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Femoral Neck Stress Shielding after Birmingham Mid Head Resection Hip Arthroplasty – Case Report and Literature Review

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Authors' contributions

This work was carried out in collaboration between both authors. Author PW designed the study and wrote the manuscript. Author SK assembled and edited the radiology imaging figures. Both authors performed literature searches and proof read the manuscript for final approval.

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Case Report

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ABSTRACT

We describe the presentation of substantial neck thinning due to stress shielding about a well-fixed Birmingham Mid Head Resection femoral implant. Despite significant resorption of proximal peri-articular bone adjacent to the modular femoral head, secondary bone remodeling about the implant stem and proximal femur has occurred and stress shielding has appeared to stabilize, resulting in a satisfactory clinical outcome to date. For total hip arthroplasty utilizing short femoral implants we recommend consideration of alternative design stems to reduce the risk of stress shielding.

Keywords: Hip; mid-head resection; arthroplasty; metal on metal; stress shielding.

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1. INTRODUCTION

Management of younger aged higher activity demand patients with established hip joint osteoarthritis represents a difficult clinical problem. Not only do younger patients have longer to live but they also typically demonstrate less favorable arthroplasty survivorship rates [1,2]. Considerations particularly relevant for the selection of arthroplasty devices in this group include bearing surface durability, impact resistance, bone preservation and the ease of future revision.

While the use of metal on metal bearing hip arthroplasty implants has substantially declined, HRA continues to demonstrate exceptional results in appropriately selected patients [1,3-6]. HRA is traditionally indicated in younger patients with the most favorable results being observed in males with larger size femoral head geometry. As HRA requires sufficient bone quality to support the femoral component, the procedure may be contraindicated in the presence of extensive femoral head cystic change, avascular necrosis, proximal femoral deformity or significant osteopenia. The Birmingham Mid Head Resection arthroplasty (BMHR; Smith & Nephew Advanced Surgical Devices; TN, USA) was therefore developed in order to address the requirements of young patients with osteoarthritis assessed as unsuitable for HRA on these grounds [7].

The BHMR is a short stem total hip replacement with a large diameter metal on metal bearing articulation (Fig. 1). Typically the monoblock cobalt chromium BHR component is used for the acetabular side bearing. The BMHR femoral implant is modular with two components. The femoral head component resembles a traditional resurfacing implant but requires subtotal resection of the femoral head and couples with the BMHR stem component by means of a morse taper junction. The BMHR stem is titanium alloy with a splined distal portion for rotational stability and a proximal conical flare with hydroxyapatite coating designed to promote proximal osseointegration and physiologic loading. The BMHR (femoral)/ BHR (acetabular) implant has a 5 year revision rate of 5.8% in the 2014 Australian National Joint Replacement Registry [1].

2. CASE PRESENTATION

A 41-year-old male presented with established secondary osteoarthritis of the right hip due to haematogenous septic arthritis diagnosed at age of 13. Successful eradication of joint infection had been conducted by open joint lavage by anterior approach arthrotomy and antibiotic management. Since childhood the patient remained infection free with normal inflammatory markers.

Fig. 1. Birmingham Mid Head Resection (BMHR) arthroplasty femoral component

At age 38 the patient reported his first onset of groin pain consistent with symptomatic articular pathology. Radiographs demonstrated established osteoarthritis of the right hip with a small-moderate sized acetabular geode and slight deformity of proximal femur (Fig. 2). DEXA scan demonstrated moderate reduction of bone density in both hips and lumbar spine (average T Score -2.1). Endocrinology service review identified no risk factors for osteopaenia on clinical history or blood test evaluations.

On the basis of the progressive arthritic symptoms at age 41, the patient was recommended for treatment by hip joint arthroplasty. Birmingham Mid Head Resection (BMHR) arthroplasty was selected in consideration of the patient's younger age, high activity demands and relative osteopenia.

Surgery was conducted via a standard posterior approach to the hip joint using a 58 mm BHR acetabular component, a 52 mm BMHR femoral head implant and a size 3 stem (Fig. 3). For implantation of BHR and BMHR metal-metal devices we favor the posterior approach as it facilitates consistently reproducible access for accurate implantation of the acetabular component despite retention of the femoral head. The patient's surgical intervention and peri-operative recovery was unremarkable. Tissue specimens and culture swabs taken at the time of surgery revealed no evidence of residual infection.

