Benefits of Posterior Single-Incision Less-Invasive THA using the SL-Plus Cementless Stem

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Abstract

Four hundred six consecutive cementless total hip arthroplasties in 363 patients performed using a posterior, single-incision, less-invasive surgical approach were prospectively followed for a minimum two years. All surgeries were performed using the SL-Plus cementless femoral component and a press-fit, ingrowth acetabular component.

Mean patient age was 62.5 years. The mean incision length was 9.8 cm. The mean operative time was 54.4 minutes. Mean blood loss was 324 ml. Forty-nine percent of patients required a blood transfusion. Length of hospital stay averaged 3.6 days.

Harris Hip Scores improved from 34 pre-operatively to 87 post-operatively. Patients returned to full, unrestricted activities at a mean 4.8 weeks. Five patients underwent revision, 3 for loose acetabular components, 1 for dislocation, and 1 for deep infection. Complications included 12 dislocations, 4 wounds with delayed healing, 4 superficial wound infections, 1 deep infection, 4 venous thromboemboli, 4 patients with transient post-operative confusion, 4 femoral fractures (3 trochanteric and 1 shaft), and 3 nerve palsies.

Component position was considered acceptable in 94.6% of patients. Three acetabular components failed to osseointegrate, while no femoral component was loose at final follow-up. Radiolucencies were limited to the upper part of the femur and were non-progressive. Osteolysis, stress shielding, and heterotopic ossification were minimal.

This series of less-invasive total hips shows that a) rapid recovery and satisfactory results can consistently be achieved utilizing this less-invasive technique and b) consistent primary and secondary stability are achieved with this cementless implant.

Introduction

Total hip arthroplasty (THA) has been shown to be clinically effective in treating patients with degenerative arthritis and other destructive conditions of the hip. Significant advances in total hip replacement include the introduction of small incision techniques, termed "minimally-invasive," "mini-incision," or "less-invasive" by various authors [2,3,7,13,15,23,24,26-29,32].

A few authors have performed small-incision THA's for over 20 years [14]. Renewed interest in small-incision surgery has resulted in recent development of single and 2-incision techniques. Single, small-incision techniques include anterior, direct lateral, and posterior approaches. All 3 approaches have been used with success [3,7,14,15,23,24,26-29,32]. Two-incision techniques are performed either under direct visualization or with the use of fluoroscopy [2,3,13]. Surgeons have claimed advantages of each technique; however, no specific advantage of any technique has ever been demonstrated scientifically. Although "minimally-invasive surgery" (MIS) is often used to describe all of these techniques, the author prefers a more accurate term, "less-invasive surgery" (LIS), which will be used to describe the technique herein.

Cementless fixation in THA has become commonplace in the past 20 years. Varying degrees of success have been attributed to multiple prosthetic factors including material, surface finish, and stem geometry. Specifically, the flat tapered stem design has achieved a high level of success in numerous studies [6,9,11,15-19,21]. In 1979, Professor Karl Zweymuller implanted the first tapered titanium femoral component of his design. This stem features a rectangular cross-section with corners that engage the femoral cortex to provide rotational stability. The six-degree longitudinal taper provides axial stability. This design has withstood the test of time with only minor design modifications over the past 25 years. Today it remains one of the most successful total hip femoral components in existence [6,9,11,16,19].

The SL-Plus femoral modification of the Zweymuller stem was developed in 1993. Since then nearly 400,000 stems of this design have been implanted. The stem is comprised of a titanium-aluminum-niobium alloy and features a slender neck to minimize impingement, a lateral trochanteric flare to enhance rotational stability, and a hyperbolic curve along the medial aspect to better fit the calcar femoralis.

Materials and Methods

The author began utilizing the SL-Plus femoral component through a posterior, single-incision, less-invasive approach in May of 1997. Since then, over 1,500 *consecutive* THA's have been performed using this technique. The first 443 consecutive THA's in 394 patients form the population for this study. Thirty-seven hips in 31 patients were excluded due either to death or loss to follow-up prior to the 2-year minimum follow-up period, leaving 406 THA's in 363 patients as the basis for this study. Forty-three patients had staged bilateral procedures.

Patient Selection

Only patients requiring extensive hardware removal, having significant deformity, requiring structural bone grafts, or undergoing femoral osteotomy were excluded from the study. Patient demographics are laid out in Table 1. The mean age was 62.5 years, with a wide range varying from 23 to 93 years. Body Mass Index (BMI), calculated by dividing the weight in kilograms by the squared height in meters, also varied widely from 19.1 to 47.3. No patient was excluded due to weight or BMI. The most common diagnosis was osteoarthritis, comprising 93.3% of the THA's performed.

Bone quality was quantified according to the method of Dorr [8]. While the majority of hips were Types A and B, 8% of the hips were Type C. Patients were categorized as functional class A, B, or C according to the method of Charnley [5]. There were roughly equal numbers of patients in each functional class.

