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ORIGINAL STUDY

The use of ultrasound in the diagnosis of adverse reaction to metallic debris following metal on metal hip replacement

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Background and purpose: The role of imaging in the diagnosis of adverse reaction to metallic debris (ARMD) with metal on metal (MoM) hip replacements is still unclear. A comparative study was undertaken to evaluate the efficacy of ultrasound in diagnosis of ARMD.

Patients and methods: The study group included 35 patients with a clinical and histological diagnosis of ARMD. The control group included 16 asymptomatic patients of MoM hip replacements with low blood metal ions levels. Various sonographic features around hip in patients diagnosed with ARMD were recorded.

Results and Interpretation: Fluid collection around iliopsoas and gluteal tendons following a MoM hip replacement is highly suggestive of ARMD and should not be thought of as an uncomplicated tendonitis. This study shows ultrasound as a reliable investigation in the diagnosis of ARMD following MoM hip replacements.

Keywords : ultrasound ; metal on metal hip replacement ; adverse reaction to metallic debris.

INTRODUCTION

Metal on metal (MoM) bearing surface for hip replacement has been a cause for concern in recent joint registry reports *(1,24)*. Whilst hip resurfacing has the advantage of femoral bone conservation and was advocated for patients who are likely to outlive a primary conventional total hip replacement, it has a unique set of complications such as fracture neck of femur and adverse reaction to metallic debris (ARMD). ARMD is a challenging problem associated with MoM hip replacements, an umbrella term encompassing metallosis, pseudo-tumors and aseptic lymphocytic vasculitis associated lesions (ALVAL) as there is no clear consensus to differentiate each of the terminology. This term has been used in previous publications *(16,18)*. The Medicines and Healthcare products Regulatory Agency (MHRA) had earlier issued an alert with reports of revision surgery for soft tissue reactions following MoM hip arthroplasty *(21,22)*. Recommendations for blood metal ion level testing and cross sectional imaging has been advocated for symptomatic patients. The role of imaging in the diagnosis of this complex problem is unclear. A retrospective review of results in a comparative

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study was undertaken to evaluate the efficacy of ultrasound in the diagnosis of ARMD.

PATIENTS AND METHODS

The study group included 35 patients (26 female and 9 male) with a clinical and histological diagnosis of ARMD following a MoM hip arthroplasty. Mean age of the patients in the study group was 55.8 (range 40 -71) years. The control group included 16 asymptomatic patients (4 female and 10 male) with metal on metal hip replacements, who had low blood metal ions levels (Whole blood chromium and cobalt levels less than 2 µg/L). The mean age of the patients in the control group was 65.5 (range 32 – 80) years. The primary procedure was either a MoM hip resurfacing arthroplasty or resurfacing femoral head on a conventional femoral stem. The hip resurfacing prosthesis used in patients included in the study and control groups was the Articular Surface Replacement (ASR® DePuy International Ltd). The femoral component of the ASR (ASR XL form) was used in some patients with a stem (Corail or SROM® DePuy International Ltd) to articulate with the standard ASR resurfacing acetabular component. The bearing surfaces in both the above forms of hip replacement are therefore identical in terms of composition and manufacturing processes. The study and control groups have been drawn from a series of more than 500 ASR hips used at the senior authors centre from 2004 to 2009. This series of patients has been described previously in other studies. Only patients who had ultrasound evaluation have been included in the current study. All patients underwent the primary hip arthroplasty through a posterior hip approach by the senior author. All patients in the study (ARMD) group subsequently underwent a revision surgery to an alternative bearing surface and intra-operative tissue samples were sent for histological analysis. The histological features of ARMD in our series have been described in detail in previous studies *(16,18)*. In general, most of the tissues retrieved from ARMD patients exhibit two dominant, and often co-existent, cellular responses: histiocytic and lymphocytic.

