ORIGINAL ARTICLE

Acetabular fracture: Long-term follow-up and factors associated with secondary implantation of total hip arthroplasty

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Accepted: 10 December 2012

KEYWORDS
Acetabular fracture;
Total hip arthroplasty;
Long-term follow-up

Summary
Hypothesis: The present study sought to determine long-term outcome in acetabular fracture and the factors associated with secondary implantation of a total hip arthroplasty and/or with poor functional results.

Material and methods: Seventy-two patients admitted between 2000 and 2005 were followed up for a maximum 11 years (mean, 6.8 years): 16 females, 56 males; mean age at injury, 41.6 years (median, 40 years). There were 45 simple acetabular fractures, 27 complex fractures and 27 dislocations. Late complications were: osteoarthritis (n=29), osteonecrosis of the femoral head (ONFH: n=8) and heterotopic ossification (n=2).

Results and discussion: Twenty-five total hip arthroplasties (THA) were performed, with a mean time to surgery of 3.7 years. Associated factors for THA were: VAS (P<0.0001), PMA (P<0.0001), osteoarthritis (P<0.0001), ONFH (P<0.0002), initial dislocation (P=0.0002), no functional treatment (P=0.0014), surgical treatment (P=0.0065), initial traction (P=0.0068), anterior and posterior congruency defect (P=0.0072 and P=0.0001), and initial intra-articular foreign body (P=0.045). Factors associated with poor or bad functional results were the same, plus: etiology (P=0.0021), BMI (P=0.03) and posterior wall fracture (P=0.0325).

Level of evidence: 4; retrospective study.
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Introduction

About 3% of fractures seen in traumatology involve the acetabulum; the associated rate of short-term complications ranges from 50 to 80%, and depends on whether the initial trauma was high-energy, on immobilization following treatment and on surgical management, with long-term complications depending on the type of fracture,
which may have consequences that are hard to screen for initially. Although acetabular fracture is a focus of interest, few large series have been published over the years, some still standing as references today [1—7].

The basic principles of surgical management were established in the 1960s by Judet et al., who first described the underlying anatomy and mechanism [2]. Indications and approaches have been listed and discussed by both proponents and opponents, so that management is now well-formulated [8,9].

The present study reports results at 10 years’ follow-up, with an analysis of secondary total hip replacement (THR).

Material and method

A retrospective study was conducted on all patients presenting with acetabular fracture in the Emergency Department of the Pellegrin Hospital (Bordeaux, France) and admitted between January 1st, 2000 and January 1st, 2005, whether or not undergoing THA during the 10 years of follow-up.

Data included firstly general parameters: age, gender, occupation, smoking and alcohol status, body mass index (BMI) and pre-trauma American Society of Anesthesiologists (ASA) score.

Trauma etiology was classified as road accident, high fall, fall from body height or sports-related. Work accidents were also noted.

The Injury Severity Score (ISS) was determined from emergency medical records [10].

Patients were grouped according to lesion type on the Judet et al. classification [2], based on initial plain X-ray and systematic 3D CT reconstruction.

Treatment was classified as: functional, by simple non-weight-bearing immobilization; conservative, by 1 month's axial traction and 2 months' non-weight-bearing immobilization; or surgical after initial traction. Initial management was determined by fracture type, displacement, congruence, reduction following traction, presence of foreign body, and the surgeon's judgment.

For all patients undergoing conservative or surgical treatment, data for traction type and duration, hospital stay, intensive care, bed-rest-related complications, time to gait resumption and time to resumption of work and sports were collected.

For patients undergoing surgical treatment, data for pre- and post-operative neurological signs, surgical approach, trauma-to-surgery time, pre- and post-operative blood transfusion, surgeon-assessed satisfaction, and reduction quality according to Matta's criteria [11] were collected. Reduction with residual displacement less than 2 mm was considered satisfactory and greater than 2 mm dissatisfactory [12,13].

Long-term functional status was assessed by recontacting the patients to determine the Postel Merle d'Aubigné (PMA) score, current pain on a 0—10 visual analogue scale (VAS), pain-related activity restriction on the WHO scale, osteoarthritis on recent X-ray of the operated hip, and secondary THA with trauma-to-THA interval [14].

Systematic comparative radiologic analysis between the injured and non-injured hip screened for arthritic evolution and secondary heterotopic ossification on Brooker’s classification.

The number of patients requiring THA was recorded, with etiology and trauma-to-THA interval.

