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Acetabular fractures

A 16-YEAR PROSPECTIVE EPIDEMIOLOGICAL STUDY

A. Laird,
J. F. Keating

From the Royal Infirmary, Edinburgh, Scotland

We prospectively analysed the epidemiology of acetabular fractures over a period of 16 years in order to identify changes in their incidence or other demographic features. Our study cohort comprised a consecutive series of 351 patients with acetabular fractures admitted to a single institution between January 1988 and December 2003.

There was no significant change in the overall incidence of acetabular fractures, which remained at 3 patients/100 000/year. There was, however, a significant reduction in the number of men sustaining an acetabular fracture over the period ($p < 0.02$). The number of fractures resulting from falls from a height < 10 feet showed a significant increase ($p < 0.002$), but there was no change in those caused by motor-vehicle accidents. There was a significant reduction in the median Injury Severity score over the period which was associated with a significant decrease in mortality ($p < 0.04$) and a reduction in the length of hospital stay. The incidence of osteoarthritis noted during follow-up of operatively-treated fractures declined from 31% to 14%, reflecting improved results with increasing subspecialisation. Our findings suggest that there will be a continuing need for some orthopaedic surgeons to specialise in the management of these fractures. In addition, the reductions in the Injury Severity score and mortality may be associated with improved road and vehicle safety.

The surgical management and subsequent outcome of acetabular fractures are well documented.[1-7] Open reduction and internal fixation is suitable for most patients with incongruity or instability of the hip.[7] However, acetabular fractures are not common. In most published studies the majority were sustained in road traffic accidents. There have been significant improvements in automobile safety in the last two decades[8,9] and most industrialised countries have introduced stringent legislation limiting speed and imposing restrictions on the alcohol consumption of drivers. These changes have been thought to contribute to a decline in the incidence of acetabular fractures. In the UK, specialist service provision for these injuries remains unsatisfactory.[10,11]

The literature on the epidemiology of acetabular fractures is scant. Gansslen et al[12] studied the epidemiology of injuries to the pelvic ring and found that most were the result of road-traffic accidents. More recent publications have suggested that the incidence of acetabular fractures has decreased with the introduction of seatbelt legislation.[8,13] To date, however, there has been a limited amount of British research into the management of these fractures[10,14,15] and no study of their epidemiology. Our aim, therefore, was to analyse the epidemiology of acetabular fractures over a period of 16 years in order to determine whether there had been any significant change either in their incidence or other demographic features.

Patients and Methods

We undertook this study at the trauma unit of the Royal Infirmary of Edinburgh. The estimated mean catchment population of the unit was 602 897 over the period between January 1988 and December 2003.[16] The population is relatively stable with an annual rate of migration of 0.5%. The unit provides definitive orthopaedic treatment for all major trauma in Edinburgh and surrounding areas, including all patients with acetabular fractures.

Data for all patients admitted to the trauma unit were collected prospectively at the time of presentation and stored in a database. Basic details including age, gender, the mechanism of injury, the site of injury and the nature of treatment were recorded. We used this database to identify all patients who had sustained an acetabular fracture during the period of study.

■ A. Laird, Medical Student
College of Medicine and Veterinary Medicine, University of Edinburgh Medical School, Teviot Place, Edinburgh EH8 9AG, UK.

■ J. F. Keating, FRCS Ed(Orth), Consultant Orthopaedic Surgeon
Department of Orthopaedic Trauma
Royal Infirmary, Little France, Old Dalkeith Road, Edinburgh EH16 4SU, UK.

