Strabismic Complications Following Endoscopic Sinus Surgery: Diagnosis and Surgical Management

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Introduction: Endoscopic surgical techniques improve the surgeon’s view of sinus structures but are subject to extraocular muscle complications that cause permanent diplopia. Methods: A series of 15 patients with strabismus following endoscopic sinus surgery was reviewed retrospectively to characterize the type of muscle injury and report the results of surgical correction. Results: A variety of insults to the medial rectus (MR) muscle occurred, ranging from contusion, hematoma, oculomotor nerve damage with paralysis, muscle transection, and muscle destruction. Inferior rectus and superior oblique muscle trauma was observed. High-resolution computed tomography and magnetic resonance imaging scans proved essential in determining the extent and nature of muscle injury. Surgical approaches included anterior orbitotomy with muscle recovery and transposition procedures. Conclusions: Several extraocular muscles may be traumatized. Timing and type of surgical treatment depend on severity, type of injury, and number of muscles involved. If the remaining posterior segment of the MR muscle is longer than 20 mm and is contractile, muscle recovery via anterior orbital approach is suggested. If injury is more severe, muscle transposition procedures may be helpful. In cases where there is coexistent medial and inferior rectus injury, transposition procedures may not be possible. Inactivation of the antagonist and use of an orbital periosteal flap as a globe tether to center it may be options.

During the past decade, endoscopic techniques have been developed to improve the surgeon’s view of sinus structures and to facilitate diagnosis and treatment of sinus diseases. These new procedures entail risk of orbital and ocular complications if the orbit is entered. Endoscopic surgery undertaken by surgeons for chronic sinus disease is often complicated by the finding that the lamina papyracea separating the orbit from the sinus is either completely damaged or markedly attenuated because of the nature of the sinus disease. This and the very nature of the surgery, even with endoscopic visualization, is still fraught with risk. Reported orbital complications include periorbital ecchymosis, proptosis, retrobulbar hemorrhage, nasolacrimal duct injury, damage to the medial rectus (MR) muscle, and injury to the optic nerve. Extraocular muscle damage may cause permanent strabismus with troublesome diplopia. The newer powered devices used for endoscopic sinus surgery reduce the risk of hemorrhage during sinus surgery but have a greater potential to damage extraocular muscles when accidentally misdirected. The aim of this study was to characterize the type of muscle injury and report the results of surgical correction.

METHODS

This is a retrospective review of 15 referred cases over the 8-year period 1994 to 2002, who presented with strabismus as a complication of endoscopic sinus surgery. No patient in this series had history of strabismus or strabismus surgery prior to the endoscopic sinus surgery. Two patients (Case 4 and 7) in this series have been reported as parts of previous publications. Each patient underwent a complete ophthalmic and ocular motility examination, including best-corrected visual acuity in each eye. Characteristics of any anomalous head position were measured with a goniometer as the patient read binocularly at distance and near. Facial asymmetry or lid anomalies were noted. Strabismic deviation was measured in the six cardinal gaze positions as well as head tilts where appropriate. Versions were assessed in all nine gaze positions. Ocular torsion was measured subjectively using double Maddox rods and objectively by viewing the fundus with indirect
ophthalmoscopy. Sensory status was evaluated with and without an abnormal head position using the Titmus fly stereo acuity test (Titmus Optical Co., Inc., Petersburg, VA) and/or the Worth four dot test (Western Ophthalmic Corp., Lynwood, WA).

Forced duction and force generation tests were performed, as described, on all patients. Topical anesthetic was applied to the eye being tested and the other eye was covered. The patient was instructed to look in the direction of suspected limited rotation. The examiner grasped the globe with a toothed forceps, as close to the limbus as possible opposite the side of gaze limitation. If the globe could not be passively rotated further than the patient’s effort, restriction was diagnosed; if passive rotation was possible, paresis was diagnosed. The force generation test was performed concurrently with the forced duction test with the same grasp of the globe with the patient maintaining the same position. The examiner applied traction in the opposite direction and evaluated the resistance encountered. The forced generation test estimated muscle force and graded muscle function as normal, reduced (pa
tetic muscle), or absent (palsied muscle).

Saccadic velocity was observed clinically. The patient was asked to cover one eye and alternate gaze between two targets separated at least 20 degrees horizontally or vertically. Saccades were measured in gaze fields with an unrestricted range of movement. The briskness of the generated saccade was noted and the agonist and antagonist velocities and saccades from the fellow normal eye in the same direction were compared. Slow or floating saccades indicated muscle weakness.