Various statistical analyses were performed, using the Fisher test, due to the small cohort size, on R software.

Search of the records for patients admitted between January 1st, 2000 and January 1st, 2005 with acetabular fracture retrieved 121 cases, only 72 of whom could be traced for follow-up functional assessment.

Of these 72 patients, 56 were males (78%) and 16 females (22%). Mean age was 41.4 years (range, 16—75; median, 40 years): 12 under 25 years, 39 between 26 and 50 years, and 21 between 51 and 75 years.

Etiology mainly concerned road accidents (69%) or high falls (21%), followed by simple falls (6%) and sports accidents (4%). There were only two work accidents. Mean ISS was 7.36 (range, 3—16; median, 7). Only 28% of acetabular fractures were isolated.

The 72 cases comprised 45 simple fractures and 27 complex fractures, with 27 associated dislocations (38%) and seven intra-articular foreign bodies (10%). Posterior wall fractures were the most frequent (25%), followed by transverse fractures (18%), associated posterior wall and transverse fractures (15%), anterior wall fractures (10%), anterior column fractures (10%), both-column fractures (8%), T fractures T (7%), posterior wall and posterior column fractures (4%), and anterior column plus semi-T fractures (3%). Initial dislocation was mainly associated with posterior wall fracture (13/27) or associated posterior wall and transverse fracture (7/27).

Fourteen of the 72 patients received functional, 28 conservative and 30 surgical treatments. Fifty-six had traction: 48 transfemoral and eight transstibial.

Surgical approaches were enlarged ilio-inguinal (1), Kocher Langenbeck (16), Mears or triradiate with trochanterotomy (11), plus one Hardinge approach for a primary THA. An ilio-femoral external fixator was used in one case. Mean time to surgery was 12.8 days (median, ten days; range, 1—72 days). Only three patients were operated on later than post-trauma day 20. Surgeon-assessed satisfaction after initial treatment was 90%.

Mean hospital stay was 26 days (range, 2—180; median, 20 days). 17% of the patients followed up had been through intensive care. Complications following trauma and hospitalization comprised: 11 sciatic deficits (all pre-operative, including six cases of paralysis related to proven initial dislocation), eight infections and one phlebitis. Nine of the cases of initial paralysis involved the whole sciatic territory, and the other two the external popliteal sciatic territory alone; only one case of sciatic paralysis showed no recovery, and another showed partial recovery despite secondary neurolysis. The eight infections comprised: three urinary infections, one infection of a second lesion site, one external fixator pin infection, and three surgical site infections (one superficial and two deep), one of which required material ablation with resection of the femoral neck and head. Non-weight-bearing was for a mean 69 days (range, 7—120 days).

Follow-up, when performed, was for a mean 6.8 years (range, 2.5 months to 11 years) post-trauma. Fifty-five patients (76%) returned to work and 37 (51%) resumed sport.
Mean BMI at last follow-up was 25 (range, 18−39). Forty-eight patients had BMI less than 25 and 24 greater than 25. The mean WHO score for post-traumatic change in subjective health status was 0.53 (range, 0−2), with an overwhelming majority showing no change in level or type of activity. Mean VAS score at end of follow-up was 3.25 (range, 0−10).

Mean PMA score was 14.4 (range, 3−18; median, 16). At end of follow-up, 44 patients showed excellent (17−18) or good (16−15) PMA scores, and 28 moderate (12−14) or poor (≤ 11).

Control X-ray diagnosed ONFH in eight cases (11%), osteoarthritis in 29 (40%) and secondary heterotopic ossification in only two cases (3%) on the Brooker classification, independently of initial treatment. Osteoarthritis was classified according to Kellgren and Lawrence (7 grade 1, 8 grade 2, 10 grade 3 and 4 grade 4) and to Tönnis (15 grade 1, 10 grade 2 and 4 grade 3) [15,16].

Twenty-five THAs were performed, at a mean 3.7 years (range, 2.5 months to 11 years) (Fig. 1); seven were secondary to ONFH, one to Chiron grade-4 femoral head fracture, seven following conservative treatment due to contraindications to anaesthesia for initial surgery, and ten following secondary osteoarthritis.

Results

Comparing patients with and without THA highlighted various associated factors, 47 of the 72 follow-up patients (65.3%) never underwent THA, versus 25 (34.7%) who did.

The two groups differed little in age or sex ratio, which did not emerge as associated factors (P = 0.59 and P = 0.55, respectively). Sixteen of the 25 THA patients were under and only 9 over 50 years of age (Fig. 2).

