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Consecutive exotropia: why does it happen, and can medial rectus advancement correct it?

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Abstract

Purpose—To investigate whether consecutive exotropia following medial rectus muscle recession is associated with muscle slippage and to assess the effectiveness of treating the condition with medial rectus advancement.

Methods—The records of patients with consecutive exotropia after medial rectus recession were reviewed to determine medial rectus muscle insertion location at the time of advancement surgery. Measurements before and after medial rectus advancement were compared. Success was defined as alignment within 10^{Δ} of orthotropia. The dose effect of medial rectus advancement was determined by nonlinear regression.

Results—A total of 20 patients were included. The mean age (± standard deviation) at time of surgery was 19 ± 19 years (range, 1.1–65.4). The mean preoperative exotropia was $28^{\Delta} \pm 16^{\Delta}$ (range, 12^{Δ}–60^{Δ}). Medial rectus slippage of 2.5 ± 1.7 mm (range, 1.0–5.0 mm) was found in 14 patients (36%) who had previously undergone medial rectus recession. Surgery corrected about 4^{Δ} of exotropia per mm total medial rectus advancement. Although 95% of patients were aligned successfully immediately after surgery, averaging $2^{\Delta} \pm 4^{\Delta}$ esotropia, there was significant late exodrift, averaging 17^{Δ} at final follow-up. At final follow-up, 1.6 ± 1.8 (range, 0.10–6.2) years after surgery, 50% of patients maintained alignment within 10^{Δ} of orthotropia (mean, $3^{\Delta} \pm 4^{\Delta}$ exotropia); the rest experienced recurrent exotropia of $25^{\Delta} \pm 8^{\Delta}$.

Conclusions—Medial rectus slippage is common in consecutive exotropia. Medial rectus advancement effectively treated consecutive exotropia, whether or not there was muscle slippage. It is however, associated with late exodrift; hence patients should be warned about potential for further XT recurrence.

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Consecutive exotropia may occur after strabismus surgery for esotropia. The incidence of consecutive exotropia reportedly varies between 3% and 29%.[1–4] Risk factors include adduction deficit, amblyopia, anisometropia, A or V pattern, dissociated vertical deviation (DVD), hypermetropia, absent or poor binocularity and iatrogenic causes (ie, previous medial rectus recession of >7 mm, multiple surgeries, miscalculation).[1–3] Surgical treatment generally entails medial rectus advancement, with and without resection, or lateral rectus recession.[4–12] Advancing one or both previously recessed medial rectus muscles may improve adduction deficit and has the advantage of incorporating surgical exploration of the medial rectus muscle to detect slippage while avoiding disturbance of the antagonist lateral rectus muscle. This study aimed to investigate whether consecutive exotropia is associated with unfavorable medial rectus insertion due to slippage, to assess the effectiveness of medial rectus advancement in treating consecutive esotropia, and to identify factors for favorable postoperative outcomes.

Subjects and Methods

This study was approved by the University of California–Los Angeles Institutional Review Board and adhered to the US Health Insurance Portability and Accountability Act of 1996. The medical records of all patients diagnosed with consecutive exotropia at Stein Eye Institute, University of California–Los Angeles, from April 1997 to January 2014 were retrospectively reviewed. Patients who underwent bilateral medial rectus recession with and without lateral rectus resection for childhood esotropia who then developed manifest exotropia of $>10^{\Delta}$ at distance were considered.

The records of previous surgeries were available if provided by the referring strabismologist. The conjunctiva was carefully scrutinized for evidence of conjunctival scars over the medial rectus muscle. Patients with unknown esotropia surgery but obvious scars over the medial rectus muscle and intraoperative findings of medial rectus recession were also included. Patients meeting any of the following criteria were excluded: previous surgery for recurrent consecutive exotropia; <1 month of postoperative follow-up; associated neurologic, traumatic, or sensory strabismus.

The following data were collected: sex, age at initial surgery for esotropia, age at surgery for consecutive exotropia, amount of previous medial rectus recession (if available), pre- and postoperative alignment, amount of medial rectus slippage (when present), best-corrected visual acuity, refractive error, presence of amblyopia, anisometropia, adduction deficits, DVD or hypertropia, and A or V pattern. Stereopsis results were not uniformly available and were not included.