Three of the 15 patients had a Hess screen test before and after surgery. Multipositional surface coil magnetic resonance imaging (MRI) of the orbits was performed in 14 of the 15 cases. A computed tomography (CT) scan of the orbits done elsewhere was available with 15 (14 of the 15 cases. A computed tomography (CT) scan of the orbits done elsewhere was available with the same grasp of the globe with the patient maintaining the same position. The examiner applied traction in the opposite direction and evaluated the resistance encountered. The forced generation test estimated muscle force and graded muscle function as normal, reduced (par
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coronal (perpendicular to the orbital axis), and sagittal views were obtained as needed.

Iris angiography was performed in 6 of the 15 patients. These were patients who would require surgery on multiple rectus muscles of the injured eye.

The surgical strategy in each case was individualized based on the nature of muscle injury, the time of presentation, and clinical picture at presentation and type of previous orbital and muscle surgery. When indicated, anterior orbitotomy with recovery of the functional muscle stump was performed with the assistance of an orbital surgeon. The orbit was approached through a fornix-based transconjunctival incision. Dissection towards the orbital apex proceeded along the internal perio

tal surface. The rectus muscle stump was identified and freed of adjacent scar tissue and a non-absorbable double-armed suture was placed through the edge. The muscle stump was advanced as far as possible anteriorly, without creating significant restriction to ocular rotation and sutured to the sclera.

Full-tendon width rectus muscle transposition procedures were performed to replace function in the field of action of a totally destroyed or palsied muscle. When full tendon-width vertical rectus muscle transpositions were performed to the medial rectus insertion, a 4-mm resection of each vertical rectus was added to reduce the created slack and enhance the effect. Augmentation with posterior fixation sutures as described by Foster was also used to enhance the effect of the transposition. In cases with high risk of developing anterior segment ischemia or when the iris angiogram showed delayed iris filling or evidence of filling defects, ciliary vessel sparing full tendon-width transpositions or partial augmented vertical rectus transpositions were performed. In partial tendon-width vertical rectus muscle transposition procedure, the muscle was split in half from its insertion to 9 mm posteriorly, each half having its ciliary vessel branch. One-half of the split muscle was transposed to the desired insertion site. The other non-transposed half with its preserved ciliary vessel remained attached to its original insertion site. This procedure was performed to preserve patency of the anterior segment ciliary circulation and reduce the incidence of anterior segment ischemia. Botulinum toxin (Allergan, Irvine, CA) was injected into the antagonist muscle during the recovery phase of a palsied muscle to prevent its contracture. In the office, 1.25 to 2.5 units of botulinum was injected transconjunctivally under electromyographic control into the muscle belly around the nerve muscle function. Intraoperatively botulinum was injected under direct visualization about 6 to 8 mm from the insertion into the muscle belly, thus avoiding the tendon.

RESULTS

This is a retrospective review of 15 patients who sustained injury to the extraocular muscles or their nerves during endoscopic sinus surgery. We found a variety of insults to the extraocular muscles, ranging from contusion, hemato
toma, damage to the oculomotor nerve entry zone, or transection to complete destruction with entrapment in scar tissue. The type of endoscopic surgical procedure performed in each case, the extraocular muscles involved, and the corresponding injury are listed in Table 1. Seven of the 15 (46%) patients had injury to only one extraocular muscle, while 7 (46%) had injury to two muscles, and 1 (6%) patient had involvement of three muscles. The MR muscle was the most commonly involved (13 of 15 cases,
Interestingly, in addition to the MR, we also found various degrees of damage to the inferior rectus (IR; 7 of 15 cases, 46%) and superior oblique (SO) muscles (4 of 15 cases, 26%). All patients had unilateral extraocular muscle damage, the right eye being more commonly involved (11 of 15 cases, 73%). Injury to the MR was most commonly associated with ethmoidectomy procedures. IR injury occurred when maxillary antrostomies were performed. Details of type of sinus surgery performed were not available in three patients. Details regarding the use of powered devices during the endoscopic procedures were not available except in two cases with severe muscle damage. One case resulted in total destruction of the MR and SO muscles, as shown by preoperative imaging. In the other case there was complete MR transection with loss of a large portion of the muscle. Four patients (Cases 3, 4, 6, and 7) had previous orbital and extraocular muscle surgery for this complication before they were referred to us. Their details are shown in Table 2. Orbital repair had been done for one patient for a cerebrospinal fluid (CSF) rhinorrhea (Case 7).

