Management of Intraoperative Acetabular Fractures During Total Hip Arthroplasty

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KEYWORDS

• Total hip arthroplasty • Periprosthetic fracture • Hip fracture

KEY POINTS

- Intraoperative acetabular fracture during total hip arthroplasty (THA) is rare; however, it can be occult and can lead to severe complications if not addressed.
- There are several risk factors associated with intraoperative fracture, including cup geometry, patient factors, and use of press-fit components, among others.
- Acute fractures generally require attention with plating, whereas chronic acetabular fractures may be approached with distraction, a Burch-Schneider cage, or a custom implant.
- Consider missed intraoperative acetabular fracture with persistent groin pain after THA.

INTRODUCTION

Periprosthetic fractures of the acetabulum during total hip arthroplasty (THA) are rare complications that can profoundly affect postoperative outcomes, affecting stability, survival, and migration of acetabular components. Occult intraoperative periprosthetic acetabular fractures, although infrequently reported, are associated with persistent pain and diminished implant survival after THA and can present weeks postsurgery as persistent groin pain.[1,2]

The incidence of overt intraoperative femoral fractures during THA has been reported to range from 0.1% to 1% and up to 5% for cemented and uncemented primary THA, with a projected increase due to the growing demand for THA and decrease in mortality index.[3–11] However, intraoperative acetabular fractures have received comparatively less attention, possibly due to their relative rarity or difficulty in detection. Existing literature reports a prevalence as low as 0.4% during uncemented cup fixation, increasing to 0.7% for all THAs.[12,13]

Multiple factors contribute to the risk of acetabular fractures during the THA procedure, including iatrogenic factors such as underreaming, overreaming, and implant impaction during cementless component fixation.[12,14–16] Cadaveric studies have shown that oversized component insertion can lead to acetabular fractures; this is less common if line-to-line reaming is performed.[17] Conversely, smaller cups less than 50 mm have also been shown to pose a higher risk for intraoperative fracture.[18–20] Pathologic factors encompass osteoporosis, osteolysis, infection, dysplasia, cancer, diabetes mellitus, rheumatoid arthritis, and Paget disease.[13,16,21–23] Patients undergoing revision THA face a higher

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likelihood of intraoperative acetabular fracture compared with primary THA due to challenging surgical factors, such as the removal of well-fixed acetabular components that require excessive force for extraction.[24] Preventative measures are largely patient-specific encompassing line-to-line reaming, preoperative optimization of patient health, cementless versus cemented acetabular component insertion, and appropriate implant sizing.

Cup geometry seems to play an important role as well, especially with the popularity of cementless sockets. Cementless acetabular components can be inserted with line-to-line reaming or by underreaming the acetabulum with press-fit impaction.[25] Components can be elliptical with a peripheral flare, hemispheric, or peripheral self-locking, with a rim that is 1.8 mm larger than the cup diameter. Prior research has demonstrated that the impaction of elliptical monoblock cementless cups is more likely to result in fracture than hemispherical modular cementless cup.[1,12,17,26] Moreover, in a study of 406 patients undergoing THA, Hasegawa and colleagues[27] reported an increased risk of occult acetabular fracture with press-fit impaction of peripheral self-locking cups compared with hemispheric cups. Fractures were most frequently found on the superolateral wall with postoperative computed tomography (CT) scans. The risk of fracture is further heightened in patients with poor bone stock, sclerotic bone, and smaller pelvic footprints.[1]

Management of acetabular fractures depends on an acute or chronic presentation. As will be discussed later in the article, acute fractures generally require attention with plating, whereas chronic acetabular fractures can be approached with distraction, a Burch-Schneider cage, or a custom implant.[28,29] It is also important to note that THA itself is often a treatment of acute acetabular fractures, especially in the elderly population.[30,31]

Currently, there is no universally accepted treatment algorithm for intraoperative acetabular fractures, and literature on this topic remains scarce. Given the rarity of these fractures and their complex treatment, our narrative review aims to provide a comprehensive overview of the current literature on intraoperative acetabular fractures during THA and our institutional perioperative management. By discussing treatment options and postoperative considerations, we seek to offer guidance to surgeons facing these intricate challenges, helping them achieve optimal patient outcomes, hip stability, and proper management.

