



Original Article

# Resolution of hypertropia with correction of consecutive horizontal deviation

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## Abstract

**Background:** To study the resolution of hypertropia in patients who undergo horizontal deviation surgery for consecutive esotropia or consecutive exotropia.

**Methods:** We retrospectively reviewed the records of 23 patients with consecutive esotropia or exotropia who had concomitant vertical tropia. All patients had had surgery for horizontal deviation that required further surgery to correct consecutive horizontal strabismus and had a minimum of six months of postoperative follow-up. All patients were noted to have vertical deviation greater than 5 prism diopters (PD) in primary position on preoperative examination. Patients underwent corrective surgery for horizontal strabismus without surgical manipulation of the vertical extraocular muscles. The exclusion criteria were coexisting oblique muscle dysfunction, manifest or latent dissociated vertical deviation, and extraocular muscle palsy.

**Results:** The mean preoperative vertical deviations were  $7.6 \pm 2.3$  PD for distance and  $7.3 \pm 2.3$  PD for near. All patients had resolution of vertical deviation in all fields of gaze despite surgical correction only being made to horizontal extraocular muscles. No patients had measureable vertical tropia during six months of follow-up.

**Conclusion:** We propose that measureable hypertropia unrelated to oblique muscle dysfunction, dissociated vertical deviation, or parietic/mechanical muscle that coincides with consecutive horizontal deviation can be resolved with horizontal muscle surgery alone. Therefore, it may not be necessary to perform vertical surgery to correct coincident vertical deviation in patients with consecutive horizontal deviation. More research is needed in the form of prospective clinical trials to determine whether vertical surgery has any utility for these patients.

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**Keywords:** Consecutive strabismus; Muscles; Surgery; Vertical deviation

## 1. Introduction

Consecutive horizontal deviation occurs when ocular misalignment surgery overcorrects for misalignment in the absence of exogenous mechanical factors or an acquired

paralytic component. Patients originally with inward deviation (esotropia) can have subsequent outward deviation (exotropia). This scenario, called consecutive exotropia, occurs in 2–8% of esotropia cases treated with surgery.<sup>1–5</sup> Similarly, consecutive esotropia through overcorrection of an original exotropia has been reported to occur in as high as 6–20% of surgical cases.<sup>3,6–8</sup>

Small-angle vertical deviations can be concomitantly present in patients with consecutive horizontal deviation. There are few studies devoted to management of associated vertical tropia in patients with consecutive horizontal deviations.

Conflicts of interest: The authors declare that they have no conflicts of interest related to the subject matter or materials discussed in this article.

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Treatment for associated vertical ocular deviations mostly consists of vertically offsetting the horizontal rectus muscles during surgery that is primarily aimed at correcting the horizontal deviation. ‘Clinically significant’ vertical deviations are defined as those with a magnitude of 5 prism diopters (PD) or greater in primary position, regardless of the magnitude of deviation in other fields of gaze.<sup>9</sup> This article focuses on the spontaneous resolution of small-angle vertical tropia, unrelated to oblique muscle dysfunction, manifest or latent dissociated vertical deviation, or extraocular muscle palsy.

## 2. Methods

This retrospective chart review was approved by the Institutional Review Board at Tianjin Medical University and Tianjin Eye Hospital in Tianjin, China and complied with relevant privacy laws. All patients gave written informed consent prior to participation in conformity with the Declaration of Helsinki. Records were reviewed for all patients with consecutive horizontal deviation who were treated with surgery by a single surgeon from January 2011 to December 2013 with at least 6 months of follow up. The surgical technique was chosen by the surgeon based on each patient's clinical picture and recommendations for standard-of-care treatment. Patients were excluded if they had prior strabismus surgery involving surgical manipulation of the vertical muscle(s), sensory deviation resulting from unilateral visual impairment, limitation of extraocular movement, manifest or latent dissociated vertical deviation, or extraocular muscle palsy. Information extracted included the patients' age at diagnosis, age at surgery, prior surgeries, duration of follow-up, and the amount of horizontal and vertical deviation in primary position at distances of 6 m and approximately 33 cm to simulate far and near distances, respectively.

