Review Article
Comparison between Conventional MRI and SWIFT MRI: An Update in Diagnosis

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Abstract: There are various types of diseases that predominate in Oral and Maxillofacial region, from simplest of decay to Oral Cancer are seen in different forms and are often missed out due to lack of technology to diagnose these diseases. Diagnosis which can show us the fine details involve the use of high amount of Ionizing Radiation thus increasing the dosage of radiation that can be used on a patient. MRI uses the non ionizing radiation from the radiofrequency(RF) band of the electromagnetic spectrum, thus reducing the irradiation to the patient, it mainly relies on the phenomenon of nuclear magnetic resonance to produce a signal that can be used to construct an image. Because of its excellent soft tissue contrast resolution, MRI has proved useful in a variety of circumstances, this article focuses on an update in the field of MRI termed as SWIFT(sweep imaging fourier transform), which has virtually simultaneous excitation and acquisition of signal, it has zero echo time and has significant benefits in studying objects having very fast spin –spin relaxation times. In particular the method is expected to find extensive applications for MRI of quadrupolar nuclei such as sodium-23, potassium-39 and boron-11.

Key Words: fast, quiet, zero echo time, hard and soft tissues, MRI

INTRODUCTION:

MAGNETIC RESONANCE IMAGING IS BASED ON TOTALLY DIFFERENT PHYSICAL PROPERTIES THAN COMPUTED RADIOGRAPHY IN THAT THE RADIANT ENERGY IS IN THE FORM OF RADIOFREQUENCY WAVES, RATHER THAN X-RAYS. THIS PHENOMENON WAS FIRST OBSERVED IN PARTICLE BEAMS BY RABI AND CO-WORKERS IN 1939. SUCCESSFUL NUCLEAR MAGNETIC RESONANCE(NMR) EXPERIMENTS WERE DESCRIBED BY BLOCH AND PURCELL INDEPENDENTLY IN 1946 THUS PAVING THE WAY FOR THE DEVELOPMENT OF NMR SPECTROSCOPY AS A POWERFUL ANALYTICAL TOOL IN CHEMISTRY AND BIOLOGY. BLOCH PLACED HIS OWN FINGER IN MR SPECTROMETER AND OBSERVED A STRONG SIGNAL FROM HYDROGEN NUCLEI. BLOCH AND PURCELL BOTH RECEIVED THE NOBEL PRIZE FOR ELUCIDATING THE PHENOMENON OF MR IN SOLIDS AND LIQUIDS. THIS TECHNIQUE WAS FIRST ANNOUNCED BY LAUTRBERE IN 1972. DOMADIAN(1972) AND LAUTRBERE(1973) INDICATED THE POTENTIAL OF NMR TO OBTAIN IMAGES OF THE INTACT HUMAN BODY.10

IN NMR THERE ARE BASICALLY THREE TYPES OF THE RF EXCITATION: SEQUENTIAL, SIMULTANEOUS AND RANDOM. ACCORDINGLY, THREE DIFFERENT NMR TECHNIQUES WERE DEVELOPED, WHICH RESPECTIVELY ARE: CONTINUOUS WAVE (CW),

pulsed, and stochastic. Nowadays pulsed FT spectroscopy dominates the field of high resolution NMR. MRI has additional technical requirements over high resolution NMR. Because the objects of interest are much larger than a test tube, inevitably the static and RF fields used in MRI are more inhomogeneous than those used in high resolution NMR. In a search for solutions, researchers have reconsidered old, almost forgotten NMR techniques.5

Carious lesions are routinely detected using visual/tactile methods coupled with radiography. The accurate diagnosis of the presence or absence of disease is paramount for appropriate care. As radiographs tend to reveal only significant caries, there is a need for early stage diagnostic methods that more accurately can detect dentinal involvement. More precise methods for a definitive diagnosis for the presence of lesion, activity and size would significantly improve management of caries and decisions with respect to operative intervention or preventive care.

MRI offers a noninvasive and nondestructive technique for analyzing the anatomy of teeth without applying ionizing radiation. Standard MRI techniques (spin echo and gradient echo), however, have the potential only to produce images of soft tissue such as the pulp and the attached periodontal membrane. For visualization of the dental surface geometry, as well as for distinction between soft tissue and mineralized hard tissue(enamel, dentine and root cement) in the extracted teeth, Conventional MRI can be used but is very time consuming and are not suitable for in vivo applications.11

The rapid-scan FT technique and SWIFT technique have many common properties, but are different in point of view to system response on excitation. They consider the system response in frequency domain and time domain, respectively. Due to this difference the SWIFT technique has a few advantages, one of them is that the spectra obtained by SWIFT technique are insensitive to the linearity of the sweep rate. This gives the opportunity to use a broad class of frequency modulated pulses having more uniform excitation profiles than the chirp excitation required in rapid-scan FT. The main advantage of SWIFT is the virtually simultaneous excitation and acquisition of signal. Accordingly, the method has a "zero echo time", and so has significant benefits for studying objects having very fast spin-spin relaxation (or very short T2).5

The advantages of SWIFT over Conventional MRI

(1) Fast: The method avoids not only delays associated with refocusing pulses or gradient inversion, but also time for an excitation pulse, which is integrated with the acquisition period 1,2,4,5

(2) Sensitive to short T2: The method is sensitive to all excited spins having T2 > 1 / SW (SW = spectral width). Of course, to be specifically resolved, T2 > N / SW must be satisfied, which is theoretically feasible even for solid objects by increasing SW. For example, water molecules in teeth have T2 values in the range of only 50 to 500 microseconds, whereas most soft tissues have T2 values in the range of tens of milliseconds.1,2,4,5

(3) Reduced motion artifacts: Because the SWIFT method has no "echo time" it is less sensitive to motion artifacts. It loses less signal due to either diffusion in the presence of a gradient or uncompensated motion than other fast sequences. 1,2,4,5

(4) Reduced dynamic range requirement: Because the different frequencies are excited sequentially the resulting signal is distributed in time with decreased amplitude of the acquired signal. This allows more effective utilization of the dynamic range of the digitizer. 1,2,4,5

(5) Quiet: SWIFT method uses a small step when changing gradients between projections, fast gradient switching that creates loud noise can be avoided. This property is very important for people having ligyrophobia 1,2,4,5.

