

Extraocular muscle injury during endoscopic sinus surgery: an ophthalmologic perspective

K-A Park and SY Oh

Abstract

Purpose The purpose of this study is to describe the clinical characteristics and treatment results of medial rectus muscle (MR) transection incurred during endoscopic sinus surgery.

Methods This retrospective study included 16 patients with MR transection incurred during endoscopic sinus surgery between 1994 and 2015. The operative notes of the surgical procedure, the pattern of strabismus, the type of muscle injury, the type of corrective strabismus surgery, and the surgical outcomes were reviewed.

Results Nine patients had partial resection of MR and seven patients had complete transection of MR, resulting from an injury incurred during endoscopic sinus surgery. Three of the nine patients with partial resection injury were initially diagnosed as complete resection and subsequently re-diagnosed as partial resection in a review of the images during this study. Five of the nine patients with partial MR resection underwent only simple recession/resection surgery. Patients with complete MR transection underwent muscle transposition or globe fixation surgeries and often multiple operations were required.

Conclusions The results of this study showed that the treatment strategies could vary depending on the nature of muscle injury. In cases with complete transection, muscle transposition or globe fixation surgeries are often required, with multiple operations. However, partial muscle resection with only simple recession/resection surgery shows a favorable outcome in many cases. The use of proper imaging techniques, a thorough review of the images with various planes, and close follow-up are important for determining the nature of the muscle injury.

Eye (2016) 30, 680–687; doi:10.1038/eye.2016.15; published online 19 February 2016

Introduction

Endoscopic sinus surgery has been widely used as a mainstay of surgical treatment for disorders of the paranasal sinuses during the last 2 decades. It is well-established as a safe and effective surgical method. Despite the relative safety of the procedure and recent advances in this field, complications are still encountered. Ophthalmic injuries are rare but devastating complications. Powered devices that are widely used currently can be another source of ophthalmic injury if the suction cutting tip is misdirected into the orbit. Damage to extraocular muscles can cause severe permanent strabismus with diplopia, which has a poor prognosis even with treatment. Owing to the rare occurrence of extraocular muscle injury following endoscopic sinus surgery, there are few reports on the treatment strategies in these patients.^{1–4} In the present study, we reported the results of surgical correction in patients with medial rectus (MR) injury incurred during endoscopic sinus surgery and further discussed the treatment strategies.

Methods

This study was approved by the Institutional Review Board of Samsung Medical Center (Seoul, Republic of Korea). All research was performed in compliance with the tenets of the Declaration of Helsinki. We retrospectively reviewed the medical records of patients with MR injury incurred during endoscopic sinus surgery, who were referred to the Samsung Medical Center between January 1994 and February 2015. Patients were identified from

Department of Ophthalmology, Samsung Medical Center, Sungkyunkwan University School of Medicine, Seoul, Korea

Correspondence: SY Oh, Department of Ophthalmology, Samsung Medical Center, Ilwondong, Kangnam-gu, Seoul 135-710, Korea
Tel: +82 2 3410 3566;
Fax: +82 2 3410 0074.
E-mail: syoh@skku.edu

Received: 9 August 2015
Accepted in revised form: 5 November 2015
Published online: 19 February 2016

outpatient logbooks. In this study, we included patients with partial or complete transection of the MR incurred during endoscopic sinus surgery, which had been confirmed using orbital magnetic resonance imaging (MRI) or computed tomography (CT). Some of these patients had participated in a study of the otolaryngologic perspective of extraocular muscle injury during endoscopic sinus surgery in the otorhinolaryngology department in the same hospital.⁵ We reviewed the operative reports of all patients describing the endoscopic sinus surgery and the medical records for demographic data, initial ocular deviation and ocular motility, surgical methods for strabismus, poststrabismus surgery ocular deviation and ocular motility, reoperations, and complications. Available preoperative and postoperative imaging (MRI and/or CT) data were evaluated. All patients were classified as complete *vs* partial MR resection according to the orbital imaging results.

All patients underwent a complete ophthalmic and ocular motility examination. Ideally, measurements of ocular alignment were obtained using prism alternate cover testing at 6 m fixation and 33 cm fixation; however, when this was not possible, the Krimsky test at 33 cm fixation was used. Voluntary ductions were performed on all patients using a 4-point scale ranging from 0 to -4: 0 = patient has full movement in the affected eye; -2 = patient is unable to move the affected eye past the midline; -3 = patient is unable to move the affected eye to the midline; and -4 = patient has no adducting movement in the affected eye. Forced duction and force generation tests were performed on all patients. Two examiners (SO and KP) performed all the tests for ocular alignment and surgeries as well. The surgical strategy in each case was individualized based on the nature of the muscle injury, the clinical presentation, and the type of previous orbital and muscle surgery.

