Reconstructive REVIEW
An Open Access Journal
Volume 8, Number 1
September 2018
ORIGINAL ARTICLE http://dx.doi.org/10.15438/rr.8.1.206

Check for updates

Correction of Femoral Acetabular Impingement at the Time of Primary THA

McPherson E [1], Sherif S [1], Chowdhry M [1], Dipane M [1]

Abstract

Background: Primary total hip arthroplasty (THA) is considered one of the most cost-effective and functionally beneficial procedures to treat end-stage coxarthrosis worldwide. However, there is a small percentage of patients who are plagued by residual anterior hip pain and limited hip flexion. One explanation for this problem is bone and soft tissue impingement in the anterior hip region. In the native hip, the problem is described as femoral acetabular impingement (FAI). FAI is a form of developmental dysplasia of the hip (DDH). Not infrequently, these dysplastic acetabula are also retroverted. In primary THA, a retroverted boney acetabulum adversely affects prosthetic hip function. Specifically, when the acetabular cup is inserted in an anteverted position and the native acetabulum is retroverted, the proximal femur will impinge upon the retroverted acetabular bone with flexion and internal rotation. This causes mechanical dysfunction, prosthetic subluxation, and pain. We aptly name this condition prosthetic femoral acetabular impingement (PFAI).

Methods: In this study we address PFAI with an anterior acetabular bone wall reduction (AABWR). In a consecutive series of 426 primary THA's, we prospectively removed all impinging anterior retroverted bone during the THA procedure. Specifically, after final socket preparation and insertion, an AABWR was performed when acetabular bone extended more than 5 mm beyond the prosthetic acetabular cup. All acetabular cups were placed between 25-35 degrees of anteversion. Retroverted acetabular bone extending beyond the acetabular cup was removed along with impinging capsular tissues. All femoral stems were positioned between 15-20 degrees. We hypothesize that with an AABWR, groin pain and hip flexion will be commensurate with that of patients who did not require an AABWR (i.e., non-retroverted acetabulum).

Results: The study group consisted of 426 primary THA's. Three hundred patients (70%) had an AABWR and 126 patients did not require an AABWR. There were 140 females (47%) and 160 males (53%) in the AABWR group and 88 females (70%) and 38 males (30%) in the non-AABWR group. The average amount of bone resected in the AABWR group was 1.32 cm (0.3 cm to 3.4 cm). For females, the average bone resection measured 1.1 cm (0.3 to 2.0 cm). For males, the average bone resection measured 1.53 cm (0.3 cm to 3.4 cm). Harris Hip Scores (HHS) at minimum of 1 year follow-up (range 1 to 11.5 years) averaged 91 (64 to 100) for the entire study. In the AABWR group, HHS averaged 92 (71 to 100). Average hip flexion was 110 degrees (100 to 130 degrees). In the non-AABWR group, HHS averaged 87 (71 to 100). Average flexion was 109 degrees (88 to 125 degrees). In the AABWR group, 12 patients (4%) experienced groin pain symptoms. Ten of these patients rated his/her peak groin pain at a level of 1 (scale 0-4) and the remaining 2 patients rated his/her peak groin pain at a level of 2. As time progressed, 50% of these patients saw their groin pain resolve. In the non-AABWR

Keywords: *THA, Total Hip Arthroplasty, FAI, Femoral Acetabular Impingement, PFAI, Prosthetic Femoral Acetabular Impingement, Hip Subluxation, Anterior Hip Decompression, AABWR, Anterior Acetabular Bone Wall Reduction, Groin Pain, Hip Flexion*
Level of Evidence: *AAOS Therapeutic Level III*
Educational Value & Significance: *JISRF Level A*

group, 2 patients (1.6%) experienced groin pain and both patients rated his/her pain at a level of 1.

Discussion: Maximizing hip flexion and function for the active patient undergoing primary THA requires meticulous surgical technique. PFAI may be one reason for unexplained anterior hip pain in the highly active patient that demands higher hip flexion and rotation. Our experience shows that the anterior acetabular rim and part of the anterior column can be removed at the time of primary THA without compromising the THA procedure. The AABWR is now an integral part of our primary THA technique.

Background

Femoral Acetabular Impingement (FAI) causes hip pain when the native femoral neck contacts the acetabular rim in flexion. Impingement is most pronounced with flexion (above 80 degrees) and internal rotation. At the impingement point, soft tissues are damaged either by a pincer effect on the acetabular rim or via a cam effect upon the peripheral acetabular articular surface [1]. FAI more commonly occurs when the native acetabulum is retroverted (Figures 1a & 1b) [2,3]. This is a form of developmental dysplasia of the hip (DDH) that is underappreciated, as upon casual review radiographs of patients with retroversion dysplasia appear relatively normal. Retroversion dysplasia is a major cause of early degenerative arthritis in the middle-aged patient population and can lead to early Total Hip Arthroplasty (THA). Correction of acetabular retroversion with a periacetabular osteotomy in the pre-arthritic hip joint helps reduce pain and improve functional hip flexion [4-6].