Prostheses

All patients received the SL-Plus femoral component (Plus Endoprothetik AG, Rotkreuz, Switzerland) and a hemispherical, press-fit, ingrowth acetabular component (EPF or Plus-Fit, Plus Endoprothetik AG; or Reflection, Smith and Nephew Orthopaedics, Memphis, TN). One hundred thirty-five Plus-Fit (33%), 68 EPF (17%), and 203 Reflection cups (50%) were implanted. Supplemental acetabular screws were used in most patients. High offset femoral components were not available at the time of implantation in this series of patients.

Surgical Technique

Preoperative planning with templates is done for each patient. Following correction for any leg-length inequality, implants of appropriate size are drawn onto the preoperative radiograph. Particular note is made of the distance from the tip of the greater trochanter to the proximal shoulder of the femoral prosthesis to us in surgery to determine proper restoration of the leg length (Figure 1).

After adequate induction of general anesthesia and administration of preoperative antibiotics, the patient is positioned securely in the lateral decubitus position. A 15 cm line is drawn from the tip of the trochanter along the lateral shaft of the femur. The tip of the greater trochanter is then palpated and marked with a spinal needle. Placement of the incision is then planned in the following manner: A mark is made 4 cm distal to the needle, and from this point another line is drawn, perpendicular, in a posterior direction, for a distance of 4 cm. A line is drawn from this point distally 11 cm in length to intersect the femoral shaft line, creating a 20-degree angle. The incision is then made collinear with this line, in a proximal direction (Figure 2). In general, the incision length used approximated the body mass index divided by 3 in centimeters.

Skin and subcutaneous tissue are divided sharply with a scalpel. The fascia is divided in line with the direction of muscle fibers to the proximal and distal ends of the incision. A Charnley retractor, modified to minimize skin tension, is then placed beneath the fascial layer. The hip is internally rotated, and bursal tissue is taken down, exposing the short external rotators, which are taken down as a flap with the posterior capsule.

With the hip at 90° flexion, internal rotation will allow the femoral head to dislocate posteriorly. Osteotomy of the femoral neck is then performed with a saw.

Acetabular exposure is obtained with placement of retractors antero-superiorly and postero-inferiorly (Figure 3). Care is taken not to place excess tension on the skin or other soft tissues with the retractors. Reaming is performed using standard semicircular power reamers. Most acetabular components are under-reamed by 1-2 mm (Figure 4). The cup is placed in a position of 40° abduction and 20° anteversion. One or more screws are used when necessary for stability, followed by placement of the acetabular liner (Figure 5).

The proximal femur is delivered into the incision with a femoral elevator retractor levering on the anterior neck. A second retractor is placed inferiorly along the calcar and a sharp Hohmann retractor placed superior to the tip of the greater trochanter to protect the abductors (Figure 6). Femoral preparation is accomplished using broaches only. It has been our practice to use a pneumatic impactor for broaching, although preparation may be done with hand broaches also. A spinal needle is placed through the abductors to identify the tip of the greater trochanter, and a longitudinal measurement is made from the shoulder of the broach or trial femoral component to the tip of the trochanter. The goal is to implant the femoral component to the appropriate level as templated on the preoperative radiograph. A trial reduction is performed. Adjustments are made as needed to restore leg lengths, offset, soft tissue tension, and stability by changing the neck length, prosthesis height, rotation of the liner build-up, or excision of impinging bone or soft tissue. Once stability and range of motion are deemed acceptable, the final femoral implant is impacted in approximately 20° anteversion, and the hip again reduced after gentle impaction of the modular head onto the trunnion of the stem (Figure 7).

The wound is closed by repairing the capsule edge to edge with heavy, braided #5 non-absorbable suture (Figure 8), reapproximation of the gluteal fascia with absorbable suture, and then closure of the subcutaneous layer and skin (Figure 9).

Postoperative Care

All patients received antibiotic prophylaxis with cefazolin for 36-48 hours. Cephazolin-allergic patients received vancomycin. Postoperative pain was controlled with a morphine or meperidine intravenous PCA pump for 2 days, followed by oral hydrocodone. Recently, we have used a subcutaneous bupivacaine infusion catheter for 48 hours and injection of the hip capsule with a combination of ½% bupivacaine with epinephrine, morphine sulfate, ketorolac, and methylprednisolone acetate. Mechanical prophylaxis with pneumatic compression devices during the hospitalization period, elastic stockings for 6 weeks, and early mobilization were used for prevention of thromboembolism. Patients also received 325 mg of aspirin twice daily and a cox-2 inhibitor for 6 weeks. High-risk patients received coumadin or enoxaparin for 6 weeks post-operatively. Physical therapy was initiated on the first postoperative day, allowing immediate full weight bearing as tolerated. Patients were discharged from the hospital when independent and safe.

