Prospective Evaluation of Extraocular Motility Following Double-Plate Molteno Implantation

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Objective: To determine the incidence and type of extraocular motility disturbance after double-plate Molteno implantation.

Methods: In a prospective clinical series, we evaluated preoperative and postoperative ocular motility at 3 and 6 months in 24 eyes of 24 patients undergoing double-plate Molteno implantation. Visual acuity, motility testing, and subjective and objective diplopia were evaluated at each examination.

Results: Within the first 6 months postoperatively, new or worse strabismus developed in 11 (46%) of the 24 study patients. Three of the 11 patients had a generalized restriction of the superior rectus and the superior oblique muscles, all of which persisted 6 months after surgery. Four patients had clinical features consistent with an acquired Brown syndrome, and 6 months after surgery, 3 of the 4 patients had a residual deviation, although the deviation in 1 patient resolved. A superior oblique palsy developed in 3 patients, and a lateral rectus palsy developed in 1 patient. All 4 of the muscle palsies resolved or were resolving during the follow-up period, which ranged from 6 to 12 months.

Conclusions: Extraocular motility disturbances are not rare after double-plate Molteno surgery. Muscle palsies, acquired Brown syndromes, and generalized restrictions occurred in similar proportions.

Clinical Relevance: Patients should be counseled before Molteno surgery concerning the risk of strabismus and diplopia.


Aqueous drainage implants are widely used to control intraocular pressure when medications, laser surgery, and trabeculectomy have failed or are likely to fail, such as with neovascular or inflammatory glaucoma or in children. Multiple complications are associated with implantation, including hypotonia, cataracts, choroidal effusion and hemorrhage, corneal decompensation, flat anterior chamber, retinal detachment, endophthalmitis, tube or plate erosion, and hyphema. Ocular motility disturbances have been documented in several case reports and series after tube shunt implantation, but the actual incidence has not been reported.

We report our experience with ocular motility disturbances evaluated prospectively in 24 eyes of 24 consecutive patients undergoing double-plate Molteno implant surgery who were observed for at least 6 months postoperatively.

Preoperative and postoperative motility data, subjective and objective diplopia, and the motility disturbance, if any, that was most consistent with the clinical picture are presented in Table 2. One patient did not return for the 3-month visit, and 2 patients were excluded from the 6-month evaluation because they had additional surgery between their 3- and 6-month visits. In 11 (46%) of our 24 patients, a new postoperative ocular motility abnormality developed. Ten (91%) of the 11 patients diagnosed as having a new strabismus had a visual acuity of 20/60 or better in both eyes, allowing ocular measurement to be performed by cross-cover testing. Of the 13 patients who did not have a new ocular deviation diagnosed after surgery, only 5 (38%) had a visual acuity of 20/70 or better in both eyes. In the patients who had poor visual acuity in 1 or both eyes, accuracy of the ocular alignment, as measured by the Krimsky method, depended on the pupil, which in many of the patients was irregular or eccentric from previous intraocular surgery. Therefore, the incidence of ocular deviation may be underestimated in the study because the patients with poor vision may have been measured less accurately by the Krimsky method. They also were less likely to have diplopia. Patients 10 and 24 had poor vision and a new or changing exotropia that was thought to be most consistent with a

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PATIENTS AND METHODS

After institutional review board approval, 24 consecutive patients with complicated glaucoma who were undergoing double-plate Molteno implantation surgery were recruited from the Department of Ophthalmology, Indiana University School of Medicine, Indianapolis. All patients underwent ocular motility measurements preoperatively by a pediatric ophthalmologist (N.S.) or by another trained ophthalmologist (A.A.D.-D.). Of the 24 patients, 21 were observed postoperatively for at least 6 months (range, 6-12 months). Patients 8, 23, and 24 were observed for a minimum of 4 months because of subsequent intraocular surgery or being unavailable for follow-up. There were 12 women and 12 men, with a mean age of 67 years (range, 42-91 years). The patient characteristics, demographics, and preoperative data are presented in Table 1.