THA in patients with uncorrected retroversion dysplasia is fraught with pitfalls. First, positioning of the acetabular cup in a manner that follows the native acetabular rim can result in clinical impingement [7]. Following the native acetabular rim is the most commonly accepted method of cup placement when there is normal acetabular anteversion and inclination [8]. However, if the surgeon does not appreciate that the native acetabular socket is retroverted, then placement of the prosthetic cup in this retroverted position will fail to solve the impingement problem that caused the original degenerative process. Additionally, excess femoral pelvic inclination resulting from lumbar hyperlordosis and/or spine fusion can cause the acetabular socket to be "functionally' retroverted [9]. Furthermore, if acetabular retroversion is recognized and the prosthetic acetabular cup is placed in the correct anteversion and inclination, clinical impingement can still occur if the retroverted bone is not removed. This is not an uncommon scenario

Figures 1a – 1b
Diagrams of anteroposterior view of the right hip demonstrating retroversion dysplasia.

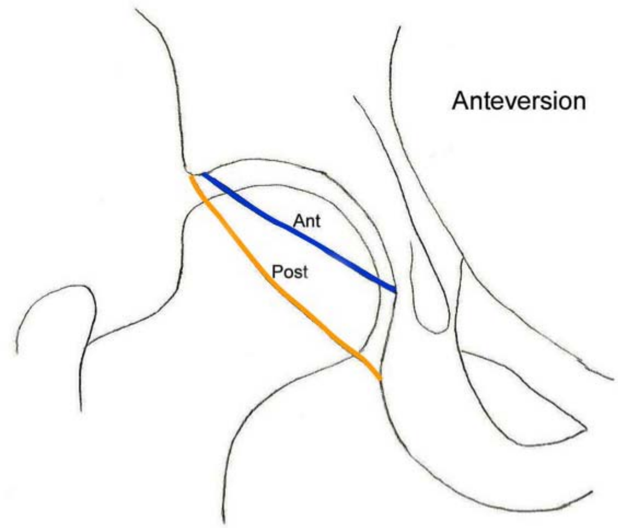

Figure 1a. Diagram of acetabulum on anteroposterior radiograph. In a normal acetabulum, the socket is anteverted. On the AP radiograph, the anterior rim is above the posterior rim. Three dimensionally, the acetabular socket is open and faces in an anterior direction.

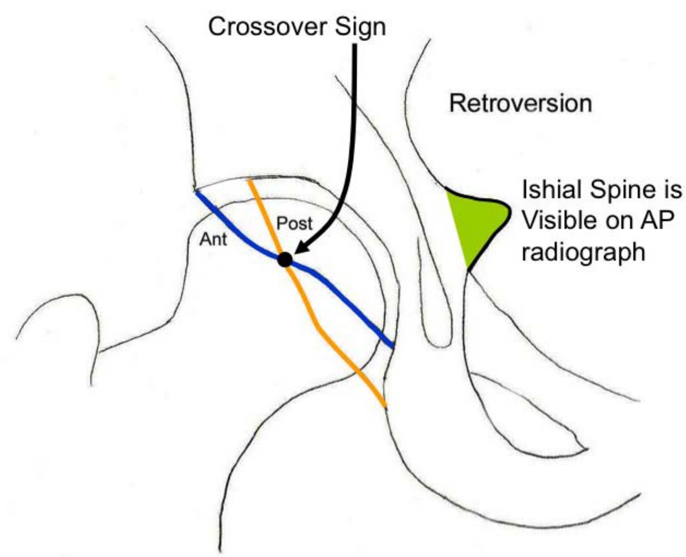

Figure 1b. Diagram of acetabular retroversion. On the AP radiograph, the anterior rim is in a lower position, whereas the posterior rim is higher. Radiographically, the two rim lines cross, creating the crossover sign. Frequently with acetabular retroversion, the ischial spine is prominently seen. Three dimensionally, the acetabular socket is closed and faces in a posterior direction. This configuration can also be seen with fixed flexed pelvic deformation, secondary to spine disease.

that we encounter clinically. The retroverted bone impinges upon the femur in hip flexion, causing pain and continued functional debility. We describe this latter scenario as Prosthetic Femoral Acetabular Impingement (PFAI). In the highly active young patient who demands a higher functional hip range, even mild relative retroversion of the acetabulum causes impingement in flexion and internal rotation. Repetitive PFAI can also adversely affect prosthetic bearing wear [5,10,11]. If significant PFAI occurs, repetitive subluxation movements of the total hip bearing can result in abnormal bearing wear patterns. With large diameter alternative bearings, such as ceramic-ceramic, metal-metal, or ceramic-metal, repetitive subluxation can cause stripe wear marks [12-15].

In primary THA, acetabular retroversion can be corrected by reaming the acetabulum to a hemisphere and inserting the prosthetic cup into the "normalized" anteverted position. However, if the retroverted bone still remains, this can cause impingement. In this study, we utilize the surgical technique of removing retroverted acetabular bone at the time of primary THA. We call this maneuver an *"Anterior Acetabular Bone Wall Reduction"* (AABWR). This study prospectively reviews the clinical results of 426 consecutive primary THA's that utilized a large diameter monolithic acetabular cup. We review the incidence of AABWR and review the clinical results of patients that required this maneuver for correction of native acetabular retroversion. We hypothesize that with corrected acetabular cup placement and an aggressive AABWR, groin pain scores and overall Harris Hip function will be commensurate with that of patients not suffering from native acetabular retroversion.

