Complications of total hip arthroplasty: periprosthetic fractures of the acetabulum

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Abstract Periprosthetic fractures of the acetabulum are a rare but potentially disastrous complication of total hip arthroplasty. Such fractures occur either as early perioperative complications or late complications when they are associated with either significant trauma or as a result of the loss of the structural integrity of the bone supporting the prosthesis, such as aseptic osteolysis. The incidence of such fractures appears to be increasing with the increased use of uncemented acetabular components. This article explores the current literature on the epidemiology, etiology, and classification of periprosthetic acetabular fractures as well as offering potential treatment strategies.

Keywords Periprosthetic fracture · Total hip arthroplasty · Acetabulum

Introduction

Periprosthetic fractures of the acetabulum are less common than periprosthetic fractures of the femur. They occur intraoperatively, present as a late complication secondary to either trauma or pathologic processes reducing the structural integrity of supporting bone, or can be associated with revision surgery.

Intraoperative acetabular fractures are rare occurrences during primary total hip arthroplasty (THA) [1•, 2•, 3, 4••]. Haidukewych et al. [4••] report fractures occurring predominantly during impaction of a cementless acetabular component, however, fractures were also noted during hip dislocation and reaming. Takigami et al. have also reported pelvic discontinuity after overzealous reaming [5]. Despite the reports of fractures occurring during common steps required for the insertion of either cemented or cementless acetabular

components, fractures associated with cemented sockets are exceedingly rare, whereas Haidukewych et al's series, which is the largest reported, shows a prevalence of 0.4 % in cementless socket fixation. The same series reports significant differences in acetabular fracture rates dependent on the type of acetabular shell used. Press fit impaction of elliptical shells was more likely to cause a fracture of the acetabulum than a true hemispherical cup, reamed "line to line," and there was a further significant increase in fractures when a monoblock elliptical design was used. This concurs with other studies both clinical and cadaveric, which have shown acetabular fractures to occur more commonly with an under reamed press fit cup compared with a "line to line" reamed cup [1•, 2•, 3].

Other authors have reported fractures occurring in the presence of abnormal bone. Zwartelee et al's [6] systematic review of cementless acetabular components in patients with rheumatoid arthritis showed an acetabular fracture rate of between 2 % and 5 %. McGrory [7] has reported a fracture of the acetabulum occurring during THA in a patient with Paget's disease. Osteoporosis has also been implicated as a risk factor for acetabular fracture at the time of implantation of a cementless socket [2•, 8] Fig. 1.

Intraoperative fractures of the acetabulum may go unrecognized at the time of surgery and are sometimes only diagnosed when a postoperative radiograph is performed, or when the patient has unexpected pain in the weeks after surgery [2•]. On occasion, minor trauma has resulted in significant early postoperative acetabular fracture and our feeling is that this is most likely to represent a missed intraoperative fracture that has progressed and displaced [8].

Revision surgery is more likely to result in intraoperative acetabular fracture than primary THA. This is due to a combination of both patient factors and surgical factors. Patient factors include poor bone stock and more elderly patients with an increased prevalence of osteoporosis. Surgical factors include well fixed acetabular components sockets, which may be difficult to remove, poor technique when removing components, such as attempting to lever out

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Fig. 1 The peripheral diameter of elliptical shells is greater than a standard hemispherical shell

the socket and the use of excessive force. The development of acetabular cup removal devices which the surgeon can use to cut around an uncemented shell help in minimizing the force used to remove such components.

Late presentations of periprosthetic acetabular fractures may occur as a result of trauma, chronic migration of a socket or secondary to osteolysis around the socket [9, 10] and may be associated with infection. Periacetabular osteolysis can occur in both cemented and cementless systems [11–13], and there have been reports of cases where this has led to acute acetabular fracture [14, 15].

