Review Article

Dental Magnetic Resonance Imaging: A Future toward Radiation Free Imaging

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ABSTRACT

The use of magnetic resonance imaging (MRI) as a diagnostic tool for evaluating the dentoalveolar complex is growing. A comprehensive review of the recent indications and potential uses in the dental specialties of orthodontics, endodontics, prosthodontics, periodontics, oral surgery, pediatric dentistry, and operative dentistry is still missing and is therefore provided by current literature. Currently, dental MRI is being used for cephalometry in orthodontics and dentofacial orthopedics, identifying the inferior alveolar nerve, impacted teeth, and dentofacial anatomy for dental implant planning, detecting dental pulp inflammation, characterizing periapical and marginal periodontal pathology, detecting caries, and more. In addition to specific procedures related to the complex architecture of the dentofacial complex, the presence of hard tissues, and foreign-body restorations, dedicated coils created especially for enhancing the dentofacial complex's anatomy are used. The tremendous growth of clinical applications in recent years has been associated with numerous technological advancements in MRI. Although research on the application of MRI in the medical field has been conducted, relatively less has been discovered about its usage in dentistry. Consequently, the current review was conducted to evaluate the applicability, practicality, and efficacy of MRI in the field of dentistry due to the paucity of existing research.

Key words: Dentistry, Diagnostic imaging, Implant, Magnetic resonance imaging, Temporo mandibular joint

INTRODUCTION

Magnetic resonance imaging (MRI) is a non-invasive technique that can detect internal structures, distinguish between soft and hard tissues, and identify certain bodily functions. Existing imaging methods are challenged by the dento-maxillofacial region's complicated architecture, which includes a collection of different hard and soft tissues as well as cavities filled with fluid and air. MRI was previously employed mostly for soft-tissue diseases, salivary glands, and the temporomandibular joint (TMJ) in the head-and-neck area. Dental professionals have restricted access to facilities in clinics and imaging centers and are not given information on which indications MRI is useful.[1]

However, by creating specific sequences and equipment for dental imaging with shorter acquisition times and lower costs, attempts have been made to establish MRI in dentistry. Although the term "dental MRI" has been used, it does not refer to a particular imaging sequence or coil. Dental MRI is the collective term for the goal of using conventional or modified imaging techniques, as well as standard and specialized coils for the dento-maxillofacial area, to concentrate on particular indications related to dentistry.[2]

In Freiburg, Germany, the first MRI equipment specifically designed for dentistry was unveiled. The manufacturers claim that the device's receiver coil is specifically made for dentistry, which improves patient setup and guarantees high-quality images. MRI acquisition is made simpler by customized scan procedures designed for dental indications. An automated dental anatomy focus view gives operators essential direction.[3] An automated focus view on dental anatomy gives operators crucial direction. This optimized process strives for a 20-min or less in-room setup, scan, and cleanup time, which is similar to a dental cone beam computed tomography (CBCT) scan. Furthermore, the system's 24 sqm footprint is far smaller than that of current MRI scanners, and its nearly helium-free cooling method lowers the need for infrastructure.[4]

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The development of the facial skeleton can also be observed by MRI with the help of control points. More recently, MRI has found application in implant dentistry by providing more accurate information about bone height, bone density, and contour.[3]

DISCUSSION

Principle of working

MRI is basically imaging water in the tissue since it operates by collecting a resonance signal from the hydrogen nucleus. Modifications to the two most popular imaging sequences – spin echo and inversion recovery – have improved the signal-noise ratio, contrast resolution, and imaging time. A typical spin-echo examination consists of one set of spin-lattice relaxation time (Tl)-weighted images, short repetition time (TR), and one set of spin-spin relaxation time (T2)-weighted images. Multi-slice, multi-echo spin echo imaging has emerged as the primary MRI technique utilized for clinical imaging.[5]

A well-known imaging technique in many medical specialties, MRI has become crucial for the non-invasive diagnosis of soft-tissue diseases due to its significant advantage of not requiring ionizing radiation, which prevents the biological damage related to other three-dimensional(D) imaging methods such as computed tomography (CT) and CBCT. In the imaging of the transverse and panoramic planes, which dentists are most familiar with, MRI and the latter are nearly identical in terms of spatial resolution and data visualization capabilities.[4]

