Augmented superior rectus transposition with medial rectus recession in patients with abducens nerve palsy

Preeti Patil-Chhablani, DNB, Krishnapriya Kothamasu, VR, DO, Ramesh Kekunnaya, FRCS, Virender Sachdeva, MS, and Vivek Warkad, MS

PURPOSE
To evaluate the surgical outcome of augmented superior rectus transposition (SRT) and medial rectus recession (MRc) in patients with abducens nerve palsy.

METHODS
The medical records of consecutive patients with abducens nerve palsy who underwent unilateral or bilateral simultaneous SRT with MRc from January 2012 to December 2014 were analyzed. Patients with previous strabismus surgery or botulinum toxin injection were excluded. Primary outcome measures were esotropia in primary position and abduction deficit. Data collected included age, sex, etiology, pre- and postoperative deviation, pre- and postoperative abduction deficit, anomalous head posture, induced vertical or torsional deviations postoperatively, reoperations, and details of other complications. Success was defined as postoperative alignment within 10° of orthotropia; failure, as residual esotropia of ≥20°.

RESULTS
A total of 15 eyes of 13 patients were included. The most common cause of abducens nerve palsy was trauma (10 patients). The mean preoperative esotropia was 55.4° ± 24°, which improved postoperatively to 9.9° ± 10° (P = 0.0000). The mean preoperative abduction deficit was −5 units, decreasing postoperatively to −3.1 (P = 0.000). Nine patients (69%) achieved success; 2 were classified as failures. One patient each developed postoperative hypotropia and intorsion; however, these were transient and did not require additional procedures. No patients developed anterior segment ischemia.

CONCLUSIONS
Augmented SRT with MRc is effective in the management of abducens nerve palsy; however, its success in large deviations remains variable. Long-term follow-up is essential to determine the incidence of vertical and torsional deviations. (J AAPOS 2016;20:496-500)

Multiple surgical approaches have been described to treat the esotropia and abduction deficit resulting from palsy of the abducens nerve. While small deviations may be corrected by recession-resection procedures of the horizontal rectus muscles, larger deviations and significant abduction deficits require vertical rectus transposition procedures. Mixed success has been reported with variations of transposition procedures, including total and partial vertical rectus transpositions (VRT), augmentation sutures, plication of the lateral rectus, and resection of the transposed muscles. Reports of induced vertical deviations after transposition of the vertical rectus muscles and the fear of anterior segment ischemia prompted adoption of superior rectus transposition (SRT) alone in order to provide an abducting force. SRT, with or without medial rectus recession (MRc), was initially described by Johnston and colleagues in patients with abducens nerve palsy and esotropic Duane syndrome (Johnston SC, et al. Invest Ophthalmol Vis Sci 2006;47: ARVO e-Abstract 2475). Mehendale and colleagues further described the detailed surgical method and reported the success of this procedure in patients with esotropic Duane syndrome and abducens nerve palsy. Other studies have shown SRT with MRs to be effective in the management of patients with Duane syndrome. Although both Duane syndrome and abducens nerve palsy are characterized by abduction deficiency, the
former is also characterized by an associated aberrant innervation and the lateral rectus might not be paretic, whereas the lateral rectus muscle in abducens nerve palsy might be completely paretic and flaccid. The purpose of this study was to evaluate the outcomes of SRT with MRc in patients with abducens nerve palsy and to analyze the preoperative factors that may be associated with a suboptimal outcome.

**Subjects and Methods**

This study was approved by the Institutional Review Board of the Hyderabad Eye Research Foundation and L V Prasad Eye Institute and adhered to the tenets of the declaration of Helsinki. The medical records of consecutive patients diagnosed with abducens nerve palsy who underwent simultaneous SRT with Foster augmentation and MRc at L V Prasad Eye Institute between January 2012 and December 2014 were reviewed retrospectively.

