The radiological evaluation of acetabular fractures in the elderly

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We have examined the accuracy of reduction and the functional outcomes in elderly patients with surgically treated acetabular fractures, based on assessment of plain radiographs and CT scans. There were 45 patients with such a fracture with a mean age of 67 years (59 to 82) at the time of surgery. All patients completed SF-36 questionnaires to determine the functional outcome at a mean follow-up of 72.4 months (24 to 188). All had radiographs and a CT scan within one week of surgery. The reduction was categorised as ‘anatomical’, ‘imperfect’, or ‘poor’.

Radiographs classified 26 patients (58%) as anatomical, 13 (29%) as imperfect and 6 (13%) as poor. The maximum displacement on CT showed none as anatomical, 23 (51%) as imperfect and 22 (49%) as poor, but this was not always at the weight-bearing dome. SF-36 scores showed functional outcomes comparable with those of the general elderly population, with no correlation with the radiological reduction.

Perfect anatomical reduction is not necessary to attain a good functional outcome in acetabular fractures in the elderly.

The number of elderly patients with acetabular fractures is increasing, and by 2010 may be the largest group with these fractures.1-5 In younger patients, the indications for treatment of these fractures are well defined and accepted, but this is less true in the elderly.4-7 Factors associated with a favourable outcome are not documented as clearly as in younger age-groups.6,8-11

Recently, authors have concentrated on this segment of the population, exploring the exact indications for surgery, and reporting their results. Letournel and Judet7 described the outcome in 120 fractures in patients over 65 years of age in 1993 and this helped spur a rise in more aggressive treatment.12 Since then, many articles have been published, with varied outcomes. Several have shown that age > 55 years is an independent predictor of a poor outcome.12-14

However, there is still much controversy surrounding the optimal treatment of acetabular fractures in the elderly. Treatment described in the literature ranges from non-operative management1 to percutaneous operation,15,16 and acute total hip replacement (THR) has been used.1,17 In addition to age, authors have attempted to identify other risk factors for poor outcome in the elderly.1,2,12,17-19 In one large, single-institution study it was found that nearly 70% of the elderly patients treated surgically for acetabular fractures achieved a functional outcome similar to age- and injury-matched controls without secondary procedures.20 These patients were scored using the Musculoskeletal Function Assessment, Short Musculoskeletal Function assessment, and SF-36. Only 30% of the patients needed a later THR for post-traumatic arthritis.

In 1996, Matta9 presented a report of 262 acetabular fractures treated surgically and discussed his classification, which has since been used in many studies. More recently, Borrelli et al21 compared plain radiographs with CT scans to examine the accuracy of reduction. They found that plain radiographs were much less sensitive in detecting gaps and step-off in the articular surface than CT, and recommended their use for the assessment of reduction of the fracture post-operatively. In addition, a later study from their group showed the accuracy of CT in following articuar incongruity as fractures healed.22 The subchondral arc on CT scans was first defined as the most superior 10 mm of the acetabular articular surface which represents the 45° of roof arc necessary to consider non-operative treatment of certain acetabular fractures.3,23,24

Our study was designed to quantify possible predictors of outcome and function in elderly patients with acetabular fractures, based on
Matta. In particular, the reviewers examined the residual displacement as defined by anatomical (0 to 1 mm), imperfect (2 mm to 3 mm), or poor operative radiographs (AP and Judet views) and graded as anatomical, 1 mm to 3 mm was imperfect and > 3 mm was poor. In addition, the displacement was considered anatomical, 1 mm to 3 mm or poor. Axial cuts alone were used for CT evaluation of residual displacement. The maximum displacement was imperfect in 23 (51%) and poor in 22 (49%); however, this was not always in the region of the 45° subchondral roof arc. For this area (the superior-most 10 mm on CT axial cuts) five patients (11%) were anatomical, 25 (56%) imperfect and only 15 (33%) were poor. In all the patients, CT examination either confirmed or worsened the grading as seen on plain radiographs.

Spearman’s correlation of these data showed that the plain radiograph and the CT classifications, both overall and at the subchondral roof arc, do correlate, but are statistically different using Wilcoxon’s signed-ranks test.

