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■ REVIEW ARTICLE

Operative treatment of displaced fractures of the acetabulum

A META-ANALYSIS

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Over the past 40 years, the management of displaced fractures of the acetabulum has changed from conservative to operative. We have undertaken a meta-analysis to evaluate the classification, the incidence of complications and the functional outcome of patients who had undergone operative treatment of such injuries.

We analysed a total of 3670 fractures. The most common long-term complication was osteoarthritis which occurred in approximately 20% of the patients. Other late complications, including heterotopic ossification and avascular necrosis of the femoral head, were present in less than 10%. However, only 8% of patients who were treated surgically needed a further operation, usually a hip arthroplasty, and between 75% and 80% of patients gained an excellent or good result at a mean of five years after injury. Factors influencing the functional outcome included the type of fracture and/or dislocation, damage to the femoral head, associated injuries and co-morbidity which can be considered to be non-controllable, and the timing of the operation, the surgical approach, the quality of reduction and local complications which are all controllable. The treatment of these injuries is challenging. Tertiary referrals need to be undertaken as early as possible, since the timing of surgery is of the utmost importance. It is important, at operation, to obtain the most accurate reduction of the fracture which is possible, with a minimal surgical approach, as both are related to improved outcome.

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The work of Judet and Letournel began the changes which have led to the management of displaced fractures of the acetabulum by operation rather than conservatively.[1] They recognised that the principles applied to the treatment of displaced articular fractures should also be applied to the acetabulum.[2]

Subsequently, open anatomical reduction of the articular surface combined with rigid internal fixation and early mobilisation became the standard treatment for these injuries.[3-7]

This approach led to a reduction in the incidence of post-traumatic arthritis and an improvement in the overall outcome.[3,4,8-10] However, certain of these fractures require extensile approaches and complications such as the extensive formation of haematoma, local or systemic infection, iatrogenic nerve injury and heterotopic bone formation have been described.[3,4,11-15]

We have carried out a comprehensive review of the literature concerning the classification and surgical management of displaced acetabular fractures and subjected it to a meta-analysis in order to assess the incidence of post-operative complications and the functional outcome.

Materials and Methods

Manuscript retrieval. Publications dealing with the management of acetabular fractures were identified from a Medline search between January 1966 and February 2004 using the OVID search engine[16] with "acetabulum", "acetabular", "fracture" and "surgery" as keywords and with MeSH (Medline/PubMed's article indexing terminology) subject headings.

Full articles were retrieved and assessed for their suitability for review. The criteria for inclusion included reports on surgical treatment of displaced acetabular fractures in adolescent and adult patients, classification according to Letournel,[1] operative treatment within the first four weeks following trauma, a follow-up of at least 12 months and in the English or German language. Injuries involving the triradiate cartilage and clinical series with less than 20 patients were excluded. When the publications included patients from previous studies, only the most recent papers were used.[3-5,17,18]

Data extraction for meta-analysis. The manuscripts were evaluated regarding the type of study – a prospective or retrospective clinical

Table I. Factors analysed in the meta-analysis

Demography	Age (yrs)
	Gender
	Mechanism of injury
	Injury severity[67]
	Mortality
Fracture classification	Letournel[1]
Initial surgery	Time elapsed between trauma and surgery (days)
	Surgical approach
	Quality of reduction (satisfactory: ≤ 2 mm, unsatisfactory: > 2 mm)
Early complications	Traumatic nerve palsy
	Iatrogenic nerve palsy
	Thromboembolism
	Local infections
Follow-up	Time elapsed between trauma and follow-up (mths)
Late complications	Heterotopic ossification (Brooker classification)[50]
	Osteoarthritis[17]
	Avascular necrosis of the femoral head
Revision surgery	Revision osteosynthesis
	Hip arthroplasty
	Hip arthrodesis
Functional outcome	Merle d'Aubigné score[68]
	Harris hip score[9]

review, or a case series. The data were then extracted from these articles and further analysis was performed as to the type of fracture, operative approach, early and late complications and the functional outcome (Table I). For each factor the number of available studies and the number of patients documented were recorded.

