Determinants of functional outcome after simple and complex acetabular fractures involving the posterior wall


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We have evaluated the functional, clinical and radiological outcome of patients with simple and complex acetabular fractures involving the posterior wall, and identified factors associated with an adverse outcome.

We reviewed 128 patients treated operatively for a fracture involving the posterior wall of the acetabulum between 1982 and 1999. The Musculoskeletal Functional Assessment and Short-Form 36 scores, the presence of radiological arthritis and complications were assessed as a function of injury, treatment and clinical variables.

The patients had profound functional deficits compared with the normal population. Anatomical reduction alone was not sufficient to restore function. The fracture pattern, marginal impaction and residual displacement of > 2 mm were associated with the development of arthritis, which related to poor function and the need for hip replacement. It may be appropriate to consider immediate total hip replacement for patients aged > 50 years with marginal impaction and comminution of the wall, since 7 of 13 (54%) of these required early hip replacement.

Approximately 35% of all acetabular fractures have involvement of the posterior wall which is the most common pattern,1 with approximately 76% of these injuries having additional complex fractures.2 It has generally been perceived that isolated fractures of the posterior wall have a good outcome, but recent reviews have shown that 21% to 32% of patients have poor results.2-9 Moed et al9 had the best clinical results with a poor outcome in only 11% of patients with a simple fracture of the posterior wall.8,10,11 There have been only a few studies which have determined the functional outcome using validated instruments, and considered complex and simple fractures of the posterior wall separately.

We have studied the functional, clinical and radiological outcome in patients with simple and complex fracture patterns involving the posterior acetabular wall with reference to the type of fracture, marginal impaction, comminution of the posterior wall, residual fracture displacement, injury to the femoral head, associated injuries and increasing age. We also examined the inter-relationship between the radiological, clinical and functional results.

Patients and Methods

We identified 162 skeletally mature patients with acetabular fractures involving the posterior wall which were treated between 1982 and 1999 at a level-one tertiary referral trauma centre. A total of 34 patients were excluded, six because they had stable fractures not requiring surgery according to Tornetta’s criteria,12,13 27 because they did not have clinical follow-up for at least one year and one because he underwent immediate hip replacement; this left 128 patients in the study, which was approved by the institutional internal review board.

Anteroposterior plain radiographs of the pelvis and iliac and obturator oblique views were obtained in all patients at the initial presentation. CT scans were carried out after the patient had been resuscitated and closed reduction of any associated posterior dislocation of the hip carried out. The fractures were operated on using the Kocher-Langenbeck posterior approach,1 with the addition of an ilioinguinal approach for selected fractures with associated T and transverse patterns that required exposure of the anterior column. The joint was irrigated and debrided by distracting, but without re-dislocating, the femoral head from the acetabulum. The column fractures were then reduced and secured by lag screws. Impacted fragments at the margins were elevated and buttressed with autograft harvested from around the greater trochanter. Finally, the
DETERMINANTS OF FUNCTIONAL OUTCOME AFTER ACETABULAR FRACTURES INVOLVING THE POSTERIOR WALL

fragments of the posterior wall were reduced and secured by two or more lag screws, followed by buttress plating. Those which were too small for fixation by lag screws were buttressed by spring plates. The patients were given peri-operative antibiotics for 24 to 48 hours after surgery. Coumadin or low-molecular-weight heparin was used as thromboembolic prophylaxis until discharge from either hospital or inpatient rehabilitation. Indomethacin was used for six weeks after surgery, at the discretion of the treating surgeon, as prophylaxis against heterotopic bone formation. After operation, the patients were mobilised with weight-bearing on the uninjured side. Full weight-bearing on the injured hip was delayed for 12 weeks from fixation. All patients were reviewed clinically by the treating surgeon for a minimum of one year after operation. Clinical details and information on the nature of the injury, associated injuries and treatment, complications and the length of hospital stay were gathered from the hospital records by an independent observer (CMB). Beginning in 1997, all patients were reviewed clinically at six weeks, six months and annually thereafter, with the functional outcomes being measured by the Musculoskeletal Functional Assessment (MFA) and the 36-item Short-Form Health Survey (SF-36) questionnaires at each clinic visit. All patients treated before 1997 who had not been reviewed recently were sent the questionnaires by a research assistant (CMB). Failure to return the questionnaire within two weeks was followed by at least two attempts to contact each patient by telephone. If the patient had moved, an attempt was made to locate them by contacting the last-known family physician and any relatives listed in the hospital records.

