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CLINICAL SECTION

MRI scanning and orthodontics

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Magnetic Resonance Imaging (MRI) plays an important role in diagnosis for many head and neck lesions. Both clinical and experimental studies have shown that orthodontic appliances may produce image distortion on MRI scans of the head and neck. A case is presented in which the patient complained of unexplained right-sided facial paraesthesia, whilst undergoing fixed appliance orthodontic treatment. This was a serious symptom, which warranted investigation including a MRI scan. The compatibility of fixed appliances with MRI is discussed.

Key words: Magnetic Resonance Imaging, fixed appliances, facial paraesthesia

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Introduction

MRI has assumed a major role in medical imaging diagnostics for a number of reasons:

- Images with high tissue contrast and accuracy can be produced.
- The technique is versatile with imaging in all three planes with full flexibility of orientation.
- MRI is non invasive and non-ionizing. The images can be highly sensitive and specific. For optimal imaging, there must be a high degree of spatial and contrast resolution with a strong signal, as well as minimal artefacts. An artefact can be defined as a distortion of signal intensity or void that does not have any anatomic basis in the plane being imaged.[1]

The use of MRI within the dental and maxillofacial profession continues to evolve. The use of MRI in orthodontics is low, but it has been used to image the TMJ during functional appliance treatment.[2] There is, however, little evidence that fixed appliances need to be removed prior to taking MRI scans to prevent artefacts being produced. Moreover, there is insufficient evidence to suggest that brackets and bands are dislodged during MRI scans, which could lead to possible tissue damage. Orthodontists should be aware of the effects of certain orthodontic components on head and TMJ scans; and how the diagnostic quality of these scans may be affected. In addition, the orthodontist should be aware of the procedures that should be followed should a patient wearing fixed orthodontic appliances require an MRI scan.

We report a case of sudden onset facial paraesthesia in a young male wearing fixed orthodontic appliances. The possible conflict between fixed orthodontic appliances and magnetic resonance imaging is discussed.

Case report

A 14-year-old male Caucasian presented with a Class II division 1 incisor relationship, on a Skeletal II dental base, with crowding in both arches, an overjet of 9 mm, and a deep and complete traumatic overbite. There was no relevant adverse medical history.

Following the loss of a premolar in each quadrant, orthodontic treatment was commenced using the Tip-Edge bracket system.

Nine months into treatment, the patient made an emergency visit to his medical practitioner complaining of sudden onset facial numbness, which was progressively deteriorating. He also reported headaches that were not relieved by paracetamol. His doctor recommended he saw his orthodontist immediately, believing the symptoms to be related to appliance therapy.

Extra-oral examination

Neurological examination revealed profound paraesthesia over the right side of the patient's forehead with variable paraesthesia over the cheek, lip and chin. The corneal reflex was depressed on the affected side. All other cranial nerves were responding normally. Vision, hearing, taste and motor function were normal. The patient was fully alert and orientated. There was no clinical evidence of any connective tissue disease and lymphadenopathy was not detected.

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Intra-oral examination

The patient was in stage 1 mechanics with sound teeth and intact appliances. He was still wearing his intermaxillary traction Class II elastics. Both upper first molars had amalgam restorations and were not tender to percussion. The lower molars had some mobility indicating good elastic wear, but were not tender to percussion. There was some loss of sensation on the right side of the tongue, but no loss in taste or motor control.

History

There was no history of trauma and the patient was otherwise fit and well. The patient's mother was particularly concerned, as she had recently lost her 15-year-old son who had severe cerebral palsy and had died suddenly with neurological complications.

Diagnosis

The area affected involved all three branches of the trigeminal nerve with no obvious motor impairment. Isolated trigeminal sensory loss may be associated with, or caused by, serious disease as summarized in Table 1.[3]

The Consultant Orthodontist suspected an intracranial lesion to be the cause of paraesthesia and therefore sought an immediate opinion from his Consultant Maxillofacial colleague.