Statistics. Comparison of data between the groups was performed on a personal computer using SPSS (11.0 for Windows, SPSS Inc., Chicago, Illinois). Parametric and non-parametric data were compared using the unpaired Student's *t*-test, the Mann-Whitney U test and the chi-squared test. Differences were considered significant at $p < 0.05$.

Results

We reviewed a total of 160 manuscripts; only 34 met the inclusion criteria.[1,8,10-15,17,19-43] There were five prospective,[17,34,36,37,39] and 29 retrospective case reviews[1,8,10-15,19-33,35,38,40-43] of operatively treated displaced fractures of the acetabulum.

Demographic data. These 34 publications described a total of 3670 displaced fractures in 3639 patients. The mean age of the patients was 38.6 ± 4.6 years and 69.4% of them were male. The cause of the accident was recorded in 14 manuscripts (1667 patients).[8,11,17,20,22,25-27,29,31,35,41-43] A road traffic accident was the causative mechanism in 80.5% of patients, 10.7% had falls and in 8.8% other causes were stated. Only four studies (178 patients) analysed the injury severity score (ISS).[13,22,36,37] The mean ISS was 17.5 ± 3.5 points. Associated injuries were documented in nine manuscripts (819 patients).[17,18,20,23,25,26,30,35,37] Fractures of the extremities and head injuries were the most commonly associated injuries (Table II).

The mortality was recorded in only four studies involving a total of 561 patients.[1,12,19,37] Seventeen patients had died, a rate of mortality of 3%.

Table II. Associated injuries recorded in the meta-analysis: nine series (819 patients) included[17,19,20,23,25,26,30,35,37]

	Patients	Incidence (%)
Head	180	*22.0*
Chest	99	*12.1*
Abdomen	65	*7.9*
Pelvic ring	51	*6.2*
Extremities	330	*40.3*
Other	46	*5.6*

Table III. Meta-analysis of the type of fracture according to the Letournel classification:[1] 34 series (3670 patients) included[1,8,10-15,17,19-43]

	Patients	Prevalence (%)
Posterior wall	865	*23.6*
Posterior column	129	*3.5*
Anterior wall	61	*1.7*
Anterior column	143	*3.9*
Transverse	306	*8.3*
T-shaped	340	*9.3*
Posterior wall + posterior column	210	*5.7*
Transverse + posterior wall	638	*17.4*
Anterior column + posterior hemi-transverse	183	*5.0*
Both columns	795	*21.7*

Classification of acetabular fractures. All publications used the Letournel classification.[1] The most frequent type of fracture involved the posterior wall, accounting for 23.9% of all injuries (Table III). Fractures involving both columns were seen in 22%, those described as transverse and involving the posterior wall accounted for 17.7%, while other fracture types were less common and were seen in less than 10% (Table III).

Operative treatment. The mean time between injury and surgery was recorded in 14 publications (1496 patients) and was 8.9 ± 2.9 days.[8,10,13,14,23,26,27,29,32,35-37,39,42]

Table IV. Early and late complications recorded in the meta-analysis of the number of studies, the number of patients, the number of complications and the incidence of complications

Complication*	Studies	Patients	Complication	Incidence (%)
Traumatic nerve palsy	26	1824	299	*16.4*
Iatrogenic nerve palsy	20	2426	194	*8.0*
DVT/PE	11	806	35	*4.3*
Local infections	19	2547	112	*4.4*
HO (Brooker III/IV)	13	1424	81	*5.7*
OA (Type III/IV)	7	580	111	*19.8*
AVN	18	2010	113	*5.6*

* DVT, deep-venous thrombosis; PE, pulmonary embolism; HO, heterotopic ossification (Brooker[50]); OA, osteoarthritis (Matta[17]); AVN, avascular necrosis

Table V. Distribution of heterotopic ossification according to the Brooker[50] classification in 13 studies (1424 fractures)[10,20,22,25-27,29,34,36,37.40.42,43]

Brooker	Patients	Incidence (%)
I	232	*16.3*
II	120	*8.4*
III	35	*2.5*
IV	23	*1.6*

Table VI. Distribution of osteoarthritis according to the classification suggested by Matta[17] in seven studies (580 patients)[17,20,22,25,29,37,43]

Type	Patients	Incidence (%)
I	351	*60.5*
II	118	*20.4*
III	46	*7.9*
IV	65	*11.2*

Twenty-four articles (2311 patients) described the surgical approach.[8,10,12,14,17,19,20,22,23,25-27,29-37,39,42,43] The Kocher-Langenbeck approach was used in 48.7%, the ilio-inguinal in 21.9% and the iliofemoral in 12.4%. In 17% of the patients, other surgical approaches were used including the direct lateral, the triradiate, the extensile and combined approaches.

