ISSN: 2581-5989
PubMed - National Library of Medicine - ID: 101738774

International Journal of Dental Science and Innovative Research (IJDSIR)

IJDSIR : Dental Publication Service

Available Online at: www.ijdsir.com

Volume – 5, Issue – 2, April - 2022, Page No. : 44 - 50

MRI In Dentistry - Towards New Horizon

[1]Deepak Narang, Reader, Department of Oral Medicine and Radiology, Deshbhagat Dental College, Punjab, India.

Corresponding Author: Deepak Narang, Reader, Department of Oral Medicine and Radiology, Deshbhagat Dental College, Punjab, India.

Citation of this Article: Deepak Narang, "Mri In Dentistry - Towards New Horizon", IJDSIR- April - 2022, Vol. – 5, Issue - 2, P. No. 44 – 50.

Type of Publication: Original Research Article

Conflicts of Interest: Nil

Abstract

Magnetic Resonance Imaging (MRI) is a powerful and versatile imaging modality utilizied in various medical fields. With the emergence of commercial medical MRI in the 1980s, several MRI applications, such as cardiac, abdominal, and cranial, started to evolve medical diagnostic imaging.

Three-dimensional MRI assessment of morphology and function without ionizing radiation attracted attention in dental applications during 1980s. Dental applications of MRI, however; was sparse compared to other medical applications.

Most work in the field of dental MRI aimed at imaging soft tissues, testing the potential of implant planning, and imaging of the morphology and function of the temporo mandibular joint. MRI has not been commonly used for oral and maxillofacial imaging because the acquisition of the sequences can be negatively influenced by motion of the body, respiration, air in the oral cavity and nasal cells, implants and metal materials.

However, the utilization of MRI, enabled evaluation of spatial relationship between anatomic structures and intraosseous jaw lesions when CT imaging cannot provide clear depiction of the mandibular canal. MRI can also be useful to the typing of different expansive lesions, and to evaluate the possible infiltration of the soft tissue.

Magnetic resonance imaging (MRI) is one of the most powerful diagnostic tools in radiology and diagnostic science. Magnetic Resonance Imaging is a highly sensitive and specific imaging modality that is being used in radiology and diagnostic science. It poses very little risk to the patient and it does not emit any ionizing radiation, nor is it an invasive procedure. It is a non-invasive procedure and the images can be highly sensitive and specific.

Keywords: Magnetic resonance imaging (MRI), radiology and diagnostic science.

Introduction

Diagnostic imaging in dentistry depends mostly on x-ray–based techniques that carry some risks and limitations such as exposure to ionizing radiation and its associated increased risk of cancer[1] and the inability to visualize the pulpal tissue[2].

The application of x-ray–based three-dimensional diagnostic imaging is likely to increase in endodontics as cone-beam computed tomography (CBCT) imaging systems become more available[3,4].

However, besides exposure to radiation, such systems cannot simultaneously image calcified and noncalcified dental tissues, which is a significant limitation, particularly as regenerative endodontic procedures become more common in clinical practice[5].

MRI has become an indispensable tool for noninvasively diagnosing and monitoring disease in soft tissues without using ionizing radiation. In biological tissues, the MRI signals measured arise from the spinning magnetic moments of the hydrogen nuclei in water molecules (hereafter called ‘‘water signal’’ or ‘‘signal’’). The water signal is detectable after a radiofrequency (RF) pulse is applied, which causes the nuclear spins to resonate in the strong static magnetic field. Conventional MRI cannot easily visualize teeth because of their high mineral content; minerals occupy 50% of a tooth’s dentin and 90% of its enamel by volume, with water and proteins occupying the rest[6].

Also, because the water signal has a highly restricted molecular motion within these densely mineralized tissues, the signal decays very quickly after RF excitation. The time constant describing the signal’s free induction decay (FID) is known as the transverse relaxation time (T2). The FID of mineralized dental tissue has multiple components, with a mean T2 of about 200 microseconds[7] for the dentin and 60 microseconds[8] for the enamel.

These time intervals are less than those needed for conventional MRI pulse sequences to accomplish spatial encoding with pulsed magnetic field gradients, which typically requires more than 1 millisecond.

