

# Transverse + Posterior Wall Fractures of the Acetabulum: Epidemiology, Operative Management and Long-Term Results

**Příčné zlomeniny s odlomením zadní hrany acetabula: epidemiologie, operační léčba a dlouhodobé výsledky**

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## ABSTRACT

### PURPOSE OF THE STUDY

Associated transverse and posterior wall fractures account for approximately 20% of all acetabular fractures. To assess the risk of these concomitant bone injuries on early joint failure despite a high rate of postoperative congruency.

### MATERIAL

The analysis of 104 surgically treated patients with associated transverse and posterior wall fractures showed that more than half of these patients had associated injuries. The mean age was 35 years, and > 75% of these patients were male. A high energy trauma was the trauma mechanism in 94.2%. The mean ISS was 26.3 points.

The majority of patients showed a juxta- or transtectal fracture line. The mean articular fracture displacement was 13.5 mm. 87.5% of the patients showed a femoral head dislocation. An acetabular roof comminution was present in 16.3%. 20.2% of patients received a fracture related preoperative nerve injury to the sciatic nerve.

### METHODS

Osteosynthesis was performed 9.9 days after trauma. The Kocher-Langenbeck approach was used in > 90% for stabilization with a combination of plate and screw fixation in 71.1%. The mean operative time was 190 minutes with a blood loss of 855 ml. Postoperatively the hip joint was congruent in 90.3% with anatomical or near-anatomical joint reconstruction in > 90%. Iatrogenic nerve injury occurred in 12 patients (8.9%).

### RESULTS

67 patients (67.7%) could be followed after a mean of 42.7 months. The average subjective Visual Analog Scale pain score was 42.7. Mild or no pain was seen in 58.2%. The mean Merle d'Aubigné score was 15.4 with 56.7% of patients having a functionally perfect or good result.

52.2% had no post-traumatic osteoarthritic changes of their hip joint. A joint failure was diagnosed in 32.8% of the patients.

Analyzing only patients with anatomically reconstructed hip joints, patients showed comparable results with 61.3% having no or mild pain and 59.2% a good or excellent functional result. Posttraumatic arthrotic changes occur in only 26.5% of these patients. A joint failure was present in 32.7%. In this group, a joint failure was significantly more likely to be present with an additional acetabular comminution zone.

### CONCLUSION

Associated transverse and posterior wall fractures have a significant risk of early joint failure despite a high rate of postoperative congruency.

**Key words:** acetabulum, transverse fractures, posterior wall fractures, operative management.

## INTRODUCTION

Associated transverse and posterior wall fractures of the acetabulum are classified as partial articular fractures within the AO/OTA classification scheme (16) and are defined as a classical transverse acetabular fracture combined with one or more posterior wall fragments (Fig. 1).

The course of the transverse fracture line is variable and can be distinguished into an infratectal, juxtatectal or transtectal course. The posterior wall fragment can be classified as being posterior, postero-superior or postero-inferior (9). The femoral head can be displaced posteriorly or centrally, depending on the primary mechanical force vector.

Common injury mechanisms are the so-called dashboard-injury, but a lateral compression force to the greater trochanter can even result in this fracture type (4, 9, 18).

No exact studies exist for this fracture type, especially regarding stability of the hip joint, biomechanical data or short and long-term results.

The associated transverse and posterior wall fracture type is one of the common fracture types in the Letournel classification (9) with an expected incidence of approximately 17% (7).

The majority of these fractures are displaced and therefore should be treated operatively due to the instability of the transverse and especially the posterior wall fragment(s). According to reported results rates of open reduction and internal fixation are between 60% and 80% (9, 17).

Only general data on treatment strategy and some results can be found in the literature (9, 10, 13, 17, 21). No fracture type specific data are available.

Therefore, it is of interest to further investigate epidemiological aspects and long-term results in this specific fracture type.

## MATERIAL AND METHODS

Between 01.01.1972 and 31.12.2008 a total of 1208 adult patients (age at least 18 years) were treated with acetabular fractures at our institution. 128 of these had an associated transverse + posterior wall fracture (incidence: 10.6%).

In 122 survivors (mortality rate: 4.7%), open reduction and internal fixation (ORIF) was performed in 104 (ORIF rate: 85.2%). These 104 patients were analyzed regarding demographical data (patient age, sex), type of accident, injury mechanism, type of admission, poly-trauma rate (20) and ISS (1), concomitant pelvic ring injuries by AO/OTA classification (16), associated injuries and type of radiological diagnostics.