The quality of reduction was analysed in 24 studies (2424 fractures).[1,10,12,13,17,20,22-27,29,31,34-40,42,43] The post-operative reduction was recorded as being satisfactory, with less than 2 mm of displacement, in 85.6% of fractures. However, in 348 fractures (14.4%) the post-operative displacement was more than 2 mm indicating an unsatisfactory reduction.

Nerve palsy. Traumatic peripheral nerve palsies were noted in 18 articles.[12,14,15,19,20,23,25-27,29-37,42] Among 1824 acetabular fractures, 299 nerve injuries were recorded on admission, an incidence of 16.4% (Table IV). All were to the sciatic nerve except for two involving the femoral nerve. However, with a more selective analysis of those patients with a posterior dislocation the incidence of injury to the sciatic nerve increased to 40.3%[12,19,23,27,29,31,35,42] ($p < 0.01$).

An incidence of iatrogenic nerve palsy of 8% was recorded in 20 studies with 2426 fractures (Table IV).[1,12,14,15,17,20,22,26,27,29-35,38-40] More than 60% involved the sciatic nerve. However, the lateral cutaneous nerve was damaged in 67 of these patients, always with an ilio-inguinal approach.[26] Iatrogenic injuries to the femoral or obturator nerves were very rare being found in one and five cases respectively.[12,17,22,27]

Thromboembolic complications. Most authors did not differentiate between the incidence of deep venous thrombosis (DVT) and pulmonary embolism (PE). Thromboembolic complications were recorded in 11 articles including 806 patients.[12,14,19,20,23,26,29-31,40,41] Thirty-five had sustained a DVT or PE, an overall incidence of 4.3% (Table IV).

The documentation of prophylaxis against DVT was very inconsistent. Some articles had no information, others described different policies for certain patient groups and others changes of prophylaxis within the period of study, e.g. from warfarin to low-molecular-weight heparin. Thus, no comment can be made as to the adequacy of prophylactic regimes.

Local infection. Local wound infections were recorded in 19 studies (2547 patients).[1,8,13-15,17,19-23,26,27,29,30,32,34,40,42] They were noted in 112 patients, an overall incidence of 4.4% (Table IV).

Length of follow-up. The length of follow-up was recorded in 26 studies (2224 patients).[8,12,14,17,19-31,34-37,39,41-43] The mean follow-up was 56.0 ± 27.5 months.

Heterotopic ossification. The presence of heterotopic ossification (HO), was recorded in 23 articles[1,10,12-14,17,20-23,26-31,33,34,36,37,40,42,43] describing 2394 displaced fractures. It was seen in 613 patients, an overall incidence of 25.6%. Among these studies only 13 classified HO according to Brooker.[10,20,22,25-27,29,34,36,37,40,42,43] These included 1424 fractures and the incidence again was 25.6% (365 cases) (Table V). Brooker grade III or IV ossification was seen in 81 patients, an incidence of 5.7% (Table IV).

Nine studies found that the incidence of HO depended on the surgical approach.[10,12,17,20,25,26,34,37,40] The ilio-femoral approach was associated with the highest incidence of Brooker III and IV HO of 23.6%; with the Kocher-Langenbeck it was 11.6% and the ilio-inguinal 1.5%.

Prophylaxis against HO was recorded in five clinical studies with 221 patients.[23,34,36,37,40] Patients received either indometacin (115), local radiation (50) or both (46). In 18 studies with 2173 patients prophylaxis was either not used or not documented. Comparing these two groups of patients, the incidence was 24.4% in the prophylaxis group, slightly lower than in the non-prophylaxis group (25.7%), but this was not statistically significant.

