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Classifying medial rectus muscle attachment in consecutive exotropia

Jae Ho Jung, MD, PhD^{a,b}, David A. Leske, MS^a, and Jonathan M. Holmes, BM, BCh^a

^aDepartment of Ophthalmology, Mayo Clinic, Rochester, Minnesota, USA

^bDepartment of Ophthalmology, Pusan National University Yangsan Hospital, Yangsan, South Korea

Abstract

Purpose—To evaluate interexaminer agreement in classifying medial rectus muscle attachment in patients with consecutive exotropia.

Methods—A series of intraoperative photographs of 26 eyes in 25 patients who underwent surgery for consecutive exotropia were retrospectively studied. Two examiners independently classified the medial rectus attachment as either normal, stretched scar, slipped muscle, or lost muscle. Agreement between examiners was evaluated using the weighted kappa (κ) statistic, and causes of disagreement were assessed.

Results—Agreement was found in 15 of 26 eyes (58%), signifying “moderate” agreement ($\kappa = 0.41$). Approximately two-thirds of the disagreements, in 7 of 11 eyes (64%), were between stretched scar and slipped muscle, with characteristics of each entity being present in the same muscle.

Conclusions—The clinical distinction between stretched scar and slipped muscle appears to be obscure. We propose that they should be considered a single entity, which could be referred to as “abnormal scleral attachment.”

Consecutive exotropia is an exotropia that develops after surgical treatment for esotropia or spontaneously in a previously esotropic patient. Consecutive exotropia following surgery may be associated with several types of abnormal medial rectus muscle attachments which have been described as a slipped muscle,¹ lost muscle,² and stretched scar.^{3,4} The slipped muscle was described by Parks and Bloom¹ as a rectus muscle that retracts posteriorly within the muscle capsule, with the empty muscle capsule remaining attached to the sclera. Plager and Parks² characterized a lost muscle as the absence of any attachment of the muscle to the sclera. A stretched scar was originally described by Ludwig as a previously operated

Correspondence: Dr. Jonathan M. Holmes, Ophthalmology E4, Mayo Clinic, Rochester, MN 55905 (holmes.jonathan@mayo.edu).

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rectus muscle that is attached to the sclera by a segment of amorphous scar tissue rather than by tendon or muscle.³⁻⁵

In an adult strabismus practice, we are often faced with trying to characterize an abnormal muscle attachment years after the original surgery, without the benefit of a clear history or a sequential series of measurements. It is therefore difficult to know whether or not sudden postoperative changes occurred in the distant past (consistent with a slipped muscle) or whether slower changes occurred (consistent with a stretched scar). Surgeons are most often faced with needing to characterize the muscle attachment purely based on its current appearance.

Negishi and colleagues⁶ classified medial rectus insertion status during surgery as either normally recessed, if the muscle was firmly attached to the sclera; stretched scar, if the muscle was attached to the globe by thick connective tissue; or slipped muscle, if the muscle was attached to the globe by a very thin translucent membrane.² Although Negishi and colleagues⁶ have suggested that these are distinct entities, there appears to be a lack of consistency applying these definitions in the literature. Reviewing the figures in manuscripts by Ludwig,³ Ludwig and Chow,⁴ and Negishi and colleagues,⁶ it is not clear that each type of medial rectus muscle attachment can be classified uniquely. The purpose of the present study was to evaluate interexaminer agreement when classifying medial rectus muscle attachment (normal vs slipped muscle vs stretched scar vs lost muscle) in patients with consecutive exotropia.

Materials and Methods

The procedures used in this study were approved by the Institutional Review Board of the Mayo Clinic, Rochester, Minnesota, and complied with the US Health Insurance Portability and Accountability Act of 1996. As part of the standardized surgical consent process, patients permitted intraoperative photography, and it was our routine to take photographs of abnormal surgical findings. We retrospectively evaluated the medial rectus muscle attachment in eyes with consecutive exotropia by studying the intraoperative photographs of patients who underwent surgery for consecutive exotropia by a single surgeon (JMH) between 2005 and 2014. We defined consecutive exotropia as exotropia of at least 10 by prism and alternate cover test at distance fixation following previous medial rectus muscle recession for esotropia, with or without lateral rectus resection.