Table 2 shows the preoperative alignment, imaging findings, previous surgeries if any, management strategies, and postoperative alignment of the patients. Preoperatively four patients had a normal head posture. In these patients the strabismic deviation was so large that they did not attempt to overcome it with a compensatory head posture. In the 15 patients, preoperative face turn ranged from 0 to 40 degrees (mean 14.5 degrees) and chin position ranged from 0 to 15 degrees (mean 6.6 degrees). Postoperatively the face turn ranged from 0 to 7 degrees (mean 2 degrees) (P = 0.006) and the chin position ranged from 0 to 3 degrees (mean 1 degree) (P = 0.1). Postoperatively eight of these patients had a normal head position and the other five had residual anomalous head posture of less than 7 degrees. Six of the 11 (Cases 3, 4, 5, 7, 8, and 12) (54%) patients who underwent surgery had a normal head position as the muscle being as paretic; no anatomic abnormalities noted on MRI scans, and the muscle subsequently recovering its function.

No surgical intervention was performed in two patients (13%). Three patients (20%) had an anterior orbitotomy to recover the functional muscle stump (20%). Five patients (33%) had transposition procedures to replace the lost muscle function. One patient (6%) had an orbitotomy and a subsequent transposition procedure. One patient (6%) had an extirpation of the lateral rectus (LR) combined with a medial periosteal globe fixation procedure to center the globe. One patient (6%) had a recession of the contralateral IR to correct the hypertropia secondary to ipsilateral IR paresis (6%). Two patients (13%) presented recently and are awaiting management. Seven of the 11 patients (63%) who had surgical correction required two or more surgical procedures.

In Cases 1 and 2 where the MR was intact but paretic due to contusion injury, no surgery was performed and the patients were observed. Case 1 had a mild contusion to the
<table>
<thead>
<tr>
<th>Patient No.</th>
<th>Preop Dev</th>
<th>MRI Findings</th>
<th>Previous Procedures</th>
<th>Surgery</th>
<th>Postop Dev</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>RXT-25</td>
<td>Hematoma MR, damage to nerve branch to MR, contusion injury MR</td>
<td>None</td>
<td>Botulinum toxin RLR</td>
<td>Small XP</td>
</tr>
<tr>
<td>2</td>
<td>18 RXT, 3 LHT</td>
<td>RMR intact but not contracting</td>
<td>1. RLR recess</td>
<td>Ant orbitotomoy recovery of RMR attachment to globe, RLR recess</td>
<td>4 XT P, 20 XT LG</td>
</tr>
<tr>
<td>3</td>
<td>20 RXT, 6 RHT</td>
<td>Partial damage, thin filament in continuity of RMR</td>
<td>1. RLR recess</td>
<td>Botox LLR twice</td>
<td>4 XP</td>
</tr>
<tr>
<td>4</td>
<td>12 RHT, 14 XT</td>
<td>Stump of proximal LMR at 20 mm with some function</td>
<td>1. Orbital exploration</td>
<td>1. Ant orbitotomoy, recovery, advancement LMR, botox LLR</td>
<td>12 EP</td>
</tr>
<tr>
<td>5</td>
<td>40 RXT</td>
<td>Strand of RMR present along full length</td>
<td>1. Ant orbitotomoy recovery RMR, post–7-mm stump found and attached to globe, Botulinum toxin RLR</td>
<td>RLR*</td>
<td>20 XT</td>
</tr>
<tr>
<td>6</td>
<td>50 RXT, RHT 4, excyclo</td>
<td>Transsection RMR, middle missing, 12-mm proximal stump</td>
<td>1. Orbital exploration</td>
<td>Full-tendon augmented transposition with resection of RSR, RIR to RMR, botox LLR</td>
<td>8 XT</td>
</tr>
<tr>
<td>7</td>
<td>70 RXT, 12 RHT, excyclo</td>
<td>5–10-mm proximal RMR stump</td>
<td>1. Orbital repair CSF leak</td>
<td>Full-tendon augmented transp with resection of RSR, RIR to RMR, botox LLR</td>
<td>4 XP</td>
</tr>
<tr>
<td>8</td>
<td>50 RXT</td>
<td>Transection MR, adhesion between MR stump and optic nerve</td>
<td>1. Orbital repair CSF leak</td>
<td>Partial aug transp with resec RSR, RIR to RMR, botox LLR</td>
<td>2 RHT</td>
</tr>
<tr>
<td>9</td>
<td>50 RXT</td>
<td>Absent RMR and RSO</td>
<td>1. Full-tendon augmented transp with resection of RSR, RIR to RMR, botox LLR</td>
<td>Harada-Ito RSO</td>
<td>4 Rhypo</td>
</tr>
<tr>
<td>10</td>
<td>RHT 10P, RHT 40D</td>
<td>Tethering of RIR to orbital floor with scar tissue</td>
<td>1. Full-tendon augmented transp with resection of RSR, RIR to RMR, botox LLR</td>
<td>LIR recess</td>
<td>8 XT</td>
</tr>
<tr>
<td>11</td>
<td>35 XT, 12 RHT, pupil dilated</td>
<td>Entrapment/transsection RMR, RIR, and inf division third nerve</td>
<td>1. Full-tendon augmented transp with resection of RSR, RIR to RMR, botox LLR</td>
<td>Orhot in prim.</td>
<td>Ortho in prim.</td>
</tr>
<tr>
<td>12</td>
<td>XT-100</td>
<td>Destruction LMR and LIR with no function, damage to LSO</td>
<td>1. Full tendon transp with resection of RSR, RIR to RMR, botox LLR</td>
<td>Nasal periosteal globe fixation, extirpation of LIR, orbitotomoy repair of floor fracture</td>
<td>LHT-4</td>
</tr>
<tr>
<td>13</td>
<td>LHT 14</td>
<td>LIR intact, paretic</td>
<td>1. Full tendon transp with resection of RSR, RIR to RMR, botox LLR</td>
<td>1. RLR recess</td>
<td>8 RHT</td>
</tr>
<tr>
<td>14</td>
<td>50 RXT, 30 RHT</td>
<td>Mild destruction of post-third MR, RIR intact</td>
<td>1. Full tendon transp with resection of RSR, RIR to RMR, botox LLR</td>
<td>Plan: Botulinum toxin RLR, RSR</td>
<td>Ortho in prim.</td>
</tr>
<tr>
<td>15</td>
<td>60 LXT, 15 LHT</td>
<td>LMR transection, LIR intact but not contracting</td>
<td>1. Full tendon transp with resection of RSR, RIR to RMR, botox LLR</td>
<td>Plan: LIR to orbital wall</td>
<td>Ortho in prim.</td>
</tr>
</tbody>
</table>