CLASSIFICATION AND MANAGEMENT OF INTRAOPERATIVE ACETABULAR FRACTURES

Classification

Navigating the complexities of intraoperative acetabular fractures and assessing stability are crucial in preventing aseptic loosening and poor outcomes. In 1996, Peterson and Lewallen introduced a classification system for acetabular fractures after THA, which has since evolved through various adaptations: type 1: clinical and radiographic stability of the acetabular component; type 2: the acetabular component was deemed unstable.[13] Laflamme and colleagues[32] added the type 3 acetabular fracture, which is a missed intraoperative acetabular fracture noticed on postoperative radiographs. Perhaps the most comprehensive and widely used systems today are the 1995 Vancouver system and the 2003 Paprosky and Della Valle classification, which take multiple factors into account and serve as a foundation for fracture management.[33,34] Davidson and colleagues[35] further simplified the Paprosky and Della Valle system detailing the following 3 fracture types: I: nondisplaced and not compromising stability of reconstruction, II: nondisplaced that may compromise stability of reconstruction; III: displaced. More recently, a classification proposal by Pascarella and colleagues[10] in 2019 incorporates fracture timing. Despite limited therapeutic use and complexity, it is worth noting the 2014 unified classification system, which assesses stability, location, and associated fracture features (Table 1).[36]

Conservative Management

Per the Paprosky and Della Valle classification system, type 1 fractures can typically be treated without any type of augmentation. To ensure the best outcomes, arthroplasty surgeons must be well versed in the geometry of the acetabular component and adhere to appropriate reaming protocols. It is important to note that many of type I fractures are often not recognized in the intraoperative setting. Interestingly, Haidukewych and colleagues[12] reported a significant increase in intraoperative acetabular fractures when using an acetabular component with an elliptical flare.

Intraoperative acetabular fractures during THA are rather rare and can possibly go unnoticed for weeks.[32] Generally, intraoperative acetabular fractures can be managed without any supplemental plating or screw augmentation. Intraoperative acetabular fractures can occur during acetabular reaming, component impaction, or hip dislocation. It is important to frequently inspect the acetabulum, especially

Table 1
Adaptation of the evolution of periprosthetic acetabular fracture classification systems

Classification System	Factors	Types	Subtypes
Vancouver (1995)	*Location, stability, configuration*	Type A: *proximal metaphyseal* Type B: *diaphyseal* Type C: *distal fractures beyond longest revision stem, can include distal metaphysis*	Subtype 1: *simple cortical perforation* Subtype 2: *nondisplaced linear crack* Subtype 2: *displaced or unstable*
Peterson and Lewellen (1996)	*Stability, pain*	Type 1: *acetabular component clinically and radiographically stable. Minimal pain with hip motion* *Type 2: unstable acetabular component. Painful hip motion*	—
LaFlamme (1998)	*Stability*	*Same as Peterson and Lewallen, but with the following* Type 3: *missed intraoperative acetabular fracture seen on postoperative radiographs*	—
Paprosky and Della Valle (2003)	*Timing, method, stability*	Type1: *intraoperative during component insertion* Type 2: *intraoperative during removal* Type 3: *traumatic* Type 4: *spontaneous* Type 5: *pelvic discontinuity*	1A: *recognized, stable, nondisplaced* 1B: *recognized, unstable, displaced* 1C: *not recognized* 2A: *<50% bone loss* 2B: *>50% bone loss* 3A: *stable component* 3B: *unstable component* 4A: *<50% bone loss* 4B: *>50% bone loss* 5A: *<50% bone loss* 5B: *>50% bone loss* 5C: *associated with radiation*
United Classification System (UCS) (2014)	*Stability, location, anatomic features*	A: *apophyseal or extraarticular/ periarticular* B: *bed of implant or around implant* C: *distant to implant* D: *dividing the bone between 2 implants* E: *each of 2 bones supporting 1 arthroplasty* F: *facing and articulating with a hemiarthroplasty*	B1: *stable prosthesis, good bone* B2: *loose prosthesis, good bone* B2: *loose prosthesis, bad bone* Specific to hip: IV.6: *acetabulum/pelvis* IV.3: *femur, proximal*

