CINE MAGNETIC RESONANCE IMAGING OF EYE MOVEMENTS

C. C. BAILEY[1], J. KABALA[2], R. LAITT[2], M. WESTON[2], P. GODDARD[2], H. B. HOH[1], M. J. POTTS[1] and R. A. HARRAD[1]

Bristol

SUMMARY

Cine magnetic resonance imaging (MRI) is a technique in which multiple sequential static orbital MRI films are taken while the patient fixates a series of targets across the visual field. These are then sequenced to give a graphic animation to the eyes. The excellent soft tissue differentiation of MRI, combined with the dynamic imaging, allows rapid visualisation, and functional assessment of the extraocular muscles. Good assessment of contractility can be obtained, but the technique does not allow study of saccadic or pursuit eye movements. We have used this technique in 36 patients with a range of ocular motility disorders, including thyroid-related ophthalmopathy, blow-out fracture, post-operative lost or slipped muscle, and Duane's syndrome.

The study of extraocular muscle contractility is important in the diagnosis and management of a variety of forms of strabismus. The excellent soft tissue differentiation of magnetic resonance imaging (MRI) combined with dynamic imaging allows good assessment of eye muscle contractility.[1] The multiple scans necessary to generate the cine loop could not be achieved with computed tomography (CT) in view of the prolonged exposure to ionising radiation.[2] At present there are no known adverse effects from MRI.[3]

A similar technique was described in a case of Duane's type II exotropia,[4] but we believe this is the first report of the use of this method in a wide range of ocular motility disorders. We have used the technique in 36 cases with a range of disorders, including thyroid-related ophthalmopathy, blow-out fracture, Duane's syndrome, post-operative slipped muscle, and post-detachment diplopia.

METHOD

A Siemens 1.0 Magnetom Impact MRI scanner was used.

From: [1]Bristol Eye Hospital, Bristol; [2]Department of Radiology, Bristol Royal Infirmary, Bristol, UK.

Correspondence to: C. C. Bailey, Bristol Eye Hospital, Lower Maudlin Street, Bristol BS1 2LX, UK.

Images were obtained using the FISP 2D sequence (fast imaging with a steady state progression). The patient was positioned within the head coil in the magnet. A strip of paper with six separate marks set 30° apart was suspended in front of the patient and aligned either transversely or sagittally depending on the eye movement of interest. The patient was asked to look sequentially at each mark on the paper, and a scan was performed in each position. Each image took 15 seconds to acquire. After the patient had fixated all six points the procedure was repeated in reverse order. The images generated were then displayed as a continuous video loop. The total time required to generate a video loop for each patient was only 6 minutes.

