Fractures of the acetabulum in patients aged 60 years and older

AN EPIDEMIOLOGICAL AND RADIOLOGICAL STUDY

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Using a prospective database of 1309 displaced acetabular fractures gathered between 1980 and 2007, we calculated the annual mean age and annual incidence of elderly patients > 60 years of age presenting with these injuries. We compared the clinical details and patterns of fracture between patients > 60 years of age (study group) with those < 60 years (control group). We performed a detailed evaluation of the radiographs of the older group to determine the incidence of radiological characteristics which have been previously described as being associated with a poor patient outcome.

In all, 235 patients were > 60 years of age and the remaining 1074 were < 60 years. The incidence of elderly patients with acetabular fractures increased by 2.4-fold between the first half of the study period and the second half (10% (62) vs 24% (174), p < 0.001). Fractures characterised by displacement of the anterior column were significantly more common in the elderly compared with the younger patients (64% (150) vs 43% (462), respectively, p < 0.001). Common radiological features of the fractures in the study group included a separate quadrilateral-plate component (50.8% (58)) and roof impaction (40% (46)) in the anterior fractures, and comminution (44% (30)) and marginal impaction (38% (26)) in posterior-wall fractures.

The proportion of elderly patients presenting with acetabular fractures increased during the 27-year period. The older patients had a different distribution of fracture pattern than the younger patients, and often had radiological features which have been shown in other studies to be predictive of a poor outcome.

The incidence of acetabular fractures in the elderly is expected to rise with the increase in the ageing population. It has been predicted that elderly patients represent the fastest growing group which sustain acetabular fractures, due to the result of a fall on to the greater trochanter. These fractures are characterised by displacement of the anterior column, an associated separate fragment of the quadrilateral plate and anterocentral displacement/dislocation of the femoral head. In addition, these radiological features which correlate with a poor outcome after reduction and fixation have been identified as potential indications for early total hip replacement (THR) in older patients. Articular impaction of the medial roof (the ‘Gull Sign’) or posterior wall, dislocation of the hip, comminuted posterior-wall fractures, and injury to the femoral head have all been associated with early failure after attempted reduction and internal fixation. Although these radiological features have been correlated elsewhere with a poor outcome, their prevalence in elderly patients with a fracture has not been established. The data indicating trends in the patterns of fracture sustained by elderly patients have been extrapolated from only a few small series.

We reviewed our large database of acetabular fractures to establish whether the mean age of patients presenting with these fractures has increased over time and to evaluate characteristics between series based on age (< 60 years vs ≥ 60 years). Additionally, we studied variations in the pattern of fracture sustained by younger and older patients to identify which subtypes of fracture are most common in the elderly. Finally, we evaluated the incidence of the radiological characteristics previously reported to be associated with a poor outcome after internal fixation in our patients aged over 60 years. We hypothesised that the prevalence of elderly patients with displaced acetabular fractures has increased over time, that these fractures commonly include displacement of the anterior acetabular structures and that the characteristics reported as indicators of a poor outcome are common in these patients.
Patients and Methods

We identified a series of 1309 consecutive patients operated on over a period of 27 years between June 1980 and June 2007 from a comprehensive prospective database of displaced acetabular fractures treated by a single surgeon (JMM). The database has been maintained in a consistent manner since its inception in 1980 as outlined previously. Clinical details such as age, gender, date of injury, mechanism of injury, and associated injuries and characteristics of the fracture (fracture classification, presence of hip dislocation and associated soft-tissue injuries) are recorded at the time of presentation.

The fractures were classified by the senior author (JMM) into one of five elementary patterns (posterior wall, posterior column, anterior wall, anterior column, transverse or five associated patterns (T-shaped, posterior column with posterior wall, transverse with posterior wall, anterior with posterior hemitransverse, associated both column)) as described by Letournel et al., and Letournel and recorded in the database. If the database lacked information for the pattern of the fracture, the operation notes were checked for the determination of the pattern or the radiographs were evaluated to complete the classification. In all, 14 patients did not have such a classification recorded on the database and had neither a diagnosis in the notes nor on the radiographs. These 14 patients were recorded as unknown in the categorical analysis.

