The Effect of Achieving Immediate Target Angle on Success of Strabismus Surgery in Children

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• PURPOSE: To determine if achieving the ideal postoperative target range increases the long-term success of pediatric strabismus surgery.
• DESIGN: Interventional case series.
• METHODS: Children below 12 years old with horizontal strabismus who underwent surgical correction by recession, resection, advancement, or a combination of both between 1996 and 2011 were included. Alignment was measured within 1 week and at a minimum of 6 months after surgery. The ideal postoperative target range was defined as 0–8 prism diopters (PD) of esotropia in exotropic patients and within 4 PD of orthotropia in esotropic patients measured within 1 week after the surgery. Success was defined as a measurement within 10 PD of orthotropia at the latest postoperative visit. The main outcome measures were surgical success rate and the factors affecting it.
• RESULTS: We included 352 patients with mean follow-up of 18 months. Overall, patients within the target range had a higher success rate than those outside it (75.6% vs 57% $P = .0004$). This was highly significant for exotropia ($P = .0002$) but not for esotropia ($P = .4$). Multiple regression analysis revealed that being within target range was the strongest predictor of long-term success (odds ratio [OR] = 2.3, range 1.4–3.7). Overall, surgeries on patients with esotropia were more likely to be successful than on those with exotropia (OR = 1.9, range 1.2–3), and premature patients had poorer outcomes (OR = 0.2, range 0.1–0.8).
• CONCLUSION: Achieving the ideal target range within 1 week after surgery is associated with a high rate of long-term success in exotropia surgery in children. (Am J Ophthalmol 2015;160(5):913–918.

STRABISMUS SURGERY IS A COMMON OPHTHALMIC procedure that strengthens or weakens the impact of the extraocular muscles on the globe to correct ocular misalignment. Although it is safe and effective, up to 60% of patients need more than 1 operation to obtain long-term satisfactory ocular alignment.[1,2] The aim of surgery is to place the eyes in an immediate postoperative "target angle" predicted to achieve the best long-term success and reduce the rate of reoperations. This aim is based on the expected postoperative drift in alignment, which can vary among patients in rate, amount, and direction.[3,4] It is generally accepted that postoperative drift is small (less than 4 prism diopters [PD]) for esotropia and average undercorrection drift of 10 PD occurs in exotropia.[5] Since one of the factors reported to affect surgical success is the immediate angle after surgery[2,6,7] and variable postoperative drift can occur, a "target range" is a more realistic and achievable goal.[4,8,9]

There is a paucity of literature relating target angle with long-term outcome. A recent study on adult strabismus patients done in our institution showed that eyes placed within a defined target range increased the success of long-term ocular alignment.[10] This study was performed to answer the following questions: (1) does achieving the immediate postoperative target angle increase the success rate in children? and (2) what preoperative factors affect the surgical success in this population?

METHODS

FOLLOWING APPROVAL FROM THE ETHICS REVIEW BOARD of The Hospital for Sick Children, Toronto, Canada, we performed an interventional case series of children who underwent strabismus surgery at the hospital from January 1, 1996 to December 31, 2011. Requirement for consent was waived by the ethics review board.

All surgeries were performed by 2 surgeons. The patients were less than 12 years of age at time of surgery, and underwent primary or reoperation of horizontal rectus muscles in the form of recessions, resections, advancement, or a combination of these. All patients must have had a follow-up visit within 1 week of surgery and a minimum of 6 months of follow-up. Patients with neurogenic or mechanical etiologies for their strabismus and neurologic or behavioral complications that prevented angle measurement were excluded. Patients undergoing vertical or oblique muscle surgery in conjunction with horizontal rectus muscle

Accepted for publication Jul 14, 2015.
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0002-9394/$36.00
http://dx.doi.org/10.1016/j.ajo.2015.07.022

surgery or who had simultaneous vertical offsets of the horizontal muscles of more than 5 mm were also ineligible.

The following parameters were collected for the study: age at the time of surgery, visual acuity, presence or absence of amblyopia and binocularity, significant medical history (such as the presence of developmental delay, attention-deficit hyperactive disorder, prematurity, and autism), type and severity of strabismus, number of previous strabismus surgeries, type of strabismus surgery done, presence or absence of surgical complications, and the alignment within 1 week postsurgery and at last follow-up visit. The absence or presence of binocularity was assessed with Titmus stereoacuity test or Bagolini lenses. The angle of deviation was measured in PD using alternate prism and cover test (APCT) with fixation at 33 cm and 6 m. The modified Krimsky reflex method was used in patients whose vision in 1 eye was less than 6/60 Snellen equivalent and in very young patients in whom APCT could not be obtained. Significant refractive errors were corrected and the ocular deviations were measured using the corrective lenses. Surgery was planned after achievement of at least 2 stable measurements (less than 5 PD difference) in the 3 months before surgery.