Materials & Methods

Between August 2006 and June 2017, 455 primary THA procedures were performed at a single institution by the senior author (ejm). The study group included all patients who received a large diameter monolithic all-metal porous coated cementless acetabular cup. Patients who were excluded from the study group included those with traumatic or developmentally acquired acetabular deformities that needed an acetabular cage or a protrusio revision cup with augmentation and/or structural bone graft (29 patients). The study group thus included 426 consecutive primary THA's utilizing a large diameter monolithic all-metal cup.

All THA's utilized a standardized technique. A less invasive postero-lateral approach was used [16]. Patients were secured in the lateral decubitus position using the Hip Grip System (Sun Medical, Redding, CA). Positioning was carefully performed by the operating surgeon (ejm). The anterior-inferior brace was positioned over the pubic symphysis and anterior superior iliac spine. The anterior-superior brace was centered over the xiphoid process. The posterior-inferior brace was centered over S1. The posterior-superior brace was positioned at the mid scapula level. The positioning technique allowed the posterior ilioischial line to be parallel to the length of the operative table. This line was used to help assist in cup positioning (Figure 2b).

With the less invasive postero-lateral approach, the superior one-half of the short external rotators were released from the upper posterior greater trochanter down to the base of the femoral neck. The hip capsule was preserved with transverse incisions made at the acetabular rim and the base of the femoral neck. A longitudinal incision was made along the femoral neck axis.

Acetabular cup preparation was performed with serial reaming in 2 mm increments, starting initially at 41 mm. The first ream was directed medially through the remaining cotyloid pads to the quadrilateral surface. Reaming was then performed in plane of 25-35 degrees of anteversion and a lateral opening of 40 degrees. Trialing was performed using a metallic hemisphere trial cup 1 mm larger than the last reamer. The trial cup was positioned at an anteversion angle of 25-35 degrees and a lateral opening of 40 degrees. The ilioischial line was used to assist as a reference (parallel to the long axis of the operative table). Any anterior acetabular bone that extended more than 5 mm beyond the acetabular cup was removed with osteotomes. This included the anterior rim, the anterior column, and the lateral portion of the superior ramus. Bone removal was performed as needed to assure flexion clearance up to 110-125 degrees, and to prevent impingement with the femur in flexion and internal rotation. The amount of bone removed (excluding osteophytes) was measured. If greater trochanteric impingement was evident with the combined flexion and internal rotation maneuver, then the anterior portion of the greater trochanter was trimmed with an osteotome to relieve this abutment. When necessary, as much as 20% of the greater trochanteric bone was removed. The acetabular cup utilized in the series was the Magnum™ Cup (Zimmer-Biomet, Warsaw, IN). The Magnum Cup is a monolithic cup with a metal internal bearing. The cup bearing was a Cobalt-Chromium (CoCr) alloy, treated with a hot isostatic pressure (HIP) technique that optimizes metal density. The carbide content was 2% by volume. The outer diameter was coated with a titanium plasma spray (applied as the cup was kept cool). The Magnum Cup also has four radial fins on its outer diameter. The cup was inserted with a flat face insertion device. Anteversion was selected between 25-35 degrees. The lateral opening was selected

Figures 2a – 2g
Case example of anterior acetabular bone wall reduction in a 69-year-old male (BMI 32) with end-stage arthritis of the left hip.

Figure 2a. Anteroposterior radiograph showing end-stage arthritis of the left hip. This patient also shows radiographic evidence of shallow socket dysplasia. Intra-operatively, after reaming the acetabulum to the native hip center, the acetabular socket was demonstrably retroverted.

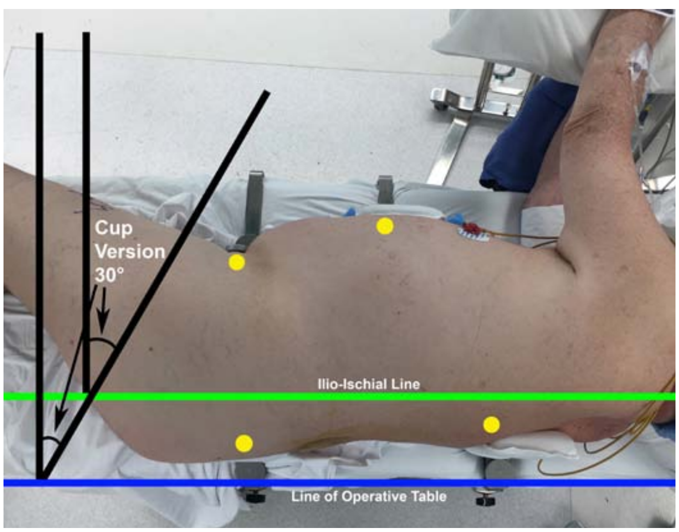

Figure 2b. Intra-operative positioning of patient for left THA in the lateral decubitis position. The yellow circles show fixation points of the Hip Grip devices. Anteriorly, the fixation points are the pubic symphysis and xiphoid process. Posteriorly, the fixation points are S1-S2 and the upper thoracic chest at T5-T6 region. The blue line depicts the edge of the OR table for reference. The patient is positioned such that the ilioischial line (green line) is parallel to the long axis of the OR table. Thus, when positioning the acetabular cup anteversion, the OR table can be used as a reference parameter to provide consistent cup version placement. In this case, cup version was selected at 30 degrees.

