Acetabular fractures

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Summary
The relative infrequency and complexity of acetabular fractures provide a challenge for trauma surgeons. In young patients, the management may be complicated by other injuries. The aim of treatment is to maintain a stable congruent joint. Although there is a role for non-operative treatment the hip joint tolerates instability and incongruity poorly. Operative treatment is complex due to the limitations of the surgical approaches, and the complex three-dimensional anatomy. The relative merit of each surgical option must be considered, and the decision is often a compromise of exposure vs. complications. In the older patients, achieving a stable congruent hip, with open reduction and internal fixation, may not be possible due to poor bone quality. Total hip replacement may be considered a better option. Outcome of acetabular fractures is dependent on the quality of surgical reduction and fixation, in turn this has been related to the experience of the surgeon.

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Introduction
Treatment of fractures of the acetabulum is a challenge for orthopaedic surgeons for several reasons:

- There are two distinct groups that make up the majority of acetabular fracture patients.
  - High energy trauma in young active patients, frequently associated with poly-trauma.
  - Older patients with poor bone stock who frequently present with complex fracture patterns.
- Irreversible damage to the articular surface.
- Comprehension of fracture patterns requires a detailed understanding of complex three-dimensional pathoanatomy.
- Difficult surgical access.
- Prolonged rehabilitation.
- Significant potential post-operative complications.

Anatomy and biomechanics
The acetabulum is formed by the ilium, pubis and ischium and during development they are linked together to form the triradiate cartilage. The triradiate cartilage has its apex in the floor of the acetabulum and fuses between 18 and 23 years of age. For the purposes of fracture description the...
nomenclature described by Letournel and Judet\(^1\) is most commonly used. The anterior column (Fig. 1) includes the anterior iliac crest, anterior acetabulum and superior pubic ramus. The posterior column extends from the sciatic notch to the ischial tuberosity and includes the posterior wall of the acetabulum. Fractures involving the anterior and posterior columns characteristically pass through relatively weak areas. The columns are attached to the sacrum through a strut of dense bone called the sciatic buttress. This transmits load between the torso (via the sacrum) and the lower extremity (via the columns). The main weight bearing surface of the acetabulum is cradled between the anterior and posterior columns and is referred to as the dome or roof. Fractures may also involve the anterior and posterior walls of the acetabulum in isolation or in combination with column fractures. The cortical bone overlying the acetabulum within the inner wall of the true pelvis is called the quadrilateral plate.

Key to the management of acetabular fractures is the nerves and blood vessels that supply the muscles around the hip and the blood supply of the femoral head and acetabulum (Fig. 2). The superior and inferior gluteal neurovascular bundles supply the gluteus medius/minimus and gluteus maximus, respectively. These structures can be damaged at the time of injury or intraoperatively. The deep branch of the medial femoral circumflex artery (MFCA) is the primary blood supply to the femoral head and must be protected to ensure viability of the femoral head. This vessel has a constant extracapsular course\(^2\) that runs along the inferior border of obturator externus and then superiorly over the anterior surface of the inferior gemellus, obturator internus and superior gemellus close to their common femoral insertion. Terminal branches then perforate the joint capsule, 2–4 mm lateral to the bone cartilage junction, at the level of the superior gemellus. An anastomosis between the inferior gluteal artery and the deep branch of the MFCA runs along the inferior border of the piriformis. The acetabulum and hemi-pelvis are abundantly supplied as a result of its muscular attachments. However, problems can arise when the soft tissue approach involves extensive stripping from both the inner and outer table of the pelvis.

**Classification**

Acetabular fractures are commonly classified using the Letournel–Judet system.\(^1\) This classification system describes the fracture in terms of elementary fractures and associated fractures (Fig. 3), and has been assimilated into the AO comprehensive classification system.

A column fracture describes a fracture that has separated all or part of the column from the axial skeleton. T-shaped and transverse fractures involve fracture lines extending through the acetabular part of both columns; however, the superior part of the columns remains in continuity with the axial skeleton. A T-shaped fracture differs from a transverse fracture as it also has an extension which runs through the inferior part of the acetabulum and splits the rami. A both columns fracture can be considered a ‘high’ T-shaped fracture where both columns have been separated from the sciatic buttress.\(^3\) A fracture is described as
Figure 2 Nerve and blood supply of the femoral head and gluteal muscles. G Max—gluteus maximus origin; G Med—gluteus medius origin; G Min—gluteus minimus origin; Ob Int—obturator internus; Ob Ex—obturator externus; QF—quadratus femoris.