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Table 1
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Classification System	Factors	Types	Subtypes
Pascarella (2019)	*Timing, stability*	Type 1: *intraoperative* Type 2: *postoperative/ traumatic*	1A: *stable prosthesis* 1B: *unstable prosthesis* 2A: *stable prosthesis* 2B: *unstable prosthesis* 2C: *unstable prosthesis, mobilized before trauma*

the anterior/posterior wall during each step to ensure there are no visible fracture lines or eccentrically reaming. Moreover, intraoperative acetabular fracture should also be suspected when the cup sits more medial than expected or the surgeon is not achieving the expected press-fit fixation. The arthroplasty surgeon should consider occult acetabular fracture in patients with persistent groin pain after THA. Because these fractures may not be visualized on intra- and postoperative radiographs, they warrant CT pelvis scan for further evaluation.[2]

Li and colleagues and Haidukewych and colleagues have published the largest series to date of intraoperative acetabular fractures.[12,37] In the study by Haidukewych and colleagues, 17 of 21 patients were managed without any supplemental plating due to stability of the acetabular component. In the remaining 4 patients, another acetabular component was used that allowed for multiple screws to be placed through the acetabular component. Li and colleagues[37] reported that 20 out of 24 of their patients underwent multiscrew fixation of the acetabular component, and the remaining 4 did not warrant any screw augmentation. Thus, it is important that arthroplasty surgeons are familiar with the pelvic anatomy and safe zone for screw placement, and it remains a key pillar in the treatment of acetabular fractures.

At our institution, on identifying an intraoperative fracture, we immediately halt reaming and instrumentation to visually inspect the entirety of the acetabulum. The focus is on preventing further fracture propagation and identifying noncontiguous fracture lines. We also assess the integrity of the medial wall to ensure that the acetabular component can be safely impacted without compromising the medial wall. The integrity of the posterior column is also assessed to discern if a traumatologist should be consulted to assist with plating of the posterior column (Case 1). Intraoperative fractures of the posterior acetabular column portend worse outcomes and higher failure rates.[32] If stability is deemed to be adequate for a primary cementless acetabular component, then the acetabular component is augmented with screw fixation. However, it would be advisable to add bone graft from the femoral head or sequential reaming into the noted defect. The investigators believe it is prudent to augment acetabular fixation with at least 3 screws through the acetabular shell, but this is surgeon dependent.

Plating of the Anterior or Posterior Column

A critical challenge in stabilizing intraoperative acetabular fractures is determining whether fracture fixation can be achieved using the same approach used for THA. For instance, with a direct anterior or anterior-based muscle-sparing approach, it becomes unfeasible to plate the posterior column in the event of a transverse, posterior column, or posterior wall fracture. Thus, an additional approach would be required to stabilize these areas of the pelvis with plate and screws. Furthermore, when dealing with an intraoperative acetabular fracture involving the anterior column, a modified Stoppa and ilioinguinal approach may be needed if a posterior- or lateral-based approach is being used for THA. In such cases, it would be prudent for the arthroplasty surgeon to consult with an orthopedic traumatologist for assistance in managing these complexities.

At our institution, most of the THAs, particularly conversion THAs, are performed through a posterior-based approach. If posterior column plating is warranted, our orthopedic traumatologist partners are often consulted to assist with single or dual-plate fixation to the posterior column. In addition, they assess the need for an anterior column screw. Failure of the acetabular component after intraoperative acetabular fractures is secondary to instability of the posterior column.[32] Plating of the posterior column is crucial, especially in the acute setting, for successful outcomes and osteointegration of the acetabular component when significant posterior column involvement is present. An anterior intrapelvic buttress plate may be placed to lateralize the acetabulum if there is significant medialization of the femoral head secondary to a destabilizing fracture involving the quadrilateral surface.