Follow-up Evaluation

Patient were routinely seen in the office at 6 weeks, 3 months, 6 months, 1 year, and annually thereafter. All patients completed questionnaires, and clinical evaluations were done using the Harris Hip Score (HHS) [12]. Standard anteroposterior and lateral radiographs were obtained at each follow-up visit. Lengths and angles were measured from the radiographs using the X-Caliper electronic measuring device (Eisenlohr Technologies, Inc., Davis, California). Cup anteversion was determined from anteroposterior radiographs using the method of Pradhan [20]. Heterotopic ossification was evaluated using the Brooker classification method [4]. An independent physician performed all radiographic assessments.

Results

Clinical follow-up Evaluation

The minimum follow-up period was 24 months (range, 24-62 months). The incision length averaged 9.8 cm and ranged from 7 cm to 15 cm (Table 2). The mean operative time was 54.4 minutes. Average blood loss was 324 ml, and approximately ½ of patients required a blood transfusion. The mean length of hospital stay was 3.6 days.

The mean HHS improved from 34 to 87 (Table 3). Patients were also evaluated for return of function. As part of the routine clinical follow-up evaluation, patients were asked about resumption of their normal everyday activities. On average, patients said they were able to perform these by 4.8 weeks postoperatively.

Five revisions were required in this group of patients. One total hip was removed due to deep infection. Three additional acetabular components were revised due to failure of osseointegration and progressive loosening, and 1 for dislocation. No additional femoral component was revised for any reason.

Peri-operative complications included 12 dislocations (3.0%), 4 patients with delayed wound healing (1.0%), 4 who developed a superficial wound infection (1.0%), 1 deep infection requiring removal of the prosthesis (0.2%), 4 patients with deep venous thrombosis and/or pulmonary embolism (1.0%), 4 who exhibited transient confusion post-operatively (1.0%), 3 trochanteric fractures (0.7%), 1 femoral shaft fracture (0.2%), and 7 acute medical complications (1.5%). (Table 4)

Radiographic Follow-up Evaluation

Radiographic evaluation showed that the mean cup abduction angle was 41.2° and mean anteversion 14.6° (Table 5). Only 22 components (5.4%) were considered malpositioned. The mean acetabular inclination was <30° or >50º in 16 patients (3.9%), and anteversion was <0º or >30º in 4 patient (1.0%). Two femoral components (0.5%) were in >5º of varus.

Three acetabular components were radiographically loose. All 3 were components with a relatively smooth, grit-blasted surface finish (Plus-Fit) implanted without screw supplementation. None were malpositioned. All 3 required revision and are doing well at latest follow-up. Although several femoral components exhibited radiolucencies in zones 1 and 7 on the antero-posterior radiograph, and in zones 8 and 14 on the lateral radiograph, they were all non-progressive, and all femoral components were radiographically osseointegrated and clinically stable (Figure 10).

Only 4 patients (1.0%) exhibited minor osteolysis of the calcar femoralis. One hundred two femurs exhibited minor stress shielding of the proximal calcar, better described as “calcar rounding,” as is often seen with stable femoral implants. No patient exhibited more severe radiographic evidence of stress shielding. One hundred twenty-six patients (31.0%) had Brooker Grade I or II heterotopic ossification, and only 12 patients (3.0%) had Grade III. No patient had Grade IV heterotopic ossification.

Discussion

Total hip arthroplasty has remained an effective treatment for degenerative arthritis and other destructive conditions of the hip. Although results using standard methods are quite satisfactory, surgeons are persistently challenged to improve upon existing techniques and technology.

The body of data supporting less-invasive surgical techniques for THA is growing. Light and Keggi first described an anterior less-invasive technique for THA in 1980 [14]. Since then, Keggi and associates have published additional data supporting the efficacy of his technique. In 2,132 primary, anterior, less-invasive THA’s utilizing a multitude of various cemented and cementless implants, operative time, blood loss, and early complication rates were all low, although the minimum follow-up period was only 6 months [15].

Subsequently, Wenz compared 124 less-invasive, anterolateral THA’s with 65 standard anterolateral THA’s using incisions as long as 25cm or more [29]. Although follow-up again was short, he demonstrated reduced operative times, decreased transfusion requirements, and earlier functional recovery in the less-invasive group without any increase in complications or component malposition.

Several studies have looked at short-term advantages of the posterior single-incision approach. Waldman described 32 posterior less-invasive THA’s followed a minimum 7 months [27], and he subsequently compared 31 less-invasive THA’s to 91 standard-incision THA’s [28]. He found a reduction in hospital time and fewer complications in the less-invasive group. In a prospective study comparing mini-incision with navigation to a traditional posterior approach with navigation, DiGioia demonstrated significantly more rapid improvement in limp, distance walked, and stair climbing at 3-month and 6-month follow-up visits [7]. Swanson prospectively compared his first 100 posterior, single-incision LIS THA's with 50 standard incision historical controls and found less blood loss, shorter operative time, less pain management problems, shorter hospital stay, quicker return to activities, and lower overall complication rate in the less-invasive group without any difference in component positioning [26]. Similarly, Sculco and colleagues found early advantages including less blood loss and quicker functional recovery with their posterior, less-invasive THA's, although a 5-year prospective randomized study comparing 42 less-invasive THA's to 42 standard-incision THA's showed no long-term differences [23,24,32]. Most importantly, these studies demonstrate that the posterior less-invasive, single-incision technique is safe and predictable with no short or long-term ill effects.