The senior author practised at three separate institutions within the greater Los Angeles area during the period of study and therefore the consecutive series includes those patients enrolled at all three institutions. Approval of the Institutional Review Board was obtained to maintain the database at each site and the use of the database series for this specific investigation was also approved. From 1980 to 1990 the practice was based at a level-one academic trauma institution where most of the patients had been admitted after presentation at the emergency room (Los Angeles County-University of Southern California Medical Centre). Subsequently, the senior author’s practice evolved into one which was referral-based where most patients were transferred to his care from outside institutions (1990 to 2006, Good Samaritan Hospital, Los Angeles; 2006 to 2007, St John’s Health Centre, Santa Monica, California). Specific information regarding each patient’s admission, whether directly from the emergency department or through referral was not recorded in the database and thus the investigation was hampered in establishing precise trends in referral patterns over the period studied.

We identified 235 patients who were 60 years of age or older at the time of presentation and this group served as the study group. The remaining 1074 younger patients served as a control group.

We evaluated the mean age and range for the entire series and the study and control groups. The mean age of the patients was calculated for each year of the study, as were the proportion ratios of elderly to total patients enrolled each year. For statistical analysis of incidence, the study group was divided and the early period (1980 to 1993) compared with the late period (1994 to 2007). Gender, the mechanisms of injuries and associated injuries in both the older and younger patient groups were also evaluated. We compared these data to identify significant differences between the groups.

The fracture classification data were evaluated for the patterns of fracture affecting both the younger and the older groups and compared to identify trends and differences.

Radiological analysis. We performed a systematic review of the literature to identify radiological findings implicated as poor prognostic indicators after fixation of acetabular fractures in patients regardless of age or which had served as indications for early joint replacement in any previously published studies. Studies were identified by an initial Medline search of articles using the keywords ‘acetabular fracture’ and/or ‘outcomes’, ‘predictors’, ‘failure’ and ‘acute arthroplasty’. We reviewed the titles and abstracts and retrieved all studies which potentially discussed correlations between radiological characteristics of injuries and outcome. From these studies we reviewed the list of references to identify other relevant studies. We identified 16 publications, of which was a book which discussed radiological parameters identified as potential indicators of poor outcome after open reduction and internal fixation (ORIF) of acetabular fractures. From these studies we identified the following radiological features which if identified on the images at presentation could be considered as possible indicators of poor prognosis: 1) comminution of posterior wall fractures; 2) marginal impaction associated with posterior wall fractures; 3) articular impaction injury involving the medial radiological roof (Gull sign); 4) impaction injury to the femoral head; and 5) dislocation of the hip.

On presentation, all the patients were initially evaluated by three standard radiological views comprising anteroposterior (AP) pelvis and the 45° oblique views of Judet and, after 1983, by CT. We excluded patients whose films could not be located or whose films did not contain a CT scan and all three views of the pelvis from the radiological sub-analysis portion of the study. These patients were not, however, removed from the epidemiological review as they had complete entries in the database. We retrieved complete image files for a total of 173 patients.

A fellowship-trained orthopaedic surgeon (TAF) specialising in the treatment of acetabular fractures assessed the retrieved images of the 173 patients aged 60 years and older. Each set of images was carefully evaluated to determine the presence of previously identified poor prognostic radiological features. Additionally, we evaluated the precise location of articular impaction, the direction of femoral head displacement/dislocation and the presence or absence of a separate fracture fragment of the quadrilateral plate.

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Statistical analysis. Parametric data were examined using Student’s t-test and the categorical variables by the chi-squared test. A p-value ≤ 0.05 was considered to be statistically significant.

Results

The mean age of the younger group was 36 years (11 to 59) and that of the study group 70 years (60 to 98). Patients in both groups had similar distributions of gender with a male predominance of 70% (751) in those less than 60 years and of 68% (160) in those older than 60 years.

In the 235 patients aged more than 60 years, we identified a significant increase in acetabular fractures between 1980 and 2007 (0% in 1980 vs 30% (7) in 2007; p = 0.001). During the 27-year period, the age of the patients increased significantly (p < 0.001, Fig. 1), and the prevalence of elderly patients enrolled in our database increased (Fig. 2). During the first half of the study period (1980 to 1993), 10% (62) of patients were more than 60 years of age (mean age 38 years, SD 15.8), while during the second half (1994 to 2007), 24% (174) of patients were in this age group (mean age 45 years, SD 18.3; Table I, Fig. 2). There was a trend towards an increase in the annual proportion of elderly patients treated (Fig. 2).

The most common mechanism of injury in the study group was a fall (49.8% (117)), but this accounted for only 17.7% (190) of the younger group’s fractures (p < 0.001). The younger patients, on the contrary, were most commonly injured as a result of a motor-vehicle accident (66.0% (709)), while in the elderly group this applied to only 37.4% (88) (p < 0.001; Table II).