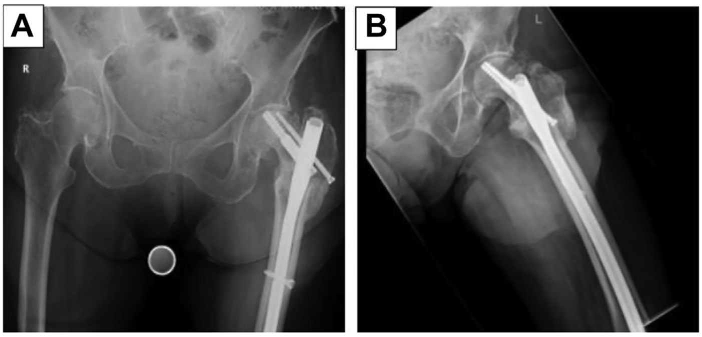

Fig. 1. (*A*) Anteroposterior (AP) and (*B*) lateral radiographs of a left hip that underwent previous cephalomedullary nailing for left hip fracture. Notice the reverse Z-phenomenon (inferior lag screw migrated medially cutting through the femoral head and the superior lag screw).

Acetabular Distraction

It is important to assess the stability of the fracture if a fracture line is noticed along the medial wall or acetabular roof. There is the chance that an acetabular component may not be able to obtain adequate press fit fixation with a primary acetabular component. A technique that we commonly use at our institution (Case 1) is acetabular distraction. If press-fit fixation is not occurring, we assess the stability of the acetabulum to sustain acetabular distraction. The acetabulum is reamed until we have engagement of the anterosuperior and posteroinferior regions of the acetabulum at the periphery and not medializing during this process. We ream roughly 3 to 5 mm less than the impacted cup. Subsequently, several screws are placed through a revision acetabular component to augment fixation. It would be prudent for the arthroplasty surgeon to place bone graft from acetabular reaming into the fracture lines and at the center of the acetabulum.

Acetabular Roof Reinforcement Plate

Resch and colleagues and Krappinger have described the use of an acetabular roof reinforcement plate (Depuy Synthes, Battlach, Switzerland) for management of geriatric acetabular fractures.[31,38] This construct consists of an inner and outer diameter that fits within the acetabulum and an upper fin on the top side of the ring, which has several screw holes to place 3.5-mm screws. This plate provides robust support for acetabular component placement. Although Resch and colleagues' technique was not specifically designed for intraoperative acetabular fractures, it can be used as an option, depending on the severity of the fracture. The key advantage of this plate is that it allows patients to weight-bear immediately after surgery, eliminating the need for restrictions of weight-bearing status. However, using this acetabular roof reinforcement plate through an anterior-based approach may prove challenging.

CASE

Case 1

Patient 1 is an 83-year-old woman with multiple medical comorbidities that previously sustained a left pertrochanteric fracture after a fall from standing. She underwent cephalomedullary nailing to stabilize her left hip. She was previously a community ambulator using a cane for assistance with mobilization. During her postoperative course, she sustained screw cutout of the left hip cephalomedullary nailing (Fig. 1) with concomitant progression of left hip osteoarthritis.

She underwent a left conversion THA for the progression of osteoarthritis and screw cutout of the cephalomedullary nail. This conversion

