Iatrogenic Injury to Medial Rectus After Endoscopic Sinus Surgery

Bipasha Mukherjee¹ · Omega Priyadarshini¹ · Srikanth Ramasubramanian² · Sumita Agarkar²

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Abstract Endoscopic sinus surgery (ESS) is the mainstay of the treatment in sinus disorders, to re-establish the drainage of the affected sinus. The close proximity of the orbital structures to paranasal sinuses makes them vulnerable to inadvertent injury during the sinus surgery. Medial rectus (MR) muscle is the most commonly injured extraocular muscle during ESS due to its anatomic proximity to the thin medial wall of the orbit. This is a non-comparative, retrospective, interventional case series of six patients presenting with MR injury after ESS. We discuss the management, outcome and review the published literature. A total of six patients met the inclusion criteria. The presenting complaints were diplopia, squinting and limitation of ocular movements. Two patients underwent surgical exploration of the MR muscle and reattachment of the muscle along with injection botulinum to the antagonist lateral rectus muscle. Two patients who had small angle strabismus and who were able to fuse were advised orthoptic exercises and prisms as management. Remaining two patients were advised surgical intervention to correct strabismus but they declined further surgical intervention. Management of MR injury following ESS is complex, often resulting in suboptimal outcomes. Since early intervention is associated with better outcomes, early referral by otolaryngologists to ophthalmologists would result in better outcome.

Keywords Endoscopic sinus surgery · Medial rectus injury · Diplopia

Introduction

Functional endoscopic sinus surgery (FESS) is the procedure of choice for the treatment of obstructive sinus disorders. FESS is aimed at restoration of normal sinus function and ventilation by a minimally invasive surgical procedure. Despite recent advances in imaging and instrumentation which allow good pre-operative assessment and better intraoperative visualisation, complications can and still do happen.

As the paranasal sinuses are situated in the close proximity of the orbit, there is a risk of inadvertent orbital entry during FESS. A wide variety of orbital complications following FESS have been reported in the literature. These include optic nerve damage, nasolacrimal duct injury, orbital haemorrhage, and extra ocular muscle injury. We report a series of six cases of medial rectus injury following FESS.

Materials and Methods

This is a retrospective, non-comparative, interventional case series of patients presenting with diplopia and/or strabismus after endoscopic sinus surgery. Patients who presented with complications after endoscopic surgery other than sinus surgery (e.g., endoscopic dacryocystorhinostomy) as well as patients who had injury to other orbital structures (such as optic nerve and nasolacrimal duct) were excluded from this study. The study adhered to the tenets of Declaration of Helsinki, and an institutional review board approval was obtained (Table 1).

✉ Bipasha Mukherjee
beas003@yahoo.co.uk

¹ Orbit, Oculoplasty, Reconstructive & Aesthetic Services, Sankara Nethralaya, Medical Research Foundation, 18, College Road, Chennai 600 006, India

² Department of Pediatric Ophthalmology & Strabismus, Sankara Nethralaya, Medical Research Foundation, Chennai, India

Table 1 Summary of the patients with MR injury post FESS

Pt. no	Age/sex	Laterality and indication for FESS	Presentation	Interval between injury and presentation (weeks)	MRI/CT findings	Previous procedures/treatment	Management/advice given
1	18/F	Left sided FESS with septoplasty and turbinectomy for chronic sinusitis	Diplopia in left gaze	3	Fracture medial orbital wall with persistent entrapment of MR	Orbital exploration to release entrapped MR	Oral steroids, Orthoptic exercises to improve accommodative facility and fusion
2	53/M	Bilateral FESS and septoplasty for chronic sinusitis	Outward deviation of right eye	2	Right medial orbital wall defect involving the lamina papyracea with edema of the right medial rectus muscle. The fibres of MR posterior to the defect were not discernible. Transected MR	Oral steroids	Orbital exploration with release and reattachment of MR was advised, patient lost to follow up
3	25/M	Right sided FESS for nasal polyp	Binocular horizontal diplopia and squinting of right eye	2	Breach in the medial wall of the right orbit and non visualization of the right medial rectus	Oral steroids	Anterior orbitotomy to reattach MR, with inj Botulinum (5 IU) to LR as primary procedure LR recession after 6 months as secondary procedure
4	28/F	Bilateral FESS for DNS and nasal polyps	Binocular Diplopia and inability to move the left eye outwards	2	Left medial wall breach. Thin, irregular MR tethered to the medial orbital wall at the mid orbit level	Nil	Oral steroids Advised orbital exploration and release of entrapped muscle, but patient refused
5	23/M	Right sided FESS for removal of maxillary sinus granuloma	Restriction of right eye movements, binocular diplopia in primary and right gazes, abnormal head posture	6	Right orbital floor fracture with absence of medial rectus fibers in the mid orbit level and inferior rectus entrapment in floor of the orbit	Nil	Orbital exploration, reattachment of MR and Inj Botulinum (2.5 IU) to ipsilateral LR
6	49/M	Left sided FESS for ethmoidal polyp	Limitation of ocular motility in left eye	8	MR tethered to the discontinuous and irregular medial wall of the orbit. MR fibers not visualized beyond the mid orbit level	Nil	Fresnel prisms