The operating surgeon's standard procedure was to explore the medial rectus in all cases where an adduction deficit was observed preoperatively and if the lateral rectus muscle was not tight on forced duction testing (which might explain the deviation). A series of intraoperative photographs was taken during medial rectus muscle exploration.

Classification of Medial Rectus Attachment

Two examiners (JMH and JHJ), both fellowship-trained in pediatric ophthalmology and strabismus, independently classified the status of medial rectus attachment by evaluating the series of intraoperative photographs. The first examiner was unaware of the results of the second examiner and this masking was designed to minimize observer bias. Each examiner

classified the type of medial rectus muscle attachment as one of four previously described categories: (1) normal attachment, with the medial rectus muscle fibers firmly attached to the sclera; (2) stretched scar, with the muscle not directly attached to the sclera and attachment formed by tendonlike connective tissue clearly distinguishable from muscle tissue and located between sclera and the distal end of medial rectus muscle fibers; (3) slipped muscle, with primary attachment of the distal end of the medial rectus muscle being a thin translucent membrane with posteriorly retracted muscle fibers not directly attached to the sclera; and (4) lost muscle, with the primary attachment of the distal end of the medial rectus muscle to the pulley or the distal end of the muscle fibers being behind the pulley.^{1,3,4,6}

Analysis

Agreement between examiners was evaluated using the weighted *kappa* statistic (κ).⁷ The reasons for disagreements were noted. In order to assess whether there was any bias toward agreement or disagreement with fewer or greater number of photographs, we compared the number of photographs from eyes that had agreement between examiners with eyes that had disagreement between examiners using the Wilcoxon rank sum test. All statistical analyses were performed using SAS software (version 9.4, SAS Institute Inc, Cary, NC).

Results

A series of intraoperative photographs were taken during medial rectus muscle exploration in 26 eyes of 25 patients (11 males) with consecutive exotropia. The mean patient age was 43.5 ± 18.3 years (range, 20–82 years). Of these, 23 patients had undergone their first surgery for consecutive exotropia and 2 patients had undergone surgery for recurrent consecutive exotropia. Regarding original diagnosis, 20 cases had infantile esotropia and 5 had acquired esotropia.

Agreement was found in 15 of the 26 eyes (58%); disagreement, in the remaining 11 eyes (42%). See Table 1. ($\kappa = 0.41$). Disagreement regarding classification of medial rectus muscle attachment was as follows: in 7 of 11 eyes (64%), there was disagreement between slipped muscle and stretched scar (Figure 1); in 1 eye (9%), between slipped muscle and lost muscle (Figure 2); in 2 eyes (18%), between stretched scar and lost muscle (Figure 3); and in 1 eye (9%), between slipped muscle and a normal (Figure 4).

The median number photographs of eyes with agreement and disagreement were similar (median, 8 vs 9; range, 1–32 vs 3–21; $P = 0.3$), suggesting little bias toward agreement or disagreement based on number of photographs.

Discussion

In our study evaluating the intraoperative appearance of the medial rectus insertion in patients who had undergone surgery for consecutive exotropia, only “moderate” agreement was found between two examiners classifying the type of medial rectus attachment based on intraoperative photographs. The majority of disagreements involved differentiating between

stretched scar and slipped muscle, primarily because there appeared to be features of both stretched scar and slipped muscle within the same muscle.

