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Is Ultrasound Screening Reliable for Adverse Local Tissue Reaction After Hip Arthroplasty?

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ABSTRACT

There is increasing awareness of prevalence of adverse local tissue reaction (ALTR) surrounding metal-on-metal (MoM) and highly cross-linked polyethylene (HXLPE) bearings, and sensitive and simple screening modalities for ALTR are required. We examined reliability of ultrasound screening for ALTR in 131 hips of 105 patients who received both ultrasound and MRI examinations after hip arthroplasty with MoM or HXLPE bearings. Using the MRI results as reference, sensitivity, specificity and accuracy of ultrasound were 74%, 92% and 84% around MoM bearings, and 90%, 83%, and 85% around HXLPE bearings. Ultrasound detected ALTR in 11 hips that were not shown with MRI. Ultrasound examination is assumed to be a reliable screening tool for detecting clinically important ALTR lesions developing in the anterior region around MoM or HXLPE bearings.

The introduction of renewed metal-on-metal (MoM) hip resurfacing and MoM total hip arthroplasty (THA) for large femoral heads in the late 1990s led to an increasing interest in the use of these systems for hip reconstruction, with more than 1 million units implanted worldwide [1]. Yet, while representative MoM resurfacing systems have yielded favorable 10-year outcomes, particularly in young male patients over time [2,3], there have been increasing concerns regarding the adverse local tissue reaction (ALTR) surrounding MoM bearings [4–10]. These tissue reactions manifested as cysts, fluid collection, enhanced bursae and solid masses, and were collectively referred to as metallosis, delayed-type hypersensitive reaction, aseptic lymphocytic vasculitis-associated lesions, pseudotumor, pseudotumor-like tissue, or adverse reaction to metal debris [4–7]. Various periprosthetic reactions were also found around contemporary metal-on-highly cross-linked polyethylene (HXLPE) bearings associated with corrosion at the modular head-neck junction [11,12]. ALTRs were assumed to be the cause of symptoms, the increased incidence of osteolysis on radiographs, and the requirement for revision surgery. Although the progressive characteristics of ALTR were not clarified, it was found that a delay in revision surgery in patients with extended soft-tissue damage was more likely to result in unsatisfactory outcomes [13]. With the significant frequency of ALTR, even in asymptomatic patients with a normal appearance of radiographs [14], it could be worth encouraging initiative screening for ALTR in both symptomatic and asymptomatic patients to allow for the early detection of a reaction and for the application of surgical treatment before severe soft-tissue destruction develops.

Representative administrative agencies and academic societies have proposed management procedures for patients following MoM arthroplasty, with special attention given to ALTR screening [1,15]. Among the major components in these evaluations, including reports of clinical findings, radiographs, blood metal ion levels, joint aspiration and cross-sectional imaging, the direct assessment of abnormally occupied lesions by magnetic resonance imaging (MRI) or ultrasound is weighted the highest weighting deciding the course of action against ALTR [1,15]. At present, MRI is widely used for assessing ALTR owing to its advantages of superior imaging contrast for soft-tissue abnormalities and the ready availability of three-dimensional assessment of abnormal lesions [8,9,16–20]. However, considering the cost, the required waiting and examination times, and several contraindications (such as for patients with cardiac pacemakers, ferromagnetic hemostatic clips and claustrophobia), MRI may not be suitable as a screening tool for ALTR in a large cohort of patients.

Ultrasound examination has advantages over other imaging modalities, including an absence of ionizing radiation, an absence of metal artifacts introduced by implants, its comparatively low cost and its availability for use at follow-up consultations [21]. Some reports have previously demonstrated the utility of ultrasound in the evaluation of ALTR around MoM bearings [9,22–24]. Therefore, ultrasound may be a suitable tool for the screening of periarticular soft-tissue reactions following hip arthroplasty. However, the reliability of ultrasound screening compared with MRI has been scarcely examined [25].

In our clinic, during routine postoperative follow-up, we have been prospectively conducting ultrasound examinations around the hip in

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consecutive patients who have received primary THA with MoM or contemporary HXLPE bearings. The purpose of this study was to examine the reliability of ultrasound for screening of ALTR compared with the findings on MR images. Since the pathology associated with ALTR and metal susceptibility artifacts on MRI may be different around MoM and HXLPE bearings, we separated patients by bearing type.