The MFA is a validated 101-item self-administered health-status instrument designed to detect differences in function among patients after traumatic musculoskeletal injuries. A lower score indicates better function, with a score above 40 in any domain indicating profound functional impairment. It has recently been demonstrated to perform well in patients with fractures of the acetabulum. The SF-36 is a well-established and validated general health-status measure.

Two orthopaedic fellows (NR, YGL) who were not involved with the management of the patient and were blinded to their outcome reviewed the initial, immediate post-operative and final radiographs. Their consensus opinion was recorded for each parameter. There was no instance when consensus could not be reached. Pre-operative assessment of the fracture was made using the initial antero-posterior radiographs and Judet views as well as the pre-operative CT scans. The fractures were classified into the ten types as described by Letournel. Radiographs and CT scans taken after reduction of any associated hip dislocation were reviewed for the presence of loose intra-articular fragments, posterior-wall displacement, fractures of the femoral head, marginal wall impaction and comminution of wall fragments. A fracture was considered to be comminuted only if it consisted of three or more fragments with attached articular cartilage. Non-articular cortical fragments were not included in this count. Radiographs taken within two weeks of surgery, at one year and at the final follow-up were reviewed for maximum residual displacement of the fracture and 67 patients (52%) were supplemented by an available CT scan. All articular displacement was considered, including the posterior wall or the articular component of an associated-column fracture. The final radiograph was used to assess osteoarthritis, the grade of heterotopic ossification and the presence of avascular necrosis. The grade of heterotopic ossification was determined according to the method of Brooker et al as modified by Moed and Smith. Radiological arthritis was evaluated according to the method of Kellgren and Lawrence and Gunther and Sun. The raters considered avascular necrosis to have occurred if the femoral head showed segmental sclerosis, or if there was segmental collapse of the head which predated radiological changes on the acetabular side and loss of joint space, in order to minimise misinterpretation of early degenerative arthritis as avascular necrosis.

Statistical analysis. This was performed using SPSS version 10.0 (SPS Inc., Chicago, Illinois). Routine descriptive statistics were used to describe the clinical characteristics and functional and radiological outcome. Bivariate comparisons were made using either the Mann-Whitney or Pearson chi-squared tests. Specific hypotheses were tested by modelling the outcome of interest (function, heterotopic ossification, avascular necrosis, total hip replacement, and residual displacement) as a linear function of the predictor variables (fracture pattern, marginal impaction, wall comminution, residual displacement, damage to the femoral head and also arthritis, heterotopic ossification and avascular necrosis), while adjusting for patient age, gender and length of follow-up as potential confounding variables. A p value < 0.05 was considered to be statistically significant. For clarity, statistically significant bivariate relationships were reported, but only if these remained statistically significant after adjusting for the potential confounders noted above.

Results

According to Letournel’s classification there were 44 simple and 84 associated posterior-wall fractures. In the latter group the complex fracture was transverse in 51 patients, involved the posterior column in 22 and was a T-shaped acetabular fracture in 11.

A total of 61 (48%) of patients were men under 50 years of age who had sustained multiple injuries in a motor-vehicle accident. The mean age of the patients was 41.6 years (18 to 75), and 100 (78%) were men. A motorised vehicle was involved in 108 (84%) of the 128 cases. The mean Injury Severity Score was 23.4 (9 to 50). A total of 34 patients (27%) presented with an associated head injury, which was generally mild, with a mean Glasgow Coma Score of 12.7 (6 to 14). An associated pelvic fracture was
### Table I. Clinical details and injury characteristics by fracture pattern