All ultrasound procedures were reported by a musculoskeletal radiologist and the procedure was performed using a high frequency probe of 9-13 MHz (Sonoline Antares® Siemens). All ultrasound procedures were performed on the anterior and lateral aspects of the operated hip. No specific instructions of rest or exercise were given to the patients prior to having the ultrasound. Some of the patients in the later part of the series had ultrasound imaging on the posterior aspect along with the standard. Sonographic evidence of fluid collection around the hip was recorded and qualified by its site and characteristics (anechoic or echogenic). It is not possible to quantify the exact amount of fluid collection by an ultrasound procedure. Anechoic effusion is a dark looking area without internal echoes when compared to echogenic effusion which contain internal echoes or reflections. Iliopsoas and gluteal tendons along with associated bursae were also characterised with ultrasound imaging. Reflection of iliopsoas tendon was noted on ultrasound of the anterior aspect of hip at the level of acetabulum and traced till the neck of femur. Normal tendons would inherently have increased reflectivity. Abnormalities such as low or absence of tendon reflection found during the ultrasound procedures were recorded.

RESULTS

Study Group

All patients diagnosed with ARMD had abnormalities identified on ultrasound. Sonographic evidence of fluid inside the joint was noted in 30 patients (85.7 %) but fluid confined to the joint only was seen in 2 patients (5.7%) out of 35 procedures.

Sonographic evidence of significant fluid extravasation beyond the joint was seen in 33 patients (94.3 %). Amongst the patients with fluid extravasation beyond the joint, 32 and 30 patients had collections in the region of iliopsoas and trochanteric bursa respectively (Figure 1, 2). Echogenic reflections in fluid collection were noted in 31 out of 35 procedures (88.6 %).

Hypo-reflectivity of iliopsoas and gluteus tendons was seen in some patients with echogenic fluid collections around the hip. Absence of tendon

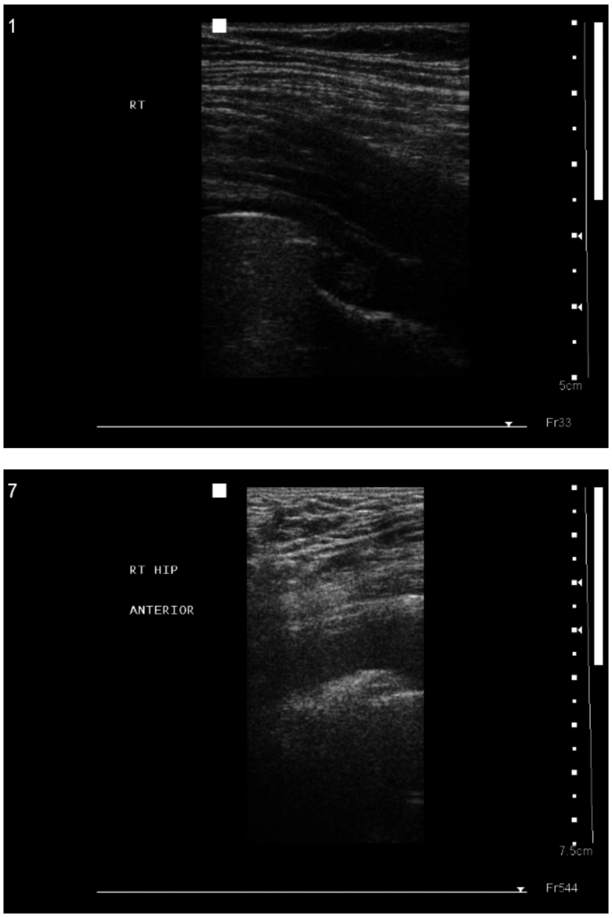

Fig. 1. — (a, b): Ultrasound images for anterior aspect of hip showing fluid collection and hypo-reflectivity of iliopsoas tendon

Fig. 2. — (a, b): Ultrasound images for lateral aspect of hip showing fluid collection and hypo-reflectivity of gluteal tendons

reflection on ultrasound was seen in other patients and this may be because of damaged or ruptured tendons. Progression of such changes was noted in 5 patients, who had a repeat ultrasound within an interval of 3-6 months prior to the revision hip surgery. 1 patient had a progression from anechoic to echogenic joint effusion.

Control Group

Only one patient out of 16 patients in the control group had a sonographic evidence of small anechoic effusion inside the joint (6.25 %). No patient in the control group had sonographic evidence of fluid extravasation beyond the joint.

The ultrasound findings in the study (ARMD) group were statistically significant (p value < 0.05) when compared to the control group (Bar diagram in Figure 3). The sensitivity of the different ultrasound findings varied for the diagnosis of ARMD (Table I). The predictive values of individual ultrasound features were analysed (Table II, III and IV).