All patients underwent a preoperative strabismus examination 3 weeks before the Molteno implantation surgery. Subjective diplopia in any gaze was elicited, and head position abnormalities were noted. In patients with preoperative subjective diplopia, the diplopia was confirmed using the red glass test. Ductions and versions were evaluated in the 9 diagnostic gaze positions, and motility disturbances were graded on a scale of 0 to 4 (0 indicating full motility; 4, inability to pass the midline to the position tested). Ocular alignment was measured by cover testing using prisms to quantify the heterotropia or heterophoria. In patients with poor fixation, ocular alignment was estimated using the Krimsky modified technique. The Bielschowsky head-tilt test was performed in selected patients with symptoms of vertical diplopia, head position abnormalities, or vertical deviations on examination. Cycloduction deviations were measured using the double Maddox rod test. Best-corrected visual acuity was assessed by the Snellen chart or by approximation using finger counting or hand motion vision in patients with poor acuity. Because of corneal edema from high intraocular pressures, patients 3, 8, and 21 (Table 2) obtained better visual acuity postoperatively than preoperatively once the intraocular pressure was controlled and the corneal edema had resolved.

Follow-up visits for strabismus evaluations, as described earlier, were scheduled at 1 week, 4 weeks, 3 months, and 6 months in all patients. Patients 23 and 24 were excluded from the study after their 3-month examination because they underwent additional ocular surgery. Patient 8 was unavailable for follow-up after 4 months. The follow-up was extended past 6 months if the patient had postoperative diplopia or if an ocular misalignment occurred after Molteno implantation and was still present. One of us (A.A.D.-D.) did all follow-up measurements, and if a new postoperative heterotropia occurred, the patient was reexamined by a pediatric ophthalmologist (N.S.).

After informed consent was obtained, the Molteno implantation surgery was performed with the use of either general or retrobulbar anesthesia. In 23 of the 24 patients, a similar surgical procedure was performed in which the Molteno plates were placed in the superior nasal and superior temporal quadrants, with 1 of the plates being passed under the superior rectus muscle to prevent tube prolapse. Patient 12 had a single plate placed in the superior nasal quadrant before the present surgery; therefore, the lateral quadrants were chosen for the double-plate Molteno surgery, with 1 plate being passed under the lateral rectus muscle.

For all procedures, the surgical technique was similar. A 4-0 silk superior rectus bridle suture was placed, and the eye was rotated inferiorly. A 180° peritomy was performed anterior to the quadrants where the plates were to be placed, with relaxing incisions made as needed. The quadrants were exposed using blunt dissection. Using a von Graefe muscle hook, a 4-0 silk suture was placed under the superior rectus muscle in 23 patients and the lateral rectus muscle in the 1 patient in whom the plates were placed temporarily. For the superior rectus muscle plates, 1 plate was passed beneath the superior rectus tendon either nasally to temporally or temporally to nasally, depending on which quadrant had been selected for placement of the tube into the anterior chamber.

A 4-0 braided white silk suture was placed through the anterior positioning holes, and the acrylic plates were secured to the sclera about 10 mm posterior to the limbus. Care was taken to center the plates between the adjacent rectus muscles in each quadrant and to avoid placing any part of the plate under a muscle or violating the muscle sheaths. The silicone tube was cut, bevel up, to a length that would allow about a 2-mm extension into the anterior chamber. A 9-0 nylon suture was placed through the tube about 1 mm from the tip and tied to occlude the lumen. A 23-gauge needle was introduced into the anterior chamber parallel to the iris plane at the posterior limbus, and the tube was inserted through this tract. A glycerin-preserved scleral patch graft was rehydrated in a solution of gentamicin sulfate and isotonic sodium chloride, placed over the tube entry site at the limbus, and secured with 10-0 nylon sutures at the corners. The Tenon tissue and conjunctiva were then secured at the limbus and anchored using 8-0 polyglactin sutures. The anterior chamber was formed as necessary, and the Molteno tube placement was confirmed. Standard postoperative care included the administration of cycloplegic drops, topical steroids (1% prednisolone), and antibiotic drops 4 times daily. The ligation on the tube was released by argon laser suture lysis when necessary, generally between 2 and 4 weeks after surgery.