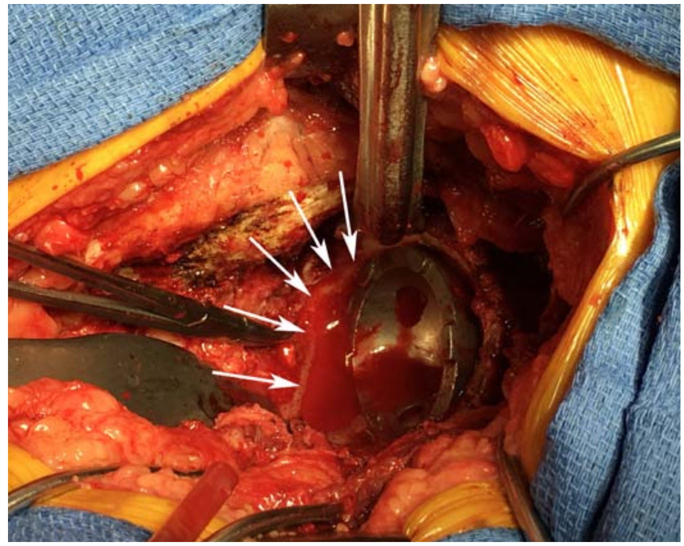

Figure 2c. Intra-operative picture of trial cup placement (viewed from the posterolateral approach). The cobra retractor (top of picture) is located at the 11 o'clock position of the left acetabulum. The retractor on the left side of the picture is placed just under the acetabular teardrop. The acetabular cup has been placed at 30° of anteversion, relative to the ilioischial line. This picture shows the retroverted acetabular bone anteriorly (arrows). All of this bone is removed with the "anterior hip decompression" maneuver. Inferiorly, the retroverted bone blends into the superior ramus and with the anterior bone wall reduction, some of the superior ramus is removed with the decompression maneuver.

Figure 2d. Photograph of resected anterior acetabular bone. We resected the anterior acetabular rim and part of the anterior column. At the maximum retroverted position, 2.2cm of bone was removed. Technically, this bone was removed with 1.5cm straight and curved osteotomes.

at 40 degrees. The cup was mated with either a Magnum CoCr head (Zimmer-Biomet, Warsaw, IN) or a Dual Articulation (DA) bearing (Zimmer-Biomet, Warsaw, IN). The inner head of the DA bearing was always a 28mm Delta ceramic head (CeramTec, Plochingen, Germany) with a titanium sleeve inserted into the ceramic head for neck length adjustments. We used two femoral stem designs in this study. Both were titanium alloy stems with proximal

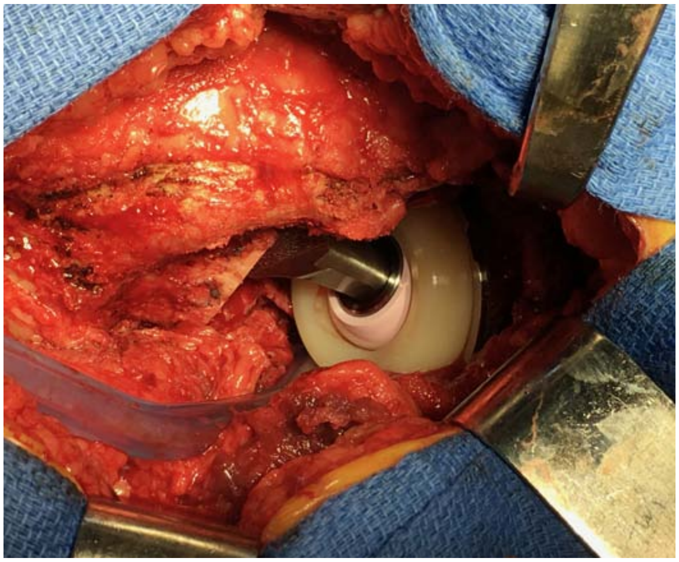

Figure 2e. Intra-operative photograph of the THA construct. In this case a Dual Articulation bearing was mated to the Magnum cup. The picture is taken with the hip in flexion of approximately 45 degrees and the femur internally rotated approximately 40 degrees.

Figure 2f. Intra-operative photograph showing hip stability after anterior hip decompression procedure. In this picture the patient's head is located to the right and the hip is flexed approximately 40 degrees. Notice that with 75 degrees of internal rotation, the hip still remains stable.

porous plasma spray coating. Depending on the boney architecture, we used either the Mallory-Head® stem (Zimmer-Biomet, Warsaw, IN) or the Taperloc® stem (Zimmer-Biomet, Warsaw, IN).

