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Surgical management of clinically significant hypertropia associated with exotropia

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Abstract

Purpose—To report the surgical treatment of hypertropia coexisting with exotropia, with either vertical offset surgery or additional vertical muscle surgery simultaneous to correction of the exotropia.

Methods—A total of 35 patients with exotropia and hypertropia who underwent a horizontal muscle surgery for exotropia were included. To determine efficacy in resolving a vertical deviation in patients with exotropia, 28 patients were compared in 2 groups: those who underwent horizontal muscle surgery with vertical offset and those who underwent horizontal muscle surgery with additional vertical muscle surgery. An additional 7 patients who had exotropia and hypertropia but did not undergo vertically corrective surgery were included for comparison.

Results—Vertical offset of horizontal rectus muscles (4 mm) resulted in 8^Δ correction of the distance hypertropia. Vertical rectus muscle recession used in the treatment of larger hypertropic deviations with exotropia had a 3^Δ correction per 1 mm of recession. Success rates for hypertropia correction were similar between groups, 63% vertical offset and 71% vertical muscle groups; overcorrections occurred in 29% of the vertical muscle group. The vertical correction in both groups was stable in 88% over 6 months postoperatively.

Conclusions—Vertical offset of the horizontal muscles simultaneous with exotropia correction has a beneficial effect in small-angle hypertropia (<14^Δ). Vertical rectus muscle surgery in patients with hypertropia greater than 10^Δ had equivalent success; however, in intermittent exotropia the hypertropia was prone to overcorrection.

Vertical deviations often coexist with exotropic horizontal strabismus and have been described in up to 50% of the patients who present with exotropia.^{1,2} This report focuses on the constant, small-angle vertical tropia, unrelated to oblique dysfunction, dissociated vertical deviation (DVD), or paretic muscle. This small-angle vertical tropia can be present in patients with intermittent exotropia, consecutive exotropia, constant exotropia, and

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Literature Search: The National Library of Medicine's database was searched through PubMed and MEDLINE for all years with the search terms: *vertical transposition of horizontal recti*; *vertical offset of horizontal recti*; *exotropia AND vertical*; *exotropia (all) AND hypertropia* (title and abstract). Additionally the core clinical journals for human literature were searched for *exotropia AND hypertropia AND NOT superior oblique palsy*. Additional sources included the identical search terms in the database of the *American Orthoptic Journal*. Finally, articles cited in the reference lists of other articles were evaluated for similar reports.

congenital exotropia. There are few current studies devoted to surgical management of exotropia that clarify the surgical management of the vertical tropia in these patients.

The authors of several studies³⁻⁷ have examined the treatment of vertical deviations in association with horizontal strabismus. Most of these studies concentrated on transposition or vertical offset of the horizontal rectus muscles during surgery for a horizontal deviation to correct the associated vertical deviation.

These studies have helped to define potential options for the treatment of small-angle hypertropia associated with primarily horizontal strabismus. However, most have included both esotropic as well as exotropic patients, with the assumption that the vertical effect will be similar. Also, we were unable to find any report that specifically addressed the addition of vertical rectus muscle surgery with horizontal surgery to treat vertical deviations larger than 10^Δ associated with exotropia. In one study on surgical treatment of consecutive exotropia,⁸ the authors noted a 29% incidence of simultaneous oblique surgery. And, in another similar study on the treatment of consecutive exotropia,⁹ the authors noted a 26% incidence of either DVD or vertical tropia without addressing the treatment of the vertical deviation.

The purpose of our study was to further explore the best surgical management of a vertical tropia associated with exotropia only and unrelated to concurrent oblique dysfunction, DVD, or paretic muscle. In this article we describe the magnitude of effect for vertical offset surgery to correct a vertical tropia associated with exotropia. Also, we provide indications and guidelines to add a vertical rectus muscle surgery simultaneously to surgical treatment of exotropia.

Methods

A retrospective case cohort series was conducted of 35 patients obtained from the patient registry at the University of Wisconsin–Madison. Patients were included in the study if they were diagnosed with exotropia (including intermittent exotropia) and a hypertropia and underwent a vertical offset of the horizontal muscles or horizontal surgery in combination with vertical rectus muscle surgery. Seven of these patients were diagnosed with exotropia and hypertropia but did not undergo vertical corrective surgery and are included for comparison (comparison group). Patients were included with previous strabismus surgery, including previous vertical muscle surgery. Exclusion criteria included mechanical or restrictive strabismus, neurological disorders (excluding cerebral palsy), thyroid dysfunction, visual acuity less than 20/50 in the worse seeing eye, an A- or V-pattern strabismus, DVD, previous superior oblique muscle surgery, simultaneous inferior or superior oblique muscle surgery, or follow-up less than 5 weeks.

