A Clinicoradiologic Study of the Birmingham Mid-Head Resection Device

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Abstract

This is a 1.2- to 5.3-year survival and clinicoradiologic study of patients with the Birmingham Mid-Head Resection (BMHR) device (Smith & Nephew Orthopaedics, Warwick, United Kingdom). Sixty consecutive hips implanted with this device between 2003 and 2007 were reviewed with hip outcome questionnaires, clinical examination, and radiographs at a minimum follow-up of 1 year. There were no revisions, mechanical failures, or signs of femoral neck stress shielding. All hips were functioning well and showed no significant adverse clinical or radiographic features. Birmingham Mid-Head Replacement offers the prospect of circumventing the need for a more invasive procedure such as hip replacement in patients who would benefit from a conservative arthroplasty but lack femoral head bone quality, which is a prerequisite for a successful hip resurfacing.

Hip arthroplasty devices in young, active patients are subject to the dual hazards of high-demand activity and extended lifetime use, making the prospect of multiple revisions in the future a reality. This makes conservative hip arthroplasty particularly appealing for use in young patients. Modern hip resurfacing, which had been developed in response to this need, is demonstrating excellent medium-term results, subject to good patient selection. However, poor-quality bone stock and distorted anatomy around the femoral head and neck can imperil the prospect of long-term success with a hip resurfacing.

Poor femoral head bone quality can be due to cystic change, femoral head osteonecrosis, localized osteopenia, or osteoporosis. In hip dysplasia with wandering acetabulum, it is frequently found that the uncovered portion of the femoral head is often stress shielded, leading to severe osteopenia in its lateral half, increasing the risk of failure after a resurfacing. Furthermore, anatomic distortions of the proximal femur such as sequelae of severe Perthe’s disease or slipped upper femoral epiphysis can create a situation whereby inadequate peripheral support to the femoral component necessitates suboptimal component placement or cement build up of the defect. Both these steps are detrimental to a resurfacing device and endanger its long-term success. In all the above conditions, the alternative to a resurfacing procedure previously had been a stemmed total hip replacement (THR).

The Birmingham Mid-Head Resection (BMHR; Smith & Nephew Orthopaedics, Warwick, United Kingdom) device was developed as a viable alternative to hip resurfacing for patients who would benefit from a conservative arthroplasty, but in whom poor bone makes a resurfacing unsuitable. The BMHR device consists of an uncemented short stem made of titanium alloy (straight stem) or cobalt-chrome alloy (curved stem) and a large-diameter cobalt-chrome metal-on-metal bearing that is identical to the Birmingham Hip Resurfacing (BHR) bearing. As a
short-stemmed device, it does not violate as much of the medullary canal of the femoral shaft as the standard THR and facilitates future revision. A strategically placed osteotomy through the base of the femoral head exploits the natural internal shape of the femoral head and neck to create the perfect geometry for robust stem fixation. This region of the femoral head and neck are prepared to form a cone that offers a secure fit to the proximal load-bearing cone of the BMHR stem (Figure 1). This resection level also ensures removal of poor-quality bone in the proximal femoral head, while retaining the distal part of the femoral head, which contributes to load transfer from the stem. Continued load bearing through this segment prevents stress-shielding deterioration of the neck, which has been a regular feature with other neck-preserving THRs.5

Figure 1: Osteotomy through the base of the femoral head allows for creation of a cone internally, which provides the ideal shape for fixation of a conical stem. Figure 2: The two types of BMHR stems are shown. It is technically more difficult to position the curved stem precisely because it involves free hand rasping. The straight stem has the advantage that preparation can be done with a rotating drill on an intramedullary guide bar, eliminating potential inaccuracies from free hand rasping. Rotational stability in the straight stem is provided by the flutes in the stem.

The proximal conical portion of the stem has a porous, hydroxyapatite (HA)-coated surface. The distal portion is narrower than the proximal part and prevents distal load bearing. To provide rotational stability, one of two strategies is used: 1) using a curved stem, or 2) providing longitudinal flutes on a straight stem (Figure 2).

The socket component and the bearing of the device are identical to those of a BHR, which offers the advantage that the cup and the bearing have a
known excellent medium-term clinical track record. A modular head that matches the socket fits onto the BMHR stem through a 12/14 taper.

This is a 1- to 5-year survival and clinicoradiologic study of patients with the BMHR device.

Methods

Sixty consecutive hips (56 patients) treated with a BMHR device between 2003 and 2007 were reviewed at a minimum 1-year follow-up. The first 13 hips (12 patients) were treated with a curved-stem BMHR device, and the next 47 hips (44 patients) were treated with a straight-stem BMHR device. Follow-up ranged from 1.2 to 5.3 years (mean, 2.1 years). Mean age at surgery was 58 years (range, 30-73 years), and the men:women ratio was 2:1. The diagnoses included femoral head avascular necrosis (10), 2 of which were steroid induced, 2 posttraumatic, and the remainder idiopathic; congenital/developmental dysplasia (7); destructive osteoarthritis with or without severe cystic change in the femoral head (40); Perthe’s disease (2); and previous history of slipped upper femoral epiphysis (1).

