Metal-on-Metal Hybrid Surface Arthroplasty. Surgical Technique

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**Supplementary material**

Commentary and Perspective, data tables, additional images, video clips and/or translated abstracts are available for this article. This information can be accessed at [http://www.ejbjs.org/cgi/content/full/88/1_suppl_2/234/DC1](http://www.ejbjs.org/cgi/content/full/88/1_suppl_2/234/DC1)

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INTRODUCTION
With the introduction of wear-resistant bearings, particularly metal-on-metal couples, total hip resurfacing is emerging as a viable alternative prosthetic solution to conventional total hip arthroplasty for young patients with end-stage osteoarthritis of the hip. The clinical results reported in our JBJS original article in which the surgical technique was presented were bone-stock and technique-dependent, especially on the femoral side—where the area available for component fixation is relatively small. The surgical technique for resurfacing differs from that for total hip replacement because the surgeon must work around the head of the femur to obtain access to the acetabulum; this situation presents potential pitfalls and results in specific recommendations. On the basis of our initial and mid-term results, our experience with metal-on-metal resurfacing has been characterized by progressive changes in (1) the surgical technique itself, (2) the instrumentation used for the procedure, and (3) the design of the acetabular implant.

A detailed description of the early technique and instrumentation has already been published\(^1\), and the technique described here for a successful implantation of the resurfacing prosthesis represents the result of our extended experience with hip resurfacing. Because we have identified risk factors for femoral neck fracture\(^2\) and for loosening of the femoral component, the technique modifications include a much improved bone preparation, which has been responsible for reducing loosening and radiographic signs of loosening. The purpose of this article is to present our current indications and contraindications, revised technique, and postoperative protocol.

SURGICAL TECHNIQUE
Templating
Preoperative planning is essential. A Conserve Plus hip resurfacing prosthesis (Wright Medical Technology, Arlington, Tennessee) is used
Twenty percent magnified templates are placed over both the anteroposterior and the Johnson lateral (also known as the cross-table or horizontal lateral) radiographs of the hip. The anteroposterior template is oriented to provide a 140° stem-shaft angle. A series of 5-mm dotted lines radiating from the center of the head assists in positioning the pin in the optimal position with respect to the ligamentum teres (Fig. 2). The dotted lines that are parallel to the neck indicate how much bone the reamer will remove and how close the reamer will come to the external surface of the femoral neck. The template on the lateral radiograph shows the position of the stem, which should be translated anteriorly and directed slightly posteriorly to clear the anterior osteophyte that is invariably present (Fig. 3).

**Patient Preparation**

We prefer operating rooms with a clean-air setting equipped with...
horizontal airflow. Most metal-on-metal surface arthroplasties are performed with the use of epidural, supplemented with general hypotensive, anesthesia.

The patient is positioned on his or her side with the pelvis stabilized by padded supports in a neutral position on the pubis, the sacrum, and the anterior and posterior aspects of the thorax and with the table tilted slightly anteriorly. This enables maximum rollback of the patient during acetabular reaming. The lower extremity must allow ≥90° of flexion at the hip and be adducted for the femoral head to be delivered through the split in the gluteus maximus.

**Approach**

Although other approaches are possible, we prefer the posterior approach because no important muscle groups are transected. There is no release of the abductor muscles, which play the most important role in stabilizing the hip during walking and other bipedal activities. The only muscle groups that are released are the short external rotators, which are repaired at the conclusion of the procedure. No important gait disturbances result from a release of the external rotators, even if they are not repaired, because external rotation can be accomplished by other muscles.

The incision starts 6 to 8 cm distal to the top of the greater trochanter, continues along the center of the shaft, and then angles posteriorly from the tip of the trochanter for about 4 to 6 cm (Fig. 4). The length of the incision varies according to the size of the patient. The fascia lata is divided, and then the gluteus maximus fibers are separated. Originally, the gluteus maximus tendon was completely sectioned as it inserted into the linea aspera, but we found that this is not always necessary, particularly in thin patients with a small femoral head (<48 mm). Next,
the short external rotator muscle fibers are divided and may be tagged for reattachment. The capsule is then incised posteriorly.

