with an inferior displacement of the LR muscle, and nasal displacement of the SR muscle in magnetic resonance imaging (MRI) of the orbit. Patients with neurological or developmental disorders and those who had undergone previous strabismus surgery were excluded from the study. Originally, this study was designed with a 4-year follow-up after surgery. No patients meeting the inclusion criteria were excluded from the study during the study period.

Before surgical intervention, all patients received complete ophthalmic and orthoptic examinations. The angle of ocular deviation was measured by the alternate prism cover test at 6 and 0.33 m with the patient’s optimum myopic correction. For patients in whom neither eye could abduct past the midline, the Krimsky test was used with prisms placed in front of both eyes. The limitation of ocular movements was divided into four grades (-1 = minimal limitation, -4 = no movement toward and/or beyond the primary position).\textsuperscript{4,9,10} A- and B-scan echography (Ocuscan; Alcon Laboratories, Inc., Fort Worth, TX) were performed in all patients to determine the axial length of the globes.

The orbits of all patients were imaged using MRI (1.5 Tesla Magnet, Siemens Symphonia, Munich, Germany). High-resolution coronal and axial T2-weighted spin echo images were obtained with the following settings: repetition time = 550 ms and echo time = 15 ms, field of view = 21 × 21 cm, pixel matrix = 256 × 512, three acquisitions, slice thickness 3 mm, and distance factor 0.25. All patients were instructed to remain still in the infraducted eye position. We tried to avoid the influence of gaze position on the anatomic relationships between the globe and extraocular muscles. Therefore, we controlled the gaze at the same position in all patients. As suggested by Yokoyama et al.\textsuperscript{8} and Yamaguchi et al.,\textsuperscript{11} we used infraduction to analyze the results of MRI for every patient under the same conditions.

For the orbital measurement, we used a coronal slice image 9-mm anterior to the globe-optic nerve junction in each orbit to avoid any influence of globe shape, such as staphyloma. On this slice image, we first traced the outlines of the cross-sectional orbits and the SR and LR muscles and then the area centroid of each object was determined using the XY center tool of the Syngo via postprocessing software (Siemens A.G., Munich, Germany). Lines were drawn between the orbital centroid and each extraocular muscle (LR and SR) centroid. As recommended by Yokoyama et al.\textsuperscript{8} and Yamaguchi et al.,\textsuperscript{11} the angle of dislocation of the globe was defined as the angle formed by a line connecting the area centroid of the SR muscle and the globe and another line connecting the area centroid of the LR muscle and the globe (including the superior temporal quadrant of the orbit) (Figure 1).

The forced-duction test under general anesthesia for verifying restriction preoperatively was applied for all cases. Forced-duction testing was graded on a 3-point scale as mild, moderate, or severe.\textsuperscript{12} The forced-duction test was performed again postoperatively.

**Surgical Technique**

The surgical approach was conducted according to the previous description by Yokoyama et al.\textsuperscript{8} All surgeries were performed under general anesthesia. As an initial procedure, the forced-duction test was...
performed on the affected eye. In case of mild or no restriction of the MR muscle, we only performed surgery for muscle union of the SR and LR muscles. In this surgery, a fornix-based conjunctival incision was made between the SR and LR muscles. The SR and LR muscles were isolated and cleared of the surrounding check ligaments and intermuscular septum. A double-armed 5-0 polybutylate-coated polyester suture (Ethibond; Johnson & Johnson, Sint-Stevens-Woluwe, Belgium) was placed by passing a needle through the lateral one-quarter of the SR muscle and the other needle through the superior one-quarter of the LR muscle, positioning this suture 14 to 15 mm posterior to the insertion of the two muscles. The suture was then tied to pull the two muscles together. The muscles did not split and there was no attachment to the sclera (Figure 2).\(^8,11\) Conjunctiva was closed with an interrupted 8-0 polyglycolic acid suture (Vicryl; Ethicon, Inc., Somerville, NJ). If esotropia remained after the muscle union of the SR and LR muscles, we added a MR muscle recession later. In eyes that had MR contracture during the forced-duction test, MR muscle recession (8 to 10 mm)\(^4\) was performed along with the muscle union.

Examinations were performed 1 week prior to surgery and were repeated postoperatively at 1, 3, 6, and 12 months; thereafter, examinations were performed on an annual basis for 4 years. Orbital MRIs were performed 1 week prior to surgery and were repeated postoperatively at 1 and 12 months; thereafter, they were performed on an annual basis for 4 years.

**Statistical Analysis**

The data were analyzed with SPSS version 16 for Windows, (SPSS, Inc., Chicago, IL). Descriptive statistics, mean, and standard deviation for numeric variables were calculated. Differences between preoperative and first postoperative month values were compared. The paired samples \(t\) test was used for these comparisons. Dunn's test was used for simultaneous estimation of all pairwise comparisons of postoperative values at 1 month and 1, 2, 3, and 4 years. A \(P\) value less than .05 was considered statistically significant.