In patients 3, 13, and 22, a motility disturbance developed that was consistent with a superior oblique paresis following surgery. In all 3 patients, the diplopia was present by the second postoperative week and had resolved by 6 to 10 months. In patient 12, who had temporal placement of the Molteno implant in the left eye, a left esotropia on leftward gaze developed, consistent with a left lateral rectus paresis, at 4 weeks after the surgery but that resolved by 6 months. In these 4 patients, it is possible that there was a component of restriction causing the ocular misalignment, but the deviation resolving is more consistent with a paresis.

In patients 15, 16, 19, and 20 (17%; 95% confidence interval, 1.8%-31.6%), clinical features developed that were consistent with an acquired Brown syndrome. Patient 15 came to us at 4 weeks after uncomplicated double-plate Molteno surgery with diplopia in adduction, elevation of the surgically treated eye, and a slight...
hypotropia in the primary position but no abnormal head posture. At 4 months, the patient had no further evidence of diplopia. Patient 16 had diplopia 2 weeks after surgery that persisted, requiring strabismus surgery at 6 months for intractable diplopia. Patients 19 and 20 had persistent diplopia in adduction and elevation, and patient 20 continued to have a slight head turn, but no strabismus surgery was required.

In patients 6, 9, and 17, clinical features developed that were consistent with a generalized restriction in upward gaze. Diplopia persisted throughout the postoperative follow-up in patients 6 and 9, but in patient 17, cystoid macular edema developed, with visual acuity falling to 20/400 in the operative eye, and the patient no longer had diplopia.

In all 11 patients, the strabismus had developed as early as 3 months postoperatively (patient 3 missed his 3-month follow-up, but at his 2-week examination, the hypertropia was already present). In the patients in whom a muscle palsy developed, the deviation resolved or was resolving at the last examination. In 2 of the 3 patients with a superior oblique palsy, the deviation resolved at 6 to 10 months, and in the other patient, it was resolving by 6 months. In patient 12 with the temporally placed Molteno implant, a lateral rectus palsy developed that resolved at 3 to 6 months. In the 4 patients with a clinical picture of an acquired Brown syndrome, the deviation was still present at the 6-month follow-up. The patients with a generalized restriction were observed for a maximum of 6 to 7 months and had persistent strabismus.

**COMMENT**

Ocular motility disturbances are an important complication of aqueous drainage implants. Several case reports and series after tube shunt implantation have been documented, but the actual incidence has not been reported.

Prata et al. reported a pseudo-Brown syndrome in 2 cases involving a Krupin-Denver valve and a Baerveldt implant. Cardakli and Perkins reported recalcitrant diplopia following a Krupin valve insertion with disc, despite multiple attempts at corrective surgery. One patient evaluated in the Krupin Eye Valve Filtering Study also had postoperative diplopia with hypertropia. Smith et al. retrospectively reported postoperative heterotropia in primary gaze and the restriction of gaze into the quadrant of the implant in 23 (77%) of 30 eyes following implantation of a Baerveldt 350-mm² seton. Eleven (65%) of their 17 functionally binocular patients had diplopia in primary gaze. Ball et al. reported the development of a pseudo-Brown of the superior oblique tendon syndrome after a Baerveldt implant was placed in the superonasal quadrant. The patient experienced immediate diplopia measuring 8 prism diopters (PD) of hypertropia in primary gaze and 25 PD of hypotropia in adduction in the surgically treated eye after release of the tube ligature. The authors thought that the pseudo-Brown syndrome resulted from expansion of the fibrous capsule around the bleb, causing a mechanical restriction and capture of the superior oblique tendon by the Baerveldt plate.

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In 1992, Munoz and Parrish reported a rapidly progressive restrictive hypertropia caused from a fat-adherence syndrome after unintentional penetration of the posterior Tenon capsule during the placement of a superotemporal single-plate Molteno implant. Munoz and Parrish in 1993 reported 4 cases of what they thought was a convergence insufficiency type of exotropia following Baerveldt implantation. Fellenbaum et al. reported only 1 case of acquired Brown syndrome following Baerveldt implantation in 30 eyes of 30 patients. Smith et al. retrospectively compared Baerveldt and double-plate Molteno implant procedures and described 1 patient in their group having the Baerveldt implant in whom postoperative diplopia developed.

