Surface Replacement of the Hip Can Result in Decreased Acetabular Bone Stock

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Abstract

Background The recent interest in hip resurfacing arthroplasty is motivated by its potential advantages over THA. One advantage of hip resurfacing arthroplasty is that it conserves bone on the femoral side; however, it is unclear whether it does so on the acetabular side.

Questions/purposes We determined whether the amount of acetabular reaming and acetabular bone removal required for hip resurfacing arthroplasty is equal to, less than, or greater than that for THA.

Patients and Methods We prospectively evaluated the femoral neck size of 180 hips at the time of primary THA in an identical manner to when carrying out a hip resurfacing arthroplasty. Based on the femoral neck measurement, we determined the minimum cup size that would be used and reamer size required if the hip was undergoing a resurfacing. We compared this to the reamer size actually required to prepare the acetabulum for the THA cup. We calculated the difference between the predicted reaming size for resurfacing and the actual reaming size to determine the effect of resurfacing on acetabular bone stock.

Results Overall, 71%, 57%, and 41% of THAs would have had extra acetabular bone removed to implant a hip resurfacing arthroplasty cup with a line-to-line (0-mm), 1-mm, or 2-mm press fit, respectively.

Conclusions When compared to THA, hip resurfacing arthroplasty commonly results in additional acetabular bone resection.

Introduction

There is a recent resurgence in interest in hip resurfacing arthroplasty (HRA) in young and active patients requiring THA. This is fueled by the possible advantages of HRA over THA, which include increased ROM, decreased dislocation, improved biomechanics, decreased wear, improved function, and bone conservation [8, 11, 12, 15]. However, the literature does not demonstrate any advantage of HRA compared to THA [1, 5, 7, 9, 17, 19, 20], except for the undeniable fact that it is bone conserving on the femoral side [3, 16]. However, is there a difference between HRA and THA regarding bone stock preservation on the acetabular side?

In THA, the acetabular cup size and amount of reaming depend on the size of the native acetabulum and the degree of press fit required. With HRA, it is related to the diameter of the femoral neck (to avoid femoral notching); by design, it is most commonly 6 mm greater than the size of the femoral head and is also dependent on the degree of press fit required. The press fit with a HRA cup varies by manufacturer (between 0 and 2 mm). It is unclear from the literature whether or not these factors alter the amount of acetabular bone that must be reamed away to insert a cup in a HRA as compared to a conventional THA. Some studies suggest there is no difference in acetabular bone loss with

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HRA and THA [13, 21], while others demonstrate increased bone loss with resurfacing [10, 14]. None of these studies address this issue in the same patient.

We therefore determined (1) whether the amount of acetabular reaming, and as a result, acetabular bone removal, required for HRA is equal to, less than, or greater than that required for THA in the same patient; and whether there is a difference in bone loss (2) based on gender and (3) in hips in which a HRA could be indicated.

Patients and Methods

We carried out a prospective study of 180 consecutive primary THAs (in 177 patients) performed with a cementless cup between May 2008 and November 2010. There were 102 women and 78 men, with a mean age of 65 years (range, 23–87 years), weight of 77 kg (range, 46–107 kg), and height of 175 cm (range, 132–180 cm). The preoperative diagnosis was osteoarthritis in 122 hips (120 patients), developmental dysplasia in 24 hips (24 patients), osteonecrosis in 19 hips (20 patients), inflammatory arthritis in seven hips (seven patients), and other diagnoses in eight hips (eight patients). The right hip was involved in 97 cases and the left in 83 cases.

All surgery was performed by a single surgeon (MT) using a mini-posterior approach to the hip. The hip was dislocated posteriorly and the femoral neck was exposed. If present, the anterior femoral neck osteophytes were resected with an osteotome, as would be the case if the patient had a HRA. The surgeon sized the femoral neck using a technique identical to that in a HRA. The surgeon used femoral neck gauges in 2-mm increments (Zimmer, Inc, Warsaw, IN) to measure the superior to inferior size of the femoral neck (Fig. 1). The femoral neck size ranged from 38 to 58 mm with a mean of 48 mm (Fig. 2). The average femoral neck in men (50 mm) was larger than in women (46 mm). The surgeon then cut the femoral neck based on the preoperative templating for the THA and exposed the acetabulum.