Fig. 2. Preoperative radiograph demonstrating established right hip secondary osteoarthritis

Fig. 3. Immediate postoperative radiograph after management by Birmingham mid Head resection arthroplasty

At one-year post surgery the implants were radiographically stable and well osseo-integrated (Fig. 4). Clinically the patient was pain-free and had resumed high-grade physical activity including longer distance cycling.

Clinical review at 2-years post surgical intervention demonstrated early superior femoral neck thinning beneath the femoral head component (Fig. 5). The patient remained asymptomatic and functionally excellent, riding his bicycle 150 km per week and he was also pain-free whilst participating in multiple other sporting pursuits. MRI demonstrated no evidence of fluid collections or soft tissue irregularity about the joint (Fig. 6). Bone Scan demonstrated generalized osteoblastic activity about the proximal femur consistent with bone remodeling. Minimal bone scan activity immediately adjacent to the femoral stem prosthesis was observed (Fig. 7). Blood inflammatory markers including C reactive protein, white cell count and ESR were unremarkable. The blood plasma chromium level was 31 nmol/L (reference range 10-100 nmol/L) and the blood plasma cobalt level was acceptably raised at 51 nmol/L (reference range 0-20 nmol/L). On the basis of these observations, a diagnosis of early stress shielding was made. Arrangements were made for continued surveillance on a 6 monthly basis.