Results

We identified 16 patients with MR transection incurred during endoscopic sinus surgery. A summary of patient characteristics was provided in Table 1. Representative cases were shown in Figure 1. The mean age of the patients was 47 ± 14 years (range 20–64 years). All patients had unilateral extraocular muscle damage, with more common involvement of the right eye (10 patients, 63%). Nine patients had partial resection of MR and seven patients had complete resection of MR from the injury incurred during endoscopic sinus surgery (Figure 2). Three of the patients with partial resection injury were diagnosed as complete resection at their initial visit and were re-diagnosed as partial resection during the retrospective review of the previous images. In these cases, different planes (sagittal plane in case 9), different

imaging methods (MRI in case 11), or images taken after a time interval (case 12) showed a strand of MR connected to the proximal and distal MR stumps, ruling out complete transection (Figure 3). A microdebrider, a refined endoscopic surgical tool that provides powered dissection, was used in all cases with the exception of case 9, in which there was no information on surgical instrumentation in the medical records of another hospital.

A summary of findings on preoperative ophthalmic evaluation was provided in Table 1. The mean preoperative angle of exotropia in the primary position at distance fixation was 53 ± 15 prism diopters (PD) (range 15–75 PD). The mean adduction deficit was -3.0 ± 1.0 (range -1 to -4). The visual acuity in the operated eye ranged from 20/20 to no light perception. Fourteen patients (88%) had diplopia in the primary position preoperatively and all patients had a normal head posture preoperatively. Table 2 showed the previous surgeries if any, management strategies, and postoperative alignment of the patients. The mean time between MR injury during endoscopic sinus surgery and the first corrective surgery for the strabismus was 9 ± 5 months (range 0–19 months). The mean follow-up duration was 3 ± 1 years (range 1.5–5 years).

Four of the nine patients with partial MR transection showed improvement of ocular movement, at 4 months follow-up in 2 patients and at 2 months in 1 patient, before strabismus surgery. One patient showed complete recovery at 2 months without strabismus surgery. Five of the nine patients with partial MR transection underwent only MR resection and lateral rectus muscle recession. During the MR resection surgery, care was taken not to pull the MR, which could potentially convert incomplete transection to complete transection. Of the two patients with partial MR resection, who were unable to move the affected eye to the midline, one patient underwent the globe tethering technique using a suture/titanium T-plate anchoring platform system⁶ as an initial surgery and the other patient, who previously had undergone lateral rectus muscle recession and MR resection, underwent full tendon transposition and MR repeat resection. In two cases with complete MR transection, a proximal MR stump was found through an anterior orbitotomy approach.⁷ Owing to severe fibrosis around the site of injury, it was impossible to completely free the muscle stump from the fibrotic tissues and advance the muscle stump anteriorly. Instead, the hang-back suture was fixated tightly where the eye was positioned to the midline. In these cases, suture tightening was required after the surgery due to recurrence of exodeviation over time. Three patients with total MR transection underwent the muscle union procedure⁸ with lateral rectus muscle recession. Two patients had successful postoperative results; however, the other patient with 70 PD exotropia and 15 PD right hypertropia, who underwent the muscle

Table 1 Patient characteristics, type of endoscopic sinus surgery, type of injury, and summary of findings in ophthalmic evaluation