**RESULTS**

The study population consisted of 35 eyes from 20 patients (11 female, 9 male) who underwent the union of the muscle bellies of the LR and SR muscles with or without recession of the MR muscle for the treatment of highly myopic strabismus. All 20 patients had acquired progressive esotropia and hypotropia. The mean age of onset for strabismus was 34.8 ± 3.1 years (range: 21 to 44 years). Fifteen of the 20 patients had bilateral high axial myopia, and 5 patients had unilateral high axial myopia. Their axial lengths ranged from 26 to 36 mm (mean: 30.6 ± 2.8 mm), and their spherical equivalents of refraction ranged from -10.00 to -28.00 diopters (mean: -19.01 ± 3.1 diopters).

All patients were examined at 1 month and 1, 2, 3, and 4 years postoperatively.

The surgical results of patients with highly myopic strabismus are shown in Table 1. A statistically significant difference was found between preoperative and first postoperative month values in the angle...
of globe dislocation \((P = .001)\). Figure 1 shows the measurement of the angle of globe dislocation in a patient with highly myopic strabismus. There were statistically significant differences between preoperative and first postoperative month values in the angles of horizontal and vertical deviations \((P = .001\) and \(.049\), respectively). A statistically significant difference was found between preoperative and first postoperative month values in abduction and supraduction \((P = .001\) and \(.038\), respectively).

No significant differences were found between 1 month and 1, 2, 3, and 4 years postoperatively, which reflects the stability of improvements in the angle of globe dislocation, the angles of horizontal and vertical deviation abduction, and supraduction after surgery \((P > .05\) for each comparison).

The forced-duction test revealed positive results (severe or moderate restriction) in the abduction of 24 eyes of 13 patients before surgery. The MR recession was performed at the same time as the muscle union in these 24 eyes. After surgery, a forced-duction test in these eyes demonstrated negative results in abduction. Nine eyes were cured only by uniting the SR and LR muscles. We recessed the MR muscle 5 to 9 months later in 2 eyes of 2 patients because they remained esotropic despite the union of the SR and LR muscles. Two patients had -1 adduction after larger MR recession operation.

No intraoperative or postoperative complications occurred in any treated eye.

Figure 3 shows preoperative and postoperative photographs of one case.

### TABLE 1

<table>
<thead>
<tr>
<th>Variable</th>
<th>Preop</th>
<th>Postop 1 Month</th>
<th>Postop 1 Year</th>
<th>Postop 2 Years</th>
<th>Postop 3 Years</th>
<th>Postop 4 Years</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of eyes/patients</td>
<td>35/20</td>
<td>35/20</td>
<td>35/20</td>
<td>35/20</td>
<td>35/20</td>
<td>35/20</td>
</tr>
<tr>
<td>Angle of dislocation of the globe (°)</td>
<td>(178 ± 10</td>
<td>(101 ± 6</td>
<td>(103 ± 5</td>
<td>(102 ±9</td>
<td>(101 ±4</td>
<td>(103 ±7</td>
</tr>
<tr>
<td>(mean ± SD [min to max])</td>
<td>(160 to 200)</td>
<td>(90 to 115)</td>
<td>(90 to 120)</td>
<td>(90 to 120)</td>
<td>(90 to 120)</td>
<td>(90 to 120)</td>
</tr>
<tr>
<td>Angle of esotropia (PD)</td>
<td>(58.6 ± 2.5</td>
<td>(6.8 ± 1.4</td>
<td>(6.7 ± 1</td>
<td>(6.9 ±1</td>
<td>(6.7 ± 1.2</td>
<td>(6.8 ± 0.7</td>
</tr>
<tr>
<td>(mean ± SD [min to max])</td>
<td>(50 to 90)</td>
<td>(0 to 10)</td>
<td>(0 to 10)</td>
<td>(0 to 15)</td>
<td>(0 to 15)</td>
<td>(0 to 15)</td>
</tr>
<tr>
<td>Angle of hypotropia (PD)</td>
<td>(12.5 ± 1.3</td>
<td>(3.3 ± 1.1</td>
<td>(3.5 ± 0.2</td>
<td>(3.4 ± 0.1</td>
<td>(3.2 ± 0.4</td>
<td>3.3 ± 0.05</td>
</tr>
<tr>
<td>(mean ± SD [min to max])</td>
<td>(8 to 20)</td>
<td>(0 to 4)</td>
<td>(0 to 5)</td>
<td>(0 to 5)</td>
<td>(0 to 5)</td>
<td>(0 to 5)</td>
</tr>
<tr>
<td>Abduction</td>
<td>-2.9 ± 1.6</td>
<td>-0.7 ± 0.8</td>
<td>-0.7 ± 0.1</td>
<td>-0.8 ± 0.2</td>
<td>-0.9 ± 0.4</td>
<td>-0.7 ± 0.5</td>
</tr>
<tr>
<td>(mean ± SD [min to max])</td>
<td>(-2 to 4)</td>
<td>(0 to 2)</td>
<td>(0 to 2)</td>
<td>(0 to 2)</td>
<td>(0 to 2)</td>
<td>(0 to 2)</td>
</tr>
<tr>
<td>Supraduction</td>
<td>-2.4 ± 0.9</td>
<td>-0.6 ± 0.1</td>
<td>-0.6 ± 0.1</td>
<td>-0.7 ± 0.2</td>
<td>-0.5 ± 0.05</td>
<td>-0.7 ± 0.2</td>
</tr>
<tr>
<td>(mean ± SD [min to max])</td>
<td>(-1 to 3)</td>
<td>(0 to 2)</td>
<td>(0 to 2)</td>
<td>(0 to 2)</td>
<td>(0 to 2)</td>
<td>(0 to 2)</td>
</tr>
</tbody>
</table>