Mean BMI in the THA group was 26.2 and 24.4 in the non-THA group, which was not a significant difference (P = 0.1), nor was there a significant difference in BMI distribution between the two groups (P = 0.29) (Fig. 3).

Twenty-eight of the 47 patients without THA (60%) were victims of a road accident, 13 (28%) of a high fall, three (6%) of a simple fall and three (6%) of a sports accident; the corresponding figures for the 25 patients in the THA group were 22 road accidents (88%), two high falls (8%) and one simple fall (4%); i.e., etiology was not significantly correlated with secondary THA (P = 0.074).

Fourteen of the THA patients had isolated acetabular fracture, compared to six in the non-THA group (P = 0.78). Mean ISS scores were 7 and 8, respectively (P = 0.32), with no significant difference in distribution (P = 0.86).

A large majority of patients without THA had had a simple fracture: 11 of the posterior wall (23%), seven of the anterior wall (15%), six transverse (13%) and five of the anterior column (11%); the others had had complex fractures: five posterior wall and transverse (11%), four both-column (9%), two posterior wall and posterior column (4%), five T fractures (11%) and two anterior column and posterior semi-T fractures (4%) (Fig. 4). Ten of the 47 patients (21%) had initial hip dislocation, and two an intra-articular foreign body.
Likewise, a large majority of secondary THA patients had
had simple fractures: seven of the posterior wall (28%),
seven transverse (28%), and two of the anterior column;
the others had had complex fractures: 6 posterior wall and
transverse (24%), two both-column (8%), and one posterior
column and posterior column (Fig. 3). Seventeen of the 25
THA patients (68%) had initial hip dislocation, and five an
intra-articular foreign body. Hip dislocation, and intra-articular
foreign body were significantly associated with secondary
THA (P = 0.0002 and 0.045, respectively; no other correla-
tions with fracture type emerged.

Fourteen of the 47 non-THA patients underwent func-
tional treatment, 14 surgical treatments and 19 conservative
treatment; 16 of the 25 THA patients underwent surgical
treatment and nine conservative treatment. Only functional
and surgical treatment were significantly associated with,
respectively, non-performance (P = 0.0014) and performance
of secondary THA (P = 0.0065). Traction was also associated
with secondary THA (P = 0.0068) (Table 1).

Initial satisfaction with the reduction achieved by what-
ever treatment showed no significant difference between
the THA (84%) and non-THA (94%) groups (P = 0.23). Poor
congruence at the anterior and posterior walls, in contrast,
correlated significantly with secondary THA (P = 0.0072 and
P < 0.0001), whereas acetabular roof congruence did not
(P = 0.09) (Table 1).

In surgically managed patients, time to surgery was not
a significant factor in secondary THA. Regarding surgical
approach, only the Mears approach correlated with sec-
dary THA (P = 0.04).

At end of follow-up, non-THA patients had a mean VAS
score of 1.85 and mean PMA score of 16.2, versus 5.88 and
11.08 respectively in the THA group: VAS (P < 0.0001) and
PMA scores (P < 0.0001) were thus significantly associated
with secondary THA. End of follow-up radiologic control
found 11 cases of osteoarthritis and one ONFH but no het-
erotopic ossification in the non-THA group, compared to
18 cases of osteoarthritis, seven ONFHs and two heterotopic
ossifications on pre-operative X-ray in the THA group; ONFH
(P = 0.002) and osteoarthritis (P = 0.0001) were thus signifi-
cantly associated with secondary THA.

**Discussion**

Analysis of 121 files from the period January 2000 to January
2005 provided epidemiological data in agreement with the
recent literature. The ratio of one female to 3.2 males was
comparable to those of Mayo’s 1994 series of 161 cases and
to Chiu et al.’s 2000 series of 72 patients with a ratio of
about 1:2:5 [1,6,7,13,17–28].

Age distribution was also broadly similar to literature
reports, with a mean age of 41.5 years, a range of 16–70
years and a median of 38 years. Only Helfet et al.’s 1992
series stands out [29]. Age distribution, however, differed
according to trauma etiology, the mean age of road-accident
victims being lower than for simple falls.