Radiographic assessment

The mainstay of radiographic assessment remains plain radiographs. An A-P view of the pelvis should be supplemented by Judet views. These are taken with the pelvis internally rotated by 45° and externally rotated by 45°. This allows better visualization of the anterior and posterior columns of the acetabulum. The walls may be difficult to see as they are potentially obscured by the implant. CT scanning is also very useful and in particular new algorithms that help differentiate metal from bone can often help provide additional information and visualization of the fracture pattern. Where there is an intrapelvic component CT angiography is recommended for preoperative planning.

Classification

The most widely used classification system is that of Paprosky 2003 [16] (Table 1). This system can help to formulate management plans. Note this is a separate classification to the Paprosky classification of acetabular defects [17], which is more familiar to most hip surgeons.

Table 1 Paprosky classification of periprosthetic acetabular fractures

1.	Intraoperative during component insertion	a	Recognized, stable component, undisplaced fracture
		b	Recognized, displaced fracture, cup unstable
		c	Not recognized intraoperatively
2.	Intraoperative during removal	a	Less than 50 % bone stock loss
		b	Greater than 50 % bone stock loss
3.	Traumatic	a	Component stable
		b	Component unstable
4.	Spontaneous	a	Less than 50 % bone stock loss
		b	Greater than 50 % bone stock loss
5.	Pelvic discontinuity	a	Less than 50 % bone stock loss
		b	Greater than 50 % bone stock loss
		c	Associated with pelvic radiation

Modified with permission from Della Valle CJ, Momberger NG, Paprosky WG. Periprosthetic fractures of the acetabulum associated with a total hip arthroplasty, in Ferlic DC, editors. Instructional Course Lectures 52. Rosemont, IL, American Academy of Orthopaedic Surgeons; 2003. p 281–90

Davidson et al. [18] have offered a simplified version of this classification, however, they have restricted this to intraoperative fractures only, hence, the equivalent of the Paprosky types 1 and 2:

- I. Undisplaced fracture not compromising the stability of the reconstruction.
- II. Undisplaced fracture which may compromise the stability of the reconstruction.
- III. Displaced fracture.

Management

The over-riding principle of treating periprosthetic acetabular fractures is that the columns must be sufficiently stable to be able to support an acetabular implant, and to prevent movement at the bone implant interface. In addition, there must be enough bone with or without augmentation to enable the implant to be implanted securely. Different strategies may be used to achieve this and use of the Paprosky Classification provides a potential guide to decision making.

Fracture recognized intraoperatively, component stable, undisplaced fracture

These fractures can be treated conservatively – in Haidukewych's series [4••], 17 of 21 fractures which were noticed at the time of surgery were deemed to be stable and no further treatment was undertaken. All of these went on to unite and no revisions were required. In Sharkey's [2•] group only 2 of the 9 fractures which were noticed intraoperatively were

deemed to be completely stable to avoid any further treatment and again both of these went on to unite satisfactorily.

In 7 of the cases in Sharkey's series the authors deemed that although the fracture was stable they were unsure of the stability of the implant, hence, further screws were used to augment fixation of the implant. It is worth noting, however, that there was a significant incidence of persistent postoperative groin pain in this group despite the fracture uniting.

We would strongly recommend using supplemental screws if a fracture is recognized intraoperatively even if this is undisplaced and the implant appears to be stable on testing with a cup introducer.

Fracture recognized intraoperatively, displaced fracture, unstable Cup

If there is significant movement at the fracture site then pelvic stabilization should be undertaken prior to implanting the definitive cup [16]. This is most commonly achieved by single or double plating of the posterior column. This is most easily performed if a posterior approach has been utilized, but it is also possible via a direct lateral approach. If a direct anterior approach has been used then posterior column plating is not possible via the same incision.

Once the acetabulum has been stabilized, an assessment must be made as to whether the bone stock is sufficient to allow a component to be implanted. If there is insufficient bone, bone grafting or the use of trabecular metal augments should be considered.

An important decision as an operating surgeon is to consider whether you or an available colleague has the appropriate skills and equipment to achieve sufficient acetabular stability to safely implant and acetabular component. This is clearly a difficult decision as leaving a patient without a hip replacement is undesirable. However, this may be preferable to implanting a large but unstable component that will inevitably fail if the acetabulum has not been stabilized.

