The Journal of Arthroplasty 31 (2016) 146–151

Contents lists available at ScienceDirect

The Journal of Arthroplasty

journal homepage: www.arthroplastyjournal.org

How Should We Follow-Up Asymptomatic Metal-on-Metal Hip Resurfacing Patients? A Prospective Longitudinal Cohort Study

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ARTICLE INFO

Article history:
Received 25 May 2015
Accepted 11 August 2015

Keywords:
asymptomatic
blood metal ions
follow-up
hip resurfacing
metal-on-metal
ultrasound

ABSTRACT

Current surveillance for metal-on-metal hip resurfacing (MoMHR) patients is not evidence based. This study established changes that occurred in 152 asymptomatic MoMHRs using repeat ultrasound and patient-reported outcomes. Factors associated with (1) ultrasound progression and (2) developing new pseudotumors were analyzed. Patients underwent repeat assessments 4.3 years later. Ultrasound progression was observed in 19% (n = 29), with 10% (n = 15) developing new pseudotumors. Key predictors of ultrasound progression included high blood cobalt ($P = .00013$) and chromium ($P = .00065$), and high initial ultrasound grade ($P = .003$) and volume ($P = .036$). No asymptomatic MoMHRs with initially normal metal ions (<2 μg/L) and normal ultrasounds (33% of cohort) developed new pseudotumors. This patient subgroup does not require repeat follow-up within 5 years.

Numerous metal-on-metal (MoM) hip arthroplasty designs have experienced high failure rates due to pseudotumors [1,2]. Patients developing these problems often require revision surgery. As lesions can be destructive with significant bone and muscle damage, outcomes after revision can be poor [3,4]. To identify patients with pseudotumors early, regulatory authorities have published guidance regarding the regular follow-up of MoM hip patients [5–7].

Presently, there is no consensus on how to follow up asymptomatic MoM hip resurfacing (MoMHR) patients, with this patient subgroup being the most difficult to manage clinically [8,9]. European guidance recommends annual follow-up with radiographs and blood metal ions in these patients. However, the US Food and Drug Administration guidance recommends annual clinical review, whereas the Medical and Healthcare Products Regulatory Agency in the United Kingdom recommend reviewing asymptomatic MoMHR patients according to local protocol. Recent work has demonstrated that worldwide MoM hip follow-up guidance is neither evidence based nor financially sustainable, with most protocols lacking the sensitivity to detect asymptomatic pseudotumors [10].

Most MoMHR patients remain asymptomatic and do not develop pseudotumors [11,12]. However, a small but significant number of asymptomatic patients do develop pseudotumors [8,9,13], and it is important to identify these individuals early in order to prevent bone and soft tissue damage. At present, there is no clear guidance as to which parameters should be used to distinguish asymptomatic MoMHR patients who can be safely discharged and need not be subjected to repeated investigations from those asymptomatic MoMHR patients who need monitoring. Decisions regarding which asymptomatic MoMHR patients require monitoring, at what intervals, and how frequently such follow-up should be repeated require well-designed prospective longitudinal cohort studies. At present, very few such studies exist involving MoMHR patients, with most reporting on serial magnetic resonance imaging (MRI) at short-term follow-up in small cohorts [14,15]. Ultrasound is another commonly used and recommended modality for cross-sectional imaging in MoM hip patients [5,16]. It has many advantages over MRI: it is cheaper, faster to perform, and not affected by metal artifact. Furthermore, ultrasound is sensitive when screening for pseudotumors [16] with results comparable to MRI [17], and recent work suggests that ultrasound has a role in the surveillance of asymptomatic pseudotumors [18].