Figure 3 Elementary and associated fracture patterns.1

a wall fracture if it is limited to the acetabular wall. It is accepted, however, that with this system there is the potential for overlap between a large wall fracture and a column fracture. However, isolated wall fractures do not tend to extend into the sciatic notch, involve the quadrilateral plate or extend into the obturator ring. 

Approximately 50% of acetabular fractures are either posterior wall or both columns.

Pathology

Motor vehicle accidents are the most common cause of acetabular fractures and the type of fracture has been shown to correlate with direction of impact. In the majority of cases, the acetabular fracture will result from impact transmitted to the acetabulum through the femoral shaft or greater trochanter. The type of fracture will also be dependent on the hip position at the time of impact. Frontal collision with an impact applied through the axis of the femur results in fractures of the posterior wall and column. An adducted leg position predisposes the occupant to a posterior wall fracture and an abducted hip a posterior column fracture. Loading through the greater trochanter (e.g., side impact) is postulated to cause anterior wall and column fractures, transverse, T-shaped and both column fractures.

Assessment

General

All acetabular fractures should be assessed in accordance with ATLS protocols. In one large series reported from a tertiary referral centre, 56% of acetabular fractures had at least one additional injury (19% head injury, 8% abdominal injury, 18% chest injury, 6% genito-urinary, 35% extremity injury, 4% spinal injury).

Specific

Dislocation of the femoral head is reported in 32–39% of acetabular fractures. Anterior dislocations in association with acetabular fractures are very rare. Damage to the femoral head is commonly seen. Preoperative sciatic nerve injury was reported in 12% of Letournel and Judet’s series of 940 patients. Sciatic nerve palsies are frequently seen in association with posterior dislocation and most commonly involve the peroneal branch. Recovery from sciatic nerve injury is variable. In contrast, femoral nerve injury is very rare, and the recovery good. Preoperative assessment of femoral nerve function is important as injury is more frequently associated with intraoperative trauma. Acetabular fractures in isolation rarely cause haemodynamic instability but this may be a feature of an associated pelvic fracture. Open fractures are reported with an incidence of ≤ 1%. Closed degloving injuries (Morel-Lavallée lesion) occur in up to 16% of patients. The injury is the result of the soft tissue being stripped away from the fascia and is associated with haematoma, fat necrosis and ischaemic skin flaps. Microbiology cultures taken from these areas have demonstrated high rates of bacterial colonisation (46%) despite the closed nature of the injury. Surgical skin incisions may also further compromise skin viability. It has been recommended that the injury should be surgically debrided, before or during acetabular surgery, through an incision centred on the lesion. In most cases, the de-gloved area should be left open and allowed to heal by secondary intention.

Labral tears and avulsions are a constant feature of some fractures. This problem is seen particularly with transverse fractures and it has been recommended that these lesions may require resection or repair.

Investigations

X-ray

The X-ray assessment of acetabular fractures is well described using the AP and Judet views (iliac and obturator obliques). Each view allows an optimum view of different aspects of the anatomy relevant to acetabular fractures. On the AP view the ilio-pectineal and ilio-ischial lines represent outlines of the anterior and posterior columns, respectively (Fig. 4). The obturator oblique demonstrates the obturator ring, posterior wall and lower portion of anterior column. This is the best view to observe the ‘spur’ sign which is frequently seen in both column fractures. The spur is formed by the inferior apex of the intact ilium which is formed when both columns are split from the sciatic buttress. The iliac oblique demonstrates the iliac wing, greater sciatic notch, posterior column and edge of anterior wall. It is important to appreciate that these views are obtained by tilting the patient 45° on each side with the X-ray tube and film vertically aligned. Views obtained by tilting the machine result in significant distortion. Disruption
of the various landmarks described will allow the fracture pattern to be interpreted. To interpret the AP and Judet views a systematic approach should be used. In addition to looking for ilio-ischial and ilio-pectineal line disruption, for posterior and anterior column fractures, respectively, it is recommended that an assessment be made of the iliac wing and obturator ring using the appropriate oblique views. A fracture extending into the obturator ring is representative of a T-shaped or both column fractures. If the fracture extends into the iliac wing above the acetabulum, then an anterior column fracture must be present.