Fracture Not recognized intraoperatively

Some in this group will present in the early postoperative phase and may be diagnosed on the initial post-operative radiographs. In other instances, they may be missed initially and present with delayed displacement and even pelvic discontinuity [8]. The former group represents perhaps the most difficult in terms of decision making. Whilst a fracture may be recognized, it is impossible to adequately determine either the stability of the fracture or the stability of the implant. In Sharkey's series [2•], 2 out of 4 patients in this group had early symptomatic loosening requiring revision surgery.

Our recommendation in this group is to closely observe cases with undisplaced or minimally displaced fractures when

the component is appropriately positioned. In most cases the fracture will unite, but a delayed revision may be required for a loose component. If the fracture is displaced or the component is malpositioned or has migrated then an early revision is usually appropriate Fig. 2.

Intraoperative fractures during component removal (a <50 %, b >50 % bone loss)

Some bone loss is inevitable during revision surgery and in particular attempting to remove a well fixed acetabular implant, hence, good surgical technique to minimize this is essential. Adequate exposure of the rim of the socket is key, along with using appropriate instruments such as an acetabular removal tool. Levering of the socket should be avoided as this may be one of the riskiest maneuvers for damaging soft bone.

Despite this, acetabular fractures do occur even in the hands of the most experienced surgeons. It may be hard to differentiate between a IIa and a IIb fracture, however, the important questions relate to the structural integrity and stability of the acetabulum and the fixation of the implant.

The first goal is to achieve a stable pelvis. In most cases this may be achieved by plating the posterior column either with a single or double plating technique. In severe cases of pelvic discontinuity, this may not be sufficient as is discussed later.

Again if there is inadequate bone stock, bone grafting or the use of trabecular metal components/augmentation must be considered and as with the Ib fractures there is a question regarding whether or not to perform the procedure in 2 stages Fig. 3.

Fig. 2 A radiograph demonstrating an intraoperative periprosthetic acetabular fracture, which was not detected by the surgeon until a postoperative radiograph was performed

Fig. 3 **a**, Prerevision radiograph of a cemented hip replacement; **b**, a posterior column was caused intraoperatively and was recognized, but felt to be stable. Twelve months postoperatively, the patient had a nonunion of the posterior column

Traumatic fracture – component stable

The questions posed by this group are similar to the Ic fractures ie, it is difficult to be certain that either or both the fracture and component are completely stable. In Petersen's series [9], they report 8 such fractures which were treated initially by restricting weight bearing and activity modification. Of these, 6 went on to unite, whilst 2 required early revision. However, of the 6 that did unite, 4 still required early revision for ongoing problems.

These fractures can be treated nonoperatively, however, there is a very high likelihood that they will require operative intervention and should be monitored carefully with serial radiographs.

Traumatic fracture – component unstable

This type of fracture requires operative intervention. Again the principles of obtaining pelvic stability, adequate bone stock, and a securely fixed implant remain the cornerstones of the procedure. Traumatic fractures are usually highly mobile Fig. 4.

Spontaneous (a <50 %, b >50 % bone loss)

These fractures are less common than those secondary to trauma. In Petersen's series 3 of the 11 reported fractures occurred spontaneously. Springer et al. [19] reported 7 cases of spontaneous periprosthetic transverse acetabular fractures after revision surgery using trabecular metal cups. In all cases the patients were female and the cup size was large (>58 mm). They felt this was related to further weakening of the bone stock after surgery. This may be of increasing concern in the future

with the increased use of trabecular metal, particularly in revision surgery.