Christmann and Wilson reported 3 cases of vertical strabismus occurring following Molteno implantation. Two patients were unable to elevate the globe after double-plate Molteno implants were positioned superiorly, and 1 patient could not fully depress the globe after the double-plate Molteno implant was placed inferiorly. The authors attributed the strabismus to a posterior fixation suture effect (Faden operation) that resulted in scarring between the muscle belly and the globe after the operation. Wilson-Holt et al. described 10 patients in whom diplopia associated with hypertropia developed following inferior double-plate Molteno implantation. Dobler et al. reported the same complication in 2 cases of diplopia in their series of 76 patients receiving Molteno implants who were observed long term. Kooner et al. reported mechanical downward and inward displacement of the globe with the restriction of motility due to large filtering.
<table>
<thead>
<tr>
<th>Patient No./Sex/Age, y</th>
<th>Treated Eye</th>
<th>Snellen Preop Visual Acuity</th>
<th>Tube Placement</th>
<th>Motility Test Used</th>
<th>Preop Motility</th>
<th>Postop Motility in Primary Gaze by Month of Follow-up</th>
<th>Subjective and/or Objective Diplopia</th>
<th>Postop Strabismus Diagnosed</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/M/62</td>
<td>R</td>
<td>20/50</td>
<td>HM</td>
<td>Superior nasal</td>
<td>Krimsky, cross-cover</td>
<td>40 L exotropia</td>
<td>40 L exotropia</td>
<td>No/no</td>
</tr>
<tr>
<td>2/M/72</td>
<td>L</td>
<td>20/400</td>
<td>20/25</td>
<td>Superior nasal</td>
<td>Krimsky, cross-cover</td>
<td>Normal</td>
<td>Normal</td>
<td>No/no</td>
</tr>
<tr>
<td>3/M/74</td>
<td>R</td>
<td>CF1</td>
<td>20/100</td>
<td>Superior temporal</td>
<td>Krimsky, cross-cover</td>
<td>3 exotropia</td>
<td>Missed examination</td>
<td>8 R hypertropia</td>
</tr>
<tr>
<td>4/M/55</td>
<td>R</td>
<td>20/60</td>
<td>20/70</td>
<td>Superior nasal</td>
<td>Cross-cover, double Maddox rod</td>
<td>Normal</td>
<td>Normal</td>
<td>Normal</td>
</tr>
<tr>
<td>5/M/71</td>
<td>L</td>
<td>20/30</td>
<td>20/40</td>
<td>Superior nasal</td>
<td>Cross-cover, double Maddox rod</td>
<td>Normal</td>
<td>No/no</td>
<td>Normal</td>
</tr>
<tr>
<td>6/F/69</td>
<td>R</td>
<td>20/20</td>
<td>20/25</td>
<td>Superior temporal</td>
<td>Cross-cover, double Maddox rod</td>
<td>Normal</td>
<td>Normal</td>
<td>Normal</td>
</tr>
<tr>
<td>7/F/83</td>
<td>L</td>
<td>LP</td>
<td>HM</td>
<td>Superior nasal</td>
<td>Krimsky, cross-cover</td>
<td>30 L exotropia</td>
<td>30 L exotropia</td>
<td>No/no</td>
</tr>
<tr>
<td>8/F/91</td>
<td>L</td>
<td>20/20</td>
<td>20/30d</td>
<td>Superior nasal</td>
<td>Krimsky, cross-cover</td>
<td>Normal</td>
<td>Normal</td>
<td>Normal</td>
</tr>
<tr>
<td>9/F/76</td>
<td>L</td>
<td>20/20</td>
<td>20/50</td>
<td>Superior temporal</td>
<td>Cross-cover, double Maddox rod</td>
<td>4 esophoriaa</td>
<td>4 esophoriaa</td>
<td>No/yes</td>
</tr>
<tr>
<td>10/F/65</td>
<td>L</td>
<td>20/25</td>
<td>CF</td>
<td>Superior temporal</td>
<td>Krimsky</td>
<td>Normal</td>
<td>Normal</td>
<td>10 exotropia</td>
</tr>
<tr>
<td>11/F/71</td>
<td>R</td>
<td>20/400</td>
<td>20/20</td>
<td>Superior temporal</td>
<td>Krimsky</td>
<td>10 R exotropia</td>
<td>10 R exotropia</td>
<td>No/no</td>
</tr>
<tr>
<td>12/M/60</td>
<td>L</td>
<td>20/20</td>
<td>20/60</td>
<td>Superior temporal placement of tube, plates under the lateral rectus</td>
<td>Cross-cover</td>
<td>4 L hypertropia</td>
<td>2 L hypertropia</td>
<td>No/yes on leftward gaze only</td>
</tr>
<tr>
<td>13/M/68</td>
<td>R</td>
<td>20/40</td>
<td>20/30</td>
<td>Superior temporal</td>
<td>Cross-cover</td>
<td>Normal</td>
<td>4 R hypertropia 5 exophoriaa</td>
<td>No/yes</td>
</tr>
<tr>
<td>14/M/69</td>
<td>R</td>
<td>CF1</td>
<td>20/100</td>
<td>Superior temporal</td>
<td>Krimsky</td>
<td>Normal</td>
<td>Normal</td>
<td>Normal</td>
</tr>
<tr>
<td>15/M/68</td>
<td>L</td>
<td>20/20</td>
<td>20/25</td>
<td>Superior temporal</td>
<td>Cross-cover</td>
<td>3 L hypertropia (deficient elevation in adduction OS)</td>
<td>1-2 L hypertropia (deficient elevation in adduction OS)</td>
<td>No/yes, but only for 3 mo postop</td>
</tr>
<tr>
<td>16/M/42</td>
<td>L</td>
<td>20/20</td>
<td>20/80</td>
<td>Superior nasal</td>
<td>Cross-cover</td>
<td>20 L exotropia</td>
<td>7 L hypertropia + 35 L exotropia (deficient elevation in adduction OS)</td>
<td>No/yes</td>
</tr>
<tr>
<td>17/F/71</td>
<td>R</td>
<td>20/30</td>
<td>20/30</td>
<td>Superior temporal</td>
<td>Cross-cover</td>
<td>Normal</td>
<td>10 R hypertropia</td>
<td>6 R hypertropia</td>
</tr>
<tr>
<td>18/M/66</td>
<td>R</td>
<td>20/60</td>
<td>HM</td>
<td>Superior nasal</td>
<td>Krimsky</td>
<td>Normal</td>
<td>Normal</td>
<td>4 R hypertropia</td>
</tr>
<tr>
<td>19/F/44</td>
<td>L</td>
<td>20/25</td>
<td>20/50</td>
<td>Superior nasal</td>
<td>Cross-cover</td>
<td>Normal</td>
<td>Normal</td>
<td>2 exotropia</td>
</tr>
</tbody>
</table>
blebs following double-plate Molteno implant surgery in 1 patient. Tayeri et al described 5 patients with a variety of motility disturbances following Molteno implantation. We presented our early results of ocular motility disturbances in patients having double-plate Molteno implants and noted ocular motility disturbances in 10 (59%) of 17 patients.