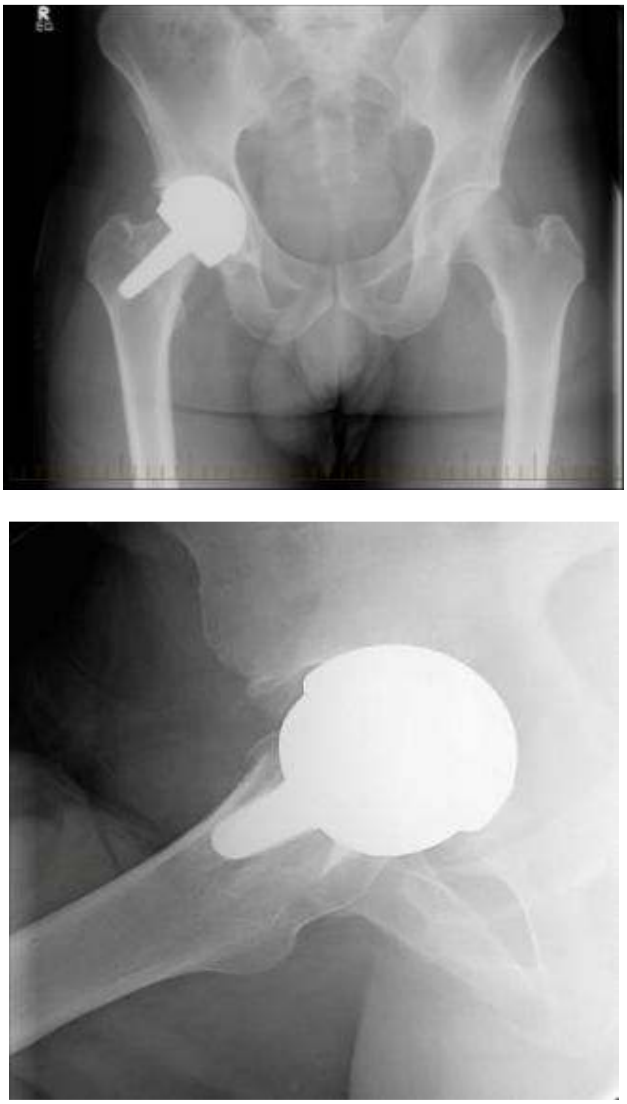

Fig. 4. 1-year postoperative anterio-posterior and lateral radiographs

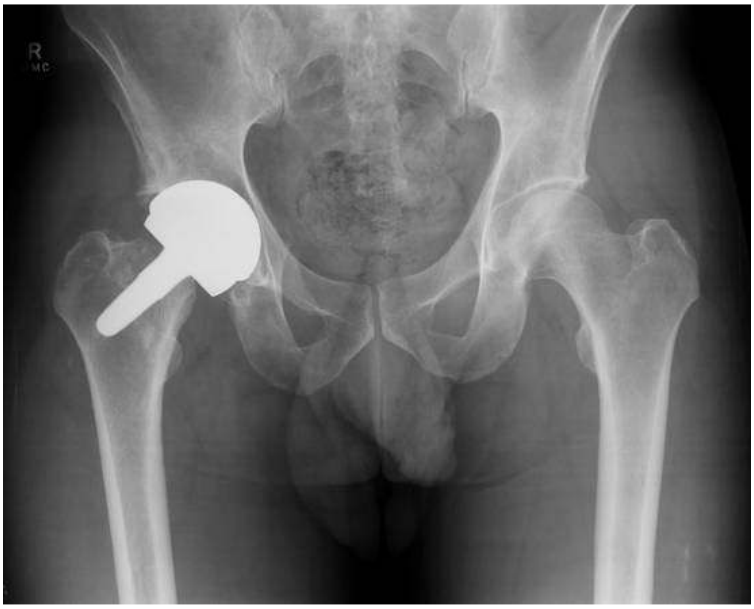

Fig. 5. 2-year postoperative radiograph demonstrating initial femoral neck thinning with radiographically stable implants. Patient was clinically asymptomatic

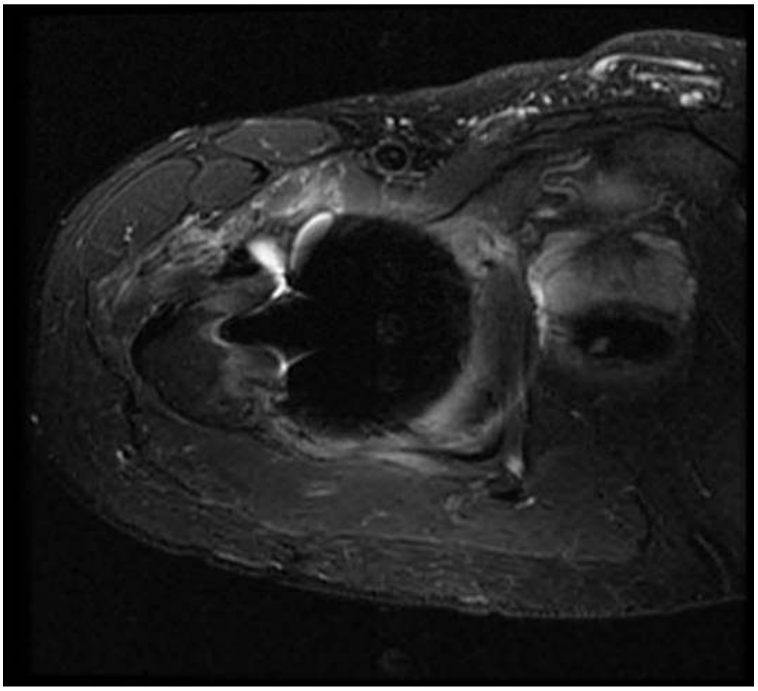

Fig. 6. Axial MRI right hip (metal artifact reduction sequences) taken at 2 years post intervention. No atypical metal bearing associated fluid collection or soft tissue pseudo-tumour formation identified

Clinical review at 2.5 years post surgical intervention demonstrated radiographic evidence of progressive stress shielding however the implants remained well osseo-integrated (Fig. 8). The patient maintained clinically excellent function. Blood plasma chromium level remained within normal range and cobalt levels had reduced (27 nmol/L).

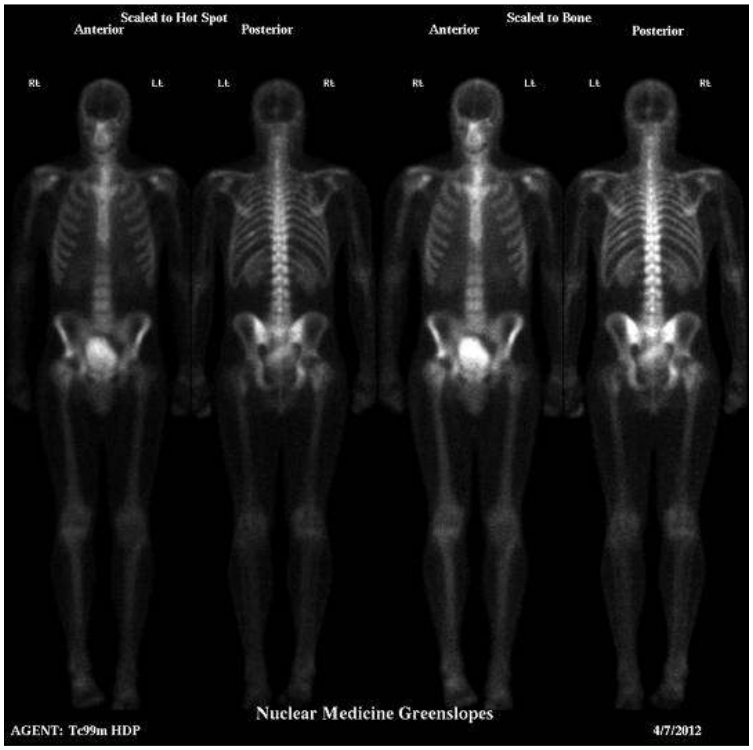

Fig. 7. Tc99 Bone scan taken 2 years post BMHR implantation demonstrating generalized proximal femoral osteoblastic activity consistent with bone remodeling