A careful, meticulous closure was performed. The hip capsule was closed as a separate layer. In all cases, the hip capsule was closed from the superior acetabulum down to the prosthetic femoral neck. The released proximal short external rotators were repaired to the posterior greater trochanter with sutures placed into the bone. All soft tissues

Figure 2g. Post-operative radiograph in recovery room. The pelvis is mildly externally rotated toward the left. The acetabular theta angle measures 32 degrees. Notice in the radiograph the retroversion of the native right hip in which the ischial spine is visible and there is a subtle crossover sign (black dot).

were anatomically closed as best as possible.

All surgeries were performed with body exhaust suits (Stryker Corporation, Kalamazoo, MI) in non-laminar flow rooms. Anesthesia consisted of a general anesthetic combined with epidural anesthesia with low dose intrathecal preservative free morphine sulfate (0.1 mg). Wound closure was performed without drains. Intravenous antibiotics were administered preoperatively and continued for 24 hours, adhering to SCIP guidelines [17].

Post-operatively, patients were kept to 50% weight bearing for six weeks then progressed to full weight bearing. Patients were examined at 6 weeks, 3 months, 1 year, and annually thereafter. Hip review assessment was recorded with Harris Hip Scoring. Radiographs were taken at 6 weeks, 1 year, and every year thereafter. All charts were reviewed for complications and implant failures. Complications were defined as requiring re-operations for any reason. Failures were defined as requiring implant removal for any reason or declaring the hip joint clinically infected based upon the International Consensus Meeting on Musculoskeletal Infection [18].

Statistical analysis was performed using IBM SPSS Statistics 25 software. Spearman correlation analysis was utilized to check the presence of statistical correlation between researched variables. In order to verify the statistical significance between the two independent groups, the Mann-Whitney U test was used. Chi-square testing made it possible to compare if groups are equinumerous and if there is a significant relationship between nominal variables. For statistical significance a level of $p < 0.05$ was adopted.

Results

In this study group of 426 THA's, the average age was 64-years-old (21 to 93). There were 228 females and 198 males. Fifteen patients are now deceased. Of these 15 patients, there were no complications or reoperations. In the first 5.5 years of the study, we mated the Magnum cup with a Magnum CoCr head. Over these 5.5 years, 219 CoCr heads were used. After the Magnum head was discontinued in North America, we mated the Magnum cup with a DA bearing. Over the remaining 5.5 years of the study, we used 207 DA bearings. The study was comprised of two cohorts, one that underwent an anterior acetabular bone wall reduction (AABWR group) and one that did not (non-AABWR group). In the AABWR group, 267 of 300 femoral stems (89%) were of the lateral offset design (145 Mallory-Head and 122 Taperloc stems). In the non-AABWR group, 104 of 126 femoral stems (83%) were a lateral offset design (62 Mallory-Head and 42 Taperloc stems). The acetabular cup size ranged from 44 mm to 62 mm. The most common cup size utilized was 50 mm (93 cups).

Three hundred of the 426 patients (70%) had an AABWR. There were 140 females (47%) and 160 males (53%). The average age in the AABWR group was 62-years-old (21 to 88). The average amount of bone resected in the AABWR group was 1.32 cm (0.3 cm to 3.4 cm). In the non-AABWR group, there were 126 patients, of which 88 were females (70%) and 38 were males (30%). The average age in the non-AABWR group was 64-years-old (25 to 93).

In the entire study, 61% of females and 81% of males required an AABWR. For females, the average bone resection measured 1.1 cm (0.3 to 2.0 cm). For males, the average bone resection measured 1.5 cm (0.3 cm to 3.4 cm). Younger patients (< 55-years-old) required an AABWR 69% of the time (56 of 81 patients). Older patients (≥ 55-years-old) required an AABWR 71% of the time (244 of 345 patients). Statistical analysis revealed that males were more likely to require an AABWR than females ($p < 0.001$), while older patients are just as likely as younger patients to require an AABWR ($p = 0.778$).

In the AABWR group, Harris Hip Scores (HHS) averaged 92 (71 to 100). Average hip flexion was 110 degrees (100 to 130 degrees). In the non-AABWR group, HHS averaged 87 (71 to 100). Average flexion was 109 degrees (88 to 125 degrees). In the AABWR group, 12 patients (4%) experienced groin pain symptoms. On a scale from 0 to 4, the peak groin pain rating was 1 in 10 of the 12 patients and the remaining 2 patients rated his/her peak groin pain at a 2. As time progressed, 50% of these patients saw their groin pain resolve. In the non-AABWR group, 2 patients (1.6%) experienced groin pain and both patients rated his/her pain at a 1. Mann-Whitney U testing demonstrated that patients who had an AABWR showed a statistically higher HHS score ($U = 9344$, $p < 0.001$) and a statistically greater hip flexion range ($U = 16126.5$; $p < 0.05$) compared to the non-AABWR group. With Chi-square testing, the incidence of groin pain between the two groups was not statistically different ($\lambda 2\ (2) = 1.85$; $p > 0.05$).