Traumatic brain injury (TBI) was graded according to the Glasgow Coma Scale (GCS) (19). Accompanying chest and abdominal injuries were classified according to the Organ Injury Scaling (OIS) (15). Additional pelvic ring injuries were analyzed alone and according to the complex pelvic trauma definition (2). A fracture-related nerve damage was divided into primary and secondary (iatrogenic) nerve damage.

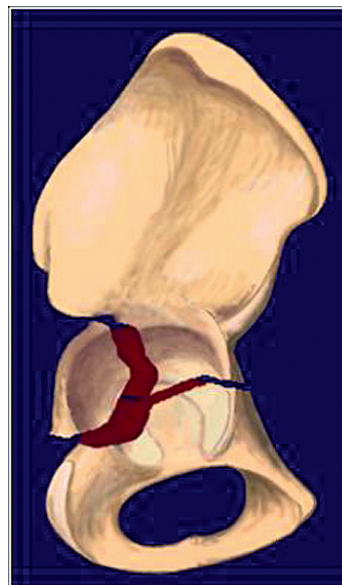


Fig. 1. Schematic view of a typical transverse/posterior wall fracture.

The primary fracture displacement, additional hip dislocation, acetabular roof arc measurement (11), time of surgical stabilization, surgical approach, and surgery time with blood loss as well as damage to the femoral head (contusion, impaction), the acetabulum (contusion, impaction, comminution zones) and the presence of an associated fracture of the posterior wall or intra-articular fragments were recorded.

The postoperative radiological result was graded according to Matta (12).

The follow-up was recorded using a standardized documentation form (17) including pain analysis and neurological impairments (5). The long-term functional outcome was classified according to the Merle d'Aubigné-score (14). Assessment of the radiological result included follow-up x-ray examination for post-traumatic osteoarthritis changes according to (in: (17)), the presence of femoral head necrosis according to Ficat and Arlet (6) and the presence of heterotopic ossification according to Brooker (3). In addition, the implantation of a secondary total hip prosthesis was documented.

A radiological joint failure was defined as the presence of post-traumatic osteoarthritis grade 4 and/or the presence of post-traumatic femoral head necrosis grade 3 or 4 and/or the presence of heterotopic ossification of grade 4 and/or secondary implantation of a total hip prosthesis.

## RESULTS

### Demographic data

There were 82 male and 22 female patients (78.8% vs. 21.2%). The average age was  $35.5 \pm 12.4$  years (18–71 years).

The cause of the accident was a high energy trauma in 94.2% and a simple fall from standing or walking in 12.1%. 82.7% of patients were injured in road traffic accidents. In the majority of patients a direct collision (86.5%) was the main injury mechanism with a lateral

force to the pelvis in 51.9% and an anterior-posterior force in 31.7%. Most patients (75%) were transferred to our hospital. 29.8% of the patients had an isolated pelvic trauma, 55.8% had multiple injuries and 14.4% were polytraumatized. The mean ISS was  $26.3 \pm 9.6$  points (9–48 points).

### Concomitant injuries

A total of 73 patients (70.2%) had associated injuries. An additional TBI was present in 33.7% of patients: 26x mild, 7x moderate 2x severe.

A chest trauma was present in 30.8% of cases (18x OIS I+II, 12x OIS III, 2x OIS IV+V). 4 patients (3.8%) suffered from blunt abdominal trauma. 24 patients (23.1%) sustained fractures of the upper and 49 patients (47.1%) fractures of the lower extremities. An open acetabular fracture was seen in one patient.

Complex pelvic trauma was seen in seven patients (5.2%) (5x bladder ruptures, 1x urethral injury, 1x laceration of the common iliac vein).

An additional pelvic ring injury was present in 32 patients (30.8%). In 11.5% a contralateral type A2-injury and in 12.5% patients a type B1-injury was present. 2 patients had an additional type B2 pelvic injury.

In five patients (4.8%) a pelvic ring type C-injury was present with four of these having posterior pelvic ring stabilization.

### Radiological diagnostics

Radiological diagnostics included a standard anterior-posterior pelvic radiograph in all cases. Additional oblique views (ala and obturator oblique views) were performed in 55 patients (52.9%). A CT-scan of the pelvis was performed in 65 patients (62.5%).

