

Marginal Impaction in Posterior Wall Fractures of the Acetabulum

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OBJECTIVE. The purposes of this study were to describe the CT features of isolated posterior acetabular wall fractures with associated marginal impaction and to discuss the potential therapeutic implications of recognizing this type of fracture.

CONCLUSION. Marginal impaction is an important cause of articular incongruity that adversely affects prognosis. Radiologists should be capable of identifying posterior acetabular wall fracture patterns because they may be the first to suggest diagnoses.

Isolated posterior wall fracture is the most common type of acetabular fracture, accounting for 20–35% of cases [1–5]. This fracture type is classified as elementary in the Letournel-Judet system [6, 7]. The relatively simple fracture pattern is often misleading, causing orthopedic surgeons to consider its treatment to be straightforward and have a favorable outcome [8]. However, the prognosis may be critically influenced by certain features of acetabular fractures [2, 5, 9–11], which have been included in the comprehensive classification proposed by the *Arbeitsgemeinschaft für Osteosynthesefragen* (Association for the Study of Internal Fixation [AO group]). The AO classification subdivides articular fractures involving only the posterior wall (type A1) into three distinct subgroups: pure fracture-dislocation with one fragment (type A1.1), pure fracture-dislocation with multiple fragments (type A1.2), and pure fracture-dislocation with marginal impaction (type A1.3) [12–14]. The term “marginal impaction” describes a severe form of intraarticular hip fracture in which the affected articular fragment and subchondral bone are rotated and impacted against the underlying cancellous bone along the fracture margin [9, 13] (Fig. 1). The associated displacement creates incongruity, which ultimately leads to the development of osteoarthritis if not recognized and adequately treated [9, 14–16]. The reduction of type A1.3 fractures requires elevation of the impacted articular surface and bone grafting of the resulting defect [8] (Figs. 2 and 3).

Because most posterior wall fractures are comminuted or associated with marginal impaction [8], radiologists should be able to recognize their CT features. These features affect surgical planning, and their proper interpretation can enable the avoidance of unreduced impaction and the production of an incongruent joint surface [8, 9]. However, to our knowledge, the radiologic literature contains no report describing the CT features of acetabular fractures with marginal impaction. The main purposes of this study were to describe the imaging features of marginal impaction in posterior acetabular wall fracture and the potential therapeutic implications of recognizing this fracture type.

Materials and Methods

The institutional review board approved this retrospective study, and informed consent was not required. The registry of all isolated unilateral posterior acetabular wall fractures treated surgically at a level 1 trauma center between January 2000 and January 2012 was searched to identify all fractures with marginal impaction (type A1.3). One of the authors, with more than 10 years of experience with acetabular fractures, performed open surgical reduction and internal fixation in all patients. Decisions to perform surgery were based on the presence of hip instability, comminution, or articular impaction on radiographic or tomographic images analyzed by the orthopedic surgeons.

The orthopedic surgeons performing the procedures described posterior wall fractures of the acetabulum using the AO classification system. Only patients for whom complete surgical descriptions were available were included in the study.

Keywords: acetabular fracture, acetabulum, AO classification system, marginal impaction

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Posterior Wall Fractures of the Acetabulum

