Torsion and Pattern Strabismus

Potential Conflicts in Treatment

Burton J. Kushner, MD

**Importance:** Rectus muscle transposition to treat pattern strabismus or torsion may have an adverse outcome if the surgeon is unaware that it will affect both pattern strabismus and torsion in contradictory ways.

**Objective:** To highlight the potential adverse affects of rectus muscle transposition on torsion or pattern strabismus.

**Design and Participants:** A retrospective nonblinded medical record review of patients treated by the author between January 1, 1990, and June 30, 2009, in whom rectus muscle transposition to address pattern strabismus worsened torsion, or in whom transposition to address torsion worsened pattern strabismus. The main outcome was a worsening of either torsion or pattern strabismus.

**Setting:** A tertiary care university referral center.

**Intervention:** Rectus muscle transposition surgery to either treat pattern strabismus or torsion.

**Main Outcome Measures:** The presence of new or worsened pattern strabismus or torsion. The outcome measures were determined before data collection began.

**Results:** Eight patients were identified by the review, 5 in whom torsion developed because of transposition to address pattern strabismus and 3 in whom pattern strabismus developed after transposition to address torsion. The presence of bifoveal fusion and/or Graves orbitopathy were risk factors for these adverse outcomes.

**Conclusions and Relevance:** Rectus muscle transposition to address pattern strabismus may cause torsion, and transposition to address torsion may cause pattern strabismus.

*JAMA Ophthalmol. 2013;131(2):190-193*

When a horizontal rectus muscle is transposed vertically or a vertical rectus muscle is transposed horizontally, 3 changes in force vectors occur. One is a change in the primary action of the muscle. Its primary action is weakened when the eye is rotated in the direction the muscle is transposed. For example, if a medial rectus muscle is infraplaced, its adducting force is weaker when the eye is in downgaze compared with upgaze. This effect is desired when one transposes horizontal rectus muscles vertically to treat an A or V pattern. As a second effect, a force vector is created in the direction the muscle is moved. For example, if a medial rectus muscle is infraplaced, a new force vector for depression is created. This effect is desired when the horizontal rectus muscles are raised or lowered to treat an elevation or depression deficiency with a Knapp or reverse Knapp procedure, respectively. This effect is the mechanism by which sixth cranial nerve palsy or Duane syndrome can be successfully treated with horizontal transposition of the vertical rectus muscles; this procedure creates a force for abduction. Finally, a torsional vector is created that rotates the eye in the direction from which the muscle was transposed. For example, if a left medial rectus muscle is infraplaced, a torsional vector is created to excyclorotate the eye. This is the rationale behind transposing the rectus muscles to treat symptomatic torsion. Incyclotropia could be treated by nasal transposition of the superior rectus muscles or temporal transposition of the inferior rectus muscles; they can be transposed in the opposite direction to treat symptomatic excyclotropia.

Given the aforementioned principals, it is evident that the direction one would transpose rectus muscles to treat an A or V pattern would worsen the associated tor-
sion, and the direction one would transpose rectus muscles to treat torsion would worsen an accompanying A or V pattern. For example, V patterns are typically associated with exocycloversion owing to the common accompanying finding of inferior oblique muscle overaction.\textsuperscript{1} V patterns can be treated with medial rectus muscle infraposition or lateral rectus muscle suprareposition, both of which should worsen the accompanying exocycloversion caused by the overacting inferior oblique muscles.\textsuperscript{11} Similarly, exocycloversion could be treated with temporal transposition of the superior rectus muscles or nasal transposition of the inferior rectus muscles. However, either of these procedures would be expected to worsen any tendency for a V pattern, which frequently accompanies symptomatic exocycloversion.\textsuperscript{12}

For reasons outlined herein, these contradictory effects of rectus muscle transposition for treating torsion or alphabet patterns usually do not cause adverse clinical outcomes. However, in some circumstances, such surgical procedures can lead to unwanted results. The purpose of this study is to present examples of such occurrences and suggest guidelines for how to avoid them.

This study complied with the Health Insurance Portability and Accountability Act and the institutional review board of the University of Wisconsin.

