FEMORAL NECK STRESS SHIELDING AFTER BIRMINGHAM MID HEAD RESECTION HIP ARTHROPLASTY – CASE REPORT AND LITERATURE REVIEW

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 at 3 years post implantation, 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.

KEY WORDS

Hip, Mid-head resection, Arthroplasty, Metal on Metal, Stress shielding.

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 managed with larger size femoral heads. 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 (Figure 1). Typically the monoblock cobalt chromium BHR component is used for the acetabular side articulation. 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 12/14 morse taper. 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]

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.

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 (Figure 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 posterior approach using a 58mm BHR acetabular component, a 52mm BMHR femoral head implant and a size 3 stem (Figure 3). 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.

At one-year post surgery the implants were radiographically stable and well osseo-integrated (Figure 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 (Figure 5). The patient remained asymptomatic and functionally excellent, riding his bicycle 150km 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 (Figure 6). Bone Scan demonstrated generalized osteoblastic activity about the proximal femur consistent with bone remodeling. Minimal bone scan activity adjacent to the femoral stem prosthesis was observed (Figure 7). C reactive protein, white cell count and ESR were unremarkable. The serum chromium level was 31 nmol/L (reference range 10-100 nmol/L) and the serum 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.

Clinical review at 2.5 years post surgical intervention demonstrated radiographic evidence of progressive stress shielding however the implants remained well osseo-

integrated and stable (Figure 8). The patient maintained clinically excellent function. Serum chromium level remained within normal range and cobalt levels had reduced (27 nmol/L).

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

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 (Figure 11).

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 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 within 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], reports of femoral side osteolysis raise concern with regards to the longer term performance of the implant.[13] Asaad et al. 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 correleate with the presence of metal bearing related pseudo-tumour formation, but not implant orientation or size.[13] 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.[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, 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 design of features that may reduce the risk of prosthetic stress shielding and peri-prosthetic bone reabsorption.

SUMMARY

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.

FIGURES

Figure 1: Birmingham Mid Head Resection (BMHR) arthroplasty.

Figure 2: Preoperative radiograph demonstrating established right hip secondary osteoarthritis.

Figure 3: Immediate postoperative radiograph after management by Birmingham Mid Head Resection Arthroplasty.