Osteoarthritis. The overall incidence of osteoarthritis (OA) in 11 studies with 1211 patients was 26.6% (Table IV).[1,17,20,22,25,26,28,29,31,37,43] In seven studies with 580 patients, it was graded according to the classification described by Matta.[17,20,22,25,29,37,43] The incidence in these

Table VII. Revision operations recorded in the meta-analysis with the number of studies, the number of patients, how many had a revision operation and the overall incidence of revisions

	Studies	Patients	Revision surgery	Incidence (%)
Revision of the osteosynthesis	6	679	17	*2.5*
Hip replacement	16	1517	129	*8.5*
Arthrodesis	6	841	9	*1.1*

studies was considerably higher reaching 36.8%. However, only 111 (19.1%) of patients developed severe OA (grade III and IV) (Table VI).

The incidence of OA as related to the quality of reduction was recorded in seven studies (685 patients).[1,20,22,29,31,37,43] If the reduction was satisfactory (≤ 2 mm), the incidence was 13.2% (76 of 577 patients). However, if the reduction was not satisfactory (> 2 mm), it increased to 43.5% (47 of 108 patients). The mean follow-up of the patients included in these studies was 60 months (18 to 120).

Only two studies looked at the incidence of OA with respect to the type of fracture.[37,43] Stöckle et al[37] only included patients who had undergone operation through an extended iliofemoral approach. Kang and Min[43] described patients for whom an unusual method of cable fixation for displaced fractures had been used. Thus, no conclusions regarding a correlation between the incidence of OA and the type of fracture can be established.

Avascular necrosis of the femoral head. The incidence of avascular necrosis of the femoral head (AVN) was noted in 18 studies with 2010 patients,[1,8,11-14,17,20,21,23,26,27,29-31,34,37,43] with an overall incidence of 5.6% (113 patients) (Table IV). In five studies (303 patients), the occurrence was recorded in patients who had sustained a posterior dislocation with an overall incidence of 9.2% (28 patients).[11,12,17,29,31] The incidence in the remaining patients who did not have a posterior dislocation was 5% (85 of 1707 patients).[1,8,13,14,20,21,23,26,27,30,34,37,43] There was a statistically significant difference between the two groups (p = 0.003).

Revision surgery. Information about further operations such as subsequent revision of the osteosynthesis, arthroplasty of the hip or arthrodesis was available in 17 clinical studies (1779 fractures).[8,10,17,22-27,29,30,34-37,42]

There was an overall incidence of revision surgery of 8% (142 patients). Table VII gives details of the different operations undertaken and their incidence, with arthroplasty the most frequent with a rate of 8.5%. The mean time interval between injury and arthroplasty was documented in only five studies (62 patients), being 24.8 months (11 to 62).[22,23,27,35,37]

Functional results according to outcome scoring systems. A total of 16 studies (1610 patients) used the modified Merle d'Aubigné score to assess the functional results;[8,11,13,17,22,23,26,29-31,35,37,39,40,42,43] five studies (600 patients) recorded the Harris hip score (HHS).[20,21,27,36,37] Using the Merle d'Aubigné score, 810 patients (50.3%) were graded as excellent, 468 (29.1%) as good, 138 (8.6%) as fair, and 194 (12.0%) as poor. With the HHS, 263 patients (43.9%) had an excellent result, 176 (29.3%) were graded as good, 69 (11.5%) as fair, and 92 (15.3%) as poor.

A comparison of functional outcome in those studies with a follow-up of less than three years with those with more than three years showed a slight improvement with time. Studies with less than three years of follow-up showed 75.1% excellent and good results in the Merle d'Aubigné score after 26 months, whereas the other group had 78.7% excellent and good results after 62 months.

Seven studies (906 patients) correlated the results of the Merle d'Aubigné score with the type of fracture.[17,27,29,31,37,39,43] Fractures of the anterior wall and of the posterior column had the worst functional outcome with 48% and 37% of fair and poor results, respectively (Table VIII). The best functional outcome was obtained with fractures of the anterior column and transverse fractures with almost 90% of excellent and good results (Table VIII). Simple fractures showed a better functional outcome than associated fracture types (80.9% and 72.3%, excellent and good results, respectively) (Table VIII), (p = 0.07).