For this cohort of patients the mean duration of follow-up was 72.4 months (24 to 188). A total of 13 patients (28.9%) subsequently underwent THR. The mean time to THR was 31.5 months (6 to 96). One patient later needed a revision because of infection, and one had several dislocations which required revision to a constrained liner. None of these patients needed any reconstructive or bone-augmenting procedures because of their previous acetabular fracture.

A summary of the functional outcomes for the group as measured by SF-36 is shown in Table II. The mean physical component score for all the patients was 46 (16 to 64). The mean mental component score for all the patients was 50 (26 to 63).

The physical and mental components were examined for correlation with the fracture pattern and the accuracy of reduction, but with one exception no statistically significant differences were found. Comparing the anatomically graded radiographs with the poorly graded radiographs, the mental scores were slightly higher in the poorly graded group (p = 0.04; score of 56 vs 48).

### Table I. Acetabular fractures by type

<table>
<thead>
<tr>
<th>Fracture type</th>
<th>Number of patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anterior column</td>
<td>1</td>
</tr>
<tr>
<td>Anterior wall</td>
<td>4</td>
</tr>
<tr>
<td>Posterior wall</td>
<td>9</td>
</tr>
<tr>
<td>Transverse</td>
<td>2</td>
</tr>
<tr>
<td>Transverse, posterior wall</td>
<td>3</td>
</tr>
<tr>
<td>Anterior column, posterior hemitransverse</td>
<td>11</td>
</tr>
<tr>
<td>Association both column</td>
<td>11</td>
</tr>
<tr>
<td>T-type</td>
<td>2</td>
</tr>
<tr>
<td>Posterior column, posterior wall</td>
<td>2</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>45</strong></td>
</tr>
</tbody>
</table>

The study was approved by the institutional review board as part of a broader retrospective review of fracture outcomes in older populations. All the patients consented to participation in the study. All the records of the study patients were reviewed by an orthopaedic trauma fellow (MLP) and an orthopaedic resident (ANM). Neither of the reviewers was directly involved in the initial care of the patients. The patient demographics and fracture patterns were documented. Much of this information was contained in a prospectively maintained database.

### Statistical analysis

Correlations between normally distributed variables (age, SF-36 physical and mental components) were examined using Pearson’s correlation coefficient, r. All other correlations were calculated using Spearman’s rank correlation, ρ. A correlation > 0.4 was considered at least moderate (Systat v. 10.2; SystatSoftware Inc., Richmond, California).

### Results

The distribution of fracture types in the final cohort is shown in Table I. According to Matta’s classification the residual displacement after reduction, was anatomical in 26 patients (58%), imperfect in 13 (29%), and poor in six (13%). The distribution of fracture types is as follows:

- **Anterior column** (35 patients): 11 (31%), 9 (26%), 5 (14%)
- **Posterior wall** (35 patients): 7 (20%), 11 (31%), 17 (49%)
- **Anterior wall** (35 patients): 7 (20%), 14 (40%), 3 (8%)
- **Transverse** (35 patients): 1 (3%), 11 (31%), 23 (66%)
- **Transverse, posterior wall** (35 patients): 1 (3%), 12 (34%), 13 (37%)
- **Anterior column, posterior hemitransverse** (35 patients): 2 (6%), 13 (37%), 19 (54%)
- **Association both column** (35 patients): 2 (6%), 13 (37%), 19 (54%)
- **T-type** (35 patients): 1 (3%), 11 (31%), 23 (66%)
- **Posterior column, posterior wall** (35 patients): 1 (3%), 12 (34%), 13 (37%)
- **Posterior column, posterior wall** (35 patients): 1 (3%), 12 (34%), 13 (37%)
- **Posterior column, posterior wall** (35 patients): 1 (3%), 12 (34%), 13 (37%)
- **Posterior column, posterior wall** (35 patients): 1 (3%), 12 (34%), 13 (37%)

Spearman’s rank correlation coefficient was calculated for all the variables. The results were as follows:

- **Age** vs **SF-36 physical component score**: r = 0.26 (p = 0.04)
- **SF-36 mental component score** vs **SF-36 physical component score**: r = 0.48 (p < 0.001)
- **Spearman’s rank correlation coefficient** vs **SF-36 physical component score**: ρ = 0.32 (p = 0.01)
- **Spearman’s rank correlation coefficient** vs **SF-36 mental component score**: ρ = 0.48 (p < 0.001)

The study included 45 patients who met our inclusion criteria and were enrolled in the study. They all completed the SF-36 health survey. The remainder did not have a complete set of radiographs, owing to a change from film to digital radiology at our institution during this time. There were no significant differences in this group with respect to patterns of injury or surgical fixation. There were ten women and 35 men. There were no bilateral cases. The mean age at the time of surgery was 67 years (59 to 82). All the fractures were classified initially by the senior author in his pre-operative planning and evaluation, based on Letournel’s classification system.

Reduction of the fracture was evaluated on post-operative radiographs (AP and Judet views) and graded as anatomical (0 to 1 mm), imperfect (2 mm to 3 mm), or poor (> 3 mm), based on the residual displacement as defined by Matta. In particular, the reviewers examined the radiographs for gap, not step-off. Post-operative CT scans were reviewed and also classified according to a modification of Matta’s scheme. For the CT classification, 0 mm of residual displacement was considered anatomical, 1 mm to 3 mm was imperfect and > 3 mm was poor. In addition, the observers noted where the greatest displacement occurred, paying particular attention to the superior 10 mm and the subchondral roof arc.

### Patients and Methods

Between January 1992 and January 2006, the senior author treated 574 acetabular fractures surgically. Of these, 149 patients were over 55 years of age at the time of surgery. For this investigation we included patients over the age of 55 who had a full complement of radiographs, including immediate post-operative anteroposterior (AP), iliac oblique and obturator oblique Judet views, as well as a CT scan of the pelvis taken within one week of surgery. There were 45 patients who met our inclusion criteria and were enrolled in the study. They all completed the SF-36 health survey. The remainder did not have a complete set of radiographs, owing to a change from film to digital radiology at our institution during this time. There were no significant differences in this group with respect to patterns of injury or surgical fixation. There were ten women and 35 men. There were no bilateral cases. The mean age at the time of surgery was 67 years (59 to 82). All the fractures were classified initially by the senior author in his pre-operative planning and evaluation, based on Letournel's classification system.

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A summary of the functional outcomes for the group as measured by SF-36 is shown in Table II. The mean physical component score for all the patients was 46 (16 to 64). The mean mental component score for all the patients was 50 (26 to 63).

The physical and mental components were examined for correlation with the fracture pattern and the accuracy of reduction, but with one exception no statistically significant differences were found. Comparing the anatomically graded radiographs with the poorly graded radiographs, the mental scores were slightly higher in the poorly graded group (p = 0.04; score of 56 vs 48).
Physical and mental components were also compared between the patients who later needed a THR and those who did not. Again, there were no statistically significant differences between the scores. Patients who did not have an arthroplasty had a mean physical component score of 46 versus 47 for those who did have an arthroplasty (p = 0.43); the mean mental component score was 49 for those without and 52 for those with an arthroplasty (p = 0.27).

Discussion
As the population continues to age, pelvic fractures in the elderly will be an increasing problem. More than half of pelvic fractures involve patients over the age of 65. According to the United States Census Bureau, by 2030 almost 20% of the population will be over 65, and by 2050 this percentage will be doubled. The subset of the population over the age of 85 will triple by 2050. In addition to this increase in population the incidence of high-energy pelvic trauma is also increasing.

Several studies on the outcomes obtained following fixation of acetabular fractures in the elderly are contradictory. However, we believe that those elderly patients should be treated with primary open reduction and internal fixation whenever possible. Using our algorithm, acceptable results can be obtained in selected patients (Fig. 1).

In addition, our study has shown that reduction criteria are not as stringent as in younger patients and still lead to an appropriate functional outcome. As part of the algorithm, it is recommended to minimise the surgical trauma to the patient by, for example, minimising incisions and surgical time. This algorithm is facilitated with the knowledge that slightly imperfect fracture reduction can still lead to an adequate outcome.