We presented our early results of ocular motility disturbances following Molteno implantation. Subjective assessment of diplopia may underestimate the incidence of ocular motility disturbances following double-plate Molteno implantation. Subjective assessment of diplopia may underestimate the incidence of ocular motility disturbances following double-plate Molteno implantation. It is evident from our data that a variety of ocular motility disturbances may occur following glaucoma tube shunt implantation with the Molteno implant. Several possible mechanisms may contribute to these motility disturbances, including mechanical effects from the bleb crowding the orbit, incorporation of an extraocular muscle in the fibrous capsule of the bleb over the plate, a posterior fixation or Faden effect induced by scarring of the muscle belly to the globe, possible fat adherence if the posterior Tenon capsule has been violated, or possible direct trauma or edema temporarily causing a paresis. Forced-duction testing was not performed in this study to differentiate mechanical from paretic disturbances. Christmann and Wilson presented evidence that a motility disturbance in their patients seemed most consistent with a posterior fixation type of effect. This proposal was supported by histopathological findings. Wilson-Holt et al thought that the hypertropia in their 10 patients following inferior double-plate Molteno implants was due to tense fibrotic cysts above the plates 1 to 4 months postoperatively. Kooner et al also thought that the motility disturbance in their patient was caused by mechanical blockage due to a large tense bleb, with mechanical restriction noted on forced-duction testing. Munoz and Parrish thought that the hypertropia in their patient was a fat-adherence syndrome due to the rapid progression of the