There have been many reports of poor functional results
in patients aged more than 55 or 65 years, some authors
recommending surgery to avoid secondary disassembly of
the osteosynthesis [30–35]. Wright et al. in 1994 [12] and
Liebergall et al. in 1999 [28] even set an age limit of 40 years
for good outcome. In the present series, neither age nor
PMA score in the over-50-year-old were correlated with secondary
THA. In view of the poor results in elderly osteoporotic
patients, Spencer recommended restricting internal fixation
to younger subjects [32]. In the present series, there were
no cases of disassembly in over-50-year-old.

The role of prior health status in acetabular fracture
is to be borne in mind: early evolution varies greatly
according to BMI. The present results and those of Porter
et al. reveal overweight as a negative factor. Porter also
reported longer hospital stay, higher complications rates and
poorer functional outcome associated with osteoarthritis
and implantation surgery [36,37].

The predominant etiology is road accidents, to a variable
degree that seems to evolve over time, with early reports of
up to 96%. The present series showed a much lower rate, as
preventive legislation has greatly reduced the rate of seri-
ous road accidents: road accidents were associated with bad
functional results, but not with secondary THA.

The distribution of fracture types varies between series.
Letournel et al. [38], in a series of 910 patients, reported
55% simple fractures, whereas reports from the early 1990s
[6,17,22,28] found higher rates of complex fracture, corre-
sponding to the higher rate of road accident etiology. The
present study found 37% of simple and 63% of complex frac-
tures, both in the initial cohort of 121 patients and in the
72 patients followed up (Tables 2 and 3).

The present study, unlike the 2009 SOFCOT round-table
[39], found no association between initial ISS and sec-
dondary THA or poor functional results. The present rate of
complications was comparable to recent reports (Table 4).

At end of follow-up of the 72 patients, those with poste-
rior wall fracture seemed most at risk of a poor functional
result. Judet et al. reported 18% moderate or poor results

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Total hip arthroplasties (THA) and non-THA groups according to initial treatment, approach and quality of reduction and congruence.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>THA (n)</td>
</tr>
<tr>
<td>Functional treatment</td>
<td>0</td>
</tr>
<tr>
<td>Conservative treatment</td>
<td>9</td>
</tr>
<tr>
<td>Traction</td>
<td>24</td>
</tr>
<tr>
<td>Surgical treatment</td>
<td>16</td>
</tr>
<tr>
<td>Approach</td>
<td></td>
</tr>
<tr>
<td>Enlarged ilioinguinal</td>
<td>1</td>
</tr>
<tr>
<td>Kocher Langenbeck</td>
<td>7</td>
</tr>
<tr>
<td>Mears</td>
<td>7</td>
</tr>
<tr>
<td>External fixator</td>
<td>0</td>
</tr>
<tr>
<td>Hardinge</td>
<td>1</td>
</tr>
<tr>
<td>Reduction</td>
<td></td>
</tr>
<tr>
<td>&lt; 2 mm</td>
<td>84%</td>
</tr>
<tr>
<td>&gt; 2 mm</td>
<td>16%</td>
</tr>
<tr>
<td>Congruence</td>
<td></td>
</tr>
<tr>
<td>Anterior</td>
<td>56%</td>
</tr>
<tr>
<td>Posterior</td>
<td>12%</td>
</tr>
<tr>
<td>Roof</td>
<td>60%</td>
</tr>
</tbody>
</table>
for isolated posterior wall fracture and 24% for complex fracture involving the posterior wall [2]. Wright et al. reported seven out of 56 patients as requiring THA or arthrodexis, five of whom had posterior wall or transverse fracture [12]. Laird and Keating reported 18 THAs, half of which were related to posterior wall, transverse or complex posterior wall/transverse fracture [40]. Posterior wall fracture is of poor prognosis due to the high rate of comminution, inducing either real instability or posterior congruence defect leading to secondary osteoarthritis. Given the poor results in over-50-year-old despite good reduction, Kredel et al. therefore recommended primary THA for fractures involving the posterior wall [34].

Forty-eight percent of stress is transmitted to the superior part of the acetabular cartilage surface, 28% of which to the anterior and 24% to the posterior wall [41]. Posterior wall cartilage damage increases stress on the superior part of the acetabulum, with consequently increased risk of wear [41]. Likewise, transectal involvement with more than 2 mm displacement, in both-column or anterior column fracture, increases stress on the superior part of the acetabular surface, with consequent risk of osteoarthritic evolution [42–45]. Anatomic reduction counters these biomechanical modifications [45,46].