Patients were classified into 2 study groups, determined on the basis of surgery, that was performed by 1 of 3 surgeons between 2001 and 2008. The first group included 11 patients aged 6 to 42 years who underwent a horizontal muscle vertical offset surgery simultaneously with horizontal rectus muscle surgery to correct the exotropia (vertical offset group). The second group included 17 patients ages 1 to 84 years who underwent vertical rectus muscle surgery to correct the hypertropia simultaneously with horizontal rectus muscle surgery to correct the exotropia (vertical muscle group). The treatment of the vertical deviation was not randomized but by the surgeon's preference for treatment of the vertical deviation at the time of surgical correction for the exotropia.

All patients underwent complete ophthalmological and orthoptic examination. Visual acuity was recorded as linear Snellen acuity with a random, computer-generated letter set in all but 3 patients who were too young for testing; these patients had no sign of amblyopia or vision

deficit. Presence of stereopsis was defined as 200 arcsec or better of stereo acuity on either the Titmus circle or animal stereogram. Alternate cover testing in primary position determined the magnitude of measured vertical and horizontal angle of deviation at near (33 cm) and distance (6 m). All patients had cover testing performed in 6 cardinal fields of gaze with accommodation controlled on an appropriate fixation target with appropriate cycloplegic refraction. No patient was treated postoperatively with over-minus spectacle correction. All patients underwent passive forced duction testing to rule out restrictive strabismus under general anesthesia at the time of surgery.

Surgical correction in the vertical offset group consisted of unilateral recession-resection/advancement in 9 patients with a 4 mm vertical offset of both horizontal muscles in the opposite direction of the hypertropia (1 patient had a 5.5 mm offset). The remaining 2 patients had bilateral surgery with a 4 mm supra-placement of one horizontal rectus muscle and a 4 mm infra-placement of the other horizontal rectus muscle. Surgical correction in the vertical muscle group consisted of superior rectus muscle recession in 11 patients and inferior rectus muscle recession in 6 patients; 5 of these patients had adjustable sutures on the vertical muscle. The vertical muscle recession formula was 1 millimeter of recession for each 3^Δ of vertical hypertropia. All calculations were determined on the basis of the postadjustment measurement of the vertical muscle position. Additionally in the vertical muscle group, 4 patients had bilateral lateral rectus muscle surgery, 5 had unilateral recession-resection surgery with contralateral vertical rectus muscle surgery, and 8 patients had unilateral one muscle horizontal surgery and same-sided vertical rectus muscle surgery.

Successful outcome was defined as a hyperphoria or an intermittent hypertropia with a vertical angle of deviation at 6 months postoperatively (1 month if 6-month data were unavailable), less than or equal to one half the preoperative vertical angle, or less than 8^Δ , and with no reversal of the hypertropia, at both distance and near. Comparison of the mean of the hypertropic deviation between groups was performed with the Kruskal-Wallis test, and within groups with the Wilcoxon signed rank test. Success rates between the 2 groups for hypertropia correction were performed by use of the Fisher exact test.

University of Wisconsin Institutional Review Board approval was obtained, and informed consent was obtained from the patient or parents. This study also complied with Health Insurance Portability and Accountability Act regulations.

Results

Charts of 35 patients were available for analysis, and 6-month postoperative data were available in 29 patients (83%) and, in the remaining 6 patients, the 5-week postoperative data were used. Patient age ranged from 1 to 84 years.

Of the 35 patients with exotropia, 10 patients carried the diagnosis of intermittent exotropia, 2 of these 10 had convergence insufficiency type, 18 patients had consecutive exotropia, 4 patients had constant exotropia, 2 had congenital exotropia, and 1 had cerebral palsy and exotropia (e-Supplement 1, available at jaapos.org).

The preoperative and postoperative magnitude of the hypertropic deviation measured for distance and near is shown in Table 1. There was no difference in magnitude of preoperative hypertropia between the vertical offset group and the comparison group or the vertical muscle group at either distance or near. However, there was a statistically significant difference in the preoperative distance hypertropia between the comparison group and the vertical muscle group ($p = 0.05$). In the vertical offset group, the range of preoperative distance hypertropia was 6^Δ - 20^Δ and preoperative near hypertropia was 0^Δ - 25^Δ ; this difference was not significant. In the vertical muscle group, the range of preoperative

distance hypertropia was 5^{Δ} - 25^{Δ} and preoperative near hypertropia was 0^{Δ} - 20^{Δ} ; the difference in the distance and near measurements was significant ($p = 0.007$).