Correspondence should be sent to Mr J. F. Keating; e-mail: john.keating@ed.ac.uk

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Based upon a previous analysis of this database the mean accuracy was 98.3% (95.6 to 99.7).[17]

We then undertook an analysis of all of these cases. Patient records were retrieved. Any miscoded patients were excluded, but both local and tertiary referral patients were included. Patients with fractures of the pubic ramus and pelvic fractures not involving the acetabulum were also excluded. The fractures were evaluated using plain anteroposterior radiography augmented by oblique Judet views.[18] CT was used in displaced fractures or in cases of high fractures of the superior pubic ramus in which there was uncertainty about acetabular involvement. From 1994 the fractures were classified using the Letournel[6] system prospectively. Those occurring between 1988 and 1993 were classified retrospectively based upon an analysis of the radiographs and CT scans by the senior author (JFK). Associated injuries, management and complications were recorded on a computer database for subsequent analysis. Patients who had sustained bilateral acetabular fractures were recorded in the database on only one occasion.

Patients with displaced fractures were considered for treatment by internal fixation. Instability of the hip or incongruity on plain radiographs and Judet views were the main reasons for this. Incongruity of > 3 mm on any plain radiograph was regarded as an indication for surgery if there were no contraindications. Non-operative treatment was considered for elderly patients and for those with transverse fractures and fractures of the low anterior column and both columns with secondary incongruence.

Throughout the study our standard thromboprophylactic regime was subcutaneous 5000 IU of heparin twice daily. For those patients with multiple injuries and hypotension this was withheld until haemorrhage had been controlled and any coagulopathy had been reversed.

Patients with undisplaced fractures were followed up until union. Our protocol is to follow-up patients with displaced fractures treated by internal fixation for two years or longer if indicated because of the development of complications. The mean follow-up period was 33 months (12 to 96).

The resulting data set comprised 351 patients of whom 231 (65.8%) were men and 120 (34.2%) were women.

The data set was used to analyse changes in the following: 1) incidence over time; 2) incidence of displaced/undisplaced fractures over time; 3) trends in age and gender; 4) alteration in the mechanism of injury; 5) changes in the nature of the types of fracture; 6) patterns of associated injury (Injury Severity score[19] (ISS)); 7) mortality; and 8) other outcomes – total hip replacement, avascular necrosis of the femoral head, symptomatic deep vein thrombosis and palsy of the sciatic nerve.

In addition to analysing these changes over the study period, we also compared the results during three separate time intervals: 1) 1988 to 1992; 2) 1993 to 1997; and 3) 1998 to 2003.

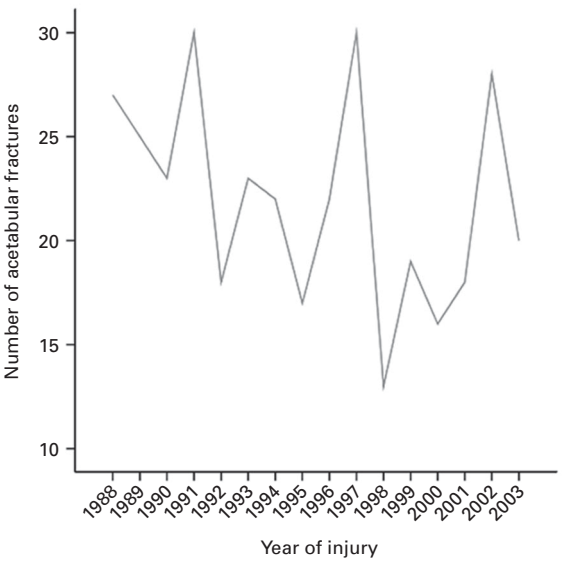

Fig. 1

Graph showing incidence of all acetabular fractures over time.

Statistical analysis. The chi-squared test was used for categorical data and the Kruskal-Wallis non-parametric analysis of variance for non-parametric data and analysis of variance for parametric data (SPSS for Windows version 12.0; SPSS, Chicago, Illinois). Values for $p < 0.05$ were regarded as significant.