Ant = anterior; aug = augmented; Botox = botulinum toxin; CSF = cerebrospinal fluid; D = downgaze; EP = esophoria; ET = esotropia; HT = hypertropia; hypo = hypotropia; inf = inferior; IO = inferior oblique muscle; IR = inferior rectus muscle; L = left; LG = left gaze; LR = lateral rectus muscle; MR = medial rectus muscle; ortho = orthophoria; P = primary position; partial TWT = partial tendon-width transposition; R = right; resec = resection; SO = superior oblique muscle; SR = superior rectus muscle; transp = transposition; U = upgaze; XP = exophoria; XT = exotropia.

*The procedures in the table are numbered to represent their sequence.
MR and had a rapid recovery with full function over a three-month period. Case 2 had a slower recovery. Botulinum toxin injection of the antagonist LR was performed in the clinic. Incomplete recovery of MR function resulted in limitation to adduction in the involved right eye and exotropia in left gaze. The patient was satisfied with correction of his head turn and single vision in the primary position and refused the suggested faden procedure on the left LR. In Case 14, there was damage to the posterior third of the MR and contusion to the IR with possible injury to the inferior division of the third nerve with associated paresis of both MR and IR. We plan to inject botulinum toxin into the LR and superior rectus and observe muscle recovery.

In Cases 3, 4, and 5 the MR was recovered through an anterior orbitotomy approach and was reattached to the globe. This was combined with botulinum toxin injection in the antagonist LR. These were the cases of muscle transection where the remaining posterior MR segment was long; the muscle showed some contractility on multipositional MRI scanning (Figure 1) or the muscle was only partially damaged.

In Case 11, on axial MRI scans it was difficult to distinguish muscle transection from entrapment in the medial orbital wall bony defect (Figure 2). The mid portion of the muscle segment seemed transected. Sagittal views showed the MR to be intact throughout its length but pulled into the sinus near the middle of the muscle, confirming its entrapment.