The acetabulum was reamed in a standard fashion for THA, aiming for a position of 45° abduction and 15° to 20° anteversion, using hemispherical cutout reamers (Precimed SA, L'Echelette, Switzerland). The final reaming size was based on the preoperative templating, intraoperative findings, the desired press fit, and adequacy of fit of the cup trial. Unlike HRA, the surgeon determined the final reaming size independent of femoral neck size. All cementless cups were press fit between 1 and 2 mm. The amount of press fit depended on the quality of host bone and stability of the cup trial. The press fit was 1 mm in 88 cases (49%) and 2 mm in 92 cases (51%). A press-fit, porous-coated, hemispherical cup was implanted in all

Fig. 1 An intraoperative photograph shows a femoral neck gauge measuring the superior to inferior size of the femoral neck.

Fig. 2 A graph shows the femoral neck sizes in women (solid line) and men (dashed line) expressed as a percentage of the total number of hips in each group.

cases. A Trilogy® cup (Zimmer) and a Pinnacle® cup (DePuy Orthopaedics, Inc, Warsaw, IN) were each used in 90 cases. Acetabular component size ranged from 44 to 62 mm, with a mean of 54 mm.

Based on the femoral neck measurement, we determined the size of the resurfacing cup that would be used if the same hip were to undergo resurfacing. We then determined the reamer size required to prepare the acetabulum for a resurfacing cup by subtracting the manufacturer's suggested press fit of 0, 1, or 2 mm from the size of the resurfacing cup. We compared this to the reamer size actually required to prepare the acetabulum and implant the THA cup. We calculated the difference between the predicted reaming size for a HRA and the actual reaming size used to determine whether implanting a resurfacing cup in the same hip resulted in further acetabular bone loss, bone gain, or required equal bone removal as carrying out THA. This calculation was performed for the overall group, men and women, and hips in which a HRA could be indicated. The HRA candidate group included those hips with

idiopathic osteoarthritis or arthritis secondary to a cam or pincer impingement. Hips with the diagnosis of inflammatory arthritis, osteonecrosis, or developmental dysplasia or hips requiring adjuvant screw fixation at the time of THA were excluded from this group. Overall, there were 94 hips (93 patients) that met these requirements. For analysis, the candidate group was further subdivided into men younger than 65 years (20 hips in 20 patients), since the Australian Joint Registry identified this age group of men as having the best survivorship [2].

Results

Overall, if a HRA were performed on the same hip instead of a THA, 71% and 57% of the cases would have extra acetabular bone removed to implant the cup with a line-to-line (0-mm) or 1-mm press fit, respectively (Fig. 3). The amount of extra bone that would be removed to carry out a HRA averaged 3.3 mm (range, 1–10 mm) for the cups inserted with a 0-mm press fit and 2.8 mm (range, 1–9 mm) for a 1-mm press fit. In 15% and 28% of the hips, less acetabular bone would be removed if it underwent HRA rather than THA with a 0- or 1-mm press-fit cup, respectively. The bone gain averaged 2.1 mm (range, 1–5 mm) with a 0-mm press fit and 2.1 mm (range, 1–5 mm) with a 1-mm press fit. With a 2-mm press fit, a similar number of hips would have gained or lost acetabular bone stock whether a HRA or THA was carried out, with bone loss averaging 2.6 mm (range, 1–8 mm) and bone gain averaging 2.2 mm (range, 1–6 mm).

Fig. 3 A graph shows the percentage of hips in the entire study group that would have lost bone (black), gained bone (dark gray), or had the same amount of acetabular bone removed (light gray) if a HRA was performed instead of a THA with a 0-, 1-, or 2-mm press-fit resurfacing cup.

Women were more likely than men to require extra acetabular bone reaming to accommodate a 0- or 1-mm press-fit cup for HRA instead of THA, while men required more bone removal to accommodate a HRA cup with a 2-mm press fit (Fig. 4).