Case (age ^a /sex)	ESS/injury side	Type of MR injury	Other Cx.	Initial deviation	Preop. deviation ^b	Initial add. ^c	Preop. add. ^{b,c}	Preop. FGT ^b	Preop. FDT ^b	Preop. diplopia ^b	Length of proximal stump
1 (20/M)	EMMA (R)/right	Complete resection	None	30 XT	50 XT	-3	-3	Severe weakness	LR: mild restriction	+	7 mm
2 (46/F)	EMMA (R)/right	Complete resection	None	50 XT	50 XT	-4	-4	Moderate weakness	LR: moderate restriction	+	18 mm
3 (61/M)	EMMA (B)/right	Complete resection	None	50 XT	70 XT	-4	-4	Severe weakness	MR, LR: moderate restriction	+	15 mm
4 (61/M)	EMMA (B)/right	Complete resection	IR injury	80 XT 15 RHT	70 XT 15 RHT	-4	-4	Severe weakness	No restriction	+	7 mm
5 (58/M)	EMMA (L)/left	Complete resection	CRAO, optic nerve transection, complete 3rd nerve palsy	50 XT, 20 LHT	50 XT, 20 LHT	-4	-4	Severe weakness	No restriction	-	No stump visible
6 (49/F)	EMMA (B)/left	Complete resection	Temporary IR palsy	50 XT 4 LHT	50 XT	-4	-4	Severe weakness	LR: moderate restriction	+	8 mm
7 (59/M)	EMMA (B)/right	Complete resection	IR injury	50 XT 18 RHT	50 XT	-4	-4	Severe weakness	IR: mild restriction	+	11 mm
8 (64/F)	EMMA (L)/left	Partial resection	None	45 XT	45 XT	-2	-2	Moderate weakness	MR, LR: mild restriction	+	-
9 (49/M)	EMMA (R)/right	Partial resection	None	30 XT	35 XT	-3	-3	Moderate weakness	LR: mild restriction	+	-
10 (45/M)	EMMA (B)/right	Partial resection	CSF leakage	75 XT	75 XT	-4	-4	Severe weakness	No restriction	+	-
11 (46/M)	EMMA (R)/right	Partial resection	Orbital hemorrhage	80 XT	50 XT	-4	-2	Moderate weakness	No restriction	+	-
12 (44/M)	EMMA (R)/right	Partial resection	None	60 XT	70 XT	-4	-2	Severe weakness	No restriction	+	-
13 (36/M)	EMMA (B)/right	Partial resection	Optic nerve injury	35 XT	40 XT	-3	-3	Moderate weakness	No restriction	+	-
14 (54/M)	EMMA (L)/left	Partial resection	Entrapment of MR	35 XT	30 XT 2LHoT	-3	-1	Moderate weakness	MR: moderate restriction	+	-
15 (20/M)	EMMA (B)/left	Partial resection	None	10 XT	Ortho (Spont. recovery)	-1	Normal (Spont. recovery)	Normal (Spont. recovery)	No restriction	- (Spont. resolution)	-
16 (54/M)	EMMA (B)/left	Partial resection	Orbital hemorrhage	20 XT	15 XT	-2	-2	Moderate weakness	MR, LR, IR: moderate restriction	+	-

Abbreviations: add., adduction; B, bilateral; CRAO, central retinal artery occlusion; CSF, cerebrospinal fluid; Cx., complications; EMMA, ethmoidectomy and middle meatal antrostomy; ESS, endoscopic sinus surgery; F, female; FDT, forced duction test; FGT, force generation test; IR, inferior rectus; L, left; LHT, left hypertropia; LHoT, left hypertropia; LR, lateral rectus; M, male; MR, medial rectus muscle; Post., posterior; Preop, preoperative; R, right; RHT, right hypertropia; Spont., spontaneous; XT, exotropia. ^aYears. ^bResults of the preoperative examination at the final preoperative visit. ^cVoluntary ductions were performed using a 4-point scale ranging from 0 to -4: 0 = patient has full movement; -2 = patient is unable to move the affected eye past the midline; and -3 = patient is unable to move the affected eye to the midline.

union procedure, had 20 PD exotropia and 15 PD right hypertropia postoperatively.

The mean postoperative horizontal angle of ocular deviation was 4 ± 6 PD (range 0–20 PD) exotropia at the final postoperative visit. The mean postoperative

adduction deficit was -1.5 ± 1.0 (range -0.5 to -3). All patients were acceptably aligned in central gaze after strabismus surgery, with the exception of one patient who had concomitant inferior rectus muscle injury. Five of the 12 patients (42%) required ≥ 2 surgical procedures.