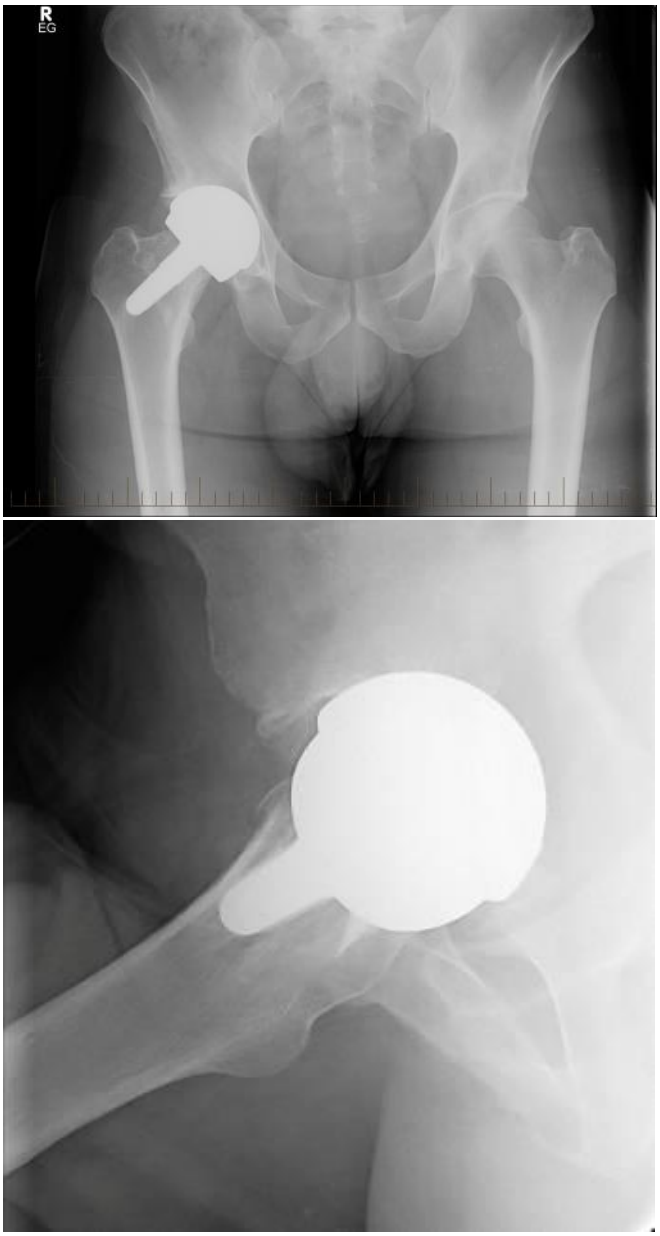

Figure 4: 1-year postoperative anterio-posterior and lateral radiographs.

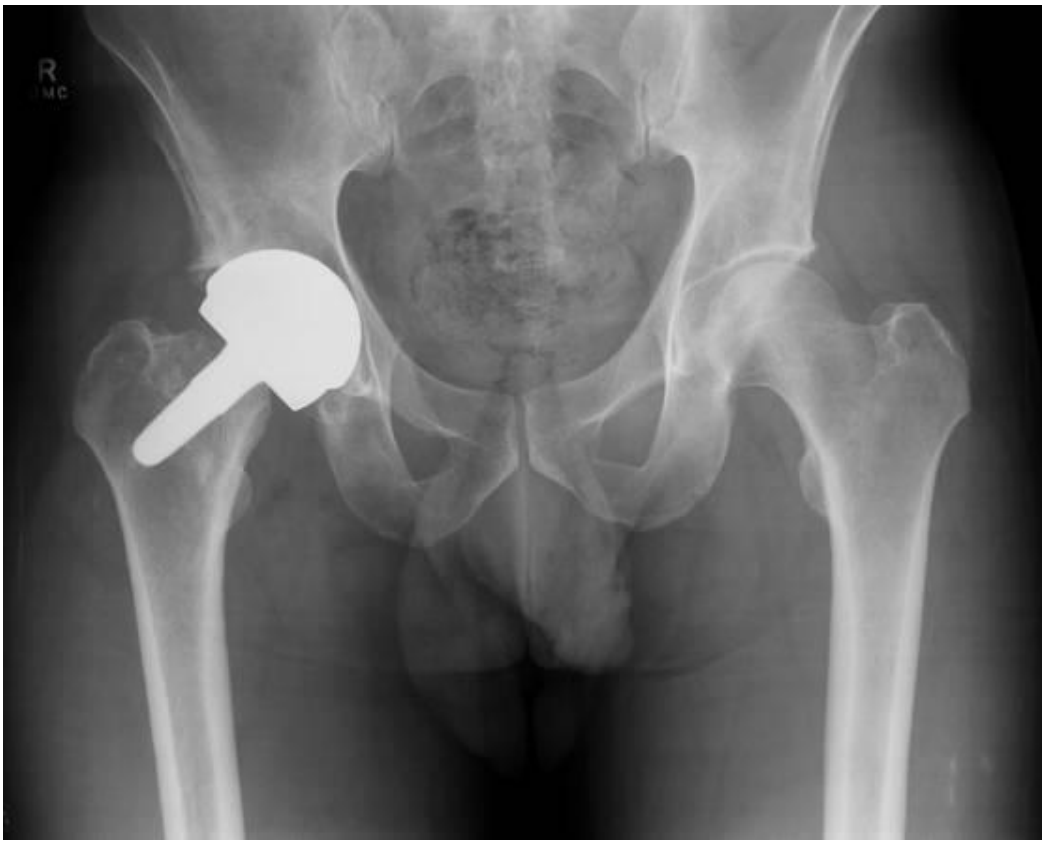

Figure 5: 2-year postoperative radiograph demonstrating initial femoral neck thinning with radiographically stable implants. Patient was clinically asymptomatic.