*Preop = preoperative; postop = postoperative; SD = standard deviation; min = minimum; max = maximum; PD = prism diopter

**DISCUSSION**

Many surgical methods to stabilize the globe in high myopia have been described, including tenotomy, large recession of the MR muscle, recession of the nasal conjunctiva, recession-resection procedures and/or the traction suture, disinsertion, and myectomy of MR muscles with LR resection. A large amount of the recession of the MR muscle is effective in some cases, but relapse can occur.

Krizok et al. reported that a common recession and resection procedure may even aggravate the deviation. Recently, several researchers have paid special attention to the shift in the extraocular muscle paths in myopic strabismus, reporting that these shifts were caused by a posterior prolapse of an elongated eyeball beyond the muscle cone in the orbit. Rutar and Demer suggested that LR-SR muscle band degeneration leads to downward shift of the LR muscle. Noting the displacement of the SR and LR muscles in myopic strabismus fixus, some authors have reported the superior fixation of the LR muscle belly, hemitransposition of the SR and LR muscle, and loop myopexy between the SR and LR muscle. Yokoyama et al. introduced a surgical procedure uniting the muscle bellies of the SR and LR muscles for patients with highly myopic strabismus. Some authors reported that patients in whom contracture of the MR muscles was not found were cured only by this procedure and the recession of the MR muscle was not essential for treating highly myopic strabismus.
In our study, the deviant paths of the SR and LR muscles were confirmed with MRI either preoperatively or at the time of operation. We performed surgical procedures involving the muscle union of the SR and LR muscles with or without MR recession for the treatment of strabismus associated with high myopia. To the best of our knowledge, this study is the largest series in the literature. We considered previous reports and recessed the MR muscle at the same time as performing muscle union when forced ductions confirm tight muscle. In cases that had restricted abduction for several years, contracture of the MR muscle is likely to have occurred.

Yamaguchi et al. and Yokoyama et al. performed a surgical procedure involving the muscle union of the SR and LR muscles with or without MR recession in 23 eyes of 14 patients who had a diagnosis of highly myopic strabismus. They reported that the preoperative angle of globe dislocation of 184° decreased to 100° during the postoperative period and the angle of ocular deviation of 58.8 prism diop ters (PD) decreased to 0.7 PD postoperatively. They revealed that this procedure was effective for restoring the dislocated globe into the muscle cone and for improving both ocular motility and deviation.

In the literature, some authors have presented this procedure as useful for treating convergent...
We achieved satisfactory outcomes from uniting the muscle bellies of the SR and LR muscles with or without MR recession in myopic strabismus cases. The preoperative mean angle of globe dislocation of 178° decreased to 101° on the postoperative period. The angle of horizontal deviation was 58.6 PD and decreased to 6.8 PD postoperatively, and the angle of vertical deviation was 12.5 PD and decreased to 3.3 PD postoperatively. In all cases, abduction and supradductions were significantly improved after surgery. We observed that the physiological muscle plane may be reestablished by this surgery. Postoperatively, the angles of the dislocation of the globe, angles of horizontal or vertical deviations, abductions, and supradductions were stable for all patients throughout the follow-up period. This procedure has many advantages, including elimination of the risk of scleral perforation because no suture is placed in the globe. Additionally, the risk of anterior segment ischemia is eliminated or minimized because the anterior ciliary circulation would be less compromised, as the muscles are not cut.

We determined that the surgical procedure involving the muscle union of the SR and LR muscles with or without MR recession was sufficient to restore the dislocated globe back into the muscle cone and to achieve improvement of esotropia-hypotropia, abduction, and supradduction in patients with highly myopic strabismus. We especially recommend an additional recession of MR muscle when forced ductions confirm tight muscle. We observed that the postoperative outcomes remained stable during the 4 years of follow-up.

REFERENCES