

# TOTAL HIP ARTHROPLASTY WITH METASUL ARTICULATION

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Metasul is the brand name for metal-on-metal articulation manufactured by Sulzer Orthopedics. The reason for having a metal-on-metal articulation is to reduce the volume of wear particles that are produced with total hip replacement. The outcome of reduced particle formation will, hopefully, be reduced osteolysis. The surgical technique for a Metasul total hip replacement articulation is the same as hip replacement with any other articulation surface. The acetabular insert and the femoral head must be Metasul components so that the metal, the clearance of the femoral head and the acetabulum, and the contact areas match. Otherwise, point contact could occur with excessive wear. Currently, we perform total hip replacements with Metasul articulation in all patients below the age of 75 years. We perform the surgery with a minimally invasive incision that varies from 2½ to 4 in depending on the thickness of the thigh. The technique for acetabular preparation in Metasul implantation is described in this article.

**KEY WORDS:** metasul, metal-on-metal, articulation  
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Contemporary total hip replacement began in the early 1960s when Sir John Charnley introduced the cemented metal on plastic low-friction hip replacement. In this same decade McKee and Farrar developed and used a metal-on-metal implant.<sup>1,2</sup> The McKee-Farrar total hip replacement was used until the mid-1970s but was discarded because the loosening of the cup was greater than that with the Charnley prosthesis.<sup>2</sup> Acetabular revision occurred in 4.4% of hips by 10 years in 1 study<sup>1</sup>; Dobbs<sup>2</sup> and Jantsch et al<sup>4</sup> had 51% and 34%, respectively, loosening of the acetabular component.

Metal-on-plastic hip replacements with time had their own problems with loosening, particularly associated with polyethylene particulate debris and osteolysis.<sup>5,6</sup> Because polyethylene was strongly implicated as the source of the most inflammatory particles, interest again developed in hard-on-hard articulation surfaces. Therefore, in the late 1980s, Bernard Weber in St Gallen, Switzerland, stimulated the development of a modern metal-on-metal design that was named Metasul (Sulzer Medica, Winterthur, Switzerland). The articulating surfaces were made from the Protasul-21 WF (Sulzer Medica) cobalt chrome alloy. Weber began implanting the Metasul implants with cemented cups in 1988. The results with his first 110 hips, implanted between 1988 and 1992, are 98% good or excellent results at a 2 to 7 year follow-up (average, 3.5 years).<sup>7</sup>

We began using the Weber Metasul cup in 1991 (Fig 1). Between 1991 and 1994, we replaced 70 hips using this Metasul cup. Nine patients died, and we had phone contact with 5 when these patients were studied at 4 to 7 years postoperatively. Fifty-six patients with 56 hips had com-

plete follow-up for an average of 5.2 years (4 to 6.8 years).<sup>8,9</sup> Three patients required revision, 1 for acetabular loosening and 2 for dislocation. Forty-seven of the 53 patients not revised were evaluated clinically with self-assessment questionnaires. Thirty-six of 53 (77%) rated their outcomes as excellent, 7 (15%) as very good, 2 (4%) as good, 1 (2%) fair, and 1 poor. These results clearly showed that Metasul metal-on-metal total hip arthroplasty performed as well or better than traditional standard metal-on-plastic articulation total hip replacements for the same time period. Schmalzreid et al<sup>10</sup> estimated that the combined linear wear of the acetabular and femoral components of the McKee-Farrar metal-on-metal implants retrieved at 20 years was 4.2  $\mu$ /yr. Schulte et al<sup>11</sup> measured wear of the Charnley metal-on-polyethylene prosthesis on radiographs at 20 years and reported an average rate of 0.1 mm/yr, which is 25 times greater than the 0.0042 mm/yr from the retrieved McKee-Farrar implants. More recently, Ritter et al,<sup>12</sup> whose patients were followed-up for an average of 5.2 years reported that 2 (2%) of 100 all polyethylene cups and 8 (6%) of 138 metal-backed cups were revised. Twenty-three (23%) of all polyethylene cups and 54 (39%) of the metal-backed cups had loosened.

The primary failure mechanism with metal-on-plastic bearing has been wear. Weber described notable differences in wear between metal-on-plastic and the original McKee-Farrar implant.<sup>7</sup> Retrievals of Metasul metal-on-metal implants showed wear of 0.002 mm/yr, compared with 0.1 to 0.2 mm/yr year for metal-on-plastic implants.<sup>13,16</sup> Implant retrieval of Metasul as reported by Doorn and Campbell<sup>17</sup> confirmed that wear from these implants was at the low levels of 2 to 10  $\mu$ /yr as predicted from laboratory studies.

Weber<sup>7</sup> and Dorr et al<sup>8,18</sup> both reported good clinical results and no accelerated early cup loosening with the cemented acetabular component. Therefore, press-fit fixation with the porous-coated anatomic porous replacement (APR) cup and modular insert (Sulzer Medica, Austin, TX)

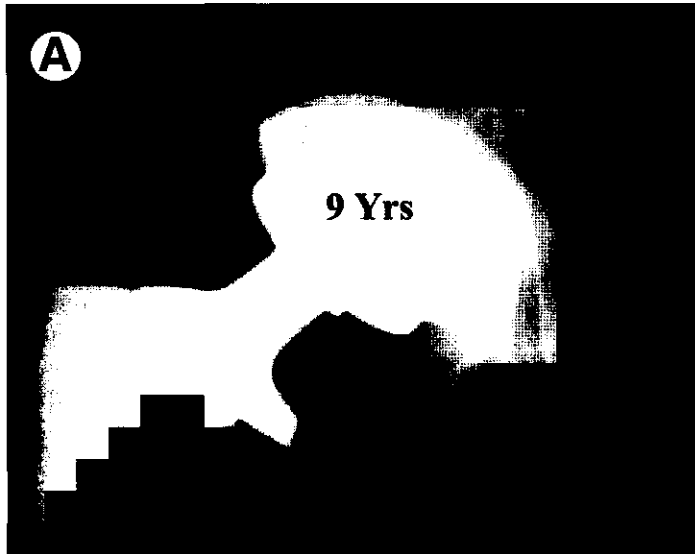


Fig 1. Weber cup (cemented Metasul acetabular component). AP (A) and lateral (B) radiographs at 9 years postoperatively.

was entered into an Investigational Device Exemption (IDE) study with the Food and Drug Administration (FDA) in 1994 (Fig 2). The use of a porous-coated cup for bone ingrowth fixation and a modular Metasul insert was approved by the FDA in August of 1999. The current use of Metasul with the press-fit application is with the Converge cup (Sulzer Medica, Austin, TX). Results with the press-fit APR cup from the IDE study agreed with the results from the cemented cups. Forty-five patients with 48 hips were followed-up for an average of 3.1 years (range, 2.0 to 5.2 years), 95.8% had excellent or good results (83.3% excellent and 12.5% good). There have been no revisions for a loose cup or stem. One patient had disassociation of the polyethylene insert from the metal shell that did require replacement of the polyethylene liner. Radiographically there were no loose cups or stems (Fig 3). These patients have a Harris Hip Score average of 95.9 (70 to 100) and an average pain score of 42.1 (30 to 44). These clinical results have encouraged us to continue to use Metasul inserts with the Converge cup in healthy patients under age 75 years.