(6) SWIFT may also be operated in rapid updated

mode to reach high temporal resolution in dynamic studies.1,2,4,5

(7)The unique abilities of SWIFT MRI also include simultaneous imaging of both hard and soft issues, with resolution in which minute anatomical and pathological abnormalities can be detected. 1,2,4,5,12

(8)From dental point of view it can assess both pulpal and periodontal tissues simultaneously.1,2,4,5,12,20,25,26,27

(9)Recent reports show that it is effective in early detection of Oral Cancer. The SWIFT MRI offers 3-dimensional assessment of cortical and medullary bone in fine detail and excellent qualitative agreement with histopathologic findings. Imaging with the SWIFT MRI technique demonstrates great potential to identify mandibular invasion by oral carcinoma.6,7,8

(10) Since conventional MRI techniques are not able to fully eliminate the long T2 component, there is always a possibility of false-positive results of cortical bone invasion owing to periodontal disease or inflammation, which is not the case with SWIFT MRI.6,7,8

(11)SWIFT MRI can be used to detect microcracks in teeth, which can help the patient avoid pulpal involvement in the future.8,9,11,19

(12)It helps analyse the density of the bone, this helps in the placement of successful implants in patients.1,2,4,5,6,7,8,9,11

(13)When it comes to breast lesions, SWIFT MRI again proves better than Conventional MRI by providing a environment that is more comfortable for the patient as less compression is required in the technique.13,14

SHORTCOMINGS OF SWIFT MRI1,2,4,5,6,7,8,9,10,11

(1)Expensive
(2)Claustrophobia
(3)Quenching
(4)Facilities not widely available
(5)Hardware to support the technique is not fully developed, due to which full utilisation of the technique is not always possible.

1. CONCLUSION:

SWIFT (Sweep Imaging with Fourier Transformation) is a radically different approach to MRI with many unique and powerful features, including nearly silent operation and the ability to visualize hard tissues (e.g., cortical bone, enamel, dentin). These capabilities are expanding the utility of MRI into areas of research and clinical application where previously it played little or no role.

In addition to SWIFT's potential for in-vivo MRI, it creates new opportunities for MRI of materials. SWIFT currently operates in 3d radial acquisition mode. A series of segmented hyperbolic secant excitation pulses is accompanied by acquisition in the gaps. Each excitation, after correlation with the pulse results in a free induction decay (FID). The spectrum corresponding to the FID is a projection. There is very little "dead time" between excitation and acquisition, making SWIFT useful for imaging of short T2 materials, but in total imaging times comparable to fast gradient echo sequences9

Magnetic resonance imaging is regarded as a highly accurate examination in the assessment of extension of tumor in the soft tissues, but its role in depicting extension of tumor to the mandible is considered limited owing to frequent overestimation of cortical invasion.This overestimation results from signal changes associated with inflammatory conditions including periodontal disease and peritumoral edema, which are comparable to those seen with neoplastic invasion.

Like many of the tissues of the musculoskeletal system, cortical bone produces no signal with conventional MR techniques, limiting the characterization of image contrast and differentiation of adjacent soft tissues. In biological tissues, MR signal comes from the spinning of magnetic moments of hydrogen nuclei. The signal is detectable after a radiofrequency (RF) pulse application. Because the molecular motion within densely mineralized bone is highly restricted, the signal from bone quickly decays after RF excitation. The time constant describing the signal's decay, known as the transverse relaxation time (T2), is approximately 200 microseconds in cortical bone. In conventional MRI, excitation and acquisition events are separated by the length of time known as the echo time (TE), which is typically longer than 1 millisecond, which is too long to detect the signal from cortical bone.6,7,8

Though Breast lesions are out of scope of dentistry, but since this is a review on SWIFT MRI, literature related to its application in detecting breast lesions is also mentioned here. Breast lesions with MRI relies on contrastenhancement kinetics and morphology necessitating high temporal and spatial resolution respectively. Most currently utilized MR techniques can only provide high temporal resolution at the cost of diminished spatial resolution and vice versa. The near continuous acquisition of signal with SWIFT allows for extraordinary temporal resolution without sacrificing spatial resolution. Unlike currently available MR techniques, SWIFT demonstrates T2* insensitivity providing more accurate evaluation of dynamic enhancement. SWIFT's ability to provide both high spatial and temporal resolution make it ideal for evaluation of dynamic contrast enhancement which is essential to breast imaging.10,13,14

A fast and quiet method of MRI known as SWIFT (sweep imaging with Fourier transformation) creates new opportunities for imaging in medicine.SWIFT uses time-shared excitation and signal acquisition. This allows the detection of signals with a broad distribution of relaxation

times, including extremely short T2. This technique offers delineated assessment of cortical and medullary bone, which is not possible with conventional imaging techniques. 1,2,4,5,6,7,8,9,10,11

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