In this series there have been 5 dislocations (1%). All dislocations occurred during the postoperative recovery period (i.e., within the first 6 weeks). Of these dislocations, 3 were posterior and 2 were anterior. All 3 posterior dislocations occurred in the non-AABWR group (2.4%), while both anterior dislocations occurred in the AABWR group (0.7%). One posterior dislocation in the non-AABWR group required a reoperation to change the modular head to a longer length. All other dislocations were treated with a closed reduction and Spica bracing for 6 weeks. In these 4 cases there were no further dislocations. Statistical analysis demonstrated that there was no significant correlation between the two groups in terms of dislocation rate ($p > 0.05$).

There were 13 failures (3%) in the study group. The reasons for failure are listed in Table 1. The most common reasons were for a periprosthetic femur fracture after a fall, and conversion to dual articulation from a metal-to-metal hip bearing due to metal-related synovitis. There were 4 femoral neck cracks noted during femoral stem insertion. None required cabling or stem exchange. Despite having used 219 metal-to-metal hip bearings, there have been only 4 reoperations (1.8%) for metal-related synovitis and pain. In these cases we did not see any large pseudotumors (defined as greater than 4 cm in diameter). Of the 13 failures, 9 occurred in the AABWR group and 4 in the non-AABWR group. Statistical analysis demonstrated that there was no significant correlation between the two groups in terms of failure rate ($p > 0.05$).

Discussion

In THA, positioning of the acetabular cup is technique-dependent. Many surgeons espouse placing the prosthetic cup in a manner that follows the native acetabular rim. Others suggest cup placement at a set angle (10 to 30 degrees

Table 1 – Failures

Reason for Failure	Number	AABWR/ Non-AABWR	Time from Index THA (months)
Periprosthetic Femur Fracture	4	3 / 1	1 – 14
Conversion to Dual Articulation from Metal-Metal THA due to Metal Synovitis	4	2 / 2	9 – 62
Periprosthetic Joint Infection	2	2 / 0	10 – 15
Recurrent Dislocation	1	0 / 1	1
Loose Acetabulum	1	1 / 0	5
Loose Femoral Stem	1	1 / 0	31

of anteversion) based upon approach and surgeon philosophy [7]. Acetabular cup positioning is more important in patients who require higher functional hip range and performance. If a patient requires high hip flexion, the placement of the acetabular cup in an orientation that follows the native acetabular rim can result in adverse consequences. Specifically, if the native hip is dysplastically retroverted, then the prosthetic cup will maintain this retroverted orientation [10]. With high hip flexion (beyond 90-95 degrees), impingement will occur, resulting in clinical anterior hip pain, repetitive subluxation, or possibly recurrent dislocation [19]. If a large diameter bearing (LDB) is placed, the risk of dislocation is reduced, but repetitive subluxation is still likely to occur [20,21]. This will also cause abnormal bearing wear. This is of special significance with an alternative bearing, such as metal-metal, ceramic-ceramic, or metal-ceramic, where repetitive subluxation creates a stripe wear phenomenon [12,14,15]. Furthermore, with an adverse wear scenario, the accelerated wear debris will result in adverse wear debris phenomenon including osteolysis, pseudotumor formation, bearing fracture, and/or implant loosening [7-9,19-24].

To optimize functional hip range and minimize repetitive subluxation, cup positioning should be centered within the patient's anticipated functional hip range. We have found that by placing the acetabular cup at a predetermined angle of 25 to 35 degrees of anteversion (relative to the ilioischial line) in every patient, we consistently center the acetabular cup to allow acceptably higher hip flexion, yet avoid hyperextension impingement with external rotation. This clinical study was conducted in an attempt to reduce the sequela of PFAI in primary THA. We chose to be aggressive in removing impinging anterior acetabular bone in a manner that would provide salutary improvement in groin pain and improved hip flexion without incurring an increased complication rate. By performing an AABWR during primary THA, we have so far enjoyed a relatively satisfying course with this study. It is our observation that males are more likely to require an AABWR than females (p-value <0.001), while older patients (≥55) are just as likely as younger patients (<55) to need an AABWR (p-value = 0.778).

In this series, the incidence of unexplained groin and hip pain is low. We believe that by performing an AABWR, we restored functional hip flexion to a level that is commensurate with that of patients who do not have acetabular retroversion. Thus, both groups enjoy relative pain-free activities of daily living. Patients who have challenged their hips with increased functional activities have not experienced any adverse consequences at an average follow-up of 5.3 years. Flexion range was also a priority in this study, to allow for improved functional range for patients who demand a higher activity profile. Increased functional range was achieved by setting combined implant anteversion between 40 and 55 degrees. By additionally removing all anterior bone extending beyond the prosthetic acetabular socket, the hip can flex further. This is borne out with our hip range measurements. The AABWR group showed a statistically greater hip flexion range compared to those who did not require an AABWR. This observation was unexpected, as we had hypothesized flexion in the two groups would be commensurate, but nonetheless pleasing. In addition, by reducing the anterior impinging bone, overall HHS scores were distinctly better in the AABWR group. We attribute the improved scores mainly to overall improvement in pain reduction, as the HHS is highly weighted towards the patient pain score. By replacing the arthritic joint and removing anterior impinging bone, the pain score is optimized.

