Major Article

Surgical success and lateral incomitance following three-muscle surgery for large-angle horizontal strabismus

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PURPOSE To evaluate motor alignment, motility, and sensorial outcomes of simultaneous three-muscle surgery for large-angle horizontal strabismus, with special attention to lateral incomitance and long-term success.

METHODS The medical records of consecutive patients with large-angle deviations ($\geq 30^{\Delta}$) who underwent simultaneous surgery on three horizontal muscles to correct esotropia or exotropia were reviewed retrospectively. Successful motor alignment was defined as residual deviation of $\leq 10^{\Delta}$ and consecutive deviation in primary position of $\leq 4^{\Delta}$, with no induced lateral incomitance $>5^{\Delta}$ between lateral gazes. Sensory success was defined as an improvement in stereopsis of ≥ 2 octaves. Surgical procedures included a combination of recessions and resections/plications depending on surgeon preference. The majority of cases were two-muscle recessions combined with one-muscle resection or plication.

RESULTS A total of 19 patients with exotropia and 9 patients with esotropia were included. In the esotropic group, the mean age at surgery was 48 ± 15 years and the mean preoperative deviation improved from $45.6^{\Delta} \pm 11.9^{\Delta}$ to $1.5^{\Delta} \pm 1.6^{\Delta}$ ($P < 0.001$); there was no undercorrection, recurrence or overcorrection. In the exotropic group, the mean age at surgery was 44 ± 25 years, and the mean preoperative deviation improved from $44.1^{\Delta} \pm 8.7^{\Delta}$ to $5.8^{\Delta} \pm 9.6^{\Delta}$ ($P < 0.001$), recurrence occurred in 2 (22%). Overall motor success at distance was 85%, with 1 (3.8%) unsuccessful patient due to induced incomitance. Sensory success was 44% for esotropia and 31% for exotropia. No patient lost stereopsis.

CONCLUSIONS Patients undergoing three-muscle surgery for horizontal strabismus had good motor outcomes with low incidence of induced lateral incomitance. Motor and sensorial outcomes for esotropia were very stable. (J AAPOS 2017;■:1-5)

The goal of surgical treatment of large-angle strabismus is to achieve a satisfactory motor alignment in primary position without limiting ocular rotations or inducing lateral incomitance. Some investigators have defined large-angle esotropia as a deviation of 30^{Δ} and a large-angle exotropia as a deviation $>35^{\Delta}$; others consider $>40^{\Delta}$ to be large.[1-12] There is currently no consensus on how many muscles to operate on for large-angle strabismus.[10,11] However, it is generally agreed that an important consideration when performing asymmetric surgery is avoidance of induction of lateral incomitance.[10,13,14] Those who prefer to operate on three or four horizontal rectus muscle surgery for esotropia argue that this approach helps to diminish the chances of convergence impairment and incomitance, which can result from excessive medial rectus recession and may contribute to a late exotropic drift in patients with esotropia.[6] Previous studies have reported that overall success of three-muscle surgery for large-angle horizontal strabismus ranges from 42% to 83%.[5,6,9,10,15-17] Limited information is available regarding lateral incomitance. The purpose of this study was to evaluate alignment, motility, and binocularity outcomes of three-horizontal-muscle surgery for large-angle horizontal strabismus, with special attention to induced lateral incomitance and long-term success.

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Subjects and Methods

This study was approved by the University of California Institutional Review Board. The medical records of all consecutive patients with horizontal strabismus, exotropia, and esotropia measuring $\geq 30^{\Delta}$ who underwent simultaneous surgery on three horizontal rectus muscles at the Stein Eye Institute, University of California Los Angeles, between 2008 and 2016 were reviewed retrospectively. Information registered at the last follow-up visit or before reoperation was used for analysis. Patients were included if they completed at least 6 weeks of postoperative follow-up. Exclusion criteria included strabismus secondary to paresis, paralysis, restriction or misinnervation, history of amblyopia, nystagmus, neurological disease, and previous strabismus surgery.