Materials and Methods

From September 2010, we have been prospectively conducting ultrasound examinations around the hip at the routine postoperative follow-up of consecutive patients who have received primary THA with MoM or contemporary HXLPE bearings in our institution. We reviewed patients who had received MRI examinations of the hip within one month from the time of their ultrasound examination. Patients were excluded if they were at their <12-month follow-up after surgery, showed loosened acetabular and/or femoral components on plain radiography, had a suspicion or diagnosis of infection in the THA, or experienced dislocation within 12 months before the examination. These exclusions were to eliminate effects other than the bearing on the development of periarticular soft-tissue reactions. In total, we assessed 131 hip arthroplasties in 105 patients, with 64 MoM bearings (MoM group) and 67 HXLPE bearings (HXLPE group). MRI was conducted in patients where an abnormality on ultrasound was detected (41 patients), where sustained discomfort or pain was reported (37 patients), and where there was a diagnosis of osteonecrosis or osteoarthritis in the opposite hip (27 patients). The MoM group comprised 29 hip resurfacings and 35 THAs with a large femoral head of a diameter of ≥42 mm. The HXLPE group comprised bearings with 13 Longevity liners, 42 Crossfire liners and 12 X3 liners (Table 1). All operations were performed in the lateral position via a posterior approach without trochanteric osteotomy. A cementless porous-coated cobalt-chromium cup was used in patients in the MoM group, and a cementless plasma-sprayed titanium-shell was used in patients in the HXLPE group. The MoM group had a significantly higher frequency of male patients than the HXLPE group, reflecting the generally recommended indication of hip resurfacing in males [26]. Patients were specifically asked if they experienced pain, stiffness, or discomfort in the groin, hip, and thigh. Subtle, abnormal feelings were included in the description of pain, because abnormal periarticular soft-tissue reactions may present with only subtle symptoms [9]. No significant differences in the frequency of symptoms were observed between the two groups.

Ultrasound

Ultrasound examination was performed using a Toshiba scanner and a 6-MHz convex transducer or a 7.5-MHz linear transducer (Xario XG SSA-680A; Toshiba Medical Systems, Tochigi, Japan) by one observer (T.N.). Longitudinal images parallel to the neck of the femur (resurfacings) or neck of the femoral component (THAs), and transverse images perpendicular to the body axis were obtained so as to cover the entire anterior area of the hip joint in the supine position. In the lateral position, longitudinal and transverse images covering the lateral area around the greater trochanter and the posterior area of the hip were obtained. Ultrasound images were stored as still pictures and in video format as the hip moved actively in flexion as well as in internal and external rotations; these videos were to facilitate differentiation among the acetabular/femoral bone, acetabular/femoral components, joint cavity, capsule, and the surrounding ligaments/muscles.

After an interval of ≥1 month, the still and video images were evaluated by two observers (T.N., M.T.) via consensus agreement, without knowledge of the clinical symptoms or MRI findings. Three qualitative classifications were determined (Fig. 1): (a) "normal pattern" without soft-tissue abnormality (Movie 1a); (b) "cystic pattern", with marked hypoechoic space between the capsule and bearing surface or extending from the joint space (Movie 1b); and (c) "solid pattern", with irregularly enlarged lesions, including predominantly hyperechoic materials (Movie 1c). The cystic and solid patterns were considered abnormal.

MRI

The MRI protocol comprised T1- and T2-weighted fast spin echo (FSE), and short-tau inversion recovery (STIR) sequences [8,9] in the coronal and axial directions at 1.5 Tesla equipment (HDx; General Electric Healthcare, WI, USA). To reduce metal susceptibility artifacts from the implant, fat suppression was performed by high-frequency encoding bandwidths (±62.5–125 kHz), FSE, and STIR sequences [16–18,23]. The presence or absence of abnormal lesions, such as fluid collection, cysts, and solid masses (Fig. 1), was evaluated by two observers (T.S., N.S.) without knowledge of the symptoms and ultrasound findings. If abnormal lesions were present, the location was noted with reference to one of the three sections on the axial images (zone A: anterior to the joint; zone L: lateral to the greater trochanter; zone P: posterior to the joint) (Fig. 2). The greatest size of the lesion in either the axial or coronal MR images and the characteristics of abnormal lesions were evaluated according to

Table 1
Demographics of Patients in the MoM and HXLPE Groups.

	MoM Group (n = 64)	HXLPE Group (n = 67)	*P* Value[b]
Sex (male/female)	27/37	9/58	0.0003
Age (years) [a]	61 (30–86)	67 (50–82)	0.0791
Implant *in situ* (months) [a]	88 (12–168)	68 (12–162)	0.0102
Operation (Hip resurfacing/THA)	Hip resurfacing: 29 THA: 35	THA: 67	
Brand of implant[c]	BHR: 52 ADEPT: 12	Longevity liner: 13 Crossfire liner: 42 X3 liner: 12	
Head size (mm)[a]	46 (42–54)	31 (26–44)	<0.001
Radiological findings			
Presence of osteolysis	5 (8%)	2 (3%)	0.2667
Clinical findings			
Presence of symptoms	34 (53%)	38 (57%)	0.7272

Note: Values are number of hips (%) unless otherwise stated.
[a] Values are averages (ranges).
[b] Data grouped into distinct categories were compared using the Fisher exact test, and the continuous data using the Mann-Whitney U test.
[c] BHR: Birmingham Hip Resurfacing, Smith & Nephew, TN, USA; ADEPT: Finsbury Orthopaedics, UK; Longevity liners: Zimmer, IN, USA; Crossfire liners and X3 liner: Stryker Howmedica Osteonics, NJ, USA.