Each patient underwent routine ophthalmological examination before surgery, including corrected visual acuity measurement, cycloplegic refraction measurement, ocular motility evaluation, double Maddox rod test, stereoacuity test, anterior segment assessment and fundus examination. All patients underwent alternate cover test in primary position to determine the magnitude of the vertical and horizontal angles of deviation at near (33 cm) and far (6 m) distances. All patients underwent passive forced duction test under general anesthesia at the time of surgery to rule out restrictive strabismus. Binocular version was full in all patients. Surgical approaches included reversal of the lateral or medial rectus recession, recession of the lateral or medial rectus, and resection of the medial or lateral rectus.

### 2.1. Statistical analysis

The primary outcome measure was postoperative vertical deviation drift compared with preoperative vertical deviation. Resolution of vertical deviation was defined as hypertropia under 5 PD at the last postoperative visit. Mean postoperative deviation at each time-point was compared among groups using a paired Student's *t*-test (two-tailed,  $\alpha = 0.05$ ).

## 3. Results

Twenty-three cases met the inclusion criteria for this study, including 12 with consecutive esotropia and 11 with consecutive exotropia. Of the 12 patients with consecutive esotropia, 9 (75%) underwent reversal of the lateral rectus recession, 1 (8.3%) had medial rectus recession, and 2 (16.7%) required reversal of the lateral rectus recession and recession of the medial rectus. Of the 11 patients with consecutive exotropia, 4 (36.4%) underwent reversal of the medial rectus recession, 2 (18.2%) had lateral rectus recession, and 5 (45.5%) required reversal of the medial rectus recession and recession of the lateral rectus. The average age at surgery was  $20 \pm 9$  years (range 5–39 years). The mean preoperation vertical deviation was  $7.6 \pm 2.3$  PD for distance and  $7.3 \pm 2.3$  PD for near. Measurements for preoperative and postoperative hypertropia at near and distance are shown in Table 1. Preoperatively, no patients experienced vertical diplopia with prism correction for horizontal deviation alone. No patients had objective torsion or compensatory head posturing or tilting. Postoperatively, no patient manifested hypertropia or intermittent hypertropia in any field of gaze at 6 months follow-up. All patients showed orthophoria ( $<5$  PD) at the final follow-up visit. In this series, none of the patients experienced postoperative complications.

Patients with both primary gaze consecutive esotropia (Fig. 1) and consecutive exotropia (Fig. 2) showed significantly less vertical deviation postoperatively compared with preoperative measurements ( $p < 0.01$ ).

## 4. Discussion

The treatment of constant vertical tropia associated with consecutive horizontal deviation, in the absence of oblique muscle dysfunction, dissociated vertical deviation, or extraocular muscle palsy, has been enigmatic. Previously, Pratt–Johnson and Tillson determined 5 PD to be an appropriate baseline and indicator of whether surgical intervention may be warranted.<sup>11</sup> The findings in our report are dramatic in that the vertical deviation present preoperatively in all patients with consecutive horizontal deviation underwent spontaneous resolution with surgical treatment of the horizontal component alone in all cases. Previously, it had been documented that hypertropia in the setting of intermittent exotropia was correctable solely with treatment aimed at the exotropia.<sup>10</sup> However, to date, there are no case reports of resolution of vertical deviation with correction of consecutive horizontal strabismus. We have described the resolution of the vertical component of tropias in patients whose indication for surgery dealt with horizontal deviation alone. Our data suggests that additional surgery intended to correct the component of vertical deviation may not be necessary in some patients with consecutive horizontal deviation.

Previous investigators<sup>12–14</sup> have hypothesized a linear relationship between the millimeters of vertical offset of the horizontal muscles and the shift in prism diopters. However, our study shows this relationship to be nonlinear in patients who had horizontal surgery alone. Therefore, patients with consecutive

Table 1  
Patient characteristics.