Fig. 8. 2.5-years postoperative radiograph

At 3 years and 4 years post surgical intervention, neck thinning due to stress shielding had stabilized on serial radiographs (Figs. 9 & 10). Both femoral and acetabular implants appeared radiographically osseointegrated. Progressive slight increase in density of the femoral calcar was observed. The patient remained clinically asymptomatic.

Fig. 9. 3-year postoperative radiograph demonstrating no radiolucency at bone-implant interface. Medial calcar bone remodeling with increasing density observed. Patient remained clinically asymptomatic

Fig. 10. 4-year post-operative radiograph

Fig. 11. 5-year post-operative radiograph at most recent clinical review. Patient remains asymptomatic and bone resorption due to stress shielding appears to have stabilized. Proximal femoral remodeling observed with increased medial calcar bone density and formation of tension trabeculae from the tip of the prosthetic femoral stem

At most recent review, at 5 years post hip resurfacing arthroplasty, the patient remained very satisfied with the clinical result being pain free even in high activity function. Radiographs demonstrated the implants remained stable and well osseo-integrated without further femoral neck resorption compared to previous radiographs (Fig. 11).

3. DISCUSSION

After hip resurfacing arthroplasty, femoral neck thinning is typically a benign phenomenon that has been well documented [8-12]. While progressive neck thinning and more severe femoral osteolysis may be associated with HRA failure, femoral neck thinning after HRA is typically asymptomatic, non progressive, limited to less than 10% of femoral neck width and often associated with a compensatory increase in medial calcar bone density. Stress shielding has been also well documented in femoral implants with conventional hip replacement designs, particularly those of a more rigid nature with extensive porous ingrowth surfaces encouraging distal stem osseointegration.

Despite BMHR arthroplasty demonstrating acceptable early survivorship within clinical and registry data [1,7], literature reports of femoral side osteolysis and our own observations raise concern with regards to the longer term clinical performance of this implant [13]. Asaad et al. [13] report a 100% survivorship for 49 BMHR implants at mean follow-up of 6 years, with 7 (16%) demonstrating femoral neck osteolysis. Femoral neck osteolysis was found to strongly correlate with the presence of metal bearing related pseudo-tumour formation, but not implant orientation or size. As a result of the observed rate of femoral osteolysis the authors ceased using the BMHR arthroplasty and recommended against continued use of this device. Of interest, the same authors in earlier publications reported no cases of femoral osteolysis within the first two years of BMHR implantation, a common finding amongst other short-term series concerning this device [7,14-16].

While proximal bone resorption due to stress shielding about any implant is of concern, it is potentially of greater significance when observed about shorter femoral stem implants due to the limited surface area available for both osseointegration and implant support. In particular, femoral bone resorption such as demonstrated in this case report would be associated with a progressive increase in varus moment upon the bone-implant construct, with potential consequence on longer term implant stability and survivorship.

Whilst commercial distribution of the BMHR has discontinued, the significance of stress shielding and neck thinning around this implant is of importance for two reasons. Firstly, the clinical outcome and radiographic appearances are of practical use in in the guidance of recommendations for ongoing surveillance and management of patients managed with this device. In addition, patient selection, stress shielding and proximal bone resorption around short stem implants is of significance in the context of a growing trend towards the development of short length stem and neck-preserving arthroplasty implants. In the design of short stem femoral prostheses, consideration needs to be made with respect to prosthetic design features that may reduce the risk of stress shielding and peri-prosthetic bone reabsorption.

4. CONCLUSION

We present a case of significant stress shielding with secondary femoral neck thinning in an otherwise well-functioning Birmingham Mid Head Resection arthroplasty used for the management of osteoarthritis. For total hip arthroplasty utilizing short femoral implants we recommend consideration of alternative design stems to reduce the risk of stress shielding.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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