Ludwig³ and Ludwig and Chow⁴ originally described stretched scar as a postoperative change in the length of the scar between the tendon and sclera that can occur weeks to years following strabismus surgery, even with proper surgical technique. In contrast, a slipped muscle was attributed to suboptimal suture placement at the time of the original surgery, such that the muscle slipped within the muscle sheath.^{3,4} The authors described intraoperative characteristics of lengthened scar segments and used photographs to illustrate stretched scars.^{3,4} Negishi and colleagues⁶ defined a stretched scar as a muscle attached to the globe by thick connective tissue; a slipped muscle, as a muscle attached to the globe by very thin connective tissue where a muscle hook was clearly visible through the tissue.⁶ Reviewing photographs of Ludwig³ and Ludwig and Chow⁴ in the original description of stretched scar, some cases appeared to have translucent tissue between the distal end of the muscle and the sclera that allowed visualization of the muscle hook through this thin connective tissue, indistinguishable from other descriptions of a slipped muscle. This appearance of thin translucent tissue in some of the authors' photographs of stretched scar^{3,4} is, paradoxically, considered a diagnostic hallmark of a slipped muscle by Negishi and colleagues.⁶ Another example of conflicting diagnostic criteria is found in a retrospective study by Tinley and colleagues⁸ who reported the effect of single medial rectus muscle advancement in stretched scar and reported stretched scar as "the muscle hook ... visible through the scar" which was almost identical to the definition of a slipped muscle in the study of by Negishi and colleagues.⁶ Considering these published manuscripts together, there is disagreement in the literature as how to define stretched scar versus slipped muscle. In addition, in the current study, when we applied strict criteria regarding the appearance of the muscle (such as those of Negishi and colleagues⁶), we found only "moderate" agreement between expert examiners.

One of the primary reasons for disagreement in the present study was our finding of several cases that had features of both stretched scar and slipped muscle within the same rectus muscle. We therefore now propose that both stretched scar and slipped muscle should be considered a single entity, which might be referred to as an "abnormal scleral attachment."

From a practical standpoint, eyes with abnormal medial rectus attachments may require similar surgical techniques. There is some agreement that true medial rectus muscle fibers need to be sutured firmly onto sclera, described by Jampolsky⁹ as "putting red meat against the sclera" and that anomalous connective tissue should be simultaneously excised.^{3,4,6,10} Therefore, identification of the location of the true medial rectus muscle fibers may be more important than classifying muscle attachment status in patients with consecutive exotropia.

In cases of abnormal rectus muscle attachment, there remains disagreement regarding what suture material should be used to reattach the normal muscle fibers to the sclera. Ludwig^{3,4} reported that a large postoperative drift occurred more frequently in cases when absorbable sutures were used, in contrast to when nonabsorbable sutures were used, and suggested that absorbable suture-induced inflammation hindered healing and weakened the muscle reattachment process, increasing the risk for recurrence of the deviation. Nevertheless,

several authors^{6,8,10,11} have used absorbable suture material to reattach previously recessed medial rectus muscles whether or not associated with abnormal scleral attachment. Further studies are needed in consecutive exotropia to address adjustable versus nonadjustable sutures, ideal suture material, optimal target angle, and surgical outcomes.

Our study was limited by the small number of patients and by the fact that evaluation relied on photographic evidence. Furthermore, we had no “gold standard” for the type of muscle attachment, and therefore our study can only address “agreement” or “disagreement” between two experienced observers independently evaluating a series of photographs, rather than validity of each assessment. Further studies might include histological examination of resected tissue, and/or intraoperative classification of the type of attachment by a third surgeon, and/or additional evaluators of the photographs to provide a “gold standard” consensus opinion on the nature of each type of attachment. Such additional data would then allow comparison of a consensus gold standard to each photographic reading performed, providing an assessment of the validity of the photographic evaluation. The current study was specifically designed to assess the level of agreement between observers, which proved to be only “moderate” at best. An additional weakness is that we limited our analysis to visual inspection of a photograph of the insertion. We did not allow two surgeons to assess the tensile strength of the attachment and/or the attachment's response to manipulation and/or whether there was a “step”¹⁰ in the tissue. Nevertheless, a striking finding of our study is that the disagreement between two surgeons was primarily due to features of previously described slipped muscles and previously described stretched scars in the same attachment, specifically, areas of thin translucent tissue and areas of thick white scar within the same attachment, making it difficult to dichotomize into slipped muscle versus stretched scar. It seems unlikely that additional tactile manipulation of these diverse tissue types (when present in the same muscle attachment) would allow definitive dichotomization into slipped muscle or stretched scar for some cases of consecutive exotropia.