In this review, we would be remiss in not discussing our favorable findings regarding the large diameter Magnum cup. Our aseptic loosening rate was low (<1%). The number of revisions due to reactive metal wear was also low (1.8%). We attribute our favorable results to three main factors: 1) implant mating, 2) implant design, and 3) implant biomaterial. Repetitive subclinical subluxation (as opposed to dislocation) is a problem with LDB cups that are not well-mated [24]. With the less invasive posterolateral approach, we chose a "combined" hip version of 40 to 55 degrees [8]. On the acetabular side, our cups were placed with an anteversion of 25 to 35 degrees with a theta angle no greater than 40 degrees. Femoral anteversion was chosen to be between 15 and 20 degrees. This combined anteversion allows for functional hip flexion while minimizing head subluxation and cup edge scratching, which can lead to excess metal wear. The Magnum cup is a pure 180-degree hemisphere with insertion tabs on the extra-articular surface of the cup. This minimizes any bearing overload points. Additionally, the Magnum cup has 4 anti-rotation fins that help with initial stability. Finally, the CoCr alloy used for the bearing was treated with a hot isostatic pressure (HIP) technique that optimizes metal density, guarding against excess metal wear. This assumes first that the bearing couple is well-mated.

Although the Magnum cup continues to be sold, the large diameter metal head was discontinued in 2011. Since that time, we continue to use the Magnum cup as our first line choice in all primary THA's. We now utilize the dual articulation bearing, which thus far, at short- to intermediate-term follow-up (6 years), provides similar functional efficiency for our THA patients.

There are limitations to this study. First, the study was not randomized. A more definitive study would have exclusively identified patients with acetabular retroversion and randomized this group into two cohorts, those receiving an AABWR and those not. This study design was considered, but upon initial interrogation of study enrollees, we encountered a near unanimous opposition to this methodology. Secondly, this study used a large diameter cup and head construct. We believe this may have artificially reduced our complication rate. Had we utilized a traditional 32 or 36 mm head with a high molecular weight polyethylene socket, we may have incurred a higher dislocation rate. Thus, our AABWR maneuver cannot be extrapolated to provide similar efficacy with 32 or 36 mm head constructs. We recommend a similar study should be conducted in patients with 32 and/or 36 mm heads.

In essence, we performed an aggressive periacetabular "decompression" with removal of all bone extending beyond the prosthetic acetabular cup and with the removal of hypertrophic capsular tissue. We believe this maneuver complements the pain reducing effect of the THA procedure by decreasing the chance of mechanical impingement that can be a significant pain generator. This was borne out in our low groin pain scores. We further submit that had we not performed this maneuver, the hip flexion range in the AABWR group would have been significantly lower. Patients who suffer from stiff hips are limited not only by the arthritic process, but also by retroverted anterior acetabular bone that mechanically blocks flexion. We did worry that an over-aggressive anterior bone resection could weaken the pelvic ring, resulting in fracture or long-term pain, but the groin pain scores seen in the AABWR group improved over time as bone remodeling progressed. Additionally, we did not have any clinical cases of pelvic ring fractures. We believe the AABWR maneuver to be a safe and effective technique.

If a LDB THA is chosen for hip reconstruction, we advocate careful cup and stem positioning. The combined anteversion of 40 to 55 degrees chosen in this series appears to be acceptable for high flexion and combined hyperextension-extension-external rotation range. Based on our experience, we believe the removal of all retroverted acetabular bone extending more than 5 mm beyond the prosthetic acetabular cup is a critical step when using this bearing construct. The combination of careful cup/stem positioning along with an AABWR will minimize lever impingement. Our intermediate-term results in this study are encouraging. We hope that in the long-term this will have the salutary effect of minimizing abnormal bearing wear patterns. This series requires long-term follow-up to validate this claim. In this series we are also monitoring serum cobalt and chromium ion levels in our metal-metal bearing patients. Lastly, we advise against any cup additions (e.g., elevated posterior hoods) that would reduce implant range of motion. Hip stability should be obtained with careful selection of implant positioning, stem offset, and intraoperative trialing using a hemisphere cup without additions. Our experience shows that the anterior acetabular rim and part of the anterior column can be removed at the time of primary THA without compromising the THA procedure. The AABWR is now an integral part of our primary THA technique.