All procedures were performed using a posterior mini-incision approach similar to that used for BHR. The details of the approach and the details of BMHR device implantation are described elsewhere. Sometimes, the ideal choice of implant was clear from preoperative radiographic examination; otherwise, the choice was made at surgery. During surgery, the femur was prepared as for BHR and the cysts curetted and dead bone excised before an assessment was made. The extent of bone loss and the quality of the remaining bone were the deciding factors on whether to perform BHR or proceed to BMHR. Patient hospital stay was 4 to 6 days after surgery. Perioperative antibiotic prophylaxis and thromboprophylaxis used were the same as those described in a previous report on metal-metal resurfacings. All patients began mobilizing on the first postoperative day. The first 15 patients were allowed 50% partial weight bearing with 2 elbow crutches for 1 month, followed by full weight bearing with 2 elbow crutches for an additional month before progressing to a walking stick for 1 month and then walking unaided. In the remaining patients, the period of assisted weight bearing was reduced to 1 month with elbow crutches and an additional month with a walking stick. We have now reverted to the earlier standard protocol (2 elbow crutches for a total of 2 months, partial weight bearing for 1 month, and full weight bearing for 1 month, followed by a walking stick for 1 month), as indicated above for the following two reasons. By definition, these patients had initial weaker bone and therefore needed protected weight bearing for a longer period. Furthermore, with an uncemented stem, the increased period of protected walking allowed better bony ingrowth before subjecting the stem to full loading. These patients did not need outpatient physiotherapy after discharge.

Reoperation or revision for any reason was considered a failure.
All patients with a minimum follow-up of 1 year were invited to attend a review clinic. Before the clinic appointment, patients completed Oxford and Harris Hip score questionnaires. Patients were examined by one of the investigators, an orthopaedic surgeon (J.D., C.P., or D.J.W.M.). An anteroposterior view radiograph of the pelvis including both hips and a cross-table horizontal beam lateral view of the index hip(s) was taken. Radiologic assessment of the acetabulum was performed using the zones of De Lee and Charnley along with assessment of the femoral stem using Amstutz9 criteria. Femoral neck thinning was assessed by comparing the width of the femoral neck in the 2-month radiographs with the most recent radiographs, using the femoral component as a reference for radiographic magnification error. Reduction of width by at least 10% of the original neck width was considered significant. Brooker grading was used for heterotopic ossification. Survival analysis was performed using a Kaplan-Meier survival plots and 95% confidence intervals.

Results

At a maximum period of 5.3 years (mean, 2.1 years; range, 1.2-5.3 years), no patient was lost to follow-up. Further, there were no implant failures, reoperations, or radiologic signs of osteolysis or aseptic loosening.

One patient experienced a circulatory collapse during the procedure. After resuscitation, the procedure was completed. He recovered fully with no sequelae and returned to full-time work. There were no other intraoperative or postoperative complications. All patients living in the United Kingdom attended one of the review clinics in 2008. Three patients who lived abroad and were unable to attend returned questionnaire responses by mail and underwent radiography at local centers.

Figure 3: Hip outcome scores of the 60 patients at follow-up. The best possible Oxford Hip score is 12, and the best possible Harris Hip score is 90. Three patients indicated that the poor score recorded was not related to the operated hip but to a painful and poorly functioning knee or a contralateral hip.
The median Oxford Hip score of these patients at follow-up was 12 and the mean 14. It should be noted that the Oxford score measures hip pain and disability but not hip function. The best possible score is 12 and the worst is 60. Median Harris Hip score at follow-up was 90 and the mean 87, with a best possible score of 90 (Figure 3). Three patients noted that the pain and disability they recorded on the questionnaires originated from a joint other than the operated hip such as the contralateral hip or a knee joint.

Mean cup inclination angle in the entire cohort in the coronal plane was 40°, and the femoral stem-shaft angle in patients with the straight stems was 143°. One 56-year-old woman showed a continuous 1-mm radiolucent line around zone 1 of the straight stem but is asymptomatic and has resumed full mobility and activity. There was no change in the position or orientation of either component in this or any other patient. Four patients had Brooker grade I heterotopic ossification. No patient had significant neck thinning or signs of femoral neck stress shielding (Figures 4 and 5). There were no cases of osteolysis around the femoral or acetabular components and no failures from aseptic loosening. No patient is awaiting a revision.

Figure 4: Radiographic series of a 59-year-old man with Sjögren’s syndrome and steroid-induced extensive advanced femoral head avascular necrosis managed with a BMHR. After the first year, he returned to all his sporting activities including skiing, mountain walking, and rock climbing.
Figure 5: A 31-year-old computer engineer with Henoch Schönlein purpura and steroid-induced extensive femoral head avascular necrosis was managed with a straight-stem BMHR device. He recovered fully and returned to all his activities.

One patient had a clinically discernible limb length discrepancy. A 34-year-old man with post-Perthe’s sequelae had severe foreshortening of the femoral neck and a preoperative limb-length discrepancy of 60 mm (Figure 6). He underwent a complex reconstruction, whereby a longer neck was carved from the coxa magna femoral head, significantly adding to the limb length. His residual limb length discrepancy (LLD) was 28 mm. This correction, combined with improved hip flexibility, allowed him to compensate his LLD fully at the pelvis.