Exotropia in central gaze at distance (6 meters) and near (1/3 meter) was measured by prism and alternate cover test or, in small, uncooperative children, by the Krimsky method. Adduction deficit was recorded on a scale from −4 to 0, with −4 implying no adduction beyond midline, −3 implying 75% adduction deficit, −2 implying 50% adduction deficit, −1 implying 25% adduction deficit, and 0 implying full adduction. Amblyopia was defined as interocular visual acuity difference of ≥2 lines not explainable by organic lesion. Occlusion therapy for amblyopia was instituted before surgery in 3 patients who were less than 10 years of age until vision was stable. Hyperopia was defined as spherical equivalent of ≥ +2.50 D. Anisometropia was defined as interocular difference in spherical equivalent of at least 1.00 D.

A single surgeon (JLD) performed all medial rectus advancements under general anesthesia. Adults were offered adjustable sutures. After conjunctival incision, the medial rectus muscle was exposed by lysing overlying postsurgical adhesions. Cautious dissection of any fibrous tissue covering the muscle's anterior edge was performed to determine the presence of slippage and to rule out stretched scar.

Classically, muscle slippage is defined as a disinserted muscle that has retracted posteriorly within its muscle capsule while the empty capsule remains attached to the sclera at the intended new insertion site.[13] The current study defined muscle slippage as muscle not directly attached to the sclera at the intended insertion site. A stretched scar is also a form of disinserted muscle because it is not also directly attached to the sclera, but, as have Ludwig and Chow,[14] we distinguished stretched scar as an amorphous tendonlike scar tissue found between the sclera and the true medial rectus radial tendon fibers. A normally recessed medial rectus muscle was identified when tendon tissue containing radial fibers obscured the view of the muscle hook underneath it. The distance from the limbus to the medial rectus insertion was measured using a curved ruler.

Because we wanted to quantify the amount of muscle slippage, we documented the distance of the medial rectus muscle from the limbus at advancement surgery and at medial rectus recession based on previous records. After the anterior extent of the medial rectus muscle was identified, the muscle was secured with suture and advanced, aiming for a slight overcorrection.

For nonadjustable procedures, two single-armed absorbable 6-0 polyglactin 910 sutures were passed in full thickness, double loop, locking fashion at the superior and inferior margins of the medial rectus tendon at its insertion. The medial rectus muscle was sharply disinserted from the sclera and was advanced according to Parks's medial rectus resection table,[15] aiming to achieve initial postoperative alignment of orthotropia to 8^{Δ} of esotropia. Medial rectus advancement of 1 mm was considered equivalent to 1 mm of medial rectus resection. The muscle was resutured to the sclera at the new insertion site. For adjustable suture cases, a 6-0 polyglactin 910 double arm suture was placed in the center of the medial rectus tendon at its insertion and each end was passed partial thickness through the tendon, with locking bites at each edge. After medial rectus disinsertion, the sutures were tunneled partial thickness through the original insertion site, with advancement according to Parks' resection table. Conjunctiva was then closed using interrupted 9-0 polyglactin 910 sutures. Suture adjustment, when necessary, were performed in the recovery room 1–3 hours postoperatively.

Response to advancement was studied by comparing pre- and postoperative deviations at 1 week, 4–8 weeks, and final follow-up. Successful outcome was defined as orthotropia within 10^{Δ}.

Results

A total of 20 patients met inclusion criteria. Because our institution is a referral center, 17 patients had initially undergone surgery elsewhere, and 3 had been primarily operated by the senior author (JLD) for esotropia. Of the 20, 14 had known amounts of medial rectus recession.

There were 5 cases (25%) of congenital esotropia, 2 (10%) of partially accommodative esotropia, and 7 (35%) of acquired nonaccommodative esotropia. Six patients (30%) had no surgical records and were classified as having childhood esotropia of unknown type. Nineteen patients had undergone surgery for esotropia during childhood, at mean age of 3.1 ± 2.0 years (range, 0.5–6.3 years). The exception was a male who had esotropia since 11 years of age but had undergone corrective surgery at 31 years of age.

The mean interval between surgery for esotropia and consecutive exotropia was 14.6 ± 19.3 years (range, 0.0563.4 years). One patient developed consecutive exotropia 4 days after medial rectus recession and underwent reoperation for a slipped muscle within 2 weeks. Three patients (15%) underwent surgery for consecutive exotropia between 6 months and 1 year after initial operation for esotropia; 6 (30%), between 1 and 5 years; and 10 (50%), more than 5 years. Eighteen patients underwent bilateral medial rectus advancement, and 2 underwent unilateral medial rectus advancement. Seven patients (35%) underwent medial rectus tendon transposition for A- and V-pattern exotropia, and 2 (10%) underwent either vertical rectus or inferior oblique surgery alongside medial rectus advancement.