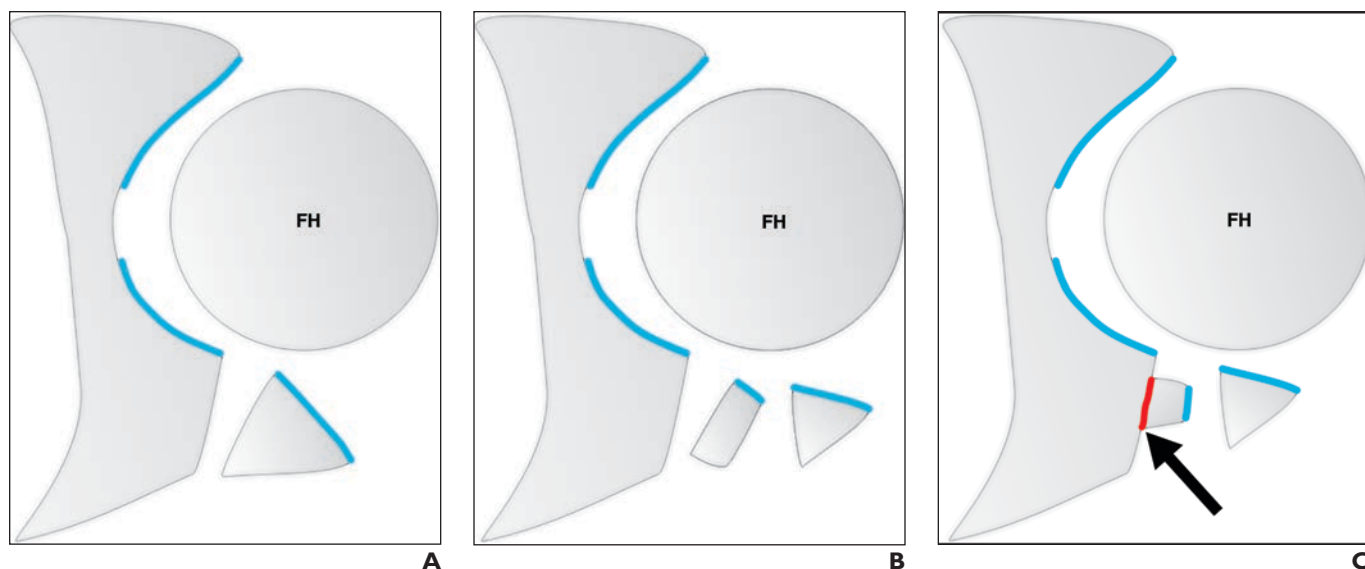


Fig. 1—AO subclassification of type A1 posterior wall fractures in axial plane.

A–C, Drawings show type A1.1 (**A**), fracture-dislocation with single fragment; type A1.2 (**B**), fracture-dislocation with multiple fragments; and type A1.3 (**C**), fracture-dislocation with posterior wall fragments associated with marginal impactation (*arrow*). Note that affected articular fragment and subchondral bone (*blue*) are perpendicular to femoral head (FH) and acetabular margin.

Reduction quality and hip congruency were evaluated immediately after treatment by surgeons using postoperative radiographs, and radiologic grading was performed after the final follow-up imaging study using the Matta criteria [17]: excellent (normal appearance of the hip joint), good (mild changes with minimal sclerosis and < 1 mm joint narrowing), fair (intermediate changes with moderate sclerosis and < 50% joint narrowing), and poor (advanced changes). Anteroposterior and 45° oblique radiographs of the pelvis (Judet views) were initially obtained for all patients. The reviewers also examined any ad-

ditional CT images obtained in consensus, with knowledge of the radiographic findings.

One radiologist and the orthopedic surgeon performing the procedure retrospectively reviewed CT images of patients with surgically proven marginal impactation, when available, to describe the imaging features and the potential therapeutic implications of recognizing this fracture type.

Statistical analyses were primarily descriptive. Routine descriptive statistics were used to calculate the percentage of marginal impactation relative to the total number of isolated posterior acetabular wall fractures.

Results

The study sample consisted of 192 subjects who underwent surgical treatment of isolated unilateral posterior acetabular wall fractures. Forty-six (24%) patients were women (mean age, 34 years; range, 22–81 years) and 146 (76%) were men (mean age, 32 years; range, 17–78 years). Fifty-four (28%) patients had type A1.1, 102 (53%) patients had type A1.2, and 36 (19%) patients had type A1.3 acetabular fractures.

Posterior hip dislocation was identified in 125 (65%) patients on the basis of initial ra-