<table>
<thead>
<tr>
<th>Fracture pattern</th>
<th>Isolated PW</th>
<th>PW + TV</th>
<th>PW + PC</th>
<th>PW + T</th>
<th>Overall</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number</td>
<td>44</td>
<td>51</td>
<td>22</td>
<td>11</td>
<td>128</td>
<td>NA</td>
</tr>
<tr>
<td>Mean age (SD) yrs</td>
<td>41.8 (13.1)</td>
<td>40.5 (13.4)</td>
<td>42.8 (14.0)</td>
<td>43.8 (11.1)</td>
<td>41.6 (13.1)</td>
<td>0.829</td>
</tr>
<tr>
<td>Gender, male (%)</td>
<td>38 (76.4)</td>
<td>38 (74.5)</td>
<td>38 (74.5)</td>
<td>8 (72.7)</td>
<td>100 (76.1)</td>
<td>0.440</td>
</tr>
<tr>
<td>Side, right (%)</td>
<td>17 (38.6)</td>
<td>22 (43.1)</td>
<td>8 (36.4)</td>
<td>4 (36.4)</td>
<td>51 (39.8)</td>
<td>0.958</td>
</tr>
<tr>
<td>Mean ISS (SD)</td>
<td>23.5 (10.4)</td>
<td>23.5 (10.3)</td>
<td>18.7 (7.3)</td>
<td>23.4 (9.2)</td>
<td>23.4 (10.0)</td>
<td>0.147</td>
</tr>
<tr>
<td>Mean GCS (SD)</td>
<td>14.4 (1.6)</td>
<td>14.5 (1.6)</td>
<td>15.0 (0)</td>
<td>15.0 (0)</td>
<td>14.6 (1.4)</td>
<td>0.376</td>
</tr>
<tr>
<td>Mean time to OR</td>
<td>6.0 (10.6)</td>
<td>6.2 (5.8)</td>
<td>4.4 (7.6)</td>
<td>2.6 (2.8)</td>
<td>5.5 (7.9)</td>
<td>0.484</td>
</tr>
</tbody>
</table>

#### Associated injury

- **Spine (%)**
  
  - 3 (6.8)  
  - 5 (9.8)  
  - 3 (13.6)  
  - 0 (0)  
  - 11 (8.8)  
  - 0.569

- **Chest (%)**
  
  - 17 (38.8)  
  - 24 (47.1)  
  - 4 (18.2)  
  - 4 (36.4)  
  - 49 (38.2)  
  - 0.124

- **Abdomen (%)**
  
  - 5 (11.4)  
  - 9 (17.6)  
  - 1 (4.5)  
  - 3 (17.3)  
  - 18 (14.1)  
  - 0.249

- **Upper limb (%)**
  
  - 15 (34.1)  
  - 16 (29.4)  
  - 2 (9.1)  
  - 1 (9.1)  
  - 33 (25.8)  
  - 0.093

- **Lower limb extremity (%)**
  
  - 21 (47.7)  
  - 25 (49.9)  
  - 7 (31.8)  
  - 7 (31.8)  
  - 60 (46.9)  
  - 0.376

- **Initial nerve deficit (%)**
  
  - 16 (36.4)  
  - 12 (23.5)  
  - 8 (36.4)  
  - 4 (36.4)  
  - 40 (31.3)  
  - 0.296

- **Initial vascular deficit (%)**
  
  - 1 (2.3)  
  - 2 (3.9)  
  - 2 (9.1)  
  - 0 (0)  
  - 5 (3.9)  
  - 0.509

#### Acetabular fracture

- **Comminuted wall (%)**
  
  - 18 (40.9)  
  - 28 (54.9)  
  - 11 (50.0)  
  - 6 (54.5)  
  - 63 (49.2)  
  - 0.598

- **Marginal impaction (%)**
  
  - 10 (22.7)  
  - 23 (45.7)  
  - 16 (72.7)  
  - 4 (36.4)  
  - 53 (41.4)  
  - 0.001

- **Intra-articular fragments (%)**
  
  - 13 (29.5)  
  - 16 (31.4)  
  - 4 (18.2)  
  - 4 (36.4)  
  - 37 (29.9)  
  - 0.623

- **Femoral head lesion (%)**
  
  - 7 (17.2)  
  - 16 (31.4)  
  - 3 (13.6)  
  - 2 (19.2)  
  - 29 (22.7)  
  - 0.277

