Surgical Results of Patients With Unilateral Superior Oblique Palsy Presenting With Large Hypertropias

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ABSTRACT

Purpose: Surgical management of superior oblique palsy (SOP) is challenging because of combined vertical, horizontal, and torsional misalignment. The authors report the surgical results of patients with large primary position hypertropias (> 20 prism diopters [PD]) due to unilateral SOP.

Methods: Criteria for success included correction of the anomalous head posture, primary position alignment between orthotropia and 6 PD of undercorrection, and no reoperation required for residual deviations in any direction of gaze.

Results: Forty-five patients met inclusion criteria. Mean preoperative alignment in primary gaze was 26.5 ± 6.5 PD compared to 3.0 ± 4.4 PD postoperatively (P < .001). Twenty-three (51%) cases met the criteria for success with one operation. Of the patients who had single muscle surgery, 14% had a successful outcome, with a mean 67% (17.3 PD) reduction in hypertropia. Of patients who underwent simultaneous multiple muscle surgery, 58% met the criteria for a successful result, with a mean 92% (24.6 PD) reduction in primary gaze hypertropia. Success was the highest in patients who underwent ipsilateral inferior oblique combined with contralateral inferior rectus recessions with (60% success) or without (65% success) a Harada–Ito procedure.

Conclusion: Undercorrections are frequent following surgery for unilateral SOP with preoperative deviations greater than 20 PD in primary position, especially after single-muscle surgery. Simultaneous multiple muscle surgery rarely results in overcorrection and is recommended in patients with SOP and more than 20 PD of hypertropia in primary position.

INTRODUCTION

Surgical management of superior oblique palsy is aimed at achieving fusion and eliminating any anomalous head posture. Although some patients with superior oblique palsy spontaneously recover, most patients with torticollis or diplopia require treatment. Treatment for superior oblique palsy commonly consists of surgical intervention because lateral incomitance often limits prism use, and botulinum toxin studies have not been encouraging for long-term improvement. Vertical diplopia, torsional diplopia, or significant torticollis are all indications for surgery. Several operative techniques have been recommended for the treatment of superior oblique palsy, including weakening the ipsilateral inferior oblique muscle, simultaneous multiple muscle surgery rarely results in overcorrection and is recommended in patients with SOP and more than 20 PD of hypertropia in primary position.
surgical option has not been well defined in previous studies, especially for the subset of patients with large primary gaze deviations.

Several studies have reported the efficacy of different surgical procedures,\(^3\)\(^-\)\(^7\)\(^,\)\(^10\)\(^-\)\(^12\) and there are many reports comparing the success of two or more surgical techniques.\(^8\)\(^,\)\(^9\)\(^,\)\(^14\)\(^-\)\(^18\) However, most patients in these studies had hypertropias less than 20 prism diopters (PD) in primary gaze. Those who reported on subsets with large hypertropias had a small number of patients who underwent only one type of procedure. In these studies, undercorrections are common in patients with more than 20 PD of deviation in primary position.\(^7\)\(^,\)\(^9\)\(^,\)\(^12\)\(^,\)\(^14\)\(^,\)\(^17\) However, the literature is not clear whether patients with superior oblique palsy with primary gaze deviations greater than 20 PD should have one or two muscles operated on simultaneously. In this study, we present cases with large-angle hypertropias of at least 20 PD treated by different surgical procedures and compare the postoperative results.

**PATIENTS AND METHODS**

This study was approved by the University of California, Los Angeles Institutional Review Board and conformed to the requirements of the United States Health Insurance Portability and Accountability Act and the tenets of the Declaration of Helsinki. The records of patients with superior oblique palsy who underwent surgery over a 25-year period treated by a single surgeon (ALR) at the Jules Stein Eye Institute were identified. Patients who were amblyopic, had bilateral superior oblique palsy, or had a previous surgical procedure were excluded. The minimum postoperative follow-up required for inclusion in the study was 6 months.