Patients who had undergone previous surgery or botulinum toxin injections were excluded. All patients underwent a complete ophthalmic evaluation, and surgery was planned after documenting stability of the deviation and after a minimum period of 6 months after trauma. SRT to the lateral rectus with Foster augmentation suture was performed via the fornix or limbal approach, depending on the surgeons’ preference. Preoperative forced duction testing was performed in all cases. The superior rectus muscle was identified, hooked, and secured using a double armed 6-0 polyglactin 910 suture. Its attachments to the levator palpebrae superioris and the superior oblique tendon were carefully dissected. The superior rectus muscle was then disinserted and reattached adjacent to the superior border of the lateral rectus muscle along the spiral of Tillaux. Foster augmentation was performed using 5-0 polyester Dacron suture, 8 mm behind the insertion of the lateral rectus muscle, incorporating one-fourth of the thickness each of the superior and lateral rectus muscles as well as the underlying sclera. An ipsilateral medial rectus recession was performed in all subjects using fixed sutures. The amount of recession was based on the amount of deviation in primary position, tightness of the medial rectus as judged subjectively by preoperative forced duction testing, and standard tables were used to calculate dosage. Our previous experience showed that SRT alone could correct up to 15A of esodeviation, and the amount of medial rectus recession was calculated with this in mind.

Table 1 provides guidelines followed by operating surgeons. All surgeries were performed by 4 surgeons (PPC, RK, VS, VW).

Data collected included age, sex, etiology of the abducens nerve palsy, pre- and postoperative deviation in the primary position, pre- and postoperative abduction deficit, anomalous head posture, any induced vertical or torsional deviations postoperatively, reoperations, and other complications, if any. Primary deviation was measured and prisms were split between two eyes to measure the large deviations. Limitation of ductions was measured on a scale from 0 to −8, with 0 indicating no limitation; −4, failure of the eye to cross the midline; and −8, that the eye was fixed in extreme adducted position with no abduction at all. Head turn was measured in degrees using a goniometer, with the patient reading a vision chart at 3 meters. In preschool children, the head turn was measured while an engaging target was shown at a distance of 3 meters. Subjective torsion was measured using a double Maddox rod test. Fundus evaluation was also performed to judge the presence of objective torsion, if any. Surgical success was defined as postoperative primary position deviation within 10A of orthotropia; failure was defined as a residual esodeviation of >20A.

The paired t test was used to analyze the preoperative and postoperative changes in esotropia in primary position and limitation of abduction. A P value of <0.05 was considered statistically significant.

**Results**

A total of 17 subjects were identified, of whom 3 underwent bilateral surgery. Of these, 3 children (<10 years of age) and 1 adult with near complete recovery of abduction were excluded, leaving 15 eyes of 13 patients for analysis. The mean age of the subjects at the time of surgery was 43.3 years (range, 21-65 years). Trauma was the most common cause of the abducens nerve palsy (10 patients); one patient each had congenital abducens palsy, nonresolving ischemic palsy and abducens nerve palsy secondary to excision of a cerebello-pontine angle tumor.

The average amount of medial rectus recession performed was 5.7 mm/eye (range, 4.5-6.5 mm). Mean postoperative follow-up was 5.2 months (range, 1.5-12 months). Mean preoperative deviation was 55.4A ± 24A (range, 30A-110A). Mean postoperative deviation was 9.9A ± 10A (P = 0.0000), ranging from orthotropia to 25A of residual esotropia. Nine patients (69%) achieved alignment defined as ±10A of orthotropia. The abduction limitation improved by an average of 2 units, from −5 units (range, −2 to −6) preoperatively to −3.1 (range, −1 to −4) postoperatively (P = 0.0000). Positive forced duction testing, indicating a tight medial rectus muscle, was noted in 6 eyes (40%). In the remaining 9 eyes, abduction deficit improved from a mean of −4.8 units preoperatively to −2.7 units postoperatively (P = 0.0001). Three subjects had a small limitation of adduction (−0.5, −0.5, −1) in the early postoperative period, but in 2 cases it improved completely by final follow-up. Mean preoperative head turn was 21.6° (range, 10°-30°), which reduced to a mean postoperative head turn at final follow-up of 7.2° (range, 0°-15°) and was statistically significant (P = 0.0005). Two patients

<table>
<thead>
<tr>
<th>Esotropia in primary position, PD</th>
<th>Amount of MR recession, mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>30</td>
<td>4</td>
</tr>
<tr>
<td>40</td>
<td>5</td>
</tr>
<tr>
<td>50</td>
<td>5.5</td>
</tr>
<tr>
<td>60</td>
<td>6</td>
</tr>
<tr>
<td>70</td>
<td>6.5</td>
</tr>
</tbody>
</table>

**Table 1.** Approximate guide for amount of medial rectus recession, in combination with superior rectus transposition. 

MR, medial rectus muscle; PD, prism diopter.
had large residual esotropias (ie, \( \geq 20^\circ \)) and were classified as failures.