Results

Incidence over time. Between 1998 and 2003, our unit treated 84 493 adults. Of these, 351 had sustained an acetabular fracture. There was no change in the overall incidence of these fractures over the 16-year period (Fig. 1). The breakdown of the results into the three time periods showed 123 cases between 1988 and 1992, 114 between 1993 and 1997, and 114 between 1998 and 2003. This relates to an insignificant decrease in the mean number of cases each year from 24.6 to 22.8 to 19 in these time periods, respectively (analysis of variance, $p = 0.24$). Of the original cohort of 351 patients, 274 (78%) were from our local catchment area and 77 (22%) were tertiary referrals. Exclusion of these tertiary referral patients from our analysis did not alter the findings in relation to the incidence of fractures. With the estimated mean catchment adult population of 602 897 over the period of study, the annual incidence of acetabular fractures in the local population was therefore 3 patients/100 000/year.

Incidence of displaced/undisplaced fractures over time. Of the 351 acetabular fractures, 219 were displaced and 132 undisplaced. Over the three time periods (1988 to 1992, 1993 to 1997, 1998 to 2003) the number of displaced fractures changed from 75 to 79 to 62 and the number of undisplaced fractures from 48 to 32 to 52, respectively. However, there was no significant overall change in the distribution of

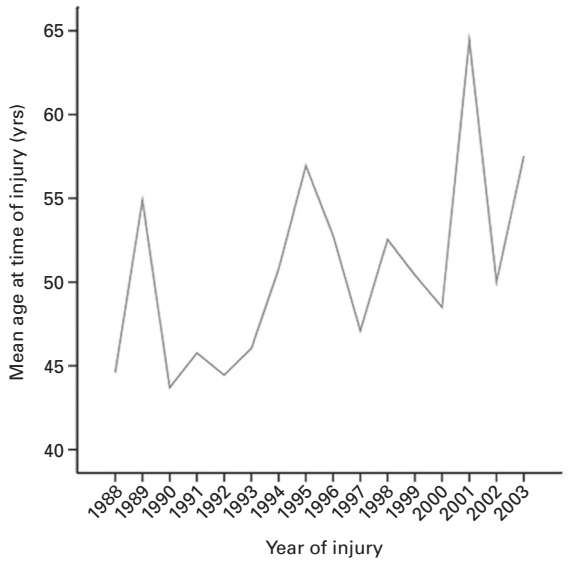

Fig. 2

Graph showing mean age at time of injury by year.

Table I. Classification of the acetabular fractures according to Letournel[6]

	Number (%)	
Classified		
Posterior wall	38	(*23.3*)
Posterior column	11	(*6.7*)
Anterior wall	3	(*1.8*)
Anterior column	24	(*14.7*)
Transverse	14	(*8.6*)
T-shaped	18	(*11.0*)
Posterior column/posterior wall	7	(*4.3*)
Transverse posterior wall	15	(*9.2*)
Anterior column/posterior hemitransverse	11	(*6.7*)
Both columns	22	(*13.5*)
Total	163	(*100.0*)
Not classified	188	
Total	351	

displaced and undisplaced fractures (Kruskal-Wallis analysis of variance, $p = 0.3$).

All 132 undisplaced fractures were managed conservatively. Of the 219 displaced acetabular fractures, 153 underwent open reduction and internal fixation while 66 were managed conservatively. Of those treated surgically, the mean time from injury to surgery was 138 hours (3 to 576). The mean length of hospital stay for all patients with an acetabular fracture was 24 days (1 to 238). This declined from 33 days at the beginning of the study to 19 days by the end ($p < 0.001$).

Trends in age and gender. The mean age of patients sustaining an acetabular fracture between 1998 and 2003 was 50 years (16 to 98). The mean age of those with displaced fractures was 46.8 years (16 to 96) and those with undisplaced fractures was 55.6 years (16 to 98). There appeared to be an increase in the mean age of the patients during this time (Fig. 2). For the three time intervals, the mean age increased from 46.8 years (16 to 98) to 50.2 (16 to 95) to 53.7 (16 to 97), respectively. These differences were not significant (analysis of variance, $p = 0.07$).

During the period of 1988 to 1992, the male-to-female predominance was 75% to 25%, between 1993 and 1997 it was 63% to 37% and between 1998 and 2003 it was 59% to 41%. This slight increase over time in the incidence among women was statistically significant (chi-squared test; $p < 0.02$).