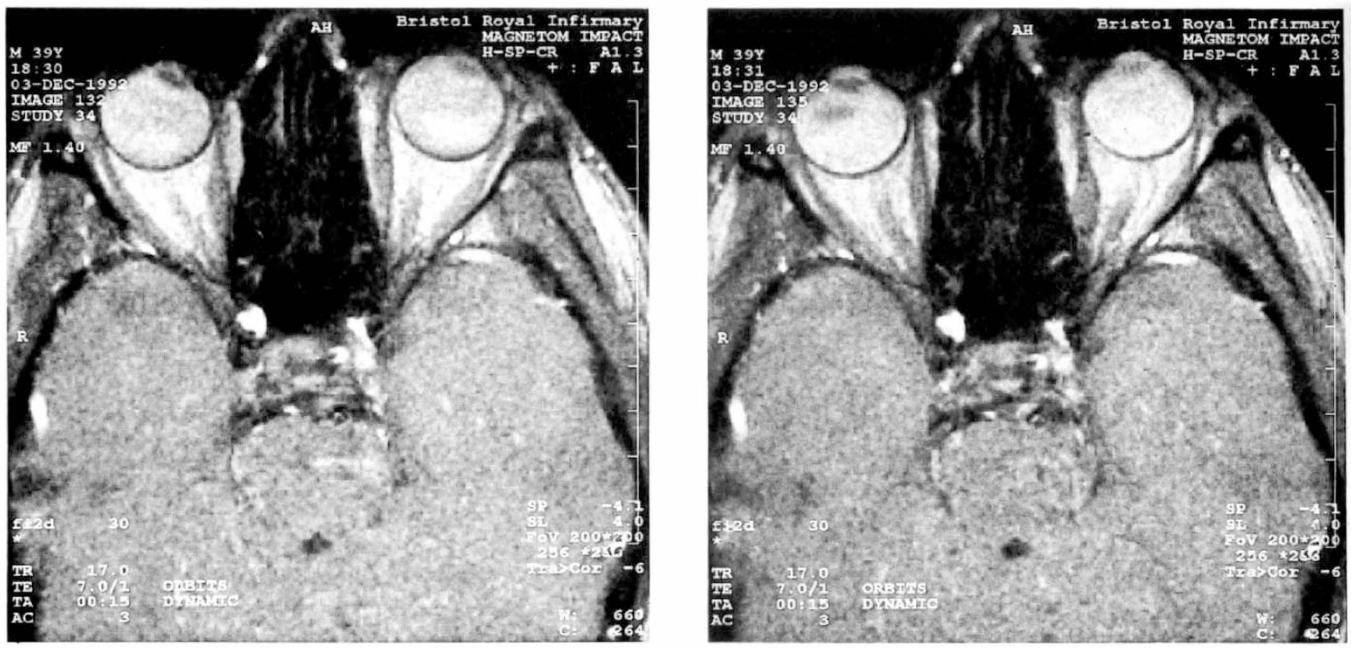
RESULTS

In the cases of thyroid eye disease, restriction of movement of the globe, associated with enlargement of the extraocular muscles, could be seen. Loss of the normal movement of the optic nerve occurred,[5] due either to stretching of the nerve or splinting within the orbital fat.

Three cases of type I Duane's syndrome were studied. Co-contraction of the medial and lateral recti on attempted adduction was demonstrated, and globe retraction could be clearly seen.

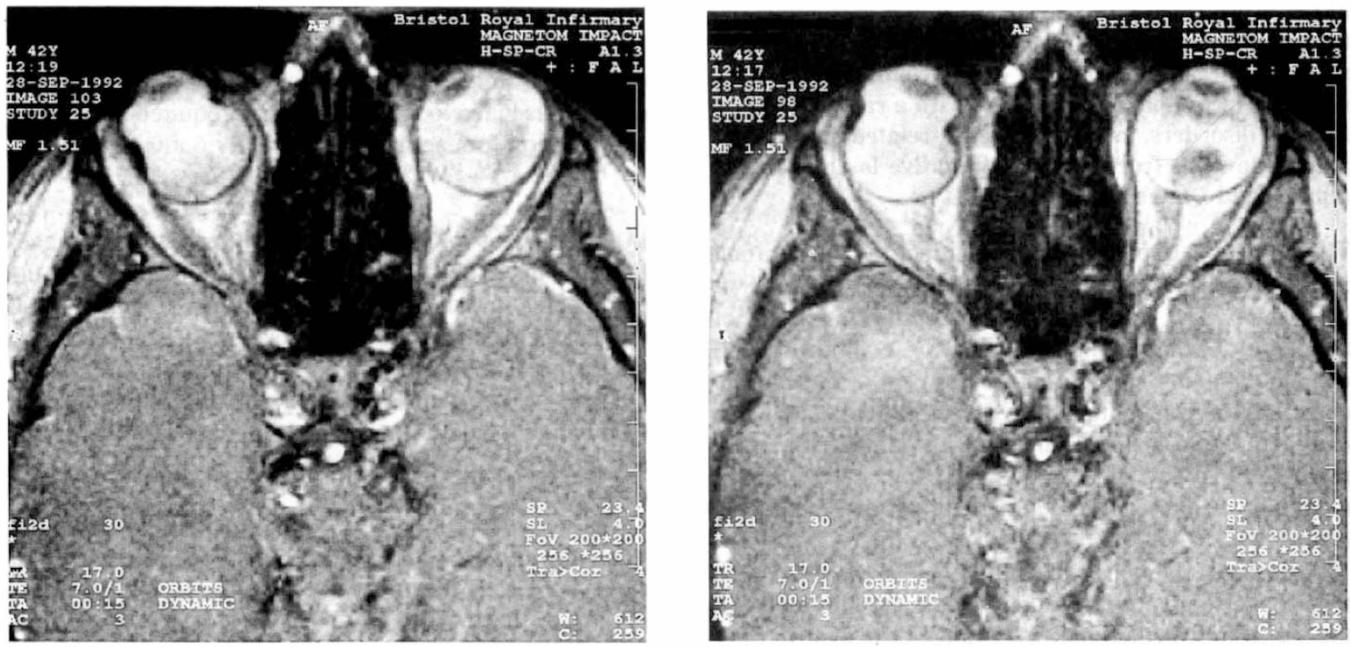
Five cases of diplopia and limitation of eye movement following squint surgery were examined. In two of these a slipped muscle was diagnosed, because although the muscle was still clearly attached to the globe, only the posterior portion was seen to contract (Fig. 1).