In other words, the signal from mineralized dental tissues decays before MRI signal digitization occurs, resulting in MRI images with little or no image intensity (black zone). Consequently, conventional MRI techniques in dentistry have been restricted to imaging pulp, attached periodontal membrane, and other surrounding soft tissues or have required indirect imaging of enamel and dentin through contrast produced by MRI-visible medium[9-13]

The magnetic resonance imaging process

The Magnetic Resonance Imaging Process the MR imaging process can be divided into a few simple steps[14]

- The patient is placed in a magnetic field and essentially becomes a magnet.
- A radio wave is sent in.
- The radio wave is turned off.
- The patient emits a signal
- The signal is received and used for reconstruction of the picture.

The important hardware components of a typical MR machine can be added to this simple frame work. The patient is placed in the main magnet, which produces an external magnetic field, made more uniform by smaller "shim" coils. Transmit radio frequency (RF) coils send radio waves into the patient while receiver (rf) coils receive the signals emitted from the patient, these coils are also known as surface coils e.g., Head, body, spine, T.M.J. Image processing and display are done by a computer.

Physical principles of the m.r.i.

MR images obtained in clinical practice are based on the hydrogen nucleus. Hydrogen is by far the most abundant nucleus in the human nucleus (1019 nuclei / mm3). It has the highest tissue conc (100 mmol / kg) and the strongest magnetic moment (or strength and direction of the magnetic field of any element).

These properties allow the signal produced by hydrogen to be more than 1000 times stronger than that of any other element. In clinical MRI, differentiation between normal and diseased tissues relies on detections of their relative water (and hence hydrogen) content.

The nucleus of an atom consists of neutrons which have no charge, and protons which have a positive charge. The proton spins continuously around its own axis. A moving electric charge produces its own magnetic field.

Therefore, each proton has its own local magnetic field aligned along two poles, similar to a bar magnet, also known as a magnetic dipole. Nuclei with an even number of protons and neutrons the dipoles pair up and cancel out each other's magnetic effect. Contrast this situation with that of an odd no of protons or neutrons resulting in a net magnetic dipole moment.

How mr images are generated

All the H+ protons in a patient precess at the same frequency (Larmor), excited by the same RF pulse, with no way of distinguishing among the sources of the signals emitted by different parts of the body. The secret of localising the source of MR signals from a specific site in the patient's body was unlocked by Dr. Paul C. Luterber in 1973.

He proposed adding a weaker magnetic field the gradient field, to the stronger main magnetic field. The gradient field is a non - uniform magnetic field that is strong at one end and gradually becomes weaker at the other end. It is produced by gradient coils and can be applied in any direction, this multidirectional ability gives MRI the capability of forming multiplanar images.

The gradient field when superimposed on the main magnetic field modifies its strength. According to the Larmor equation, where proton frequency is directly proportional to magnetic field strength. There would be a gradient of different precession frequencies. The RF pulse can be customised to precisely the required range of frequency called band width, thus forming the basis for slice selection in MRI.

Magnetic resonance contrast agents

The signal intensity emitted by a tissue can be altered by injecting contrast agents. These agents change the signal intensity of tissues by altering T1 or T2 relaxation times. Contrast enhancement is mainly determined by vascularity and the interstitial vascular space of the tissue involved. In the jaws they are added to study the presence of enhancement within a lesion or RIM enhancement at the margin of a lesion such as Odontogenic cyst or Tumor.

MR contrast materials are classified into ferromagnetic, paramagnetic and super magnetic categories, the paramagnetic being the most popular & useful. Paramagnetic contrast agents have the greatest relaxation as protons in water molecules. The only paramagnetic agent is the lanthanide known as Gadolinium diethylene thiamine pantothenic acid (Gd-DTPA), which shortens T1 & T2 relaxation times[15]

Fat suppression

Kitagawa et al have diagnosed the utility of fat suppression in the imaging of oral maxillofacial lesions. It is especially useful when using (Gd - DTPA). As fat has high signal intensity on T1 weighted images, fat suppression techniques can be divided into relaxation - rate dependent methods & chemical shift methods (Widely used, introduced by Dixon).

Information provided with each m.r.i.

Varies with brand of the machine, models & software.