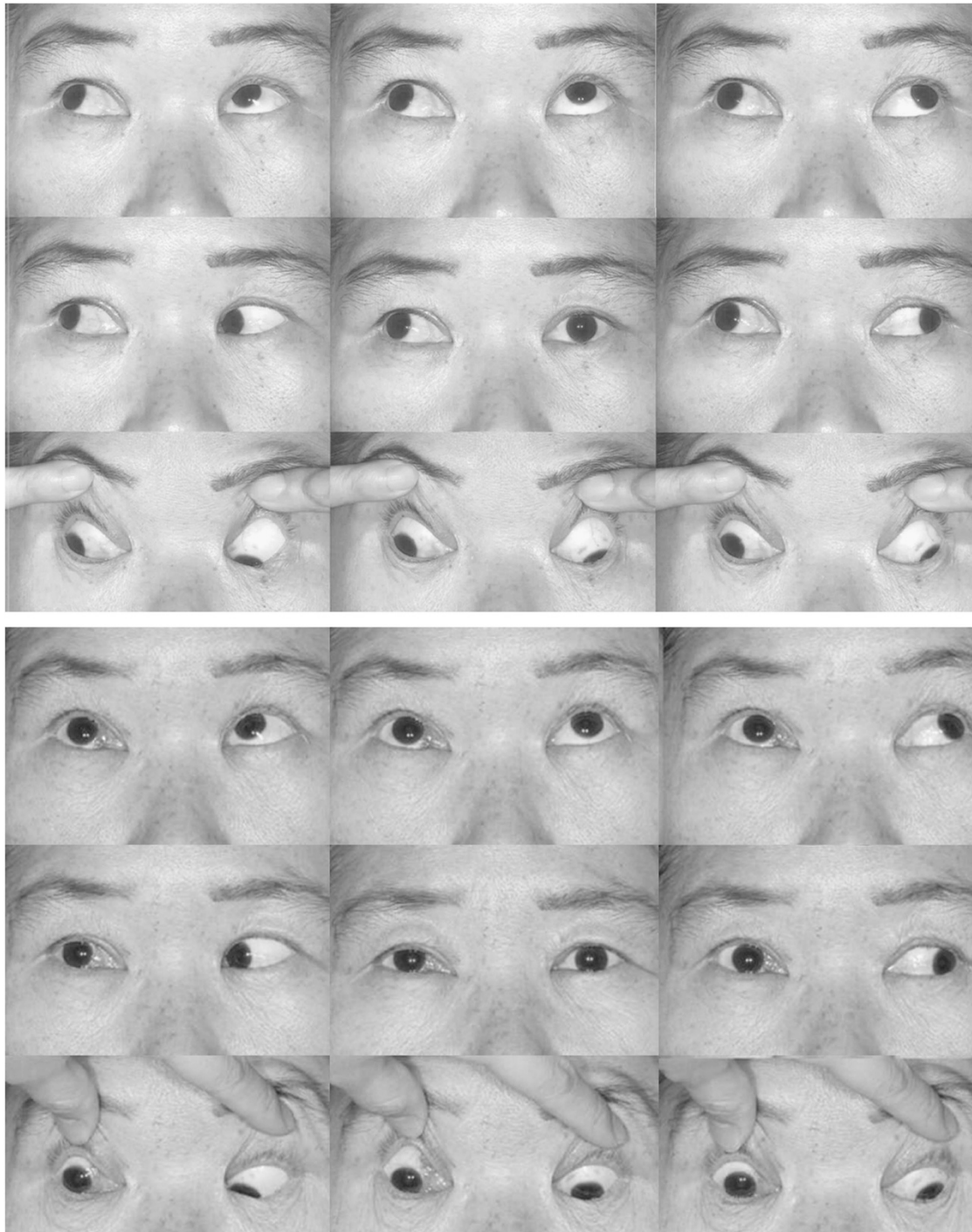


Figure 1 A 46-year-old woman with complete MR muscle transection following endoscopic sinus surgery (case 2). She underwent multiple strabismus surgeries including muscle transposition surgery. Before (top) and 1 month following the final strabismus surgery (bottom).