Table I. — Sensitivity for different ultrasound findings in ARMD diagnosis

	Sensitivity
Fluid confined to the joint only	5.7 %
Fluid extravasation beyond the joint	94.3 %
Echogenic reflections	88.6 %

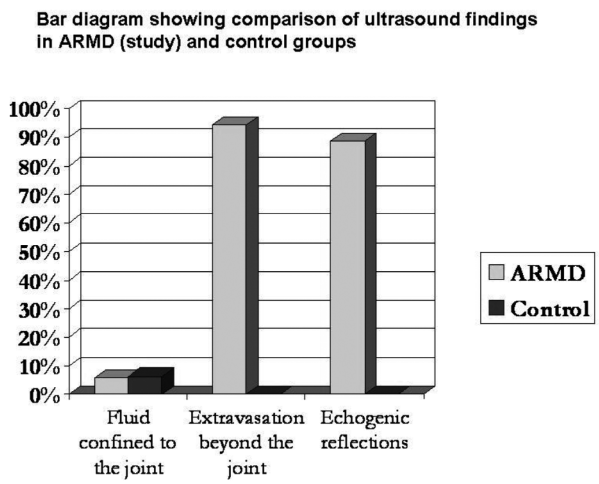

Fig. 3. — Bar diagram showing comparison of ultrasound findings in ARMD (study) and control groups

Table II. — Predictive values for ultrasound evidence of fluid confined to the joint (or inside the joint only)

Fluid confined to the joint		ARMD Diagnosis		
		Positive	Negative	
USG Hip	Positive	2	1	3
	Negative	33	15	48
		35	16	51

Sensitivity =TP/(TP+FN) = 2/(2 + 33) = 5.7 %

Specificity =TN/(FP+TN) = 15/(1+15) = 93.7 %

Positive Predictive Value =TP/(TP+FP) = 2/(2 + 1) = 66.6 %

Negative Predictive Value =TN/(FN+TN) =15/(33 +15) = 31.25 %

Table III. — Predictive values for ultrasound evidence of fluid extravasation beyond the joint

Fluid extravasation beyond the joint		ARMD Diagnosis		
		Positive	Negative	
USG Hip	Positive	33	0	33
	Negative	2	16	18
		35	16	51

Sensitivity = TP/(TP+FN) = 33/(33 + 2) = 94.3 %

Specificity = TN/(FP+TN) = 16/(0 + 16) = 100 %

Positive Predictive Value = TP/(TP+FP) = 33/(33 + 0) = 100 %

Negative Predictive Value = TN/(FN+TN) = 16/(2 + 16) = 88.8 %

Table VI. — Predictive values for ultrasound evidence of echogenic fluid reflections

Echogenic reflections		ARMD Diagnosis		
		Positive	Negative	
USG Hip	Positive	31	0	31
	Negative	4	16	20
		35	16	51

Sensitivity = TP/(TP+FN) = 31/(31 + 4) = 88.6 %

Specificity = TN/(FP+TN) = 16/(0 +16) = 100 %

Positive Predictive Value = TP/(TP+FP) = 31/(31 +0) = 100 %

Negative Predictive Value =TN/(FN+TN) = 16/(4 + 16) = 80%

DISCUSSION

Metal ion levels following hip resurfacing has been related to the orientation, component size and the type of prosthesis *(3,8,17,19,28)*. Local and systemic effects of metal ions following hip arthroplasty has been discussed by several authors *(14)*. Willert et al described an immunological reaction in retrieved periprosthetic tissues with characteristic histological features of diffuse and perivascular infiltrates of T and B lymphocytes and plasma cells *(31)*. This feature of of aseptic lymphocytic vasculitis associated lesions (ALVAL) was suggested as a possible cause of failure in MoM hip replacements *(5,7)*. Hart et al have shown the relationship of circulating metal ions to the variation in lymphocyte counts following MoM hip replacements *(13)*.‘Pseudotumor’ is a term used to describe the soft tissue mass in patients presenting with varied problems following hip resurfacing