Alteration in the mechanism of injury. Of the 351 fractures, 39 (11.1%) were of an unknown aetiology or the data had not been recorded. The four main mechanisms of injury were motor-vehicle accidents (134 patients, 38.2%), falls from heights < 10 feet (96 patients, 27.4%), falls from heights > 10 feet (45 patients, 12.8%), and pedestrians hit by a vehicle (29 patients, 8.3%). Other mechanisms included assault (one) sport and (one) crush injuries (six).

There was a statistically significant change in the mechanism of injury between 1988 and 2003 (Kruskal-Wallis test, $p < 0.013$). Over the three periods of time, the number of acetabular fractures resulting from motor-vehicle accidents decreased from 48 to 44 to 42. The number of fractures resulting from falls from heights < 10 feet showed a significant increase from 21 (17%) to 32 (28%) to 43 (38%) ($p < 0.02$). Falls from heights > 10 feet showed no significant change in trend with a subtle decrease over the three time periods of 18 (15%) to 14 (12%) to 13 (11%). Those acetabular fractures caused by pedestrian accidents showed a slight downward trend from 15 (12%) to nine (8%) to five (4%) patients. There was no change in the pattern of displaced and undisplaced fractures related to each mechanism of injury.

Changes in the type of fracture. We used the Letournel system to classify 163 (46.4%) displaced fractures. The remaining 188 (53.6%) (displaced and undisplaced) were not classified. The 56 displaced fractures treated earlier in the study could not be classified accurately since the original radiographs were not available. Fractures of the posterior wall were the most common with no change in the incidence of subtypes of fracture being seen over the period of study (Table I).

Patterns of associated injury. The ISS was calculated for 313 patients (89%). Adequate data were not available to calculate the score for the remaining 38 (11%). However, the median score showed a downward trend (Fig. 3) over the period of study. Over the three time periods, it decreased from 16 (n = 105) to 12 (n = 105) to 10 (n = 103). The difference between the first and third time periods was significant ($p < 0.007$).

Mortality. There was a reduction in mortality associated with acetabular fractures. A total of 17 patients died from their acetabular fracture and associated injuries. There were nine deaths between 1998 and 1992, seven between 1993 and 1997 and one between 1998 and 2003. This

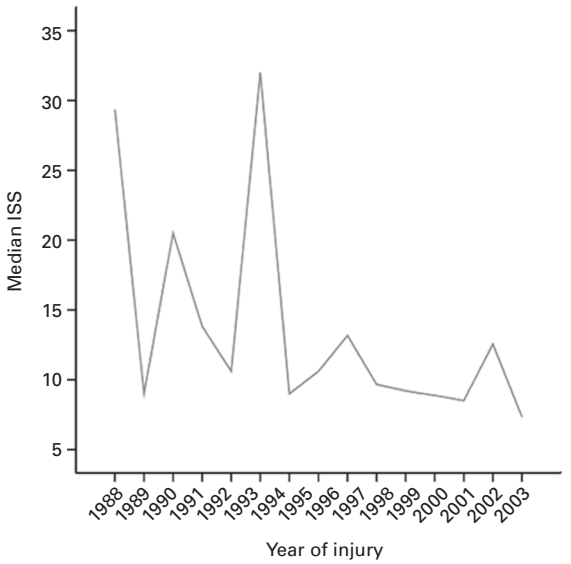

Fig. 3

Graph showing median Injury Severity score[19] (ISS) over time.

change was significant (chi-squared test, $p < 0.04$). Of those who died, nine had multiple trauma with a median ISS of 41. The remaining eight patients were elderly with a mean age of 81 (65 to 92) years and died from general medical complications. The decline in mortality could be explained by the reduction in the number of severely traumatised patients over the period of study.