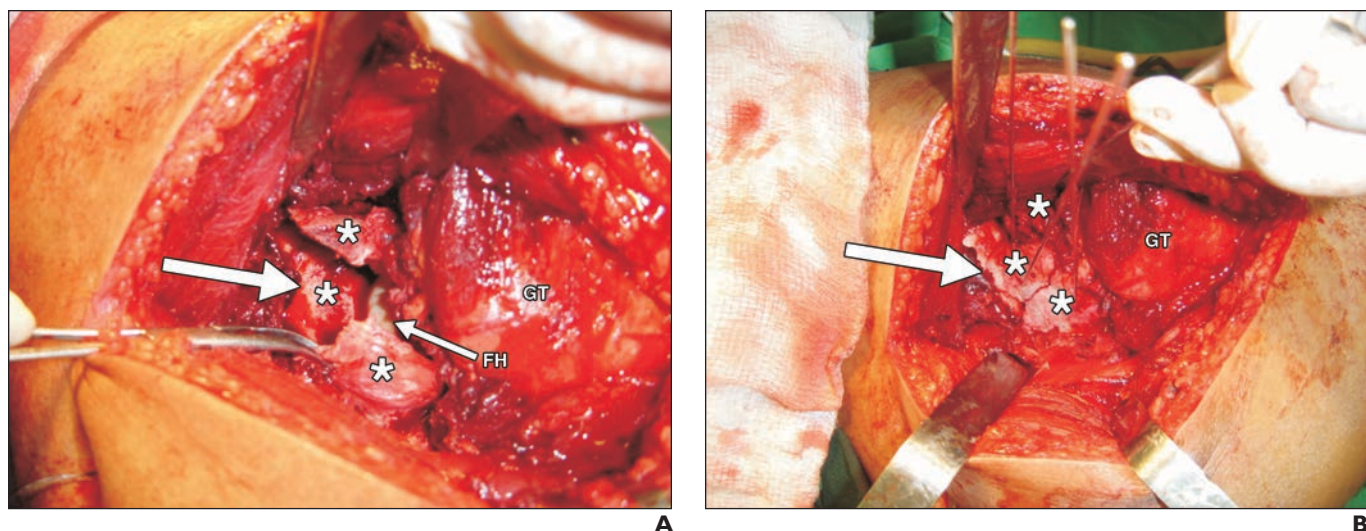


Fig. 2—32-year-old man with isolated posterior acetabular wall fractures with associated marginal impactation. Intraoperative photographs show type A1.3 posterior wall fragments (*asterisks*) associated with marginal impactation before and after reduction. GT = greater trochanter.

A, Photograph shows impacted fragment (*arrow*) lies perpendicular to femoral head (FH).

B, Photograph shows fragments (*asterisks*) were reduced using femoral head as template, including the impacted fragment (*arrow*).

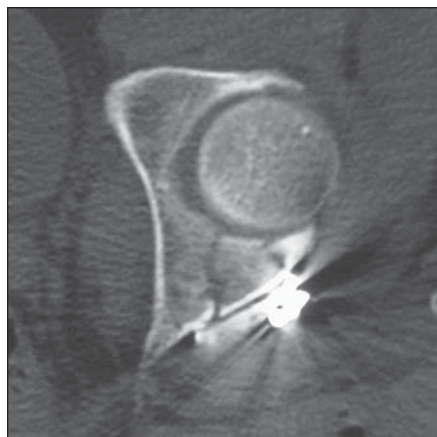


Fig. 3—32-year-old man with isolated posterior acetabular wall fractures with associated marginal impaction. Postoperative axial CT image shows anatomic reduction and subchondral support of impacted area.

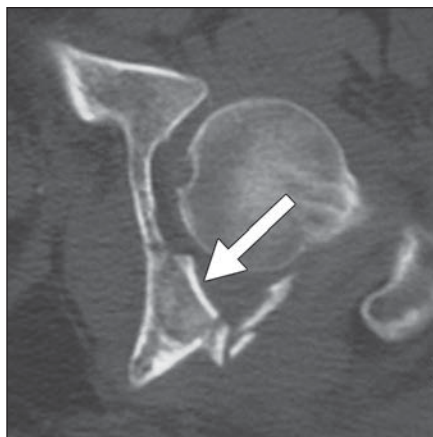


Fig. 4—18-year-old man with type A1.3 posterior wall acetabular fracture. Preoperative 2D CT image in transverse plane shows isolated posterior acetabular wall fractures with marginal impaction. Fragment (arrow) is rotated and impacted into underlying cancellous bone at angle of nearly 90° to acetabular margin.

diography. These patients underwent manipulation and lower femoral traction as the primary treatment.

Most patients were transferred from other hospitals to our institution for orthopedic surgery, and posttrauma abdominopelvic CT was routinely performed at the hospitals that provided initial care. Of the 192 patients who underwent surgery at our institution during the study period, 54 patients had simple fractures of the posterior acetabular wall with a single fragment. In the 138 patients with reported cases of “comminuted fracture,” “fracture with multiple fragments,” or “complex fracture” of the acetabulum, confirmed by radiography performed at admission, CT was performed according to our institution's orthopedic protocol, and the images were analyzed preoperatively by the orthopedic surgeon who performed the procedure. Surgical records indicated that 36 of these 138 patients presented articular impaction that was not evident on radiographs. The presence of articular impaction was not described on any radiologic report.