Different methods in imaging using MRI

1. Ultra-short echo time
2. Zero echo time
3. Sweep imaging with Fourier transformation
4. Intraoral coils.

MRI is basically imaging water in the tissue because it depends on the hydrogen nucleus to produce a resonance signal. Changes have been made to the two most often used imaging sequences, spin echo and inversion recovery, to increase their signal-noise ratio, contrast resolution, and imaging time. Multi-slice, multi-echo spin echo imaging is now the main MRI technique used for clinical imaging; a typical spin-echo examination consists of one set of spin-lattice relaxation time T1 weighted images, a short TR, and one set of spin-spin relaxation time. T2-weighted images.[6]

Numerous applications of dental MRI have been studied, such as cephalometry for dentofacial orthopedics and orthodontics, identifying caries, spotting inflammation in the dental pulp, describing periapical and marginal periodontal pathologies, and visualizing the inferior alveolar nerve, impacted teeth, and dentofacial anatomy for dental implant planning. Dedicated coils and specialized procedures improve image quality, especially for complex dentofacial structures.[6]

Consequently, the present review was directed to evaluate the applicability and practicality of MRI in the field of dentistry due to the paucity of current research.[4]

DIAGNOSTIC IMAGING OF TMJ

One of the finest diagnostic methods for determining the pathology of the TMJ is MRI, which may be used to assess the position, morphology, mobility, degree of degenerative variations in the joint, inflammation, and presence of connective tissue/autoimmune diseases.[3]

Furthermore, TMJ MRI scan can aid in the diagnosis of pathology in the silent joint, where disc displacement and degenerative alterations may exist but not produce noise, be extremely painful, or cause significant discomfort, but lead to poor results.[4]

NEOPLASTIC DISEASES OF SALIVARY GLANDS

MRI is the preferred technique for assessing salivary gland pathology over CT if meningeal and associated neural (facial, trigeminal, hypoglossal, and lingual nerves) involvement is suspected. Imaging markers, including invasion of surrounding structures (bone, skull base, meninges, and adjacent cervical spaces) and rupture of the capsule in pleomorphic adenoma – all of which are more easily detected by MRI – indicate malignancy.[5]

MRI microscopy is the process of imaging the parotid gland using a small surface coil that is <100 mm in diameter in order to provide images with a greater spatial resolution than those produced by conventional coils. This makes it possible to examine the parotid gland more accurately (quantitatively as compared to qualitatively) in Sjogren's disease patients in order to gauge the disease's severity. Numbers of sialectatic foci, undamaged glandular lobules, and glandular fat are often used.[6]

Post gadolinium, T1 weighted fat-suppressed images are preferred for determining the invasion. Ill-defined borders of the tumor on postcontrast images are also highly suggestive of malignancy.[6]

IMPLANTOLOGY

It is crucial to take structural limits into account when practicing implantology. For instance, the T1-weighted 3D sequence provides a remarkable depiction of the mandibular canal position, a very important limitation in the posterior atrophic jaw.[7]

Because of its exceptional soft tissue contrast, MRI can offer additional diagnostic value. For instance, it can be used to directly image peripheral nerve tissue, like the inferior alveolar nerve, which is helpful for implant planning. By using soft-tissue contrast in particular sequences, MRI provides a special benefit and added value.[6]

However, more studies are required to improve dental MRI accuracy, for instance, by reducing acquisition time to minimize motion artifacts or enhancing spatial resolution. These results could aid in the development of radiation-free backward implant planning for prosthetics. Given that younger people are more radiation-sensitive, this is especially crucial. However, before this imaging modality can be employed outside of clinical

settings, further research is needed on dental MRI and implant placement.[7]

EVALUATION IN ENDODONTICS

For endodontic purposes, recent MRI investigations have achieved high imaging resolutions of about 0.7 mm. The dental pulp's vascularization and the distinction between an inflamed and healthy pulp were demonstrated without the use of contrast agents. Edema and the subsequent signal increase allow MRI to identify periapical inflammation early on, even in the absence of demineralization or bone resorption.[5]