Demographic data

Depending on the software, the patients Name, Age & Sex along with the date & time of examination are provided. The name of the radiology clinic, as well as of the radiologist and the referring physician may be included.

Machine settings

In contrast to plain radiography, the machine settings are indicated. Strength of the magnet in Tesla units. Compare & contrast T1 & T2 - weighted images. Hydrogen proton densities for the type of tissue being examined (bone for eg.) T2 sequence are done first to study pathology, then T1 followed by contrast studies.

Patient orientation

The patient's left & right sides are identified. It is important to note L/R side labelling to know what side is being studied

M.r.i. sequence

Faster scans can be used to study tissues in their functional state and are called functional M.R.I.'s Some methods employed are

1. Grass [gradient acquisition in steady state]
2. Flash [fast low angle shot]
3. Fiss [fast imaging in steady state]
4. Fast [Fourier acquired steady state technic]
5. Fsei [fast spin echo imaging]

Applications of Mri in various branches of dentistry

Orthodontics

The accuracy of clinical diagnosis of normal and abnormal disc position has been reported to be 73% with M.R.I. The M.R.I. Scanning can be used to determine the relationship of the Disc to the condyle.

The location of reference points in 3 dimensions for Radiographic Cephalometry can be done with M.R.I. with respect to imaging of the human skill. The availability of 3-D, Reconstruction of data from CT & MRI scans provide. The most realistic means of visualising structures. MRI can be used to collect growth data without exposing the patient to radiation hazards[16]

MRI can be used to assess tongue volume correctly. They are superior to cephalometries and other imaging techniques for the estimation of oropharynx and hypopharynx sizes.

Tmj disorders

The effects of orthodontic treatment on Temporomandibular Joint (TMJ) are still subject to doubts and discussions. The use of complementary exams has always been a constant in the evaluation of this interrelation and can be exemplified by conventional radiographic examinations that were widely used to assess the implications of orthodontic treatment on the TMJ.

However, this modality of imaging examination has limitations, because the TMJ is one of the structures of the human body more difficult to be well visualized radiographically due to overlapping of several adjacent bony structures.

Thus, the effects of orthodontics on TMJ structures are still controversial. With the advent of imaging examinations with specificity, sensitivity and greater accuracy in the reproduction of articular anatomic structures, such as magnetic resonance imaging (MRI), computed tomography and cone-beam volumetric computed tomography as well as 3D reconstruction methods, this interrelationship can be evaluated with greater exactness[17].

Added to this fact, there was accomplishment of clinical studies with designs and more rigorous methodological criteria, generating higher levels of evidence. The correct occlusal relationship as a result of orthodontic treatment is not obtained at the expense of non-physiological positioning of both the condyle and the articular disc.

Thus, when orthodontics is used correctly does not cause adverse effects in the TMJ. The application of forces during certain orthodontic mechanics, especially orthopaedic situations, can cause alterations in condylar growth and bone structures of the TMJ.[18]

Thus, the mechanics application should be performed properly and the professional must have knowledge of these impacts. In some studies by analysis of imaging examinations, it was observed that there were improvements in situations of pre-existing TMD at the beginning of orthodontic therapy.

However, these data are only suggestive and more randomized clinical trials are necessary to obtain more precise conclusions. Further randomized controlled clinical trials, with longitudinal and interventional nature are necessary, for the determination of more precise causal associations, within a context of a scientific evidence-based dentistry. Slice thickness, slice gap & field of view: All are inter related which affects the spatial resolution of the image.

For the Jaw, slice thickness of 5-6 mm with a gap of 1.6 to 2 mm has been suggested by Van Rensberg & Nostje' In the TMJ, slice thickness of 3 mm with 0.5mm slice gap has been suggested by Brooks. Field of view represents a zooming in the area of interest to appear enlarged and separate from adjacent structures. Field of view of jaws is set at 24 -2 8 cm, and is limited to 10 cm for the TMJ.[14,15]

Endodontics

The accuracy of MRI is as similar to CT. MRI scan are not affected by artifacts caused by metallic restorations like Amalgam, metallic extra coronal restorations, which can be major problem with CT technology.[19,20] MRI may be useful to access the nature of endodontic lesions and for planning periapical surgery. But on the other side MRI have few drawbacks.

