Applications of magnetic resonance imaging in dentistry

Magnetic resonance imaging (MRI), is fast outpacing any other modality for *in vivo* viewing of soft tissues in the human body without the need to resort to invasive procedures or exposure to dangerous radiation. Although conventional dental X-rays will continue to be used in dentistry, the scope of dentistry is expanding and subsequently the need for imaging. This paper reviews the current status of MRI as it pertains to dentistry. Bloch and Purcell independently pioneered the first successful experiments and were subsequently awarded the Nobel Prize in Physics in 1952 as stated by Sutton[1]. Lauterbur[2] indicated the potential of magnetic resonance to obtain images of the intact human body.

Electrical signals generated from the response of hydrogen nuclei (protons) to a strong magnetic field and radio-frequency (RF) waves are used to produce an image. Hydrogen is used in imaging as the process needs a nucleus where the total number of protons and neutrons is odd and hydrogen is very abundant within the body according to Lee *et al.*[3]

When the nuclei are subjected to a strong external magnetic field, the protons which are randomly aligned line up with a slight majority in the same direction as the magnetic field. This is the equilibrium condition. To produce a signal, the equilibrium is disturbed by adding energy in the form of RF pulse into the system via the body coil. As the energy dissipates, a signal from the restabilizing system is detected by surface coil receivers, relayed to a computer which processes the data into images. Data acquisition times are in *minutes, while image reconstruction* takes only a few seconds according to Sutton[1].

The significant advantage of MRI over the other modalities is its ability to distinguish among various soft tissues as stated by Brooks and Miles[4]. Its indications include inflammatory and neoplastic lesions of the nasopharynx, salivary glands, paranasal sinuses as well as orbits and intracranial structures. So far, MRI has proved to be most valuable in the diagnosis of internal derangement of the tempero-mandibular joint (TMJ) due to its ability to define the cartilaginous disk. A substantial number of studies have concentrated on studying the TMJ. Katzberg *et al.*[5], Westesson *et al.*[6] and Latchaw[7] noted that anterior, medial or lateral displacement of the disk is easily detected when both sagittal and coronal views are obtained. Schach and Sadowsky[8] compared MRIs and arthrograms of 26 symptomatic TMJs of patients. They concluded that MRI was extremely useful in diagnosis of TMJ related problems. Eagan and Kudlick[9], however, reported that MRIs failed to illustrate adhesions and perforations when compared to post-surgical reports on patients undergoing TMJ operations.

van Spronsen *et al.*[10] compared cross-sectional areas of jaw muscles in long faced subjects with controls and found that they were smaller in the former which could explain their smaller maximum molar bite forces. Lauder and Muhl[11] estimated tongue volume with MRIs and concluded that although reliable, defining the lateral and inferior boundaries was difficult at times. Lam *et al.*[12] demonstrated the utility of MRIs for identification of orofacial tissues and localization of soft tissue lesions. Westesson *et al.*[13] performed MRIs 2 years postoperatively after vertical ramus osteotomy in 10 patients and found imaging to be an excellent method to study morphological changes of the muscles of mastication and osseous fragments when compared to controls. Traxler *et al.*[14] studied the relevance of MRI for diagnosing tumors of the parotid gland. The excellent soft tissue contrast, possibility of imaging in various planes and sections and high resolution achieved by surface coils made it possible to visualize lesions and surrounding anatomy in great detail. Henken[15] found MRI useful in differentiating aglossia from hypoglossia in type 1 oromandibular limb hypogenesis syndrome, while Sano *et al.*[16] reported MRI to be superior to computed tomography (CT) and ultrasonography in reporting on a case of unilateral masseteric hypertrophy. McMillan and Hannam[17] used MRI to locate needle electrode recording sites in the human masseter muscle and felt it to be a useful adjunct in future studies.

In clinical endodontics there is need for improved diagnostic methods for accurate pulp pathosis and configuration of root canals. Lockhart *et al*[18] imaged extracted human teeth to establish possible future applications of MRI in pulp pathosis. They reported high accuracy of images of periodontal membrane and gross pulpal anatomy. However, due to limitation of slice thickness, detailed resolution was poor. Baumann *et al.*[19] used stray-field imaging (STRAFI), a newly developed and as yet experimental magnetic resonance microscope, for imaging carious mandibular molar root canals and pulp chamber. Magnetic fields used were high and time taken for data collection was 8–10 hours while image reconstruction took 1 hour. Inspite of these drawbacks, MR microscopy may open a new dimension of nondestructive image reconstruction.

The ferromagnetic content of certain dental materials is a known cause of image degradation due to artifacts especially when imaging the lower midface. Hinshaw *et al.*[20] reported that stainless steel materials such as orthodontic bands used for braces, and pins and posts that are commonly drilled into teeth are mainly responsible for artifacts.

One of the contraindications for MRI is the presence of ferromagnetic substances within the body in the form of pacemakers, aneurysm clips, shrapnel etc., which could be dislodged causing complications. In a recently published list of materials, by Bogdan[21], tested for attractive forces in different magnetic field strengths, some dental and orthodontic materials were included. Stainless steel bands, dental amalgam, silver points and permanent amalgam crowns were safe, while chrome alloy archwire was considered safe although it was attracted by magnetic forces. Sadowsky *et al.*[22] recommended that while only removable components such as archwires should be removed to decrease the artifacts, security of banded and bonded attachments should be checked in most orthodontic cases requiring diagnostic procedures.

The benefits of MRI are substantial and new applications are continually being developed as the technique and equipment undergo refinement. Inspite of its present selective and restrictive uses due to costs, MRI quality has already set it apart from other imaging modalities and it is only a matter of time before its use in dentistry is an everyday occurience.

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