Ten studies (979 patients) looked at the quality of reduction and the subsequent Merle d'Aubigné score,[1,17,23,29-31,37,39,40,43] showing unfavourable functional results if the initial reduction was unsatisfactory (Table IX). Similarly the HHS was related to the quality of reduction in three studies of 108 patients[26,27,36] with an even higher incidence of unfavourable functional results if the initial reduction was unsatisfactory (Table IX).

Discussion

Letournel[1] and Judet and Letournel[2] revolutionised the treatment of acetabular fractures. Operative concepts are better understood and the management has changed, moving toward a more rational approach. Several authors have reported series of more than 250 patients undergoing surgery for displaced fractures of the acetabulum.[1,17,27] Others with smaller numbers of patients have been included in this meta-analysis. Neither data from Letournel and Judet's monography[44] nor from the German pelvic study group,[45] could be included since they were not available in publications retrieved by Medline, which was one of the inclusion criteria. Nevertheless, the studies which have been assessed have allowed us to perform a comprehensive analysis of the results of treatment in this group of patients.

Several classification systems for acetabular fractures have been published.[1,6,46,47] The Letournel classification[1] was used in all the studies included in the current meta-analysis, and remains the most commonly used.[1] Beaule, Dorey and Matta[48] have shown a high inter- and intra-observer reliability for this classification system when used by dedicated pelvic and acetabular surgeons.

Table VIII. The Merle d'Aubigné score related to the type of fracture in 916 patients[17,22,29,31,37,39,43]

	Patients	Incidence (%)	Excellent/good (%)	Fair/poor (%)
Posterior wall	204	*22.2*	*82.4*	*17.6*
Posterior column	27	*2.7*	*63.0*	*37.0*
Anterior wall	16	*1.7*	*56.2*	*47.8*
Anterior column	37	*4.0*	*89.2*	*10.8*
Transverse	51	*5.6*	*86.3*	*13.7*
Simple fracture types	335	*36.6*	*80.9*	*19.1*
T-shaped	128	*14.0*	*71.1*	*28.9*
Posterior wall + posterior column	47	*5.1*	*83.0*	*17.0*
Transverse + posterior wall	136	*14.8*	*71.3*	*28.7*
Anterior column + posterior hemitransverse	43	*4.7*	*72.1*	*27.9*
Both columns	227	*24.8*	*71.4*	*28.6*
Total associated fracture types	581	*63.4*	*72.3*	*27.7*

Table IX. Results of functional outcome scores compared with the quality of reduction. The Merle d'Aubigné score was analysed in ten studies (979 patients)[1,17,23,29-31,37,39,40,43] and the Harris hip score analysed in three studies (108 patients)[20,27,36]

	Satisfactory	Unsatisfactory
	Patients (%)	Patients (%)
Merle d'Aubigné score		
Excellent	543 *(62.4)*	53 *(48.2)*
Good	203 *(23.4)*	28 *(25.4)*
Fair	46 *(5.3)*	11 *(10.0)*
Poor	77 *(8.9)*	18 *(16.4)*
Harris hip score		
Excellent	52 *(56.5)*	3 *(18.8)*
Good	26 *(28.3)*	1 *(6.2)*
Fair	4 *(4.3)*	4 *(25.0)*
Poor	10 *(10.9)*	8 *(50.0)*

* satisfactory ≤ 2 mm; unsatisfactory > 2 mm

The most common types of fracture treated by operation were of the posterior wall, both columns and transverse associated with posterior wall fractures. These accounted for nearly two-thirds of the cases. However, these numbers do not reflect the true incidence of types of fracture, since this meta-analysis also included studies which only analysed subgroups of acetabular fractures, such as posterior wall fractures,[19,21,27,31,35] or only associated fracture types.[13,39,40] Nevertheless, Letournel and Judet[44] described a very similar distribution in their monograph, indicating that this meta-analysis reflects an average patient group. The German pelvic study group found a higher incidence of fractures of the posterior and anterior columns.[45]