This article reports on a prospective cohort of 152 asymptomatic MoMHRs who were comprehensively assessed between 2007 and 2008 [8]. Ultrasound and patient-reported outcomes were repeated at a mean of 4.3 years since initial assessment and at a mean of 8.2 years since primary MoMHR. The present study aimed to assess factors associated with (1) ultrasound finding progression and (2) developing new pseudotumors. This information will assist in risk stratifying patients,

One or more of the authors of this paper have disclosed potential or pertinent conflicts of interest, which may include receipt of payment, either direct or indirect, institutional support, or association with an entity in the biomedical field which may be perceived to have potential conflict of interest with this work. For full disclosure statements refer to http://dx.doi.org/10.1016/j.arth.2015.08.007.

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http://dx.doi.org/10.1016/j.arth.2015.08.007

thereby allowing recommendations to be devised for the follow-up of asymptomatic MoMHR patients.

Patients and Methods

Between 2007 and 2008, we performed an ethically approved prospective cohort study involving 201 asymptomatic MoMHRs in 158 patients (mean age, 56.0 years; 61% male) [8]. This study was designed to determine the prevalence of pseudotumors in asymptomatic patients after MoMHR, given little was known about this clinical entity at the time. Therefore, asymptomatic MoMHR patients participating in this initial study were assessed at variable time points from their index arthroplasty, although all patients were assessed at a minimum of 3 years from MoMHR. In 2007/2008, all patients completed an Oxford Hip Score (OHS) and the University of California, Los Angeles (UCLA) activity score questionnaire. Patients were also investigated using hip radiographs, blood metal ions, and hip ultrasound. Details about this initial patient cohort and the investigations performed have been described previously [8]. In 2012/2013, these patients underwent repeat hip ultrasound examination and completed a further OHS and UCLA score questionnaire. The OHS was scored from 0 (worst outcome) to 48 points (best outcome) [19], and the UCLA activity scores were from 1 (wholly inactive) to 10 (regular participation in impact sports) [20].

Repeat investigations were performed in 152 of the asymptomatic MoMHRs (122 patients) at a mean of 4.3 years (range, 3.2-5.0 years) from the initial assessment (Table 1). The mean duration from MoMHR implantation to final follow-up was 8.2 years (range, 6.2-12.4 years). Forty-nine MoMHRs in 36 patients from the initial cohort were not recruited to the present study for the following reasons: death (4 hips in 3 patients), revision to a total hip arthroplasty (16 hips in 13 patients), declined to participate, or did not attend scheduled ultrasound appointments (29 hips in 20 patients). The demographics for these 49 MoMHRs as well as the results of their initial assessment are summarized (Table 2).

Mean time from initial assessment to revision for the 16 revised MoMHRs was 2.5 years (range, 0.4-4.4 years), and the mean time from primary MoMHR to revision was 6.6 years (range, 3.1-9.4 years).

Table 1
Summary of the Study Cohort.

	152 Hips in 122 Patients
Gender, male/female	99 (65%)/53 (35%)
Age at first ultrasound (y), mean (range)	60.7 (33.3 to 74.7)
Patients with unilateral or bilateral MoM hips, unilateral/bilateral	92 (75%)/30 (25%)
Hip resurfacing design	
Birmingham Hip Resurfacing (Smith & Nephew, Warwick, UK)	82 (54%)
Conserve Plus (Wright Medical, Memphis, TN)	64 (42%)
Recap (Biomet, Bridgend, UK)	6 (4%)
Time between hip resurfacing and first ultrasound (y), mean (range)	3.9 (3.0 to 7.4)
Time interval between repeat ultrasounds (y), mean (range)	4.3 (3.2 to 5.0)
Acetabular component position	
Inclination (°), mean (range)	46.2 (21.3 to 65.5)
Anteversion (°), mean (range)	15.9 (2.0 to 33.0)
Blood metal ion concentration (μg/L), median (IQR)	
Cobalt	2.3 (1.5 to 4.2)
Chromium	2.4 (1.3 to 4.9)
OHS (0-48 scale)	
Median (IQR)	
- 2007/2008 score	47.0 (45.0 to 48.0)
- 2012/2013 score	46.0 (42.8 to 48.0)
Mean (range)	
- Change in score	−0.9 (−17 to 7)
UCLA score (1-10 scale), mean (range)	
- 2007/2008 score	7.2 (3 to 10)
- 2012/2013 score	7.2 (2 to 10)
- Change in score	0.1 (−4 to 5)
Hips with pseudotumors revised after repeat ultrasound	4 (3%)