Motor alignment and sensory function were evaluated with patients wearing the appropriate optical correction to obtain best visual acuity. Ocular alignment was measured pre- and postoperatively using the alternate prism cover test in the six cardinal diagnostic positions of gaze at 12 feet and at near using an accommodative target at 14 inches.[18] In patients with poor visual acuity, motor alignment examination was assessed with the Krimsky test.[18] Lateral gazes incomitance was calculated in prism diopters as the difference between the angle of deviation measured in lateral gazes. Ocular rotations were measured using a scale ranging between 0 and $\pm$ 4.[18]

Sensory function was measured at near using the Titmus Fly stereoacuity test (Titmus Optical Co Inc, Petersburg, VA). Patients were classified into one of four groups for stereopsis outcomes as follows: bifoveal fusion, 40 arcsec; peripheral fusion, 50–300 arcsec; gross stereopsis, >300-3552 arcsec; and no stereopsis, >3552 arcsec. Stereopsis outcomes were assessed as a continuous variable by taking the natural log of the value of stereopsis, assigning 10,000 sec to "no stereopsis."

Intraoperative forced duction testing (FDT)[19] was performed at the beginning of the surgery. Surgical procedures included a combination of recessions and resections or recessions and plications, using standard surgical techniques.[20,21] Surgical strategy was determined by the results of FDT[19]; recessions were performed whenever the FDT revealed a tight muscle and also were the preferred bilateral procedure when FDT was negative.

Surgeries were performed by three surgeons using a standard surgical technique (same dose of surgery was done in the same muscle of each eye), except that one surgeon (JLD) preferred plications to resections. Two surgeons (SLP, FGV) followed an algorithm to calculate the amount of surgery by dividing the total distance angle of deviation in the primary position by 2 then determining the amount of recession plus resection/plication for that "half angle" in one eye and performing the same amount of surgery on the same muscle on the fellow eye; in most cases a recession was performed in the fellow eye, except for 2 patients in the esotropic group. The eye that had two-muscle surgery was always the eye with worse visual acuity in the cases where visual acuity differed between eyes. The third surgeon (JLD) followed an algorithm based on a total amount of surgery of 18–19 mm total divided among the three operated muscles, with the same muscle operated on each eye having the same dose of recession. Whenever possible, adjustable sutures were used, using the bow tie technique.[22]

All patients were examined within 3 hours after surgery; postoperative adjustment was performed in the recovery room. The target angle for adjustment was orthotropia at distance for esotropia and a small esotropia ($<4^{\Delta}$) for exotropia, measured with the patient wearing the appropriate optical correction fixing on a target at a distance of 20 feet. All patients were examined within the first 2 weeks of and at variable time points thereafter for at least 6 weeks.

Surgical success was calculated using the motor-alignment/sensory definition in Table 1. Phorias were considered a successful result. The long-term success was assessed with the recurrence rate, defined as percentage of patients with undercorrection of $>10^{\Delta}$ at 6 months' follow-up. Means were compared using the *t* test, with *P* values <0.05 considered statistically significant.

Results

A total of 28 patients (16 males) were included, 9 with esotropia and 19 with exotropia. Neither age at presentation (21 $\pm$ 22 years for esotropia [range, 1-56 years] and 30 $\pm$ 28.2 for exotropia [range, 3-82 years]) nor age at surgery (48 $\pm$ 15 years for esotropia [range, 33-79 years] and 44 $\pm$ 25 years for exotropia [range 3-82 years]) differed significantly between groups. The majority of patients with esotropia were female (67%); the majority with exotropia, males (68%). All 9 patients with esotropia were adults when surgery was performed; 5 were presumed to have infantile esotropia, according to patient information, and 4 had acquired esotropia. The esotropia was constant in all patients. Of the 19 exotropia patients, 9 (48%) had an intermittent poorly controlled deviation, 17 (89%) had a basic type, and 2 (11%) had a divergence excess type. Motor-alignment characteristics are shown in Table 2.

Three patients underwent simultaneous vertical muscle surgery; 1 esotropic patient underwent a recession of the left superior rectus for a hypertropia, 1 exotropic patient underwent bilateral inferior oblique recessions, and 1 exotropic patient underwent superior rectus recession for a hypertropia.

All esotropic patients underwent recession of one medial rectus on adjustable suture; 5 patients had simultaneous lateral rectus muscle resection or plication on adjustable suture. Three patients (33%) required postoperative adjustment for immediate overcorrection of $13^{\Delta} \pm 7^{\Delta}$, with a post-adjustment esotropia of 1^{Δ}. Fifteen adult exotropic patients underwent adjustable suture surgery. All had one adjustable lateral rectus muscle recession and 4 patients had simultaneous adjustable medial rectus muscle resection or plication. One exotropic patient underwent postoperative adjustment with a final postoperative adjustment target of 4^{Δ}. All of the patients underwent a two-muscle recession plus a resection/plication of one muscle, except for 2 esotropic patients. These 2 underwent one-muscle recession, combined with two-muscle resection in