FESS functional endoscopic sinus surgery, *MR* medial rectus, *LR* lateral rectus

Fig. 1 a Patient no. 1: diplopia chart (done with *red filter* in front of right and *green filter* in front of the left eye) showing crossed and L/R diplopia in all right gazes except down gaze; uncrossed and R/L in all left gazes; and fusion in all other gazes. **b, c** Axial and Coronal CT scans showing medial wall dehiscence (*arrow*)

A total of 6 patients, 4 males and 2 females, were included, in the study, with age ranging from 18 to 53 years. Duration between FESS and presentation in our clinic ranged from 2 to 8 weeks.

All patients underwent a comprehensive ophthalmic examination with a special emphasis on ocular motility and strabismus evaluation. Any abnormal head posture was also noted. All patients underwent imaging in the form of either a computerized tomography (CT) or magnetic resonance imaging (MRI).

Results

Case 1

An 18-year-old female underwent left functional endoscopic sinus surgery, with septoplasty and turbinectomy, following which she developed double vision and limited ocular movements in her left eye. MRI of the orbits showed an entrapped medial rectus (MR) in a left medial orbital wall defect. Two weeks after the primary surgery, patient underwent a second surgical intervention by an orbital

surgeon elsewhere in an attempt to release the entrapped muscle. However, as she continued to have diplopia, she presented to us 3 weeks following the second procedure.

On examination, her ophthalmic evaluation was within normal limits. Cover test showed an esotropia of 5 prism dioptres (PD) in primary gaze for both distance and near. Ocular motility (EOM) examination showed limitation of abduction (−1) as well as adduction (−1) in the left eye. Diplopia charting showed uncrossed horizontal diplopia in primary gaze which worsened in the left gaze. She was able to fuse in the primary gaze with effort (Fig. 1a). Forced duction test (FDT) showed a tight left medial rectus. CT scan revealed persistent MR entrapment in the left medial orbital wall defect (Fig. 1b, c). A course of oral steroid was given to the patient but the diplopia persisted. However as she was able to fuse in primary gaze with effort, she was advised orthoptic exercises to improve her fusion.

Case 2

A 53-year-old male underwent bilateral FESS and septoplasty for chronic sinusitis following which he developed double vision associated with swelling, pain and outward

Fig. 2 a, b Patient no. 2 in primary position (**a**) and T2 weighted MRI axial scan showing breach in the medial wall of right orbit with position of MR which is not visualized

deviation of the right eye. He presented to us 2 weeks after the procedure and was on a tapering course of systemic steroids at the time of the presentation.

On examination his ophthalmic evaluation was within normal limits. Cover test showed exotropia and hypotropia of the right eye. Ocular motility examination showed limited adduction (−4) and minimal limitation of dextro-elevation (−1). He was unable to initiate adduction saccade. MRI showed a right medial orbital wall defect and edematous medial rectus. The fibres of MR posterior to the defect were not discernible. Fibres anterior to the defect were thinned out. Clinical and radiological findings were

suggestive of right eye MR transection. He was advised orbital exploration and release of entrapped medial rectus with strabismus surgery. However, the patient was lost to the follow up.