## TECHNIQUES

### Surgical Approach

The patient is placed in the lateral position and the pelvis and chest are secured by a hip grip (Sunmedica, Redding, CA). Our technique is the posterior approach, and this will be described with the use of an APR porous-coated metal shell with a Metasul modular insert. We used the APR porous-coated stem that had a grit-blasted diaphysis for almost all hip replacements regardless of age or bone type. Any Sulzer stem that has a 12/14 taper that accepts the Metasul modular femoral head can be used.

The skin incision is centered just anterior to the prominent tubercle of the posterosuperior greater trochanter and extended 3-finger-breadths superiorly and posteriorly and 3-finger-breadths distally (a 6-in incision). This incision exposes the gluteus maximus muscle in the proximal two thirds of the incision and the tensor fascia for the distal one

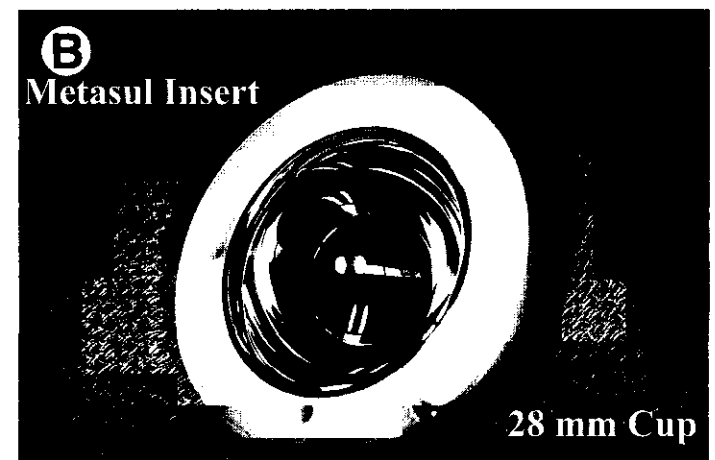
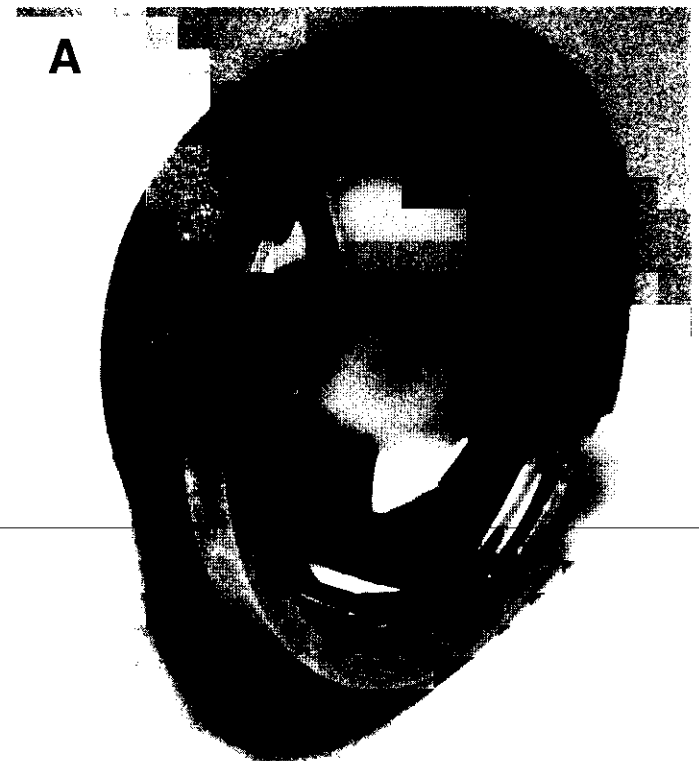


Fig 2. APR Cup (press-fit) (A) and Metasul liner (B).

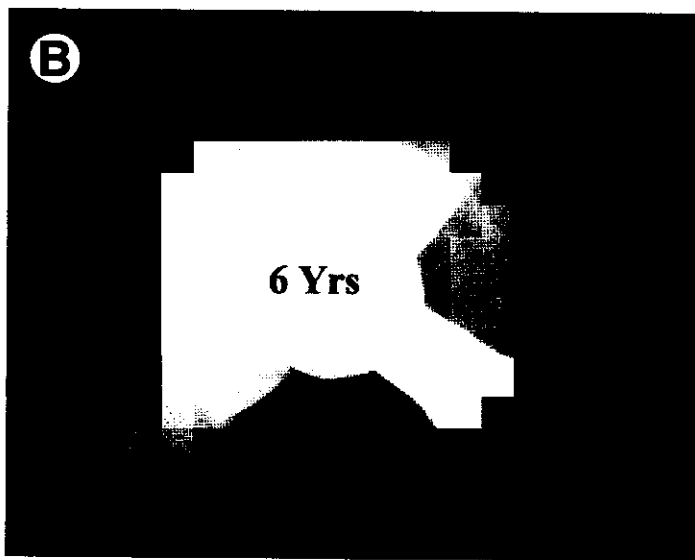


Fig 3. APR Cup with Metasul liner (press-fit cup and stem). AP (A) and lateral (B) radiographs at 6 years postoperatively.

third (Fig 4). The gluteus maximus muscle is divided at the herring-bone junction of its fibers by electrocautery so that the neurovascular supply to the muscle will not be torn manually, dividing the muscle. The exposure reveals the posterior hip from the lesser trochanter to the superoposterior greater trochanter where the gluteus medius tendon attaches to the trochanteric bone (Fig 5A). The capsule and external rotators are reflected from the greater trochanter as a single flap (Fig 5B). A retractor is placed between the gluteus medius and gluteus minimus muscle to expose the gluteus minimus muscle proximal to the piriformis tendon. The incision begins in the gluteus minimus 3 cm superior to the piriformis tendon and extends through the attachment of the quadratus femoris muscle over the lesser trochanter (Fig 6). This exposure allows easy dislocation of the hip. After dislocation a ruler is used to measure the hip length from the lesser trochanter to the center of the femoral head (Fig 7). This length is compared with the preoperatively planned length of the femoral neck cut. As a general rule, the length of the neck cut is directly related to the length of the femoral neck (Table 1). If the neck shaft angle is not  $130^\circ$ , the comparative neck cut

for the neck length may differ. Bone wax is placed on the cut surface of the femoral neck to prevent bleeding from the femur into the acetabulum during acetabular preparation.