Success rate for correcting the hypertropia was 63% (7/11) in the vertical offset group, and 71% (12/17) in the vertical muscle group. A plot of the postoperative hypertropia is shown in Figure 1 (near deviation) and Figure 2 (distance deviation). The magnitude of change within each group was significant at both distance and near for the vertical offset and vertical muscle groups but not significant for the comparison group. The preoperative and postoperative magnitude of the exotropic deviation measured for distance and near was compared between groups. In the vertical offset group the distance exotropia measured 35^{Δ} preoperatively and 9^{Δ} postoperatively. In the vertical group it was 23^{Δ} preoperatively and 3^{Δ} postoperatively. There was no statistically significant difference between the 3 groups in postoperative horizontal alignment.

The vertical offset group consisted of 11 patients: 2 had X(T), 6 had CXT, 2 had XT, and 1 had cerebral palsy. In this group, 3 patients preoperatively had stereopsis. A comparison group was used to determine whether magnitude of the vertical correction in this vertical offset group was a true effect. Seven exotropic patients with hypertropia (6 with CXT and 1 with XT), and no preoperative stereopsis were identified. These patients had an average preoperative hypertropia of 7^{Δ} distance and 4^{Δ} near, and an average postoperative hypertropia of 5^{Δ} distance and 4^{Δ} near. The pre- and postoperative measurements for hypertropia were not statistically different.

Patients in this vertical offset group had a statistically greater correction for the distance vertical hypertropia than patients in the comparison group that did not undergo vertically corrective surgery ($p = 0.0485$). The magnitude of the hypertropia correction when vertically offsetting the horizontal muscles averaged 8^{Δ} at distance and 5^{Δ} at near. However, it should be noted that successful resolution of the hypertropia was highly correlated to successful and stable horizontal alignment. Of the 6 patients with hypertropia less than 5^{Δ} at 6 months, 5 of these had horizontal deviations of less than 7^{Δ} . Only one overcorrection of the hypertropia occurred in this group. Two patients in the vertical offset group had intermittent exotropia and hypertropia (12^{Δ} and 14^{Δ}), one patient had complete resolution of the exotropia and hypertropia for more than 2 years; however, the second had excellent alignment at 1 month but recurrence of the exotropia with reversal of the hypertropia at 6 months.

The vertical muscle group consisted of 17 patients, of whom 8 had X(T) (2 of these CI type), 7 had CXT, and 2 had congenital exotropia. Preoperatively, 6 patients had stereopsis. Of the 17, 11 patients underwent superior rectus muscle recession, and 6 underwent inferior rectus muscle recession (mean recession, 4.3 mm).

The magnitude of the vertical correction effect in the vertical muscle group averaged 10^{Δ} for near and 11.5^{Δ} for distance (3^{Δ} per mm of recession). The difference was statistically different than the comparison group ($p = 0.006$ near; $p = 0.007$ distance), but not statistically different than the vertical offset group. There were 5 overcorrections of the vertical hypertropia in the vertical muscle group. Four of these patients had intermittent exotropia; this represented a 50% overcorrection rate for patients with basic intermittent exotropia. Taking all intermittent exotropia patients, there was a significant overcorrection of the hypertropia compared to nonintermittent exotropes ($p = 0.01$). However, there was no statistically significant difference in the magnitude of the exotropia or hypertropia in the intermittent exotropes that were overcorrected than in those that were not. Of the remaining 3 failures in the vertical muscle group, 2 were intermittent exotropes with preoperative stereoacuity, successful stable 6-month horizontal alignment, and no hypertropic deviation at near, but recurrent hypertropia at distance.

Of the 17 patients in the vertical muscle group, 9 had a distance near incomitant hypertropia, with the near vertical deviation measuring half the distance deviation or less, or 8^Δ less near hypertropia than the distance hypertropia (if the distance hypertropia measured more than 15^Δ). In general the amount of surgical recession on the vertical rectus muscle was calculated on the distance plus near measurement divided in half. This approach was successful in 7 of the 9 patients. Finally, 3 patients, despite initially having excellent resolution of the vertical tropia at one month, had partial recurrence of hypertropia at 6 months. No patient in either group developed stereopsis that was not present preoperatively, despite successful vertical and horizontal alignment.