Many authors have highlighted the need for optimal reduction to improve functional results [17,22,47,48]. The learning curve for acetabular fracture surgery argues for management in reference centers [40]. Outcome also depends on initial dislocation or comminution of the dome and posterior wall, subsequent osteoarthritis, ONFH and heterotopic ossification, and also on the patient’s age [2,5,12,24,29,30,49,50]. Results for conservative management without surgery depend on traction reduction quality, and will be good if residual displacement is less than 3 mm and poor if more [51]. Intra-articular foreign bodies should also be investigated to prevent adverse evolution [35,50].

Acetabular fracture should be seen as a bipolar rather than a unipolar lesion. The present findings illustrate how, aside from certain types of fracture on the acetabular side, it is dislocation and the consequent involvement of the femoral head cartilage or ONFH that are significantly associated with poor functional results and secondary THA. Femoral head status should be assessed before undertaking treatment [28]: 20% of patients with femoral head fracture require THA within 6 months [52].

Madhu et al. showed, in 2006, that interval to surgery played a significant role in achieving anatomic reduction and in medium-term functional results with both simple and complex fractures: the optimal interval is between 10 and 15 days for a good or excellent result, and five to 15 days for anatomic reduction [25]. Moreover, later surgery increases the risk of ONFH [53].

<table>
<thead>
<tr>
<th>Authors</th>
<th>Sex ratio M/F</th>
<th>Mean age</th>
<th>Number</th>
<th>Etiology</th>
<th>Mean FU yrs</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heeg et al. [18]</td>
<td>4.4/1</td>
<td>34</td>
<td>54</td>
<td>96</td>
<td>38</td>
</tr>
<tr>
<td>Ruesch et al. [19]</td>
<td>2.56/1</td>
<td>40</td>
<td>12</td>
<td>94</td>
<td>0</td>
</tr>
<tr>
<td>Mayo [1]</td>
<td>1.82/1</td>
<td>31</td>
<td>14</td>
<td>78</td>
<td>15</td>
</tr>
<tr>
<td>de Ridder et al. [20]</td>
<td>2.26/1</td>
<td>46</td>
<td>17</td>
<td>19</td>
<td>23</td>
</tr>
<tr>
<td>Helfet et Schmeling [6]</td>
<td>2.65/1</td>
<td>41</td>
<td>12</td>
<td>67</td>
<td>20.20</td>
</tr>
<tr>
<td>Alonso et al. [21]</td>
<td>1.56/1</td>
<td>32</td>
<td>15</td>
<td>95</td>
<td>5</td>
</tr>
<tr>
<td>Liebergall et al. [28]</td>
<td>1.4/1</td>
<td>36.4</td>
<td>17</td>
<td>90</td>
<td>10</td>
</tr>
<tr>
<td>Chiu et al. [17]</td>
<td>2.43/1</td>
<td>51</td>
<td>18</td>
<td>60</td>
<td>0</td>
</tr>
<tr>
<td>Deo et al. [22]</td>
<td>6/1</td>
<td>36</td>
<td>16</td>
<td>76</td>
<td>24</td>
</tr>
<tr>
<td>Murphy et al. [7]</td>
<td>4.56/1</td>
<td>29</td>
<td>14</td>
<td>80</td>
<td>20</td>
</tr>
<tr>
<td>Kumar et al. [23]</td>
<td>11/1</td>
<td>39.5</td>
<td>15</td>
<td>64.40</td>
<td>24.70</td>
</tr>
<tr>
<td>Im et al. [26]</td>
<td>6.5/1</td>
<td>41</td>
<td>21</td>
<td>93</td>
<td>7</td>
</tr>
<tr>
<td>Oh et al. [24]</td>
<td>2.75/1</td>
<td>46.6</td>
<td>22</td>
<td>80</td>
<td>20</td>
</tr>
<tr>
<td>Madhu et al. [25]</td>
<td>5/1</td>
<td>36.7</td>
<td>17</td>
<td>76</td>
<td>24</td>
</tr>
<tr>
<td>Gupta et al. [27]</td>
<td>38.4</td>
<td>19–68</td>
<td>63</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>SOFCOT 2009</td>
<td>3.14/1</td>
<td>43</td>
<td>14–86</td>
<td>83</td>
<td>6</td>
</tr>
<tr>
<td>Present series</td>
<td>3.2/1</td>
<td>41.4</td>
<td>16–90</td>
<td>72</td>
<td>70.25</td>
</tr>
</tbody>
</table>