The following demographic information was obtained for the patients’ records: age, gender, etiology, and the affected eye. The ophthalmologic examination performed, according to limits of ability to cooperate, included visual acuity, ductions, versions, ocular alignment according to alternate occlusion test with prism in near and far fixation in all cardinal gazes, and Bielschowsky head tilt test. In general, visual acuity was assessed using projected age-appropriate optotypes. Near stereopsis was assessed using the Titmus test using the proper refractive correction. Ocular alignment was assessed using cover–uncover and alternate prism cover testing at distance (20 feet) in the cardinal gaze positions. Motor alignment at near was assessed at 14 inches. All motor evaluations were done using spectacle correction. Torticollis was assessed in the patient’s habitual head position in degrees. Subjective excyclotropia was detected by double Maddox rod test.\(^19\) A cycloplegic refraction, slit-lamp evaluation of the anterior segment, and direct or indirect examination of the posterior segment were performed in all cases. Superior oblique palsy was diagnosed on the basis of history and examination findings based on analysis of versions, ocular alignment in diagnostic gaze positions, head tilt test, and subjective torsion. Ocular versions were graded from -4 (inability to move the eye past midline) to +4 (maximum observable overaction), with 0 being normal movement.\(^20\)

The operative reports and surgeon’s notes were reviewed. All of the procedures for each case were recorded and included the type and number of muscles operated on and the amount of surgery performed. Surgical procedures included inferior oblique recession; superior oblique tuck; inferior oblique recession and ipsilateral superior rectus recession; inferior oblique recession and contralateral inferior rectus recession; inferior oblique recession and contralateral inferior rectus recession with Harada–Ito procedure; superior oblique tuck and contralateral inferior rectus recession; superior oblique tuck and inferior oblique recession; superior oblique tuck, contralateral inferior rectus recession, and ipsilateral superior rectus recession; superior oblique tuck, inferior oblique recession, and ipsilateral superior rectus recession; and inferior oblique recession, ipsilateral superior rectus recession, and contralateral inferior rectus recession.

The operative technique by this surgeon for both the superior oblique tuck and Harada–Ito procedures has been described elsewhere.\(^12\)\(^,\)\(^21\) The decision to use different surgical approaches was based on the amount and directionality of lateral incomitance, the amount of excyclotorsion, and the amount of deviation in primary, up, and down gaze.

Postoperative examinations were performed routinely between 1 day and 1 week, and then at 1- and 6-month intervals. Both the preoperative and postoperative evaluations were done by the operating surgeon. At each postoperative visit, a complete evaluation of ocular alignment, head posture, ocular torsion, and complications were noted.
Statistical Analysis

Criteria for surgical success included correction of head posture and a primary position alignment between orthotropia and 6 PD of undercorrection. Patients who required reoperation for a residual deviation in any field of gaze despite being aligned between orthotropia and 6 PD of undercorrection in primary gaze were not considered surgical successes. Statistical analysis was performed using JMP version 9.0.0 software (SAS Institute, Inc., Cary, NC) and Microsoft Excel (Microsoft Corporation, Redmond, WA). To compare means between groups, a paired, one-tailed Student’s t test was used. To compare preoperative characteristics such as age and primary position deviation among the various surgical groups, a Wilcoxon rank sum test was performed. A P value of less than .05 was considered statistically significant.

RESULTS

Forty-five patients underwent surgery for a primary gaze hypertropia of at least 20 PD due to unilateral superior oblique palsy. Table 1 lists the frequency of each procedure performed, etiology of superior oblique palsy, and mean age for all patients and each procedure subgroup. There was no difference in age or preoperative alignment among treatment groups (P < .05 for both comparisons). An anomalous head posture was noted in 44 (98%) patients. Of these, 32 (72%) had contralateral head tilt, 2 (4%) had ipsilateral head tilt, 2 (4%) had a chin depression, 1 (2%) had an ipsilateral head turn, and 6 (13%) had a combination of head tilt and turn. The mean postoperative follow-up period was 16 months (range: 6 months to 16 years).

Seven (16%) of the cases were one-muscle surgeries, 29 (64%) were two-muscle surgeries, and 9 (20%) were three-muscle surgeries. The “other multiple muscle” surgery group was composed of two two-muscle surgeries (a superior oblique tuck and inferior oblique recession combination and a superior oblique tuck and contralateral inferior rectus recession combination) and three three-muscle surgeries (a superior oblique tuck, inferior oblique recession, and ipsilateral superior rectus recession combination; a superior oblique tuck, inferior oblique recession, and ipsilateral superior rectus recession; and contralateral inferior rectus recession combination). The preoperative largest angle of deviation for the majority of patients was in primary position, contralateral gaze, and down gaze (Table 2). Seven (16%) of the patients had equally large deviations in primary position, contralateral gaze, and up gaze, all of whom had inferior oblique and superior rectus recessions (with one patient having an additional superior oblique tuck). Only 2 (4%) patients had comitant strabismus, and both underwent inferior oblique and contralateral inferior rectus recessions. Of note, all 7 patients who underwent single muscle surgery had a large amount of incomitance (range: 22 to 45 PD).

