Direct Visualization of Cartilage Delamination in FAI at 3T using Multiband Acceleration

Jutta Ellermann[1], Abraham Padua[2], Edward Auerbach[1], and Dingxin Wang[1,3]

[1]CMRR, Department of Radiology, University of Minnesota, Minneapolis, Minnesota, United States, [2]Siemens Healthcare, Houston, Texas, United States, [3]Siemens Healthcare, Minneapolis, Minnesota, United States

TARGET AUDIENCE: Clinicians and researchers curious to employ novel MRI techniques for improved resolution or timesavings in MSK imaging.

PURPOSE: To evaluate the benefit and effectiveness of multiband technology for magnetic resonance imaging of the hip. One of the most common clinical indications for hip MR Imaging in todays clinical practice is related to hip pain of young adults, which are evaluated for Femoroacetabular Impingement (FAI). FAI has been shown to cause labral and chondral lesions and lead to osteoarthritis (OA) (1). Joint preservation surgery is recommended for patients with symptoms unamenable to medical management and normal or limited cartilage damage (2). Joint preservation procedures, which are the fastest growing orthopaedic arthroscopic interventions, however, are contraindicated in patients with moderate-to-advanced cartilage changes. Unfortunately, moderate cartilage damage can be challenging to diagnose. Radiographic evaluation using Tönnis grading is the standard of care but has been shown to have poor inter-observer reliability. MRI evaluation would seem the logical alternative, but accuracy of MRI and MR arthrography for detecting chondral damage in FAI is poor (3). It is hypothesized, that multiband slice accelerated turbo spin echo (TSE) (4, 5) can provide 35% time savings with similar image quality for most of the clinical imaging protocol and that the alternative benefit of higher resolution at maintained imaging time can provide improved diagnostic accuracy visualizing cartilage debonding at clinical field strength.

METHODS: Hip imaging was performed on 4 volunteers using a 3T Siemens MRI scanner (Prisma; Siemens Healthcare, Erlangen, Germany) with an 18-channel body coil (Siemens, Erlangen) and an integrated 32-channel spine coil array. Approval of the Institutional Review Board (IRB) with informed consent had been obtained. Multiband RF pulses were generated for simultaneous multi-slice excitation and echo refocusing. The VERSE technique was applied to the RF pulses to reduce peak power and SAR. Low resolutions multislice 2D GRE scan integrated into the multiband TSE sequence was used as the reference scan to obtain the coil sensitivities [4]. Imaging parameters were as follows: FOV = 160×160 mm^2, matrix size = 320×320, in-plane resolution = 0.5×0.5 mm^2, slice thickness = 2 or 3 mm, total slices = 26 for 3 mm and 38 for 2 mm, 20% slice spacing, 100% phase oversampling, excitation/refocusing flip angle = 90 º/140º, readout bandwidth = 180-260 Hz/pixel, echo spacing = 12 ms, **Multiband Slice Accelerated TSE:** slice acceleration factor = 2; T1-W: TR/TE = 695/12 ms, ETL = 3, iPAT acceleration factor = 2, TA = 1:34 min; PD-W with spectral fat saturation: TR/TE = 3070/41 ms, ETL = 9, , TA = 4:12 min; T2-W with spectral fat saturation: TR/TE = 4200/52 ms, ETL = 12, TA = 4:32 min; CAIPIRINHA FOV shift factor = 2 was used for PD-W and T2-W**; Standard TSE:** T1-W: TR/TE = 695/12 ms, ETL = 3, 2 concatenations, iPAT acceleration factor = 2, TA = 2:36 min; PD-W with spectral fat saturation: TR/TE = 3070/41 ms, ETL = 9, TA = 6:30 min; T2-W with spectral fat saturation: TR/TE = 6680/52 ms, ETL = 12, TA = 6:36 min. Hyper-echo was used for all PD-W and T2-W acquisitions.