Figure 6: A 34-year-old man with post-Perthe’s sequelae affecting his left hip and severe symptomatic arthritis treated with reconstruction of the proximal femur carving neck out of the mushroom-shaped femoral head. Excellent corticalization is observed in the newly created neck.

Seven patients (mean age, 51 years) had a preoperative shortening greater than 10 mm each (average, 17 mm). Postoperatively, they had a net mean gain of 11 mm, resulting in the effect that none had a residual shortening of more than 10 mm (average, 6 mm) at follow-up (Figure 7).
Figure 7: Limb length discrepancy before and after BMHR. The highest readings refer to the radiographs shown above in Figure 6.

Discussion

In our large series of 2600 BHRs, 11 patients with femoral head avascular necrosis were associated with worse survivorship (10% cumulative failure rate at 10 years) compared with patients with osteoarthritis or with all other diagnoses (4% cumulative failure rate at 10 years). One reason for this higher failure rate is that the pathologic factors that caused nontraumatic avascular necrosis (steroids, alcohol, etc) have a tendency to continue to cause additional femoral head collapse in some patients. Therefore, we consider avascular necrosis a relative contraindication to resurfacing. In such patients, it is preferable to use a device that is less dependent on the integrity of the femoral head bone but is less invasive than THR. A neck-preserving proximal load-bearing short-stem device that does not invade the medullary canal of the femur is the ideal option.

Any neck-preserving femoral implant should meet two primary criteria: 1) conserve bone to facilitate a revision in the event of implant failure, and 2) prevent proximal stress shielding. It is critical that the device be proximally loaded because experience has shown that distally load-transmitting devices lead to stress-shielding resorption of the femoral neck. In the past, there was no way to avoid this, because all the devices until that time used a resection line passing through the proximal femoral neck. From this level, the interior of the neck flares out and the reverse taper shape is unfavorable for the fixation of any device. The BMHR prosthesis consists of a short, uncemented conical stem transmitting load to the base of the femoral head and neck and thus prevents proximal stress shielding (Figures 4 and 5).

During the initial clinical and radiographic evaluation, the decision to use a BMHR device rather than BHR is based on preoperative radiographic assessment and templating. Often a definitive decision must be deferred until physical examination of the femoral head is made during surgery. It is possible to carry out a BHR and avoid the need for a BMHR device despite of the presence of cystic change in the femoral head, provided the cysts are located at its zenith or on its surface (ie, the regions from which bone would be removed during femoral preparation). However, large cysts in the femoral head and neck and especially those located in the lateral head-neck junction of the femur are associated with poor long-term outcome and therefore BHR is best avoided. A BMHR device is also preferable in patients with...
severely deformed femoral heads such as sequelae of Perthe’s disease or slipped upper femoral epiphysis. Furthermore, compared with BHR, BMHR allows additional neck lengthening and/or augmentation of the femoral offset as seen from the limb length discrepancy correction achieved (Figure 7), especially in patients with complex anatomy.

Several surgical details merit consideration. Because BMHR uses a larger-diameter stem than with BHR, it is essential that the initial guidewire placement in the femur is centrally located in both the anteroposterior and lateral planes. Eccentric guidewire placement can lead to a breach of the cortex when the stem drill is used. Even in the absence of a breach, if the stem is fixed eccentrically, it leads to abnormal load transfer and spot welding or pedestal formation on one side and stress shielding on the other. Excessive varus placement of the femoral component increases the risk of failure and should be avoided. Excessive valgus tends to reduce the femoral offset and also leads to stress shielding of the superolateral neck and should be avoided.

After the femur is prepared, the stem should be seated using gentle impaction with a hammer. The splines on the BMHR stem take on a tight press fit and offer rotational stability distally. Proximally the fit is line to line. When the implant is well seated, no attempt should be made to drive it in any farther, to prevent the stem from splitting the femur.

The initial cohort of 13 consecutive curved-stem BMHRs are being followed in a radiostereometric analysis study that has shown no detectable migration,12 confirming the inherent stability of the design and that the stability is comparable with that seen with BHR.13 Furthermore, no patients have shown radiologic signs of stress-shielding resorption of the neck in either the anteroposterior or the lateral view radiographs, even at 5 years. This confirms the absence of a stress-shielding effect from the device.

The BMHR was initially available with a curved stem. This meant that the bone for the stem had to be rasped free-hand, which can lead to inaccuracy in placement. To reduce the chance of surgical error, the straight-stem device was introduced with longitudinal flutes for rotational stability. This eliminated the need to hand rasp. It may be suggested that the design change between the curved and the straight stems implies that the good results of the curved stem cannot be extrapolated to the straight stem. However, the collective evidence accrued thus far in the form of the excellent early clinical and radiographic results reported here, combined with the absence of observable stress shielding, and the evidence of stability as shown by radiostereometric analysis, offers a reason to be optimistic that the BMHR device will prove to be a strategic tool in the management of end-stage hip arthritis in the young, especially when the femoral head
anatomy or bone quality is suboptimal or suspect.

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