The preoperative and postoperative vertical deviation in primary gaze for each of the six different operations are shown in Figure 1. The mean angle of preoperative vertical deviation in primary gaze was

### Table 1

<table>
<thead>
<tr>
<th>Procedure</th>
<th>No. (%)</th>
<th>Mean Age (y) (Range)</th>
<th>Etiology: Congenital/Acquired</th>
</tr>
</thead>
<tbody>
<tr>
<td>All patients</td>
<td>45 (100)</td>
<td>33.7 (7–87)</td>
<td>21/24</td>
</tr>
<tr>
<td>SO tuck</td>
<td>3 (7)</td>
<td>36.0 (9–87)</td>
<td>1/2</td>
</tr>
<tr>
<td>IO recession</td>
<td>4 (9)</td>
<td>28.3 (12–44)</td>
<td>2/2</td>
</tr>
<tr>
<td>IO recession/SR recession</td>
<td>8 (18)</td>
<td>44.3 (31–69)</td>
<td>4/4</td>
</tr>
<tr>
<td>IO recession/IR recession</td>
<td>20 (44)</td>
<td>33.9 (7–61)</td>
<td>8/12</td>
</tr>
<tr>
<td>IO recession/IR recession/Harada–Ito</td>
<td>5 (11)</td>
<td>49.0 (41–64)</td>
<td>3/2</td>
</tr>
<tr>
<td>Other multiple muscle combination</td>
<td>5 (11)</td>
<td>34.2 (7–51)</td>
<td>3/2</td>
</tr>
</tbody>
</table>

SO = superior oblique; IO = inferior oblique; SR = superior rectus; IR = inferior rectus.

aMultiple muscle combinations included SO tuck and contralateral IR recession; SO tuck and IO recession; SO tuck, contralateral IR recession, and ipsilateral SR recession; SO tuck, IO recession, and ipsilateral SR recession; IO recession, ipsilateral SR recession, and contralateral IR recession.
26.5 ± 6.5 PD (range: 20 to 42 PD) and the mean angle of postoperative vertical deviation, measured at the patient’s last postoperative appointment prior to either discharge or further treatment, was 3.0 ± 4.4 PD (range: 0 to 22 PD). These findings are presented according to the procedure done for the first surgery in Table 3.

The number of surgeries required to achieve surgical success, according to the first surgery performed, are summarized in Table 4. One of the two patients who had an inferior oblique recession as their only operation had a late undercorrection for which a second operation was planned but not done after the patient was lost to follow-up. Additionally, one of the four patients who underwent an inferior oblique and inferior rectus recession plus Harada–Ito procedure as their only operation was overcorrected by 3 PD. Although both of these patients underwent only one surgery, neither was considered a surgical success by our definition. Twenty-five

### Table 2

**Gaze Deviation Patterns According to First Procedure Performed**

<table>
<thead>
<tr>
<th>Largest Gaze Deviation</th>
<th>SO Tuck</th>
<th>IO Recession</th>
<th>IO/SR Recession</th>
<th>IO/IR Recession ± Harada–Ito</th>
<th>Other Combinations&lt;sup&gt;a&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary gaze (n = 3)</td>
<td>0</td>
<td>0</td>
<td>1 (1)</td>
<td>1 (1)</td>
<td>1 (0)</td>
</tr>
<tr>
<td>Primary and contralateral gaze (n = 10)</td>
<td>0</td>
<td>0</td>
<td>1 (0)</td>
<td>8 (7)</td>
<td>1 (0)</td>
</tr>
<tr>
<td>Primary, contralateral, and down gaze (n = 23)</td>
<td>3 (1)</td>
<td>4 (0)</td>
<td>0</td>
<td>14 (8)</td>
<td>2 (1)</td>
</tr>
<tr>
<td>Primary, contralateral, and up gaze (n = 7)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2 (2)</td>
<td>0</td>
</tr>
<tr>
<td>Equal in all gazes</td>
<td>0</td>
<td>0</td>
<td>2 (2)</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

<sup>a</sup>Multiple muscle combinations included SO tuck and contralateral IR recession; SO tuck and IO recession; SO tuck, contralateral IR recession, and ipsilateral SR recession; SO tuck, IO recession, and ipsilateral SR recession; IO recession, ipsilateral SR recession, and contralateral IR recession.