The Kocher-Langenbeck approach is used most frequently in the operative treatment of acetabular fractures.[8,10,12,14,17,19,20,23,25-27,29-35,42,43] Most authors used reconstruction plates and screws in order to achieve stable fixation, although Kang and Min[43] used cable fixation. The meta-analysis showed that in more than 85% of patients plain radiographs taken after operation showed a satisfactory reduction with displacement of ≤ 2 mm. The accuracy of reduction is thought to be strongly related to the fracture type.[17,27,44] Mears et al[27] showed in his study of 424 fractures treated by operation, that simple fractures were reduced anatomically in 87% of patients, whereas associated fractures could be reduced anatomically in only 59%. Matta[17] had similar results, achieving anatomical reduction in 96% of simple fractures and only 64% of associated fractures. Both agree that both column and T-type fractures showed the least accuracy of reduction.[17,27] The quality of reduction is also considered to be related to the timing of surgery. Mears et al[27] found that if surgery was delayed for more than 11 days after injury, there were significantly fewer anatomical reductions. Finally, the quality of reduction is strongly related to age showing a decrease in accuracy in the elderly.[17] Mears et al[27] showed that patients above the age of 70 years have a poorer reduction with more intra-articular damage, such as fracture, abrasion or impaction of the acetabulum or femoral head. However, since active elderly individuals are physiologically younger and have higher demand,[49] accurate reduction is required.

In most of the studies the quality of reduction was assessed by plain radiographs, but today computed tomography is more appropriate.[29]

The meta-analysis demonstrated an overall incidence of post-traumatic nerve palsies associated with acetabular fractures of 16.4%, which is comparable with the findings of Letournel and Judet.[44] This rises to more than 40% in fractures involving a posterior dislocation of the hip. The sciatic nerve, especially its peroneal part, is in close anatomical relationship to the posterior wall in the greater sciatic notch. Iatrogenic nerve injuries were found in 8%, mainly to the sciatic nerve. The high number of injuries to the lateral cutaneous nerve is only described in the study of Mayo et al;[26] other studies usually omit mention of damage to this nerve. Helfet and Schmeling[49] found an incidence of post-traumatic nerve injury of 29% in 103 patients. Iatrogenic nerve palsies were found in 5% of their patients, mostly due to intra-operative traction or compression. However, double crush lesions of the sciatic nerve were associated with a poor outcome.[49]

Meta-analysis showed an incidence of 25.6% of HO following operation for acetabular fractures. However, only 5.7% of patients will develop HO grade III or IV according to the Brooker classification.[50] These results are consistent with those reported in other studies.[45] The development of HO was highly dependent on the surgical approach with