AP and Judet views also allow the roof arcs, as described by Matta and Merritt, to be determined. On each of the three views, two lines are drawn from the geometric centre of the femoral head: one line vertical and the other to the fracture. The angle between these two limbs is recorded. Medial, anterior and posterior roof arc measurements are recorded from the AP, obturator oblique and iliac oblique, respectively. These measurements allow the amount of superior intact acetabular dome to be described.

**CT**

CT allows the fracture pattern to be assessed in more detail and provides valuable information with regard to comminution, marginal impaction (in wall fractures) and intra-articular fragments.

Clues to the fracture pattern can be determined by observing the direction of the fracture lines on the CT. On the axial views, splits in the coronal plane often represent column fractures. Sagittal splits, in the roof of the acetabulum, are seen commonly with transverse or T-shaped fractures. Oblique fractures that do not extend into the quadrilateral plate are seen with wall fractures.

CT scans can help differentiate multi-fragmentary T-shaped from both column fractures. T-shaped fractures have at least one part of the acetabulum attached to the sacrum via the sciatic buttress.

**Initial treatment**

**Reduction**

Acetabular fractures are frequently associated with dislocation. It is important to perform and maintain a reduction as soon as possible. Persistent dislocation has the potential to influence long-term outcome. A dislocated femoral head is susceptible to cartilage necrosis secondary to point loading, and avascular necrosis (AVN) as the result of a compromised blood supply. Overlying neurovascular bundles may also be compromised; the sciatic nerve is particularly at risk with posterior dislocation.

Reduction will require conscious sedation or general anaesthetic. The use of muscle relaxants is preferable to facilitate an atraumatic reduction. Following reduction a dynamic assessment of stability should be made as this may influence management if non-operative treatment is being considered.

Reduction can be maintained with skin or skeletal traction. Traction also helps to prevent shortening and minimise difficulty in reduction, especially when reduction is delayed.

Careful radiological assessment must be made to ensure a congruent reduction. If there is an incongruent reduction on the AP pelvis X-ray, or the patient is being considered for non-operative treatment then a fine cut (≤3 mm) CT scan should be performed to detect intra-articular fragments.
Venous thrombo-embolism prophylaxis

Pelvic and acetabular fractures are both associated with significant risk of venous thrombo-embolism (VTE). There remains significant controversy over appropriate VTE prophylaxis. Chemical prophylaxis should not be considered until the patient has been shown to be haemodynamically stable. It is believed mechanical prophylaxis has some benefit, and can be considered immediately. Patients who experience a significant delay in operative treatment or who have not received optimal prophylaxis should be considered for further investigation and, where proximal clot is identified, an inferior vena caval (IVC) filter. Venography remains the gold standard technique as newer techniques, MRI and CT venography, have demonstrated high false positive rates and unnecessary use of IVC filters should be avoided. A recent survey of trauma surgeons dealing with pelvic and acetabular fractures reported that routine preoperative screening was performed by 48% of surgeons, with the majority using ultrasound. Approximately 3/4 used chemical prophylaxis, 3/4 used mechanical prophylaxis and 1/2 used at least one method.

Non-operative treatment

Indications

For non-operative treatment to be considered, the hip has to be stable, and the femoral head contained within sufficient congruent weight bearing acetabulum.

Displaced fractures involving the columns or walls have the potential to cause loss of congruence between the femoral head and acetabulum. If the fracture occurs within the superior part of the acetabulum it will both reduce the surface area involved in weight bearing and cause instability. In single column fractures, significant displacement within the weight bearing dome will always result in incongruity as the intact column remains attached to the axial skeleton.

Wall fractures do not usually significantly affect the weight bearing surface area but can cause instability. Both instability and reduced weight bearing surface area are poorly tolerated by the hip and predispose to early degenerative change.