The mean patient age (± standard deviation) at medial rectus advancement surgery was 19 ± 19 years (range, 1.1–65.4 years). The mean exotropia in central gaze was $28^{\Delta} \pm 16^{\Delta}$ (range, 12^{Δ}–60^{Δ}) at distance and $29^{\Delta} \pm 17^{\Delta}$ (range, 10^{Δ}–65^{Δ}) at near. Nineteen patients (95%) had basic exotropia (distance and near deviation within 10^{Δ}) and only 1 patient had convergence insufficiency (near exceeding distance deviation by 10^{Δ}).

Of the 14 patients with known amounts of previous medial rectus recession, 5 (36%) had an average muscle slippage of 2.5 ± 1.7 mm (range, 1.0–5.0 mm). Of these 5, 4 (80%) had a successful outcome at final follow-up and had a smaller preoperative exotropia (mean, $15^{\Delta} \pm 3^{\Delta}$; range, 12^{Δ}–20^{Δ}) than did the remaining patient, who presented with $>45^{\Delta}$ exotropia and had an unsuccessful outcome.

In the immediate postoperative period, the mean alignment was $2^{\Delta} \pm 4^{\Delta}$ of esotropia (range, 8^{Δ} esotropia to 4^{Δ} exotropia). At 4–8 weeks postoperatively, there was an average exoshift of 7^{Δ}. A total of 17 patients (83%) were within 10^{Δ} of orthotropia ($4^{\Delta} \pm 4^{\Delta}$ of exotropia). At final follow-up, 1.6 ± 1.8 years (range, 0.10–6.2 years) after surgery, 10 patients (50%) maintained alignment within 10^{Δ} of orthotropia (mean, $3^{\Delta} \pm 4^{\Delta}$ exotropia; range, 0^{Δ}–10^{Δ}), whereas the remaining patients developed recurrent exotropia averaging $25^{\Delta} \pm 8^{\Delta}$ (range, 12^{Δ}–35^{Δ}).

Groups with successful and unsuccessful surgical outcomes after bilateral medial rectus advancement were compared. There were no significant differences in the risk factors considered ($P > 0.05$; Table 1). Nonlinear regression demonstrated that the dose effect of

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medial rectus advancement was the same early and late, at about 4^{Δ}/mm medial rectus advancement, because the slopes of the regressions do not differ (Figure 1). However, there was a 17^{Δ} parallel exoshift in the regressions over time. Absence of significant restriction by the ipsilateral lateral rectus was demonstrated by intraoperative forced duction testing in all patients. Limitation of adduction as a function of medial rectus advancement was evaluated. Preoperatively, adduction deficit ranging from −0.5 to −2 was present in 65% (13/20) of patients. After bilateral medial rectus advancement, 9 of these 13 patients (69%) exhibited normalized adduction.

Discussion

About 1/3 of patients with consecutive exotropia exhibited medial rectus muscles inserted posteriorly to the expected sites and were considered to have undergone slippage. Medial rectus advancement effectively treated consecutive exotropia, without regard to medial rectus slippage, achieving correction of about 4^{Δ} of exotropia per mm total medial rectus advancement to successfully align 95% of patients in the immediate postoperative period. However, medial rectus advancement was associated with significant late exodrift, averaging 17^{Δ} at last follow-up (1.6 ± 1.8 years). Thus at last visit only 50% of patients maintained alignment within 10^{Δ} of orthotropia, whereas the rest exhibited exotropia recurrence.

Muscle slippage may occur immediately with limited ductions after strabismus surgery, but it may also occur progressively.[13,14] Signs of acute medial rectus muscle slippage include a large exotropia associated with limited adduction and palpebral fissure widening on adduction.[16,17] Detection of acute muscle slippage is not difficult. However, delayed medial rectus slippage, thought to be more common, may not be as easily recognized.[14,16,17] Ludwig and Chow[14] attributed this to stretched scar, an amorphous connective tissue interposed between an operated muscle tendon and sclera that presents with minimal or no version limitation, less separation of the tendons from the sclera, and thicker appearance of the scar segments.

In the present study, the diagnosis of slipped medial rectus was made by intraoperative observations of a single surgeon. Histopathology was not performed because it is not interpretable without informed surgical context and was not considered necessary. Stretched scars were not present in any of the operated medial rectus muscles, because striated tendon fibers were present at each insertion site.

