MAGNETIC RESONANCE IMAGING IN TEMPOROMANDIBULAR DYSFUNCTION

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ABSTRACT

The diagnosis of temporomandibular joint dysfunction has increased with the advent of modern diagnostic procedures. Due to its non-invasive, no danger radiation properties as well as ability to contrast between soft tissues, magnetic resonance imaging has emerged as a forerunner and procedure of choice for temporomandibular joint dysfunction.

INDEX WORDS: MRI TMJ DYSFUNCTION

MAIN TEXT

The temporomandibular joint, undeniably, has been an important consideration in the Orthodontic treatment planning. Recently, however, its importance has assumed greater proportions with controversy based on whether orthodontic treatment causes or relieves temporomandibular joint dysfunction (TMJD).

Solberg et al., [1] (1979) and Kicros et al., [2] (1987) had reported that 32 percent (%) of all adults will suffer from some form of TMJD in their life time. These disorders may manifest symptoms that range from mild localised pain to severe debilitating syndromes. Non invasive early recognition and treatment of TMJD ramains a diagnostic challenge.

Until recently, all diagnostic methods used for TMJD, were either invasive or involved exposure to dangerous radiation. Bloch and Purcell who independently developed and carried out the first successful nuclear magnetic resonance experiments were awarded the Nobel prize for Physics in 1952 as stated by Bogdan, [3] (1992). Lauterbur, [4] (1973) first indicated the potential of magnetic resonance to form images. Earlier studies were restricted in clarity due to relatively large surface coils used for head and body imaging. The advent of much smaller surface coils made it possible to image TMJs with higher resolution.

Magnetic resonance imaging (MRI) represents a significant increase in tissue contrast sensitivity when compared to computerized tomography and arthography. This is due to the possibility with MRI to contrast between soft tissues.

Carr et al.,[5] (1991) stated that for the first time the junction of the posterior band of the disk with posterior ligament (bilaminar zone) could be routinely demonstrated.

Schach and Sadowsky [6], (1998) ; Brady et al,.[7], (1993) and Tasaki and Westesson, [8] (1993) all carried out studies on MRIs of TMJs and found it to be a most reliable tool for demonstration of internal changes in the TMJ.

Eagan and Kudlick, [9] (1993) reported that MRI failed to illustrate adhesions and perforations of the disk while Lieberman et al., [10], (1992) found that MRI failed to depict abnormalities in 16 out of 32 children who had positive findings at history and /or physical examination.

Principle of MRI

Nuclei have an inherent spin that generates a magnetic field (moment), the magnitude of which is dependent on the number of protons and neutrons. Nuclei in which the total number of protons and neutrons is odd have stronger magnetic fields and are most amenable for imaging eg : 1H, 13C, 19F and 31 P.

Of the biologically important nuclei the hydrogen nucleus provides the most sensitivity to the MR process. According to Villafana , [11](1992) this is due to both its large magnetic moment and its abundance in the body in the form of water and other biologically important molecules.

In any given medium there is no externally detectable magnetic field due to random arrangements of magnetic vectors which cancel each other. When subjected to a strong external magnetic field, the magnetic vectors of individual nuclei tend to align with the magnetic field with a slight excess of protons in the parallel direction. This is called the preparatory phase and represents an equilibrium condition of the nuclei within a magnetic field according to Brooks and Miles [12], (1993).

When the longitudinal arrangement of the nuclei, under the influence of the external magnetic field, is disturbed by addition of energy in the form of radio-frequency electromagnetic waves (RF waves) the nuclei project transverse magnetization. If the RF waves are turned off , the nuclei are at some given excitation state in the transverse plane. As they revert to the longitudinal alignment, energy is released which is detected by surface coils. This phase is called the excitation phase.

The time constant associated with recovery of longitudinal alignment is called T1. The decay of the signal is at a time rate characteristic of the particular chemical and tissue composition of the Hydrogen nuclei and will convey information about the tissue properties at each point in the medium.

Due to the resonance caused by the RF waves, the spins of nuclei are phasic at the time RF waves are turned off. The time constant associated with the loss of this phasic coherence is called T2. Both of the processes i.e. return to longitudinal alignment and loss of phasic coherence lead to loss of transverse magnetization and a consequent loss in detected signal. The quality of the image produced depends on the amount of transverse magnetization.

For image generation the detected signals are spatially localized by the use of three linear gradients in the x-y-z planes. These gradients are induced in specially designed coils by passage of an electric current and their superimposition on the main magnetic field. To accomplish imaging the x-y-z axes generation process essentially goes through the selected slice until combination signals are accumulated from the entire slice. Figure 1shows the longitudinal section through an MR magnet with the patient positioned in the body coil for abdominal scanning.