When considering column fractures there has been some debate over the criteria used for consideration of non-operative management. Matta and Merritt and Olson and Matta produced radiological criteria derived from their clinical experience. Measurements were proposed based on roof arc angles (see X-ray section). Roof arc angles were measured on the AP and both Judet views and felt to be acceptable if the hip was congruent and all three roof arc measurements were $\geq 45^\circ$. This corresponds to an intact superior 10 mm of acetabulum on the CT scan. These assessments must be performed out of traction. Tornetta performed dynamic stress views using fluoroscopy and found 7% of patients with roof arcs $\geq 45^\circ$ to be unstable. Vrahas et al. performed a biomechanical study and considered medial, anterior and posterior roof arcs of $\leq 45^\circ$, 25$^\circ$ and 70$^\circ$, respectively, to be indications for operative intervention.

In both column fractures, the columns are detached from the axial skeleton but are constrained by the remaining soft tissue attachments. The soft tissue has the potential to hold the fracture fragments and maintain congruity despite displacement within the weight bearing dome. This situation is described as secondary congruence and has the potential to be treated non-operatively.

Fractures of the acetabular walls should be considered separately. Olson and Matta felt that involvement of $> 50\%$ of the posterior wall was unsuitable for non-operative treatment. A biomechanical study determined that $\leq 20\%$ involvement of the posterior wall is likely to be stable, $\geq 40\%$ is likely to be unstable.

It would therefore be acceptable to make a radiological assessment (plain X-rays and CT) of stability using the described roof angles as a guide. In those patients that are considered appropriate candidates for non-operative treatment an EUA should be considered to allow confirmation.

In summary, non-operative management should be considered in the following circumstances:

- Co-morbidities limiting physiological reserve.
- Insufficient bone stock to allow adequate fixation.
- A hip joint that is congruent within a sufficient superior acetabular dome to allow it to be stable under physiological loads.
- Undisplaced column fractures.
- Displaced column fractures that involve the inferior part of the acetabulum.
- Wall fractures with sufficient intact wall to maintain hip stability.
- Congruent both column fractures.

Treatment

If non-operative management is chosen then the patient must be kept non-weight bearing for 4–8
weeks. Traction through a tibial pin may be appropriate to prevent further displacement. When implemented appropriately, good results are achievable.

Open reduction and internal fixation

ORIF is the treatment of choice in those fractures that fail to fulfil criteria for non-operative treatment in patients who have sufficient physiological reserve.

The timing for operative intervention has been shown to be important with several studies reporting poorer results when ORIF is attempted at greater than 3 weeks post-injury. With progressive delays reduction becomes harder to achieve. When possible, ORIF should take place at 2–5 days to avoid the increased bleeding seen in the first 48 h. Reduction has been shown to correlate directly with outcome5 and the clinical results of delayed reconstruction (>21 days) is poor in comparison with earlier intervention.15 Delay is also associated with an increase in VTE and skin problems. Urgent ORIF may be necessary in the following circumstances:

- Reduction of an associated dislocation of the femoral head cannot be maintained.
- Retained intra-articular fragments.
- Closed reduction has not been possible.
- Closed reduction has resulted in a new onset neurological deficit.
- Open fracture.

Preoperative preparation

As for all trauma surgery every attempt should be made to optimise the patient medically. The patient should be cross matched for 6 units of blood as blood loss of 1–2 l, but potentially up to 6 l, is not unusual.5 For this reason a cell saver is also beneficial. Surgical preparation is also necessary as the surgery is complex and intensive for equipment and manpower. A preoperative plan using all available imaging will allow most problems to be anticipated and allow the correct equipment to be available.

The appropriate pelvic instrumentation with specialised reduction aids are required in addition to a radiolucent table and image intensifier. Some fractures will benefit from intraoperative traction either using the table attachments or a femoral distractor. Intraoperative nerve monitoring has been described but is not routinely used in most centres.13 Assistance is mandatory and experienced assistance is invaluable.

The patient should then be positioned on a radiolucent operating table, and the image intensifier is then used to check that satisfactory AP, Judet’s, inlet and outlet pelvic views can be achieved. These views can be obscured by bowel gas or contrast within the GI tract.