#### TABLE II. Clinical outcomes according to fracture pattern

<table>
<thead>
<tr>
<th>Fracture pattern</th>
<th>Isolated PW</th>
<th>PW + TV</th>
<th>PW + PC</th>
<th>PW + T</th>
<th>Overall</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number complications</td>
<td>44</td>
<td>51</td>
<td>22</td>
<td>11</td>
<td>128</td>
<td>NA</td>
</tr>
<tr>
<td>Late THR (%)</td>
<td>3 (6.8)</td>
<td>6 (11.8)</td>
<td>4 (18.2)</td>
<td>3 (27.3)</td>
<td>16 (12.5)</td>
<td>0.205</td>
</tr>
<tr>
<td>DVT (%)</td>
<td>1 (2.3)</td>
<td>2 (3.9)</td>
<td>1 (4.5)</td>
<td>2 (18.2)</td>
<td>6 (4.7)</td>
<td>0.136</td>
</tr>
<tr>
<td>Infection (%)</td>
<td>2 (4.5)</td>
<td>3 (5.9)</td>
<td>1 (4.5)</td>
<td>2 (18.2)</td>
<td>8 (6.3)</td>
<td>0.345</td>
</tr>
<tr>
<td>Iatrogenic nerve injury (%)</td>
<td>1 (2.3)</td>
<td>1 (2.0)</td>
<td>0 (0)</td>
<td>0 (0)</td>
<td>2 (1.6)</td>
<td>0.869</td>
</tr>
</tbody>
</table>

#### Residual displacement in mm (%)

- 0 to 2
  
  - 42 (95.6)  
  - 42 (82.4)  
  - 15 (68.2)  
  - 9 (81.8)  
  - 108 (84.4)  
  - 0.015

- 3 to 5
  
  - 2 (4.5)  
  - 9 (17.6)  
  - 7 (31.8)  
  - 1 (9.1)  
  - 19 (14.5)  
  - 0.034

- 6 to 10
  
  - 0 (0)  
  - 0 (0)  
  - 0 (0)  
  - 1 (9.1)  
  - 1 (0.8)  
  - 0.034

#### Arthritis (%)

- Any (grade 1 to 4)
  
  - 9 (20.5)  
  - 22 (43.1)  
  - 14 (63.6)  
  - 4 (36.4)  
  - 49 (38.3)  
  - 0.011

- Mild (grade 1 and 2)
  
  - 4 (9.1)  
  - 14 (27.5)  
  - 6 (27.3)  
  - 3 (27.3)  
  - 27 (21.1)  
  - 0.018

- Severe (grade 3 and 4)
  
  - 5 (11.4)  
  - 8 (15.7)  
  - 8 (36.4)  
  - 1 (9.1)  
  - 22 (17.2)  
  - 0.037

#### Heterotopic bone (%)

- Indocid prophylaxis
  
  - 26 (59.1)  
  - 32 (62.7)  
  - 15 (68.2)  
  - 8 (72.7)  
  - 81 (63.3)  
  - 0.783

- Any (grade 1 to 4)
  
  - 20 (45.5)  
  - 20 (39.2)  
  - 11 (50.0)  
  - 4 (36.4)  
  - 55 (43.0)  
  - 0.929

- Mild (grade 1 and 2)
  
  - 17 (38.6)  
  - 13 (25.5)  
  - 7 (31.8)  
  - 4 (36.4)  
  - 41 (32.0)  
  - 0.283

- Severe (grade 3 and 4)
  
  - 3 (6.8)  
  - 8 (15.7)  
  - 4 (18.2)  
  - 0 (0)  
  - 14 (10.9)  
  - 0.362

- Avascular necrosis (%) | 3 (6.8) | 5 (9.8) | 5 (22.7) | 2 (18.2) | 15 (11.7) | 0.364

* PW, posterior wall; TV, transverse; PC, posterior column; T, associated T type
† THR, total hip replacement; DVT, deep-vein thrombosis
‡ significant, p < 0.05
§ OR, operating room
¶ NA, not available

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Table III. Comparison of the 128 patients with and without functional outcome results

<table>
<thead>
<tr>
<th>Variable*</th>
<th>Completed functional outcome questionnaires</th>
<th>Did not complete functional outcome questionnaires</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number</td>
<td>84</td>
<td>44</td>
</tr>
<tr>
<td>Mean age in years (SD)</td>
<td>42.6 (12.4)</td>
<td>39.6 (14.4)</td>
</tr>
<tr>
<td>Male (%)</td>
<td>66 (78.6)</td>
<td>34 (77.3)</td>
</tr>
<tr>
<td>Mean ISS (SD)</td>
<td>23.6 (9.4)</td>
<td>23.2 (11.3)</td>
</tr>
<tr>
<td>Mean GCS (SD)</td>
<td>14.7 (1.2)</td>
<td>14.2 (1.8)</td>
</tr>
<tr>
<td>Mean time to operation in days (SD)</td>
<td>4.7 (4.6)</td>
<td>7.2 (12.0)</td>
</tr>
<tr>
<td>Associated injuries (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Upper limb</td>
<td>19 (22.6)</td>
<td>13 (29.5)</td>
</tr>
<tr>
<td>Lower limb</td>
<td>42 (50)</td>
<td>18 (40.9)</td>
</tr>
<tr>
<td>Fracture type (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Associated acetabular fracture</td>
<td>61 (72.6)</td>
<td>23 (52.3)</td>
</tr>
<tr>
<td>Acetabular fracture (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Comminuted wall</td>
<td>40 (47.6)</td>
<td>23 (52.3)</td>
</tr>
<tr>
<td>Marginal impaction</td>
<td>33 (39.3)</td>
<td>20 (45.8)</td>
</tr>
<tr>
<td>Intra-articular fragments</td>
<td>20 (23.8)</td>
<td>17 (38.6)</td>
</tr>
<tr>
<td>Femoral head lesion</td>
<td>22 (26.2)</td>
<td>7 (15.9)</td>
</tr>
</tbody>
</table>