The first patient was a 60-year-old with bilateral traumatic abducens nerve palsy and a preoperative deviation of approximately 110°. He underwent bilateral MRc of 6 mm with SRT and had a postoperative residual deviation of 20°. The patient declined further surgery.

The second patient had traumatic abducens nerve palsy, with a preoperative deviation of 50° and an abduction deficit of −5. She underwent MRc of 5 mm with SRT. Her postoperative deviation was 25°, with −4 abduction deficit. Intraoperative forced duction testing was negative. She was comfortable with a small head turn and deferred further surgery.

One patient developed a small hypotropia of 4° in primary position but did not require a reoperation for the same. Another patient complained of torsional diplopia and was found to have a 15° intorsion in the immediate postoperative period. The patient was asymptomatic on final follow-up, although objective torsion as assessed by presence of fundal torsion persisted. Details of individual patients are summarized in Table 2.

### Discussion

Abduction deficit and esotropia resulting from a paresis or palsy of the abducens nerve can be managed by a variety of means. However, in the setting of associated medial rectus contracture, recession of the tight medial rectus becomes necessary, and transposing both the vertical rectus muscles is fraught with the risk of anterior segment ischemia. The technique of SRT offers a distinct advantage in these cases. We previously reported our results with SRT in Duane syndrome. The present study was performed to determine whether SRT showed a similar success in cases with abducens nerve palsy. A mean reduction 46.9° of esotropia and an improvement in abduction of 2 units was found. This compares favorably with previously published studies on SRT. Figure 1 illustrates the effect of SRT with MRc in a patient with traumatic abducens nerve palsy. Table 3 compares the results of the present study with previous studies describing various modifications of vertical rectus muscle transposition for abducens nerve palsy.

Abduction deficit improved from an average of −5 units preoperatively to −3.1 postoperatively. This is comparable to the results reported by Mehendale and colleagues. A tight, contracted medial rectus muscle may also contribute to abduction limitation in cases with abducens nerve palsy. A positive forced duction test, indicating a tight medial rectus muscle, was noted in 6 eyes (40%). However, significant improvement in abduction was seen even in those without a contracted medial rectus muscle, with a preoperative abduction deficit of −4.8 units improving to −2.7 units postoperatively. Therefore, MRc with SRT can result in significant reduction of abduction deficit even in eyes with no contracture of the medial rectus muscle.

The amount of MRc that must be performed should be calculated with the understanding that SRT can correct up to 15° of esotropia. However, individual cases vary, and factors that may contribute to the final surgical plan include medial rectus tightness, abduction deficit, residual function of the lateral rectus muscle as judged by a preoperative forced generation testing or evaluation of the adducting saccade, and primary position esotropia. The maximum MRc was 6.5 mm from the insertion; the
average, 5.7 mm/eye. Although previous studies have reported use of adjustable sutures to “fine tune” the amount of recession required,\textsuperscript{5,8} we used fixed sutures in all our cases with comparable results. We did not find significant adduction deficits in our patients.

Our 2 treatment failures had residual esotropia of $20^\circ$.

Despite further analysis of these cases, we were unable to find a single common factor that could have led to the unsatisfactory outcomes; however, both cases had large preoperative deviations.

Induced vertical deviations have been reported with full vertical rectus transpositions\textsuperscript{1,12} and remain a concern with SRT alone. One would expect a weakening of the vertical action of the superior rectus muscle after the transposition and a resultant hypotropia. Only 1 of our patients developed a postoperative hypotropia ($4^\circ$), but additional surgery was not required. Hypotropia may become evident with time, and a longer follow-up would be desirable in these cases to document the development of vertical deviations. Mehendale and colleagues\textsuperscript{5} reported