One-third of our patients had slippage in one of the medial rectus muscles (36%). In a similar study by Cho and Ryu,[5] slipped medial rectus muscle was found in 22% of patients and was associated with limited adduction. Advancing the medial rectus muscle has reportedly improved the adduction deficits. In the current study, 4 of 5 patients with slipped medial rectus muscle exhibited adduction deficit preoperatively, but all had successful surgical outcome after medial rectus advancement. These 4 patients were observed to have smaller preoperative exotropia (mean, $15^{\Delta} \pm 3^{\Delta}$) compared to the only patient with large preoperative exotropia (45^{Δ}) and had unsuccessful surgical outcome. Our results suggest that medial rectus advancement alone may be adequate for smaller-angle consecutive exotropia.

The current sample of cases does not permit reliable conclusions about the utility of the magnitude of consecutive exotropia as a clue to the existence of medial rectus slip. In fact, 5 mm medial rectus slip was found in a 31-year old patient who developed sudden 15^{Δ} exotropia 4 days after bilateral medial rectus recession with minimal adduction deficit (−0.5), highlighting poor correlation between the amount of medial rectus shift and the amount of consecutive exotropia. This suggests that exotropia angle and adduction deficit may poorly predict medial rectus slippage. Our experience mirrors that of Chen and colleagues,[16] who asserted that only direct operative exploration was diagnostic of slipped muscle.

In this series, the mean preoperative exotropia of 28^{Δ} is comparable to that of previous studies (26^{Δ}–33^{Δ}) that incorporated medial rectus advancement for treatment of consecutive exotropia.[4–8] The average time of 14.6 years between surgery for esotropia and exotropia is also similar to previous studies (8.7–37 years). Most patients could not precisely date onset of consecutive exotropia; hence, we investigated the time interval between surgery for esotropia and exotropia. Half of the patients in our study had surgery for consecutive exotropia within 5 years of surgery for esotropia; the other half had surgery later (7.5–63.4 years).

At 4–8 weeks after surgery, our patients experienced an average exoshift of 7^{Δ}, similar to that noted by Donaldson and colleagues.[4] The small esotropia measured in our patients in the immediate postoperative period compensated for the expected exoshift such that 83% were still within 10^{Δ} of orthotropia at 4–8 weeks postoperatively. However, the target alignment of 5^{Δ}–10^{Δ} of esotropia in the immediate postoperative period advocated by Donaldson and colleagues[4] to compensate for this exoshift seems insufficient, because an average exoshift of 17^{Δ} was observed here at final follow-up.

At final follow-up, the 50% of our patients experienced recurrent exotropia. Mohan and colleagues[12] reported that the success rate dropped significantly from 92% at follow-up of 1 year to 53% at 5 years, mostly because of recurrent exotropia.

Reports of the dose–effect relationship for correction of consecutive exotropia by medial rectus advancement range from 3^{Δ}–5^{Δ}/mm in the immediate postoperative period to 2.9^{Δ}–4^{Δ}/mm at final follow-up using linear regression analysis.[5,6,9] In the current study, linear regression fit both early and late surgical effects reasonably well. In each time period, there was a regression slope of about 4^{Δ} of exotropia correction per mm of medial rectus advancement; this represents the incremental effect of a change in surgical dose. However, in the late time period, there was an exoshift of approximately 17^{Δ} in the regression Y intercept that superimposed on the early linear response to surgery. This late exodrift would be appropriately compensated by targeting the surgical dose for 17^{Δ} initial overcorrection, although other clinical considerations could motivate a different target angle. It should be noted that simply dividing the late surgical effect in any single patient by the total surgical dose confounds the effects of dose–response slope with late postoperative drift, and will give a misleading impression of the incremental effect of changes in dose. The incremental effect is represented by the linear regression slope.

We identified no clinical factors predictive of favorable outcomes after medial rectus advancement. Kasi and colleagues[7] reported that aside from absent to minimal adduction deficits, smaller preoperative exotropia, absence of amblyopia and A or V pattern were significantly predictive of successful surgical outcomes. Cho and Ryu[5] suggested that patients who were older at medial rectus advancement and had a longer time between surgery for esotropia and exotropia had better outcomes.[5] Like Donaldson and colleauges[4] and Mohan and colleagues,[12] we did not find amblyopia to be a significant contributor to surgical outcome for consecutive exotropia.

Adduction was normalized in 69% of our patients following medial rectus advancement. Ohtsuki and colleagues[8] reported a comparable improvement in adduction deficit (71%) for medial rectus advancement to the original insertion; reported rates of improvement in adduction approach 91%–100%.[5,6–8] These outcomes argue that medial rectus advancement should be performed when preoperative adduction is limited.