### Figure 1

Preoperative and postoperative deviation. SO = superior oblique; IO = inferior oblique; SR = superior rectus; IR = inferior rectus.

*Indicates statistically significant reduction in primary gaze deviation.

*Multiple muscle combinations included SO tuck and contralateral IR recession; SO tuck and IO recession; SO tuck, contralateral IR recession, and ipsilateral SR recession; SO tuck, IO recession, and ipsilateral SR recession; IO recession, ipsilateral SR recession, and contralateral IR recession.
(56%) patients achieved primary gaze alignment between orthotropia and 6 PD of undercorrection at last follow-up. Two of these patients required re-operation for a residual deviation in down gaze (n = 1) and contralateral gaze (n = 1), and were not considered a surgical success by our criteria. Twenty-three (51%) cases met our criteria for surgical success with one operation. Of these, 22 (96%) were patients who had two or more muscles operated on (Table 5).

The highest success rate with one surgery belonged to the groups that had the combination of inferior oblique recession and contralateral inferior rectus recession (65%) and those who had this combination in addition to the Harada–Ito procedure (60%). Of the patients who required further treatment, 13 (72%) achieved success after a second surgery. No patients were overcorrected in the immediate postoperative period, which we defined as the first follow-up visit, usually the next day after surgery. Forty (89%) patients were aligned between orthotropia and 6 PD of undercorrection within this immediate postoperative period (“immediate success”). Five patients were undercorrected (mean: 13.2 ± 5.4 PD) in the immediate postoperative period. Of these, one was undercorrected by 8 PD after an inferior oblique and inferior rectus recession and required no further treatment up to 26 months of follow-up. The other four were undercorrected by 10 to 22 PD after either inferior oblique recession or superior oblique tuck and required one to three more surgeries to achieve successful results. Between the first postoperative visit (within 1 week) and last follow-up visit prior to further surgery (2 months to 16 years), 14 (31%) of the 40 patients with immediate success developed deviations greater than 6 PD.

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Mean Preoperative Deviation (PD) (Range)</th>
<th>Mean Postoperative Deviation (PD) (Range)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>All patients</td>
<td>26.5 (20–45)</td>
<td>3.0 (0–22)</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>SO tuck (n = 3)</td>
<td>28.6 (26–30)</td>
<td>11.3 (0–22)</td>
<td>.002</td>
</tr>
<tr>
<td>IO recession (n = 4)</td>
<td>23.8 (20–30)</td>
<td>6.5 (0–14)</td>
<td>.02</td>
</tr>
<tr>
<td>IO recession/SR recession (n = 8)</td>
<td>23.5 (20–30)</td>
<td>2.5 (0–6)</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>IO recession/IR recession (n = 20)</td>
<td>25.9 (20–45)</td>
<td>1.6 (0–8)</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>IO recession/IR recession/Harada–Ito</td>
<td>26.4 (20–35)</td>
<td>1.8 (0–8)</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>Other multiple muscle combinationsa (n = 5)</td>
<td>35.0 (25–45)</td>
<td>3.2 (2–5)</td>
<td>.005</td>
</tr>
</tbody>
</table>

PD = prism diopters; SO = superior oblique; IO = inferior oblique; SR = superior rectus; IR = inferior rectus.
aMultiple muscle combinations included SO tuck and contralateral IR recession; SO tuck and IO recession; SO tuck, contralateral IR recession, and ipsilateral SR recession; SO tuck, IO recession, and ipsilateral SR recession; IO recession, ipsilateral SR recession, and contralateral IR recession.