Table 2 Comparison of acetabular fracture epidemiology data in main published series.
<table>
<thead>
<tr>
<th>Author</th>
<th>Period</th>
<th>Number</th>
<th>Mean FU</th>
<th>Etiology</th>
<th>Sex ratio/f</th>
<th>Mean age</th>
<th>Simple fracture</th>
<th>Complex fracture</th>
<th>Time to surgery</th>
<th>Approach</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rommenset et al. [50]</td>
<td>1998–2005</td>
<td>77 FU</td>
<td>45 m</td>
<td>38</td>
<td>4</td>
<td>4.5/1</td>
<td>54.60%</td>
<td>13 complex</td>
<td>4d</td>
<td>41 L, 36 KL</td>
</tr>
<tr>
<td>Sen and Veerappa [51]</td>
<td>1994–2002</td>
<td>32 FU</td>
<td>4.1 yrs (2–12)</td>
<td>29/3</td>
<td>42 (15–66)</td>
<td>19 simple (8 pw, 2 ac, 9 tran)</td>
<td>45%</td>
<td>NS</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td>Gupta et al. [27]</td>
<td>1997–2003</td>
<td>63 FU</td>
<td>53 m (37–96)</td>
<td>NS</td>
<td>38.4 (19–68)</td>
<td>23.80%</td>
<td>76.19%</td>
<td>12.33d (4–30)</td>
<td>47.6% KL, 22.2% L, 9.5% Mears, 3.2% IFE, 17.5% KLIF</td>
<td></td>
</tr>
<tr>
<td>Giannoudis et al. [33]</td>
<td>1995–2003</td>
<td>29 FU</td>
<td>35 m (24–90)</td>
<td>28</td>
<td>N5</td>
<td>1</td>
<td>26/3</td>
<td>42 (19–79)</td>
<td>29 pw</td>
<td>6d (0–18)</td>
</tr>
<tr>
<td>Ebraheim et al. [47]</td>
<td>1998–2004</td>
<td>32</td>
<td>43 m (24–70)</td>
<td>29</td>
<td>2</td>
<td>1</td>
<td>25/7</td>
<td>41 (14–80)</td>
<td>32 pw</td>
<td>KL</td>
</tr>
<tr>
<td>Madhu et al. [25]</td>
<td>1991–2003</td>
<td>254 FU</td>
<td>2.9 yrs (2–4)</td>
<td>193 (76%)</td>
<td>31 (24%)</td>
<td>212/42</td>
<td>36.7 (17–81)</td>
<td>105 (41%)</td>
<td>149 (59%)</td>
<td>15 L, 12 KLTrocht, 5 Mears</td>
</tr>
<tr>
<td>Oh et al. [24]</td>
<td>1994–2003</td>
<td>15 tran</td>
<td>43 m (24–84)</td>
<td>12</td>
<td>3</td>
<td>11/4</td>
<td>46.6 (22–74)</td>
<td>7 tran</td>
<td>8 tran pw</td>
<td>6.4d (1–14)</td>
</tr>
<tr>
<td>Laird and Keating [40]</td>
<td>1988–2003</td>
<td>351 FU</td>
<td>33 m (12–96)</td>
<td>134 + 29</td>
<td>96 + 45</td>
<td>1 (+46 nc)</td>
<td>231/120</td>
<td>50 (16–98)</td>
<td>90</td>
<td>138h (3–576)</td>
</tr>
<tr>
<td>Im et al. [26]</td>
<td>1996–98</td>
<td>15 FU</td>
<td>3.5 (3–4.2 yrs)</td>
<td>14</td>
<td>1</td>
<td>13/2</td>
<td>41 (21–61)</td>
<td>1T</td>
<td>26 II, 41 KL, 5 Mears, 1 II KL</td>
<td></td>
</tr>
<tr>
<td>Kumar, 2004</td>
<td>1994–2000</td>
<td>72op73frac</td>
<td>45 m (24–96)</td>
<td>47</td>
<td>18</td>
<td>3 + 5 other</td>
<td>66/6</td>
<td>39.5 (15–76)</td>
<td>34</td>
<td>d11.7 (1–35)</td>
</tr>
<tr>
<td>Murphy et al. [7]</td>
<td>1986–1996</td>
<td>176 FU</td>
<td>2–10 yrs (6.3)</td>
<td>80%</td>
<td>144/82</td>
<td>29 (14–76)</td>
<td>84 (47%)</td>
<td>96 (53%)</td>
<td>d6 (2–18)</td>
<td>140 KL, 8 II, 3 KL II</td>
</tr>
<tr>
<td>Russel, 2001</td>
<td>1993–1997</td>
<td>131 FU</td>
<td>127</td>
<td>4</td>
<td>89/42</td>
<td>48 pw, 9 tran, 8 pc</td>
<td>66% = 20 both C, 17 Tranpw, 7 ac st, 4 pc pw, 3T</td>
<td>8.6 (1–36)</td>
<td>d8.6 (1–36)</td>
<td></td>
</tr>
<tr>
<td>Deo et al. [22]</td>
<td>1991–1996</td>
<td>79 FU</td>
<td>6 m and 5 yrs</td>
<td>76%</td>
<td>24%</td>
<td>6/1</td>
<td>36 (16–81)</td>
<td>34% = 13 tran, 8 pw, 5 ac, 2 pc</td>
<td>38% KL, 24% II, 20% Mears, 15% II KL, 3% IFE</td>
<td></td>
</tr>
<tr>
<td>Saterbak et al. [49]</td>
<td>1987–1994</td>
<td>42 FU</td>
<td>49 m (24–104)</td>
<td>38</td>
<td>4</td>
<td>35 (20–78)</td>
<td>20 pw</td>
<td>18 pwT or 2 pw pc</td>
<td>7 (2–18)</td>
<td>35 KL, 7 Mears</td>
</tr>
</tbody>
</table>