The indications for the 16 MoMHR revisions were symptomatic pseudotumor (n = 14), dislocation (n = 1), and femoral component loosening (n = 1). All hips were revised to a non-MoM bearing. The 14 revisions for symptomatic pseudotumor all had blood metal ions above 2 μg/L and abnormal ultrasound imaging when assessed in the initial study (Table 2). The mean pseudotumor volume on initial ultrasound was 48.5 cm^3 (6.8-135.2 cm^3), with 50% (n = 7) cystic in nature, 36% (n = 5) mixed, and 14% (n = 2) solid lesions. All pseudotumors were confirmed both intraoperatively and on histopathologic examination. At latest follow-up, the mean postrevision OHS was 31.4 (range, 11-48). Fifteen revised MoMHRs remain in situ, with 1 pseudotumor patient subsequently undergoing re-revision for recurrent dislocation within 8 months of the revision procedure.

The same experienced musculoskeletal radiologist performed all ultrasound examinations in the initial study and the 2012 study. Ultrasound imaging (Sonoline Antares; Siemens Medical Solutions, Malvern, PA) was performed following verbal patient consent using a standard technique, which encompasses a systematic approach to assess the anterior, medial, lateral, and posterior hip regions. This examination technique is recommended by the European Society of Skeletal Radiology and is widely used for examining the hip joint [21], and allows for the assessment of a range of pathologies associated with hip arthroplasty [22].

The radiologist graded all scans and measured volumes of any lesions present. In each instance, the radiologist was blinded to all clinical information. Each ultrasound scan was assigned to one of four grades: (1) normal, (2) bursa (psoas bursa, trochanteric bursa/thickening), (3) pathological effusion, and (4) pseudotumor. A small amount of intra-articular fluid was considered normal, but when the depth of fluid exceeded 15 mm at the anterior joint line, this was classified as a pathological effusion. Simple fluid collections in the anatomical psoas or trochanteric bursa were classified as such, but complex bursal collections with evidence of communication with the hip joint were classified as pseudotumors. A pseudotumor was defined as a cystic, solid, or mixed mass with evidence of communication with, but extending beyond the confines of, the anatomical hip joint. When lesions were present, the volume (product of the maximum recorded dimension in each of three orthogonal planes in centimeters), consistency (solid, cystic, or mixed), and location were recorded for each lesion.

Outcomes of interest were (1) the proportion of MoMHRs with progression of ultrasound findings between repeat scans and (2) the proportion of MoMHRs developing new pseudotumors between repeat ultrasounds. Hips were considered to have progression of ultrasound findings between repeat scans if at least one of the following criteria were present: (1) an increase in ultrasound scan grade, (2) an increase in lesion volume but no change in ultrasound grade, (3) change in pseudotumor consistency from liquid to solid, and/or (4) need for revision surgery. Progression of pseudotumors to a solid consistency has been associated with adverse outcomes [3,23]; therefore, this change was deemed to be clinically significant. All MoMHRs not meeting these criteria after repeat ultrasound examination were considered to have no evidence of progression.

Statistical analysis

All statistical analyses were performed using the R library [24]. Either the median and interquartile range (IQR) or the mean and range were used depending on data distribution. For paired analyses, change in volume between ultrasound scans was assessed using a paired *t* test, and change in grade between scans was assessed using a Wilcoxon signed rank test. To assess factors associated with progression of ultrasound findings and the development of new pseudotumors, statistical tests were chosen to reflect the exposure variable and data distribution. These included unpaired *t* tests (age, acetabular inclination and anteversion, time from primary MoMHR to first scan, time between repeat scans, change in OHS, UCLA score, initial lesion volume), the