Prior to surgery the patient will require prophylactic antibiotics. The anaesthetist must be made aware that muscle relaxants may be required and that the use of nitrous oxide should be avoided to minimise bowel gas.

Approaches

The primary aim is to achieve reduction and usually the approach that allows reduction will also be sufficient to place adequate fixation. The surgical approach is usually based on the pattern of displacement.

The surgical approach used should allow adequate visualisation for direct reduction and fixation techniques. A useful feature of any approach is the indirect access that can be achieved through palpation. This allows an assessment of reduction and facilitates indirect techniques. There are three main approaches which are used in the majority of acetabular fractures (Kocher-Langenbeck, ilio-inguinal and extended ilio-femoral, EIF) and numerous reported modifications. In Matta’s5 large series, 98% of the cases were treated using one of these operative approaches. The remaining 2% had a double Kocher-Langenbeck and ilio-inguinal approach. The benefits of each approach have to be carefully balanced with the relative risks. The bigger the approach, the bigger the complications but the smaller the approach the greater the potential difficulty and the greater risk of mal-reduction.

Kocher-Langenbeck

This standard approach involves and incision centred on the greater trochanter with a distal limb along the axis of the femur and a proximal limb directed towards the posterior superior iliac spine (PSIS) (Fig. 5). Fascia lata and glutaeus medius are split and reflection of piriformis, obturator internus and the gemelli allows access to the posterior wall and column.

All of the standard approaches that allow access to the outer table of the pelvis have the potential to allow visualisation, to a varying degree, of the acetabular surface using a capsulotomy and
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**Suitable Fracture Configurations:** Posterior wall; Posterior column; Transverse; Posterior wall plus posterior column; (Posterior wall with transverse and T-shaped – if simple otherwise consider extended iliofemoral).

**Extension 1:** Surgical hip dislocation

**Suitable Fracture Configurations:** As above + suitable for high multifragmentary transverse fractures and associated fractures of the femoral head.

**Extension 2:** Triradiate

**Suitable Fracture Configurations:** Allows greater access to iliac crest for the treatment of both column fractures with significant posterior displacement.

*Figure 5* Kocher-Langenbeck incision, extensions and indications.
dislocation or distraction of the femoral head. A surgical hip dislocation can be performed as part of the Kocher-Langenbeck and allows direct access to the entire articular surface of the femur and acetabulum. This is particularly useful when addressing large femoral head fractures. This approach preserves the deep branch of the MCFA and involves a trochanteric flip osteotomy that includes the insertion of gluteus medius and the origin of vastus lateralis. The trochanter is retracted anteriorly, a capsulotomy is performed and the hip is dislocated. The blood supply to the femoral head via the deep branch of the medial femoral circumflex is at risk. Care must be taken when releasing the short external rotators. A cuff of 1.5 cm should be left at the trochanteric insertion. An alternative osteotomy involves a standard trochanteric osteotomy with reflection of the abductors superiorly off the pelvis, maintaining the superior gluteal vascular pedicle. This procedure is usually accompanied by an additional skin incision directed anteriorly from the greater trochanter towards the anterior superior iliac spine (ASIS). This is described as the triradiate approach.

Ilio-inguinal
The inner table of the anterior column is accessed through an approach which detaches the abdominal wall from the iliac crest and opens the inguinal canal. Iliacus is then stripped from the inner table of the acetabulum. It requires the mobilisation of the contents of the inguinal canal and the femoral neurovascular bundle (Fig. 6).

Many modifications have been described for this approach. Most of these approaches aim to allow additional access to the outer table of the anterior column. One approach involves a longitudinal extension of the ilio-inguinal incision based on the ASIS.

Extended ilio-femoral
This approach is derived from the ilio-femoral approach described by Smith Peterson and extends posteriorly along the iliac crest (Fig. 7). The abductors are reflected off the outer table of the pelvis on the superior gluteal neurovascular pedicle.

