

## Ultra-Short Echo-Time (UTE) Imaging for Early Diagnosis of Dental Demineralization

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**Background:** The main limitation of MRI for dental application results from its inability of assessing hard tissue structures and hence its very limited performance in delineation of the mineralized components of the tooth. Dentin comprises up to 70% mineral hydroxylapatite, about 20% organic material and only 10% water. In enamel, the mineral content can even get as high as 96%. Due to the high mineral content, the concentration of free protons is extremely low causing only weak magnetization and due to the susceptibility interfaces in the mineral structures, the spin-spin relaxation rates results below 1ms for dentin and below 250µs for enamel. First in vitro and in vivo direct imaging of dental hard tissues has recently been reported by applying ultrashort echo time (UTE) [1,2] imaging techniques, which could be successfully applied for the delineation of pulp, dentin and enamel in extracted teeth and volunteers. The purpose of this study was to evaluate the

	HR Survey	T1W spin echo	UTE
<b>Technique</b>	Spoiled GE	Multi-spin echo	Spoiled GE
<b>k-space encoding</b>	Cartesian	Cartesian	3D radial
<b>Excitation</b>	slice selective	slice selective	non-selective
<b>Flip angle [°]</b>	20	90	10
<b>Echo time [ms]</b>	2	8.1	0.05
<b>Repetition time [ms]</b>	3.8	625	4.7
<b>Pixel BW [Hz]</b>	500	240	800
<b># echoes</b>	1	16	1
<b>Acquired res. [mm<sup>3</sup>]</b>	2.5x2.5x5	0.4x0.4x1	0.8x0.8x0.8
<b>Recon res. [mm<sup>3</sup>]</b>	1.5x1.5x5	0.4x0.4x1	0.5x0.5x0.5
<b>Field of view [mm<sup>3</sup>]</b>	300x300x200	230x230x8	80x80x80
<b>Scan time</b>	0:51	5:32	9:50

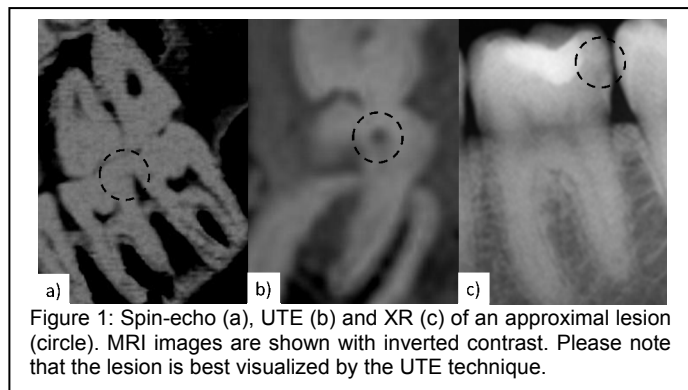
Table I: MRI Acquisition Protocol

feasibility of the UTE technique for the identification of caries lesions in patients.

**Methods and Materials:** Five patients were enrolled in this feasibility study. According to the clinical oral investigation, the caries status of the patients included: caries-free (3), moderate occlusal and approximal caries (1), and severe occlusal and approximal caries (1). Four patients had dental fillings including amalgam, gold, ceramic and composite fillings. One patient had a crown and one patient had an interim crown. The MRI protocol is summarized in Table I. All data were acquired with a

prototype two times two-element carotid artery coil sized 120 × 50 mm. The two segments were located on either side of the jaw aligned with the teeth and fixated with a Vac-Lok neck cushion. Due to the local demineralization and concomitant accumulation of acids and saliva in the caries lesion, the proton density and the local T2/T2\* are supposed to increase causing a local signal enhancement. In this study, areas showing a signal enhancement of more than two times the standard deviation of the surrounding tissue were classified as lesions. For all patients additional dental X-ray imaging was performed within 2 weeks prior or after the MRI examination.

**Results:** Including planning and measurement of the coil sensitivity pattern, the MRI protocol could be completed in less than 45 minutes in all patients. Although some artifacts were caused by the dental fillings in the HR Survey, no patient had to be excluded due to insufficient image quality in the T1W and the UTE scans. All clinically identified lesions were clearly visible in the UTE scans. In two of the three “caries-free” patients, approximal lesions were identified, which could be validated by the subsequently performed X-ray (Fig. 1). A secondary lesion in the proximity of the interim crown was clearly visible in the UTE scan, but could not be verified by X-ray due to the superposition of the crown material. In comparison to the UTE technique, only progressed lesions, which likely showed already enamel breakdown could be clearly identified by the spin echo technique. Early lesions



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(Fig. 1) showed only very little intensity variation in the spin echo technique and could not be reproducibly identified.

**Discussion:** MRI appears applicable to the identification of early demineralizations. Due to the higher sensitivity, UTE techniques appear more promising than spin echo techniques. Besides the lack of radiation, a major advantage of the MRI approach is the three-dimensional information, which facilitates identification of secondary lesions and approximal lesions, which are difficult to detect by X-ray imaging due to the superimposed filling materials and other structures.

**References:** [1] Boujraf et al., ISMRM 2009:4518; [2] Boujraf et al., ISMRM 2009:4519