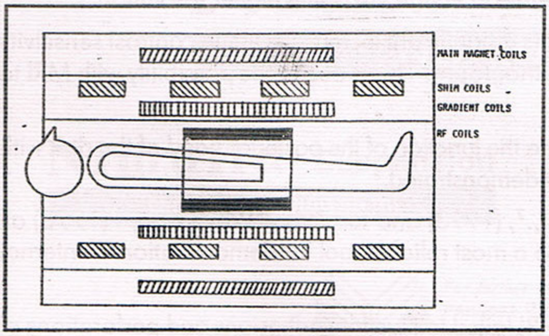

Fig. 1 Longitudinal section through an MR magnet with the patient positioned in the body coil for scanning the abdomen.

TMJ Technique

Brady et al.[7], (1993); Tasaki and Westesson , [8] (1993) ; and Westesson et al. [13], (1992) studied and reported on techniques for TMJ MRIs.

Carr et al.[5], (1991) described in detail the techniques used. Two views were generally taken, sagittal (oblique sagittal) and coronal. Patients were placed in a scanner and asked to close gently in centric occlusion. A dual surface coil (10 cm or less) was placed over each TMJ to simultaneously scan both TMJs in order to reduce scanning time significantly.

According to Gallucci et al. [14], 1991) the best results were obtained when both joints were simultaneously imaged on both sagittal and coronal planes during opening and closing of the mouth, so that the TMJs could be compared and motion asymmetries be easily detected.

Sagittal images were obtained perpendicular to the condylar axis (Fig 2) with two acquisitions of 3mm thick contiguous slices in both open and closed mouth positions. Coronal images were obtained parallel to the axis of the condyle and in closed mouth position (Fig 3). Carr et al. [5], (1991) reported that these were particularly helpful in medial or lateral displacements of the disk. Tasaki and Westesson, [8] (1993) reported that coronal images helped avoid a false negative diagnosis while Brady et al. [7], (1993) felt that true coronal images were of no added value.

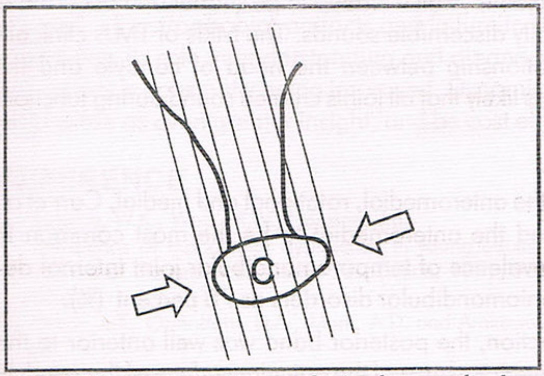

Fig. 2 Oblique sagittal image obtained perpendicular to the axis (arrows) of the condylar head (c).

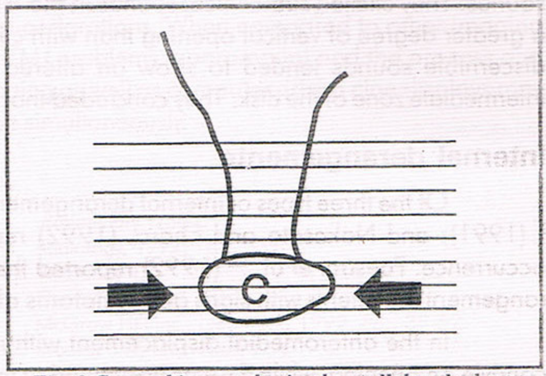

Fig. 3 Coronal image obtained parallel to the long axis of the condylar head (c).

Scanning time was in minutes and patient comfort was important to maintain a steady position during imaging. Sadowsky et al. [15], (1990) described a registration process using polyvinyl siloxane impression material to allow control of the vertical and horizontal positions of the mandible during MRI procedures and tests showed subjects were able to hold positions for adequate times without fatigue or loss of position. Vogl et al. [16], (1992) designed and used a hydraulic incremental jaw opener to obtain reproducible and stable position of TMJ articulation for MRI.

Westesson et al. [13], (1992) reported that MRI quality could be improved by reducing section thickness from 3 mm to 1.5 mm thereby improving diagnostic accuracy.

MRI of normal TMJ

The appearance of normal anatomic and functional pattern is of paramount importance for the diagnostic approach to TMJ pathologic conditions. In the closed mouth position, the disk has a medium signal intensity biconcave in contour and is interposed between the condylar head and posterior slope of the articular eminence. The posterior part is thicker than the anterior part while the junction between the two is well demonstrated and lies at 12 o'clock position in relation to the condylar head. The thinner intermediate zone of the disk is in close proximity to the anterior cortex of the condylar head. The posterior part has a layered appearance.