Six cases of orbital blow-out fracture were assessed. Although the fracture in the orbital floor and impairment of elevation of the eye could be seen in all cases, only in one could the inferior rectus be clearly demonstrated to be trapped in the orbital floor. This patient had undergone an orbital floor repair, and suffered persistent post-operative diplopia. The definition of the orbital floor was poor in the other cases, perhaps related to the presence of fibrosis and loss of orbital fat deep to the inferior rectus muscle, resulting in a loss of contrast.



(a) *(b)*

Fig. 1. *Post-operative slipped left medial rectus muscle: scans in abduction (a) and adduction (b) of the left eye. The left eye is seen on the right-hand side of the screen in keeping with scanning convention. Although the left medial rectus is seen to be attached to the globe, only the posterior portion contracts, suggesting that it has slipped back leaving only a fibrous adhesion to the globe.*



(a) *(b)*

Fig. 2. *Post-detachment diplopia: scans in abduction (a) and adduction (b) of the right eye. Note the alteration to the shape of the right globe, and distortion of the medial and lateral recti over the encircling band. There is restriction of abduction of the right eye.*

One case of post-retinal detachment repair diplopia was examined. A 276 tyre and encircling band was used when the right retinal detachment was repaired for the third time, and the patient suffered continuing vertical and horizontal diplopia post-operatively. On examination he had a right hypotropia and esotropia, with restriction of right upgaze and abduction. The axial length was 29.2 mm in this eye compared with 27.7 mm in the left eye. The cine MRI demonstrated considerable alteration in the shape of the globe, distortion of the extraocular muscles over the encircling band and impairment of elevation and abduction of the right eye. There also appeared to be some physical restriction of movement of the globe by the orbit on attempted upgaze. His diplopia was felt to be related to

the distortion of the muscles over the encircling band, alteration to the axis of rotation of the globe, and perhaps splinting of the elongated eyeball by the eye muscles (Fig. 2). It is possible that eye movement was also limited by the globe coming into contact with the orbital floor on attempted upgaze.

DISCUSSION

Cine MRI is a technique that readily allows assessment of the contractility of the eye muscles. Since no ionising radiation is involved, the multiple scans necessary to create the cine loop can be taken. Moreover, patient repositioning is not required to take the scans in different planes.[1] In a previous report of a similar technique,[4] the patient was asked to fixate each target for 100 seconds, but we found that image quality was satisfactory with a fixating time of 15 seconds. This is easier for the patient, and problems with blinking are not so readily encountered.

We have found the technique of value in cases where there is restriction of eye movement. It is particularly useful where the patient is not able to tolerate the forced duction test under local anaesthetic. However, some patients feel claustrophobic in a MRI scanner, and would not tolerate the investigation.

Static MRI scans in different positions of gaze provide useful information about ocular motility. The MRI scanner can sequence these static images to form a cine loop, and by reproducing them as a moving picture we feel that a variety of ocular motility disorders can be more readily assessed and understood. The cine MRI videotapes have been particularly helpful for teaching purposes.

Key words: Cine magnetic resonance imaging, Eye movements.

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