Patient number	Age	Pre-op horizontal deviation D/N	Pre-op vertical deviation D/N	Surgical technique	Post-op day 1 vertical deviation D/N	Post-op week 6 vertical deviation D/N	Post-op month 3 vertical deviation D/N	Post-op month 6 vertical deviation D/N
1	28	ET14/ET12	LHT8/8	Reversal of LLR	LHT 1/2	LHT 1/2	LHT 1/1	LHT 1/3
2	17	ET15/ET20	LHT6/5	Recession of LMR 6.5 mm	0/0	LHT 1/1	LHT 1/1	LHT 1/1
3	24	ET14/ET10	RHT8/8	Reversal of RLR	RHT 1/0	RHT 1/0	RHT 1/2	RHT 1/2
4	24	ET25/ET18	LHT 8/7	Reversal of RLR	LHT 1/1	LHT 1/1	LHT 1/0	0/0
5	23	ET25/ET16	LHT 6/6	Reversal of RLR	LHT 1/2	LHT 1/1	LHT 0/1	LHT 0/1
6	34	ET14/ET12	LHT11/10	Reversal of LLR	LHT 1/2	LHT 1/1	LHT 1/2	LHT 1/1
7	13	ET30/ET25	RHT 9/9	Reversal of LLR	RHT 2/3	RHT 2/2	RHT 2/1	RHT 0/1
8	9	ET66/ET66	LHT7/7	Reversal of LLR and RLR, Recession of LMR 4 mm	0/0	LHT 1/1	LHT 1/1	LHT 1/1
9	5	ET25/ET20	RHT 7/6	Reversal of RLR	RHT 1/0	RHT 1/2	RHT 1/1	RHT 1/1
10	11	ET20/ET14	LHT 4/5	Reversal of RLR	LHT 1/1	LHT 1/2	LHT 0/1	LHT 0/1
11	7	ET90/ET85	LHT 6/6	Reversal of LLR and RLR, Recession of RMR 5.5 mm	LHT 2/2	LHT 1/2	LHT 1/1	LHT 0/1
12	29	ET20/ET16	RHT 5/5	Reversal of LLR	RHT 2/2	RHT 1/1	RHT 1/1	RHT 1/1
13	28	XT16/XT25	RHT 8/6	Reversal of LMR	0/0	RHT 2 /0	RHT 2/1	RHT 1/1
14	14	XT14/XT14	LHT 7/7	Reversal of LMR	LHT 3/2	LHT 1/1	LHT 1/0	LHT 1/0
15	19	XT20/XT16	LHT 5/5	Recession of RLR 5 mm	LHT 0/1	LHT 1/1	0/0	0/0
16	14	XT30/XT25	LHT 12/12	Reversal of LMR, Recession of RLR 4 mm	LHT 2/2	LHT 3/2	LHT 2/1	LHT 1/1
17	12	XT20/XT18	RHT 7/6	Recession of LLR 6.5 mm	RHT 1/1	0/0	RHT 1 /1	RHT 1/1
18	23	XT25/XT25	RHT 8/8	Reversal of LMR	RHT 2/2	RHT 1/1	0/0	RHT 1/1
19	39	XT50/XT50	RHT 14/14	Reversal of RMR, Recession of RLR 4.5 mm	RHT 4/3	RHT 3/3	RHT 2/2	RHT 2/2
20	26	XT85/XT85	LHT 9/8	Reversal of RMRand LMR, Recession of RLR 8 mm	LHT 2/2	LHT 1/1	LHT 0/1	LHT 1/0
21	8	XT20/XT15	LHT 6/6	Reversal of RMR	LHT 0/0	LHT 1/1	LHT 1/1	LHT 1/0
22	32	XT30/XT40	RHT6/6	Reversal of RMR, Recession of RLR 3 mm	RHT 2/2	RHT 1/1	RHT 1/1	RHT 1/1
23	30	XT35/XT35	LHT 8/8	Reversal of LMR, Recession of LLR 4 mm	LHT 2/3	LHT 3/3	LHT 2/2	LHT 2/2

ET, esotropia; XT, exotropia; LHT, hypertropia in left eye; RHT, hypertropia in right eye; LLR, left lateral rectus muscle; LMR, left medial rectus muscle; RLR, right lateral rectus muscle; RMR, right medial rectus muscle. D, distance; N, near. The unit of deviation is prism diopter.

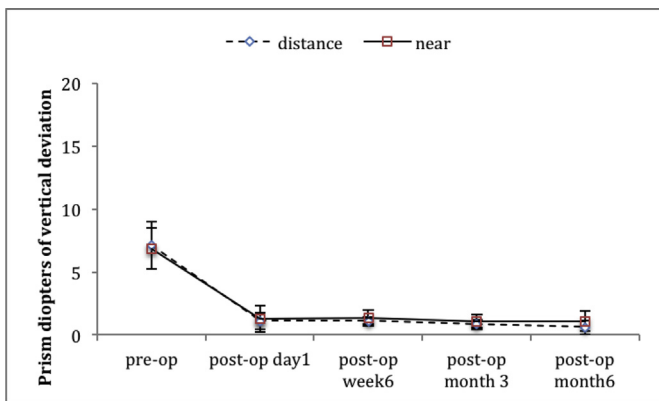


Fig. 1. Postoperative vertical deviation in consecutive esotropia patients. Vertical strabismus was significantly smaller than preoperation at all time points, for both distance and near fixation ( $P < 0.001$ ).