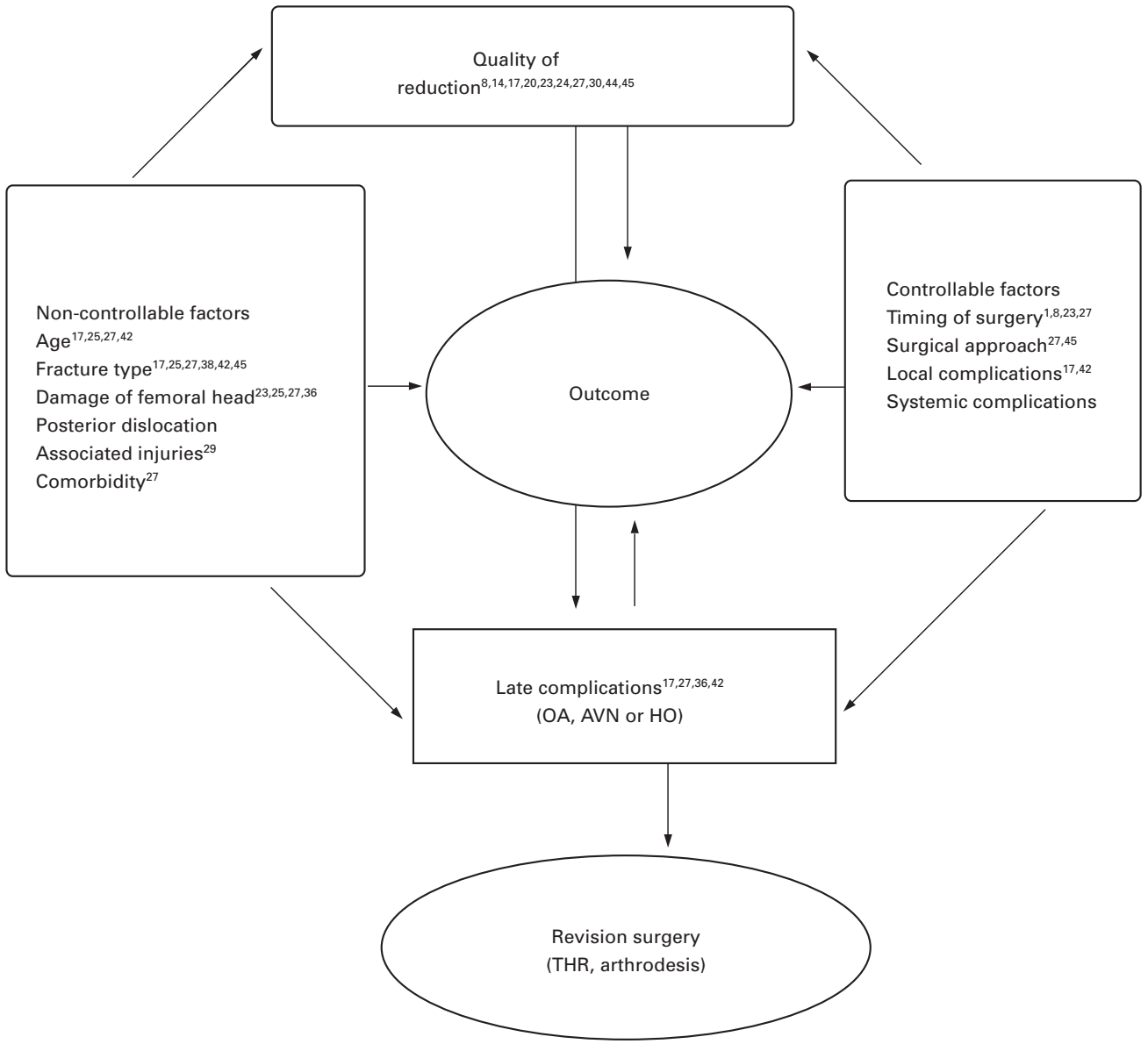

Fig. 1

Factors associated with complications and outcomes.

25% of those who had an iliofemoral approach showing Brooker III/IV ossification. The correlation of HO with more severe fractures and an extensile approach is well described.[1,12,26,37,38,51] Other risk factors include high injury severity score,[51] delay in fixation of the fracture[52] and an associated head injury.[53] HO normally developed early and is unlikely to progress after six months.[54] The meta-analysis showed no difference in the incidence whether or not prophylactic treatment was used.[55] However, other clinical studies have shown that either local radiation or oral administration of indometacin provided effective prophylaxis against HO following the surgical treatment of acetabular fractures.[51,55-58]

The overall incidence of OA following operatively treated acetabular fractures was 26.6%. Five years after injury 19% of patients had OA grades III or IV (Table IV). This emphasises Matta's[17] view that "the primary complication following a fracture of the acetabulum is post-traumatic osteoarthrosis". The incidence of OA noted by Letournel and Judet[44] was less than that found in this study. However, Matta[17] described rates of OA as high as 46%. The German pelvic study group also reported higher rates, especially in anterior column/posterior hemi-transverse, T-shaped, and posterior wall/posterior column fractures.[45] Further risk factors for the development of post-traumatic OA include associated chondral or osseous lesions of the

femoral head[16] and the quality of reduction.[4,17,44,45] The overall incidence of OA in the meta-analysis following anatomical surgical reduction was about 10%, whereas it increased to more than 30% if this quality of reduction could not be achieved.[3,44] Recently Murphy, Zuakowski and Vrahas[59] have shown an increased rate of chondrocyte apoptosis in intra-articular fractures which may explain the occurrence of OA in anatomically reduced fractures.