The hip is dislocated by flexion, adduction, and internal rotation. The major difference from a total hip replacement relates to the fact that the femoral head is in the way during a resurfacing procedure and, in order to mobilize the head, the capsule must be completely released. A subtotal capsulectomy is performed superiorly and anteriorly. Adduction and internal rotation of the lower limb beyond 90° cause the interval between the head and neck and the acetabulum to widen, facilitating resection of the anterior aspect of the capsule and then release of the capsule inferiorly. This inferior release is done with a scalpel along the anterior aspect of the neck. The capsule needs to be released inferiorly to deliver the head and to allow the insertion of the neck elevator, which is necessary for the placement of the pin-centering guide (Fig. 5). It is not necessary to excise the entire posterior aspect of the capsule, which can be retracted by a pin inserted into the pelvis to facilitate acetabular preparation. The femoral head is de-bulked as described below to facilitate capsular removal, and the head is translocated superiorly and anteriorly for preparation of the acetabulum and implantation of the acetabular component.

**Pin Centering**

The pin-centering guide is positioned with use of the angle finder, which has a range of 135° to 145°, so that the pin forms an angle of approximately 140° with the femoral shaft and the entry point of the pin is consistent with the position determined by templating. The pin should be centered in the middle of the neck in the frontal plane (on the anteroposterior radiograph) and anterior to the neck center and directed slightly from posterior to anterior in the coronal plane (on the cross-table lateral radiograph) to avoid reaming into the anterior osteophyte. A 3.2-mm Steinmann pin is then inserted to a depth of 3 to 5 cm, with use of the guide to prevent the pin from moving off line during insertion. The cylindrical reamer gauge for the anticipated final femoral head size (Fig. 6) is then used to check the positioning of the pin;
CRITICAL CONCEPTS

INDICATIONS:
Although metal-on-metal surface arthroplasty can be selected for most patients in need of a prosthetic solution for end-stage osteoarthritis of the hip, it is particularly indicated for young patients, for whom conventional total hip replacement may not last a lifetime and who likely will require revision surgery. A primary metal-on-metal resurfacing might not last any longer than a conventional total hip replacement, but it will allow an easier revision with more durable results because the femoral canal remains intact and the proximal femoral bone density is preserved. It is indicated for patients with primary or secondary osteoarthritis subsequent to trauma, osteonecrosis, rheumatoid arthritis, Legg-Calvé-Perthes disease, slipped capital femoral epiphysis, developmental dysplasia of the hip (Crowe class I or II), and protrusio acetabuli. Also, there are some situations in which a conventional total hip replacement cannot be inserted, such as in a patient with a proximal femoral deformity subsequent to a traumatic event or a patient with melorheostosis affecting the femur.

In addition, cystic defects of >1 cm in size and a small femoral head (<46 mm) constitute specific indications for cementing the metaphyseal stem. Cementing the stem increases the fixation area, which compensates for the suboptimal fixation associated with these specific risk factors.

FIG. 4
Skin incision for the posterior approach.

FIG. 5
Placement of the pin-centering guide with a redesigned arm reaching around the osteophyte. Note the angle finder, which has slots at 135°, 140°, and 145° to be aligned with the pin at 140°.
CRITICAL CONCEPTS
continued

CONTRAINDICATIONS:
The contraindications for this procedure are:

- Renal dysfunction. Even though the metal-on-metal bearing of this prosthesis has extremely low wear, metal wear particles are released and metal ions, which are normally excreted by the kidneys, potentially would have a more deleterious effect in a patient with renal dysfunction.

- Severe dysplasia of the hip (Crowe class III or IV) and a limb-length discrepancy of >2 cm. The ability to correct a limb-length discrepancy of >1 cm is limited with this technique.

- Active infection.

- Severe osteoporosis.

Relative contraindications are extensive cystic degeneration of the femoral head (single or multiple cysts of >1 cm) and/or a small femoral component (≤46 mm). Older patients with both characteristics might be better served by a conventional stem-type total hip replacement. For a younger patient with large cysts, this approach may still be acceptable because of the lack of a better alternative. However, meticulous bone preparation is necessary, and the patient must be advised to restrict high-impact physical activities.

FIG. 6
The cylindrical reamer gauge is used to check the clearance of the reamer around the femoral neck and the amount of bone that will be resected from the femoral head.

FIG. 7
The pin relocator guide allows the surgeon to modify the position of the pin in any direction.
it should be able to rotate freely with sufficient clearance around the neck to ensure that cylindrical reaming will not result in notching of the femoral neck. If the cylindrical reamer gauge impinges on the neck at any location, the pin needs to be repositioned with use of the relocator guide (Fig. 7). It is especially important to protect the superior cortex, which is thinner than the inferior side and undergoes tensile loads, to decrease the risk of creating a femoral neck fracture.