**Table 3. Comparison of current study with previous studies describing SRT and VRT for abducens nerve palsy**

<table>
<thead>
<tr>
<th>Study</th>
<th>No. with abducens nerve palsy</th>
<th>Type of surgery</th>
<th>Mean esotropia, PD Before surgery</th>
<th>Mean esotropia, PD After surgery</th>
<th>Mean abduction deficit Before surgery</th>
<th>Mean abduction deficit After surgery</th>
<th>Induced vertical deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mehendale et al\textsuperscript{5}</td>
<td>7</td>
<td>Augmented SRT with adjustable M Rc</td>
<td>47.42</td>
<td>8.71</td>
<td>--</td>
<td>--</td>
<td>2 (HoT)</td>
</tr>
<tr>
<td>Velez et al\textsuperscript{8}</td>
<td>7</td>
<td>Augmented SRT with adjustable M Rc</td>
<td>53.5</td>
<td>16.8</td>
<td>--</td>
<td>--</td>
<td>1 (HoT); 5 (HT)</td>
</tr>
<tr>
<td>Britt et al\textsuperscript{11}</td>
<td>5</td>
<td>Augmented partial VRT</td>
<td>45.2</td>
<td>--5</td>
<td>--4.8</td>
<td>--3</td>
<td>--</td>
</tr>
<tr>
<td>Yazdian et al\textsuperscript{10}</td>
<td>24</td>
<td>Augmented VRT</td>
<td>44.7</td>
<td>12.5</td>
<td>--4.22</td>
<td>--2.29</td>
<td>--</td>
</tr>
<tr>
<td>Simons et al\textsuperscript{9}</td>
<td>7</td>
<td>Augmented VRT</td>
<td>36.7</td>
<td>7.1</td>
<td>--3.78</td>
<td>--2.64</td>
<td>--</td>
</tr>
<tr>
<td>Present study</td>
<td>17</td>
<td>Augmented SRT with M Rc with fixed sutures</td>
<td>56.88</td>
<td>10.82</td>
<td>--4.85</td>
<td>--2.85</td>
<td>1 (HoT)</td>
</tr>
</tbody>
</table>

HoT, hypertropia; M Rc, HT, hypotropia; medial rectus recession; PD, prism diopter; SRT, superior rectus transposition; VRT, vertical rectus transposition.
2 patients with hypotropia. Velez and colleagues⁸ reported hypertropia in 5 of 7 patients with abducens nerve palsy in their series, 1 of which was clinically significant (14Δ). The reason for the induced hyperdeviation is unclear. Rosenbaum¹ described a possible restrictive effect of the transposed superior rectus muscle with an induced hypertropia in patients undergoing VRT. We did not encounter this in our series.

Torsional changes are also expected due to temporal transposition of the superior rectus muscle. Lateral transposition of the superior rectus muscle may cause intorsion, which may result in torsional diplopia or a compensatory head posture. However, torsional deviation has not yet been found to be clinically significant.⁵,⁶ Induced intorsion may assume a greater significance in patients with preexisting intorsion. This being a retrospective study, details for preoperative torsion were not noted in all patients. Only 1 patient complained of subjective intorsion in the immediate postoperative period. Although intorsion, as measured by a double Maddox rod test, persisted in the follow-up visits, the patient did not have subjective torsional diplopia. Velez and colleagues⁸ studied the torsional effects induced by SRT and found induced intorsion in most of their patients, although it was not clinically significant. They opined that preoperative torsional measurement is a must in all patients undergoing this procedure and that one should be especially cautious in patients with preexisting intorsion. Pre- and postoperative measurement of (subjective and objective) torsion has been incorporated as a part of our practice pattern in such cases now. Longer follow-up is needed to assess the potential torsional changes as well as possibility of development of vertical deviation, especially in abduction.

We found no serious intra- or postoperative complications and no cases of anterior segment ischemia.

The current study is limited by its retrospective nature, by the fact that multiple surgeons were involved and there may have been minor variations in surgical procedure, and by a lack of torsion measurements for all patients pre- and postoperatively. A longer follow-up period would have been desirable, and measurement of binocular field of vision would have been useful in these patients. Despite these limitations, this study highlights the utility of SRT with MRc in patients with abducens nerve palsy, especially in the presence of a tight medial rectus. However, the effectiveness of the procedure in the presence of large deviations remains to be evaluated. Although induced vertical and torsional deviations remain a concern, they are not clinically significant in the majority of cases.

Acknowledgments
The authors thank Mr. Mobd. Hasnat Ali for his help with the statistical analysis.

References