(10,25). Increased wear with MoM articulation is described as a cause of pseudotumors and early failure of MoM hip replacements *(4,15)*. The outcome for revision surgery following pseudotumor formation is considered poor when compared to that of revision of resurfacing for other causes *(11)*. There has been considerable debate amongst orthopaedic surgeons and anxiety amongst general practioners about the need for early diagnosis of ARMD. Several hip surgeons have come up with recommendations for blood metal ion level testing and cross sectional imaging in symptomatic patients with MoM hip replacements *(9,29)*. This is similar to the recommendations suggested later by MHRA *(21,22)*. Ultrasound has been suggested as 'probably the best initial investigation if a pseudotumor is suspected' *(25)*. MRI, CT and arthrography are other forms of imaging used for investigation of this problem. Hart et al have described a protocol to evaluate painful MoM hip with the use of metal artifact reduction MRI, three dimensional CT measurements of the component position and metal ion analysis *(12)*. Metal artifact reduction sequence magnetic resonance imaging (MARS - MRI) requires special software and has logistical implications for routine use in evaluating painful MoM. Several case reports have described the varied presentation and different imaging used for diagnosis of soft tissue mass formation in MoM hips *(2,6,23,30)*.

Ultrasound is an inexpensive, non-invasive and dynamic investigation and has been shown to be reliable in diagnosis of ARMD. Ultrasound has no risk of radiation unlike other forms of imaging such as CT scan which involves ionising radiation. Ultrasound imaging is operator dependent and requires considerable experience for the appropriate interpretation. Ultrasound has been previously used for investigation of painful conventional hip replacements *(26,27)*. Its role in evaluating painful MoM hip replacements is still evolving. Our study shows the high sensitivity for fluid extravasation beyond the joint in diagnosis of ARMD following metal on metal hip arthroplasty. Fluid collection around iliopsoas and gluteal tendons is highly suggestive of ARMD and should not be thought of as an uncomplicated tendonitis.

Diminished reflection of tendons seen in patients with ARMD could be a nonspecific finding because a similar appearance can be seen in an uncomplicated tendonitis. But this was a consistent ultrasound finding in the study group and would be a useful feature for diagnosis of ARMD when combined with other sonographic findings.

Recent MHRA alerts discuss the need for follow up and evaluation of patients with painful MoM hip replacements *(21,22)*. Persisting groin pain following a MoM hip replacement can be due to several causes. A detailed clinical examination and investigations are required to evaluate the cause of such pain. Ultrasound findings in our series may not be specific to ARMD but when combined with clinical findings, was found to be an extremely useful investigation. Other causes of swelling and pain such as infection following any form of total hip replacement should be excluded before a diagnosis of ARMD is contemplated. Plain radiographs have been used as a cost effective tool to determine component orientation but some authors would prefer a CT measurement to evaluate component position *(12,20)*. We feel that a CT scan would be also useful for evaluating osteolysis, particularly in patients with metallosis.

There are some limitations to our study considering the small number of patients involved in the control and study groups. The control group is smaller than the study group. Whilst our study showed high sensitivity and specificity for various ultrasound findings in diagnosis of ARMD, it would be difficult to generalize the reliability of ultrasound characteristics as this is very much operator dependent. The surgical approach and technique could have some implication on the ultrasound features of fluid distribution and tendon reflection. These issues should have minimal effect on our results because all patients in the study and control groups had similar MoM bearing hip replacement performed by a single surgeon (senior author) through a standard posterior approach. Although the radiologist was not prior informed whether the patient was in the study or control groups, it was not possible for a fully blinded study as he would be aware of some patient symptoms such as pain. We also recognize that this study does not describe the ultrasound characteristics of non-ARMD diagnosis of painful MoM hips.

Use of ultrasound in evaluating painful MoM hips has considerable implications with the feasibility of using it as a screening investigation when compared to the cost involved in using MRI for the same. We recommend a standard protocol for ultrasound and repeat examination in cases of equivocal initial imaging for evaluating symptomatic patients with MoM hip arthroplasty. We have seen a progression of findings on ultrasound imaging in some patients, who had equivocal findings on initial examination. An experienced musculoskeletal radiologist would be an asset to interpret the ultrasound images in ARMD. Further studies, perhaps a randomised study comparing ultrasound to other forms of cross-sectional imaging like MRI may be useful in future.

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