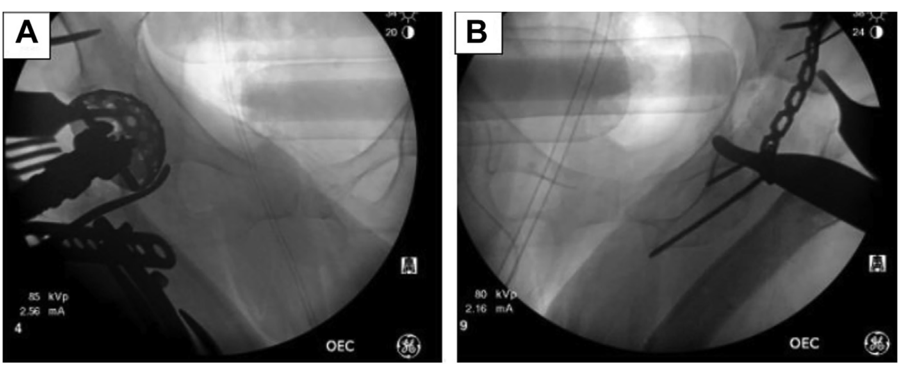

Fig. 2. Intraoperative fluoroscopic images demonstrating (*A*) fracture of the posterior column during reaming. (*B*) The posterior column was plated for additional stability.

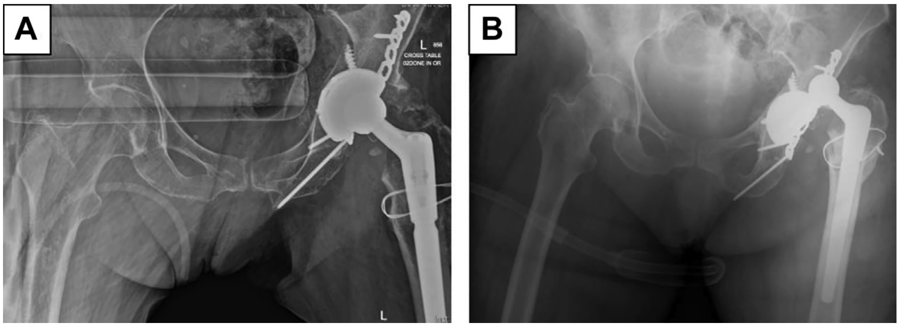

Fig. 3. (*A*) Immediate postoperative radiographs demonstrating plating of the posterior column with mild protrusion of the acetabular component. (*B*) The patient sustained a posterosuperior dislocation POD 2. Patient was managed with closed reduction. Due to persistent instability, CT pelvis was ordered to assess acetabular component orientation.

was performed through a Kocher-Langenbeck approach. Intraoperatively it was noted she had a greater trochanter deformity and a shallow acetabulum. The reaming of the acetabulum led to an acetabular fracture that was deemed to be stable (Fig. 2). Impaction of the acetabular component led to propagation of fracture along the anterior and posterior columns. At this point, the posterior column was exposed in standard fashion with identification of the sciatic nerve, before plate application. A single 3.5-mm pelvic reconstruction plate was contoured to the acetabulum, and this was thought to provide adequate stability of the posterior column.

She sustained 2 posterosuperior dislocations (Fig. 3) within 2 weeks of her conversion THA. She was managed with closed reduction under sedation initially. A pelvic CT scan was obtained secondary to acute instability and demonstrated retroversion of the acetabular component (Fig. 4). The version of the femoral component was deemed to be in good alignment. As previously noted, after intraoperative acetabular fracture during THA there is a likelihood that the acetabular components can fall into retroversion.

The decision was made to revise her acetabular component. She was brought to the operating room within 3 weeks of her index conversion THA for her left revision THA. Intraoperatively, it was noted the acetabular component was mildly retroverted, and there was posterior instability. The acetabular components were removed, and a defect in the medial wall was noted. After intraoperative assessment, it was decided additional fixation with an anterior column screw was not necessary. Acetabular reaming was undertaken, and a 57-mm (mm) reamer was last used. Bone graft was placed in the medial defect to assist with developing callus along the previous fracture

