Feasibility of Hip Prosthesis Imaging at 3T

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Target Audience MR Technologists, Medical Physicist, Radiologists and Orthopedic Surgeons

Purpose Imaging of patients with total hip replacements (THR) is increasing due to global aging, prolonging lifespans, and obesity. MRI of THRs is useful to look for complications such as fluid collections, bursae, synovitis, loosening, metallosis and ALVAL. Currently, optimal imaging with MRI requires metal artifact reduction (MAR) and is performed preferentially at 1.5T because of severe metal hardware artifacts at 3T. The purpose of this study is to develop optimized protocols for hip prosthesis MRI at 3T by assessing the feasibility of obtaining diagnostic images in acceptable scan times.

Methods After obtaining IRB approval and written informed consent, 10 volunteers with THR (3 male / 7 female; Age: 32-74; Height: 5'2" – 6'1"; Weight: 140 – 250 lbs) were scanned on a clinical 3T scanner (MAGNETOM Skyra, Siemens AG, Erlangen, Germany). A TSE sequence capable of both view angle tilting (VAT) and slice encoding metal artifact correction (SEMAC) techniques[1] was used for MAR. The protocol parameters were optimized according to the following goals and considerations:

- T1w and STIR contrasts in three orthogonal planes with acceptable spatial resolutions and coverage: Sagittal and coronal planes, which are used to assess the components, have higher resolution, thinner slices and greater MAR than axial planes. Axial planes covering the entire pelvis, are used to provide a conventional view of compartmental anatomy and bursae to the implant. T1w images have higher resolution than STIR for the same plane.
- Best possible MAR within clinically realistic scan times (<10min/series and ~45min/exam): Maximize MAR rather than specific image contrast. Use high SEMAC factor and parallel imaging acceleration (iPAT) to trade-off SEMAC gained SNR for scan time reduction. Manage SAR with reduced flip angle and optimized RF pulse profile.

To quantify the degree of MAR achieved at 3T, a phantom constructed with hip prosthesis implanted in cadaver bones and embedded in water/fat gel was imaged using the optimized protocols and then with VAT and SEMAC turned off to measure the change in artifacts.

Results Table 1 lists the optimized sequence parameters and Figure 1 presents comparative *in vivo* examples at 3T and 1.5T.

Series	FOV (mm) / %PFOV / # Sl	Acq Matrix / Thk(mm)	TR/TE/TI (ms)	ETL	iPAT	rBW (Hz/px)	SEM AC	Time
Cor STIR	360/100%/32	320/208 / 3.5	5200/40/200	15	5	822	22	9:37
Cor T1		384/307 / 3.5	660/33	23	5	1302	28	8:42
Sag STIR	300/75%/40	256/125 / 3.5	6100/38/200	13	5	814	24	9:52
Sag T1		320/192 / 3.5	650/32	11	5	1302	24	7:51
AX MOD IR	370/75%/48	256/125 / 6.5	4000/46/180	19	4	814	16	6:32
AX T1		320/168 / 6.5	650/32	17	4	1302	18	6:20

Table 1: The key parameters in the optimized protocols are listed. The total scan time is 49 min. In three subjects, an additional 5 – 10 min was needed due to SAR constraints, forcing a longer TR.

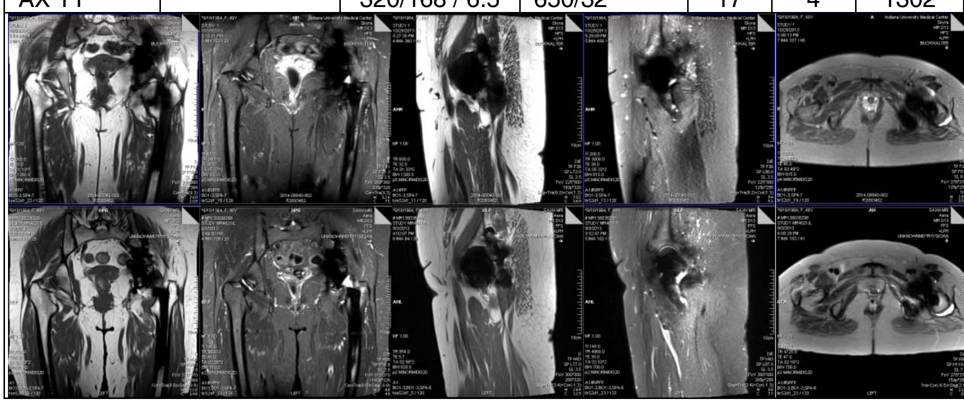

Figure 1: Examples of 3T images (top raw) obtained with the optimized protocols in Table 1 compared with prior images of the same subject at 1.5T (bottom row) also with MAR techniques. The metal artifacts were adequately suppressed at 3T, allowing visualization of anatomy and pathology (fluid collection) near the implant. The extend of artifacts at 3T is close to that at 1.5T.

The measured dimensions of the artifact (long axis/short axis) in the phantom image are 7.85cm/6.95cm for Cor STIR and 7.64cm/6.35cm for Cor T1 with the optimized protocols at 3T, compared with 13.55cm/10.8cm and 12.84cm/9.92cm without MAR techniques. The artifacts measure 9.60cm/6.22cm for Cor STIR and 9.20cm/5.98cm for Cor T1 at 1.5T with MAR and 15.18cm/11.8cm for Cor STIR and 10.85cm/7.79cm for Cor T1 at 1.5T without MAR.

Discussions For some clinical indications such as fluid collections around the prosthesis, 3T imaging is acceptable. Because many femoral stems are titanium or titanium alloys, imaging of stem complications can be performed at 3T approaching 1.5T in effectiveness. If the acetabular cup is also titanium or a titanium alloy, excellent visualization of the metal-bone interface can be achieved, similar to the results at 1.5T. The challenge will continue to be stainless steel hardware and cobalt-chrome alloy components. In these cases, imaging at 3T may not guarantee optimal results. The scan time was acceptable for the majority of subjects. However, two were unable to complete the full examination because of back pain or claustrophobia.

Conclusion Imaging of THR is clinically feasible at 3T using current scan technology and sequences. Valuable clinical information can be extracted, particularly if the clinical question involves the detection of fluid collections and bursae around the implant or if there was a specific question about the femoral stem. Image quality was inferior, but close to scans performed with similar sequences at 1.5T.

References

1. Sutter R et al Reduction of metal artifacts in patients with total hip arthroplasty with slice-encoding metal artifact correction and view angle tilting MR imaging Radiology. 2012 Oct;265(1):204-14