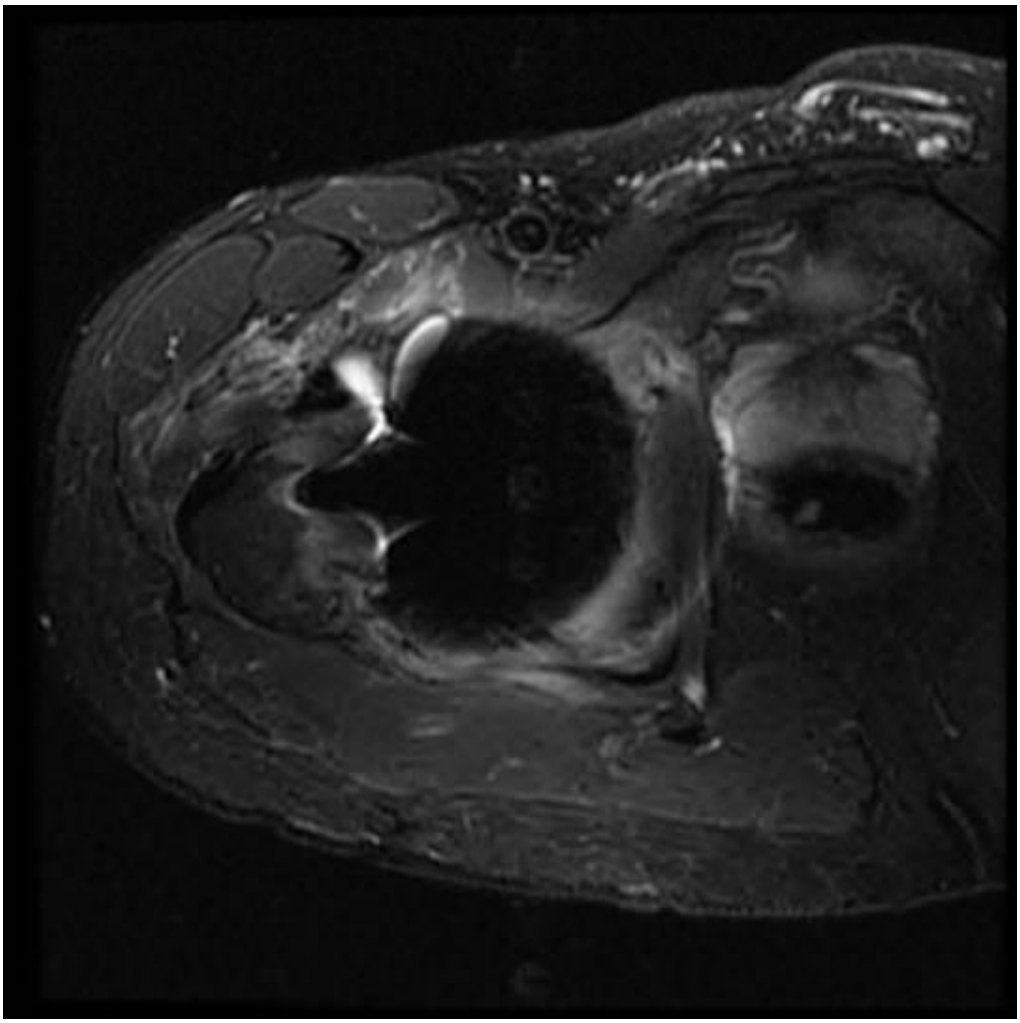

Figure 6: Axial MRI right hip (metal artifact reduction sequences) taken at 2 years post intervention. No atypical metal bearing associated fluid collection or soft tissue pseudo-tumour formation identified.

