Highly Accelerated SEMAC for MRI of Arthroplasty Implants: Comparison with optimized TSE and conventional SEMAC

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Purpose

2D turbo spin echo (TSE) pulse sequences with high bandwidth, view angle tilting and slice-encoding metal artifact correction (SEMAC) [1] achieves better metal artifact reduction than optimized TSE sequences [2]. However, current SEMAC methods require increased acquisition times, which may limit its clinical use. Conveniently, SEMAC data is inherently sparse which can be exploited to achieve substantial acceleration [3]. We prospectively test the hypothesis that SEMAC data acquisition can be highly accelerated through pseudo-randomized undersampling and iterative reconstruction while producing image qualities similar to standard SEMAC sequences.

Methods

Ten volunteers with cobalt-chromium knee arthroplasty implants underwent 1.5T MRI (MAGNETOM Aera, Siemens Healthcare) using a TX/RX 15-channel knee coil (QED, Mayfield Village, OH, USA) and a prototype implementation of SEMAC. Sagittal intermediate-weighted TSE, standard TSE SEMAC and accelerated TSE SEMAC sequences (TR, 4300 ms; TE, 33 ms; pixel size, 0.5 x 0.5 mm^2; SL, 3 mm) were acquired with 3:42 min, 9:09 min, and 3:54 min acquisition times, respectively; as well as sagittal STIR TSE, STIR TSE SEMAC and accelerated STIR TSE SEMAC sequences (TR, 4300 ms; TE, 33 ms; TI, 160 ms; pixel size, 0.5 x 0.5 mm^2; SL, 4 mm) with 3:54 min, 8:08 min, and 3:56 min acquisition times, respectively (Figure). 15 SEMAC-encoding steps were applied. For standard SEMAC, GRAPPA acceleration factor of 3 was used in a single phase encoding direction. For accelerated SEMAC, 8-fold incoherent undersampling of the 2D-phase encoding matrix and non-linear, SENSE-type reconstruction with L1-norm-based regularization was used [4]. Three fellowship-trained, full-time musculoskeletal radiologists graded the overall diagnostic quality, artifact, edge sharpness, fat suppression, and visibility of arthroplasty-bone interface, ligaments, and tendons using standardized 5-point Likert scales. Qualitative measurements were statistically analyzed using non-parametric tests. P values of less than 0.05 were considered significant.

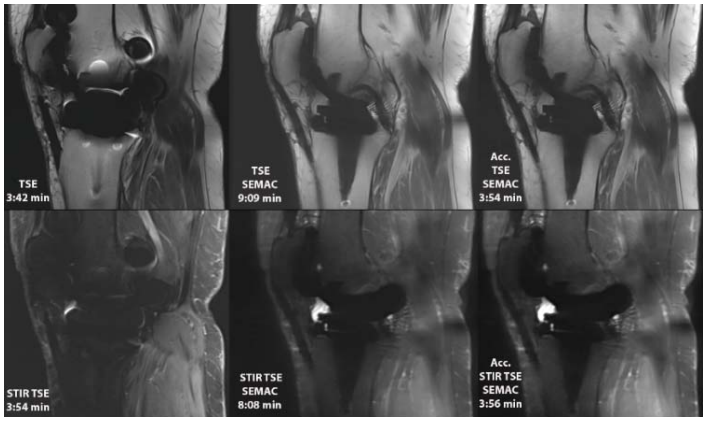

Figure: 64-year-old man with cobalt-chromium total knee arthroplasty implants. Top row shows sagittal intermediate-weighted optimized TSE, standard SEMAC and accelerated SEMAC images. Bottom row shows sagittal optimized STIR TSE, standard STIR SEMAC and accelerated STIR SEMAC images. For each sequence, the acquisition time is given.

Results

The standard and accelerated TSE SEMAC sequences achieved similar high overall diagnostic quality, artifact, fat-suppression, edge sharpness, and visibility of arthroplasty-bone interface, ligaments, and tendons with no statistically significant difference (p = 0.234 – 0.911). Both SEMAC sequences were graded significantly better in overall diagnostic quality, artifact and visibility of arthroplasty-bone interface, ligaments, and tendons, when compared to the standard TSE sequence. Mild blurring occurred on both SEMAC sequences, whereas TSE images showed no blurring.

Discussion

We demonstrate the clinical usability of a highly undersampled TSE SEMAC sequence with iterative reconstruction. This acceleration technique can result in a 50-60% decrease of acquisition time compared to a standard SEMAC sequence with conventional parallel imaging. Our initial results suggest that this method may be suitable to replace the more time-consuming standard TSE SEMAC sequences, enabling entire SEMAC arthroplasty MRI protocols within examination times comparable to those without SEMAC, e.g. typically below 30 min.

Conclusion

Incoherent k-space undersampling and iterative reconstruction can shorten the acquisition time of 2D TSE SEMAC sequences by 50-60% producing diagnostic image quality with clinically acceptable acquisition times.

References

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