Surgical tactic
In general, extensile approaches (EIF and triradiate) are avoided and a single column approach (Kocher-Langenbeck or ilio-inguinal) is used when possible. If a single column approach is used it is usually directed at the column with the greatest displacement. If both columns are involved reduction of the least displaced fracture can often be performed indirectly. If this is not possible it may be possible to extend the standard approach using one of the numerous modifications. Double incision approaches (Kocher-Langenbeck and ilio-inguinal), either simultaneous or staged, have been described to allow direct access to both columns. The decision on the approach used will depend on experience and training. Helfet and Schmeling reported on 84 complex acetabular fractures treated using a non-extensile approach (Kocher-Langenbeck or ilio-inguinal) and achieved an overall acceptable reduction (<2 mm step-off and <3 mm intra-articular gap) rate of 90.5%. It will also depend on patient factors such as age, level of function and soft tissues.

Reduction techniques
Indirect
Traction can be applied through the leg or directly to the pelvis and femur. This will allow reduction in those situations where soft tissue connection has been maintained. In certain fractures, there is a significant rotational component to the fracture displacement. In these situations, Schantz pins can be placed directly or under image intensifier control and can be used as joysticks to manipulate the fracture fragments.

Direct
Many direct techniques are used to achieve reduction of these complex fractures. Specific fracture reduction forceps are invaluable. The reduction clamps are varied in their size, angle and offset to accommodate the wide variety of fracture patterns. Temporary screws can be used in conjunction with three hole plates or forceps to help temporarily manipulate and stabilise the fracture.

Internal fixation techniques
Posterior wall
These fractures are often associated with impaction (Fig. 8). Open reduction is necessary with elevation of the depressed articular fragments with the underlying subchondral bone. The resultant defect is packed with bone graft or bone substitute. The fracture is reconstructed and stabilised where possible with lag screws augmented by a buttress plate. In those situations where comminution prevents lag screw fixation, spring plates fashioned from 1\(\frac{1}{2}\) tubular plates can be used in the buttress mode. These fixation constructs have been shown to be biomechanically superior to fixation with screws used in isolation.
Column fractures
The same principles are used as for intra-articular fractures elsewhere in the body. The aim is to achieve a stable anatomical reduction, with compression, that allows early mobilisation. This is best achieved with lag screw fixation and a plate in the neutralisation or buttress mode (Fig. 8). Lag screws can be placed between columns either through the plate or separately positioned. Biomechanical tests have shown that when plating a column fracture the construct is stiffest with two screws on each side with screws placed as close to the fracture line as possible and at the ends of the plates. As an adjunct to reduction and fixation, cerclage wires

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**Suitable Fracture Configurations:** Anterior wall; Anterior column; Transverse (occasional); Anterior column/wall with posterior hemitransverse; Both column (unless multi-fragmentary posterior column); T-shaped (rare).

**Extension 1: + Iliofemoral**

**Suitable Fracture Configurations:** As above + allows greater access to anterior hip joint and outer table of iliac crest.

**Figure 6** Ilioinguinal incision, extensions and indications.
can be placed around the ilium, through the greater sciatic notch at the level of the anterior inferior iliac spine. Using safe corridors within the pelvis, column screws can be placed. They can be placed both antegrade and retrograde and are used in both open and percutaneous techniques (Fig. 9).

**Transverse fractures**
If possible these fractures are fixed through a single column approach that allows sufficient access to lag and plate one column. As long as reduction is achieved the other column can be stabilised, indirectly, with a column screw (Fig. 10). This has been found to be a stable construct on biomechanical testing.

**Displaced fractures of the quadrilateral plate**
These fractures are difficult to treat as visualisation and access for instrumentation is limited. One useful technique is to use a spring/buttress plate.
that prevents the fracture displacing and does not rely on direct fixation.

Total hip replacement

ORIF is not recommended in older patients, especially if there is evidence of impaction or osteoporosis. In these circumstances, a limited reconstruction and total hip replacement can be considered. Total hip replacement in the acute setting can be associated with significant complications. However, in older patients, it can provide a satisfactory alternative to definitive ORIF.\(^3\)

Rehabilitation

A knee immobiliser during the immediate post-operative period is useful to protect fixation of the
posterior column and wall by preventing hip flexion during recovery. The neurological and vascular status of the limb should be checked and recorded frequently in the initial post-operative period. The patient should receive a short course of prophylactic intravenous antibiotics.

Immediate weight bearing of 20–30 lb before commencing full weight bearing at 8–12 weeks\(^5,7\) is thought to be acceptable, except in those cases where fixation is tenuous and initial protection with traction is beneficial. Limitation of hip flexion to 60° is important to protect posterior wall and posterior column fixation.