Isolated injuries were significantly more common in the study group than in the control group (p < 0.001; Table III). We found that 49.1% (527) of the younger patients presented with associated injuries compared with 29.8% (70) of the older patients. In addition, 19.7% (211) of the younger patients presented with more than one associated injury while only 9.9% (23) of the older patients had more than one injury (p < 0.001). Abdominal and chest injuries were significantly more common in the younger patients (p < 0.001), and the most common associated injuries in both groups were other limb injuries.

Patterns of fracture. Table IV summarises the classification of acetabular fractures in the study and control groups. The 14 patients who did not have classification data recorded in the database and whose operation notes or radiographs were unavailable for evaluation were all from the younger group. These 14 patients were recorded as ‘unknown’. The number of elementary fracture patterns was higher in the older patients (37.0% (87) in study group versus 29.1% (313) in control group, chi-squared test, p < 0.01). Patients over the age of 60 years were also more likely to suffer fractures involving displacement of the anterior column (associated both column, anterior column, anterior with posterior hemitransverse; anterior wall, 63.8% (150) in
study group versus 43.0% (462) in control group (chi-squared test, p < 0.001)). The incidence of associated both column fractures was similar in both (26.4% (62) in the study group versus 27.9% (300) in the control group). This difference in the prevalence of anterior fracture patterns was largely due to the increased incidence of anterior column (19.2% (45) vs 7.2% (77), chi-squared test, p < 0.001), anterior with posterior hemitransverse (14.9% (35) vs 7.6% (82), chi-squared test p < 0.001) and anterior wall (3.4% (8) vs 0.3% (3), chi-squared test, p < 0.001) fractures.

Elementary patterns of fracture involving the posterior column (transverse, posterior column) were uncommon in the elderly patients. Only one patient over 60 years of age had an isolated posterior column fracture and two had transverse patterns compared with 2.4% (26) and 4.6% (49), respectively, in the younger patients. In the older patients, most fractures which affected the posterior aspect of the acetabulum had a fracture of the posterior wall. Of these, 31 elementary posterior wall, 19 transverse with posterior wall, eight posterior column with posterior wall, and nine T-shaped fractures had a displaced posterior wall component (Table V).

Associated both column fractures were the most common type in both groups, and the incidence of both column, posterior wall, posterior column with posterior wall and T-shaped fractures were similar in both.

Radiological characteristics of fractures in patients 60 years and older. In all 173 (73.6%) of the 235 patients in the study group had complete sets of images available for evaluation. The findings are summarised in Table V. We specifically evaluated the incidence of characteristics which were identified as being predictive of a poor outcome after fixation.

Comminution of the posterior wall. There was a total of 81 posterior wall fractures, of which 31 were isolated. Of these 67 with involvement of the posterior wall were available for radiological evaluation, 25 elementary and 42 associated (Table V). This was found to have three or more fragments in 64% (16) of the elementary fractures, 71.4% (10) of the transverse and posterior wall fractures, 60% (3) of the posterior column with posterior wall fractures, and 0% of the posterior wall components associated with the ABC fractures available for analysis.
Impaction associated with the posterior-wall fractures. We found the prevalence of marginal impaction to be 52% in the elementary posterior wall fractures and 31% (13) in the associated fractures (Table V, Fig. 3a). The posterior column with posterior wall and transverse with posterior wall fractures which showed marginal impaction of the posterior wall all had associated posterior dislocation of the hip.

Impaction involving the radiological roof. There was impaction or comminution involving a portion of the subchondral bone of the superomedial roof in 46 (40.4%) of the anterior fracture patterns (25% (10)) of the associated both columns, 56% (15) of the associated with posterior hemitransverse, 48% (19) of the anterior column, and 29% (2) of the anterior wall fractures) available for radiological evaluation. This finding was also seen in 33% (5) of T-shaped fractures, 20% (1) of posterior wall column with posterior wall and 14% (2) of transverse with posterior wall fractures.

We hesitated to label this the Gull sign, first because this terminology has been used for various radiological findings within the pelvis and secondly because the impaction was occasionally easily identifiable on CT (Fig. 4) rather than as a distinct double arc on the plain radiographs as described by Anglen et al. In three patients the radiographs showed an area of severe articular comminution (and not impaction) at the superocentral roof while the remaining patients had impaction of the superocentral articular surface associated with the line of fracture. The marginal impaction most commonly involved the articular surface of the intact posterior (Fig. 4) rather than the displaced anterior column.

