Center-Acquisition-at-Partial-Ramp Imaging (CAPRI) compared to Ultra-Short Echo-Time (UTE) Imaging for Diagnosis of Dental Demineralization

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Background: Magnetic resonance imaging has proven its potential for radiation free detection of caries lesions using ultra short echo time approaches like UTE[1], ZTE[2], PETRA[3] and SWIFT[4]. A classification of lesion progression in MRI is possible due to the significant different T2* values between initial and moderate lesions[5]. T2* mapping works only for the UTE approach since the other approaches are based on a fixed echo time. UTE imaging sequence is very sensitive to gradient delay related shifts of the k-space center and off-resonance effects. CAPRI[6] allows automatic correction of gradient delays[7], reduces off-resonance and T2 induced blurring artefacts and provides T2* mapping capabilities for lesion classification. In this abstract the performance of CAPRI for visualization of caries lesions was investigated.

Methods and Materials: The CAPRI factor (cf) describes the relative position of k-space center on the gradient slope (e.g. cf = 0: UTE; cf = 1:end of slope) and defines the duration of the prephasing gradient in readout direction and therefore the minimum TE for the sequence. Five volunteers were included in this study**.** All imaging was performed on a 3T whole body imaging system (Achieva, Philips Medical, Netherlands) with a gradient slew rate of 150mT/m*s and a readout gradient strength of 21mT/m. The MRI protocol included four CAPRI sequences with constant TR = 4ms; CAPRI factors (cf) of 0 / 0.33 / 0.5 / 1 and respective echo times TE = 70 / 110 / 170 / 340µs using following sequence parameters: FOV = 200mm^3; acq. res. = 1mm; rec. res. = 0.5mm, and acq. time = 9min. In all cases a mono-exponential eddy current response was applied for correction of the trajectory shape. An automatic gradient delay correction algorithm[7] was applied once (cf = 1) for every volunteer and the resultant delays were used for reconstruction of the images with all four CAPRI factors.

Data analysis: Caries lesions were identified as areas showing a signal enhancement of more than two times the standard deviation of the surrounding dentin. Maximal width, height, and depth were quantified for all sequences. Contrast to noise values were determined by calculation of the ratio of the difference between the mean intensities of the lesion and the surrounding tissue (dentin) and the standard deviation of the dentin.

$$CNR = \frac{C_{lesion} - C_{dentin}}{\sigma_{dentin}}$$

Results: In total, the volunteers showed 9 caries lesions. All lesions could be clearly identified with all cfs. Lesion dimensions resulted similar with the different techniques. However, the delineation of small lesions improved for cf = 0.33 and cf = 0.5 (Fig. 1). This observation was supported by the improving contrast between lesion and dentin with increasing cf (Tab.I). Some limitations of cf = 1 for very initial lesions were observed, which may be attributed to the used echo time in order of the related T2* value (324±94µs)[5]. No significant differences in lesion extension were observed between the different cfs. CNR show a trend to higher values with increasing cf.

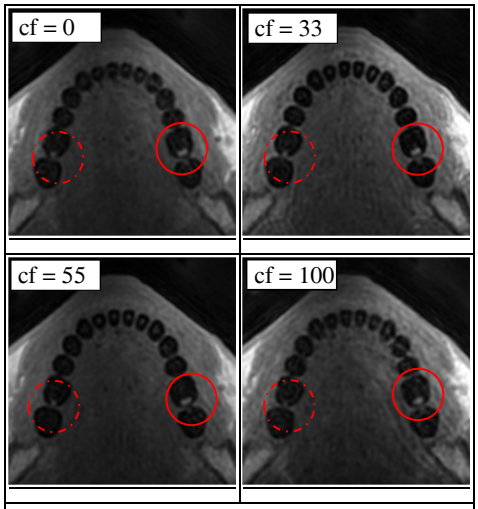

Fig 1: approximal caries lesions for different CAPRI factors

cf	CNR	w [mm]	h [mm]	d [mm]
0	7.6 ± 2.8	3.4 ± 1.2	2.6 ± 0.6	2.7 ± 1.1
0.33	7.0 ± 2.7	3.4 ± 1.3	2.6 ± 0.6	2.6 ± 1.0
0.5	8.0 ± 3.0	3.0 ± 1.1	2.4 ± 0.5	2.6 ± 1.0
1	10.3 ± 4.3	3.2 ± 1.1	2.4 ± 0.6	2.6 ± 1.1

Table I: CNR, width (w), height (h) and depth (d) of the identified lesions.

Discussion: CAPRI can be successfully applied to caries imaging. Where the slightly increased contrast may be attributed to the longer echo-time and not necessarily be directly related to the CAPRI technique, the possibility of automatic phase correction and the lower sensitivity to off-resonances makes CAPRI an attractive alternative to other ultra-short echo-time techniques.

References: [1] Bracher et. al. Dentomaxillofac Radiol.42(6) (2013); [2] Weiger et.al NMR Biomed. ;25(10):1144-51 (2012); [3] Hopfgartner et. al. 21st Proc. Ann Meeting ISMRM 2012: 2311 [4] Idiyatullin et. al. J Endod.37(6):745-52 (2011) [5] Bracher 21st Proc. Ann Meeting ISMRM 2012: 2294; [6] Bracher 21st Proc. Ann Meeting ISMRM 2011: 4507; [7] Bracher et al. submitted to 23rd Proc. Ann Meeting ISMRM 2014