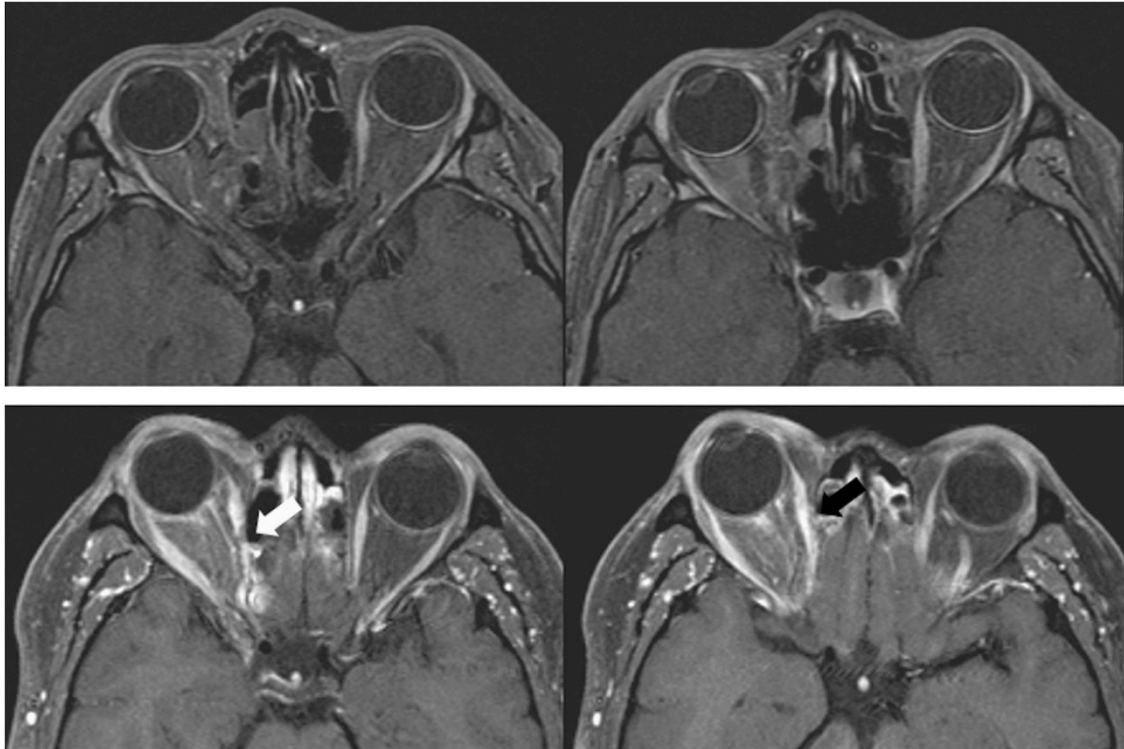


Figure 2 Axial MRI of complete muscle transection (top, case 1) and partial muscle resection (bottom, case 8) cases. In the partial muscle resection case, there was focal dehiscence (white arrow) of the right MR muscle (bottom, left). However, we could see continuity (black arrow) of the MR muscle in another image (bottom, right).

There were no intraoperative surgical complications reported and no cases of anterior segment ischemia. Two patients developed a mild transient increase in intraocular pressure of the operated eye on postoperative day 1, which resolved within 1 week before discontinuation of steroid eye drops. There was no sign of cellular reaction in the anterior chamber or pupillary abnormality in these cases.

Discussion

In this study, MR injury following endoscopic sinus surgery was divided into partial *vs* total MR resection. In the partial resection group, three patients were able to move the affected eye to the midline at the initial exam and five patients were able to move the affected eye to the midline at the final preoperative exam. Four out of the nine patients with partial MR transection showed improvement of ocular movement during the several months follow-up period before the strabismus surgery. In the complete resection group, none of the patients could move the affected eye to the midline during the preoperative follow-up period and there was no improvement in ocular movement during the entire preoperative follow-up period. Small adduction movement in some cases with complete MR resection

may be related to the relaxation of the antagonist lateral rectus muscle.

In the partial resection group, simple recession–resection surgery achieved good postoperative results in most cases. However, in the complete resection group, muscle transposition surgery or globe fixation surgery using a non-absorbable suture were needed to correct the deviation of the eyeball and resolve diplopia. In most complete MR transection cases in this study, the destruction of the extraocular muscle was severe and there were no cases with a proximal residual stump longer than 20 mm. The severity of destruction in this study may be related to the use of the powered devices.⁹ We attempted to find muscle stumps in two cases with short residual proximal muscle tissue and sutured with a non-absorbable suture; however, there was a recurrence of exodeviation over time. Recurrence of exodeviation may be due to loosening of the suture or remodeling of the tissues where the suture was anchored. Muscle transposition surgery such as the muscle union procedure was effective in these patients with complete MR transection. Nevertheless, the result was poorer when accompanied with vertical rectus muscle injury, as seen in case 4. There was no significant complication in globe fixation or muscle transposition surgeries, except for a transient increase in intraocular pressure in two patients

