Direct MRI of Human Teeth by SWIFT

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INTRODUCTION

In the US caries 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(*1*).

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(*2-4*). 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, solid-state imaging technique, SPI(*5*) and STRAFI(*6, 7*) can be used. However, these solid-state MRI methods are very time consuming and are not suitable for *in vivo* applications.

Recently a new MRI method, SWeep Imaging with Fourier Transform (SWIFT) (*8*) based on acquisition during a swept excitation, was proposed. SWIFT combines virtually simultaneous excitation of spins and acquisition of the excited signal, and has significant benefits for studying objects with very short T_2 relaxation times. Additionally, the acquisition time with SWIFT is comparable to regular fast gradient echo techniques. Here, *in vivo* and *in vitro* SWIFT images of teeth and surrounding tissue are presented and discussed.

METHOD

The ^{1}H data were acquired using two MRI scanners with 4.7 Tesla/40 cm and 4 Tesla/90 cm Oxford magnets for *in vivo* and *in vitro* study of the human teeth, respectively. Both scanners were equipped with Varian INNOVA consoles. Frequency-modulated pulses from the hyperbolic secant family (*HSn* pulses) (*9*) were used. The data acquired with SWIFT, being an inherently radial method, were reconstructed into 3D images using gridding followed by Fourier Transform(*10*).

RESULTS and CONCLUSIONS

The SWIFT sequence can be used for imaging both soft and hard tissue with a true T_1 contrast (Figure 1). The major advantage of the SWIFT technique is its sensitivity for imaging tissues with very short T_2 relaxation times, such as enamel and dentin. The fine structures of a molar tooth are recognized in Figure 2 and Figure 3. The demineralized parts of the enamel and dentin, having a larger concentration of protons (water), are seen as hyper- intense areas. These 3D images (Figure 2 and Figure 3) were acquired in 10 minutes, which is appropriate for *in vivo* studies. Additionally, because the SWIFT method uses a small step when changing gradients between projections, fast gradient switching that creates loud acoustic noise can be avoided. This property is very important for people having ligyrophobia. In conclusion, the SWIFT sequence appears well suited to studying the progress of dental caries and for early stage diagnosis of the dental caries.

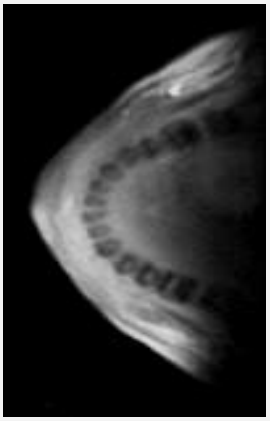

Figure1.One slice of an *in-vivo* 3D SWIFT image of a normal mandible and surrounding areas. $s\omega/2\pi$ = 62 *kHz*, matrix size = 256 x 128 x 64, 4T, ~3min.

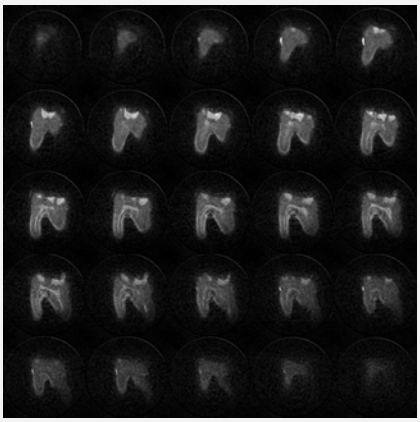

Figure 2. Axial slices of 3D SWIFT *in-vitro* images of a decayed molar tooth. $s\omega/2\pi$ = 62 *kHz*, matrix size=256 x 128 x 32, *D*=3cm, 32 averages, Total time =10min, 4.7T

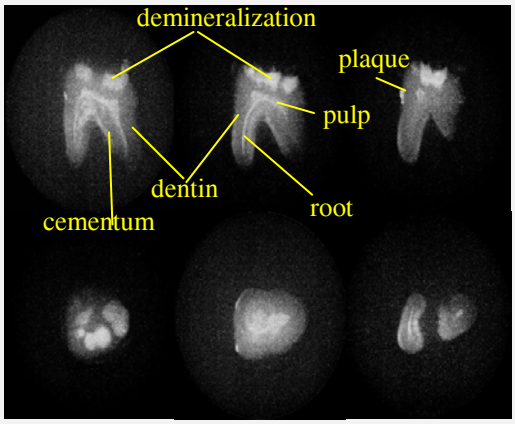

Figure 3.The labeled *in-vitro* 3D SWIFT images of a molar tooth in coronal and axial views

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