Pw: posterior wall; ac: anterior column; pc: posterior column; tran: transverse; sT: semi T
<table>
<thead>
<tr>
<th>Author</th>
<th>Dislocation</th>
<th>Head fracture</th>
<th>Infection</th>
<th>Neuro complications</th>
<th>Vasc complications</th>
<th>Non-union</th>
<th>ONFH</th>
<th>Ossif</th>
<th>OA</th>
<th>THA</th>
<th>Satisfactory (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Present series 2011</td>
<td>27 disloc, 7 FB</td>
<td>1 grade 4</td>
<td>8 inf</td>
<td>9 sci + 2 eps</td>
<td>1 phleb</td>
<td>0</td>
<td>8 ONFH</td>
<td>2 ossif</td>
<td>29 OA</td>
<td>25 THA</td>
<td>67</td>
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<tr>
<td>Rommenset al. [50]</td>
<td></td>
<td></td>
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<tr>
<td>Sen and Veerappa [51]</td>
<td>10l disloc, 20 protr</td>
<td></td>
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<td></td>
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<tr>
<td>Gupta et al. [27]</td>
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</tr>
<tr>
<td>Giannoudis et al. [33]</td>
<td>27 disloc</td>
<td>25 FB, 3 head, 11 impaction, 21 comminution</td>
<td>6 sciat</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>Ebraheimet al. [47]</td>
<td>NS</td>
<td></td>
<td>2 infect</td>
<td></td>
<td></td>
<td></td>
<td>1 ONFH (disloc)</td>
<td>6 ossif (18%)</td>
<td>1 OA</td>
<td></td>
<td>74%</td>
</tr>
<tr>
<td>Madhu et al. [25]</td>
<td>42.5% disloc</td>
<td>15% head, 9% FB</td>
<td>28 sciat (11%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oh et al. [24]</td>
<td>7 roof comminution</td>
<td>NS</td>
<td>1 sciat</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3 ossif</td>
<td>4 OA</td>
<td></td>
<td>9/15 excellent and good</td>
</tr>
<tr>
<td>Laird and Keating [40]</td>
<td></td>
<td></td>
<td>10 inf</td>
<td>17 sciat</td>
<td>6 phleb</td>
<td></td>
<td>9 ONFH</td>
<td>22 OA</td>
<td>18 THA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Im et al. [26]</td>
<td>14 disloc (93%) inc 4 reduced after 12 h</td>
<td>2 pipkin II (14%)</td>
<td>1 sciat postop</td>
<td></td>
<td></td>
<td></td>
<td>1 ONFH</td>
<td>1 ossif</td>
<td></td>
<td></td>
<td>94</td>
</tr>
<tr>
<td>Kumar, 2004</td>
<td>24 disloc (33%)</td>
<td>2 infection 2.7%</td>
<td>NS</td>
<td></td>
<td></td>
<td>3 ONFH (inc 2 disloc)</td>
<td>3 ossif (4.2%)</td>
<td></td>
<td>4 THA</td>
<td></td>
<td>75</td>
</tr>
<tr>
<td>Yu, 2003</td>
<td></td>
<td></td>
<td>2 sciatpreop</td>
<td></td>
<td></td>
<td>1 ONFH</td>
<td>3 ossif</td>
<td></td>
<td></td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Author</td>
<td>Dislocation</td>
<td>Head fracture</td>
<td>Infection</td>
<td>Neuro complications</td>
<td>Vasc complications</td>
<td>Non-union</td>
<td>ONFH</td>
<td>Ossif</td>
<td>OA</td>
<td>THA</td>
<td>Satisfactory (%)</td>
</tr>
<tr>
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</tr>
<tr>
<td>Murphy et al. [7]</td>
<td>49 disloc</td>
<td>NS</td>
<td>32 sciat</td>
<td>NS</td>
<td>NS</td>
<td>70 ossif</td>
<td>NS</td>
<td>NS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Russel, 2001</td>
<td>82 disloc, 5 protru</td>
<td>2 osteos diss, 1 infection</td>
<td>9 sciat and 11 eps</td>
<td>3 vasc, 36 DVT, 2 PE</td>
<td>NS</td>
<td>NS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Deo et al. [22]</td>
<td>1 open fract, 17% acet + pelvic fract, 38% disloc</td>
<td>5 head</td>
<td>3 infect (4%)</td>
<td>18 (23%) sciat inc 3 total</td>
<td>0</td>
<td>NS</td>
<td>6 ONFH (8%)</td>
<td>7 ossif</td>
<td>16% OA</td>
<td>9 THA in 2 yrs (11%)</td>
<td>74</td>
</tr>
<tr>
<td>Saterbak et al. [49]</td>
<td>25 disloc</td>
<td>1 infect</td>
<td>6 sciat + 2iatro</td>
<td>NS</td>
<td>3 ONFH</td>
<td>NS</td>
<td>3 OAs</td>
<td>6 + 1 THA and 2arthrodoses</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chiu et al. [17]</td>
<td>2 infect</td>
<td>6 + 1 sciat postop (1.6%)</td>
<td>1 vasc (1.6%), 1 phleb (1.6%)</td>
<td>0</td>
<td>4 ONFH (5.6%)</td>
<td>20 ossif (27.8%)</td>
<td>10 OA</td>
<td>1 prim THA + 10 THA</td>
<td>81.90</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*FB: foreign body; DVT: deep venous thrombosis; PE: pulmonary embolism; EPS: external popliteal sciatic.*
The only contraindication to surgery is the risk of weak osteosynthesis in osteoporotic patients, of whatever age [8,11,29]. Some authors recommend primary THA with a reinforcement ring, to prevent osteoporosis-related risks [54–58]. Early THA in elderly patients allows early resumption of weight-bearing, although this varies according to assembly stability, and limits the problems of secondary intervention (fibrosis, malunion, non-union and ossification), with a risk of inferior acetabular loosening [59–62].