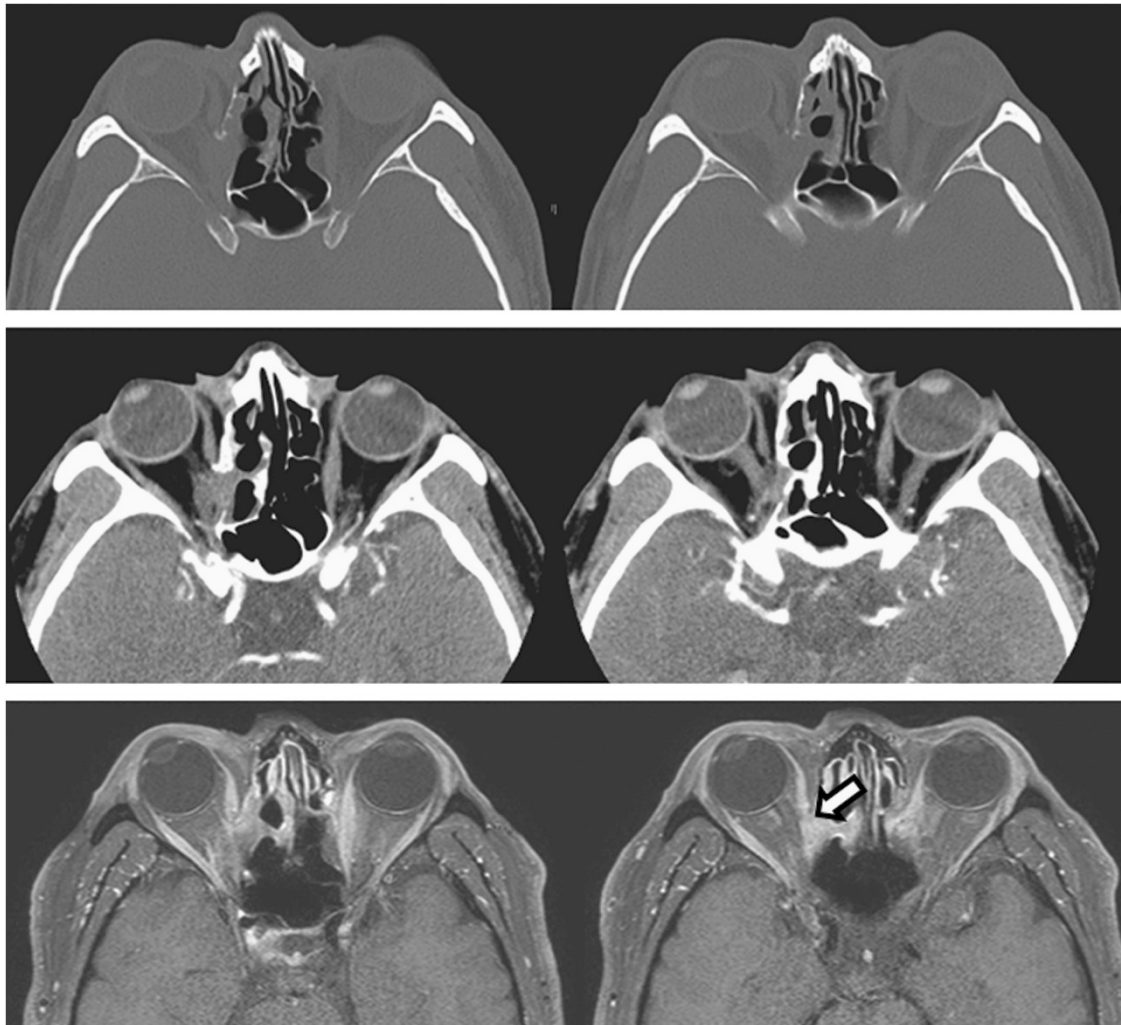


Figure 3 CT scans and axial MRI of case 11. The mid portion of the muscle segment seems transected on CT scans (top and middle). However, axial views of MRI shows partial damage to the MR muscle, ruling out complete transection (arrow).

who underwent muscle union procedure, which might be due to mechanical pressure. The different surgical response in individual cases indicated that the response to the same surgical technique could vary between individuals. The reason for this variability may be due to susceptibility of certain individuals, different severity, and amount and location of the injury from previous endoscopic sinus surgery. However, most patients with complete MR resection finally resolved diplopia and had a cosmetically fine outcome after several surgeries. If primary repair of the transected muscle is impossible in complete resection cases, surgical methods including various types of transposition surgeries or globe fixation surgeries could be selected based on the surgeon's experiences or availability.