In the 94 hips considered candidates for HRA, more bone would have been removed to prepare the acetabulum for a HRA with a 0- or 1-mm press-fit cup than if a THA was performed (Fig. 5). Bone loss averaged 3.3 mm (range, 1–10 mm), 2.9 mm (range, 1–9 mm), and 2.6 mm (range, 1–8 mm) while bone gain averaged 2.3 mm (range, 1–4 mm), 1.9 mm (range, 1–5 mm), and 2.1 mm (range, 1–6 mm) with a 0-, 1-, or 2-mm press fit, respectively.

Fig. 4 A graph shows the percentage of hips in men and women that would have lost bone (black), gained bone (dark gray), or had the same amount of acetabular bone removed (light gray) if a HRA were performed instead of a THA with a 0-, 1-, or 2-mm press-fit resurfacing cup.

Fig. 5 A graph shows the percentage of hips in the 94 hips that were ideal candidates for HRA that would have lost bone (black), gained bone (dark gray), or had the same amount of acetabular bone removed (light gray) if a HRA were performed instead of a THA with a 0-, 1-, or 2-mm press-fit resurfacing cup.

Fig. 6 A graph shows the percentage of hips in the group of 20 men younger than 65 years who were in the HRA candidate group that would have lost bone (black), gained bone (dark gray), or had the same amount of acetabular bone removed (light gray) if a HRA were performed instead of a THA with a 0-, 1-, or 2-mm press-fit resurfacing cup.

Depending on the degree of press fit, the acetabulum would only be reamed to the same extent to implant a cup in a HRA or THA in 17% or less of the hips. In the subgroup of 20 hips in men younger than 65 years who were in the HRA candidate group, insertion of a HRA cup with a 0-mm press fit would have resulted in more acetabular bone loss in 75% of the cases, averaging 2.9 mm (range, 1–10 mm), and less bone loss in 20% of the cases, averaging 1.5 mm (range, 1–2 mm) (Fig. 6). With a 1-mm press fit, 65% of the hips would have extra acetabular bone removed, averaging 3.4 mm (range, 1–9 mm), and 20% would have less bone removed, averaging 2.5 mm (range, 2–3 mm). With a 2-mm press fit, 55% of the hips would have extra bone loss, averaging 2.8 mm (range, 1–8 mm), while 40% would have gained acetabular bone stock, averaging 2.4 mm (range, 1–4 mm).

Discussion

One of the reasons for the recent resurgence in interest for HRA in young and active patients requiring THA is the preservation of bone stock for future revision surgery. Although it is undeniable that HRA is bone conserving on the femoral side compared to THA, it remains unclear whether or not there is a difference between these two procedures regarding bone stock preservation on the acetabular side. We therefore determined (1) whether the amount of acetabular reaming, and as a result, acetabular bone removal, required for HRA is equal to, less than, or

greater than that required for THA in the same patient; and whether there is a difference in bone loss (2) based on gender and (3) in hips in which a HRA could be indicated.

There are some limitations to our study, none of which have substantive impact on the results or conclusions. First, the femoral neck measurements were made in all patients having a cementless acetabular cup, not only those that would be a candidate for a HRA. However, as the early results of HRA are beginning to be published, the ideal patients for this procedure are being continuously redefined. Furthermore, the overall results of this study were subdivided to look specifically at hips that can undergo a HRA based on diagnosis, patient age, patient gender, and cup stability at the time of surgery. This led to smaller numbers of hips to analyze in each subgroup. Second, the final cup size implanted during HRA is not always the smallest size possible based on the neck measurement. Sometimes, the intraoperative findings or alignment pin angle compel the surgeon to upsize the femoral component to avoid notching of the femoral neck. As a result, the acetabulum must be reamed even further to accommodate an acetabular component larger than that based on the femoral neck size alone. This suggests the amount of acetabular bone reaming we calculated to implant a resurfacing cup in this study represents the minimum amount of bone needed to be removed. The only way to have taken this into account would be to have prepared the femoral head for a resurfacing implant and subsequently cut the femoral neck to carry out a THA. This would result in excessive surgical time and is impractical. Finally, this study looked at HRA cups that were 6 mm larger than the femoral size. There are systems that allow for a larger cup with a thicker shell to be implanted with the same femoral implant. This would result in further acetabular bone removal to implant the larger cup. This study only looked at the minimum cup size that could be used if a HRA was performed.