However, not all reports of small-incision THA's have been favorable. Goldstein compared 85 small-incision THA's with 85 standard-incision THA's and found only decreased intra-operative blood loss in the small-incision group, but no other difference including the incidence of transfusion [10]. Asayama and colleagues, in a double blinded, prospective study of 100 patients randomized to receive a total hip utilizing an anterolateral approach either through a limited (<10 cm) incision or a standard (14-18 cm incision) found only less intra-operative blood loss in the limited-incision group, but no other differences [1]. Woolson recently reported a retrospective analysis of 135 primary posterior THA's selected by 1 of 3 surgeons to receive either a posterior, small-incision or standard-incision surgery. They found a higher incidence of wound complications, acetabular component malpositioning, and femoral component varus and mal-sizing in the small-incision group and were unable to demonstrate any advantages with the small-incision surgery [31]. However, in all 3 of these studies, only the length of the incision varied, not the deep surgical technique.

Most alarming is a recent report documenting the early results and learning curve with the fluoroscopic 2-incision minimally-invasive approach popularized by Zimmer, Inc. Although the surgeon developers have reported satisfactory results in highly selected patients [2,3], a recent report showed that of the first 89 surgeons trained in the 2-incision technique, only 19 of them completed 10 or more cases over a 1-year period. Mean operative time was 146 minutes, mean fluoroscopy time approximately 2 minutes, and mean blood loss 448 ml. Complications included 8.0% femoral fracture, 1.4% nerve palsy, 1.2% dislocation, and 1.2% infection. Complication rates were not related to the surgeon's arthroplasty surgery experience or to the number of 2-incison procedures performed by the surgeon [30]. Based on this information, the author cannot recommend the fluoroscopic 2-incision technique at this time.

In the current study, we demonstrate satisfactory results in a large cohort of consecutive patients using a posterior, single-incision, less-invasive approach. Surgical time, blood loss, length of hospitalization, and recovery time were all favorable. There were no significant increases in complication rates or component malpositioning when compared to historical data using a standard posterior approach.

The reasons for favorable results found in this study are likely multifactorial. The author has performed over 1,500 posterior, single-incision, less-invasive total hip replacements since 1997. The procedure was standardized early on and has evolved over time to a minimize soft tissue trauma by utilizing the smallest incision that affords good visualization, maintaining the gluteus maximus, piriformis, and quadratus femoris attachments, retracting gently, and maintaining and repairing the capsule. It is the author's philosophy that the main goal of less-invasive surgery is to minimize the trauma imparted to the deep soft tissues, not necessarily to minimize the size of the skin incision. The incision is always made large enough to achieve full visualization of the hip joint so as not to compromise component positioning, jeopardize longevity, or lead to complications. The author has found that a good rule of thumb for determining incision length in centimeters is the body mass index divided by 3. This incision length will generally provide excellent visualization in most patients.

It is also the author's belief that the success of the procedure, whether done through a large or small-incision, is highly dependent on the implant. The Zweymuller femoral component has had unrivaled success over the past 25 years. It allows immediate full weight-bearing in all patients, regardless of the degree of osteoporosis, without the detrimental systemic effects of cemented pressurization. Although protected weightbearing is necessary with the use of some uncemented component designs, excellent primary stability can usually be achieved with a flat, tapered implant, and immediate weight bearing can be allowed without complication [6,9,11,15-19,21,22,25].

Conclusion

With advances in biomaterials striving to reduce the problem of wear in total hip arthroplasty combined with increasing life expectancies, the indications for total hip arthroplasty are expanding to include younger and older patients. Both groups have desires and needs for quicker recoveries. This less-invasive technique for total hip arthroplasty provides that without increasing risks or jeapordizing component position.

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Tables & Figure Legends

Table 1: Patient Demographics

Age (years)*	62.5 (23-93)
Gender:	
Male	177 (44%)
Female	229 (56%)
Laterality:	
Left	193 (48%)
Right	213 (52%)
Weight (kg)	75.2 (45-120)
Height (meters)	1.68 (1.3-2.0)
Body Mass Index (BMI)	26.4 (19.1-47.3)
Diagnoses:	
Osteoarthritis	379 (93.3%)
Rheumatoid Arthritis	9 (2.2%)
Systemic Lupus Erythematosus	5 (1.2%)
Osteonecrosis	5 (1.2%)
Failed Femoral Neck ORIF	4 (1.0%)
Post-Traumatic Arthritis	1 (0.2%)
Other	3 (0.7%)
Dorr Bone Types:	
A	173 (43%)
B	200 (49%)
C	33 (8%)
Charnley Functional Classes:	
A	132 (33%)
B	122 (30%)
C	152 (37%)