These include the poor resolution compared with simple radiographs and long scanning times, in addition to the greater hardware cost and limited access only in dedicated radiology units. The dental hard tissues such as enamel and dentin cannot be differentiated from metallic restorations; all the appear radiolucent. It is for those reasons that MRI is of limited use for the management of endodontic disease.[21-23]

Prosthodontics and implantology

Coward et al. conducted a study on comparison of prosthetic ear models created from data captured by computerized tomography, magnetic resonance imaging, and laser scanning. The study concluded that all 3 methods of imaging would be of value in further studies, not only for the fabrication of complex shapes such as prosthetic ears, but also for other facial prostheses.[24]

Bio effects and safety considerations

Although, there is no known Biohazard Associated with M.R.I. it is contraindicated in patients having electrically, magnetically or mechanically activated implants such as cardiac pacemakers and infusion pumps.

The potential risks associates with performing MRI in patients with Ferromagnetic implants or materials related to the induction of electric currents, heating and the misinterpretation of an artifact as an abnormality and the possibility of movement or dislodgement of an implant. Studies indicate that patients with metallic implants (Dental implant) or materials can safely undergo M.R.I.[25]

Mri & pregnancy

F.D.A. requires that M.R.I. devices indicate that the safety of M.R. imaging when used to image fetus and infants "Has not been established". Although M.R.I. is not considered hazardous to the Fetus, a cautionary Approach to M.R.I. during pregnancy is recommended till additional investigation provides more information. M.R.I. is indicated in pregnant women if other non-ionizing forms of diagnostic imaging are inadequate

(Ultrasound for e.g.) or if the examination provides more information that would otherwise require exposure to ionizing and radiation (X rays, C.T.)[26,27]

Relative disadvantages

1. Spatial Resolution of MR is lower and examination time longer.
2. Examination is not conveniently extended from one organ to another or from one part of the body to another.
3. Contact involvement arising from bone tissue are not always demonstrable.
4. Patients with pacemakers must be excluded.
5. It is not easy to subject seriously ill patients, those connected to support apparatus or those under G.A. to an MR Examination

Advantages

1. It enables differentiation among various types of normal and abnormal tissues, with clarity that is unmatched by any other imaging technique.
2. Multiplanar anatomical display.
3. Avoidance of ionising radiation hazard.
4. Relative lack of side - effects.
5. High patient acceptability.
6. Greater tissue contrast
7. The fact that parenteral contrast is not required to reveal blood vessels.
8. Ease with which views in any place are obtained.
9. The absence of artifacts due to bone or air.

Conclusion

1. Generally, it is agreed that MR was the most important innovation in Diagnostic imaging in the 1980's. Its immense value in the diagnosis of CNS pathologies, in particular is beyond doubt.
2. Its utility in many extra neurological contexts needs to be carefully examined and compared with that of longer established diagnostic methodologies.
3. The costs of MR, its intrinsic limitations, and as yet unsettled problems of hazards should be weighted.
4. Despite the diverse image acquisition technologies currency available, standards have to be adopted in an effort to balance the anticipated benefits with the associated costs and risks

References

1. Long streth WT Jr, Phillips LE, Drangsholt M, et al. Dental X-rays and the risk of intracranial meningioma: a population-based case-control study. Cancer 2004;100: 102634.
2. Newton CW, Hoen MM, Goodies HE, Johnson BR, McClanahan SB. Identify and determine the metrics, hierarchy, and predictive value of all the parameters and/or methods used during endodontic diagnosis. J Endod 2009; 35:1635–44.
3. Kotor J, Velmurugan N, Sudha R, Hemamalathi S. Maxillary first molar with seven root canals diagnosed with cone-beam computed tomography scanning: a case report. J Endod 2010; 36:915–21.
4. Blattner TC, George N, Lee CC, Kumar V, Yelton CD. Efficacy of cone-beam computed tomography as a modality to accurately identify the presence of second Mesiobuccal canals in maxillary first and second molars: a pilot study. J Endod 2010; 36:867–70.
5. Hargreaves K, Law A. Regenerative endodontics. In: Cohen's Pathways of the Pulp. 10th edn. St. Louis, MO: Mosby Elsevier; 2010:602–19.
6. Pasteris JD, Wopenka B, Valsami-Jones E. Bone and tooth mineralization: why apatite? Elements 2008; 4:97–104.
7. Schreiner LJ, Cameron IG, Funduk N, Miljkovic L, Pintar MM, Kydon DN. Proton NMR spin grouping and exchange in dentin. Biophys J 1991; 59:629–39.
8. Funduk N, Kydon DW, Schreiner LJ, Peemoeller H, Miljkovic L, Pintar MM. Composition and relaxation of

