SCIENTIFIC REPORT

Importance of sagittal orbital imaging in evaluating extraocular muscle trauma following endoscopic sinus surgery

N Ela-Dalman, F G Velez, A L Rosenbaum

Br J Ophthalmol 2006;**90**:682–685. doi: 10.1136/bjo.2005.088120

Background/aims: Orbital trauma may result in severe restrictive, paralytic, or combined strabismus. Clinical diagnosis may be extremely challenging. Orbital imaging is helpful in determining the exact site of injury, functionality, and integrity of the extraocular muscles. A typical study now includes coronal and axial views of the muscles. This study aimed to emphasise the importance of sagittal imaging of the orbit when evaluating extraocular muscle injury or entrapment.

Methods: A retrospective review of two subjects who underwent endoscopic sinus surgery procedures that resulted in trauma to the medial rectus muscle. High resolution orbital imaging studies were performed.

Results: High resolution magnetic resonance imaging (MRI) scans with coronal and axial views suggested a large section of the muscle was not present and was probably destroyed. In both cases there was a displacement of the mid-portion of the medial rectus muscle into an area of bony defect not seen on the axial and coronal views. Sagittal images demonstrated continuity between the anterior and posterior segments of the medial rectus muscle in each case.

Conclusion: Surgical strategies are dependent on accurate interpretation of MRI scans. Muscle displacement may result in axial and coronal orbital imaging misinterpretation. Sagittal views were essential to determine muscle integrity.

Orbital trauma, orbital surgery, and endoscopic sinus surgery may result in severe restrictive, paralytic, or combined strabismus.^{1–4} Clinical diagnosis and surgical correction may be extremely challenging. Orbital imaging is helpful in determining the functionality and integrity of the extraocular muscles.

High resolution orbital imaging provides detailed information about the anatomy, location relative to other structures, and contractility of a muscle.^{1–5} Multipositional imaging studies provide valuable information about whether a muscle or a segment of the muscle is functional. By comparing the changes in size of the muscle in different gaze positions, orbital imaging can determine whether the posterior segment of a transected muscle contracts or is paralysed.

In direct muscle injury, high resolution imaging may determine the exact site of injury and help determine if the muscle has been transected and if a section of the muscle has been destroyed by the injury. A typical study now includes coronal and axial views of the muscles. The purpose of this study is to emphasise the importance of sagittal imaging of the orbit when evaluating extraocular muscle injury or entrapment.

METHODS

We retrospectively reviewed two subjects who underwent endoscopic sinus surgery procedures that resulted in trauma to the medial rectus muscle. Orbital imaging studies were performed in each patient.

Both subjects were evaluated by an experienced strabismologist within a few days of the trauma. Ocular alignment data were recorded with a non-paralytic or normally innervated eye as the fixing eye. Estimation of abnormal face turn was calculated while looking at an accommodative target 20 feet away.

Ocular versions and ductions were evaluated on both patients using a six point scale: 0 equalling full movement, –4, when unable to move past the midline, and –5, when the affected eye was unable to reach the midline. Forced duction and force generation tests were performed in the office as described elsewhere.⁵

High resolution orbital imaging studies were performed using a 1.5 T General Electric Signa Scanner (Milwaukee, WI, USA) as described elsewhere, using an array of surface coils embedded in a transparent face mask.^{6,7} The head was stabilised in the supine position by tightly fastening the surface coil mask to the face using headbands and fixing the mask to the scanner gantry using foam cushions and tape. These measures avoided head rotation during scanning. An adjustable array of illuminated fixation targets was used to avoid eye motion artefacts. This array was secured in front of each orbit with a central target in the subjective central position. Images of 2.0 mm thickness in a matrix of 256×256 were obtained over a field of view of 6.0–8.0 cm for a resolution plane of 234–312 respectively. Axial skull films were obtained as well as quasi-coronal images perpendicular to the long axis of the orbit and quasi-sagittal images parallel to the long axis of the orbit.

RESULTS

Case 1

A 48 year old man underwent endoscopic sinus surgery. Right maxillary sinus polypectomy resulted in a 2.0 mm dehiscence of the right lamina papyracea with orbital fat prolapse. Immediate diplopia in all gaze fields was present postoperatively. On ocular examination, he was found to have a –6 limitation to adduction, –2 limitation to elevation and –2 limitation to depression of the right eye (scale –4 to +4). There was a 50 prism dioptres exotropia with a 15 prism dioptres right hypertropia in the primary position. His right pupil was 5.0 mm in diameter, round, and slowly reactive to light and accommodation (fig 1).