<table>
<thead>
<tr>
<th>Procedure at First Surgery</th>
<th>No. of Cases (% of Total Cases for Each Procedure)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 Surgery</td>
</tr>
<tr>
<td>SO tuck (n = 3)</td>
<td>1 (33)</td>
</tr>
<tr>
<td>IO recession (n = 4)</td>
<td>2 (50)</td>
</tr>
<tr>
<td>IO recession/SR recession (n = 8)</td>
<td>4 (50)</td>
</tr>
<tr>
<td>IO recession/IR recession (n = 20)</td>
<td>14 (75)</td>
</tr>
<tr>
<td>IO recession/IR recession/Harada–Ito (n = 5)</td>
<td>4 (80)</td>
</tr>
<tr>
<td>Other multiple muscle combinationsa (n = 5)</td>
<td>2 (40)</td>
</tr>
</tbody>
</table>

SO = superior oblique; IO = inferior oblique; SR = superior rectus; IR = inferior rectus.
aMultiple muscle combinations included SO tuck and contralateral IR recession; SO tuck and IO recession; SO tuck, contralateral IR recession, and ipsilateral SR recession; SO tuck, IO recession, and ipsilateral SR recession; IO recession, ipsilateral SR recession, and contralateral IR recession.
Four patients were undercorrected (mean: 14.6 ± 6.7 PD) and 10 patients were overcorrected (mean: 18.3 ± 6.2 PD). These primary gaze deviation outcomes are presented for each procedure performed in Table 6.

The lowest success rates belonged to the single muscle surgeries. Of the patients who had single muscle surgery, 14% had a successful outcome, with a mean 67% (17.3 PD) reduction in hypertropia. Of patients who underwent simultaneous multiple muscle surgery, 58% met the criteria for a successful result, with a mean 92% (24.6 PD) reduction in primary gaze hypertropia.

Similar results were also seen in down gaze. Average postoperative hypertropia in down gaze for the inferior oblique recession group and the superior oblique tuck group were 9.5 and 15.3 PD, respectively. All other surgery groups had average postoperative deviations of less than 6 PD in down gaze. Of the 25 patients who had successful outcomes in primary gaze with one surgery, 13 were orthotropic in primary gaze and an additional 10 were within 6 PD of orthotropia in primary gaze.

All patients had resolution of their abnormal head position after one surgery. Preoperative torsion was recorded in 41 patients and was on average 8.4 ± 3.8 degrees. Twenty-five (56%) of the patients also had horizontal deviations in primary gaze. Twenty (80%) had deviations less than 15 PD. Of the 25 patients, 18 (72%) were exotropias and 7 (38%) were esotropias. Twelve of the 18 exotropias (67%) and 3 of the 7 esotropias (42%) resolved with vertical
muscle surgery only. All of these patients had horizontal deviations less than 15 PD. Of the 5 patients who had horizontal deviations greater than 15 PD, 3 underwent horizontal muscle surgery for exotropia and 2 for esotropia. All 3 patients with exotropias were undercorrected in both vertical and horizontal deviation postoperatively, 1 of the 2 patients with esotropia was overcorrected, and 1 was orthotropic in both vertical and horizontal gaze. Of the 25 patients with any horizontal deviation, 13 (52%) had successful results after one vertical muscle surgery; however, in the 5 patients with horizontal deviations greater than 15 PD who underwent horizontal muscle surgery, only 1 (20%) was successful in both vertical and horizontal gaze with one surgery.

**DISCUSSION**

Superior oblique palsy is the most common cause of vertical strabismus and most patients will require surgical treatment. In some studies, single muscle surgery was proven inadequate for the few patients within the series who had large hypertropias in primary gaze. Morad et al. concluded that the standard ungraded 10-mm inferior oblique recession as the primary weakening procedure was effective and safe, but the only two patients in their study with hypertropias greater than 20 PD remained undercorrected and symptomatic after inferior oblique recession alone. In a series of patients undergoing superior oblique tuck, Bhola et al. found that all patients requiring reoperation had preoperative hypertropias greater than 15 PD in primary gaze. They concluded that isolated superior oblique tucking may not be sufficient to correct hypertropias greater than 15 PD, and such cases should undergo additional muscle surgery. We found that isolated inferior oblique recession and isolated superior oblique tuck are not effective for primary gaze deviations greater than 20 PD. Of the 7 patients in our series who underwent a single oblique muscle surgery, only one had a successful outcome. Additionally, patients who underwent superior oblique tuck or inferior oblique recession had worse residual hypertropias in down gaze.

There are multiple techniques for weakening the inferior oblique muscle. Favardin and Nazarpoor described 8 patients with hypertropia greater than 20 PD. Seven of those patients were aligned within 6 PD of orthotropia postoperatively and no patient was overcorrected with anterior transposition of the inferior oblique muscle. In our study, isolated inferior oblique recession resulted in undercorrection in 75% of cases. It is likely that a stronger weakening effect and an associated anti-elevation mechanism result in more vertical correction in patients undergoing anterior transposition of the inferior oblique muscle in the above-mentioned study.