Investigations and treatment

A full haematological and biochemical screen was carried out and an urgent MRI scan arranged. The patient's fixed orthodontic appliances were removed in case they reduced the diagnostic quality of the scan. The MRI scan showed a mass at the cerebello-pontine angle with the typical appearance of a cavernous haemangioma. The patient was immediately referred to the department of Neurological Surgery at the Radcliffe Hospitals NHS Trust. The lesion was successfully excized within 3 weeks of presenting in the orthodontic department.

A diagnosis of cavernous haemangioma was confirmed. It was presumed that this emanated from a small brain stem cavernous haemangioma. Follow-up over the next 6 months showed resolution of the right-sided facial paraesthesia. Orthodontic treatment was resumed to completion 2 months following recovery.

Discussion

Orthodontists should have an understanding of MRI techniques in order to understand how orthodontic appliances *in situ* may affect the diagnostic quality of these scans. In addition the orthodontist should be aware of the procedures to be followed, should a patient wearing fixed orthodontic appliances require an MRI scan.

Magnetic resonance (MR) uses magnetic energy and radio waves, rather than X-rays to create cross-sectional images or 'slices' of the human body. The MR imager is built around a large tube-shaped or cylindrical magnet. Inside the magnet are coils that transmit and detect radiofrequency signals. Images are obtained by manipulating inherently magnetic protons of hydrogen atoms. Protons are most abundant in the hydrogen atoms of water so that an MR image shows differences in water content and its distribution in various body tissues.

During the examination, a radio signal is turned on and off. The protons are first excited and then relaxed,

Table 1 Conditions associated with isolated trigeminal sensory loss.

Traumatic
- Fracture
- Direct trauma to trigeminal nerve or branches
- Iatrogenic, e.g. dentoalveolar surgery, osteotomy

Idiopathic
- Benign trigeminal sensory neuropathy

Neoplasms
- Jaw metastases
- Intracranial neoplasia including venous malformations
- Extra-cranial neoplasia: local and non-metastatic complications

Systemic non-malignant disease
- Connective tissue disorders
- Causes of polyneuropathies and mononeuritis complex, e.g. Diabetes mellitus
- Amyloidosis
- Bone disease, e.g. osteomyelitis, Paget's disease in the elderly
- Infective causes

Drugs and toxins
- Trichloroethylene, hydroxystilbamidine

Hysteria
- NB: This tends to be a subjective diagnosis, but can involve hyperventilation syndrome

emitting radio signals that can be computer-processed to form an image. The time taken for the protons to mix up is termed T2 relaxation and the time for the protons to then realign is known as T1 relaxation. The MR signal can be made to detect either T1 or the T2 values of the spins. A T1-weighted image produces sharp and detailed images of the structures. In contrast, the T2 sequence is most useful in differential diagnosis, but it is more prone to most types of artefact.[4]

Considering that over 150 million MRI procedures had been carried out by 2004, the number of safety-related incidents is small.[5] Hence, MRI is considered to be very safe. Electromagnetic fields associated with the MRI environment may pose serious risks to individuals with certain types of implants, devices or materials.[6] In general, most injuries occur as a result of magnetic field-induced movement or dislodgement of ferromagnetic objects.[7] However, other possible hazards can occur via induced electrical currents, excessive heating and the misinterpretation of an image artefact.

The potential for MR procedures to injure patients by inducing electrical currents in conductive materials is documented.[6] However, there have been no reported cases of injuries related to induced currents developing from orthodontic appliances during an MR procedure. On the whole, only minor temperature changes occur in association with conventional MR procedures involving metallic objects. Therefore, heat generated during an MR procedure involving a patient with a passive metallic appliance, particularly if small, does not appear to be a substantial hazard.[7]

Experimental and clinical studies report that orthodontic appliances can produce artefacts in MRI, mostly in the facial region.[8,9] Magnetic susceptibility is the tendency of a substance to attract magnetic lines of force. Ferromagnetic materials cause large magnetic field distortions and signal loss.[6] Dental gold and stainless steel are considered ferromagnetic, whereas nickel, titanium, amalgam filling material and silver-palladium are considered non-ferromagnetic. The artefacts produced can take on various shapes and forms, from voids to bright streaks, through the image.