During the review process in this study, we re-diagnosed three patients as partial resection, who were

diagnosed as complete resection at their initial visit. In these cases, the one-time axial CT scan alone was often not sufficient to distinguish partial muscle resection from complete transection. Ela-Dalman *et al*¹⁰ previously emphasized the importance of various views of MRI scans, especially sagittal views. In our cases, we found a strand of MR that was connected to the proximal and distal MR stumps ruling out complete transection, using a different image plane (sagittal plane), a different imaging method (MRI instead of CT), or with images taken after the time interval. A thorough review of the images is warranted in patients with MR injury or suspected MR injury. Cautious follow-up is needed with repeated imaging using various planes of MRI scans, to evaluate possible improvement in the adduction that could occur in partial MR resection.

This study had several limitations. First, the sample size was small due to the rare occurrence of this entity.

Table 2 Management strategies and postoperative results of the patients

Case	Time from injury to first strabismus surgery (m)	Surgery	Number of strabismus surgeries	Postop. deviation ^a	Postop. adduction ^{a,b}	F/U duration (y)	Postop. diplopia in central gaze ^a	Postop. head posture ^a
1	7	LR rec 10 mm, globe fixation surgery using non-absorbable suture (MR proximal stump to the sclera hang-back suture) (orbital approach), repair of bony defect, previous suture tightening, previous suture tightening, previous suture tightening	5	15 XT	-3	3	-	15°
2	0	Primary repair (outside hospital), LR rec 11 mm, partial tendon transposition, repair of bony defect, globe fixation surgery using non-absorbable suture (MR proximal stump to the sclera hang-back suture) (orbital approach), SR rec 5 mm, previous suture tightening	6	6 XT	-2	3	-	4°
3	8	LR rec 10 mm, muscle union procedure	1	Ortho	-1	2	-	0°
4	9	LR rec 9 mm, muscle union procedure, IO anteriorization	2	20 XT 15 RHT	-2	3	+	0°
5	15	Muscle union procedure, LR rec 10 mm	1	4 XT 6 LHT	-3	1.5	-	0°
6	13	Plan: muscle union procedure, LR rec						
7		Follow-up loss						
8	12	Repair of bony defect, MR res 5 mm, LR rec 8 mm	1	Ortho	-2	1.5	-	0°
9	6	LR rec 9 mm, MR res 7 mm	1	Ortho	-2	5	-	0°
10	4	Globe tethering technique using a suture/titanium T-plate anchoring platform system, LR rec 9 mm	2	Ortho	0	4	-	0°
11	8	LR rec 9.0 mm, MR res 5.0 mm	1	15 X	-1	4	-	0°
12	13	LR rec 9.5 mm, MR res 5.5 mm	1	4 XT	-0.5	2	-	0°
13	7	LR rec 10 mm, MR res 10 mm (outside hospital), full tendon transposition, MR res 5 mm	3	Ortho	-2	5	-	0°
14	19	MR res 5.5 mm, LR rec 6 mm	1	Ortho	0	4	-	0°
15		Repair of bony defect (spontaneous recovery without strabismus surgery 3 months after the injury)	0					
16	6	Plan: LR rec						

Abbreviations: F/U, follow-up; IO, inferior oblique muscle; LHT, left hypertropia; LR, lateral rectus; m, months; MR, medial rectus muscle; Postop., postoperative; rec, recession surgery; res, resection surgery; reses, re-resection surgery; RHT, right hypertropia; SR, superior rectus muscle; X, exophoria; XT, exotropia; y, years. ^aResults of the postoperative examination at the final postoperative visit. ^bVoluntary ductions were performed using a 4-point scale ranging from 0 to -4: 0=patient has full movement; -2=patient is unable to move the affected eye past the midline; and -3=patient is unable to move the affected eye to the midline.

Therefore, we could not properly compare surgical results from different surgical methods. Second, there was possible observational bias of the postoperative results. Third, it was a retrospective review, and the treatment method and imaging methods were heterogeneous. In particular, the 20-year period over which the patients were involved has seen much improvement in imaging techniques. As a consequence, there were technical differences between images of individual patients.

