Scan Time Acceleration by Using Multi-contrast Keyhole Imaging (McK) for the Identification of (Acute) Apical Periodontitis

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sBackground:

For the assessment of apical periodontitis multi-contrast imaging appears attractive for differentiation of chronic and acute lesions[1]. While the delineation of an apical lesion appears feasible in T1w-TSE due to the sufficient contrast between the lesion, the tooth and the spongious bone, a T2w image may be advantageous for further classification of the lesion like identification of acute inflammation or radicular cysts. The limiting factors for 3D isotropic high-resolution assessment of the jaw are the rather long scan times and the poor signal-to-noise ratio (SNR). Former factor can be addressed by applying multi-contrast keyhole (McK) imaging[2]. The aim of this study was to evaluate the maximal possible reduction of the overall acquisition time without compromising the diagnosis i. e. the visibility of the lesions.

Materials & Methods:

Six patients were included in the study. The data was acquired at a 3-Tesla whole body system (Achieva, Philips Medical Systems, Best, Netherlands). T1w and T2w diagnostic scans had an in-plane resolution of 0.5x0.5mm^2 and a slice thickness of 1.5mm. The reconstructed images were transferred to a PC and registered to each other to compensate for intra acquisition motion. McK was evaluated with an in-house developed software (MATLAB) to calculate the multi-contrast images.s

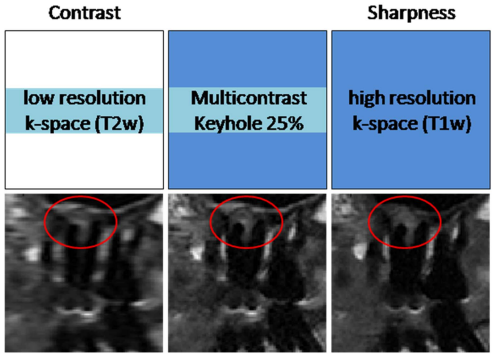

Figure I: Principle of the McK approach

McK:

Multi-contrast keyhole imaging is based on the fact that the k-center (low frequencies) dominates the resulting image contrast and values of the k-space periphery (high frequencies) dominate the resulting image sharpness. To obtain multiple high resolution images with different contrast weightings, in McK a single reference data set (T1w) with full resolution is acquired. For further contrast weightings, only the central k-space lines (contrast relevant) are acquired and the high-frequency components are shared with the reference scan. (Fig. 1). Prior to merging, the energy of both data sets (S(k=0)) was used for normalization to compensate for different power settings and acquisition times.Evaluation of McK was done for replacement factors (McK-factors) of 75 / 50 / 25 and 12.5% of the central k-space data in the T2W scan. Resulting image quality was assessed by visual rating and quantitatively by calculation of the root-mean-square-error. The RMSE was calculated by dividing the difference between the calculated (McK) and the original T2 weighted image by the maximum difference of the two original full sampled images (T1w - T2w).

Results:

The influence in image quality of the different McK-factors is shown in Figure 2. A McK-factor down to 50% appears feasible without obvious loss of image information / image contrast. McK-factors of 25% and lower lead to an obvious blur in the images and the identification of small lesions appears increasingly impaired. The quantitative analysis reveals rather high values even in cases where no obvious visual differences are observed. This is most likely caused by the normalization, which causes slight signal alterations. The trabecular structure of the spongious bone leads to a high local difference in these regions between McK and T2w images and results therefore in a high RMSE (Fig. 3) even with high McK-factors while the McK-images showed no significant loss in diagnostic image quality.

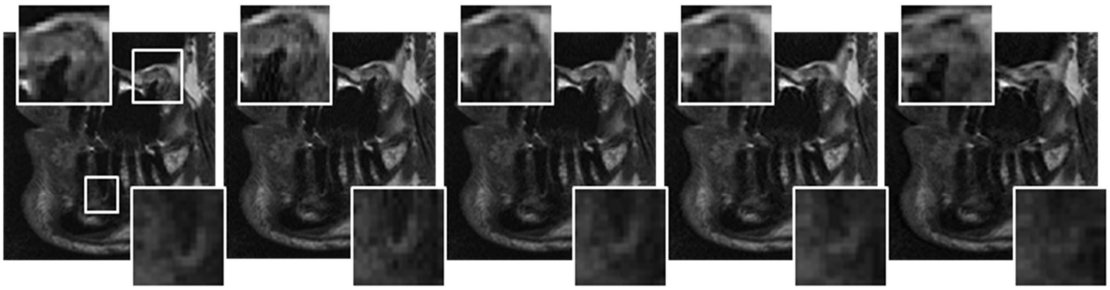

Figure III McK-images for T2 quota of 100%, 75%, 50%, 25%, 12,5% (from left to right)

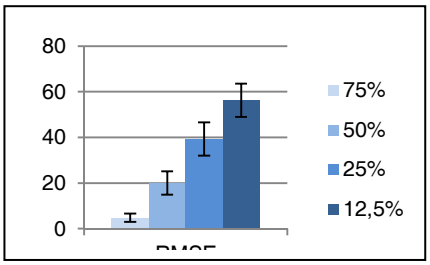

Figure IV: root-mean-square error for the different McK-factors

Conclusion:

McK imaging provides contrast properties identical to a fully sampled image for a factor of 0.5 (50%) or higher. A fully sampled reference image is mandatory for calculation of multi-contrast images. Images with different contrast but identical geometry can be collected with significantly fewer phase encodings resulting in much shorter scan times. If the technique is applied for 3D imaging both phase encoding directions could be reduced to 50% and therefore only 25% of the original scan matrix would have to be acquired.

References

[1] Bracher A-K et al. In: Int. Soc. Magn. Res. Med. 19; Montreal. Canada: 2011: 2609
[2] Bornstedt A et al. In: Europ. Soc. Magn. Res. Med. and Bio. Antalya. Turkey: 2009: 185