Our results showed that 13 of our 45 patients had a THR at a mean of 31.5 months (6 to 96) after their acetabular reconstruction. None of these patients required any other procedure such as cages or allograft, besides a primary THR, at the time of this procedure. However, these patients would have required aggressive procedures to augment a THR if it had been performed immediately. We believe that these patients actually have an improved outcome despite ‘failing’ open reduction and internal fixation. The first procedure preserved bone stock and allowed healing of the acetabulum, hence facilitating the subsequent THR. We have also demonstrated that these patients had equivalent SF-36 outcomes to those who did not need a replacement, indicating that the patients do as well with our open reduction and internal fixation as with replacement.

There was no significant correlation between the accuracy of reduction and the functional outcome. The one exception to this was the mental component when comparing plain radiographs of anatomical reductions with poor reductions. It is possible that these poorly reduced patients did better on the mental scores because of the severity of their initial injuries and the low expectations given pre-operatively. However, without correlation to fracture pattern, this is difficult to discern.

It is important to note that the scores found in these patients are very close to age-matched norms. The average SF-36 physical function score in the United States is 84.15, but this decreases to 53.2 over the age of 75. In our cohort the mean age was 67 years, the mean physical component score was 46, and the mean mental component score was 50.

We again found that CT scans evaluated acetabular reconstruction more accurately. Given the multiple comorbidities that these patients often have, we try to keep the operative time under four hours and minimise the invasiveness. These tactics help to reduce the physiological insult in this potentially frail patient population with little physiological reserve.

Although Matta et al had a 74% anatomical rate of reduction in patients under the age of 60, this was only 44% in patients over 60. In our study, the rate of anatomical reduction was also around 58% on plain radiographs, but only 11% as seen on CT in the dome. An anatomical reduction of fractures in these patients is possible in less than half, even in experienced hands. Elderly patients often have very poor bone quality and extensive comminution, which can make anatomical reduction difficult. This again emphasises that treatment of these injuries in the elderly is not only very complex, but should probably be carried out at a high-volume referral centre.

A weaknesses of this study is that the patients were not randomised to individual treatment groups, but this is true in all non-randomised studies. We had no control non-operative group against which to compare these outcomes. The literature is very sparse with regard to normative reference values in this population.

In our analysis, CT was much more discriminating in evaluating acetabular fractures in the elderly, but there was no significant correlation between the accuracy of reduction and the functional outcome scores. We have previously shown that surgical intervention in acetabular fractures in the elderly meeting the operative criteria

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Table II. Short-form 36 scored by component

<table>
<thead>
<tr>
<th>Component</th>
<th>Mean (range)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall physical component</td>
<td>46 (16 to 64)</td>
</tr>
<tr>
<td>Role physical</td>
<td>70 (0 to 100)</td>
</tr>
<tr>
<td>General health</td>
<td>65 (10 to 100)</td>
</tr>
<tr>
<td>Physical functioning</td>
<td>66 (10 to 11)</td>
</tr>
<tr>
<td>Bodily pain</td>
<td>75 (12.5 to 100)</td>
</tr>
<tr>
<td>Overall mental component</td>
<td>50 (26 to 63)</td>
</tr>
<tr>
<td>Social functioning</td>
<td>84 (0 to 100)</td>
</tr>
<tr>
<td>Vitality</td>
<td>88 (20 to 100)</td>
</tr>
<tr>
<td>Role emotional</td>
<td>72 (0 to 100)</td>
</tr>
<tr>
<td>Mental health</td>
<td>77 (32 to 100)</td>
</tr>
</tbody>
</table>

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according to our algorithm is safe and efficacious, with an acceptably low rate of major complications. Even if precise anatomical reduction is not possible, restoring gross alignment and bone stock is important. Acute stabilisation of an acetabular fracture allows pain control and immediate mobilisation, thereby avoiding the complications associated with immobilising elderly patients. Patients have equivalent functional outcomes, even with slightly worse radiological reduction than may be accepted in a younger population. Despite the grade of reduction overall being less when examined by CT, most patients did well. We now routinely use CT for post-operative evaluation of acetabular fractures in older patients.

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References