Introduction

The posterior approach to the hip for arthroplasty has been utilized extensively due to excellent exposure of the acetabulum and femur, its extensibility, and limited damage to the surrounding hip musculature [4, 11, 16, 23]. A major concern with the approach has been a high incidence of post-operative dislocation in the range of 1-5% [6, 10, 13, 18, 19, 21]. Modern techniques with retention of the anterior capsule and surgical repair of the posterior capsular structures and external rotators have reduced this problem while retaining the other advantages [5, 7, 12, 16, 24]. Pellicci [16] described a posterior capsular repair with a dislocation rate of less than 1% in a technique involving sewing the rotators and posterior capsule back through drill holes in the greater trochanter. Hedley [5] has described a similar technique, preserving the rotators and repairing the capsular structures to a tendinous cuff. This also reduced their dislocation rate to less than 1%.

To obtain the benefit of minimally invasive surgery, a number of surgeons have described utilizing a posterior approach that limits the proximal and distal extent of the incision and still allows adequate access to the joint [2, 3, 20, 23]. Chimento [2] described performing this through a 5–7 cm incision resulting in no change in post-operative complications or results. DiGioia’s method was combined with CT-based computer-assisted techniques for implant placement [3].

Based on these descriptions and experiences, the author adapted the technique that he had been using for the posterior approach with a classic long incision to a minimally invasive method. Using the latter method, the posterior incision is limited to splitting the gluteus maximus tendon and not extending the incision into the tensor fascia overlying the greater trochanter. In both techniques, preservation of the anterior capsule and repair of the posterior capsule and external rotators was felt important to maintain joint stability. The goal of the smaller incision was to reduce the peri-operative morbidity and pain, reduce blood loss, and achieve more rapid patient mobilization while maintaining accurate component position, restoration of correct leg length and offset.

Particularly with reduced length of the incision and concerns about acetabular positioning, the use of navigation helps ensure that the acetabular component can be placed in the “safe zone” as described by Lewinnek and others [1, 9, 14]. It also provides an additional method of ensuring correct leg length and offset. DiGioia [3], using a CT-based system, has described the use of computer-assisted navigation methods in total hip replacement. Leenders [8] has shown more accurate acetabular cup placement with this method. The use of navigation based on anatomic landmarks without CT imaging has been described by Zheng [25].

The computer-assisted navigation system used by the author is made by Stryker Leibinger (Stryker Navigation, Kalamazoo, Michigan, USA). The system is based on trackers that are placed on pins located in the anterior iliac crest and distal femur. Light emitting diodes (LEDs) on the trackers send signals to a camera array that converts the position and motion information through a computer-software system onto a display monitor. With other trackers attached to instruments such as reamers and insertion handles, the position of the implants can be determined relative to the bone anatomy. The system is “image-free” and relies on manual determination of the anterior frontal plane by palpating the anterior superior iliac spines and the pubic
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The femoral head center is determined by motion analysis.

Based on the combination of improved surgical methods with a minimally invasive posterior approach and computer-assisted navigation, the author now utilizes both of these as the standard technique in his primary total hip replacements.

Methods

The goal of the surgery is to reduce the trauma to the deep tissues. The length of the skin incision, while the focus of many discussions of minimally invasive surgery and what the patient observes, is perhaps less important in terms of recovery than minimizing the muscle and tendon damage that occurs during the exposure. The goal of this approach is to split only the gluteus maximus muscle and avoid incision of the tensor fascia over the greater trochanter.

The patient is positioned in a lateral decubitus position with radiolucent posts with soft-foam pad bolsters supporting the sacrum from behind and both anterior iliac crests from the front. Prior to making the skin incision, percutaneous pins are placed in the anterior iliac crest and lateral distal femur for attachment of the navigation tracker devices. By releasing the posterior support, the patient can be tilted back to palpate the two anterior iliac crests and the center of the pubic symphysis to establish the anterior frontal plane of the pelvis. After this, the patient is brought back to a lateral decubitus position and the posterior support is tightened.

The skin incision begins at the posterior-superior edge of the greater trochanter and extends posteriorly at 45° (Fig. 7.44). In a normal patient, the incision is 7–10 cm, depending on the patient's size and thickness of the subcutaneous tissue. Heavier patients may have an extension of the skin incision posteriorly over the buttock tissue to allow adequate access to the femur. The skin incision is then carried down to the fascia, splitting the gluteus maximus in line with the incision and not extending into the tensor fascia beyond the point where the muscular fibers of the gluteus maximus end. By splitting the muscle, the bursa over the edge of the trochanter can then be identified, picked up and incised. Then finger dissection is used to create an interval between the gluteus maximus inner surface and the back of the trochanter and overlying gluteus medius. The bursa and retinacular tissues over the gluteus medius and posterior trochanter are then incised and a retractor is placed underneath the gluteus medius elevating and exposing the piriformis tendon. A self-retaining Charnley type retractor is used to hold the wound open.