In Cases 6, 7, and 8, the MR was transected but the remaining proximal stumps were very short and no attempts were made to recover the stumps. In Case 9, the MR and in Case 10 the IR were irreparably damaged (no
significant muscle tissue remained). Appropriate transposition procedures were hence performed in these cases. Case 5 needed transposition as a second procedure following reattachment of a short 7-mm MR posterior stump. Even though the MR stump was reattached, it was non-functional. In Cases 12, 4, and 15, the vertical rectus muscle transpositions to the MR insertion would have been valuable but were infeasible due to coexistent IR damage. In Case 12, there was severe destruction and no function of both the ipsilateral MR and IR muscles. Hence a nasal orbital periosteal flap was created and anchored to the globe at the MR insertion site.15 This was combined with extirpation of the ipsilateral LR muscle. The globe was fixed in the primary position. In Case 4, the original injury from the endoscopic surgery was to the MR alone, but a nasal rupture of the ipsilateral IR complicated a Hummelsheim procedure at another institution (Figure 5). Preoperative iris angiography performed five months after the initial injury revealed delayed filling along the medial and inferior iris quadrants and transposition surgery was not performed. Preoperative multipositional MRI scan of the orbit revealed a functional posterior 20-mm MR stump. A repeat orbitotomy recovered the MR. Marked improvement in horizontal alignment was achieved after the MR posterior stump was reattached to the sclera (Figure 6). Case 15 had imaging evidence of MR transection with no recoverable posterior segment, and ipsilateral IR paresis with no significant recovery of function. A transposition procedure is thus not an option. We plan to disinsert the LR and reattach it to the lateral orbital wall.

Case 13 had mild damage only to the IR, whose function did not return completely after 8 months. Contralateral IR recession was performed to correct the ipsilateral hypertropia.

FIG 4. Postoperative clinical photo of Case 11 after orbitotomy and repositioning the intact MR and IR into the orbit. Note that the right pupil has normalized.

Two cases had associated optic nerve damage impairing vision to 20/100 in Case 8 and complete blindness of an eye in Case 15.

Postoperatively 10 of the 11 (91%) operated cases had a small residual deviation in the primary position and were functioning binocularly in daily life. Case 11 had a residual 7-degree left face turn and a 20-prism diopter exotropia.

DISCUSSION

Varying degrees of damage can occur to several extraocular muscles as a complication of endoscopic sinus surgery. The resultant strabismus may leave the patient severely incapacitated due to abnormal head position and/or diplopia. Management of these complications is challenging. Retrieval of a transected muscle is difficult as the posterior muscle portion may retract posteriorly, necessitating or-
bital surgical approaches. Muscle recovery is not always possible because of muscle destruction or severe damage with entrapment in scar tissue.

In our series, the MR was the most commonly traumatized muscle. There are other reports of isolated MR muscle injury complicating endoscopic sinus surgery. In addition, we found that the IR and SO muscles may also be damaged. To our knowledge, there have been no previous reports of either IR or SO muscle damage noted with endoscopic sinus surgery. Two of the patients in this series had associated optic nerve damage. There have been two previous reports of similar injuries.

High-resolution CT and surface coil MRI proved essential in determining the extent and nature of muscle injury. The added benefit of multipositional MRI was that it demonstrated muscle contractility. This provided a more precise diagnosis in complicated cases and helped to devise the most suitable treatment plan. We suggest that multipositional MRI scanning be part of the standard protocol for the work-up of such cases. Iris angiography was informative in complicated cases where multiple surgeries were required on multiple muscles. It guided us to alter surgical plans to avoid anterior segment ischemia.

Timing and type of surgical intervention depend on severity, type of injury, and number of muscles involved. Based on the results of our experience with these cases, the following management strategy is suggested. In cases where the involved muscle is intact but paretic due to contusion injury or injury is to its nerve (as noted on imaging), no immediate surgical intervention is suggested. The antagonist rectus muscle may be injected with botulinum toxin while awaiting recovery of the paretic muscle to avoid its contracture. In more severely damaged muscles, early surgical intervention is appropriate and the surgical strategy depends on the nature of the muscle injury. We suggest that in cases with transection injury, if the remaining posterior segment of the MR is longer than 20 mm and is functional, muscle recovery via anterior orbital approach should be attempted. This requires the added expertise of an orbital surgeon. If the injury is more severe with excessive muscle destruction, muscle transposition procedures may be helpful and the potentially hazardous posterior orbital exploration may be avoided. In cases where there is coexistent IR injury, vertical rectus muscle transposition procedures may not be possible. Inactivating the antagonist muscle and creating a force upon the eye to center it with the use of an orbital periosteal flap can be performed in such cases.

References