Correct acetabular exposure requires that there be complete anterior displacement of the femur so that the femur does not overlay the anterior acetabulum. This acetabular exposure is accomplished by 3 maneuvers, with a fourth sometimes needed. Step 1 is the excision of the capsule between the anterior acetabulum and the femoral neck (Fig 8). Step 2 is the relaxation of the capsule between the posterior acetabulum and the anterior femur (Fig 9). Step 3 is incision and relaxation of the reflected head of the rectus, which removes a tether against which the anteriorly retracted femur rests (Fig 10). In a hip that is muscular and tight, the skin incision will need to be extended distally and the insertion of the gluteus maximus tendon onto the femur released (Fig 11). These soft-tissue releases permit complete anterior retraction of the femur so that access is available to the entire acetabulum (Fig 12). This exposure is necessary for precise and efficient preparation of the acetabulum for the porous-coated metal shell, partic-

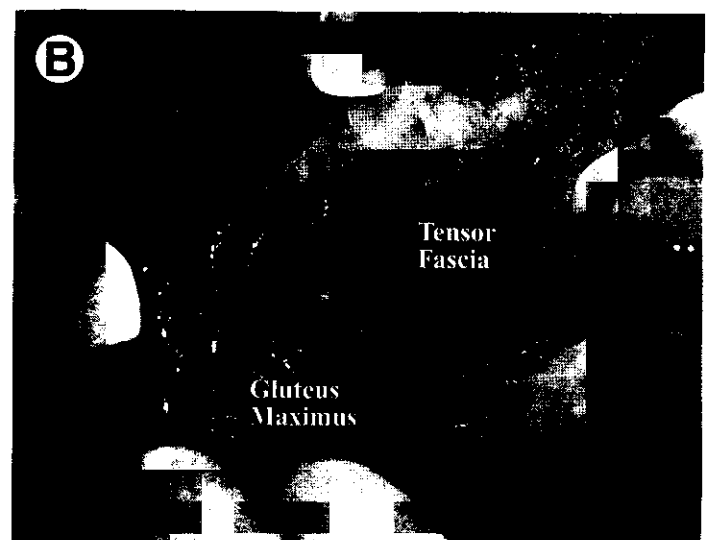
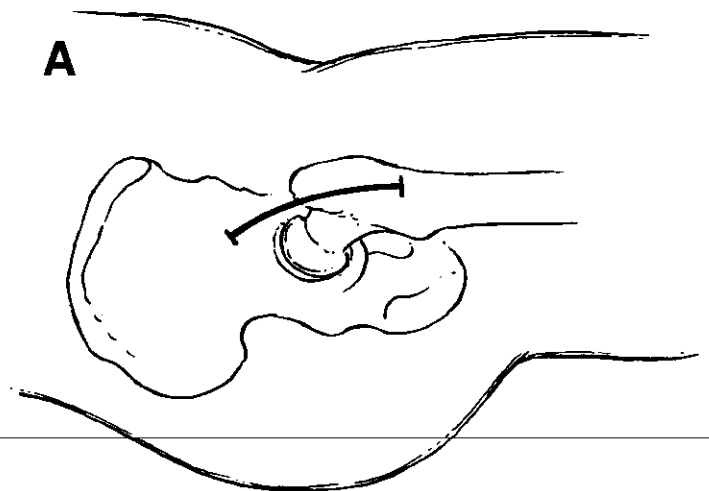


Fig 4. (A) The skin incision begins approximately 3 cm above the greater trochanter and extends distally to the vastus tubercle (7 to 8 cm). (B) The gluteus maximus muscle is revealed in the proximal two thirds of the incision and the tensor fascia in the distal one third.

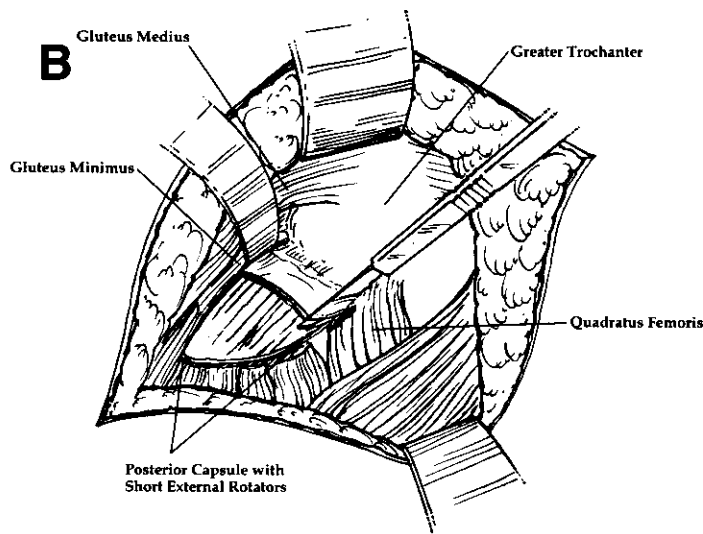
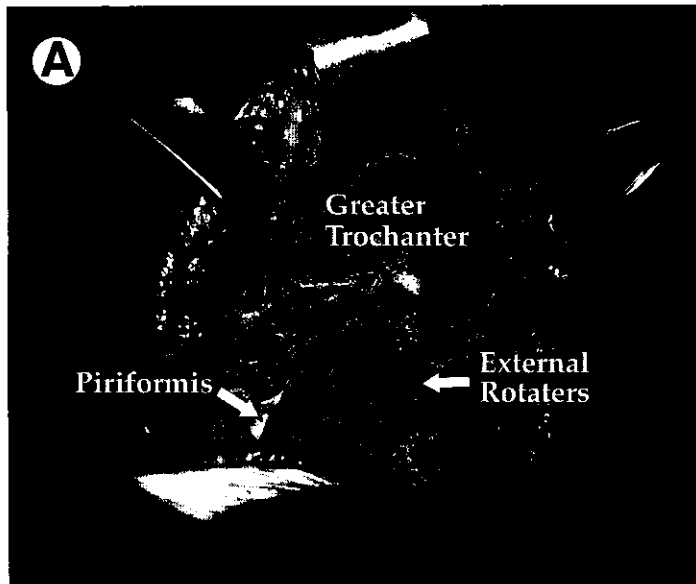