*Mean and Range

Table 2: Operative Data

Incision Length (cm)*	9.8 (7-15)
Operative Time (minutes)	54.4 (23-185)
Intra-operative Blood Loss (ml)	324 (100-2000)
Blood Replacement (units)	1.05 (0-6)
Number of Patients Requiring Transfusion:	
0 units	206 (50.7%)
1 unit	18 (4.4%)
2 units	158 (38.9%)
>2 units	24 (5.9%)
Hospital Stay (days)	3.6 (2-13)

*Mean and Range

Table 3: Clinical Results

Pre-operative Harris Hip Score*	34 (25-45)
Post-operative Harris Hip Score	87 (67-100)
Return to Full, Unrestricted Activities (weeks)	4.8 (1-11)
Acetabular Revisions	5 (1.1%)
Femoral Revisions (removal for infection)	1 (0.2%)

*Mean and Range

Table 4: Complications

Dislocation	12 (3.0%)
Delayed Wound Healing	4 (1.0%)
Superficial Wound Infection	4 (1.0%)
Deep Wound Infection	1 (0.2%)
Venous Thromboembolism	4 (1.0%)
Post-operative Confusion	4 (1.0%)
Trochanteric Fracture	3 (0.7%)
Femoral Shaft Fracture	1 (0.2%)
Femoral Nerve Palsy	2 (0.4%)
Peroneal Nerve Palsy	1 (0.2%)
Urinary Retention	3 (0.7%)
Pulmonary	2 (0.4%)
Cardiac	1 (0.2%)
Gastro-Intestinal (Ileus)	1 (0.2%)

Table 5: Radiographic Results

Acetabular Abduction Angle*	41.2° (29º-56º)
Acetabular Anteversion Angle	14.6° (2º-35º)
Number of Acetabular Components:	
Abduction <30º or >50º	16 (3.9%)
Anteversion <0º or >30º	4 (1.0%)
Number of Femoral Components Varus >5º	2 (0.5%)
Acetabular Component Loosening	3 (0.7%)
Femoral Component Loosening	0
Osteolysis (femoral)	4 (1.0%)
Femoral Stress Shielding (“calcar rounding”)	102 (25.1%)
Heterotopic Ossification:	
None	268 (66.0%)
Brooker I	77 (19.0%)
Brooker II	49 (12.1%)
Brooker III	12 (3.0%)
Brooker IV	0

*Mean and Range

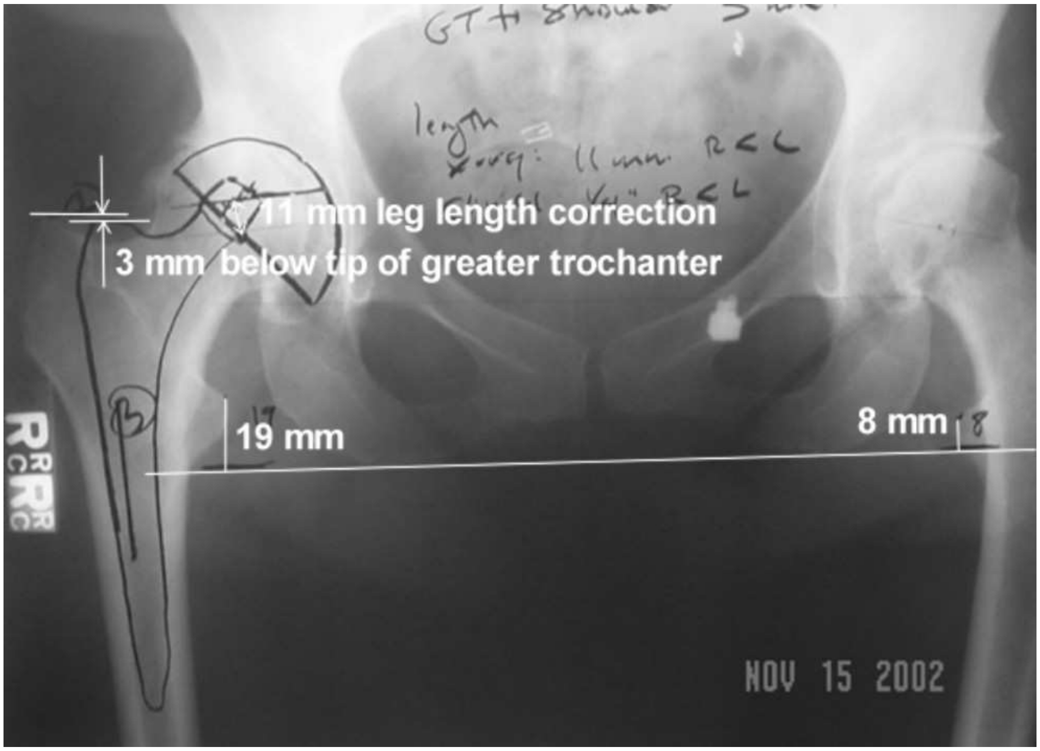

Figure 1: Pre-operative templating to determine approximate component size, offset, and correction of leg length discrepancy. The leg length difference is determined from the difference between the vertical distances from lesser trochanters to the inter-tuberosity line (19 – 8 = 11mm). The femoral component center of rotation is templated superior to the acetabular center of rotation by 11mm. The distance from the tip of the greater trochanter to the shoulder of the prosthesis is measured (3mm). In surgery, the shoulder of the prosthesis will be placed 3mm below the tip of the greater trochanter.