* ISS, injury severity score; GCS, Glasgow coma scale
† significant, p < 0.05

present in 13 patients (10%) and 60 (46.9%) had an injury to the lower limb. The fracture of the posterior wall was comminuted with more than three articular fragments, as defined above in 63 (49%) of the patients and marginal impaction was present in 53 (41%) (Table I). The latter was most common in associated fractures of the posterior column, occurring in 16 of the 22 cases (73%).

Closed reduction of the hip dislocation was undertaken as soon as possible after injury but the precise timing was not consistently available. Definite fixation of the fracture was achieved at a mean of 4.7 days from the day of injury (1 to 40).

Clinical outcome. Six patients (4.7%) developed deep-vein thrombosis, one of whom also had a non-fatal pulmonary embolism, while a further eight patients (6.3%) met the criteria for infection, defined as wound drainage or dehiscence treated with antibiotics or by debridement. The latter procedure was required in two patients (1.6%). All the infections resolved with treatment.

The peroneal branch of the sciatic nerve was injured iatrogenically in two patients (1.6%), both of whom recovered fully. A total of 40 patients (31%) presented with a nerve injury, with complete recovery in 26, partial recovery in five and no recovery in nine. There were 22 patients (17%) with complete palsy of the sciatic nerve of whom only one recovered fully, 16 showed partial recovery and five showed no recovery. One patient with isolated palsy of the tibial nerve recovered fully. Of 13 patients (10%) with palsy of the peroneal nerve, two recovered fully, seven recovered partially and four had no recovery. Of the four patients (3%) with injury to the L5 nerve-root, one recovered fully and the other three, partially.

Subsequently, 16 patients (12.5%) required a total hip replacement (THR) at a mean of 2.9 years (0.4 to 10.4) after initial surgery. In eight patients this was within two years of the acetabular fracture, in six at between two and ten years and in two after ten years. The incidence of THR varied with the type of fracture from just below 6.8% (3 of 44) for isolated fractures of the posterior wall to over 27.3% (3 of 11) for those with an associated T component (Table II), but there was no statistical significance (p = 0.21; Mann-Whitney U test) between the type of fracture and the incidence of THR. Total joint replacement was more likely to be required in posterior-wall fractures associated with marginal impaction (p = 0.01), wall comminution (p = 0.005) and in patients older than 50 years (p = 0.01). In patients aged over 50 years of age with marginal impaction and comminution of the posterior wall, the likelihood of requiring THR was 46%, compared with 9% for younger patients without these fracture characteristics (p = 0.002). THR was required more often in patients with residual displacement of the fracture of more than 2 mm compared with 2 mm or less, but this did not reach statistical significance given the sample size (p = 0.06). THR was not associated with the presence of a lesion of the femoral head after adjusting for other factors.

Radiological outcome. After open reduction and internal fixation, 108 (84%) of the reductions were within 2 mm of residual displacement (step or gap), but this varied according to the type of fracture (Table II). Only two simple fractures of the posterior wall (4.5%) had displacement greater than 2 mm (both 3 mm) compared with seven with associated fractures of the posterior column (31.8%).