Fig 5. (A) The exposure of the gluteus maximus and tensor fascia have been split. Note the piriformis tendon, external rotators, and greater trochanter. (B) The incision of external rotators and posterior capsule as a single layer from the posterior aspect of the femoral neck and trochanteric ridge. The incision should begin 2 to 3 cm above the piriformis tendon and extend through the quadratus femoris.

ularly if press-fit fixation without screws is desired. The acetabular labrum is removed to expose the edges of the acetabular walls. Osteophytes, in the acetabular floor including over the transverse acetabular ligament, are excised with an osteotome to allow visualization of the cotyloid notch. The Haversian pad in the cotyloid notch is excised. These technical maneuvers allow the most accurate and precise reaming so that the socket can be placed at the correct level and angulation for optimal position of the center of rotation of the femoral head and stability of the femoral head without impingement.

#### Acetabular Cup Position for Metasul Articulation

Reaming is first performed toward the cotyloid notch to remove the acetabular horseshoe to the level of the cortical bone of the medial acetabulum (the cotyloid notch). This medial cortical bone is the stop-point for the reamer. In

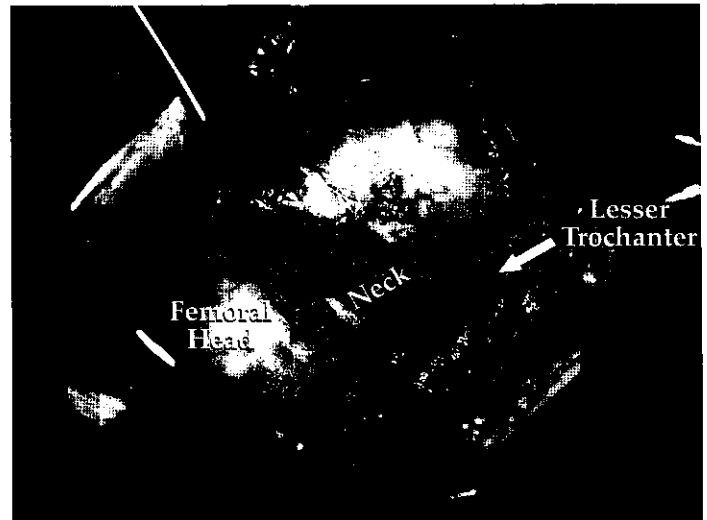


Fig 6. The exposed femoral head and neck after the incision of the posterior capsule and external rotators from the gluteus minimus to the lesser trochanter.

shallow and dysplastic acetabulae the medial bone may need to be reamed to the inner wall to allow sufficient deepening of the acetabulum for cup coverage by bone.<sup>19</sup> Twenty-five percent to 30% of the cup may remain uncovered superolaterally. After the correct depth of the acetabulum the reamer is directed superiorly and posteriorly to convert the sloping superoposterior acetabulum into a hemisphere. The depth of this reaming is to the edge of the cutting surface of the reamer. The depth is correct if the cup position at approximately 40° of abduction and 15° to 25° anteversion places the edge of the metal shell at the level of the transverse ligament inferomedially and the anterior edge of the metal shell at 5 mm below the pubic tubercle (Fig 13). Superiorly, 1 cm of the metal shell commonly extends beyond the superolateral acetabular bone to provide an abduction angle of 35° to 40°.

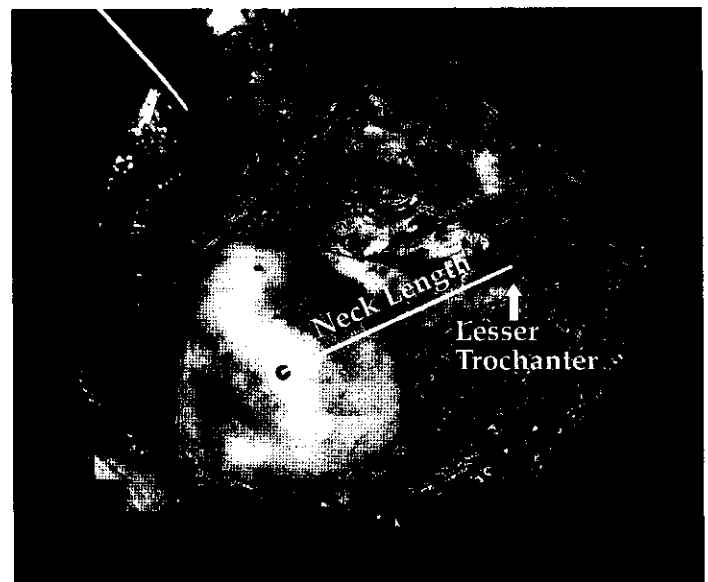


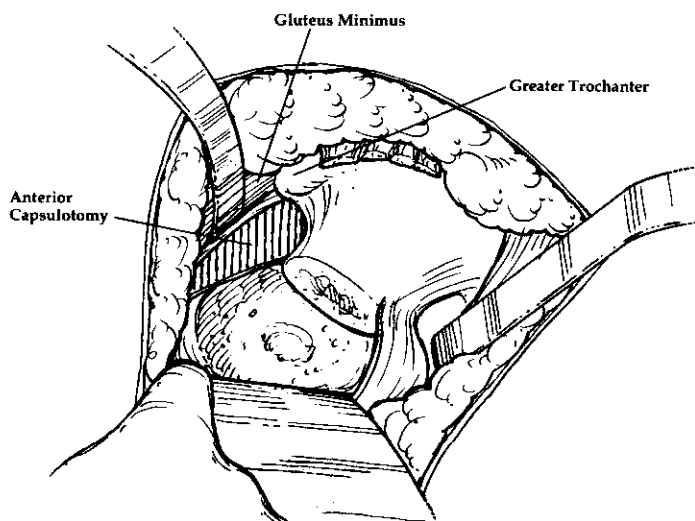
Fig 7. Measuring the femoral neck length from the lesser trochanter to the center of the femoral head after the hip has been dislocated.

