

Dental Imaging with PETRA

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Introduction: Dental imaging can offer new applications for MRI. Without ionizing radiation, carious lesions and the shape of teeth can be detected with MRI, as it has recently been shown in a couple of publications. Tymofiyeva [1] uses an indirect in-vivo method using an intraorally applied contrast-agent that penetrates carious lesions. Other works make use of the demineralization of the enamel when a tooth is affected with carious bacteria. The T_2 relaxation in rigid bodies is very short (enamel 14-240 μ s and dentine 12 μ s-1ms, at 1.5T). When the tooth is demineralized, the softened structure provides signal detectable in MRI using techniques such as UTE [2] and ZTE [3] at high-field. In this work, as an alternative PETRA [4] was used to characterize its performance in extracted teeth at 1.5T. To investigate the SNR of the PETRA sequence it was compared to a vendor-specific available UTE. An initial in-vivo PETRA measurement is presented.

Subjects and Methods: All measurements were carried out on a 1.5 T clinical scanner. For the in-vitro experiments a single loop coil was used.

The high-resolution PETRA as well as the vendor-specific UTE sequence have a hardware-limited echo time of 70 μ s. For the UTE and PETRA comparison measurements, a flip angle of 7° with 50000 radial spokes to fulfill the Nyquist theorem for artifact-free imaging was used.

The scan time and other sequence parameters are shown in table 1. For in-vitro measurements, an extracted tooth was prepared. The tooth was extracted after a dental treatment, showing a big carious lesion with residual pathological tissue. To avoid desiccation, the tooth was stored in Chloramine-T with agar. A standard small single loop coil was used for the in-vitro experiments.

In-vivo experiments were performed using a 4-channel array coil (dental extra-oral coil [5]), designed to fit the lower part of the face and provide high signal intensity from the dental arc.

Table 1	Res. (isotropic)	TR	TA	coil	sequence
in-vitro	0.31mm	9.9ms	8:17min	Single loop	PETRA
in-vivo	0.47mm	5.02ms	5:39min	DEOR	PETRA
in-vitro	0.31mm	9.9ms	8:15min		UTE

Results: Figure 1 shows an image example of the comparison in-vitro scan between UTE (right) and PETRA (left). The SNR of dentin was 11.45 with UTE and 14.11 with PETRA. For enamel, a SNR of about 4.95 and 8.10 was found for UTE and PETRA, respectively. The PETRA image has increased signal from the remaining caries lesions near the cave. The enamel has very short T_2 relaxation time and shows up dark in the image. The edge between enamel and dentine is roughly

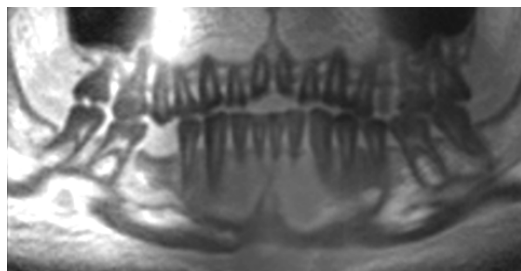


Figure 2 An in-vivo X-ray style curved slice along the jaw arc is shown. The corticalis and the spongiosa of the bones can be distinguished. The pulp of the teeth is seen at high signal and enamel on top of the teeth shows slightly darker than the dentin.

detectable and shows up sharper in PETRA images because of the higher contrast-noise-ratio. Figure 2 shows an X-ray style curved slice of the dental arc. The main features of the tooth can be seen at an isotropic resolution of 0.5mm. The pulp shows up with bright contrast as in standard imaging. The fissures are depicted dark in the image because they consist of enamel. Dental fillings do not produce severe distortion artifacts in the image.

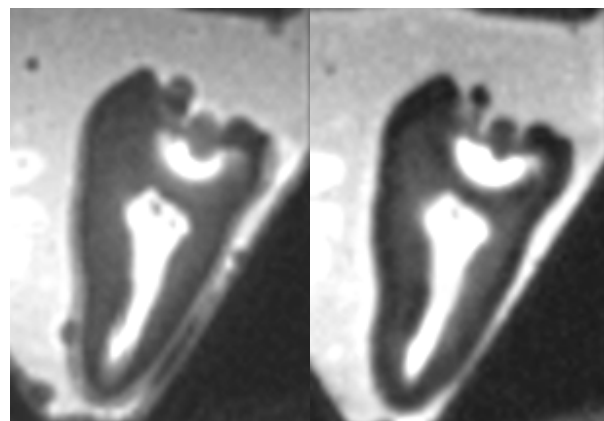


Figure 1 PETRA (left) and UTE (right) image of an extracted tooth. In general the PETRA image shows more SNR from the dental structures than the UTE images.

Conclusion: The depiction of the teeth in-vivo at 1.5T is very promising for the application in dental imaging even at lower fields (lower fields imply longer T_2 relaxation times for rigid bodies). In the in-vitro measurements, it was shown that both very short T_2 tissues in the tooth show higher SNR in PETRA than in the vendor-specific UTE images. The in-vivo measurement was well tolerated by the volunteer and the measurement time was short enough for artifact-free imaging. For detailed in-vivo considerations the sequence has to be applied in clinic to detect carious lesions. With a dedicated coil that only receives from a small FoV, the allover measurement time can be decreased [6] and a higher SNR is expected.

References: [1] Tymofiyeva et al. *Magn Reson Matter Phy* (2009) [2] Bracher et al. *Proc. ISMRM 2011* [3] Weiger et al. *Proc. ISMRM 2011* [4] Grodzki et al. *Magnetic Resonance in Medicine* (2011) [5] Düring et al. *Proc ISMRM 2009* [6] Tymofiyeva et al. *Conc Magn Reson* (2008)