References

1. Anderson LA, Peters CL, Park BB, Stoddard GJ, Erickson JA, Crim JR. Acetabular cartilage delamination in femoroacetabular impingement. Risk factors and magnetic resonance imaging diagnosis. J Bone Joint Surg Am. 2009; 91(2): 305-13.
2. Leunig M, Ganz R. [FAI - concept and etiology]. Orthopade. 2009; 38(5): 394-401.
3. Mamisch TC, Werlen S, Zilkens C, Trattnig S, Kim YJ, Siebenrock KA, et al. Radiological diagnosis of femoroacetabular impingement. Radiologe. 2009; 49(5): 425-33.
4. Clohisy JC, St John LC, Schutz AL. Surgical treatment of femoroacetabular impingement: a systematic review of the literature. Clin Orthop Relat Res. 2010; 468(2): 555-64.
5. Peters CL, Schabel K, Anderson L, Erickson J. Open treatment of femoroacetabular impingement is associated with clinical improvement and low complication rate at short-term followup. Clin Orthop Relat Res. 2010; 468(2): 504-10.
6. Peters CL, Erickson JA. Treatment of Femoro-Acetabular Impingement with Surgical Dislocation and Débridement in Young Adults. JBJS. 2006; 88(8): 1735-41.
7. Malik A, Maheshwari A, Dorr LD. Impingement with total hip replacement. J Bone Joint Surg Am. 2007; 89(8): 1832-42.
8. Ranawac CS, Maynard MJ. Modern technique of cemented total hip arthroplasty. Techniques in Orthopaedics. 1991; 6(3): 17-25.
9. Lazennec JY, Riwan A, Gravez F, Rousseau MA, Mora N, Gorin M, et al. Hip spine relationships: application to total hip arthroplasty. Hip Int. 2007; 17 Suppl 5: S91-104.
10. Kurtz WB, Ecker TM, Reichmann WM, Murphy SB. Factors affecting bony impingement in hip arthroplasty. J Arthroplasty. 2010; 25(4): 624-34 e1-2.
11. Pandit H, Glyn-Jones S, McLardy-Smith P, Gundle R, Whitwell D, Gibbons CL, et al. Pseudotumours associated with metal-on-metal hip resurfacings. J Bone Joint Surg Br. 2008; 90(7): 847-51.

12. Clarke IC, Manley MT, Implant Wear Symposium Engineering Work G. How do alternative bearing surfaces influence wear behavior? J Am Acad Orthop Surg. 2008; 16 Suppl 1: S86-93.
13. Manaka M, Clarke IC, Yamamoto K, Shishido T, Gustafson A, Imakiire A. Stripe wear rates in alumina THR--comparison of microseparation simulator study with retrieved implants. J Biomed Mater Res B Appl Biomater. 2004; 69(2): 149-57.
14. Walter WL, Insley GM, Walter WK, Tuke MA. Edge loading in third generation alumina ceramic-on-ceramic bearings: stripe wear. J Arthroplasty. 2004; 19(4): 402-13.
15. Yamamoto T, Saito M, Ueno M, Hananouchi T, Tokugawa Y, Yonenobu K. Wear analysis of retrieved ceramic-on-ceramic articulations in total hip arthroplasty: Femoral head makes contact with the rim of the socket outside of the bearing surface. J Biomed Mater Res B Appl Biomater. 2005; 73(2): 301-7.
16. Hoppenfeld S, de Boer P, Buckley R. Surgical Exposures in Orthopaedics: The Anatomic Approach. 5th ed. Philadelphia, PA: Wolters Kluwer; 2017.
17. Sutherland T, Beloff J, Lightowler M, Liu X, Nascimben L, Kaye AD, et al. Description of a multidisciplinary initiative to improve SCIP measures related to pre-operative antibiotic prophylaxis compliance: a single-center success story. Patient Saf Surg. 2014; 8(1): 37.
18. Parvizi J, Gehrke T, International Consensus Group on Periprosthetic Joint I. Definition of periprosthetic joint infection. J Arthroplasty. 2014; 29(7): 1331.
19. Gondi G, Roberson JR, Ganey TM, Shahriari A, Hutton WC. Impingement after total hip arthroplasty related to prosthetic component selection and range of motion. J South Orthop Assoc. 1997; 6(4): 266-72.
20. Beldame J, Carreras F, Oger P, Beaufils P. Cementless cups do not increase osteolysis risk in metal-on-metal total hip arthroplasty. Apropos of 106 cases. Orthop Traumatol Surg Res. 2009; 95(7): 478-90.
21. Kluess D, Martin H, Mittelmeier W, Schmitz KP, Bader R. Influence of femoral head size on impingement, dislocation and stress distribution in total hip replacement. Med Eng Phys. 2007; 29(4): 465-71.
22. Pandit H, Vlychou M, Whitwell D, Crook D, Luqmani R, Ostlere S, et al. Necrotic granulomatous pseudotumours in bilateral resurfacing hip arthoplasties: evidence for a type IV immune response. Virchows Arch. 2008; 453(5): 529-34.
23. Harvie P, Giele H, Fang C, Ansorge O, Ostlere S, Gibbons M, et al. The treatment of femoral neuropathy due to pseudotumour caused by metal-on-metal resurfacing arthroplasty. Hip Int. 2008; 18(4): 313-20.
24. McPherson EJ, Dipane MV, Sherif SM. Massive Pseudotumor in a 28mm Ceramic-Polyethylene Revision THA: A Case Report. Reconstructive Review 2014; 4(1): 11-7.

SUBMISSION HISTORY

Submitted June 6, 2018
Reviewed July 7, 2018
Revised September 4, 2018
Accepted September 5, 2018
Published September 30, 2018

AUTHOR AFFILIATIONS

1 Edward J. McPherson, Sherif M. Sherif, Madhav Chowdhry, Matthew V. Dipane
LA Orthopedic Institute
201 S. Alvarado Street Suite 501, Los Angeles, CA 90057

(Direct inquires to Matthew Dipane, itc@laoi.org)

AUTHOR DISCLOSURES

The authors declare that there are no disclosures regarding the publication of this paper.