Discussion

The treatment of a constant small-angle vertical tropia associated with exotropia and unrelated to oblique dysfunction, paretic muscle, or DVD has been enigmatic. Pratt-Johnson and Tillson¹⁰ have stated that there is no advantage in eliminating a vertical component of 5^Δ or less. Moore and Stockbridge's study¹¹ described the coincidental finding of spontaneous resolution of the vertical tropia during prism adaptation for the horizontal deviation alone in intermittent exotropes. The potential for binocular stereopsis and spontaneous resolution of the vertical deviation during surgical correction of an intermittent exotropia is a confounding factor in determining the corrective effect of vertically offsetting the horizontal muscles. The authors of only one study⁶ have looked at the vertical offset effect in exotropia alone. However, in this study all of the vertical deviations were less than 10^Δ in patients who apparently had no barriers to stereopsis. In another study,⁷ investigators eliminated the potential for spontaneous resolution of the vertical deviation by including only patients deemed to have "no potential for sensory fusion." However, because most patients in this study had esotropia, the vertical offset effect is not clearly delineated in the exotropic population.

In this study, we showed a significant correction of the hypertropia by vertical offset effect of the horizontal muscles simultaneous with correction of an exotropia in patients who were not subject to the spontaneous resolution of hypertropia described by Moore and Stockbridge.¹¹ This was significant compared with patients without stereopsis in the comparison surgery group (who received no vertical surgery) and had essentially no change in the postoperative vertical deviation.

Many authors⁴⁻⁷ have attempted to create a linear relationship between the millimeters of vertical offset of the horizontal muscles and shift in prism diopters. However, because these studies have not controlled for the spontaneous resolution effect or the preoperative stereopsis, the true relationship of the vertical deviation correction to the relative amount of vertical offset of the horizontal muscle insertion remains unclear. We believe, as Dunlap¹ described, that the vertical offset effect is unlikely to have a linear relationship to the change in vertical deviation. We did not have enough patients to examine a nonlinear relationship of the vertical offsetting of the horizontal muscles, all of our patients essentially receiving the identical dose effect. However, 2 patients who had vertical offsets but larger hypertropia ($>14^\Delta$) did not have the expected change in their postoperative deviation. This initially appears to be an unreliable treatment effect; however, if the vertical response to offset of the horizontal muscles is a geometric response, rather than linear, then the absence of effect on a large hyperdeviation of a small vertical offset should be expected. Therefore, patients with exotropia and hypertropia greater than 14 diopters (D) may be better served with larger vertical offset surgery, or vertical muscle surgery.

We could find no study that addressed the addition of vertical rectus muscle surgery simultaneous with the surgical treatment of exotropia. Roughly one half (8/17) of the

patients in this group carried the diagnosis of intermittent exotropia, and these patients respond in a significantly different way to vertical muscle surgery than non-intermittent exotropic patients. Patients with the diagnosis of intermittent exotropia had a 50% (4/8) overcorrection of the hypertropia; however, 2 of the overcorrections had no preoperative stereopsis. Therefore, in patients with intermittent exotropia and large hypertropia ($>10^\Delta$), in whom there is consideration for vertical rectus muscle surgery, preoperative evaluation with prism adaptation as described by Moore and Stockbridge¹¹ is now our standard practice in developing a surgical plan. Additionally, many of the patients in this group also had vertically incommittant measurements at distance versus near. In 7 of 9 of these patients, the formula of adding the distance to near hypertropia, dividing by two, and applying a 1 mm vertical rectus muscle recession per 3^Δ desired effect was successful.

Finally, partial recidivism of the correction of the hypertropia was seen in 18% of patients between the 1-month and 6-month visit. This included 2 patients in the vertical offset group and 3 in the vertical muscle group.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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FIG 1.

Box-and-whiskers plot showing residual postoperative hypertropia. Positive values along y-axis are residual hypertropia, and negative values are overcorrected hypertropia. Patients are listed by group and patient number in e-Supplement 1, available at jaapos.org.

FIG 2.

Box-and-whiskers plot showing residual postoperative hypertropia. Positive values along y-axis are residual hypertropia, and negative values are overcorrected hypertropia. Patients are listed by group and patient number in e-Supplement 1, available at jaapos.org.

Table 1
Hypertropia correction (in prism diopters) by group

	Pre-op HT near	Post-op HT near	Correction	<i>p</i> -value
Vertical offset	9.1	4.1	5.0 ± 2.9	0.006
Vertical muscle	8.9	−0.9	10.0 ± 3.2	0.0005
	Pre-op HT distance	Post-op HT distance	Correction	<i>p</i> -value
Vertical offset	12.2	3.8	8.4 ± 3.7	0.004
Vertical muscle	14.6	2.9	11.7 ± 3.2	0.0005

HT, hypertropia; *pre-op*, preoperative; *post-op*, postoperative.

Mean preoperative and postoperative vertical deviations and mean correction expressed as 95% confidence intervals; *p*-values determined by Wilcoxon signed rank test.