Pelvic discontinuity (a <50 %, b >50 % bone loss, c – associated with irradiation)

Pelvic discontinuity is a distinct form of bone loss, occurring in association with total hip arthroplasty, in which the superior aspect of the pelvis is separated from the inferior aspect because of bone loss or a fracture through the acetabulum [20]. Berry et al. found a prevalence of 0.9 % of discontinuity in revision

Fig. 4 **a**, 5-year postoperative radiograph showing a well fixed uncemented MoM THR; **b**, 6 years postoperatively, the patient sustained a periprosthetic acetabular fracture in a motor vehicle accident

total hip arthroplasties. This number is likely to rise with the ageing population, increasing incidence of osteopenia, and increased use of cementless metal backed acetabular implants.

Biomechanically the most stable fixation can be achieved using a bicolumnar construct. This can be achieved by plating both the posterior and anterior columns, or using posterior column plating and anterior column screws [21••]. A variation of this has been described using Steinmann pins rather than screws in the anterior column and reported to give clinically good outcomes by Parikh [22]. However, a high complication rate has also been reported [23].

An alternative decision making algorithm for pelvic discontinuity has recently been described by Rogers et al. [24]. This differentiates between acute, mobile discontinuity as occurs with an acute periprosthetic fracture, and a chronic, stiff discontinuity as often occurs secondary to severe acetabular osteolysis. Their recommendations are that an acute, mobile discontinuity should be stabilized by posterior column plating to achieve compression of the posterior column. This is then supplemented by screw fixation of a highly porous metal acetabular cup. They report good results in this group with none of the 8 cases treated in this way requiring early revision.

In the chronic discontinuity, the pelvis is much stiffer and they recommend using a cup-cage reconstruction to allow distraction of the discontinuity and adequate stability of the implant. They report an 8 year survivorship of 86 % using this technique.

A 2-stage technique for treating discontinuities and fractures of the acetabulum is a potential alternative in situations where there is poor quality bone and it is not possible to achieve a sufficiently rigid acetabular construct to achieve a stable acetabular reconstruction. The first stage involves achieving pelvic stability by open reduction internal fixation and reconstructing any bone loss. Bone grafting can be utilized at this time to augment bone defects and to enhance bone healing.

When the fracture has united (based on radiographic or CT assessment) the second stage implantation of a total hip replacement can be undertaken. Advantages of this approach are that the surgeon can wait until the fracture has united before attempting to reconstruct the acetabulum, thereby reliably achieving a stable acetabular construct; bone stock can be optimized with bone grafting; and a reconstruction using either a cemented or uncemented cup can be performed. We have utilized this technique in a small number of elderly patients who were osteoporotic and had been referred with significantly displaced unstable periprosthetic acetabular fracture that had occurred in the perioperative period. The columns reliably unite and reconstruction at the second stage is relatively straight forward. However, the disadvantages of requiring a secondary procedure and the increased length of impaired mobility and function, need to be carefully weighed against the potential advantages Fig. 5.

Discussion

The best method of treating a periprosthetic fracture is to prevent it from occurring. This involves being aware of high risk cases and considering the use of cemented acetabular fixation in elderly osteoporotic patients. The use of cementless cups has continued to increase over the last few years such that in the most recent UK National Joint Registry report [25] more Total Hip Replacements are being performed using cementless systems than cemented (44 % vs 38 %). This will probably result in an increased incidence of early periprosthetic fractures of the acetabulum in the United Kingdom. Surgeons should be careful, particularly when using an unfamiliar uncemented acetabular components. It is important to understand the geometry of the components in order to differentiate between hemispherical and elliptical components.

Fig. 5 a, An intraoperative periprosthetic fracture recognized intraoperatively, but insufficiently treated with supplementary screws; **b**, The implants were removed and the fracture stabilized with 2 posterior column plates; **c**, A second stage reconstruction was performed 5 months later