CT images were available for 15 of the 36 patients with surgically proven marginal impaction. In all of these cases, the impacted articular fragments were perpendicular to the femoral head and acetabular margin, consistent with the classification of this fracture subtype [13] (Fig. 4). Even a subtle appearance of the impacted fragment could be identified because the subchondral bone was perpendicular to the articular surface (Fig. 5).

Intraoperative anatomic reduction was achieved in 174 (90.6%) patients, and im-

perfect reduction was achieved in 18 (9.4%) patients with types A1.2 and A1.3 fractures. The main causes of imperfect reduction were failure to reconstruct the posterior wall because of the severity of bone fragmentation ($n = 9$) and failure to identify and adequately correct articular impaction ($n = 9$) (Fig. 6). Surgical reports indicated that anatomic reduction was achieved in all patients with A1.1 fractures.

Discussion

The accurate classification of acetabular fracture is the first step in surgical decision making [1, 4, 10, 13, 16]. The Letournel-Judet [6, 7] system is the most widely accepted means of classification and remains the

basis for describing acetabular fractures [3, 4, 14, 16, 18]. Although posterior wall fractures may appear to be simple on radiographs, most are comminuted or associated with impaction [8]. Letournel and Judet [7] introduced the term “marginal impaction” to describe a rotated, impacted, and fragmented fracture with depression of the osteochondral fragments into the underlying cancellous bone [9, 13]. This pattern occurs in about 23–30% of fractures involving the posterior wall [9, 14].

The aim of surgical treatment of posterior acetabular wall fractures is anatomic reduction. In cases with a single fragment, the surgical approach is simpler, usually consisting of fixation with screws; treatment may be conservative in the absence of hip instability [8]. In cases of comminuted fracture, the procedure is more complex, often requiring advanced surgical techniques [2, 8]. In the presence of articular impaction, the impacted osteochondral fragment must be identified, elevated, and rotated into anatomic position using the femoral head as a template [9]. The requirements for complex acetabular fractures also have implications for patient management because the hospital providing initial care may lack an orthopedic surgeon with expertise in treating this fracture type. Most patients included in this study were transferred to our institution for this reason. We thus believe that radiologists' recognition of marginal impaction is very important because not all orthopedic surgeons are familiar with this type of fracture.

Most acetabular fractures are also associated with hip dislocation, which can ulti-



Fig. 5—27-year-old man with type A1.3 posterior acetabular wall fracture. CT image in transverse plane subtly shows impacted fragment (arrow), which could be identified because subchondral bone is perpendicular to articular surface.

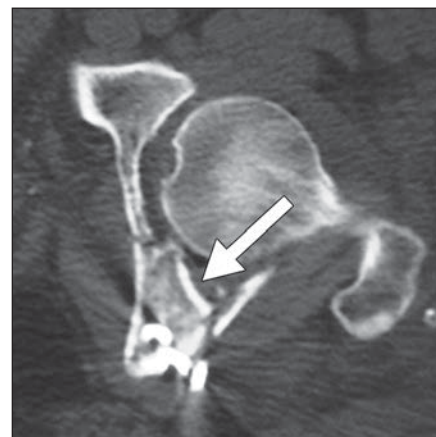


Fig. 6—18-year-old man with type A1.3 posterior acetabular wall fracture (same patient as in Fig. 4). Postoperative 2D CT image in transverse plane shows failure to adequately correct articular impaction (arrow).