**TABLE 1. Neck Length Versus Neck Cut**

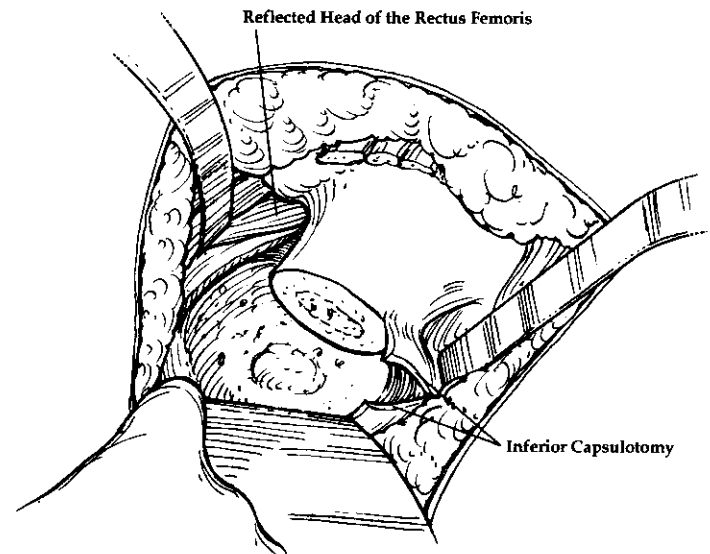
Neck Length (mm)	Neck Cut (mm)
≤ 50	15
51-59	20
60-65	25
> 70	30

The trial shell should fit tightly into the acetabular cavity if press-fit fixation without screws is desired. This means that the acetabular bone is underreamed 1 to 2 mm smaller than the cup size (ie, reamed 49 to 50 mm for a 51-mm cup). When the porous-coated cup is malletted into position, the fixation of the cup can be judged by a cortical (ringing) sound as the cup is fully seated and by an inability to pull the cup out of the acetabulum by pulling on the cup holder or by hitting on the edge of the cup with a bone tamp and mallet. If the cup moves with any of the maneuvers, 1 or 2 screws should be used.

The Metasul insert has no hood (extended liner); therefore, the cup position should be approximately 25° anteverted with abduction of 35° to 40°. The cup should fit within the bony landmarks as seen in Figure 13. The Metasul insert is placed over the mouth of the metal shell and impacted securely into the shell (Fig 14). Because the metal articulation surface has a polyethylene backing, the locking mechanism is the same as the polyethylene liners with which surgeons are familiar. The final assessment of correct position of the cup should be done after placement of the femoral component and reduction of the hip. While the hip is moved through the entire range of motion from extension/external rotation to flexion/adduction/internal rotation, the femoral head is felt and in the extreme of any position, no more than 50% of the metal head should be uncovered and the femoral bone should not impinge on the pelvis (Fig 15). If no more than 50% of the femoral head is felt in any position, then there is no threat of impingement of the metal neck on the cup. The advantage of press-fitting the cup without screws is that the cup position can easily be changed if necessary after the range of



**Fig 8. Anterior capsulotomy.** A "wedge" of anterior capsule is removed from between the greater trochanter and the anterior acetabulum.

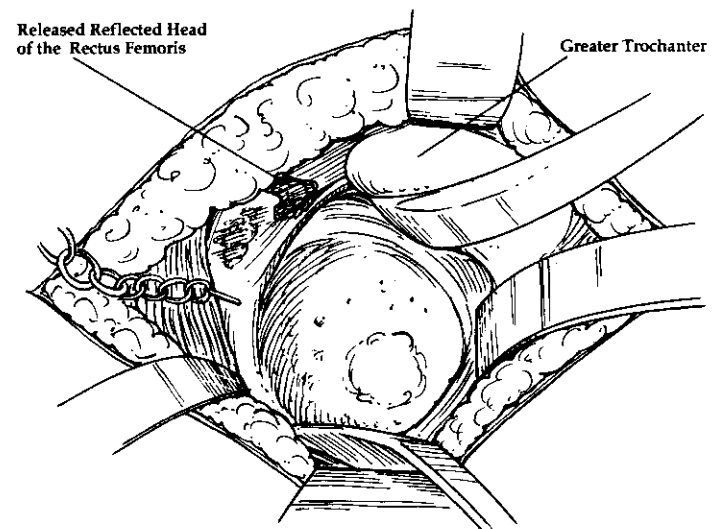


**Fig 9. Posterior-inferior capsulotomy.** A "wedge" of capsule is removed from between the femur and the posterior-inferior acetabulum.

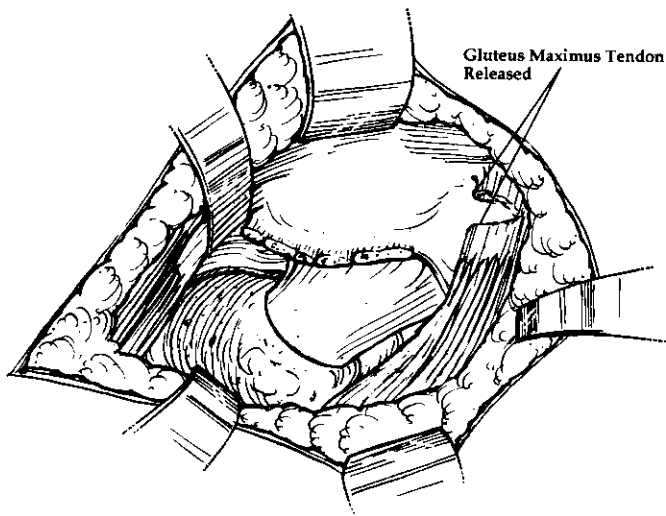
motion test by hitting on the edge of the cup with a bone tamp and then again securing the cup into the new position. Once the position of the metal shell is verified, the Metasul insert is tapped into position and checked for a secure fit.

### Femoral Reconstruction

Any femoral stem that has the Sulzer 12/14 taper accepting the Metasul head can be used with the Metasul acetabular insert. The fixation can be cemented or noncemented. Femoral reconstruction is important so the hip length and offset are correctly reproduced. This femoral reconstruction, in combination with correct mating of the head into the cup (no more than 50% uncovered in any position), will prevent impingement of the Metasul neck against the metal edge of the acetabular articulation surface.