Injury to the femoral head. In the 173 radiographs available for evaluation this was identified in 34 patients (20%) (Fig. 3b).

Hip dislocation. The prevalence of anterocentral dislocation of the hip in the anterior fracture patterns (anterior column, anterior wall, anterior with posterior hemitransverse and associated both column was 20% (23). In five of the 15 T-shaped fractures there was an anterocentral hip dislocation. Only one of the anterior fractures (an associated both column fractures had a posterior dislocation. Posterior dislocation of the hip was associated with 72% (18) of the posterior wall, 60% (3) of the posterior column with posterior wall, 78.6% (11) of the transverse with posterior wall, and 46.6% (7) of the T-shaped fractures available for evaluation.

Fractures involving separation of the anterior column/wall from the innominate bone. We identified a common series of injuries associated with the fractures involving displacement of the anterior column which has previously been discussed by other authors in relation to acetabular fractures in elderly patients. Of the 150 fractures involving displacement of the anterior column/wall (anterior wall, anterior column, anterior or with posterior hemitransverse, associated both column) 114 (76.0%) were available for radiological evaluation (Table V). In 58 (50.9%) a separate fragment involving the quadrilateral plate could be identified. This varied in size and extended in various depths towards the posterior border of the bone as previously described. The fragment invariably hinged posteriorly such that the anterior fracture was more displaced than the posterior portion (Fig. 4). The head of the femur always followed the displaced anterior acetabulum and subluxed anterocentrally, often creating an impacted region of the radiological roof (40.4% (46)). In 23 patients (20%) the subluxation resulted in complete displacement/dislocation from the laterally based radiological roof, and 19 had radiological evidence of damage to the superolateral aspect of the femoral head (Figs 4 and 5).

Table V. Radiological characteristics of fractures sustained by patients aged 60 years and more, by number and percentage

<table>
<thead>
<tr>
<th>Fracture pattern (number)</th>
<th>Number of images reviewed</th>
<th>Dislocation/subluxation (%)</th>
<th>FHI†</th>
<th>QP§ component</th>
<th>Roof impaction</th>
<th>Component</th>
<th>&gt; 3 pieces</th>
<th>Marginal impaction</th>
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<td>AHT (35)</td>
<td>27</td>
<td>9 (33.3) A</td>
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<td>ABC (62)</td>
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<td>PW (31)</td>
<td>25</td>
<td>18 (72.0) P</td>
<td>5 (20.0)</td>
<td>25 (100.0)</td>
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<td>PCPW (8)</td>
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<td>3 (60.0) P</td>
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<td>TRPW (19)</td>
<td>14</td>
<td>11 (78.6) P</td>
<td>5 (35.7)</td>
<td>14 (100.0)</td>
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<td>Toshaped (24)</td>
<td>15</td>
<td>5 (33.3) A</td>
<td>5 (33.3)</td>
<td>9 (60.0)</td>
<td>1 (6.7)</td>
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<td>7 (46.6) P</td>
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* AC, anterior column; AW, anterior wall; AHT, anterior with posterior hemitransverse; ABC, associated both columns; PC, posterior column; PW, posterior wall; PCPW, posterior column with posterior wall; TR, transverse; TRPW, transverse with posterior wall
† A, anterior; P, posterior
‡ FHI, femoral head injury
§ QP, quadrilateral plate
Discussion

In our analysis of the database of 1309 patients there were several important findings. The annual mean age at which an acetabular fracture is sustained and the preponderance of elderly patients in the study group have significantly increased over the past 27 years. However, there was a constant male-to-female ratio irrespective of age, with male predominance independent of age. The elderly patients were more likely to be injured by a fall than by a motor-vehicle accident and there were fewer associated injuries in the study group than in the control group. In the older patients, classification of the fractures showed an increased prevalence of anterior column, anterior wall and anterior with posterior hemitransverse fractures compared with the younger group and posterior-fracture patterns in this group were almost always associated with a posterior wall fracture. In the elderly group, fractures involving displacement of the anterior column (anterior column, anterior with posterior hemitransverse, associated both column and anterior wall) were commonly associated with disruption of the quadrilateral plate, an impaction injury of the medial roof, anterocentral dislocation of the hip and an impaction injury to the femoral head. Posterior wall fractures tended to be comminuted and associated with marginal impaction, and posterior dislocation of the hip.

