Classifying medial rectus muscle attachment in consecutive exotropia

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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, 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." (J AAPOS 2016;20:197-200)

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 Bloom[1] as a rectus muscle that retracts posteriorly within the muscle capsule, with the empty muscle capsule remaining attached to the sclera. Plager and Parks[2] 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 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 colleagues[6] 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. Although Negishi and colleagues[6] 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

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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^{Δ} 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.

Table 1. Frequency of each classification of medial rectus attachment by examiner[a]

	Examiner 1			
Examiner 2	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**

[a]Figures in bold indicate agreement between examiner 1 and examiner 2.

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.

Ludwig[3] and Ludwig and Chow[4] 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 after 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 colleagues[6] 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 Ludwig[3] and Ludwig and Chow[4] in the original description of stretched scar, some cases appeared to have translucent tissue between the distal