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

Figure 8: 2.5-years postoperative radiograph.

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

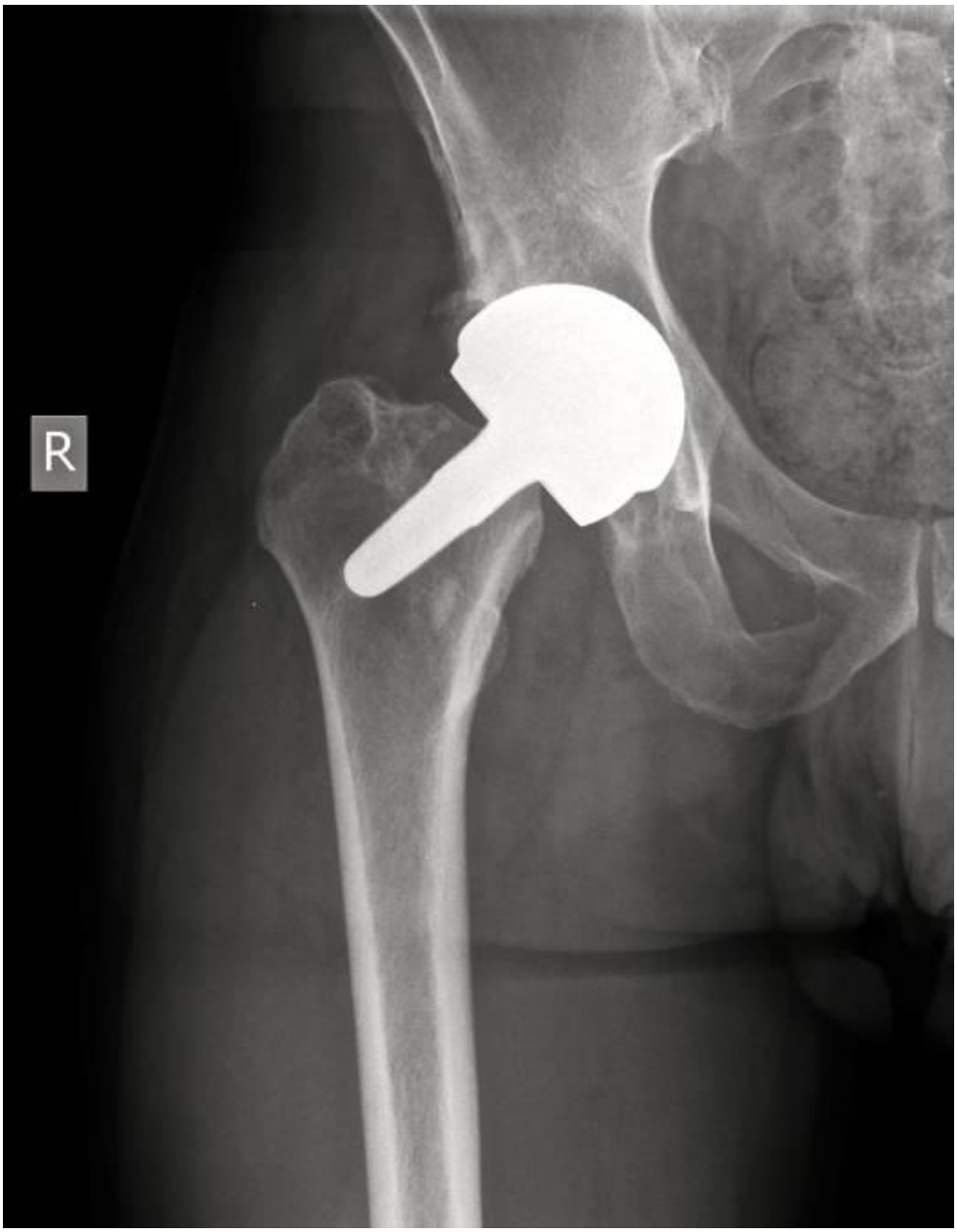

Figure 10: 4-year post-operative radiograph.