RESULTS: All multiband slice accelerated TSE sequences successfully executed within SAR safety limit. With approximately 65% acquisition time, multiband slice accelerated TSE demonstrates similar results as standard multislice TSE in T1-W (not shown), fat-saturated PD-W (Fig. 1) and fat-saturated T2-W (Fig. 2). Images were provided in the abstract. However, assessment requires PACS grade display as used for diagnostic imaging. The image contrasts are very similar between the reference TSE and the slice accelerated TSE scans. Particularly for the sagittal T2-W fat-saturated images, at 3mm slice thickness, the labral tear could be identified, however, cartilage debonding was beyond the resolution of the images. Utilizing 2mm slice thickness, the pathology could be identified. However, the acquisition times using standard TSE sequences with 2 mm thicknesses, were prohibitively long for clinical utilization (more than 6 min 30 seconds, not shown). As demonstrated in Fig.2, multiband accelerated TSE images with 2 mm thickness reveals the fluid interposed between the underlying bone and the cartilage improving diagnostic accuracy. The acquisition time after acceleration is more clinically feasible (around 4 minutes 30 seconds)

DISCUSSION: In the present study, the utility for Multiband Acceleration for improved diagnostic accuracy was tested for FAI, a very common clinical indication for hip MRI studies. The limited diagnostic value of conventional MRI or MRA at clinical field strength in the assessment of hip cartilage has been previously described and is mainly due to insufficient resolution and volume averaging in an anatomical structure, which has a spherical shape. In addition, identifying cartilage damage in FAI may be difficult due to the particular pattern of cartilage damage in this condition (4). In FAI, cartilage damage is frequently limited to the acetabulum and occurs deep within the tissue as a debonding of articular cartilage from bone (5). This leaves the superficial cartilage intact, a pattern uniquely ill suited for diagnosis with traditional TSE imaging sequences with 3 mm slice thickness, which is best at detecting a void at the articular surface. Alternative routes, such as imaging at ultrahigh magnetic fields have been successfully pursued (6), however, are limited to research settings at this time. The overall acquisition time for this modified multiband TSE based clinical hip imaging protocol can be reduced and supplemented with dedicated high yield sequences with increased slice resolution for improved diagnostic accuracy.

CONCLUSION: Accurate articular cartilage assessment is fundamental to the evaluation of and the clinical decision-making for patients with symptomatic FAI. Young patients with moderate and advanced cartilage degeneration will fail arthroscopic repair and surgeries may need to be converted into Total Hip Arthroplasty. With this improved imaging protocol for clinical 3T application, targeted high resolution imaging with multiband slice accelerated TSE will allow for more diagnostic accuracy in a standard clinical setting.

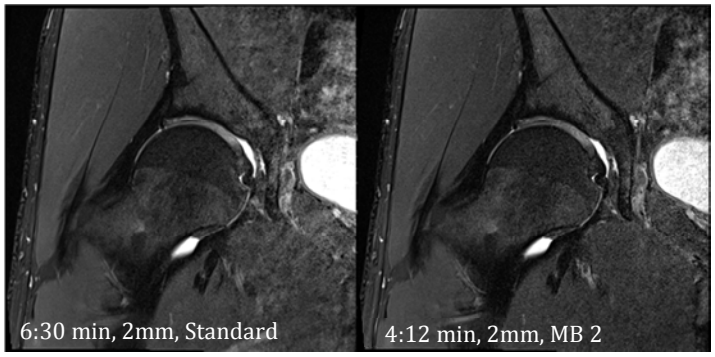

FIG. 1: COR PD-W FS, TR/TE – 4070/41 ms

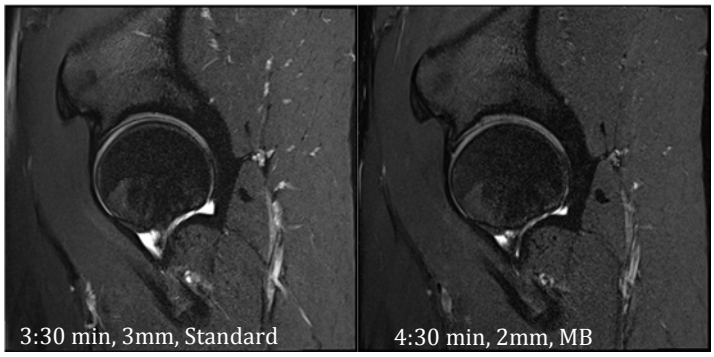

FIG. 2: SAG T2-W FS, TR/TE = 4350/52 ms

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