Other outcomes. A symptomatic deep venous thrombosis occurred in six (3%) of 219 patients with displaced fractures. Sixty-six (30%) of these patients did not undergo surgery. Of these, 13 (6%) died from multiple injuries before surgery could be performed. The main indication for non-operative treatment in 27 (12%) patients was advanced age (> 70 years). For the remaining 26 patients, the indications for non-operative treatment was a small anterior or posterior wall fragment in four (17%) patients, a low anterior column fracture in seven (26%), a low transverse fracture in seven (26%) and a both-column fracture with secondary congruence in eight (30%). Palsy of the sciatic nerve occurred in 17 (7.8%) patients with the displaced fractures in 15 (6.8%) of which it was present before surgery and in two (1%) it occurred in the early post-operative period. Six patients had full recovery, six partial recovery and four no recovery. One of the patients with palsy of the sciatic nerve died.

Infection was a complication in ten (6.5%) of the operatively-treated patients. There were three superficial and seven deep infections. There were five infections in the first period, two in the second and three in the third. The differences were not significant (chi-squared test, $p = 0.25$). The incidence of infection between 1988 and 1992 was 15%, declining to 5.6% after this period, although this difference did not achieve statistical significance. Avascular necrosis occurred in nine (4%) of the displaced fractures.

Post-trumatic osteoarthritis occurred in 22 patients (14%) treated operatively. The osteoarthritis in 18 (12%) became sufficiently symptomatic to require a total hip replacement. The incidence of osteoarthritis after fixation declined from 31% in the early years (1988 to 1992) to 14% in the subsequent years of our study ($p < 0.04$). Patterns of injury with transverse or posterior involvement were most often associated with the need for total hip replacement (posterior wall, five; transverse, two; T-shaped, five; transverse/posterior wall, two; both columns, four).

Discussion

Our study has analysed data from a well-defined catchment population over a period of 16 years in order to document any change in the epidemiology of acetabular fractures. Perhaps our most surprising finding was the lack of any major change in most of the parameters analysed. In particular, there was no significant change in the incidence of acetabular fractures during this period of time and no change in the proportion of displaced fractures. We expected to find that motor-vehicle accidents as a cause of acetabular fractures may be in decline, but obtained no evidence of this. The only significant change in the mechanism of injury was a modest increase in simple falls as a cause of fracture.

However, there were some changes in epidemiology. There was an increase in the proportion of women with these injuries and a significant reduction in the mortality over the period. This latter feature may reflect a reduction in multiple trauma shown by the fall in the ISS over the period. This fall may also account for other changes, including the shorter length of hospital stay over the period of study.

We believe that our findings are an accurate representation of trends for these injuries. The catchment population was relatively large, with a reasonable cohort of patients with acetabular fractures and data were collected prospectively for the entire period. Furthermore, the size of the population altered very little during this time, and all patients with trauma were treated at one centre. There is no other centre in our region carrying out arthroplasty surgery. We are therefore confident that our estimation of the incidence of late osteoarthritis and avascular necrosis requiring a total hip replacement is an accurate reflection of the magnitude of this problem.

Many earlier studies suggested that most acetabular fractures are caused by road-traffic accidents. Letournel[6] noted an increase in the number of acetabular fractures as the number of motor-vehicles increased, while Al-Qahtani and O'Connor[8] and Blum et al[13] showed a reduction in the incidence and severity of acetabular fractures in the five years after the requirement to use seat belts had been introduced. Our study examined the incidence of acetabular fractures after the introduction in 1983 of seat-belt legislation in the

UK. This variable was thus excluded as a modifier in our investigation.

With the passage of time other factors which might have influenced road-traffic accidents and which should be taken into account, included the continued improvement in the design of motor vehicles and the introduction of road-safety measures such as the stringent enforcement of speed and alcohol restrictions. The fall in mortality and multiple trauma may be a consequence of these measures although there has been no apparent associated decrease in the incidence of acetabular fractures.