Although the number of patients in the present retrospective study was relatively small and not intended to provide strong management recommendations for consecutive exotropia, the study revealed that about 1/3 of patients have a slipped medial rectus muscle. Surgeons operating for consecutive exotropia should be prepared to manage a slipped medial rectus muscle. Although medial rectus advancement reliably corrected exotropia in the immediate postoperative period, patients should be counseled that eventual recurrence of exotropia is likely.

Our study suggests that the size of preoperative exodeviation may not predict the presence or amount of medial rectus slippage. Hence medial rectus advancement is preferred over lateral rectus recession for consecutive exotropia because the former procedure allows surgical exploration of the medial rectus muscle to detect the presence of an unfavorable insertion. Postoperative exodrift should be considered when determining the target angles for consecutive exotropia surgery. We suggest consideration and further study of an initial overcorrection of 15^{Δ} in visually mature patients because our study showed an average late exoshift of 17^{Δ} after medial rectus advancement.

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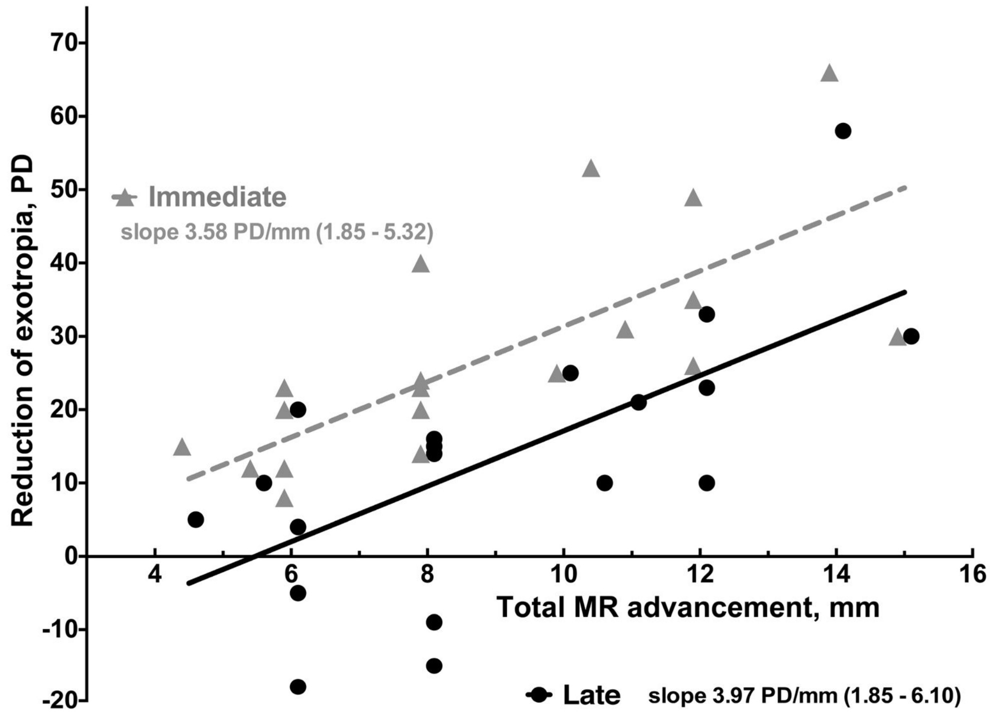

Figure 1.

Effect of total medial rectus advancement (adding bilateral amounts if surgery was binocular) on reduction of exotropia at the immediate postoperative period and last visit (1.6 ± 1.8 [0.10–6.2 years]). Note similar regression slopes, but parallel exoshift of about 17^{Δ} at last visit.

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Table 1

Factors in successful and unsuccessful surgical outcomes

	Successful (n = 10)	**Unsuccessful (n = 10)**
Preoperative distance XT, PD	22 ± 14	33 ± 15
Preoperative near XT, PD	24 ± 16	35 ± 17
Age at XT surgery	19.6.1 ± 18.6	18.6 ± 20.5
Age at ET surgery	6.5 ± 8.9	2.5 ± 1.6
Interval between XT and XT surgery, years	13.0 ± 19.0	16.1 ± 20.4
No amblyopia	6 (60%)	7 (70%)
No to minimal adduction deficits	7 (70%)	10 (100%)
No A or V pattern	7 (70%)	3 (30%)
No anisometropia	7 (70%)	5 (50%)
No DVD/HT	6 (60%)	7 (70%)

DVD, dissociated vertical deviation; *ET*, esotropia; *HT*, hypertropia; *PD*, prism diopters; *XT*, exotropia.