Case 3

Twenty five-year-old male underwent a right sided FESS for nasal polyp removal and presented to us 2 weeks following the procedure with complaints of horizontal diplopia and outward deviation of the right eye (Fig. 2a). His ophthalmic examination was normal. Cover test showed

Fig. 3 a, b: Patient 3: T1W axial MRI image showing post operative changes in the nasal cavity. a T2W coronal MRI showing thin and irregular LMR is tethered to the medial orbital wall. (Arrow)

right exotropia in primary gaze measuring 40 prism dioptre (PD). Ocular motility examination revealed limitation of adduction in the right eye. Diplopia charting showed crossed diplopia in primary and the left gaze. MRI orbit showed a breach in the medial wall of the right orbit and non visualization of the right medial rectus (Fig. 2b). Anterior orbitotomy was performed to explore the medial rectus. The cut ends of medial rectus were reattached. Injection Botulinum toxin (5 units) was injected into the lateral rectus under direct visualization. Two months following the procedure patient had residual exotropia. However he was able to achieve binocular single vision with a left face turn. Patient was given the option of prism glasses, which he declined. He underwent surgical correction of the residual strabismus 6 months after the primary procedure. Postoperatively, both the diplopia and face turn improved.

Case 4

A 28-year-old-female underwent bilateral FESS for deviated nasal septum (DNS) and nasal polyps, following which she noted double vision and inability to move the

Fig. 4 Coronal CT of patient no. 4 through posterior orbit showing a defect in the orbital floor (solid arrow). Inferior rectus appears adherent to the defect. Medial rectus fibers are not distinctly seen (a). b Axial CT showing absence of right medial rectus muscle in the mid orbit level with adjacent defect in the lamina papyracea. (Hollow arrow)

left eye outwards. She presented to us 2 weeks after the primary procedure. Her ophthalmic examination was within normal limits except for a left esotropia of 20–25 PD. Ocular motility examination showed an abduction limitation in the left eye. She had uncrossed Diplopia in all gazes except the right gaze. MRI scan of the orbit showed left medial wall breach. The medial rectus appeared thin, irregular and tethered to the medial orbital wall at the mid orbit level (Fig. 3).

Patient was initially started on a course of systemic steroids for a month but showed no improvement. She was advised a combined approach surgery by an orbital surgeon

Fig. 5 **a** Nine gazes showing limitation of adduction of the *left eye* in patient no. 5. **b** Coronal CT scan of the same patient showing defect in the floor and medial wall of left orbit with tethered MR muscle attached to the discontinuous and irregular medial wall of the orbit (*Arrow*)

and otolaryngologist to release the entrapped MR. However, the patient declined further surgery.

Case 5

A 23-year-old male developed a maxillary sinus granuloma following a road traffic accident. He underwent endoscopic sinus surgery and removal of the granuloma by an otolaryngologist. Following the surgery, patient developed limitation of right eye movements, swelling around right eye and binocular diplopia. The patient presented to us 6 weeks after the primary procedure.

On ocular examination, his vision, colour vision, IOP, pupil and fundus examination were normal. On cover test, he showed 35 PD of exotropia and 10 PD of hypotropia of the right eye. He adopted a right face turn of

approximately 45°. Ocular motility evaluation showed limitation adduction and elevation in the right eye (Fig. 4a). FDT was negative in the right eye. Force generation test showed no active force generation by the medial rectus. CT scan showed a right orbital floor fracture with absence of medial rectus fibres in the mid orbit level and inferior rectus entrapment in the floor of the orbit (Fig. 4b). He was advised exploration and reattachment of MR. On exploration, MR was found to be avulsed 6–7 mm from the site of its insertion, which was reattached to the other end. LR was isolated and 2.5 U of Botulinum toxin was injected into its belly. Two months post operatively patient had a persistent right face turn of 15° with a residual exotropia of 15 PD. As the patient was able to overcome the diplopia with a small face turn, no further intervention was done.

Case 6

A 49-year-old male from a neighbouring country presented to us with complaints of binocular horizontal diplopia and outward deviation of the left eye 2 months after undergoing left FESS locally for an ethmoidal polyp. The patient also complained of limitation of ocular motility in left eye.

On examination, cover test showed 45 PD exotropia in the primary gaze (Fig. 5a), Ocular motility examination showed limitation of adduction in the left eye. Diplopia charting revealed crossed diplopia in all gazes except the left gaze. FDT showed mild restriction in adduction. FGT showed weakness of the left MR. CT orbit showed pansinusitis, defects in the floor and medial wall of the left orbit. MR fibres were not visualised beyond the mid orbit level (Fig. 5b).

Orbital surgery was deferred as it was unlikely to benefit the patient. Patient was offered botulinum toxin injection for the lateral rectus, which he declined. During the follow up after 6 months, option of lateral rectus recession with partial tendon transposition of the vertical recti was discussed with the patient. As he was unwilling for surgery, he was fitted with Fresnel prisms with which he was able to fuse with a small face turn.