**Cylindrical Reaming**

Reaming commences with an oversized reamer, generally two or three sizes larger than the final anticipated size of the femoral head, with copious irrigation to avoid seizing (Fig. 8). It is important to start the reaming with intermittent repetitive pressure directed parallel to the axis of the pin so as not to bend the pin. (The pin rarely travels through the center of the head, and consequently the teeth of the reamer often engage the femoral head asymmetrically.) Smaller reamers are then used similarly, with the last reamer being one size greater than the final templated and anticipated size. One should be careful to stop reaming at the head-neck junction and to avoid notching of the superior aspect of the neck. This is essential because the reaming at 140° is generally at a higher neck-shaft angle than the native anatomical condition. After this initial reaming, the interval between the anterior aspect of the femoral neck

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**FIG. 8**

Cylindrical reaming should be performed very carefully to avoid notching of the neck.

**FIG. 9**

The translucent acetabular gauge is used to assess the size, depth, and sphericity of the reamed acetabulum.
A final check of the size and roundness of the acetabulum is made with the metallic ring gauges.

The acetabular component inserter is set for 42° of lateral opening (when the “guide rod” is held perfectly vertical with the patient lying in a lateral decubitus position).
and the acetabulum is increased so that the remaining anterior aspect of the capsule can be excised more easily. This will facilitate the positioning of the femoral head into a muscle pocket superiorly and anteriorly, as the lower limb is brought into extension and neutral or slight internal rotation to provide wide access to the acetabulum. A right-angle Hohmann retractor (Innomed, Savannah, Georgia) is placed over the anterior wall of the acetabulum to retract the femur anteriorly. A malleable retractor is useful to retract the muscles inferiorly and facilitate resection of the inferior aspect of the capsule. A double-pointed inferior acetabular retractor (Innomed)
is inserted to visualize the entire acetabulum.

**Acetabular Preparation**
Acetabular preparation starts with a careful assessment of the anterior and posterior walls. The soft tissues and the cartilage lying on the floor of the cotyloid foramen are removed. Reaming is performed in a manner similar to that used for a total hip replacement, with use of hemispherical reamers of increasing sizes until some cancellous bone is exposed. It is not necessary to ream to the acetabular floor in most patients. The final reamer size should be 1 mm less than the
CRITICAL CONCEPTS

PITFALLS:
The main pitfalls associated with the described technique include:

- Notching of the superior cortex of the femoral neck during cylindrical reaming, which can weaken the femoral neck and lead to femoral neck fracture. The guiding pin must be accurately positioned and checked. The pin can be relocated at any time until the final stage of reaming.

- Reaming into the anterior osteophyte when there is no structural cortex underneath. This can weaken the femoral neck as these osteophytes often become a structural part of the neck. We suggest slight anterior translation of the femoral component associated with slight posterior angulation of the component to preserve the osteophyte.

- Leaving debris on the femoral head and failing to properly dry the head during cement application. This is a critical stage of the surgical procedure that determines the quality of the initial fixation of the femoral component.

- Opinions differ regarding the role of the medial femoral circumflex artery and the intraosseous blood supply in the arthritic femoral head. This topic is definitely an important current field of investigation, but to date no association has been made.

The final outside diameter of the acetabular component. Acetabular cysts are curetted and then grafted with fragments obtained by the reaming of the femoral head. The final size, roundness, and especially depth of the reamed acetabulum are checked.
with use of translucent acetabular gauges (Fig. 9). A final check in three planes is then made with use of metallic rigid ring gauges (Fig. 10). For the thin shells, reaming is performed “line to line” (e.g., to 58 mm for a 58-mm thin-walled 3.5-mm-thick socket, which is actually 59 mm in diameter). The 58-mm ring gauge should seat to the floor of the acetabulum. If the gauge does not reach the floor or is difficult to insert, the cause is probably a ridge rim of bone at the acetabular entrance that was created posteriorly because the cutting teeth of the reamers are less than a full hemisphere. The 59-mm gauge should not go completely to the floor in order to provide a press-fit of about 1 mm. The press-fit is essentially achieved in the anterior-to-posterior direction between the anterior and posterior columns of the acetabulum.

**Acetabular Implantation**

The acetabular component is inserted after a final jet lavage and antibiotic irrigation. The outriggers on the handle of the inserter should be set on 42° of lateral opening (the guide rod will be straight up with the patient in the lateral decubitus position) and 15° of anteversion (Fig. 11). Our recommendation is to in-
crease the anteversion to 20° to 25°. The surgeon holds the inserter, and the technician or assistant impacts it until the acetabular component is firmly seated. It is important to check the fixation of the implant at this point by rocking the pelvis with use of the inserter still engaged in the socket. If the fixation is insufficient, the component should be removed and the acetabular cavity should be reamed more deeply. Minor degrees of correction can be accomplished by mallet taps on the rim with an impactor. To disengage the inserter, one should pull up on the release, have the assistant rotate it counterclockwise a few degrees, and remove the inserter by bringing the handle cephalad. The new inserter design has a lower-profile holder and is much easier to release. A ball impactor is then used to complete the insertion (Fig. 12). Protruding osteophytes (Fig. 13) are removed with an osteotome from the posterior, and especially the anterior, wall of the acetabulum within 1 to 2 mm of the socket, and the remaining wall is chamfered with a high-speed burr.