The incidence of AVN described in published papers varies from 3% to 53%.[3,44,45,60,61] The meta-analysis showed an overall incidence of 5.6%, indicating that it is grossly overestimated and that most of the observed changes in the head of the femur are probably due to OA.[17,25] However, in patients sustaining a posterior fracture dislocation of the hip, the incidence of AVN increased up to 9.2%. These findings are consistent with those reported in the literature.[12,44,45] However, further risk factors, which were not studied in this meta-analysis, include the time interval between dislocation of the hip and reduction,[44,61] injuries to the femoral head itself[45] and delayed operative treatment.[44] The pathophysiology of AVN has not been fully defined.[62] Vascular stretching and twisting during dislocation may contribute as well as local thrombosis and scarring.[63-65] Although changes in blood flow in the femoral head can be demonstrated by single-photon emission computed tomography, this method cannot predict AVN.

The results of the meta-analysis showed that 8.5% of patients with fractures treated by operation needed an arthroplasty at an average of two years following the intial procedure. However, the requirement for a subsequent arthroplasty seems to have two peaks.[25,27] Mears et al[27] showed that 11% of patients had had a total hip replacement by 5.2 years after the injury, with most procedures being undertaken between six months and two years. However, they also found that arthroplasties were performed after longer periods, as much as 19 years later.[27] Specific risk factors for revision surgery were AVN, OA and interposed metallic fixation.[27] Other risks are listed in Figure 1. None of the studies commented on whether the metalwork was removed routinely before arthroplasty. Since the incidence of OA was nearly 20% and that of AVN 5%, an incidence of subsequent arthroplasty of less than 10% is surprising. Several authors have mentioned that some patients with osteoarthritic changes in their hips refused arthroplasty.[23,30,31]

Most authors have used either the Merle d'Aubigné[8,11,13,17,22,23,26,29-31,35,37,38,40,42,43] or the HHS to assess the functional outcome.[20,21,27,36,37] Using both scores nearly 75% of patients achieved excellent or good results, similar to those in other big series.[17,27,44,45]

The long-term results are influenced by numerous factors. The type of fracture and the quality of the reduction are the main influences on functional outcome. Patients with associated fracture types according to the Letournel classification and those with injuries to the anterior wall and posterior column are most likely to have a poor functional outcome. Similar results were described by Mears et al[27] and Matta[17] noted that T-shaped and posterior wall fractures were associated with a poor functional outcome. Murphy et al[42] also found functional outcome to be related to associated fracture types.

The quality of reduction is a crucial but controllable factor.[42,44,45] An excellent or good functional outcome can be expected in between 83% and 89% of patients with an anatomical reduction. An experimental study in a cadaver model, showing that acetabular fractures with a step-off of more than 1 mm had a significant increase in peak pressure at the articular surface.[66] However, Starr et al[36] stated that an excellent functional outcome can be achieved even in patients with a poor reduction providing that the step-off is outside the weight-bearing area.

Other factors which influence functional outcome include increased age,[17,25,29,42] delay in operative treatment,[8,23] the presence of damage to the femoral head,[17,23,25,36] associated injuries[41] and local complications.[17,42] Mears et al[27] pointed out that poor outcome as assessed by the HHS is related to the use of extensile approaches and comorbidity, such as obesity, osteopenia and a history of medical disorders. Some of these factors, such as age and the timing of surgery influence the quality of reduction and therefore indirectly contribute to the functional outcome.[27] In fractures of the posterior wall, the time to reduction (> 12 hrs) as well as age is most important for functional outcome.[29] The complex network of controllable and non-controllable factors contributing to the quality of reduction and late complications are summarised in Figure 1.

A recent publication regarding the functional outcome following acetabular fractures demonstrated that despite excellent and good results as assessed by the Merle d'Aubigné score with a mean value of 16.8 points, a complete return to the level of function enjoyed before injury is uncommon.[41] The treatment of these fractures sets high demands and needs to be in the hands of experts. Tertiary referrals should be undertaken as early as possible, since the timing is of utmost importance. It is important, at operation, to obtain the most accurate reduction of the fracture which is possible, with a minimal surgical approach, as both influence the outcome.

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