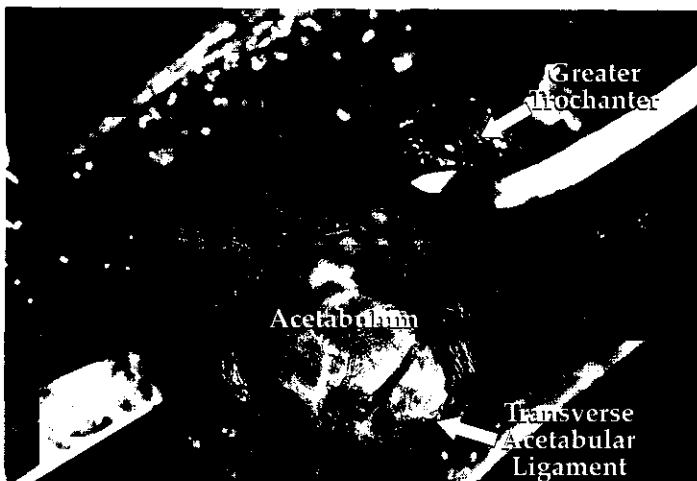


**Fig 10. The release of the reflected head of the rectus femoris from the anterior-superior acetabulum.**

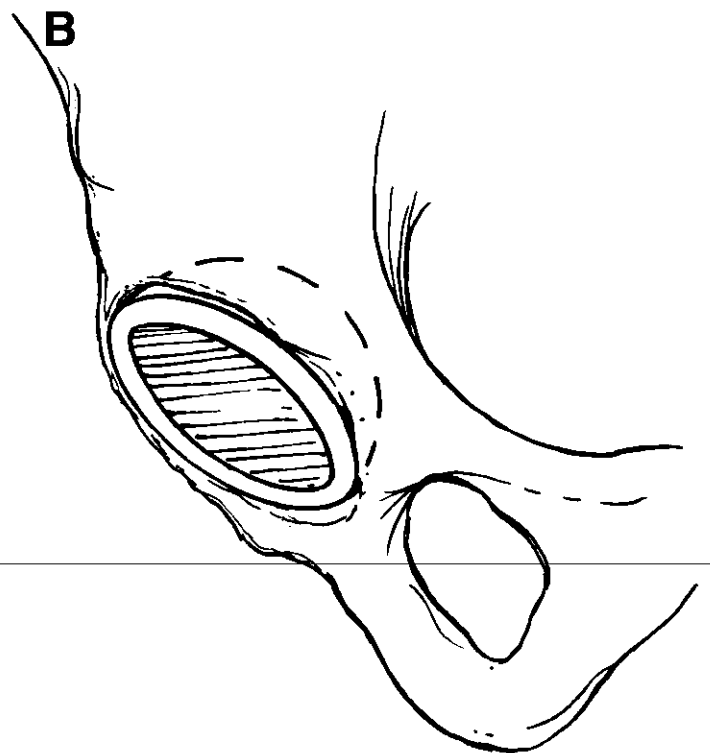
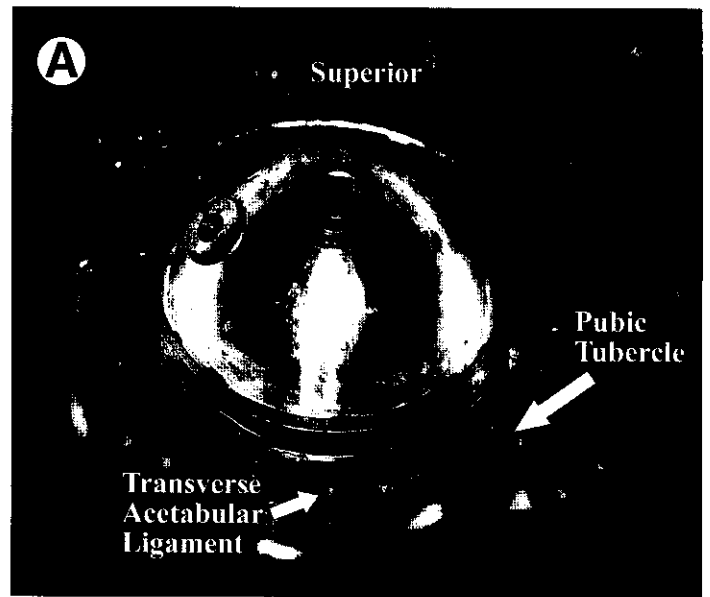


**Fig 11.** The release of the gluteus maximus tendon from the femur. This can be either a partial or complete release depending on the necessary exposure.

After completion of the femoral reconstruction, the hip is reduced and moved through an entire range of motion and evaluated for stability and impingement. Hip offset is best reproduced by ensuring that the center of rotation is correct and the femoral neck cut matches what is preoperatively planned for the neck shaft angle of the prosthesis used. The center of rotation is most correct when the edge of the metal cup is at the level of the transverse acetabular ligament and anteriorly is 5 mm below the pubic tubercle. When the hip is moved through a range of motion the offset can be judged to be correct if there is 1 finger breadth clearance of the trochanter from the pelvis in all positions, for example, the tip of the trochanter in external rotation and abduction, the lesser trochanter from the ischium in full extension and external rotation, and the femur from the anterior spine/pelvis in 90° flexion with some adduction and internal rotation. Hip length is confirmed by comparing the level of the lesser trochanter with the level of the ischium (see the preoperative radiograph for this correct position), and leg



**Fig 12.** An exposed acetabulum with retractors in place. Note the placement of the retractor from the ilium, around the greater trochanter, translating the femur anteriorly.



**Fig 13.** (A) The placement of the metal shell. Note the position of the cup is approximately 40° abducted and 15° to 25° anteverted. The edge of the cup should be at the level of the transverse acetabular ligament inferiorly and sit approximately 5 mm below the pubic cortical rim. (B) A diagram of cup placement.

length is confirmed by comparing the length of the operated leg with the opposite leg. If the lateral position is used, this comparison is done by overlaying the legs and using the patella and feet as the leg length guide. It is important to know that the superior edge of the patella of the operated (up leg) should be proximal to the superior edge of the lower leg patella and the plantar edge of the foot, likewise just short of the lower leg (Fig 16). The final assessment of leg lengths is done in the operating room after the closure is complete and the