Our finding that there has been an increase in the age of patients presenting with displaced acetabular fractures supports predictions of this trend in other studies.\(^2,4\) Our results were derived from a comprehensive prospective database which has had consistent collection of data since its inception in 1980,\(^15\) representing the largest dataset of acetabular fractures to our knowledge. However, the use of this surgeon-specific database poses several limitations on the general applicability of our observations. Initially, the senior author worked at a level-I trauma centre where most patients were admitted as emergency cases before moving to a practice where the majority of patients were referred. During this period based in a referral practice, confounding variables such as patients too critically injured to transfer or regional referral patterns could have had a casual effect on the number of young and multiply injured patients enrolled in the database. This factor could potentially threaten the validity of our conclusions. The parameters of the study population were the number of patients with complete demographic data, fracture pattern data and radiologic image files; however, our observations may not be applicable to the entire population and should be considered in the context of the senior author’s practice profile.

The mean age of the patients was 45 years in the second half of the study period compared with 38 years in the early period. More importantly, the incidence of acetabular fractures in the elderly increased during the study period such that in recent years nearly 25% of all patients presenting with displaced fractures of the acetabulum were more than 60 years of age.

Acetabular fractures were significantly more common in men, even in the study group. This is in contrast with common fragility fractures such as those of the distal radius and hip, which have a higher reported incidence in women.\(^3,25\) The reasons for this are unclear and are likely to be multifactorial. The energy or direction of force required to cause an acetabular fracture may be different from that which causes a fragility fracture at the hip and older male patients may be simply more involved in activ-
ities sufficient to sustain a fracture of the acetabulum. We also speculate that those patients with relatively high bone density and sufficiently strong cortices in the proximal femur will transfer force through the proximal femur to the acetabulum which fractures, whereas patients with low bone density and osteoporotic femoral cortices instead sustain proximal femoral fractures. A weakness of our study and of others attempting to understand risk factors for a poor prognosis of ORIF in acetabular fractures in elderly patients is the lack of quantitative assessment of the level of osteoporosis.

Our observation of variations in fracture patterns between the older and younger patients are consistent with other published reports, although caution should be observed in generalising from our results because of the study population available from this dataset. Our data show a high incidence (63.8% (150)) of fracture patterns in the older group involving displacement of the anterior column (anterior wall, anterior column, anterior with posterior hemitransverse or associated both column) compared with only 43% (462) in the younger group. These patterns may correlate with the high percentage of patients who suffered fractures from a fall rather than from a high-energy motor-vehicle accident. Falls on to the greater trochanter result in forces directed through the greater trochanter and transmitted anteromedially to the anterior column/anterior wall and the quadrilateral plate. As the femoral head displaces, it remains associated with the anterior column as described by Letournel et al, and often leaves an area of impaction in the medial roof. Impaction was commonly associated with the posterior column (Figs 4 and 5). If the femoral head completely displaces from under the intact segment of roof, an impaction injury to the superior lateral head is commonly encountered.

Recognition of this injury pattern may have important implications for the treatment of fractures in the older patient. The successful outcome from reduction and internal fixation is consistently correlated with the quality of the reduction obtained. The achievement of anatomical reduction and rigid fixation in this fracture pattern is technically challenging if not impossible. The impacted roof segment must be accessed through the fracture line and it cannot be directly visualised. The quadrilateral plate was found to be of varying size and occasionally included portions of articular cartilage from the posterior wall. Because of its small size and juxta-articular nature, alternative plating techniques such as intrapelvic plating and spring plate fixation should be considered.
The combination of roof impaction, hip dislocation and femoral head injury needs to be considered since many authors have independently correlated each of these findings with a poor outcome after fixation. In this situation early THR may offer a better solution. Nevertheless successful THR is itself dependent on the stabilisation of the displaced acetabular fragments to allow solid fixation of the acetabular component. Several reports have described the technical difficulties in achieving this when the anterior structures are involved. When elderly patients sustained posteriorly directed forces, most had associated posterior wall and there were remarkably few elementary transverse or posterior column fractures. Posterior wall fractures which did occur had a high incidence of radiological characteristics implicated with a poor outcome after fixation. The difficulty in obtaining and maintaining an anatomical reduction in the presence of comminution and severe impation of the posterior wall have been the topic of many technical discussions and many authors consider these parameters to be indications for consideration of early THR in the older patient.

In conclusion, the proportion of elderly patients presenting with acetabular fractures increased during the period of study. The fracture patterns sustained by these patients differed from those in the younger patients. Many of the radiological features which have been associated with a poor outcome from fixation of acetabular fractures were seen in the elderly patients. These fractures pose treatment challenges whether ORIF or early THR is attempted.

No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article.

References