Discussion

Endoscopic sinus surgery (ESS) is currently the preferred modality of surgical management of chronic sinus diseases. Compared to the conventional sinus surgery, ESS offers the advantages of better visualization, improved cosmesis, and reduced postoperative recovery time [1].

Modern instrumentation in the form of microdebriders and micro-resectors allow precise excision and removal of the tissue. However, these same instruments can create complications if the surgeon is not vigilant. While using these powered cutting instruments, surgeons often lack the ‘feel’ during tissue removal as compared to manual cutting instruments. As with any minimally invasive technique, the surgeon must contend with a steep learning curve, be extremely careful and arm oneself with the knowledge of precise anatomical landmarks to prevent complications.

Though uncommon, there are several potential complications of FESS, which include devastating intracranial as well as ophthalmic complications like blindness. The ophthalmic complications can be divided into four categories:—orbit, optic nerve, extraocular muscles and lacrimal drainage system [2].

The orbit, by the virtue of its position, is at particular risk. The medial walls of the orbit are lined by the thin lamina papyracea which separates the orbit from the ethmoid sinuses. It is possible to inadvertently breach the

orbital wall, specially the medial wall, using a powered instrument and to aspirate the contents of the orbit into the sinus through the breach. Diplopia along with motility restriction following FESS can occur either due to the entrapment of the muscle within the defect in the wall or due to the damage to the vascular or neural supply of the extraocular muscle [3, 4].

Restrictive ophthalmoplegia can also be caused by an inflammatory reaction and fat adherence syndrome following injury to the orbital tissues during FESS [5]. Anatomical variations like pre-existing dehiscence of lamina papyracea of ethmoid bone, altered anatomy due to prior sinus surgery or trauma, poor visualization due to excessive intraoperative bleeding further increase the risk of orbital entry and complications during sinus surgery [5–11].

Because of its proximity to the thin lamina papyracea, medial rectus muscle is the most commonly traumatized muscle during FESS. Our data corroborates this as all six patients had trauma to the medial rectus muscle.

Huang et al. [12] have analyzed 30 cases of medial rectus injury following FESS in the largest reported case series. They asserted that the MR injury following FESS can lead to one of the following four patterns:

1. Complete transection of medial rectus muscle characterized by large angle exotropia, marked adduction deficit and relatively intact abduction.
2. Partial medial rectus transection, severe contusion with or without entrapment characterized by moderate to large angle exotropia with combined adduction and abduction deficits.
3. Grossly intact medial rectus with marked medial rectus and soft tissue entrapment characterized by a small angle esotropia and marked abduction deficit.
4. Muscle contusion without any entrapment characterized by mixed degrees of ocular misalignment.

Two of our patients had esotropia suggestive of restrictive component while 2 patients had complete transection of medial rectus while two had a paretic component. Thacker et al. [13] have reported injury to the multiple extra ocular muscles including inferior rectus and superior oblique in their series; only one of the patients in our series (Case 5) had involvement of another ocular muscle (IR).

It is important to differentiate between restrictive and paretic mechanism by forced duction testing as the latter usually causes transient ocular motility dysfunction which may improve spontaneously. High-resolution Computerized Tomography and Magnetic Resonance Imaging is helpful in providing the anatomical details of the orbit and the extraocular muscles [14].

Thacker et al. have recommended that multipositional or dynamic MRI scanning should be a part of the standard

protocol while managing these cases. Dynamic MRI demonstrates muscle contractility, thereby providing functional assessment of the extra ocular muscles. According to Ela-Dalman et al. reconstructed sagittal views are essential to look for intact medial rectus muscle [15]. An entrapped but intact MR maybe missed in coronal and axial sections because of the displacement, and maybe reported as missing, even by an experienced radiologist.

Iris angiography can be done in complicated cases where multiple procedures on multiple muscles are anticipated. It can be used to modify surgical plans to avoid anterior segment ischemia in individuals who are at risk [16].

Post operative complications can be minimized by comprehensive preoperative assessment, including imaging to detect pre-existing anatomical variants. Rene et al. [3] have suggested that the eyes should be kept uncovered and monitored during FESS for any movement resulting from the traction on the orbital fat. If this is noticed, the surgeon should immediately stop the surgery. In addition, any intraoperative complaints of eye pain (if patient is under local anaesthesia), sudden appearance of subconjunctival haemorrhage, swelling or bruising of the eyelids, protrusion of the eyeball, or dilation of the pupil should be treated as the markers of orbital injury. Excessive intraoperative bleeding or disorientation is also an indication for termination of the procedure especially if the surgeon is inexperienced. Intraoperative image guidance may be used in difficult cases like revision sinus surgery, diffuse nasal polyposis and abnormal anatomy as seen on preoperative imaging scans.