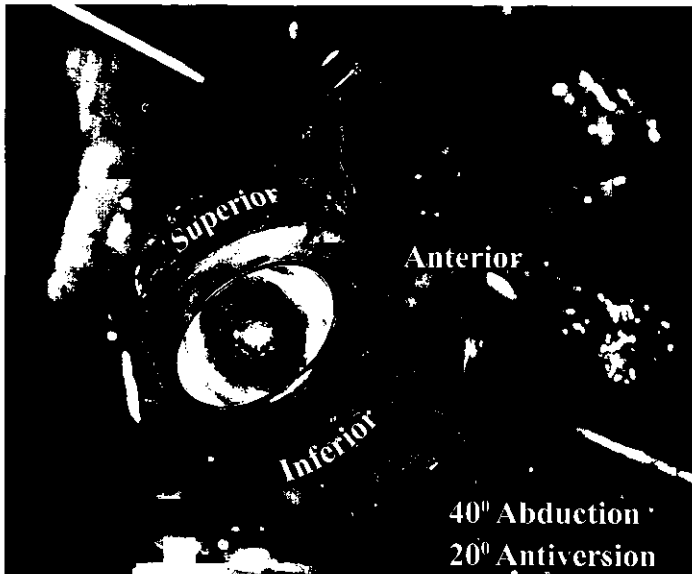


Fig 14. The Metasul liner impacted into the metal shell.

patient has been moved from the lateral to the supine position. The leg lengths can then be accurately compared. If the leg lengths are incorrect by more than 0.25 inch, the patient is returned to the lateral position and the hip opened and the leg length corrected. Usually, if the leg is lengthened at surgery for reasons of stability the cup has been anteverted too much, which requires 1 extra head length for stability. Therefore, the first assessment of the hip, when reopened, should be for the mating of the head into the cup.

#### Closure of the Hip

The closure is a repair of the posterior capsule/external rotators flap with the gluteus minimus muscle over the metal femoral head and neck (Fig 17). The quadratus femoris is also repaired over the lesser trochanter. If the insertion of the gluteus maximus tendon was transected during the exposure, it is also repaired. We close the skin with a subcuticular suture so that it provides an optimal

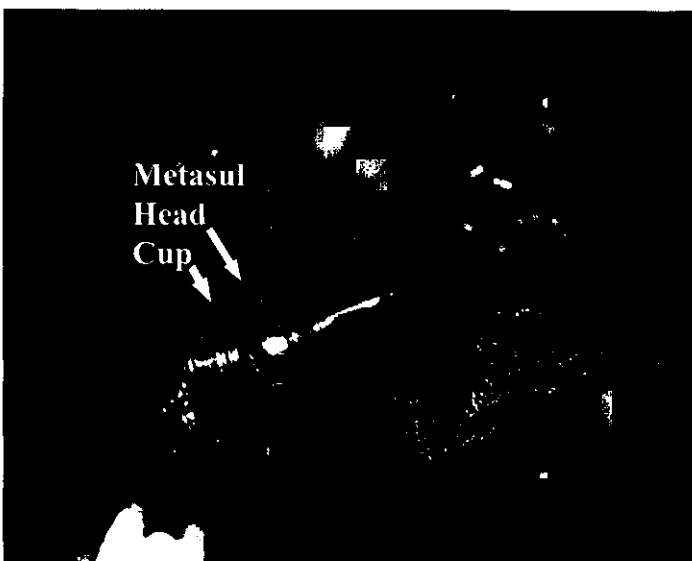


Fig 15. A reduction of the femoral head into the acetabulum.

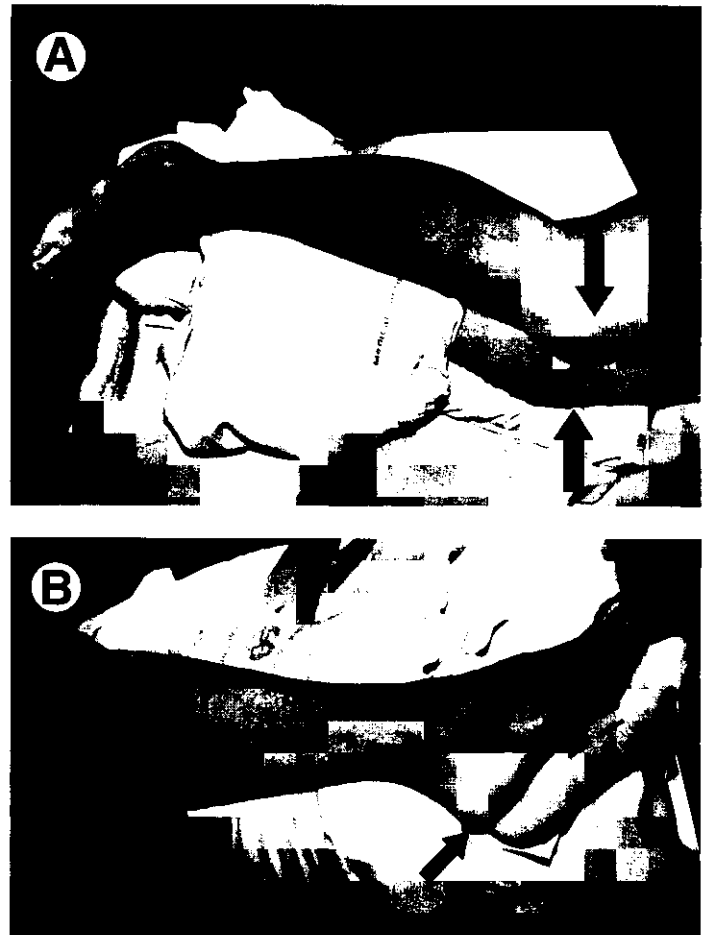


Fig 16. Leg lengths with patient in the lateral decubitus position. Note the upper leg is slightly shorter at the superior patella (A) and the foot (B). Body habitus may alter the leg orientation, and thus it is important to compare these lengths both before and after the hip is replaced.

scar for the patient and allows the patient to go home without the necessity for suture removal.

#### Postoperative Rehabilitation

Patients are allowed to be full weight bearing no matter the fixation of the stem and cup. Patients can become safe and confident with 1 crutch or cane within the 5-day hospitalization. We inform patients that their recovery will occur in a pattern that has 3 plateaus. The first 6 weeks are a time in which they will need to recover their energy and allow the discomfort in their hip to subside. Therefore, their activity level during that time must be controlled so that they do not overload the leg. Three months is considered the healing time, and they are informed that it will be 3 months before they can expect that they have any endurance capability. It will be 6 months before they feel good strength within their leg and can begin vigorous athletic activities. They will continue to recognize improvement over the first postoperative year. The patients are told that they may have a click in the hip for the first few weeks, which occurs with both metal-on-metal and metal-on-polyethylene hips until the scar has matured around the hip. After bone healing has matured (4 to 6 months for osteon remodeling) we allow the patients to do any activity that they desire.