Although our main aim was not to evaluate outcome, our findings are similar or slightly better than those published elsewhere in relation to the incidence of complications and the subsequent development of osteoarthritis.[7] Notably, the incidence of osteoarthritis in our cohort declined significantly over the period. The reported incidence of osteoarthritis in the literature is 26.6%.[7] In our study it declined from 31% to 14%. This perhaps reflects the learning curve in the management of these injuries. However, since 1994 almost all acetabular fractures have been treated by the senior author, supporting the view that the development of specialist expertise is associated with better results.

Our findings suggest that, although acetabular fractures are uncommon, they are not in decline and will continue to occur at a steady rate. This needs to be taken into account when planning services for their management. There will be a continuing need for surgeons trained in the management of these injuries, working in specialist centres with the ancillary expertise available. This will ensure that the best outcome can be achieved for most patients.

Supplementary Material

A further opinion by Mr Martin Bircher is available with the electronic version of this article on our website at www.jbjs.org.uk

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

1. **Rice J, Kaliszer M, Dolan M, et al.** Comparison between clinical and radiologic outcome measures after reconstruction of acetabular fractures. *J Orthop Trauma* 2002;16:82-6.
2. **Moed BR, Carr SE, Watson JT.** Open reduction and internal fixation of posterior wall fractures of the acetabulum. *Clin Orthop* 2000;377:57-67.
3. **Plaisier BR, Meldon SW, Super DM, Malangoni MA.** Improved outcome after early fixation of acetabular fractures. Injury 2000;31:81-4.
4. **Liebergall M, Mosheiff R, Low J, et al.** Acetabular fractures: clinical outcome of surgical treatment. *Clin Orthop* 1999;366:205-16.
5. **Matta JM.** Fractures of the acetabulum: accuracy of reduction and clinical results in patients managed operatively within three weeks after the injury. *J Bone Joint Surg [Am]* 1996;78-A:1632-45.
6. **Letournel E.** Acetabulum fractures: classification and management. *Clin Orthop* 1980;151:81-106.
7. **Giannoudis PV, Grotz MRW, Papakostidis C, Dinopoulos H.** Operative treatment of displaced fractures of the acetabulum: a meta-analysis. *J Bone Joint Surg [Br]* 2005;87-B:2-9.
8. **Al-Qahtani S, O'Connor G.** Acetabular fractures before and after the introduction of seatbelt legislation. *Can J Surg* 1996;39:317-20.
9. **Guria J, Jones W, Leung J, Mara K.** Alcohol in New Zealand road trauma. *Appl Health Econ Health Policy* 2003;2:183-90.
10. **Solan MC, Molloy S, Packham I, Ward DA, Bircher MD.** Pelvic and acetabular fractures in the United Kingdom: a continued public health emergency. *Injury* 2004;35: 16-22.
11. **Bircher M, Giannoudis PV.** Pelvic trauma management within the UK: a reflection of a failing trauma service. *Injury* 2004;35:2-6.
12. **Gansslen A, Pohlemann T, Paul C, Lobenhoffer P, Tschern H.** Epidemiology of pelvic ring fractures. *Injury* 1996;27(Suppl 1):13-20.
13. **Blum J, Beyermann K, Ritter G.** Incidence of acetabular fractures before and after introduction of compulsory seatbelt fastening. *Unfallchirurgie* 1991;17:274-9 (in German).
14. **Hull JB, Raza SA, Stockley I, Elson RA.** Surgical management of fractures of the acetabulum: the Sheffield experience 1976-1194. *Injury* 1997;28:35-40.
15. **Brueton RN.** A review of 40 acetabular fractures: the importance of early surgery. *Injury* 1993;24:171-4.
16. **General Register Office for Scotland.** www.scotland.gov.uk (17/05/05).
17. **Robinson CM, Royds M, Abraham A, et al.** Refractures in patients at least forty-five years old. *J Bone Joint Surg [Am]* 2002;84-A:1528-33.
18. **Letournel E, Judet R.** *Fractures of the acetabulum.* Second ed. Berlin: Springer Verlag, 1993:29-62.
19. **Baker SP, O'Neill B.** The injury severity score: an update. *J Trauma* 1976;16: 882-5.