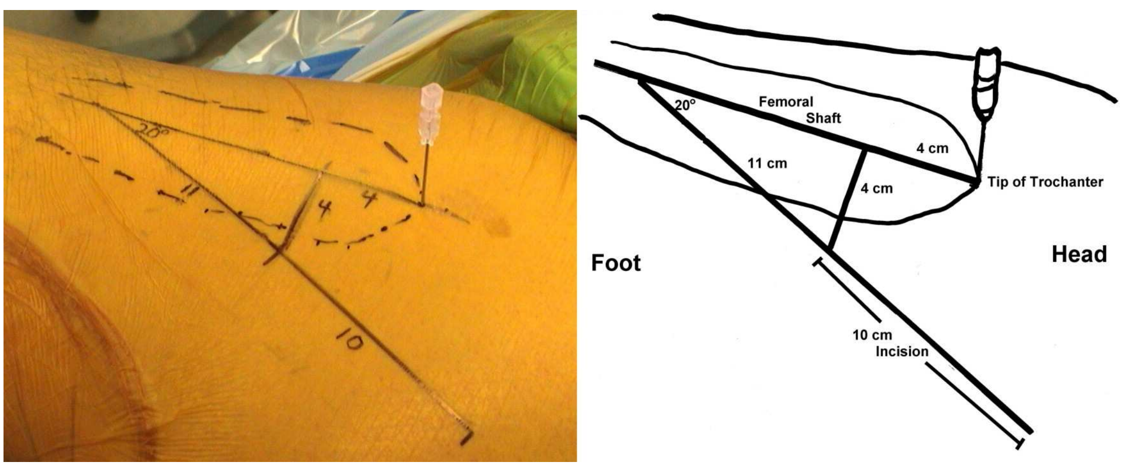

Figure 2: Placement of surgical incision with apices of incision in optimal locations for acetabular reaming and femoral broaching.

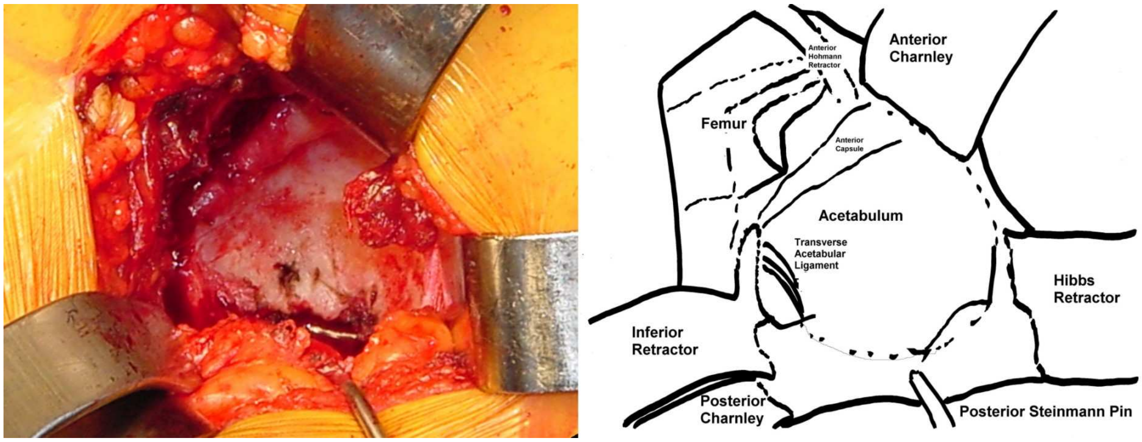

Figure 3: Acetabular exposure. Care is taken to avoid over-retraction.