It has been recommended that cases with large vertical deviations in primary gaze be managed with a combination of oblique and vertical rectus muscle surgery. In a study by Caca et al., 10 of 48 unilateral congenital superior oblique palsy cases had primary gaze hypertropias greater than 20 PD. After a myectomy and concomitant inferior oblique disinsertion-recession in combination with an ipsilateral superior rectus recession, 5 patients achieved results defined as “excellent” (0 to 3 PD), two achieved “good” results (4 to 7 PD), and 3 had “poor” results (> 7 PD) requiring reoperation. In a series of 12 patients with unilateral superior oblique palsy by Saunders, 9 patients had preoperative hyperdeviations greater than 20 PD. They found that ipsilateral inferior oblique myectomy and superior oblique tuck was effective in their patients, all of whom achieved fusion in practical fields of gaze. Hatz et al. performed inferior oblique anteriorization and recession in combination with contralateral inferior rectus recession in patients with hyperdeviations of 20 PD. Of these patients, 17% were reported to have remaining hyperdeviations greater than 5 PD. Although postoperative deviations and reoperation rates were reported in all three studies, none defined success criteria and reported success rates. Furthermore, all of these results from the aforementioned studies are from case reviews in which a small subset of the patients who presented with large hypertropias underwent a combination of oblique muscle and vertical rectus muscle surgery.

In our study, patients who underwent multiple muscle surgeries on average had a greater reduction in hypertropia and a smaller reoperation rate than the single muscle surgery group. It is likely that single muscle surgery was chosen for those patients with a large amount of incomitance because of a concern for overcorrection in ipsilateral gaze. However, of the patients who had multiple muscle surgery, none required reoperation for overcorrection in ipsilateral gaze. Among the patients who underwent multiple muscle surgery, those who had inferior oblique and inferior rectus recessions, with or without a Harada–
Ito procedure, were most likely to have successful outcomes. Unfortunately, postoperative torsion was not recorded for all patients, and it is unclear whether those who underwent the Harada–Ito procedure had better improvement of torsional diplopia.

Helveston et al. reported finding a horizontal deviation in 36% of superior oblique palsies, of which 68% resolved with vertical muscle surgery alone. Of the unilateral cases, 75% had exotropias, which they found were almost twice as likely to resolve postoperatively without horizontal rectus muscle surgery. In our patients, we found a much larger prevalence of horizontal deviations. More than half of our patients had horizontal strabismus. Similar to Helveston et al., we found the majority (72%) of these to be exotropias, which resolved postoperatively more often than the esotropias (67% vs 42%). Horizontal muscle surgery was only required in 5 of our patients whose preoperative horizontal deviations exceeded 15 PD. In our series, the reoperation rate was higher in patients who required simultaneous horizontal muscle surgery than in those who did not. The reoperations were more common in exotropic than esotropic patients (100% vs 50%). Therefore, although horizontal deviations are more likely to be present in patients with superior oblique palsy who present with large hypertropias, mild to moderate horizontal deviations should not be a definite indication for horizontal muscle surgery. A higher threshold for horizontal muscle surgery should be used because most have a tendency to resolve with any vertical muscle procedure, and patients who undergo horizontal muscle surgery tend to require more surgery because of undercorrection or overcorrection of vertical and horizontal deviation.

The results of this study should be understood within the context of its limitations. First, this was a retrospective study, in which the surgical procedure may not have been completely standardized over time. The retrospective nature of the study precludes definitive conclusions regarding indications for various surgical procedures, given that it is subject to inherent selection and follow-up bias. Finally, missing data regarding postoperative torsion in many patients precludes careful analysis of the various surgical techniques’ ability to address torsional deviations.

Patients with unilateral superior oblique palsy who have large deviations in primary gaze are challenging to treat. The most improvement in primary gaze hypertropia was achieved with multiple muscle surgery rather than single muscle surgery. Patients undergoing multiple muscle surgeries were more likely to achieve results between orthotropia and 6 PD of undercorrection and less likely to require reoperation. Furthermore, patients with superior oblique palsy who have large hypertropias are also more likely to have horizontal deviations, and up to 15 PD of horizontal strabismus is likely to resolve with vertical muscle surgery alone. Of the different multiple muscle combinations studied here, inferior oblique recession with contralateral rectus recessions resulted in the lowest reoperation rate.

REFERENCES