Radiological evidence of osteoarthritis was identified in 49 patients (38.3%) at a mean of 5.3 years (1 to 18) (Table II). It was significantly more common (p = 0.01; Mann-Whitney U test) in fractures of the posterior-wall with associated posterior-column fractures (63.6%; 14 of 22) than in simple fractures of the posterior wall (20.5%; 9 of 44) and was more common when marginal impaction was noted (p = 0.02) and when the residual step or gap was greater than 2 mm (p = 0.001). Scuffing or impaction of the femoral head did not have a significant independent effect on the development of arthritis or the need for early THR (p > 0.05). Patients with radiological osteoarthritis had significantly worse functional scores (p < 0.05). Avascular necrosis of the femoral head was identified most often in posterior-wall with associated column fractures (23%) (Table II). Unlike arthritis, it was not associated with marginal impaction or residual step or gap deformity (p > 0.05).

Mild heterotopic bone was seen in 41 (32%) patients (Table II). There was no association between prophylaxis and the development of heterotopic ossification (p = 0.853) given the sample size available. The 84 patients who completed the functional questionnaires also answered ques-
Functional outcome. Of the 128 patients, 84 (66%) completed the SF-36 and MFA questionnaires at a mean of 4.2 years (1 to 17) after operation. Of the remaining 44 patients, one had died, six refused to participate and the other 37 could not be located. The patients who completed the functional questionnaires had a similar (p > 0.05) age, gender and associated injury profile as those who did not, with the exception of significantly more associated acetabular fractures (p = 0.031; Mann-Whitney U test) in the group which completed the questionnaires (Table III). Thus scores should be considered in their respective fracture type as they are reported rather than in the aggregate (Table IV).

The mean overall MFA score was 35.75 (4 to 89). Patients had particularly poor scores for function of the lower limb (45.71 (0 to 95), sleep 44.44 (0 to 100), leisure activities 62.80 (0 to 100), activities around the home 41.93 (0 to 100) and emotional issues 45.04 (0 to 94.44), but they were significantly better for simple fractures of the posterior wall compared with those with associated frac-
tures in most domains (Table IV). Patients with associated fractures had significantly worse MFA scores (mean 55.38; 10 to 95) for function of the lower limb than all other fracture patterns (p = 0.036; Table IV).

Because age- and gender-specific population norms are available for the SF-36, we were able to compute standardised z-scores for each SF-36 domain and summary score. The mean scores for all SF-36 domains were significantly worse than the mean scores for the age- and gender-matched normal population (p < 0.001; Students t-test).

After adjusting for age, gender and length of follow-up, the functional outcome as measured by the MFA and SF-36 was consistently worse for patients with associated fracture patterns compared with those with simple fractures of the posterior wall and for those with radiological osteoarthritis (p < 0.05). As noted above, the development of arthritis was significantly associated with marginal impaction and residual displacement (p < 0.05). There was also a trend for a worse functional outcome in multiple MFA and SF-36 domains for patients with marginal impaction (0.05 > p < 0.08), and for those with residual displacement of more than 2 mm (0.05 > p < 0.08). Age, gender, femoral-head lesions, posterior-wall comminution, the presence of heterotopic ossification and additional injuries involving the limbs, head, spine or abdomen were not consistently associated with functional outcome (p > 0.10; Students t-test).

Functional outcome scores were available for 11 of the 16 patients (69%) who had undergone THR. Function as measured using the MFA and SF-36 remained seriously impaired in these patients, despite uncomplicated total joint replacement. The overall MFA score of 32.55 (11 to 61) for patients who had required THR was similar to that of those who had not undergone this procedure (p = 0.61). There was no statistically significant difference for any of the SF-36 or MFA domain scores between patients who had undergone THR and those who had not (p > 0.05).

Of the 84 patients surveyed, 37 (44%) were still receiving disability payments, and 31 (37%) were involved in legal action at the time of follow-up. These individuals were more likely than other patients to have sustained a head injury (p = 0.06) and to have an associated type of posterior-wall fracture (p = 0.05). Those involved in legal action or on disability had significantly worse MFA and SF-36 scores than patients not in this situation (p < 0.01), independent of the presence of head injury and type of fracture.

**Discussion**

We found that patients with simple and associated fractures of the posterior wall of the acetabulum had severe functional deficits as measured by the SF-36 and MFA at a mean of four years after injury. Functional outcome was significantly worse in patients with radiological arthritis and in those with associated posterior wall and posterior-column fractures. The latter group had the worst function scores for the lower limb of any type of fracture. They were associated with marginal impaction in 16 cases (72.7%) and with inability to achieve reduction within 2 mm in seven cases (31.8%). There were 14 patients (63.6%) with associated posterior-wall/posterior-column fractures who developed radiological arthritis during the period of study. Marginal impaction was independently associated with the development of arthritis, while comminution of the posterior wall was associated with a higher likelihood of residual displacement, which in turn was associated with arthritis. Marginal impaction, along with older age and arthritis, was directly and independently associated with the need for THR during the period of study. These findings are consistent with those of Wolinsky et al who found that the presence of marginal impaction, intra-articular fragments, a fracture of the posterior wall and an older age correlated highly with the need for THR after operative fixation of fractures of the acetabulum.