**METHODS**

From my personal database of patients I have examined, I identified all patients in whom rectus muscle transposition to treat or prevent torsion resulted in a symptomatic alphabet pattern or rectus muscle transposition to treat or prevent an alphabet pattern resulted in symptomatic torsion. Strabismus was measured in the appropriate diagnostic fields of gaze at 6 m with the prism and alternate cover test, as well as at \( \frac{1}{2} \) m in the primary position and in downgaze at \( \frac{1}{2} \) m. When appropriate, the Bielschowsky head tilt test was performed.\textsuperscript{13} Torsion was assessed objectively and subjectively through observation of fundus torsion and use of the double Maddox rod test, respectively.\textsuperscript{14}

**REPORT OF CASES**

The review identified 8 patients who met the inclusion criteria, including 5 in whom rectus muscle transposition to treat or prevent torsion resulted in a symptomatic torsion and 3 in whom rectus muscle transposition to treat or prevent torsion resulted in a symptomatic alphabet pattern. Because there are similarities among some patients within each of these groups, only 3 patients will be described in detail, with findings in the others summarized.

**CASE 1**

This 48-year-old man, an engineer, sustained bilateral fourth cranial nerve palsy in a motor vehicle crash. One year later he underwent bilateral superior oblique tendon tucks of 10 mm (5 mm on each side of the tuck) combined with bilateral inferior rectus muscle recessions of 4 mm to treat V pattern esotropia, subjective exocycloversion measuring a total of 15° (combined right and left eyes), right hypertropia on left gaze, and left hypertropia on right gaze. The operation resulted in orthophoria and no torsion in the primary position but a residual symptomatic total exocycloversion of 10° and esophoria of 2 prism diopeters (PD) in the downgaze reading position at \( \frac{1}{2} \) m. The patient was diplopic in that position, and his diplopia was not relieved with 2 PD base out in his bifocal segment because of torsion. Because his diplopia did not resolve, 8 months after his first surgical procedure I nasally transposed both inferior rectus muscles 7 mm. This eliminated the torsion but created esotropia of 10 PD in downgaze, associated with horizontal diplopia. Base out Fresnel prism in his bifocal segment provided some relief, but the patient was bothered by the blur from the Fresnel prism. He also had diplopia at an intermediate range in slight downgaze (eg, while looking at a computer screen), which could not be ameliorated optically through his progressive bifocal lenses. Six months after his second strabismus operation, I reversed the transposition of the inferior rectus muscles bilaterally and recessed them each 2 mm further. This eliminated his esotropia in downgaze and did not result in a recurrence of his symptomatic torsion. Patient 1 requires 2 PD of prism base down over his left eye, with which he is diplopia free at distance and in the near-downgaze reading position.

Two patients were similar to patient 1 in that they had an alphabet pattern created by horizontal transposition of the vertical rectus muscles to treat torsion. One was a patient with Graves orbitopathy, who underwent bilateral inferior rectus muscle recessions of 4 mm, performed by another ophthalmologist. To prevent postoperative incyclotropia, the muscles were simultaneously transposed temporally 5 mm; fixed scleral sutures were used, not a suspension (also referred to as a hang-back technique) or adjustable suture technique. After the operation, she had an A pattern with exotropia in downgaze. I subsequently treated this patient by performing bilateral tenectomy of the posterior seven-eighths (approximately) of the superior oblique tendons, which corrected the problem.\textsuperscript{15}

The second patient was another patient with Graves orbitopathy in whom symptomatic incyclotropia of 10° (total right and left eye) developed after bilateral inferior rectus recessions of 5.5 mm in the right eye and 4.5 mm in the left, performed by another ophthalmologist. No horizontal or vertical deviation was described in the primary position or in downgaze. To treat the incyclotropia, the same ophthalmologist transposed both inferior rectus muscles temporally 5 mm, using a fixed scleral suture technique. This corrected the incyclotropia but created exotropia of 7 PD in the primary position and 15 PD in downgaze. I subsequently examined and treated this patient with bilateral tenectomy of the posterior seven-eighths (approximately) of the superior oblique tendons, which corrected the problem.\textsuperscript{15}