Figure 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.

REFERENCES

1. Australian Orthopaedic Association. *National Joint Replacement Registry.* 2014.
2. Swedish Hip Arthroplasty Registry. Annual Report. 2013.
3. Daniel J, Pradhan C, Ziaee H, Pynsent PB, McMinn DJ. Results of Birmingham hip resurfacing at 12 to 15 years: a single-surgeon series. *The bone & joint journal.* Oct 2014;96-B(10):1298-1306.
4. Daniel J, Pynsent PB, McMinn DJ. Metal-on-metal resurfacing of the hip in patients under the age of 55 years with osteoarthritis. *The Journal of bone and joint surgery. British volume.* Mar 2004;86(2):177-184.
5. Holland JP, Langton DJ, Hashmi M. Ten-year clinical, radiological and metal ion analysis of the Birmingham Hip Resurfacing: from a single, non-

designer surgeon. *The Journal of bone and joint surgery. British volume.* Apr 2012;94(4):471-476.

6. Treacy RB, McBryde CW, Shears E, Pynsent PB. Birmingham hip resurfacing: a minimum follow-up of ten years. *The Journal of bone and joint surgery. British volume.* Jan 2011;93(1):27-33.
7. McMinn DJ, Pradhan C, Ziaee H, Daniel J. Is mid-head resection a durable conservative option in the presence of poor femoral bone quality and distorted anatomy? *Clinical orthopaedics and related research.* Jun 2011;469(6):1589-1597.
8. Laffosse JM, Aubin K, Lavigne M, Roy A, Vendittoli PA. Radiographic changes of the femoral neck after total hip resurfacing. *Orthopaedics & traumatology, surgery & research : OTSR.* May 2011;97(3):229-240.
9. Joseph J, Mullen M, McAuley A, Pillai A. Femoral neck resorption following hybrid metal-on-metal hip resurfacing arthroplasty: a radiological and biomechanical analysis. *Archives of orthopaedic and trauma surgery.* Dec 2010;130(12):1433-1438.
10. Reito A, Puolakka T, Pajamaki J. Birmingham hip resurfacing: five to eight year results. *International orthopaedics.* Aug 2011;35(8):1119-1124.
11. Heilpern GN, Shah NN, Fordyce MJ. Birmingham hip resurfacing arthroplasty: a series of 110 consecutive hips with a minimum five-year clinical and radiological follow-up. *The Journal of bone and joint surgery. British volume.* Sep 2008;90(9):1137-1142.
12. Lilikakis AK, Vowler SL, Villar RN. Hydroxyapatite-coated femoral implant in metal-on-metal resurfacing hip arthroplasty: minimum of two years follow-up. *The Orthopedic clinics of North America.* Apr 2005;36(2):215-222, ix.
13. Asaad A, Hart A, Khoo MM, et al. Frequent Femoral Neck Osteolysis With Birmingham Mid-head Resection Resurfacing Arthroplasty in Young Patients. *Clinical orthopaedics and related research.* May 16 2015.
14. Rahman L, Muirhead-Allwood SK. The Birmingham mid-head resection arthroplasty - minimum two year clinical and radiological follow-up: an independent single surgeon series. *Hip international : the journal of clinical and experimental research on hip pathology and therapy.* Jun 10 2011;21(3):356-360.
15. Sandiford NA, Muirhead-Allwood S, Skinner J, Kabir C. Early results of the Birmingham mid-head resection arthroplasty. *Surgical technology international.* Apr 2009;18:195-200.
16. Daniel J, Pradhan C, Ziaee H, McMinn DJ. A clinicoradiologic study of the Birmingham Mid-Head Resection device. *Orthopedics.* Dec 2008;31(12 Suppl 2).