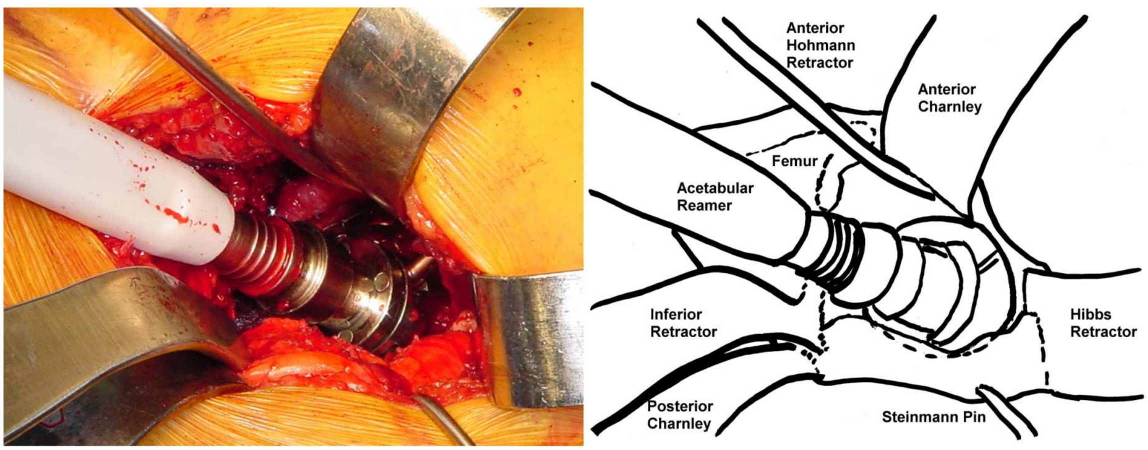

Figure 4: Acetabular reaming. Care is taken to protect skin

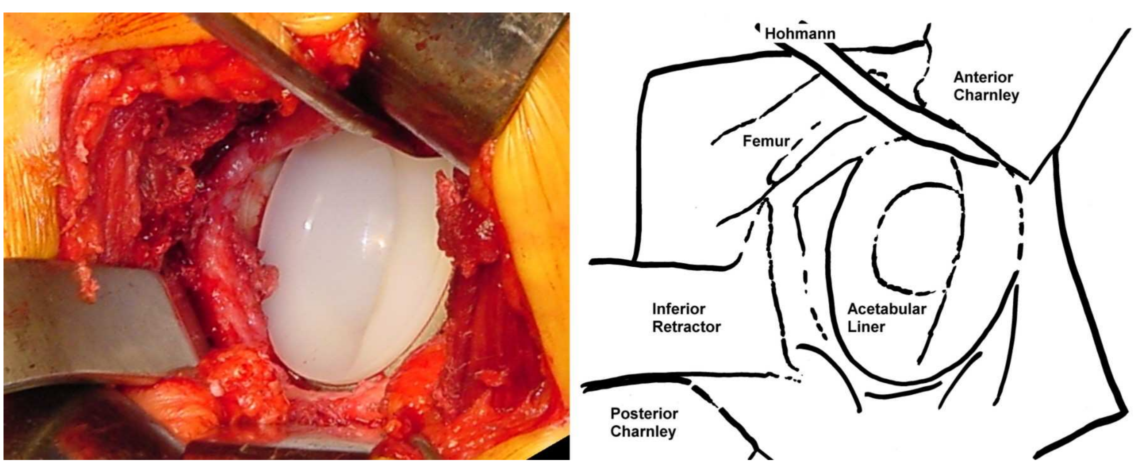

Figure 5: Acetabular component in place.

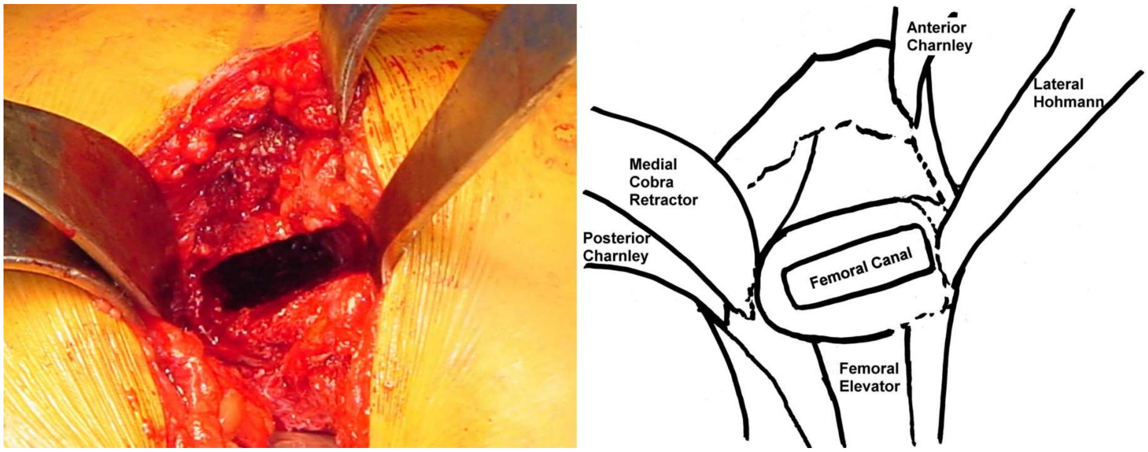

Figure 6: Femoral exposure. Care is taken to avoid over-retraction and protect skin.