In conclusion, the surgical strategy in MR transection injury should be individualized based on the nature of the muscle injury, the clinical presentation, and the type of previous strabismus surgeries. In complete and severe

muscle transection injury, primary repair of the transected muscle is often impossible. These cases might require multiple globe fixation or muscle transposition surgeries. Conversely, only simple recession/resection surgery can result in favorable outcomes in many cases of partial resection injury. If partial transection is confirmed, we recommend observation for several months before strabismus surgery, because some of them can show improvement of ocular movement during initial several months. In these cases, simple recession/resection surgery could achieve good ocular alignment even 19 months after the initial injury. If partial transection is suspected, more conservative approach is needed. In

order to determine the nature of muscle injury, a proper imaging technique and a thorough review of the images at various planes are important. Close follow-up and repeated imaging using MRI with various planes can be helpful in ambiguous cases.

Summary

What was known before

- There have been changes in the type of surgical instrumentation used during endoscopic sinus surgery. The increase in efficiency during surgery could potentially result in more extensive damage when MR muscle injury occurs. However, owing to its rare occurrence there have been a few case series on this subject.

What this study adds

- We were able to classify the MR muscle injury as partial vs complete injury. There was a large difference in the treatment strategies between the two groups. It is necessary to carry out more extensive surgery, such as transposition surgery or globe fixation surgery, than simple recession/resection surgery in complete injuries. Otherwise, simple recession/resection surgery can effectively resolve ocular deviation and diplopia in most partial resection cases. We also found that there had been misinterpretations of the images before the surgery. We recommend a thorough review of the images in these patients with MR muscle injury; in the cases in which the classification of MR injury is ambiguous, cautious follow-up is required to find a possible improvement in adduction, which could occur in partial MR resection, and repeated imaging using MRI scans with various planes will be very helpful.

Conflict of interest

The authors declare no conflict of interest.

Acknowledgements

Study design, conduction of the study, and data collection and management (KAP and SYO); data analysis,

interpretation, and drafting the manuscript (KAP); and review and final approval of the manuscript (SYO).

References

- 1 Han JK, Higgins TS. Management of orbital complications in endoscopic sinus surgery. *Curr Opin Otolaryngol Head Neck Surg* 2010; **18**: 32–36.
- 2 Thacker NM, Velez FG, Demer JL, Rosenbaum AL. Strabismic complications following endoscopic sinus surgery: diagnosis and surgical management. *J AAPOS* 2004; **8**: 488–494.
- 3 Trotter WL, Kaw P, Meyer DR, Simon JW. Treatment of subtotal medial rectus myectomy complicating functional endoscopic sinus surgery. *J AAPOS* 2000; **4**: 250–253.
- 4 Yang SQ, Guo X. [Management of large exotropia with medial rectus muscle transection following endoscopic sinus surgery]. *Zhonghua Yan Ke Za Zhi* 2010; **46**: 974–977.
- 5 Sohn JH, Hong SD, Kim JH, Dhong HJ, Chung SK, Kim HY *et al*. Extraocular muscle injury during endoscopic sinus surgery: a series of 10 cases at a single center. *Rhinology* 2014; **52**: 238–245.
- 6 Tse DT, Shriver EM, Krantz KB, Tse JD, Capo H, McKeown CA. The use of titanium T-plate as platform for globe alignment in severe paralytic and restrictive strabismus. *Am J Ophthalmol* 2010; **150**: 404–411 e401.
- 7 Underdahl JP, Demer JL, Goldberg RL, Rosenbaum AL. Orbital wall approach with preoperative orbital imaging for identification and retrieval of lost or transected extraocular muscles. *J AAPOS* 2001; **5**: 230–237.
- 8 Park KA, Oh SY. Muscle union procedure with medial rectus recession for unilateral abducens palsy. *J Pediatr Ophthalmol Strabismus* 2013; **50** **Online**: e11–e14.
- 9 Thacker NM, Velez FG, Demer JL, Wang MB, Rosenbaum AL. Extraocular muscle damage associated with endoscopic sinus surgery: an ophthalmology perspective. *Am J Rhinol* 2005; **19**: 400–405.
- 10 Ela-Dalman N, Velez FG, Rosenbaum AL. Importance of sagittal orbital imaging in evaluating extraocular muscle trauma following endoscopic sinus surgery. *Br J Ophthalmol* 2006; **90**: 682–685.