Borrelli et al distinguished between patients with a mean MFA score of 7 and those with a mean score of 32 in a detailed review of 15 patients, including nine with fractures involving the posterior wall. Those patients with higher scores had weaker hip flexion and extension, but the small sample size did not reveal any clear relationship between the type of fracture, reduction and MFA score. In a review of a heterogeneous group of 150 patients after acetabular fracture, Moed et al noted a mean overall MFA score of 24.9. Scores for fractures of the posterior wall were not reported separately, and no association was found between the MFA score and the type of fracture, gender, age and the presence of associated systemic injuries. In a previous review of 94 patients with isolated fractures of the posterior wall, Moed et al found that a poor clinical outcome was more common in patients over 55 years of age and in those with intra-articular comminution, delay in reduction of the hip of more than 12 hours and avascular necrosis, but marginal impaction was of borderline independent statistical significance with respect to the clinical outcome. Saterbak et al noted deficits of comparable severity to our findings in a group of 42 patients using the MFA score. They found that early failure was more common in patients with comminution of the posterior wall (three or more fragments) and extension of the fracture into the dome of the acetabulum and/or the ischium. Murphy et al noted that associated fracture patterns and older age were more likely to be associated with suboptimal reduction of the fracture and worse Merle d’Aubigné scores. Our data showed a clear and strong association between the type of fracture and the functional outcome measured using validated instruments (MFA and SF-36). We could not demonstrate an association between age and the quality of postoperative reduction or between age and function. However, our population was relatively young, with a mean age of 41.6 years (18 to 75). It is possible that bone quality, rather than age, is the relevant factor but this has not been quantified in our study or to our knowledge in any previous work.
Matta et al. found that the presence of a lesion of the femoral head resulted in a worse clinical outcome, but marginal impaction, intra-articular fragments, initial displacement of the fragment and associated injuries did not. We were also unable to demonstrate a relationship between associated injuries or intra-articular fragments with outcome but we found that marginal impaction was associated with the development of arthritis and also the need for THR. Lesions of the femoral head were of no independent significance with respect to any of our end-points. We did not measure initial displacement of fragments.

The clinical outcome after posterior-wall fractures can be poor despite anatomical reduction.1-9 Matta et al.2 reported 22 fractures of the posterior wall in a series of 262 acetabular fractures. Despite anatomical reduction as determined on plain radiographs in all 22 cases, a good or excellent clinical result was obtained in only 68%. He suggested that plain radiographs may not demonstrate imperfections in the articular surface. Moed et al.24 have shown that CT reveals more incongruity and correlates better with outcome than plain radiography. Unfortunately, routine post-operative CT was not available for all of our cases, but we did incorporate the CT findings in the 67 patients in whom they were available. Our raters found it difficult to separate gap from step deformity and the decision was taken to consider the maximum displacement, whether this was a pure gap or a gap with step deformity involving the fragments of the posterior wall or an associated fracture of the articular column. We felt that this was a conservative approach to the reporting of residual displacement, but if gap is less important than step, this approach may dilute the relationship of displacement with outcome. Finally, we may have overlooked misalignment or ‘hinging’ of the fracture which does not result in step or gap deformity since this is difficult to assess by plain radiography.

Individuals with fractures of the acetabulum involving the posterior wall have profound functional deficits compared with the normal population. Fractures of the posterior wall with associated fractures of the posterior column appear to have a particularly poor prognosis. Anatomical reduction alone is not sufficient to restore function to normal, but residual displacement above 2 mm along with marginal impaction is associated with the development of early radiological arthritis, which in turn is related to poor function and the need for THR. Although late THR did not restore function to the age- and gender-matched control groups, it may be appropriate to consider immediate THR for older patients with severe marginal impaction and comminution of the posterior wall given the high likelihood of their requiring THR soon after fixation of the fracture.25-27 The association of smoking with an apparent increased risk of heterotopic ossification requires further investigation, although the presence of this complication was not independently associated with poor outcome.

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