**Final Femoral Preparation**

The femoral head is delivered again, and internal rotation is aided by a towel pack held between the thigh of the assistant surgeon and the patient’s leg (Fig. 14). The neck elevator is repositioned, and the pin is reinserted through the last cylindrical reamer that was used. A final check is made to assess pin orien-

**FIG. 20**

The CO₂ blow-drier (CarboJet, Kinamed) is used to dry the femoral head before cementation.

**FIG. 21**

Cement is poured into the femoral component to just below the recessed groove.
A final check of the femoral...
head shape is made by rotating the trial femoral head component (Fig. 18). The trial component should rotate freely to ensure a cement mantle of about 1 mm all around the femoral head. All cystic material and soft tissue should be removed from the prepared femoral head with a sharp curet and burr, and additional fixation holes should be made in both the dome and the nonporous chamfered areas with use of a 1/8-in (3.2-mm) drill bit (Fig. 19). Generally, six, seven, or eight holes are made in the dome and twelve, thirteen, or fourteen holes are made in the chamfered area.

**Femoral Head Cementation**

Before cementation, the femoral head is jet-lavaged free of any fat or debris and is irrigated with antibiotic solution. A suction tip is then inserted through the stem hole and is connected to wall suction. An additional tapered suction cannula is inserted into a 3.2-mm drill hole in the lesser trochanter, and the tapered stem of the suction cannula is tapped in for a tight fit. It is important to clean and dry the surfaces. A CO2 blow-drier (CarboJet; Kinamed, Camarillo, California) is useful to dry the field and to identify any tissue that would prevent intimate contact of the cement with the bone (Fig. 20). One package of bone cement (Surgical Simplex P; Howmedica, Rutherford, New Jersey) is then mixed and is poured into the femoral component to just below the recessed groove (Fig. 21), and cement is hand-pressurized into the cylindrically reamed portion of the head (Fig. 22). If the stem is to be cemented, cement is hand-pressurized down the central hole after cleaning and drying. The femoral component is then inserted with the cement in the early dough stage, with care taken to make sure that the component is fully seated. (If needed, the impactor and mallet can be used.) Pressure is maintained until the cement has cured. All excess cement should be trimmed carefully with a scalpel and/or dental tool so that it is not pulled away from the interface. A mirror can assist in the removal of excess cement from the anterior cup-bone margin (Fig. 23).

**Hip Reduction and Closure**

After careful removal of all visible or palpable loose pieces of cement and bone debris, the hip is reduced and a complete range of motion is performed. The surgeon checks for anterior impingement by internally rotating the hip in 90° of flexion. It is desirable to have ≥40° of internal rotation. There should also be 40° of external rotation in extension. With the hip and knee extended, the hip should be pushed anteriorly to make sure it is stable. Final irrigation is done with 2000 or 3000 mL of saline solution and 1000 mL of antibiotic solution. The gluteus maximus tendon and the short external rotators are repaired with number-1 Vicryl su-
ture, and the wound is closed over one Hemovac-type drain.

**POSTOPERATIVE MANAGEMENT**

All patients are managed with prophylactic antibiotics for two days, adjusted low-dose war-
farin for three weeks, and then aspirin for an additional three weeks. Fifty milligrams of indomethacin is given preoperatively and postoperatively, and then 25 mg is given three times a day for five days. In our clinical series, beginning with the forty-ninth patient, all male patients undergoing simultaneous bilateral surgery were given a single dose of 700 cGy of radiation preoperatively and indomethacin because of the potentially more severe clinical implications associated with the development of Brooker grade-III or IV heterotopic ossification bilaterally and the slightly more established efficacy of radiation therapy as opposed to indomethacin.

Walking begins on the first postoperative day, with weight-bearing allowed as tolerated. The patients are sometimes discharged on the second day, but generally they are discharged on the third day (and on the fourth day if bilateral surgery was performed). Crutches are used for three to four weeks, and a cane is occasionally used for an additional one to two weeks. Patients return to driving and work three to four weeks after the surgery. Low-impact sports are generally permitted at three to four months postoperatively. Impact sports are not recommended for patients who have hip cysts of >1 cm in diameter.

REFERENCES