Limbal or forniceal conjunctival incisions were made according to surgeon preference, but otherwise all surgery was performed using similar patient selection criteria, surgical techniques, and tables to calculate how much muscle surgery should be performed. A hang-back suture technique was used for recessions and for advancements that fell short of original insertion. A postoperative antibiotic and steroid mixture was instilled in the operated eyes 2–4 times daily for 2 weeks. The angle of deviation within 1 week of surgery was reviewed and categorized as within or outside target range. The postoperative target range for esotropia was within 4 PD of orthotropia and for exotropia it was between 0 and 8 PD of esotropia. At the final follow-up, success was defined as an angle of deviation under 10 PD. Presence of diplopia was considered a surgical failure even if deviation was less than 10 PD.

The statistical analysis was performed using Statistical Analysis System (SAS) software version 9.2 (SAS Inc, Cary, North Carolina, USA). The *t* test for continuous variables and χ^2 test for categorical and noncontinuous variables were used. A univariate analysis was performed on binary outcome data. All independent variables with a *P* value less than .20 were included in a multiple regression analysis. The statistically significant variables were those whose *P* values were less than .05.

Our literature search was conducted through PubMed using the following keywords: "strabismus surgery success," "target angle," "esotropia surgery," "exotropia surgery," "adjustable sutures," "postoperative drifts," "strabismus and retinopathy of prematurity." The searches were limited to the English language. No date restrictions were applied.

RESULTS

THROUGHOUT THE 15-YEAR STUDY PERIOD, A TOTAL OF 673 patients under 12 years of age underwent surgery. Among these, 321 were excluded owing to lack of follow-up 1 week after surgery for target range measurements (n = 148), less than 6 months' follow-up (n = 105), simultaneous oblique muscle surgery (n = 51), vertical rectus muscle surgery (n = 6), or a diagnosis of neurogenic or mechanical strabismus (n = 11). The remaining 352 children (187 male) were included, with a mean age of 6.0 years (0.7–11.9 years). There were 122 patients with exotropia and 230 with esotropia.

Table 1 summarizes the preoperative demographics of patients with surgical success and failure. Aside from the type of preoperative strabismus, the 2 groups were not statistically different. There were more patients with esotropia in the successful group (70% vs 55%, $P = .006$). We also noted a higher number of premature patients in the surgical failure group (*t* test, $P = .051$).

The mean follow-up after surgery was 18.6 months (6–145 months). The operative and postoperative patient factors are shown in Table 2. The most common procedure performed was recession (83%) and the type of procedure done did not affect outcome ($P = .37$). No surgical complications occurred in either group. Overall, 238 of 352 patients (67%) had successful outcomes, and a higher proportion of patients with successful surgery were within the target range (75.6% vs 57%, $P = .0004$).

Table 3 shows the influence of achieving target range on surgical success by strabismus type. Overall, patients who were in target range during the early postoperative period

TABLE 1. Preoperative Demographics of Patients Having Successful and Unsuccessful Strabismus Surgery in Study of Target Angles in Pediatric Strabismus Surgery

	Children With Successful Results (n = 238)	Children With Unsuccessful Results (n = 114)	*P* Value
Mean age (y)	6.04	6.02	.94
Mean preoperative angle deviation (PD)	30.87	32.13	.33
Male, n (%)	121 (51%)	66 (58%)	.21
Developmental delay, n (%)	19 (8%)	7 (6%)	.54
Prematurity, n (%)	5 (2%)	7 (6%)	.051
Amblyopia, n (%)	20 (8%)	8 (7%)	.65
Binocularity, n (%)	68 (29%)	42 (37%)	.1
Comitance, n (%)	187 (79%)	91 (80%)	.79
Previous surgery, n (%)	31 (13%)	18 (16%)	.48
Esotropia, n (%)	167 (70%)	63 (55%)	.006
Exotropia, n (%)	71 (30%)	51 (45%)	.006

PD = prism diopters.