**CASE 2**

This 55-year-old woman had Graves orbitopathy. She had vertical diplopia and a chin-up head posture associated with tight inferior rectus muscles bilaterally. She underwent bilateral inferior rectus muscle recessions, 5 mm...
in the right eye and 6.5 mm in the left, performed by another ophthalmologist. After the operation, she was diplopia free in the primary position but had an exotropia of 20 PD in downgaze with horizontal diplopia. Torsion was not measured, and there was no description of superior oblique muscle function in the office records. To treat the exotropia in downgaze, the same ophthalmologist transposed both inferior rectus muscles nasally 5 to 7 mm, using fixed scleral sutures, 4 months after the first operation. This decreased the patient’s exotropia in downgaze to 5 PD, but she then complained of a tilting of the images. I examined patient 2 for the first time 3 months after her second surgical procedure and measured 12° of incyclotropia, split approximately equally between her eyes. Three months after my initial examination, I performed bilateral tenectomy of the anterior seven-eighths (approximately) of the superior oblique tendons. This eliminated the patient’s torsion. She is diplopia free in the primary position for distance viewing and for reading in the downgaze reading position at 1/3 m, where she controls an exophoria of 5 PD.

Two other patients were very similar to patient 2 in that they both had Graves orbitopathy and had undergone bilateral inferior rectus recessions, performed by other ophthalmologists using a fixed scleral suture technique. In both cases, the surgeon transposed the inferior rectus muscles nasally between 5 and 7 mm to prevent the occurrence of an A pattern. Symptomatic intorsion developed in both patients. In 1 patient, I reversed the nasal transposition of the inferior rectus muscles, leaving them in their recessed position. This corrected the problem and did not result in an A pattern. The other patient declined further surgery.

CASE 3

This 48-year-old woman had a history of having undergone multiple prior strabismus surgical procedures for what she thought was intermittent exotropia; prior records were not available. She had been asymptomatic for many years, but when she became presbyopic and needed a bifocal lens for reading, she was bothered by diplopia in downgaze. When I examined her, I found her to be orthophoric in the primary position at 6 m and 1/3 m, but she had an exotropia of 12 PD in the downgaze reading position at 1/3 m through her +1.50 diopter bifocal segment, associated with crossed diplopia with normal localization. To treat this A pattern, I transposed both inferior rectus muscles nasally 7 mm. This eliminated the A pattern and the exotropia in downgaze but created 9° to 11° of incyclotropia, split approximately equally between the eyes. The patient was lost to follow-up for 2 years, after which she came to see me again, inquiring whether anything could be done to eliminate her torsion. I performed bilateral tenectomy of the anterior seven-eighths (approximately) of the superior oblique tendons, which eliminated her symptoms. Another patient was very similar to patient 3 in that he also experienced symptomatic incyclotropia after nasal transposition of the inferior rectus muscles, performed to treat an A pattern. His symptoms were also resolved when I performed anterior tenectomy of the superior oblique tendons.

Transposition of the rectus muscles to treat or prevent torsion may cause or worsen an alphabet pattern, and transposition to treat or prevent an alphabet pattern may cause or worsen torsion. Nevertheless, transposition procedures of these types are frequently performed without adverse consequences for several reasons. Awareness of these reasons can help identify patients who are at risk.

Vertical transposition of the horizontal rectus muscles is a common procedure for treating alphabet patterns. It has been reported that this procedure does not cause any significant torsional change,14,16 but most studies on this subject considered only subjective torsion. Because most patients undergoing a surgical procedure for horizontal strabismus associated with an A or V pattern do not have bilateral fusional or diplopia awareness, a change in subjective torsion is not a good way to assess whether a torsional change has actually occurred after the operation.14 When the change in torsion was studied objectively with fundus photography, however, transposition of the horizontal rectus muscles in the appropriate direction to collapse an A or V pattern always worsened the associated torsion by a mean of 6.4°.11 These patients did not have torsional symptoms in part because they did not have fusional fusion and because the torsion worsened only slightly.