It is essential to check the vision, ocular motility and the pupils in early postoperative period, similar to the protocol followed after the orbital surgeries. Postoperative complaints of diplopia and/or strabismus should lead to a prompt referral to an ophthalmologist. Corticosteroids in the early postoperative period to suppress the inflammatory reaction may reduce scarring and adhesions [2].

The management of MR injury after FESS is guided by the type, site, extent of damage and the patients' symptoms. In pattern I of Huang's classification, where complete transection of the medial rectus is seen, immediate orbital exploration is indicated to reattach the cut ends of the muscle. Thacker et al. have recommended that retrieval and reattachment should be attempted only if there is muscle contractility as seen on multipositional MRI scan or if the patient presents within 3 months in the acute phase because of the potential for recovery from the nerve damage [13]. They have also suggested that in cases with transection injury, if the remaining posterior segment of the MR is longer than 20 mm and is functional, muscle recovery via anterior orbital approach should be attempted via a transconjunctival or modified Lynch incision. In our series, we reattached the medial rectus muscle through

anterior orbital approach in two patients. Both patients had poor recovery of the adduction and had significant residual strabismus requiring another procedure.

In most cases of a transected medial rectus muscle there is concomitant subtotal myectomy and as a result the two ends of the muscle cannot be reapproximated directly to one another. To overcome that breach, a "hang-back" suture, fascial graft or silicon band can be used to reattach the proximal portion of the muscle to the distal muscle stump or globe [17]. Improvement in ocular alignment in primary position may occur after surgery, but restriction in adduction often remains. In some patients even abduction deficits are seen after the surgical intervention due to scarring. Patients must be counselled about the possibility of persistent ocular motility limitation despite surgery.

If dynamic MRI does not demonstrate MR contractility, or the proximal muscle stump is too short in length, or cannot be identified intraoperatively, a full tendon vertical muscle transposition or a modified Hummelsheim (partial tendon transposition) is the procedure of choice [5, 18]. Full tendon vertical rectus muscle transposition has the risk of anterior segment ischemia, especially if combined with recession of the lateral rectus muscle [19]. To prevent this complication several approaches have been described which include injection of botulinum toxin into the lateral rectus muscle [20] or the placement of a posterior fixation suture (augmented transposition surgery) [21]. Inactivating lateral rectus muscle and use of a periosteal flap to centre the eyeball has also been reported [13].

Secondary contracture of the antagonist lateral rectus (LR) muscle can occur as early as within 2 weeks of injury to the MR. Botulinum toxin injection to the LR (1.5–5 U) may prevent secondary contracture of lateral rectus while waiting for spontaneous recovery (as in type 4 injury) or strabismus surgery [22]. A longstanding large-angle XT with severe contracture of the ipsilateral LR and massive scarring of the adjacent tissues has been reported to be corrected by the X-type augmented Hummelsheim procedure coupled with an ipsilateral LR recession providing an augmenting effect [23].

The pattern III type of injury is managed in a way similar to medial wall fracture repair along with release of the entrapped MR. There is no consensus on the optimal time of intervention for correcting ocular motility dysfunction following ESS. It is widely felt that the exploration and the release or repair of the MR within the first 2 or 3 weeks of the injury should lead to the better outcomes.

A conservative approach for 3–6 months and in some cases, even up to 12 months, is indicated in patients who have suffered contusive, neural, or vascular damage to the extraocular muscles (Pattern IV). The antagonist rectus muscle may be injected with botulinum toxin in this intervening period to avoid contracture [13].

Conclusion

Despite the technical advances, FESS is associated with the risk of inadvertent damage to extraocular muscles leading to strabismus and motility limitation. It is imperative that the surgeon is aware of the risks involved and takes suitable measures to prevent the same. The medial rectus, by virtue of its position, is commonly involved. These patients, despite multiple procedures, may have suboptimal outcomes as far as ocular motility is concerned. Early diagnosis, prompt referral, and multi-disciplinary approach in planning intervention may lead to the better outcomes.

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Compliance with Ethical Standards

Conflict of interest The Authors declared that they have no conflicts of interest.

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional research committee and with the 1964 Helsinki declaration and its later amendments.

Informed consent Informed consent was obtained from all individual participants included in the study.

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