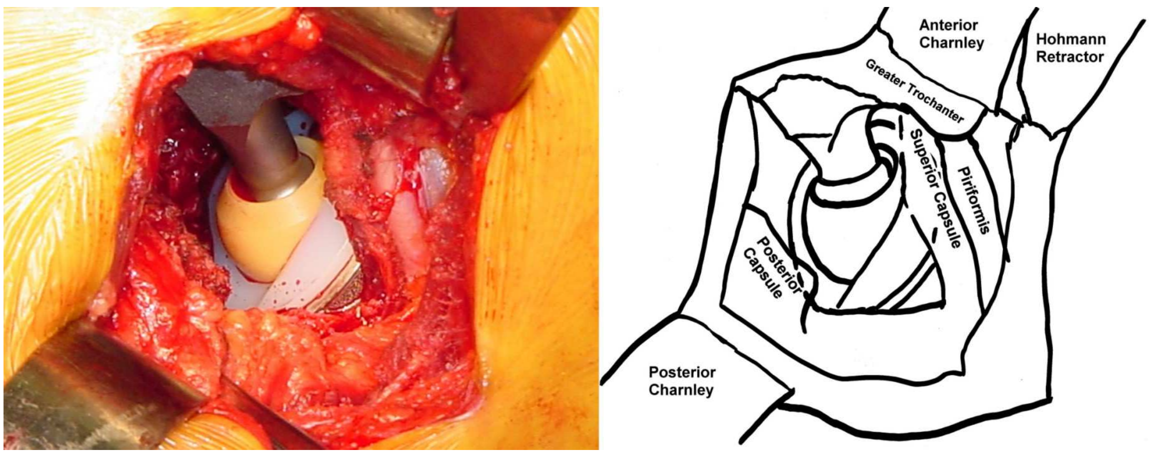

Figure 7: Total hip components in place, and hip reduced.

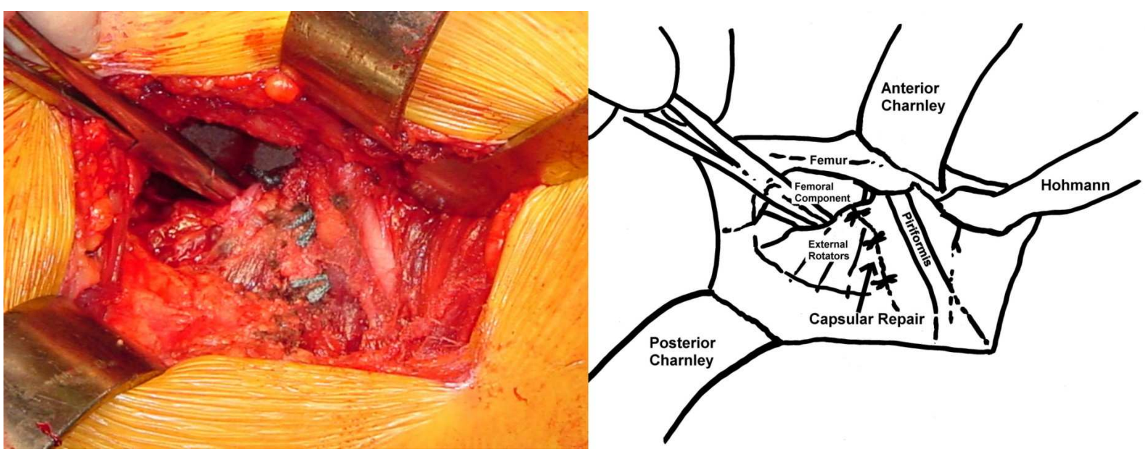

Figure 8: Capsular closure with heavy, braided suture. Note piriformis tendon remains intact.

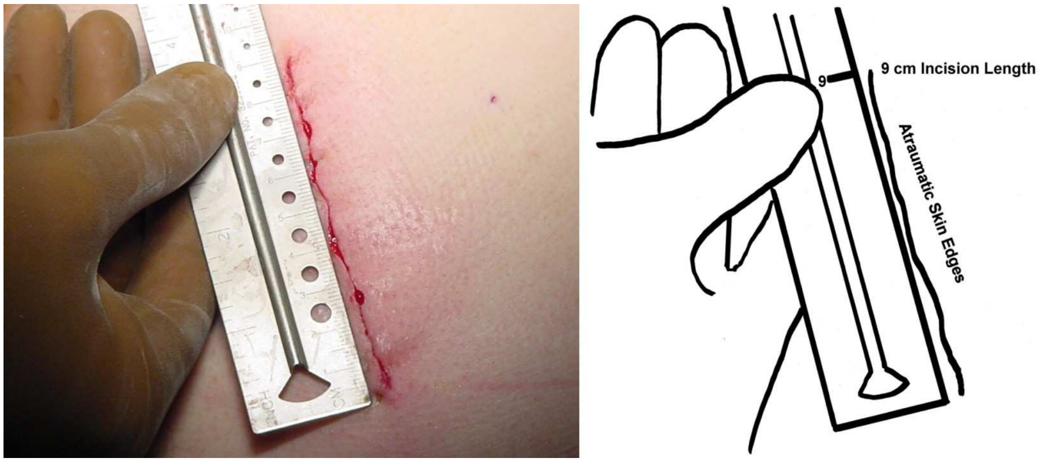

Figure 9: Incision closed. Note absence of trauma to skin.

Figure 10: Forty-eight month post-operative radiograph.