In all 8 of my patients with symptoms of either torsion or an induced alphabet pattern, symptoms occurred after transposition of the vertical rectus muscles—never after horizontal rectus muscle transposition. Vertical rectus muscle transposition to treat A or V patterns is now performed infrequently.12 In my prior studies of objective torsion, I have observed that transposition of the vertical rectus muscles has a more profound effect on torsion than transposition of the horizontal rectus muscles.11,14 Although there is no obvious difference between the torque vectors of the vertical and horizontal rectus muscles that would explain their different effects on torsion, this difference in effects is nevertheless an empirical observation, and its causes are unclear.

An A pattern exotropia with incyclotropia commonly occurs after bilateral inferior rectus recessions for Graves orbitopathy.17 Many ophthalmologists describe routinely transposing the inferior rectus muscles nasally to prevent this from happening, and torsional symptoms are usually not reported.18 One possible explanation is that many ophthalmologists use a suspension technique for suturing in this setting, with or without adjustable sutures. I have observed and reported that when rectus muscles are transposed by using a suspension technique, the transposition effect is negated. I have operated on more than a dozen patients who previously underwent rectus muscle recessions for Graves orbitopathy performed in all patients by the same surgeon, who routinely transposed both muscles nasally one-half to three-fourths tendon width to prevent an A pattern. In all these patients, I found that the muscles were not in a transposed posi-
tion when I performed the surgical procedure, and I concluded that when the muscle actively contracts it will slide to assume the shortest course around the globe and move away from the transposed position. In many patients undergoing a rectus muscle transposition using a suspension technique, I suspect that their muscles are not truly transposed once the operation is complete. In my experience, the best way to prevent an A pattern exotropia after large bilateral inferior rectus recessions for Graves orbitopathy is to simultaneously perform a procedure to weaken the torque of the superior oblique muscles.

Horizontal transposition of the vertical rectus muscles has been described as an effective procedure for treating torsion, but the occurrence of adverse alphabet patterns has not been considered a problem. This may be in part because in many cases only a single vertical rectus muscle is operated on. In the current series, all such patients underwent bilateral surgery, so the effects would be additive.

Rectus muscle transposition to treat paralytic strabismus or Duane syndrome should not be expected to cause torsional problems, because the torsional vectors that are created cancel each other. For example, if the vertical rectus muscles are transposed to the lateral rectus insertion, the superior rectus muscle will develop an intorsional vector, and the inferior rectus muscle an extorsional vector; there should be no net torsional change.

Another noteworthy observation is that 5 of the 8 patients in this series had Graves orbitopathy, and thus their relevant muscles were stiffer than normal. This would accentuate the effect of causing torsion or an alphabet pattern when the muscle is in the transposed position. Moreover, all of the patients in this series underwent procedures that involved a fixed scleral suturing technique and not a suspension technique. This is not to imply that a suspension technique is preferable, per se, because it does not produce the desired transposition effect, as described earlier.

This study has some obvious limitations. Because it is a retrospective review of rather uncommon complications, no incidence figures for these complications can be calculated. Although the patients were heterogeneous with respect to presentation and treatment, they did share many findings, from which some common principals can be formulated.

The treatment of prevention of torsion may worsen alphabet patterns, and the treatment or prevention of alphabet patterns may worsen torsion if approached by transposition of the rectus muscles. This problem is more likely in patients with bifoveal fusion potential and in those undergoing bilateral transposition surgery. It is a particular issue in patients with Graves orbitopathy, whose muscles are tight; transposition of the inferior rectus muscles nasally may prevent an A pattern but cause intorsion, and transposition temporally may treat intorsion but cause an A pattern.

Submitted for Publication: July 3, 2012; accepted July 21, 2012.

Correspondence: Burton J. Kushner, MD, Department of Ophthalmology and Visual Sciences, University of Wisconsin, 2870 University Ave, Ste 206, Madison, WI 53705 (bkushner@wisc.edu).

Conflict of Interest Disclosures: None reported.

Funding/Support: This work was supported by an unrestricted grant from Research to Prevent Blindness, New York, New York.

REFERENCES