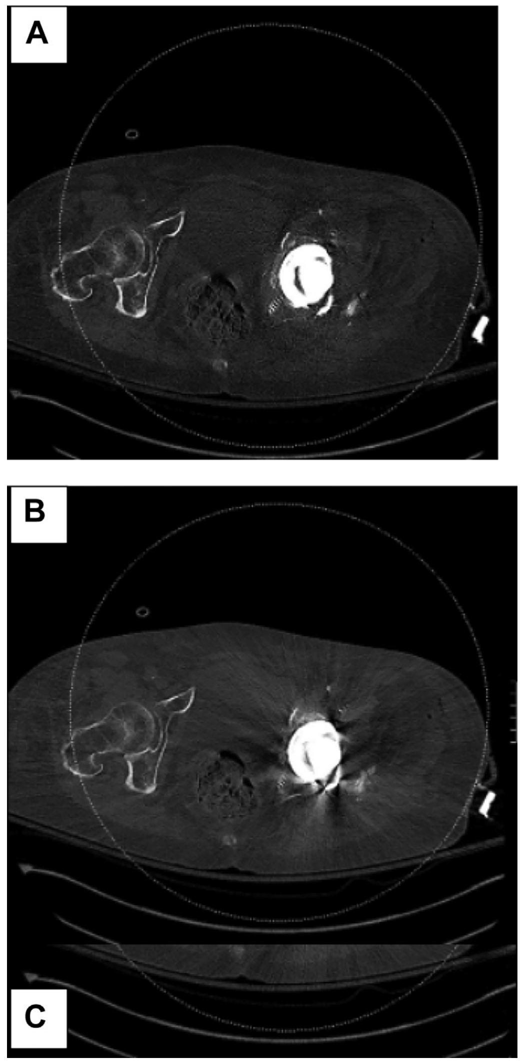

Fig. 4. Three slices (*A*, *B*, *C*) of axial CT pelvis demonstrating retroversion of the acetabular component; likely the cause of her postoperative instability contributing to the posterosuperior dislocation.

site. Subsequently, a Redapt (Smith and Nephew, Memphis, TN, USA) 60-mm multihole dual mobility acetabular component was inserted (Fig. 5). Underreaming by 3 mm allowed for a press fit. Several screws were inserted in the sciatic buttress to augment the fixation. She was kept toe-touch weight-bearing for 6 weeks, and her weight-bearing status subsequently advanced to weight-bearing as tolerated. At her 7-month visit, she is pain free, ambulating without difficulty, and has not sustained any additional dislocations or other postoperative complications.

POSTOPERATIVE PRECAUTIONS

Weight-Bearing Status

Weight-bearing as tolerated (WBAT) is the standard protocol after primary THA. However, the weight-bearing status after an intraoperative fracture during THA is fracture-, treatment-, and surgeon-dependent. Typically, at our institution, we will start patients with foot-flat weight-bearing for 3 to 4 weeks and then advance to weight-bearing as tolerated. However, there are rare instances if acetabular fixation is thought to be stable that we will allow the patient to be WBAT immediately after surgery.

Hip Precautions

At our institution, patients are placed on posterior hip precautions if they sustained an intraoperative acetabular fracture during a posterior-based approach for THA and anterior precautions if there was an acetabular fracture during an anterior-based approach. It is important to check range of motion and stability after plating of the posterior column and placement of acetabular cup/stem after sustaining an intraoperative acetabular fracture. It is important to visualize acetabular and femoral version after sustaining a fracture. There is always the potential that component can have either too much retroversion or too much anteversion and should be rectified before leaving the operating room.

Special Considerations

Deep vein thrombosis prophylaxis

Deep vein thrombosis (DVT) prophylaxis for pelvis/acetabular fractures is not the same as primary THA. At our institution, the current DVT prophylaxis protocol for primary THA is aspirin 81 mg twice daily.[39] If a patient is on an anticoagulant for a preexisting DVT, cardiovascular disease, and so on, we cease their anticoagulant medication and restart it 48 hours after THA. In the interim, they are provided low-molecular-weight heparin (Lovenox) until restarting their anticoagulant medication.