A high resolution orbital magnetic resonance image (MRI) of the orbits was obtained. Axial and coronal views showed separation and absence of the medial third of the medial

Abbreviation: MRI, magnetic resonance imaging

Figure 1 Right exotropia with limitation of adduction and vertical movements and midriasis following endoscopic sinus surgery (case 1). Informed consent was obtained for publication of this figure.

rectus muscle. Sagittal views revealed integrity of the medial rectus muscle belly. The muscle was displaced inferiorly and medially into the sinus (fig 2). A right orbitotomy with relief of the medial rectus muscle and bony defect repair was performed using an implant. Innervation spontaneously returned to the medial rectus muscle 6 months postoperatively (fig 3).

Case 2

A 53 year old man noted constant horizontal diplopia immediately following endoscopic sinus surgery. Cover test examination revealed 55 prism dioptres of left exotropia and 10 prism dioptres of left hypotropia at near and distance. The exotropia increased markedly in right gaze. Ocular rotations revealed inability to adduct the left globe past the midline (fig 4). There was also mild limitation of full elevation of the

left eye. Saccadic movements demonstrated a floating adducting saccade of the left globe.

High resolution orbital MRI scans of the orbit were performed. Coronal and axial views revealed a defect of the mid-portion of the left lamina papyracea and a discontinuity of the left medial rectus muscle in the middle portion of the muscle. There was no apparent connection between the proximal and distal segments of the muscle. Sagittal imaging demonstrated continuity of belly of the medial rectus muscle (fig 5). The patient underwent left orbitotomy. The medial rectus muscle was exposed from the insertion to an area 7.0 mm anterior to the orbital apex. The muscle was found intact, surrounded by scar tissue. Because the muscle was intact, it was decided not to proceed with a proposed rectus muscle transposition procedure. Instead, the medial rectus muscle was resected and the ipsilateral lateral rectus muscle

Figure 2 Top: Axial and coronal views showed partial absence of the mid-portion of the medial rectus muscle. Sagittal views revealed integrity of the medial rectus muscle belly. Bottom: Medial rectus muscle appearance following right orbitotomy, medial rectus muscle repositioning and orbital wall bony defect correction. (Reprinted from Thacker *et al.*,³ with permission from the American Association for Pediatric Ophthalmology and Strabismus.)

Figure 3 Spontaneous recovery of the function of the right third nerve 6 months postoperatively. The patient reverted to orthotropia in the primary position and the pupil recovered. (Reprinted from Thacker *et al*,³ with permission from the American Association for Pediatric Ophthalmology and Strabismus.)

was recessed. Postoperatively, cover testing revealed 2 prism dioptres of exotropia in the primary position. His adduction improved from -4 to -2 (fig 6).

DISCUSSION

We report two subjects who developed strabismus following endoscopic sinus surgery. High resolution MRI scans with coronal and axial views suggested a large section of the muscle was not present and was probably destroyed. However, in both cases there was an inferior and medial displacement of the mid-portion of the medial rectus muscle into an area of bony defect not seen on the axial and coronal views. Sagittal images demonstrated continuity between the anterior and posterior segments of the medial rectus muscle in each case.

Figure 5 Axial and coronal views showed partial absence of the mid-portion of the medial rectus muscle. Sagittal views confirmed entrapment but integrity of the left medial rectus muscle into the sinus near the middle of the muscle, confirming its entrapment.

Figure 4 Preoperative face turn and ocular alignment photographs showed left exotropia with marked limitation to adduction of the left eye (case 2). Informed consent was obtained for publication of this figure.

Figure 6 Preoperative face turn and ocular alignment markedly improved following resection of the left medial rectus muscle. Informed consent was obtained for publication of this figure.

High resolution multipositional quasi-coronal orbital MRI scans provide excellent imaging of all extraocular muscles and help determine the extent, nature of the injury, and whether the muscle is paralysed.¹⁻⁴ Demer *et al* reported 16 strabismus subjects with damage of the extraocular muscle caused by accidental trauma or complication of endoscopic sinus surgery.⁶ Wu *et al* prospectively studies subjects with longstanding strabismus following scleral bucking procedures for retinal detachment.⁸ Orbital imaging was important in confirming contractility of disinserted extraocular muscles, even in a deep orbit.

