Percutaneous Acetabuloplasty: A Cadaveric Study

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abstract

Periacetabular osteolysis is a common etiology of prosthesis failure in patients who undergo total hip arthroplasty. These lesions are treated by open and, more recently, percutaneous techniques. The purpose of this study was to determine the relevant surface anatomy and bony landmarks in establishing percutaneous access to periacetabular regions and identifying critical at-risk structures in establishing access. Percutaneous access to the periacetabular region was established superiorly, anteroinferiorly, and posteroinferiorly by using 5 L5-to-mid thigh fixed cadaver pelvises with latex-injected vessels using threaded guidewires. Dissection was completed to identify structures at risk, with the distance from the wires recorded to the nearest millimeter. C-arm position for the optimal visualization and placement of guidewires was recorded. Average distance from the pin and the at-risk structures ranged from 11.2 to 38.7 mm. All 3 approaches allowed for safe percutaneous access to the periacetabular regions without injuring significant anatomical structures. This study established safe starting points and orientation for guidewires and radiograph projections associated with percutaneous access to the periacetabular regions. The findings in this study will be useful for developing minimally invasive approaches to these regions for the treatment of osteolytic lesions of diverse etiology. However, a biomechanical evaluation of the impact of these bony channels on the strength of pelvis under physiological and unanticipated loading must be performed before this technique can be safely translated to clinical practice.

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Periacetabular osteolysis is a common etiology of prosthesis failure in total hip arthroplasty (THA). Multiple factors are associated with osteolysis, including high wear rates, component malposition, and impingement. Biological pathways leading to osteolysis have been the subject of great interest in orthopedic research. Cemented cups tend to have linear osteolysis at the cement-bone interface, leading to implant loosening, whereas uncemented cups commonly have expansive cystic involvement, leading to compromised bone stock. When osteolysis is detected, the treatment strategy depends on multiple factors, including patient age, severity of symptoms, activity level, rate of osteolytic progression, status of socket stability, and liner quality. When indicated, the main treatment option for symptomatic or progressive lesions is revision surgery.

Large progressive cysts that compromise component stability or bone stock are managed with component revision and reconstruction of the bony defect. Smaller progressive cysts with a well-fixed cup can be managed with isolated liner exchange, with or without curettage, and bone grafting of accessible osteolytic lesions. The grafted lesions either resolve or remain stable. Lesions are typically accessed using an open procedure with surgical hip dislocation and removal of the liner, followed by curettage and bone grafting with liner exchange. Revision THA is associated with longer hospital stay, longer operative time, and increased complications. To stop cyst progression, orthopedic surgeons can potentially use a percutaneous approach.

For uncemented sockets without screw holes, surgeons can access the osteolytic lesions through a cortical trapdoor in the ilium using an open procedure. This involves approaching the supra-acetabular region laterally, creating a cortical window with soft tissue attachment, and curing the lesion with subsequent bone or bone-substitute graft application. The same strategy for addressing the osteolytic lesion can be performed and executed through a percutaneous periacetabular approach and may be a viable technique to address a subset of such lesions. The goal of this would be to delay or obviate the need for a revision surgery, particularly in elderly patients with multiple comorbidities. To the current authors’ knowledge, the anatomical feasibility of this technique has not been evaluated in the literature.

In looking at the different periacetabular regions, various structures would be at risk during the procedure. In the supra-acetabular region, the anterior structures at risk include the femoral artery and nerve and the lateral cutaneous femoral nerve. Laterally, the superior gluteal nerve and vessels would be at risk, whereas posterosuperiorly, the sciatic nerve and superior gluteal nerve and vessels would be at risk.

In the ischial periacetabular region, surgical access would be through the medial aspect of the superior portion ischial tuberosity. The sciatic nerve laterally and the internal pudendal nerve and vessels medially would be at risk. In the pubic periacetabular region, the access would be along the superior pubic ramus. Thus, the spermatic cord (male) and round ligament (female) would be at risk.

By identifying safe corridors and landmarks associated with a percutaneous approach to periacetabular regions, the authors provide an anatomical basis for using this approach in selected patients. Most important, this approach has the potential to reduce morbidity and costs associated with treating symptomatic or progressive periacetabular osteolysis after THA.