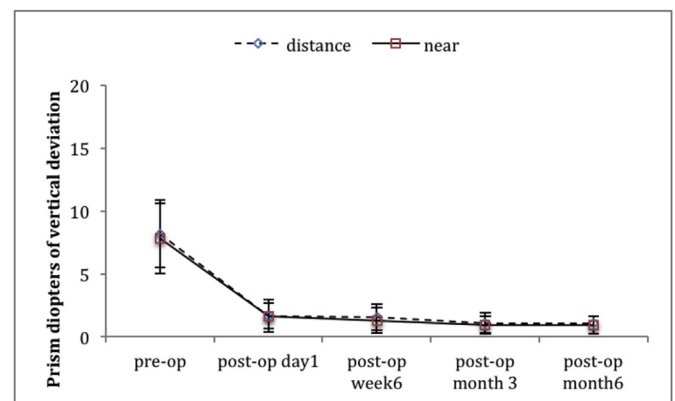


Fig. 2. Postoperative vertical deviation in consecutive exotropia patients. Vertical strabismus was significantly smaller than preoperation at all time points, for both distance and near fixation ( $P < 0.001$ ).

horizontal deviation with vertical tropia may be better served with horizontal muscle surgery alone rather than a combination surgery involving both horizontal and vertical muscles.

There is no consensus in the literature for the effect that was observed in this study regarding correction of vertical tropia in patients undergoing surgery on horizontal extraocular

muscles alone. In our patients, hypertropia was corrected by horizontal muscle surgery alone. We found these results to hold true even in patients with consecutive strabismus with large hypertropia (at least 10 PD) in whom there was consideration of vertical rectus muscle surgery.<sup>15</sup> The potential explanation may involve both mechanical and extraocular

muscle factors. Pulley heterotopy and pulley instability have both been linked to incomitant strabismus.<sup>16,17</sup> Costa et al. reported and extended study that suggested functionally distinct superior and inferior zones within the horizontal rectus extraocular muscles in both humans and monkeys.<sup>18</sup> Recently, functional evidence for differential compartmental activation of the human horizontal rectus extraocular muscles was obtained from magnetic resonance imaging during ocular counter-rolling induced by head tilt, convergence and vertical fusional vergence.<sup>19–21</sup> Shin et al. extended results to active contraction.<sup>22</sup> Rabinowitz and Demer found that the path lengths of the horizontal rectus EOMs in intermittent and alternating esotropia and exotropia were not abnormal.<sup>23</sup> This possibility could not be tested in our study.

In surgical patients with consecutive horizontal deviation and hypertropia, persistent hypertropia with vertical diplopia warrants further evaluation. Our data confirm that the absence of subjective torsion or compensatory head posture is a predictor of the postoperative resolution of hypertropia following horizontal muscle surgery alone for consecutive horizontal deviation.

We could find no study that addressed surgical treatment of solely horizontal muscle for consecutive horizontal strabismus with vertical tropia. In our study, surgical correction of consecutive horizontal deviation successfully resolved vertical tropia that was unrelated to oblique muscle dysfunction, manifest or latent dissociated vertical deviation, or extraocular muscle palsy, and was not accompanied by subjective torsion or compensatory head posture. Based on our findings, we recommend that patients with consecutive horizontal deviation and hypertropia receive surgical alignment of the horizontal muscles alone. Only if hypertropia does not resolve should vertical alignment be undertaken. Our study confirms that horizontal muscle surgery alone can lead to resolution of hypertropia in association with consecutive horizontal strabismus.<sup>9</sup>

MRI was not used in this study, but may be helpful in future studies to find a probable mechanism for our findings. Limitations of this study include its retrospective nature and the small number of patients. A prospective study, possibly with randomization of subjects to receive horizontal surgery alone or horizontal surgery in combination with vertical surgery, could add additional support to these findings.

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