However, the DVT prophylaxis protocol is different for pelvis/acetabular fractures. Lovenox, 30 mg, twice daily is used after open

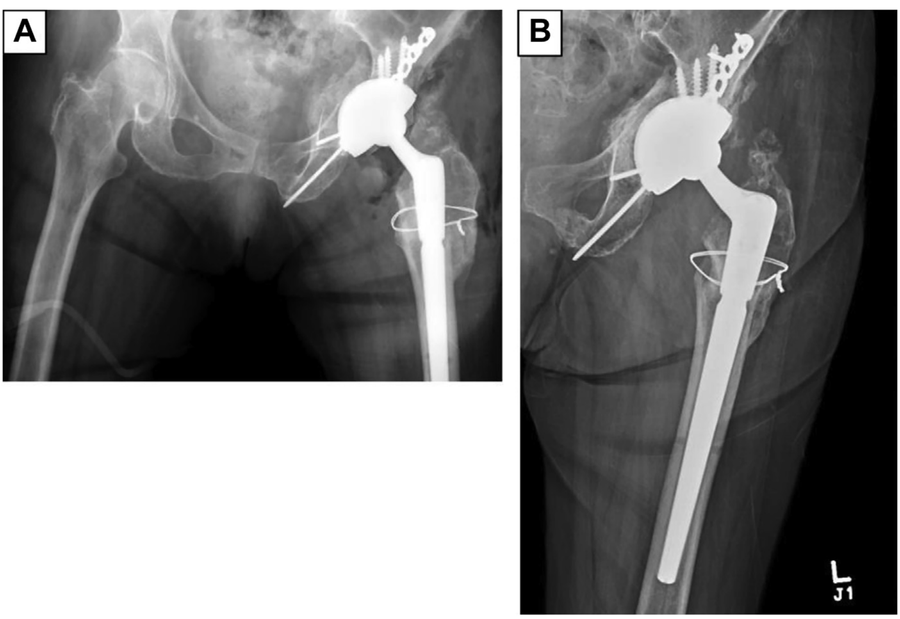

Fig. 5. (*A*) Immediate postoperative radiographs after revision of the acetabular component. (*B*) Six-month postoperative AP left hip radiograph demonstrating healing bridged callus along the posterior column and maintained alignment of the acetabular component.

reduction internal fixation for the fracture. This same DVT prophylaxis is used for an intraoperative pelvis/acetabular fracture during THA. This situation is no longer treated as a standard primary THA. However, in the recent PREVENT CLOT study it was rendered that aspirin was noninferior to Lovenox in preventing death, 90-day readmissions, and for DVT prophylaxis.[40]

SUMMARY

Intraoperative acetabular fracture, although rare, can lead to severe complications if not properly addressed. It is imperative for arthroplasty surgeons to possess a thorough understanding of how to identify and manage these injuries. Collaborating with an orthopedic traumatologist for assistance with plating the anterior or posterior column, if necessary, can be invaluable. Management options encompass conservative management, revision style acetabular component, screw/plating of anterior/posterior column, and the use of a larger cup with multiple screw augmentation options.

CLINICS CARE POINTS

- Continually inspect acetabulum during THA especially when reaming and cup impaction.
- Consider missed intraoperative acetabular fracture with persistent groin pain after THA.
- After intraoperative acetabular fracture discern if cup augmentation or plating of anterior/posterior column is warranted.
- Surgeon should familiarize himself/herself with geometry of cup and the reaming protocol.
- Consider patient's comorbidities when prescribing DVT prophylaxis.

DISCLOSURE

M. DeBaun Summit Surgical Corp: education. Smith and Nephew: food and beverage. C. Pean Stryker, OsteoCentric: food and beverage. S. Ryan Smith and Nephew, Encore Medical, DePuy Synthes, Bioventus: travel and lodging. M. Bolognesi Zimmer Biomet: Royalty, License, food and beverage, Smith and Nephew: Royalty, License, Total Joint Orthopaedics: Royalty, License. Ethicon: Consulting. Heron Therapeutics: Consulting. T. Seyler: Smith and Nephew: Consulting, faculty or speaker at venue. All other authors have nothing to disclose. T Stauffer: Eugene A. Stead Fellowship Fund.

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