In conclusion, we propose that when a rectus muscle is not directly attached to the sclera but is connected indirectly to the sclera either by a thin translucent membrane or thick scar tissue, these attachments should be considered a single entity, which might be referred to as an “abnormal scleral attachment.” Using this definition in cases of consecutive exotropia, the medial rectus muscle attachment could be classified as either “normal attachment,” “abnormal scleral attachment,” or “lost” (either attached to the pulley or the distal end of the muscle fibers behind the pulley). Further clinical outcome studies may be helpful to support or refute this suggestion.

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References

1. Parks MM, Bloom JN. The “slipped” muscle. *Ophthalmology*. 1979; 86:1389–1396. [PubMed: 396494]

2. Plager DA, Parks MM. Recognition and repair of the “lost” rectus muscle. A report of 25 cases. *Ophthalmology*. 1990; 97:131–136. discussion 6–7. [PubMed: 2314834]
3. Ludwig IH. Scar remodeling after strabismus surgery. *Trans Am Ophthalmol Soc*. 1999; 97:583–651. [PubMed: 10703142]
4. Ludwig IH, Chow AY. Scar remodeling after strabismus surgery. *J AAPOS*. 2000; 4:326–333. [PubMed: 11124665]
5. Ludwig IH, Clark RA, Stager DR Sr. New strabismus surgical techniques. *J AAPOS*. 2013; 17:79–88. [PubMed: 23415038]
6. Negishi T, Hikoya A, Isoda H, et al. Magnetic resonance imaging of the medial rectus muscle of patients with consecutive exotropia after medial rectus muscle recession. *Ophthalmology*. 2010; 117:1876–1882. [PubMed: 20541264]
7. Fleiss, JL. *Statistical Methods for Rates and Proportions*. New York: John Wiley and Sons; 1981.
8. Tinley C, Evans S, McGrane D, Quinn A. Single medial rectus muscle advancement in stretched scar consecutive exotropia. *J AAPOS*. 2010; 14:120–123. [PubMed: 20451853]
9. Boschi, A.; Fitzsimons, R.; Jampolsky, A., et al. Thyroid associated ophthalmopathy. In: de Faber, JT., editor. *9th Meeting of the International Strabismological Association*. Sydney, Australia: Swets & Zeitlinger; 2002.
10. Raz J, Bernheim J, Pras E, Saar C, Assia EI. Diagnosis and management of the surgical complication of postoperative “slipped” medial rectus muscle: a new “tendon step test” and outcome/results in 11 cases. *Binocul Vis Strabismus Q*. 2002; 17:25–33. [PubMed: 11874380]
11. Gesite-de Leon B, Demer JL. Consecutive exotropia: why does it happen, and can medial rectus advancement correct it? *J AAPOS*. 2014; 18:554–558. [PubMed: 25454022]

FIG. 1.

Example of disagreement between a stretched scar and a slipped muscle. Translucent, empty, capsule-like tissue allowed visualization of the muscle hook through the tissue characteristic of a slipped muscle (black arrow) but there was also white-colored, tendonlike tissue (white arrow) between the sclera and medial rectus muscle fibers, characteristic of stretched scar.

FIG. 2.

Example of disagreement between a slipped and a lost muscle. The translucent membrane characteristic of a slipped muscle (black arrow) was observed, but it was not clear whether true medial rectus muscle was connected to this translucent membrane. The medial rectus muscle fibers also appeared attached to the pulley structures (white arrow), which may occur with a lost muscle.

FIG. 3.
Example of disagreement between a stretched scar and a lost muscle. The true medial rectus muscle fibers were attached to the pulley structure (white arrow) instead of the sclera. Thick scar tissue (black arrow) without muscle fibers was observed to be attached to the anterior sclera, characteristic of stretched scar.

FIG. 4. Example of disagreement between a normal and a slipped muscle. Translucent membranelike tissue (A, black arrow) was attached to sclera, but the medial rectus muscle was also directly attached to sclera when this translucent membrane was removed (B, white arrow).

Table 1Frequency of each classification of medial rectus attachment by examiner^a

Examiner 2	Examiner 1			
	Normal attachment	Stretched scar	Slipped muscle	Lost muscle
Normal attachment	1	-	-	-
Stretched scar	-	7	1	1
Slipped muscle	1	6	5	1
Lost muscle	-	1	-	2

^aFigures in bold indicate agreement between examiner 1 and examiner 2