In the open mouth view, the condyle translates and rotates anteriorly, resting near or just beyond the apex of the articular eminence. The disk migrates over the apex of the condyle and has a more horizontal axis.

Fugazzola et al. [17], (1991); Kim and Lee, [18] (1991); and Brooks et al. [19]. (1992) studied the normal TMJ with MRI. The presence of osseous changes in TMJ of asymptomatic persons is controversial. Brooks et al. 12 (1992) reported minimal flattening of the condyle or articular eminence in 12 out of 24

TMJs assessed. They felt that generally no osseous changes occurred in TMJs of patients without internal derangements and the minimal flattening was of no clinical significance.

Scapino, ([20], 1991 a, [21], 1991 b) reported on the posterior attachment and felt its structure and volume at any moment was a function of condylar position. It appeared to function as a device for rearrangement of liquids, viz- blood, tissue and synovial fluid. Eriksson et al. [22], (1992) iatrogenically created disk displacements in human TMJ autopsy specimens and studied them with MRI and cryosections. Their results suggested that the integrity of the inferior aspect of the posterior attachment of the disk to the condyle is essential for keeping the disk in its position superior to the condyle.

Sutton et al. [23], (1992) compared clinical "silent joints" with those of readily discernible TMJ sounds. They elicited sub-clinical sounds in the "silent joints" which tended to be shorter and occurred at a greater degree of vertical opening than with clinically discernible sounds. The MRIs of TMJs clinically discernible sounds tended to show an altered relationship between the head of condyle and the intermediate zone of the disk. They concluded that it was likely that all joints created sound during function.

Internal derangements

Of the three types of internal derangements, the anteromedial, rotational and medial, Carr et al. [5] (1991); and Nakasato and Ehara, (1992) reported the anteromedial to be the most common in occurrence. Paesani et al. [25] (1992) reported the prevalence of temporomandibular joint internal derangement in patients with signs and symptoms of craniomandibular disorders as 78 percent (%).

In the anteromedial displacement with reduction, the posterior band was well anterior to the condyle on opening, while if it was positioned at the anterior aspect of the articular surface of the condyle it was considered a borderline case according to Hans et al. [26], (1992) who used this criteria in their study to compare clinical examination, history and MRI to identify orthodontic patients with TMJ disorders. Morphology of the disc was usually normal and untreated patients progressed to acute closed lock. Sagittal MRIs demonstrated persistent anterior displacement of the disk in open mouth views with a decrease in translation of the condyle. The disc appeared to be folded or globular in contour according to Carr et al.[5], (1991). Degenerative changes were uncommon at this stage. With progression the disc was pushed more anteriorly by the condyle during opening. Translation could return to normal. In this stage displacement was without reduction.

As the cushioning effect of the disk interposed between the condyle and articular eminence decreased, damage to the posterior ligament occurred leading to fibrosis or hyalination causing a decreased signal intensity on images. Anterior displacement without reduction was very painful due to the condyle compression of the posterior ligament, a richly innervated area, instead of the displaced disk. This eventually led to perforation of the posterior ligament and pain actually decreased. Perforations were seldom confirmed on MRI, but could be associated with degenerative changes. Superficial vascular changes in the retrodiskal tissue were an aspect of the remodelling process during progressive anterior displacements of the TMJ disk. Heffez and Jordan [27] (1992) found significant association between superficial avascularity and progressive stages of disk derangement.

Vogl et al, [28] (1991) reported that MR imaging enabled a differentiation of early stages with disc displacement, the intermediate stages, and the later stages with osseous destruction. Degenerative changes seen on MRI included flattening of the condylar head and osseophyte formation along the anterior cortex of the condylar head and flattening of the articular eminence especially on the posterior slope according to Carr et al. [5], (1991).

Rotational changes are thought to represent an early stage of internal derangement and diagnosis has become more common, with thin section sagittal MRI. Closed mouth images demonstrated the disk to be in a normal position, while more lateral images show classic anterior displacement of the disk. Open mouth images appeared normal with complete reduction of the disk. The disk again rotated into an abnormal position as the mouth was closed.

Pure medial displacement of the disk was less common. If routine sagittal imaging in closed mouth position demonstrated a normally positioned disk in the medial aspect of the joint but poor visualization or thinning of the disk laterally, medial displacement could then be suspected. Coronal imaging is then necessary and important for accurate diagnosis.

Conclusion

MRI has firmly established itself as a diagnostic modality of choice for TMJ related problems due to its noninvasive and no danger radiation properties. It is safer to use in spite of drawbacks such as expense, claustrophobia, artifacts and failure to depict perforations. When compared to other imaging modalities, its role in understanding and diagnosis of TMJ problems is paramount and the process and equipment is constantly being improved. Dynamic imaging as well as computer driven cine displays may yet provide as even greater insight, and be cost effective simultaneously.

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