It is important to review the patient clinically and radiologically at 2 weeks to assess for loss of fixation. If displacement occurs this is best dealt with within the first 3 weeks.\(^17\)

**Complications**

**Heterotopic ossification**

It is well established that there is a high incidence of heterotopic ossification (HO) following acetabular surgery. Although patient factors are relevant, this complication is particularly related to the approach. Stripping and trauma to the gluteal muscles predisposes to HO formation. Consequently, EIF and triradiate approaches have a high reported incidence, 35–57% and 86%, respectively,\(^1,6,7\) whereas there is a low incidence in patients treated with the ilio-inguinal approach 4.8%\(^1,5\) and a moderate risk, 19–26%,\(^1,7,18\) with the Kocher-Langenbeck.

There is ongoing controversy in the literature with regard to the efficacy of prophylaxis against HO. Indomethacin and radiation have both been used for prophylaxis and both have been reported as providing benefit. In comparative prospective randomised trials, radiation has been shown to be equivalent to indomethacin as a method of HO prophylaxis.\(^19\) The most recent study looking at the effect of indomethacin on HO formation, a prospective randomised trial involving 107 patients,\(^20\) did demonstrate that indomethacin had a lower HO rate when assessed by Brooker grade and CT volumetric analysis. However, this was not statistically significant and the authors concluded that indomethacin provided no advantage. A potential limitation of this study is the lack of data on patient compliance.

An additional consideration is the established detrimental effect of indomethacin on long bone healing in poly-trauma.\(^21\)

Single dose or fractionated radiation administered within 72 h post-operation has been used and in some studies that have reported low HO rates. A trial using a combination of indomethacin and radiation in patients treated with a posterior or EIF approach reported an overall incidence of 19% of which all were Brooker I.\(^22\) Radiation prophylaxis is expensive and there are theoretical concerns about malignancy and the effect on reproductive cells. In addition, there are logistical difficulties performing the treatment in the required time frame as many patients will be requiring high levels of nursing and medical support.

Not all patients with radiologically determined HO have functional limitation.\(^18\) Matta\(^5\) reported a 9% functionally significant (≥20% loss in range of motion (ROM)) HO rate in a group that received no prophylaxis (2% of ilio-inguinal, 20% of EIF, 8% of Kocher-Langenbeck). The requirement for excision of HO is reported in only 2–5%.\(^7,18\)

At present there are no good guidelines for HO prophylaxis. The argument for using prophylaxis is stronger in the presence of certain risk factors: an extensile approach,\(^6,15\) significant muscle trauma,\(^15\) head injury,\(^15\) male gender\(^20\) and delayed treatment (≥21 days).\(^15\) Within our unit the presence of two risk factors is used as an indication to treat with HO prophylaxis.

**Venous thrombo-embolism**

The incidence of distal deep venous thrombosis (DVT) is poorly documented in the large studies but an incidence of 3–6%\(^1,16\) is reported. The incidence of pulmonary embolus (PE) is reported as 2–4%\(^1,16\) and is believed to be the biggest cause of death following acetabular fractures. Peri-operative death from all causes is reported with a frequency of 0–2.5%.\(^1,5,7\)

**Infection**

In centres involved with treating large numbers of acetabular fractures, the overall infection rate is reported at 3–5%,\(^1,5,7,23\) Deep infection has been reported with an incidence of 3%.\(^5\) Several authors have reported significantly higher infection rates early in their series, related to inexperience and longer operation times. Infection rates also vary depending on the approach. Extensile approaches have been associated with infection rates of 8.5%\(^6\) whereas the ilio-inguinal approach has been reported as having a 3% infection rate.\(^24\) Obesity is a major risk factor.
Nerve injury

The most significant iatrogenic nerve injury following treatment of acetabular fractures involves the sciatic nerve, 3–11%. Care must be taken with retractor placement and maintaining a flexed knee and extended hip when performing posterior approaches. Sciatic nerve injuries also occur with ilio-inguinal approaches and this has been attributed to reduction techniques involving flexion of the hip and placing the nerve under tension. To reduce tension in the nerve the knee is kept flexed and the hip extended.