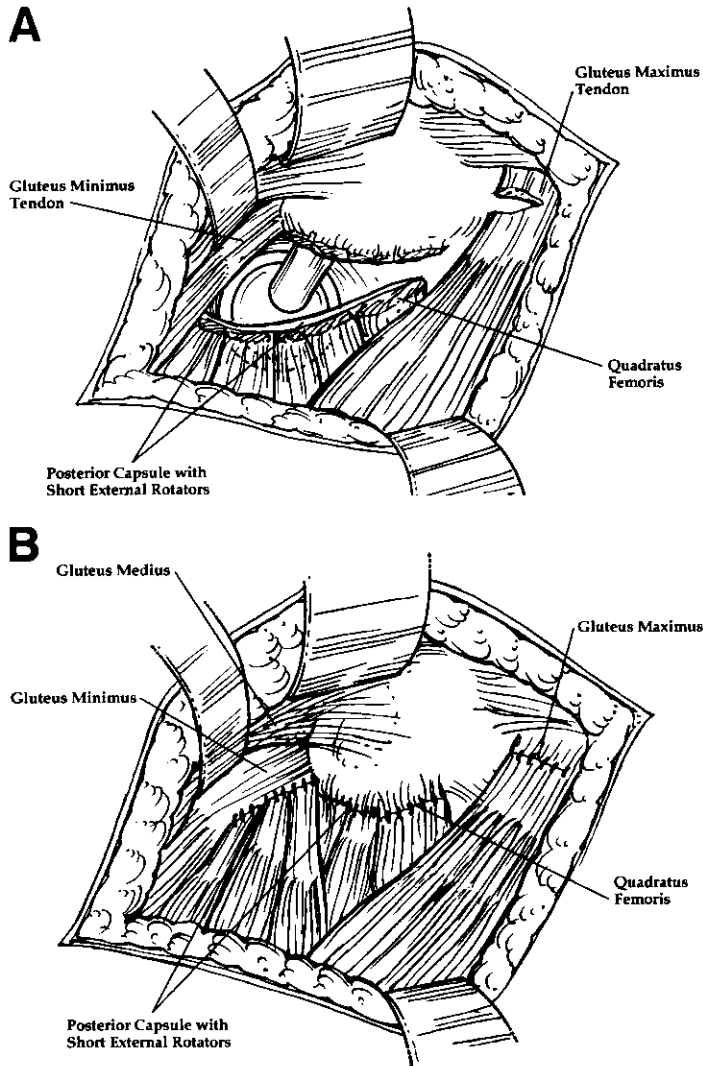


Fig 17. Closure of (A) posterior capsule, along with the short external rotators are repaired back to the gluteus minimus tendon as a single layer. (B) This covers the femoral head and neck and creates a dynamic support, helping to prevent dislocations. The quadratus femoris is repaired back to the femur over the lesser trochanter, and the gluteus maximus tendon is reattached to the stump on the femur.

## CONCLUSIONS

Because Metasul is an articulation surface that consists of the femoral head and modular polyethylene-backed insert, the surgeon can use the surgical technique of his/her choice for the approach and fixation. Cemented fixation of the stem was done by us in 50% of our study hips (and all the Weber cups were cemented), and up to 9 years after the operation, we have observed no difference in results with either cemented or noncemented cup or stem fixation. Osteolysis has also been absent in these hips.

Although wear cannot be measured radiographically because of the metal surfaces, we believe 1 great advantage with Metasul is that through time the acetabular articulation surface does not go "out of round" as does polyethylene. This maintenance of the articulation geometry not only reduces wear, but also the occurrence of late dislocations because of impingement caused by a deepened (worn) cup surface. Backside wear of the polyethylene backing of Metasul should have no clinical difference

because we have measured creep in the modular inserts to be only 0.03 mm at 1 year and beyond. Polyethylene was found in the fluid of hips with metal-on-metal articulation by aspiration of joint fluid.<sup>8</sup> Polyethylene in the joint fluid was absent after 1 postoperative year in these aspirations, and this means that the amount of polyethylene produced with this Metasul design is very low. Polyethylene has been found in the capsule of retrieval specimens, but the surgeon must remember that the only destructive consequences of polyethylene particles results from a high volume and not the mere presence of polyethylene debris.

The theoretical concerns of cancer from systemic metal ions will need long follow-up for final evaluation. Jacobs et al<sup>20</sup> has measured increased systemic ion levels with metal-on-metal articulation<sup>20</sup> but also from fretting modular femoral heads.<sup>21</sup> The ultimate consequence of this is not known. Visuri et al<sup>22</sup> have not found any correlation to cancer and the use of metal-on-metal articulations until 15 years after the operation. One consideration for metal-on-metal surfaces and cancer must be the overall consequence of an isolated case of cancer. Even if 1 patient with cancer is identified in the future, the prevalence of this complication must be measured against greater longevity of metal-on-metal total hip replacements with reduced osteolysis and, therefore, the overall reduced prevalence of revision with the attendant mortality rate of revision surgery.

The research to reduce wear has been predominant in the last 5 to 8 years with total hip replacement because of the knowledge of bone destruction by particulate debris. Certainly wear is now known to be less in those hips in which the reconstruction was optimal, which means that the femoral head mated well into the acetabular cup and there was no impingement of the metal neck on the cup or the femur against the pelvis. When abduction of the cup is 40° or less, linear wear seems to be below 0.10 mm/yr,<sup>23</sup> (Table 2), and this wear rate has meant longevity of the hip replacement for greater than 20 years with Charnley hip replacements.<sup>24</sup> Hard-on-hard bearing surfaces are a design change that is being used because of superior wear characteristics. Our experience has been with Metasul, and in this article we have summarized our technique and results. We continue to be very enthusiastic about the use of Metasul, and use this articulation surface in all patients 75 years and younger in whom we want longevity of the hip to last 15 or more years. Other surgeons use ceramic-on-ceramic and cross-linked polyethylene articulations and expect these to provide long-term durability. Whether one or another of these new articulation surfaces will be superior to the others will require continued observance over time. Certainly metal-on-metal at this time has use of 12 years with no adverse consequences.

TABLE 2. Polyethylene Wear Rate in Sockets With Different Abduction Angles

Abduction angle (deg)	No. of hips	Linear wear rate (mm/yr)	Volumetric wear rate (mm <sup>3</sup> /yr)
40° or less	21	0.07 ± 0.05	43.85 ± 29.84
41°-45°	33	0.15 ± 0.09	98.95 ± 56.54
46°-50°	33	0.19 ± 0.13	117.69 ± 93.98
>50°	23	0.21 ± 0.18	160.35 ± 136.10



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