The next step is detachment of the short external rotators and posterior capsule from their bony insertions underneath the overhanging posterior trochanter and medius tendon. By lifting up the tensor fascia with a Hibbs retractor and looking with a headlight, the proximal attachments of the quadratus are released with electrocautery from just above the lesser trochanter to the base of the neck. By using an angled Beaver knife blade on the inner surface of the trochanter, the insertions of the short external rotators are released from their bony insertions and their length preserved as much as possible (Fig. 7.45). Hemostasis may be needed for the perforating vessels of the medial femoral circumflex artery, which crosses the obturator externus and perforates the capsule between it and the obturator internus insertion.

After the short external rotators have been released, the capsular reflection of the gluteus minimus is elevated off the superior capsule and held back with a narrow retractor. A superior capsular incision is also made with the angled Beaver blade in the mid axial line along the long axis of the neck (Fig. 7.46). The capsule and rotators are then reflected back and a meniscal clamp is used to grasp the inferior capsule just above the ischium. This is divided down to its bony insertion overlying the ischium, staying deep to the obturator externus muscle,
Part II: The Hip

Fig. 7.45. Use of an angled knife blade to release the short external rotators from their attachments on the inner surface of the greater trochanter from a posterior approach.

which lays on its surface. This creates a broad flap of tissue of capsule and the three short rotators. Hemostasis is then obtained and several sutures are placed through each of the short external rotator tendons (piriformis, obturator internus and externus) and three points on the reflected posterior capsule (Fig. 7.47).

At this point, manual determination of leg length is made from a mark on the trochanter up to the pin that has been placed in the anterior iliac crest for the navigation tracking system. Without navigation tracking, a mark can be made on the skin overlying the iliac crest and measurements made to that, or a pin placed in it for heavier patients with loose soft tissues.

The hip is then dislocated with a goal of disrupting the ligamentum teres and soft-tissue restraints after which it is relocated. A partial saw cut is made through the neck just below the head, the hip is dislocated, the cut completed and the head removed. This allows the remaining femoral neck to be positioned by internally rotating, adducting, and flexing the femur to make a second, definitive femoral neck cut.

The acetabulum is exposed by placing a Cobra retractor over the anterior and inferior aspect of the acetabulum and retracting the proximal femur anteriorly. Having released the inferior capsule near the ischium and the superior capsule at the top of the acetabulum, there is usually adequate exposure with no further releases being needed. The next steps are to debride the

Fig. 7.46. Location of posterior hip capsular incisions after detaching the short external rotators with retraction of gluteus minimus and medius.

Fig. 7.47. Exposure of femoral neck and head after release of rotators and posterior capsular flap with sutures for later reattachment.
acetabulum, remove the labrum and clear the acetabular fossa with control of any bleeding that may come through the artery at the ligamentum teres. After this, the computer-assisted surgery tool is used to register the acetabular fossa and articular surface of the acetabulum.

Following this, navigated reaming of the acetabulum can be performed, which allows simultaneous direct visualization of the reaming from the posterior approach and computer monitoring of the angle of the reamer's inclination as well as the depth of the reamer relative to the acetabular fossa. An offset, angled acetabular reamer may be utilized to get around the proximal femur and trochanteric area (Fig. 7.48). Navigated reaming allows monitoring of the depth relative to the acetabular fossa as well as the inclination of the reamer. Following completion of reaming, debridement of the acetabulum and curettage of any large acetabular cysts with bone-grafting occurs as needed.

The acetabular cup, which is a press-fit bone ingrowth design, is inserted with an impactor that has a navigation tracker on its handle to guide it into the proper position of approximately 45° of abduction and 20° of flexion. By placing the cup in the opening of the acetabulum and removing all of the retractors, the soft tissues relax and allow the cup to be impacted in the proper position following the angles and depth of insertion on the computer monitor (Fig. 7.49). In very heavy or obese patients, a secondary small incision can be made posterior to the femur and the cup impactor passed through it for cup placement and impaction with navigation. Following completion of the cup placement, the impactor can be removed through the incision, peripheral osteophytes removed, and the acetabular liner placed.

The incision that has been made is essentially the posterior arm of the classic posterior-lateral incision. With the femur internally rotated 90°, flexed and adducted, the proximal femoral osteotomy faces directly out of the wound. A small proximal femoral elevator can be placed underneath it along with the self-retaining retractor. A standard femoral preparation can be performed, opening the canal with a box osteotome, starter awls, and then reaming and broaching until the femoral trials can be placed for a trial reduction (Fig. 7.50). The computer-assisted system aids in determining the appropriate amount of leg length and offset necessary to restore stability. Since the anterior capsule has been preserved, this is an additional aid in determining the proper soft-tissue tension. Once the appropriate prosthesis has been selected, it can be placed directly in the femur under direct observation to ensure correct rotation and avoidance of proximal calcar fractures. The technique also works well for cemented applications with preparation of the canal, irrigation, drying and pressure injection. Direct visualization of the canal ensures proper femoral rotation.