the proton magnetization of human enamel and its contribution to the tooth NMR image. Magn Reson Med 1984; 1:66–75.

9. Olt S, Jakob PM. Contrast-enhanced dental MRI for visualization of the teeth and jaw. Magn Reason Med 2004; 52:174–6.

10. Tutton LM, Goddard PR. MRI of the teeth. Br J Radiol 2002; 75:552–62.

11. Lockhart PB, Kim S, Lund NL. Magnetic resonance imaging of human teeth. J Endod 1992; 18:237–44.

12. Weglarz WP, Tanasiewicz M, Kupka T, Skorka T, Sulek Z, Jasinski A. 3D MR imaging of dental cavities—an in vitro study. Solid State Nucl Magn Reson 2004; 25:84–7.

13. Tymofiyeva O, Rottner K, Gareis D, et al. In vivo MRI-based dental impression using an intraoral RF receiver coil. Conc Magn Reson B Magn Reson Eng 2008;33: 244–51

14. Fullerton GD. Magnetic Resonance Imaging Signal concept. Radiagraphics 7;579-596.

15. Chui M, Blackesley D, Mohapatra S. Test image for MR Image slice profile. J Comput. Assissted Tomography. 9:11501152.

16. Okano Y, Yamashiro M, Kaneda T, Kasai K. Magnetic Resonance Imaging Diagnosis of the Temporomandibular Joint in patients with Orthodontic Appliances. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2003; 95: 255-263.

17. Sadowsky PL, Bernreuter W, Lakshmi Narayanan AV, Kenney P. Orthodontic appliances and Magnetic Resonance Imaging of the Brain and Temporomandibular Joint. Angle Orthod. 1988; 58: 9-20.

18. Olt S, Jakob PM. Contrast-enhanced dental MRI for visualization of the teeth and jaw. Magn Reason Med. 2004; 52:174-6

19. Lloyd CH, Scrimgeour SN, Chudek JA, Hunter G, MacKay RL. Magnetic resonance microimaging of carious teeth. Quintessence Int. 1997; 28:349-55.

20. Lockhart PB, Lund NL, Kim S. Correlation of magnetic resonance image and histology of human teeth. Proc Finn Dent Soc. 1992; 88:161-5.

21. Weglarz WP, Tanasiewicz M, Kupka T, Skórka T, Sułek Z, Jasiński A. 3D MR imaging of dental cavities-an in vitro study. Solid State Nucl Magn Reson. 2004; 25:84-7.

22. Appel TR, Baumann MA. Solid-state nuclear magnetic resonance microscopy demonstrating human dental anatomy. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2002; 94:256-61.

23. Plodder O, Pratik B, Rand T, Fock N, Voracek M, Undt G, Baumann A. Reperfusion of auto transplanted teeth--comparison of clinical measurements by means of dental magnetic resonance imaging. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2001; 92:335-40

24. Coward TJ, Scott BJ, Watson RM, Richards R. A comparison between computerized tomography, magnetic resonance imaging, and laser scanning for capturing 3-dimensional data from an object of standard form. Int J of Prosthod 2005, 18(5):405-413.

25. Teitelbaum GP, Yee CA, Van Horn DD, Kim HS, Colletti PM. Metallic ballistic fragments: MR imaging safety and artifacts. Radiology 1990; 175: 855-859

26. Frederikson NL. Specialized Radiographic Techniques. In: Stuart C. White and Pharoah. Oral Radiology – Principles and Interpretation. 5th Edition, Mosby 2004.

27. Balter S. An Introduction to the physics of Magnetic Resonance Imaging. Radio graphics. 1987; 7: 371-383