There is a wide range of patterns of periprosthetic fractures of the acetabulum, from the truly traumatic acute unstable fracture, to the chronic discontinuity. The management needs to be tailored to the patient, the fracture pattern, and the skills and experience of the surgeon. Many undisplaced early or traumatic fractures can be treated nonoperatively until the columns unite, and then a revision performed if the socket becomes loose. When operative intervention is required it is potentially complicated and can involve a variety of different techniques. The over-riding principles are that at the time of surgery a sufficiently rigid reconstruction of the columns needs to be achieved so that the fracture can progress to union, and a stable bone/implant interface. Impaction bone grafting [26], posterior column plating [21•, 22, 23], antegrade and retrograde anterior column screws [22, 24], bicolumnar fixation [23, 24], cup screw augmentation [2•], trabecular metal cups [21•, 27], ilioischial cages [21•, 27], and cup cages [21•] have all been described in the literature available and the surgeon managing these patients needs to have the skills to perform many of these techniques and develop an algorithm for managing these fractures. It may be necessary for some cases to be performed as a joint case between an arthroplasty and an acetabular trauma specialist.

Conclusions

Periprosthetic fractures of the acetabulum are a rare but potentially disastrous complication of total hip arthroplasty. The majority can be treated nonoperatively, however, if intervention is required input from specialist revision arthroplasty surgeons combined with pelvic trauma surgeons is likely to give the best outcome.

Compliance with Ethics Guidelines

Conflict of Interest Amol Chitre declares that he has no conflict of interest. Henry Wynn Jones declares that he has no conflict of interest. Nikhil Shah declares that he has no conflict of interest. Anthony Clayson declares that he has no conflict of interest.

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

References

1. • Kim YS, Callaghan JJ, Ahn PB, et al. Fracture of the acetabulum during insertion of an oversized hemispherical component. *J Bone Joint Surg Am.* 1995;77:111–7. *Cadaveric study showing that under-reaming by more than 2 mm when impacting a hemispherical cup can increase the chance of acetabular fracture during component insertion.*
2. • Sharkey PF, Hozack WJ, Callaghan JJ, et al. Acetabular fractures associated with cementless acetabular component insertion: a report of 13 cases. *J Arthroplasty.* 1999;14:426–31. *Case series of 13 patients with acute periprosthetic fractures of the acetabulum. They suggest that if found intraoperatively and stable, a screw may be sufficient to stabilize the implant. If found post-operatively conservative management with restricted weight bearing was sufficient to allow union to occur, although patient reported satisfaction in such patients was poorer despite clinical and radiographic fracture union.*
3. Curtis MJ, Jinnah RH, Wilson VD, et al. The initial stability of uncemented acetabular components. *J Bone Joint Surg Br.* 1992;74:372–6.
4. •• Haidukewych GJ, Jacofsky DJ, Hansen AD, et al. Intraoperative fractures of the acetabulum during primary total hip arthroplasty. *J Bone Joint Surg Am.* 2006;88-A:1952–56. *This is the largest reported series to look specifically at intraoperative acetabular fractures. They show a prevalence of 0.4% in uncemented components, whilst demonstrating a significant difference in rates depending on type of shell (elliptical higher than hemispherical).*
5. Takigami I, Ito Y, Mizoguchi T, et al. Pelvic discontinuity caused by acetabular over-reaming during primary total hip arthroplasty. *Case Reports in Orthopaedics.* 2011. Article ID 939202.
6. Zwartele RE, Witjes S, Doets HC, et al. Cementless total hip arthroplasty in rheumatoid arthritis: a systematic review of the literature. *Arch Orthop Trauma Surg.* 2012;132:535–46.
7. McGrory BJ. Periprosthetic fracture of the acetabulum during total hip arthroplasty in a patient with Pagets disease. *Am J Orthop.* 1999;28:248–50.
8. Desai G, Ries MD. Early postoperative acetabular discontinuity after total hip arthroplasty. *J Arthroplasty.* 2011;26:1570. e17–9. [Epub 2011 Mar 2]. doi: 10.1016/j.arth.2010.12.021.
9. Peterson CA, Lewallen DG. Periprosthetic fracture of the acetabulum after total hip arthroplasty. *J Bone Joint Surg Am.* 1996;78:1206.
10. Miller AJ. Late fracture of the acetabulum after total hip replacement. *J Bone Joint Surg Br.* 1972;54:483.
11. Cooper RA, McAllister CM, Borden LS, et al. Polyethylene debris-induced osteolysis and loosening in uncemented total hip arthroplasty: a cause of late failure. *J Arthroplasty.* 1992;7:285.
12. Schmalzreid TP, Jasty M, Harris WH. Periprosthetic bone loss in total hip arthroplasty: polyethylene wear debris and the concept of effective joint space. *J Bone Joint Surg Am.* 1992;74:849.
13. Maloney WJ, Peters P, Engh CA, et al. Severe osteolysis of the pelvis in association with acetabular replacement without cement. *J Bone Joint Surg Am.* 1993;75:1627.
14. Chattoo M, Parfitt J, Pearse MF. Periprosthetic acetabular fracture associated with extensive osteolysis. *J Arthroplasty.* 1998;13:843–5.
15. Sanchez-Sotelo J, McGrory BJ, Berry DJ. Acute periprosthetic fracture of the acetabulum associated with osteolytic pelvic lesions: a report of 3 cases. *J Arthroplasty.* 2000;15:126–30.
16. Della Valle CJ, Momberger NG, Paprosky WG. Periprosthetic fractures of the acetabulum associated with a total hip arthroplasty. *Instr Course Lect.* 2003;52:281–90.
17. Bradford MS, Paprosky WG. Acetabular defect classification: a detailed radiographic approach. *Semin Arthroplasty.* 1995;6:76–85.
18. Davidson D, Pike J, Garbuz D, et al. Intraoperative periprosthetic fractures during total hip arthroplasty. *J Bone Joint Surg.* 2008;90:2000–12.
19. Springer BD, Berry DJ, Cabalena ME, et al. Early postoperative transverse pelvic fracture: a new complication related to revision arthroplasty with an uncemented cup. *J Bone Joint Surg Am.* 2005;87:2626–31.