Femoral nerve injury has been reported rarely (1%) following the ilio-inguinal approach. A 1% obturator nerve injury has been reported. Hip abductor weakness has been noted to be a significant problem in posterior approaches, and this has been partly attributed to damage to the gluteal nerves during retraction.

The femoral cutaneous nerve of thigh is frequently damaged during ilio-inguinal and EIF approaches but is associated with little significant morbidity.

Vascular injury

Femoral vessel injury is reported in 0.8–2% of ilio-inguinal exposures. In addition, during this approach the surgeon should be aware of a very high incidence of retro-pubic anastomoses between the femoral and obturator vessels. These vessels need to be ligated prior to division as they have significant capacity to bleed and control may be difficult.

The superior gluteal artery can be damaged with the consequence of significant bleeding and the potential for gluteal muscle necrosis. This complication has not been demonstrated clinically.

AVN is most commonly seen in fractures associated with dislocation. The incidence varies between studies, 3–10%. Although damage of the blood supply to the femoral head occurs at the time of the injury it can also be damaged intraoperatively. Ganz’s research group have highlighted the significance of the deep branch of the MFCA and proposed that iatrogenic injury of this vessel may explain the perceived discrepancy between reported AVN rates in uncomplicated dislocations treated with closed reduction and fracture dislocations that require ORIF.

Intra-articular screw penetration

This problem is reported infrequently but can result in post-traumatic arthrosis and every effort should be taken to avoid this complication by ensuring good intraoperative imaging. The spherical shape of the acetabulum means that each screw only needs to be identified as being out of the joint on one view to confirm its extra-articular position. A useful technique in this situation is to use the image intensifier to look down the long axis of the screw. Post-operative CT can confirm screw position.

Failure of fixation

In the large reported series, failure of fixation is reported with a frequency of 1–3%. The results of revision surgery are less satisfactory than with primary fixation and if revision is required there is benefit in this being performed early.

Non-union

Very low rates of non-union have been reported but when it occurs it is seen most frequently in transverse fractures with unstable fixation. The use of indomethacin prophylaxis is also believed to contribute to non-union.

Osteoarthritis

This is reported by most outcome studies and is attributed to cartilage necrosis, articular incongruity and instability.

Cartilage necrosis can be related to irreversible damage to the articular surface at the time of injury. Femoral head damage identified intraoperatively has been shown to be predictive of a worse prognosis. This may explain why one study reported a poor outcome in 32% of their anatomically reduced posterior wall fractures. However, evidence of femoral head damage does not guarantee a poor result.

Articular incongruity (secondary to intra-articular metal work and mal-reduction) and instability both predispose to osteoarthritis as a result of abnormal loading of the articular surface.

Functional outcome

Studies published from large centres with experience in acetabular trauma report good to excellent results in approximately 80% of cases. Most of the historical data on acetabular fractures was compiled using the d’Aubigne-Postel scale. This scoring system is limited in its application as the highest score does not correlate with a return to normal activities. A ‘good’ score can be achieved.
with a patient complaining of a slight or intermittent pain with normal activity; hip flexion limited to 70° and a slight limp. Despite the potential limitations of the scoring systems used, several factors have been identified which correlate with outcome.

It has been established that the surgeon has a large influence on outcome. The most frequently associated factor with outcome is the quality of the reduction.\(^5\) Anatomical reduction has been seen to be highly significant for excellent or good results and any mal-reduction was associated with a worse outcome.\(^5\) As a result the experience of the surgeon plays an important part in the ability to achieve an anatomic reduction. Several large studies report a significant learning curve. This is demonstrated by several surgeons reporting poorer results at the start of their series.\(^1\)\(^,\)\(^16\) The timing of surgery is also important with delay >3 weeks associated with poorer functional outcome and a high incidence of AVN, OA, HO and sciatic nerve injury.\(^15\)

Approximately 10% of hips will be expected to fail within 2 years.\(^2\) THR performed in this group is seen to perform less well than in a matched cohort of THR for OA. In addition, acetabular fractures initially treated non-operatively, performed better than those treated initially with ORIF. The timing and role of THR in acetabular fractures is still being established.

References