**RESULTS**

In gaining access to the anterosuperior, lateral, and posterosuperior acetabular areas, no vital structures were at imminent risk in this study. Anteriorly, the average distance from the pin to the pubic symphysis was 11.2±1.5 mm; from the pin to the spermatic cord (in male specimens) or round ligament (in female specimens) was 13.5±0.9 mm; and from the pin to the anterior femoral nerve of the thigh was 38.7±1.9 mm. Posteriorly, the average distance from the pin to the branch of the posterior femoral cutaneous and sciatic nerves was 26.7±1.5 mm and 28.5±1.2 mm, respectively. Lateral, the average distance from the pin to the anterior branches of the superior gluteal artery and nerve was 12.5±2.3 mm.

The common projections used in this study were anteroposterior, lateral, and oblique views of the pelvis, with ancillary positions used to optimize guidewire orientation. For accessing the anterosuperior acetabular region via a pubic approach, the optimal guidewire starting position was 1 cm medial to the pubic tubercle, oriented 45° posterolaterally and 10° inferiorly, with a 45° to 50° inlet view on C-arm for optimal visualization (Figure 1). For accessing the lateral acetabular region via an iliac approach, the optimal

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**MATERIALS AND METHODS**

Five L5-to-mid thigh fixed cadaver pelvic vises (3 male and 2 female specimens) with latex-injected iliopelvic arteriovenous systems were used in this study. Specimens were placed in the supine position, and a 9-mm Steinmann pin was inserted transversely in the mid femoral diaphysis to provide control over the hip movement. Percutaneous access to the periacetabular region was established superiorly, anteroinferiorly, and posterosuperiorly under C-arm guidance using 2.5-mm threaded guidewires.

With the guidewires in place, dissection was performed along the tract to identify structures at risk and to determine their distance from the guidewires. Distances were recorded by calipers to the nearest millimeter. The angle of approach of access trajectories was measured with reference to common bony landmarks using a goniometer. Photographs demonstrating the relationship of the guidewires to the structures at risk were taken for qualitative assessment. C-arm positioning that yielded optimal visualization and guidewire placement was recorded.
guidewire starting position was 2 cm cranial to the femoral head when visualized on C-arm, staying anterior to the longitudinal line along the posterior margin of the greater trochanter. Wire orientation can be dependent on the site of the lesion being accessed. However, to minimize risk of damage to the anterior branch of the superior gluteal artery and nerve, excessive posterior obliquity of the guidewire should be avoided. Optimal C-arm projections for this approach were anteroposterior and 25° internal-oblique views (Figure 2).

In accessing the posteroinferior acetabular region via an ischial approach, optimal guidewire starting position was at the inferomedial region of the ischial tuberosity oval, oriented 40° laterally and 10° anteriorly. Optimal C-arm projections for this approach were 25° internal oblique and 45° external oblique views (Figure 3).

**DISCUSSION**

Periacetabular osteolysis is the most common cause of implant failure after THA. Rates of osteolysis have been shown to differ in respect to cemented vs cementless acetabular components. A review of 71 cemented THAs with a minimum 10-year follow-up reported osteolysis rates approaching 62%. In another study of 59 cementless THAs with a minimum 13-year follow-up, a 17% rate of osteolysis was reported.

Patterns of osteolysis also differ in cemented vs uncemented acetabular components. Osteolysis in cemented sockets occurs predominantly in a linear pattern. In contrast, well-fixed cementless sockets usually display a localized, expansile pattern. Radiographically, the patterns also differ. Cemented sockets show a clear space or gap between the cement–bone interface, with radiolucent regions occurring predominantly in DeLee and Charnley zone III. In contrast, cementless sockets display a radiolucent area starting at the implant–bone interface and expanding into cancellous bone away from the implant. Lesions often occur in zones II and III but may occur in any zone (Figure 4).

Surgery remains the only treatment option for progressive or symptomatic osteolysis. This requires an open revision with curettage and bone graft of the lesions either through the joint with surgical dislocation of the prosthetic joint or extra-articularly through cortical windows in the supra-acetabular region. The latter option can be performed using a percutaneous approach, obviating the need for extensive revision surgery.