Mean time to THA in the present series was 3.7 years, compared to 7.3 years in Romness’ series [60]. Most were performed within 3 years of fracture. In 1989 Romness cited ONFH rates following acetabular fracture ranging from 2 to 40% depending on the series [60]; subsequently, Letournel et al. reported 5.4%, Johnson et al. 13.8%, and Mayo 0.5% [1,53].

We recommend bipolar joint examination rather than unipolar examination centered on the acetabulum in case of THA. Although the present acetabular reduction satisfaction rate was comparable to other reports, for one-third of the patients undergoing secondary THA the femur was implicated, either by ONFH or by fracture of the head. A second third of THAs were related to initial conservative management for medical reasons, with major acetabular reduction defect. The final third concerned bipolar involvement by osteoarthritis. Seventeen THA patients had had initial dislocation, with femoral head cartilage lesions; these should be systematically investigated initially on CT scan or MRI, so that lesion age and severity can be taken into account in considering primary THA as a means of improving outcome [52].

Primary THA for acetabular fracture should be considered in case of femoral head fracture or comminutive posterior wall fracture and according to any degenerative or traumatic femoral head cartilage lesion and to the patient’s age.

Conclusion

The present study highlights the importance of initial reduction. It also demonstrates the importance of correct assessment and management of both acetabular and femoral head involvement for the assessment of the risk of ONFH, secondary osteoarthritis and general functional impairment liable to require secondary THA. It is essential to assess both acetabular cartilage status and impaction and femoral cartilage status, so as to guide treatment strategy.

Disclosure of interest

The authors declare that they have no conflicts of interest concerning this article.

References