Our data allowed a direct comparison of acetabular bone removal in THA and HRA in the same patients. The degree of acetabular bone loss or gain after HRA versus conventional THA is not similar and depends on the amount of press fit required by the implant design. The data suggest HRA can result in additional acetabular bone removal relative to THA and this most commonly occurs in men and when implanting cups with a 0- to 1-mm press fit. In these cases, additional acetabular bone removal of 2 to 4 mm is commonly required. These cases also represent the most frequent gender selected for HRA and the surgical press fit most commonly used.

Two previous studies suggest removal of acetabular bone during HRA is comparable to that of THA [13, 21], whereas another two studies report increased acetabular bone resection for HRA [10, 14] (Table 1). In an age- and gender-matched retrospective analysis, Moonot et al. [13]

Table 1. Literature review of studies comparing acetabular bone stock after THA or HRA

Study	Study design	Number of arthroplasties	THA cup (press fit)*	HRA cup (press fit)*	Outcome
Moonot et al. [13]	Retrospective cohort study	700 THAs 500 HRAs	Allofit, Ancafit, Trident (2 mm)	Birmingham (2 mm)	No difference in males; mean cup size 2 mm larger in females with HRA than with THA
Vendittoli et al. [21]	Prospective randomized	103 THAs 107 HRAs	Allofit (2 mm)	Durom (2 mm)	No difference between THA and HRA
Loughead et al. [10]	Retrospective	33 THAs 35 HRAs	ABG II, Trilogy (unknown)	Birmingham (unknown)	Mean cup size 4.6 mm larger with HRA than with THA
Naal et al. [14]	Retrospective	1643 THAs 249 HRAs	Allofit (0 mm)	Birmingham (2 mm), Durom (0 mm)	Mean cup size 1.6–2.7 mm and 1.7–2.4 mm larger in males and females, respectively, with HRA than with THA
Tanzer et al.	Prospective	180 THAs	Pinnacle, Trilogy (1 or 2 mm)	Not applicable	Overall, 71%, 57%, and 41% of THA cases would have had extra acetabular bone removed to implant a HRA cup with a 0-, 1-, or 2-mm press fit, respectively; outcome varied by gender

* THA cups: Allofit® (Zimmer, Inc, Warsaw, IN), Ancafit® (Wright Medical Technology, Inc, Memphis, TN), ABG II® (Stryker Orthopaedics, Mahwah, NJ), Pinnacle® (DePuy Orthopaedics, Inc, Warsaw, IN), Trident PSL® (Stryker, Newbury, UK), Trilogy® (Zimmer); HRA cups: Birmingham® (Midland Medical Technology, Ltd, Birmingham, UK, or Smith & Nephew, Solothurn, Switzerland), Durom® (Zimmer); HRA = hip resurfacing arthroplasty.

found no difference in the mean acetabular size required for THA or HRA. However, for age-matched women, the mean outside diameter of the HRA acetabular components was 2.0 mm less than that of the acetabular components in uncemented THAs. Vendittoli et al. [21] found no difference in the size of the acetabular components used in patients randomized to either a THA or HRA. This is in contrast to Loughead et al. [10] who reported more bone was removed from the acetabulum in HRA than in hybrid THA. Similarly, Naal et al. [14] found the mean cup size was larger in males and females with HRA than with THA. Each of these studies used different implants and techniques, had different patient demographics, and compared patients who underwent either a HRA or THA (Table 1). In no studies do the authors directly compare the acetabular bone removal that would be required to carry out a resurfacing or THA in the same hip, as was the case in our study.

Although some might consider the amount of bone loss associated with HRA in some of the groups we identified as small by their absolute value and, therefore, clinically unimportant, this degree of bone loss represents a difference of one or two cup sizes. This is clinically relevant since conservation of acetabular bone is extremely important for revision THA, and technical difficulties during revision increase with decreasing bone stock [4, 6, 18]. This study allows the direct comparison of acetabular bone removal in THA and HRA in the same patients. Overall, the degree of acetabular bone loss or gain after HRA versus conventional THA is not identical, and even though HRA is bone preserving on the femoral side, it commonly results in additional acetabular bone resection.

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