Several techniques have been described for the treatment of osteolysis after THA. These include complete revision with replacement of the acetabular shell, liner exchange with curettage and bone grafting through screw holes in the existing well-fixed shell, liner exchange with curettage and bone grafting through an acetabular dome cortical window if the well-fixed shell has no screw holes, and liner exchange with debridement of the lesions without bone grafting. However, all of these options require an extensive open procedure.
In the current study, the authors studied the pubic, ischial, and iliac percutaneous intraosseous approaches to the acetabulum. The current literature lacks a regional access-based classification scheme that corresponds to the most commonly encountered periacetabular osteolytic locations in uncemented THA. The 4-quadrant system described by Wasielewski et al.\(^2\) guides the choice of safe zone in acetabular cup screw placement during THA but cannot be applied to specific approaches in percutaneous acetabuloplasty. Therefore, the current authors used a periacetabular region system based on the embryologic formation of the acetabulum from the ilium, ischium, and pubis (ilioacetabular, ischioacetabular, and puboacetabular regions, respectively). This allowed the authors to standardize their approach to areas of the acetabulum commonly affected by osteolysis.\(^2\)

Similar approaches have been described in the trauma and oncology literature. Metastatic lesions of the acetabulum, rami, and ischial tuberosities have been treated successfully with fluoroscopically guided osteoplasty.\(^23-25\) Traumatologists use percutaneous screw fixation for a subset of periacetabular fractures. Routt et al.\(^26\) described percutaneous fixation of the superior pubic ramus using a more medial parasymphseal starting point in contrast to the lateral starting point in the current study. Their entry point occurred at the junction between the medial slope of the pubic tubercle and the horizontal surface of the body of the pubis on the 40° to 50° pelvic inlet view. This minimized risk to the urinary bladder by placing the entry point more ventral on the body of the pubis. In the current study, the spermatic cord in the male specimens and the round ligament in the female specimens were on average 11.2 mm lateral to the entry point.

Mouhsine et al.\(^27\) described a percutaneous approach to fixation of posterior column fractures using an ischial approach similar to that described in the current study. Their approach, with a supine patient, orientated the K-wire at a 45° angle laterally and a horizontal plane angle of 40° to 45°. This is similar to the 40° lateral and 10° anterior angle described in the current study. The sciatic nerve was on average 28.5 mm from the current authors’ starting point on the inferomedial region of the tuberosity oval.

Because of the relatively narrow columns of bone used to access these acetabular regions, concerns exist about pin penetration and damage to adjacent neurovascular structures. Shahulhameed et al.\(^28\) addressed this concern by mapping the anterior and posterior columns of the acetabulum. Their findings demonstrate adequate bone stock for placement of at least a 2.5-mm threaded guidewire and small-diameter cannulated systems with the ability to curette lesions and introduce...
bone graft material without cortical blowout or damage to adjacent neurovascular structures.28

The current authors concede that disadvantages exist with percutaneous acetabuloplasty. The main disadvantage is the inability to assess polyethylene wear and cup stability intraoperatively. However, prior studies have described methods or criteria to perform these tasks radiographically. Naudi and Engh29 described a technique of accurately accessing liner wear through the use of radiographs and component templates. However, estimating cup stability poses a unique problem. Loose cups often are symptomatic, and symptoms alone may indicate the need for revision. However, well-fixed cups often are asymptomatic but can still present with significant osteolysis. Udomkiat et al30 looked at radiographic criteria to identify loose cementless acetabular components. They described 5 criteria that radiographically represent component loosening, with a sensitivity of 94% and specificity of 100%. Using their criteria, a subset of patients will have no obvious liner wear, no signs of loosening, good function, and advanced age and may benefit from percutaneous treatment of periacetabular osteolysis. Thus, extensive revision surgery could be avoided such patients.

CONCLUSION

Osteolysis will continue to be the most common etiology for prosthetic failure following THA. With greater numbers of THAs being performed each year due to increased patient life expectancy, a need exists for less invasive treatments for patients who cannot tolerate a revision surgery. This study described percutaneous acetabuloplasty, a viable option for treating such patients. The current authors established safe starting points and orientation for guidewires and radiographic projections associated with percutaneous access to the periacetabular region and identified relevant structures at risk. These findings will be useful for developing minimally invasive approaches to these regions for treatment of osteolytic lesions of diverse etiology.

REFERENCES