High-level tissue visualization is provided by MRI, which is equal or even better than CT and CBCT. However, it requires adequate resolution, which is typically only possible with significantly longer scan intervals and without ionizing radiation exposure. The dental crown and the contour of the pulp chamber, root canals, and the carious lesion can be recognized because of the great contrast created by the high-intensity signal from water and the absence of signal from mineralized tissues.[6]

DENTAL MRI IN ORAL SURGERY

MRI sequences such as short tau inversion recovery sequence opens the opportunity of detailed structural images of soft and hard tissues in the oral and maxillofacial region, leading to enhanced preoperative radiological assessment and surgical planning. Older MRI studies evaluating imaging of the oral cavity used a conventional, nonspecific ratio.[7]

Studies of the inferior alveolar nerve have been performed using dental MRI with the application of an intravenous contrast medium. Intravenous contrast agent administration has also been used to visualize dental pulp, to evaluate pulp vitality, and to assess reperfusion of auto-transplanted teeth, as well as to demonstrate pulp cavity signal-intensity changes with age.[5]

Hard materials like teeth and cortical bone have very low signals on medical MRIs, but they can be seen because nearby soft tissues, oral fluids, or bone marrow have strong signals. The cortical bone appears black in MRI and contrasts with the surrounding soft tissue that provides signal, it has been demonstrated that MRI allows for precise and reproducible three-dimensional measurements of the mandible.[6]

Excellent image quality with a high spatial resolution of the alveolar ridge and teeth with the surrounding soft tissues was made possible by the use of coils specifically made for dental imaging, such as radiofrequency coils, wireless intraoral coils, or mandibular coils, and higher field strengths of 3 tesla. Black bone MRI sequences are better adapted to get over the drawbacks of hard tissue imaging in oral and maxillofacial radiology, according to a comparison of their use in dental practices.[7]

CONTRAST ENHANCEMENT IN DENTAL MRI

It makes it possible to see the jaw and teeth in three dimensions. The fundamental idea behind this technique is that, while teeth are MR-invisible, they can be indirectly detected by contrasting them with a magnetic resonance (MR) visible medium. This is accomplished by filling the oral cavity with a non-toxic material that produces a high MR signal, like water or MR contrast media. The picture intensities are inverted, and a 3D data set, including the buccal space, is obtained.[8]

Contrast-enhanced dental MRI may be a flexible tool for dentistry and orthodontics since it may be used to extract panoramic views similar to orthopantomography and isosurface reconstructions of the teeth and jaw. In addition, contrast-enhanced dental MRI is a viable substitute for X-ray-based imaging modalities such as dental CT and conventional radiography because it does not involve radiation exposure.[9]

The use of MRI in dentistry is promising. Its non-invasiveness, non-ionizing radiation, and capacity to distinguish between soft and hard tissues have made it one of the greatest techniques in recent decades.[10] Despite the MRI equipment's high cost, unique features, and restricted accessibility, it has recently become widely used in dentistry. When predicting malignancy, MRI indicates that invasion of the surrounding structure was an acceptable parameter. When information about the articular disc or the existence of adhesions, perforations, or joint effusion is needed, MRI is the recommended imaging method. MRI's drawbacks include the potential for claustrophobia, its high cost and noise level, and its incompatibility with cardiac pacemakers.[11]

The future of MRI in dentistry is bright. In order to improve prognosis, it can be utilized in implant dentistry, diagnosis and treatment planning, jaw lesions, TMJ illnesses, orthodontic treatment, endodontic treatment, etc.[12]

CONCLUSION

The use of MRI in dentistry is expected to grow. In order to improve prognosis, it can be utilized in implant dentistry, diagnosis and treatment planning, jaw lesions, TMJ illnesses, orthodontic treatment, endodontic treatment, etc. High-level tissue visualization is provided by MRI, which is comparable to or even better than CT and CBCT. However, it necessitates sufficient resolution, which is typically only possible with significantly longer scan times and without ionizing radiation exposure. High spatial resolution images of the alveolar ridge and teeth with the surrounding soft tissues were made possible by the use of greater field strengths for dental imaging, such as radiofrequency coils, wireless intraoral coils, or mandibular coils.

Though studies have been done on the use of MRI in the medical field, very few studies have been reported on the role of MRI in dentistry.

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