Following placement of the definitive prosthesis but before the head is impacted on, the trochanter is posi-
tioned in the center of the wound and four drill holes are made along the posterior border of the greater trochanter aimed toward the inside of the trochanter where the rotator tendons had been taken off. Pairs of sutures from adjacent tendons and capsule are then passed so that sutures may be tied over the bony bridges between them (Fig. 7.51). The selected head is impacted on to the taper and the hip is reduced. After tying the sutures through the drill holes in the trochanter, the fascia over the gluteus maximus is repaired with absorbable sutures and followed by a standard closure.

Post-operatively, patients are managed in a standard fashion with an abduction splint, dislocation precautions, and mobilization with weight-bearing as tolerated on either the day of or day following surgery. Initial external support with crutches or a walker is advanced to a cane as patients recover strength and mobility.

Results

The MIS posterior approach has been used now in 250 cases with primary total hip replacements. The population is 43% female, 57% male with a mean age of 64 years (range 21–88). The diagnosis was osteoarthritis in 89.7%. The mean BMI was 30 (range 19–54). An un cemented, press-fit acetabulum was used in all cases. A proximal bone ingrowth tapered femoral stem was used in 88% of the cases with a cemented stem used in the remainder.

With minimally invasive surgical techniques, much of the emphasis has been on the length of the skin incision. The author has followed traditional surgical teaching to make an adequate exposure and minimize tension and damage that may occur to the skin. The benefit to the patient is the minimal disruption of the main muscle layer involved, the gluteus maximus, and avoidance of splitting the tensor fascia over the greater trochanter. Particularly in obese patients, there is a large amount of subcutaneous tissue in the buttock. Extending the skin incision posteriorly allows adequate access to the joint without undue tension on the skin. Since half the patients in this series are obese (BMI greater than 30), a larger skin incision was necessary to get down to the maximus fascia. All patients had a similar split in the gluteus maximus with the skin incision varying with the thickness of the subcutaneous tissue. While normal, thin patients can easily be done with incisions of 7–10 cm, the surgeon needs to decide how much tension is tolerable to the skin edges and corners to accomplish this. In this series, we avoided any excess pressure on the skin edges. The mean incision length for patients with a BMI under 30 was 11 cm, for a BMI between 30 and 40, it was 13 cm and for patients with a BMI over 40 and gross morbid obesity it was 18 cm.
While an increased dislocation rate has classically been associated with a posterior approach, the only dislocation occurred anteriorly in a non-computer-assisted hip where the cup position on radiographs was 55° of abduction and 22° of anteversion. This is a dislocation rate of 0.4%. Three non-displaced fractures, one of the greater trochanter and two in the proximal calcaneus, occurred at surgery that required fixation and extension of the wound distally. There were no late fractures or cases of distal migration. There were no cases with sciatic or peroneal nerve palsy after surgery. There was one superficial wound infection that was treated with no sequelae.

With the availability of computer-assisted hip navigation, almost all of the last 60 cases have been done with computer assistance using a MIS posterior incision. It is not used in patients with significant pelvic abnormalities such as previous acetabular and pelvic osteotomies. From analyzing the reports generated by the system after each case, the mean value for cup abduction was 42° (range 38–47°). The mean for cup flexion was 21° (range 15–29°). The surgical goal was to place the cup in 40–45° of abduction and 17–23° of flexion. This was achieved in 88% of the cases for abduction and 80% of the cases for flexion.

To determine the positions of the acetabular cup on digitized post-operative anterior-posterior radiographs, angular measurements were made using a computer-software program (SigmaScanPro, SPSS Science, Chicago, Illinois, USA). Abduction was determined from a line across the face of the cup and another across the bottom of the ischial tuberosities. Flexion was determined by the method of Pradhan [17], which is based on the elliptical appearance of the open face of the cup on a radiograph. Fifty-two radiographs of navigated cases were compared with 28 randomly selected radiographs of previously performed non-navigated cases. Both groups had similar means and ranges. For the navigated group the means were 43° abduction (range 34–54°) and 22° flexion (range 11–31°). For the non-navigated group the means were 45° abduction (range 37–53°) and 24° flexion (range 13–40°). Using an abduction goal of 40–45°, 65% of the navigated cases were in that range compared to 52% of the non-navigated cases. This was significant with a Pearson Chi-square test at \( p=0.044 \). Since radiographic technique and positioning can affect the measured values, forthcoming studies comparing groups with CT scans would be expected to show more accurately any differences between the two groups.

**Summary**

The use of a limited posterior approach to the hip benefits patients by splitting only the muscular fibers of the gluteus maximus and avoiding disruption of the fascia lata tendon over the greater trochanter. The incision preserves the benefits of the posterior-lateral approach with extensibility and adequate access to the femur and acetabulum with direct vision. Combining the minimal posterior incision with computer-assisted hip navigation techniques allows the surgeon to place the total hip components accurately with minimal post-operative complications.

**References**