Posterior Wall Fractures of the Acetabulum

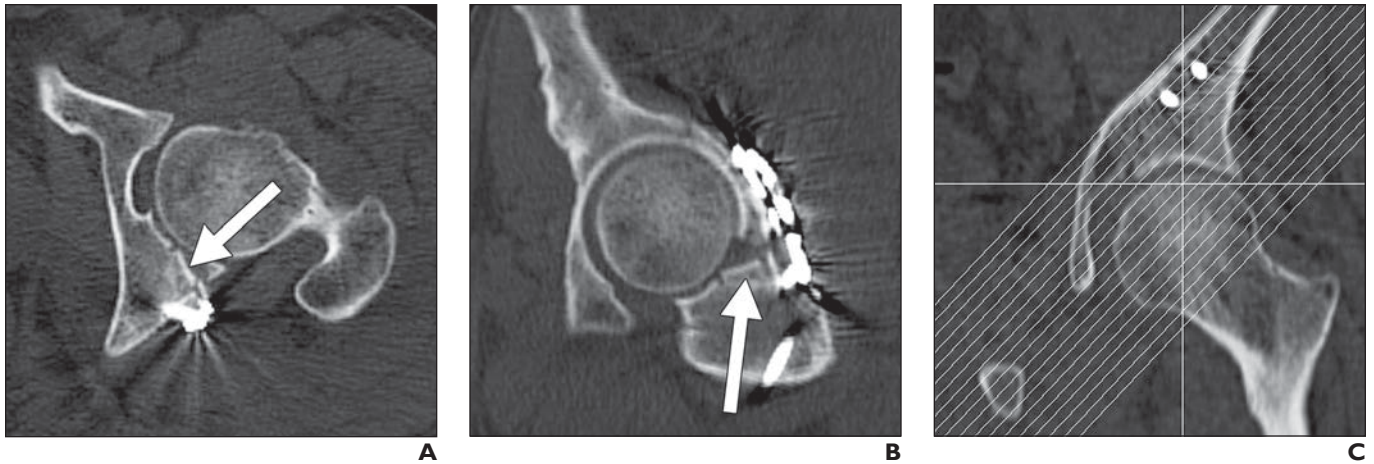


Fig. 7—26-year-old man with posterior wall fracture.

A, Postoperative transverse 2D CT image shows marginal impaction, which was not properly identified in preoperative period (arrow).

B, Sagittal oblique CT image of acetabulum clearly shows articular incongruity (arrow).

C, Sagittal oblique plane of acetabulum (diagonal lines) was planned using coronal image of hip.

mately result in a higher incidence of complications [14]. In a systematic review, Ferguson et al. [19] identified the following radiologic features potentially indicating poor prognosis with respect to acetabular fracture fixation when identified at presentation: posterior wall fracture comminution, marginal impaction associated with posterior wall fractures, articular impaction injury involving the medial radiologic roof (Gull sign), impaction injury to the femoral head, and dislocation of the hip.

Good to excellent clinical outcomes are often difficult to obtain, and surgeons often face difficulties in fragment reduction [2, 8] and postoperative evaluation of reduction quality, including acetabular articular surface shape and congruence. Despite the usefulness of the Letournel-Judet classification, this system does not address such acetabular fracture features, which may impact prognoses [4, 10].

The poor clinical outcomes of these fractures are likely due to the comminution of the posterior wall or the frequent failure to recognize and address marginal impaction [9, 11, 20]. The incongruity resulting from this type of injury can lead to the development of osteoarthritis if left untreated (Fig. 7) and also prevents proper reduction of adjacent displaced wall fragments [9, 15, 16]. All imperfect reductions in our series occurred in patients with types A1.2 and A1.3 fractures because of failures in posterior wall reconstruction and adequate correction of articular impaction.

The AO classification system incorporates preexisting concepts of the Letournel-Judet system, with the addition of groups

and subgroups to account for factors affecting prognosis [12, 14]. However, the complexity of this system has limited its clinical acceptance [4]. Consequently, the presence of marginal impaction is probably underreported because of radiologists' unfamiliarity with the AO classification. Indeed, no imaging report in our sample accurately described the presence of marginal impaction.

The study was subject to the inherent limitations of the retrospective unblinded design and use of a surgeon-specific database. For example, we could not determine whether follow-up determinations of imperfect reduction were based solely on surgical observations, on imaging findings, or on a combination thereof. Because articular impaction could not be identified on radiography, but only on CT or during surgery, CT is essential for the detection and workup of acetabular fractures before and after treatment [16]. Unfortunately, because of the retrospective nature of the study and the study period of more than 10 years, CT images were no longer available in several cases. Moreover, the surgeons were not blinded to the radiographs or available CT images, and the ability of surgeons and radiologists to consistently identify the features of acetabular fractures was not assessed. However, our main goal was to describe the imaging appearance of isolated posterior acetabular wall fractures with marginal impaction because such descriptions are lacking in the radiologic literature and radiologists' recognition of this pattern when interpreting CT images is important.

