Real-Time MRI of Joint Movement with TrueFISP

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Introduction
The evaluation of joint movement under dynamic conditions can provide important diagnostic information for detailed assessment of joint abnormalities and malformations. Real-time TrueFISP MR imaging allows the acquisition of high contrast images with high temporal resolution. This study evaluates the diagnostic potential of real-time TrueFISP for kinematic MR imaging of joint pathologies.

Methods
The dynamic joint motion study was performed on four joints (elbow, knee, metacarpal, tarsal) of five volunteers as well as on the knees of three patients on a 1.5 T SIEMENS Sonata system equipped with high performance gradients. Two different U-shaped coil supports were designed with Plexiglas to hold the flexible surface coils of the scanner manufacturer (SmallFlex and LargeFlex, respectively) and to allow for dynamic evaluation of hand, elbow, knee, as well as ankle joints. The real-time TrueFISP sequence (TR/TE 3.0/1.5 ms, flip 50°, FOV 27 x 27 cm, slice 6 mm) collects one line every 3.0 ms. The in-plane data acquisition matrix was 256 x 135. The acquisition time per image amounted to 405 ms (135 x 3.0 ms). Echo-sharing was used to improve temporal resolution. For this purpose, 15 additional lines of central k-space were collected between image one and image three. Image two was subsequently calculated from k- of image one, k+ of image three, and the 15 additional central k-lines in between. Echo sharing improved the temporal resolution to 225 ms, thus enabling the acquisition of 43 images during 10 seconds of joint movement.

Results
Despite the spatial constrictions of a closed bore whole body scanner, all evaluated joints could be assessed under dynamic conditions. The RF coil supports, in combination with the flexible surface coils, enabled optimization of the SNR and signal homogeneity over the volume of the joint under investigation. The TrueFISP sequence was characterized by high image contrast that allowed good depiction of muscles, bones, and ligaments, as well as by high temporal resolution that allowed for detailed dynamic analysis of active joint motion. Joint malformations or instabilities could be assessed in the knees of all patients. Due to the strong dependency of TrueFISP image quality on field homogeneity, a 3D shim routine proved to be a mandatory prerequisite for the removal of band artifacts in the dynamically acquired images.

Discussion
Real-time TrueFISP MRI renders detailed dynamic analysis of joint motion. Therefore, the technique appears well suited for the assessment of joint abnormalities which express themselves only under dynamic conditions, such as neuro-muscular contractures as well as joint instabilities and malformations. Furthermore, dynamic studies of joint motion can be used for the assessment of the therapeutic response after traumatic injuries.

References