### Table 2. Patient Data and Motility Disturbance With Double-Plate Molteno Implantation

<table>
<thead>
<tr>
<th>Patient No./ Sex/Age, y</th>
<th>Treated Eye</th>
<th>Snellen Preop Visual Acuity</th>
<th>Tube Placement</th>
<th>Motility Test Used</th>
<th>Preop Motilitya</th>
<th>Postop Motilityb</th>
<th>Objective Diplopiab</th>
<th>Postop Strabismus Diagnosed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20/F/48</td>
<td>R</td>
<td>20/20 20/20</td>
<td>Superior nasal</td>
<td>Cross-cover</td>
<td>Normal</td>
<td>2 L hypotropia (deficient elevation in adduction OD)</td>
<td>No/yes</td>
<td>Acquired left Brown syndrome with left head tilt persistent at 6 mo</td>
</tr>
<tr>
<td>21/M/78</td>
<td>L</td>
<td>20/400</td>
<td>Superior nasal</td>
<td>Cross-cover</td>
<td>Normal</td>
<td>Normal</td>
<td>Normal</td>
<td>No/no</td>
</tr>
<tr>
<td>22/F/58</td>
<td>R</td>
<td>20/20 20/25</td>
<td>Superior nasal</td>
<td>Krimsky cross-cover</td>
<td>Normal</td>
<td>4 L hypertropia + 12 exotropia</td>
<td>No/yes</td>
<td>Superior oblique paresis resolved over 10 mo and 2 exotropia at 10 mo</td>
</tr>
<tr>
<td>23/F/65</td>
<td>R</td>
<td>20/50 20/20</td>
<td>Superior nasal</td>
<td>Cross-cover</td>
<td>Normal</td>
<td>Normal</td>
<td>No/yes</td>
<td>Out of study since surgery on OD</td>
</tr>
<tr>
<td>24/F/76</td>
<td>L</td>
<td>20/40 CF</td>
<td>Superior nasal</td>
<td>Krimsky</td>
<td>25 L exotropia</td>
<td>10 L exotropia</td>
<td>No/no</td>
<td>Out of study since surgery on OD</td>
</tr>
</tbody>
</table>

aPreop indicates preoperative; postop, postoperative; HM, hand motion; CF, counting fingers; and LP, light perception. All motility measured in prism diopters.
bPreoperative vs postoperative diplopia.
cPreoperative. Poor visual acuity in surgical eye preoperatively secondary to corneal stromal edema from elevated intraocular pressure.
dPostoperative.
eRestriction in elevation and depression.
f4 L hypotropia in downward gaze.
g2 L hypotropia in downward and upward gaze.
h4 L hypotropia in upward gaze.
i8 L esotropia and 6 L hypertropia on leftward gaze.
j3 L hypertropia on leftward gaze.
k2 R hypertropia in downward gaze.
l Restriction in elevation and depression.
mPostoperative.

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restrictive abnormality. Price and Wellemeyer noted diplopia in their patients with inferiorly placed Molteno implants and recommended against inferior placement in patients with binocular vision, although they did not speculate on the cause of the diplopia.

In our previously reported case of acquired Brown syndrome following double-plate Molteno implant, passive forced ductions of the involved eye disclosed moderate restriction of elevation in adduction. At surgery to correct the Brown syndrome in this patient, it was noted that the blebs over the Molteno plates extended to the insertions of the horizontal rectus muscles, limiting the ability to transpose the muscle tendons to correct for the hypotropia at the same time as correcting for the horizontal strabismus.

**CONCLUSIONS**

Extraocular motility disturbances were not rare in this series following double-plate Molteno implant surgery. Although the surgical technique may vary, the technique used in this study is common. Whether placement of the tube over a rectus muscle would have resulted in different motility disturbances is not known. A variety of ocular motility abnormalities may occur, and no consistent patterns were noted. The development of extraocular motility disturbances was not related to the preoperative motility or preexisting strabismus. Postoperative extraocular motility disturbances may resolve spontaneously with time. Patients who are being considered for this procedure should be made aware of the ocular motility disturbances and double vision that could be present postoperatively.

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