Sadowsky *et al.* assessed the MRI scans of five patients with temporomandibular joint dysfunction who were undergoing fixed appliance treatment.[10] They revealed that the mouth and facial region were affected by artefacts, concluding that:

- Orthodontic appliances produce significant artefacts, specifically in the areas closest to the appliances, and in most cases, the maxillary sinuses were not clearly seen.
- The temporal and frontal lobes of the brain were affected in some patients.
- The artefacts were not considered severe enough to alter the diagnostic quality of the scans of the brain and TMJ, since the artefacts were concentrated in the region of the mouth and face.

Phantom head studies showed that steel orthodontic archwires caused greater artefact interference than bands and brackets alone. A promising finding was that the appliances they tested did not seem to cause any safety problems. A combination of orthodontic bands and brackets were tested; including Unitek brackets and bands, Ormco brackets and bands, 'A' company brackets and GAC brackets with no significant difference in image distortion between each combination. Overall, the artefacts were worse on T2-weighted images compared with T1-weighted images when all other factors were equal.[10]

Okano *et al.* proposed that the MRI diagnosis of the TMJ can be performed in orthodontic patients, preferably using ceramic brackets on the anterior teeth and directly bonded tubes on the molars. The archwires should be removed.[11]

MR procedures are deemed safe for patients with objects shown to be non- or weakly ferromagnetic. Furthermore, patients with certain devices having relatively strong ferromagnetic qualities may safely undergo MR procedures if the objects are held in place by sufficient retentive forces that prevent them from being moved or dislodged by magnetic field interactions.[7]

The magnetic field interactions of orthodontic wires during MRI have been recently reported.[12] The authors concluded:

- Steel arch wires are subjected to forces within the MRI magnetic field, which are much higher than the gravitational forces to which they are subjected.
- Steel ligature wires and arch wires made of cobalt chromium, titanium molybdenum, nickel titanium, and brass alloys showed no or negligible forces within the magnetic field.
- The translational and rotational forces within the magnetic field should pose no risk to carefully ligated arch wires.
- They recommend that bonded retainers should be checked to ensure secure attachment prior to an MRI investigation.

Research to date indicates that fixed orthodontic brackets can be left *in situ* provided the area of investigation is not the mouth itself. However, it would be sensible to have stainless steel archwires, removable

appliances, and removable palatal and lingual bars removed prior to MR imaging. One should check that all bands and bonds are firmly attached. Sadowsky *et al.* suggested tying all the brackets together with elastic chain for added safety.[10] Removal of fixed brackets and bands is only warranted when the area of interest of the scan is close to the mouth. Non-metallic fixed orthodontic appliances are of little concern.

Most MR centres have questionnaires inquiring about the existence of metals within the patient's body that could be potentially harmful to the patient during the imaging process or could render the scan useless. The questions are aimed at finding ferromagnetic objects. However, fixed orthodontic appliances are not always mentioned. The presence of non-ferromagnetic objects about the field of investigation should be noted to optimize the quality of the image. A clinician should be aware of the possible artefacts cause by dental materials in order to alert MR staff to the need for avoidance measures. The most common avoidance measure is the alteration of the plane of section.

The use of MRI is now such that consultant orthodontists may find their patients requiring such a scan. Clinicians need to consider the compatibility of fixed orthodontic appliances with MRI.

Conclusion

Orthodontists see their patients regularly. Rapidly developing medical problems can manifest themselves at any age, even in the young. However:

- all metals used in orthodontics can produce artefacts on MR images to varying degrees;
- the orthodontist can undertake measures to improve the quality of the image;
- fixed components of orthodontic appliances, such as brackets and bonds, can be left in place unless they lie in the area of investigation;
- stainless steel archwires, removable orthodontic appliances, removable palatal bars and lingual arches should be removed prior to the scan.

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