Papers of particular interest, published recently, have been highlighted as:

- Of importance:
- Of major importance

1. • Kim YS, Callaghan JJ, Ahn PB, et al. Fracture of the acetabulum during insertion of an oversized hemispherical component. *J Bone*

20. Berry DJ, Lewallen DG, Hanssen AD, Cabanela ME. Pelvic discontinuity in revision total hip arthroplasty. *J Bone Joint Surg Am.* 1999;81:1692–702.
21. •• Rogers BA, Whittingham-Jones PM, Mitchell PA, Safir OA, Bircher MD, Gross AE. The reconstruction of periprosthetic pelvic discontinuity. *J Arthroplasty.* 2012;27:1499–506. *Largest series following results of reconstructing pelvic discontinuities with either posterior column plating or cup = cage reconstruction. They suggest using posterior column plating in acute instability, whilst a cup-cage construct in patients with chronic stiff discontinuities.*
22. Parikh SN, Kreder HJ. Pelvic reconstruction for massive acetabular insufficiency. *Clin Orthop Relat Res.* 2005;434:217–21.
23. Eggli S, Muller C, Ganz R. Revision surgery in pelvic discontinuity: an analysis of seven patients. *Clin Orthop Relat Res.* 2002;398:136–45.
24. Gililland JM, Anderson LA, Henninger HB, Kubiak EN, Peters CL. Biomechanical analysis of acetabular revision constructs: is pelvic discontinuity best treated with bicolumnar or traditional unicolumnar fixation? *J Arthroplasty.* 2013;28:176–86.
25. National Joint Registry for England and Wales. 9th Annual Report. 2012 ISSN 1745–1450.
26. Schreurs BW, Zengerink M, Welten ML, van Kampen A, Slooff TJ. Bone impaction grafting and a cemented cup after acetabular fracture at 3–18 years. *Clin Orthop Relat Res.* 2005;437:145–51.
27. Kosashvili Y, Backstein D, Safir O, Lakstein D, Gross AE. Acetabular revision using an anti-protrusion (ilio-ischial) cage and trabecular metal acetabular component for severe acetabular bone loss associated with pelvic discontinuity. *J Bone Joint Surg Br.* 2009;91:870–6.