In conclusion, marginal impaction is an important cause of articular incongruity that

adversely affects prognosis, and radiologists should recognize its pattern within the subtypes of acetabular wall fractures. Future prospective studies comparatively assessing the sensitivity and specificity of imaging modalities, including CT and MRI, with those of surgery in the characterization of this fracture type would be useful.

References

1. Brandser E, Marsh JL. Acetabular fractures: easier classification with a systematic approach. *AJR* 1998; 171:1217–1228
2. Dean DB, Moed BR. Late salvage of failed open reduction and internal fixation of posterior wall fractures of the acetabulum. *J Orthop Trauma* 2009; 23:180–185
3. Durkee NJ, Jacobson J, Jamadar D, Karunakar MA, Morag Y, Hayes C. Classification of common acetabular fractures: radiographic and CT appearances. *AJR* 2006; 187:915–925
4. Harris JH Jr, Coupe KJ, Lee JS, Troscher T. Acetabular fractures revisited. Part 2. A new CT-based classification. *AJR* 2004; 182:1367–1375
5. Kreder HJ, Rozen N, Borkhoff CM, et al. Determinants of functional outcome after simple and complex acetabular fractures involving the posterior wall. *J Bone Joint Surg Br* 2006; 88:776–782
6. Judet R, Judet J, Letournel E. Fractures of the acetabulum: classification and surgical approaches for open reduction—preliminary report. *J Bone Joint Surg Am* 1964; 46:1615–1646
7. Letournel E, Judet R. *Fractures of the acetabulum*, 2nd ed. Berlin, Germany: Springer-Verlag, 1993
8. Kim HT, Ahn JM, Hur JO, Lee JS, Cheon SJ. Reconstruction of acetabular posterior wall fractures. *Clin Orthop Surg* 2011; 3:114–120
9. Giannoudis PV, Kanakaris NK, Delli Sante E,

- Morell DJ, Stengel D, Prevezas N. Acetabular fractures with marginal impaction: mid-term results. *Bone Joint J.* 2013; 95-B:230–238
10. Patel V, Day A, Dinah F, Kelly M, Bircher M. The value of specific radiological features in the classification of acetabular fractures. *J Bone Joint Surg Br* 2007; 89:72–76
11. Bhandari M, Matta J, Ferguson T, Matthys G. Predictors of clinical and radiological outcome in patients with fractures of the acetabulum and concomitant posterior dislocation of the hip. *J Bone Joint Surg Br* 2006; 88:1618–1624
12. Pascarella R, Digennaro V, Grandi G. Osteochondral impaction of the posterior acetabular surface without cortical fracture of any wall or column: an undescribed pattern of acetabular injury. *J Orthop Traumatol* 2011; 12:101–105
13. Tile M. *Fractures of the pelvis and acetabulum*, 3rd ed. Baltimore: Williams & Wilkins, 2003
14. Alonso JE, Volgas DA, Giordano V, Stannard JP. A review of the treatment of hip dislocations associated with acetabular fractures. *Clin Orthop Relat Res* 2000; 377:32–43
15. Giannoudis PV, Tzioupis C, Papathanassopoulos A, Obakponovwe O, Roberts C. Articular step-off and risk of post-traumatic osteoarthritis: evidence today. *Injury* 2010; 41:986–995
16. Geijer M, El-Khoury GY. Imaging of the acetabulum in the era of multidetector computed tomography. *Emerg Radiol* 2007; 14:271–287
17. Matta JM. Fractures of the acetabulum: accuracy of reduction and clinical results in patients managed operatively within three weeks after the injury. *J Bone Joint Surg Am* 1996; 78:1632–1645
18. Harris JH Jr, Lee JS, Coupe KJ, Trotscher T. Acetabular fractures revisited. Part I. Redefinition of the Letournel anterior column. *AJR* 2004; 182:1363–1366
19. Ferguson TA, Patel R, Bhandari M, Matta JM. Fractures of the acetabulum in patients aged 60 years and older: an epidemiological and radiological study. *J Bone Joint Surg Br* 2010; 92:250–257
20. Giannoudis PV, Nikolaou VS, Kheir E, Mehta S, Stengel D, Roberts CS. Factors determining quality of life and level of sporting activity after internal fixation of an isolated acetabular fracture. *J Bone Joint Surg Br* 2009; 91:1354–1359