Thacker *et al* described a series of strabismus complications following endoscopic sinus surgery. Multipositional MRI demonstrated whether the muscle was able to contract or not and proved essential in determining the extent and nature of the muscle injury.³

MRI scans are critical in patients with endoscopic sinus surgery with extraocular muscle injury in order to determine precise diagnosis and treatment. Conventional strabismus clinical examination may determine whether the muscle is palsied and whether a restriction is present. MRI scans are required to evaluate muscle integrity.²⁻⁴

If the muscle is paretic but intact, strabismus surgery should not be performed until sufficient time passes to allow muscle and innervational recovery. If the muscle has been transected but has a long innervated posterior segment, prompt surgical intervention may allow recovery of this segment. If the muscle has been transected and a large segment is missing or destroyed, prompt muscle transposition surgery is suggested.¹⁻³

Thus, surgical strategies are dependent on accurate interpretation of MRI scans.^{1 2 9-12} Usually the diagnosis is established by coronal and axial images. When these images were observed by experienced radiologists, a diagnosis of severe muscle trauma with a large section of muscle destruction was made in both presented cases. However, when the radiologist was requested to reconstruct sagittal images in the area of the injured medial rectus, it became clear the medial rectus was entrapped but intact. Each medial rectus had been displaced medially and inferiorly. This displaced portion of the muscle was "hidden" from view on coronal and axial views because of the displacement. Sagittal views were essential to establish an accurate diagnosis of an intact medial rectus muscle.

Consequently, if the sagittal views had not been obtained, it is probable that a vertical rectus transposition procedure would have been performed medially. When the sagittal views revealed an intact muscle, a completely different treatment strategy was followed.

Authors' affiliations

N Ela-Dalman, F G Velez, A L Rosenbaum, Department of Ophthalmology, Jules Stein Eye Institute, University of California Los Angeles, Los Angeles, CA, USA

Grant Identification: RPB Physician-Scientist Merit Award to ALR.

Correspondence to: Arthur L Rosenbaum, MD 100 Stein Plaza, UCLA, Los Angeles, CA 90095, USA; rosenbaum@jsei.ucla.edu

Accepted for publication 5 February 2006

REFERENCES

- 1 Underdahl JP, Demer JL, Goldberg RL, *et al*. Orbital wall approach with preoperative orbital imaging for identification and retrieval of lost or transected extraocular muscles. *J AAPOS* 2001;**5**:230-7.
- 2 Thacker NM, Velez FG, Demer JL, *et al*. Extraocular muscle damage associated with endoscopic sinus surgery: an ophthalmology perspective. *Am J Rhinol* 2005;**19**:400-5.
- 3 Thacker NM, Velez FG, Demer JL, *et al*. Strabismic complications following endoscopic sinus surgery: diagnosis and surgical management. *J AAPOS* 2004;**8**:488-94.
- 4 Huang CM, Meyer DR, Patrinely JR, *et al*. Medial rectus muscle injuries associated with functional endoscopic sinus surgery: characterization and management. *Ophthalm Pals Reconstr Surg* 2003;**19**:25-37.
- 5 Santiago AP, Rosenbaum AL. Test of Muscle Function. In: Rosenbaum AL, Santiago AP, eds. *Clinical strabismus management*. Philadelphia: WB Saunders, 1999:37-52.
- 6 Demer JL, Clark RA, Kono R, *et al*. A 12-year, prospective study of extraocular muscle imaging in complex strabismus. *J AAPOS* 2002;**6**:337-47.
- 7 Demer JL, Clark RA, Engle EC. Magnetic resonance imaging evidence for widespread orbital dysinnervation in congenital fibrosis of extraocular muscles due to mutations in KIF21A. *Invest Ophthalmol Vis Sci* 2005;**46**:530-9.
- 8 Wu TJ, Rosenbaum RL, Demer JL. Severe strabismus after scleral buckling multiple mechanisms revealed by high-resolution MRI. *Ophthalmology* 2005;**112**:327-36.
- 9 Ludwig IH, Brown MS. Flap Tear of Rectus Muscles: An underlying cause of strabismus after orbital trauma. *Ophthalm Pals Reconstr Surg* 2002;**18**:443-50.
- 10 Burnstine MA. Clinical recommendations for repair of orbital facial fractures. *Curr Opin Ophthalmol* 2003;**14**:236-40.
- 11 Nishida Y, Hayashi O, Miyake T, *et al*. Quantitative evaluation of ocular motility in blow-out fractures for selection of nonsurgically managed cases. *Am J Ophthalmol* 2004;**137**:777-9.
- 12 Lee H, Jilani M, Froham L. CT of orbital trauma. *Emerg Radiol* 2004;**10**:168-72.