### Fracture characteristics

According to the course of the transverse fracture component 13 transverse fractures were infratectal, 44 juxtatectal and 47 transtectal.

The mean articular fracture displacement was  $13.5 \text{ mm} \pm 8.8 \text{ mm}$  (1–37 mm). The mean displacement was 5.8 mm for infratectal, 13.1 mm for juxtatectal and 16.2 mm for transtectal fractures. Displacement in juxta- and transtectal fractures was significantly greater than for the infratectal fractures ( $p < 0.004$ , Student's t-test), whereas no significant difference was seen between juxta- and transtectal fractures.

87.5% of patients had a femoral head dislocation: 18.3% a central and 69.2% a dorso-cranial dislocation of the femoral head. Reduction was performed after 5 hours (0–100 hours) in average. 78% of these, had reduction within 6 hours after admission. An associated Pipkin type fracture was observed in five patients (4.8%).

The mean anterior-posterior roof arc was  $26.8^\circ$ , on the iliac oblique view of  $25.7^\circ$  and  $21.3^\circ$  on the obturator-oblique view. The roof-arc values for infra-, juxta- and transtectal fractures were  $50.5^\circ$ ,  $32.5^\circ$ ,  $32.8^\circ$ ,  $31.7^\circ$ ,  $20.8^\circ$ ,  $25.7^\circ$  and  $16.4^\circ$ ,  $26.8^\circ$ ,  $15.8^\circ$  respectively. A comminution zone of the acetabular roof was seen in 16.3% of the patients.

### Perioperative data

Osteosynthesis was performed by a total of 31 different surgeons on average  $9.9 \pm 7.4$  days after trauma (0–40 days).

In the majority of cases (90.4%) the Kocher-Langenbeck approach was used. An extended approach or a combined approach was used in 3.8%, in one patient a Stoppa-approach and in one patient a percutaneous approach was used.

The main type of osteosynthesis was a combination of plate and screw fixation in 71.1% with application of an anterior column screw in 23 patients. In 16 patients (15.4%) only posterior plate fixation was performed, one patient was treated primarily by osteosynthesis and total hip replacement. The others had isolated posterior screw fixation of the posterior wall. The latter two patients were excluded from further analysis.

The mean operative time was  $190 \pm 90$  minutes (30–525 minutes), intraoperative blood loss averaged  $855 \pm 700 \text{ ml}$  (100–3000 ml).

Several articular lesions were recorded by preoperative and intraoperative assessment. 29 patients (27.9%) had injuries of the femoral head cartilage (13x cartilage contusions, 16x marginal impaction). Injury to the acetabular cartilage was seen in 49% (7x cartilage contusions, 44x marginal impactions) and 30.8% had acetabular comminution zones. Intraarticular fragments were seen in 30.8%.

After primary internal fixation a congruent hip joint was seen in 90.3%. The average persistent displacement was  $1.1 \pm 2.4 \text{ mm}$  (0–13). An anatomical joint reconstruction (0–1 mm) was achieved in 76% of patients, a near anatomical reconstruction (2–3 mm) in 14.4% of patients and a poor reconstruction ( $> 3 \text{ mm}$ ) in 9.6%.

The incidence of postoperative seroma or hematoma requiring revision was 6.7%. Four patients (3.8%) developed a deep wound infection.

### Nerve injury

79.8% of patients had no preoperative nerve injury. 20.2% of patients received a fracture related preoperative nerve injury to the sciatic nerve. All but one patient (one lesion of the lateral cutaneous femoral nerve) had lesions of the peroneal part of the sciatic nerve. Postoperatively, 21 patients (20.2%) showed signs of a nerve deficit. In 19 of 21 patients with primary sciatic nerve damage the nerve deficit was found to be unchanged. One patient had complete recovery. An iatrogenic nerve injury occurred in 2 patients (1.9%).

### Long-term results

Excluded from follow-up analysis of follow-up were the patient with primary hip arthroplasty, a patient with Trisomy 21, a patient from Poland, one patient who died secondary and one patient with percutaneous fixation due to significant comorbidities.

Of the remaining 99 patients, 67 (67.7%) could be followed after a mean of  $42.7 \pm 45.7$  months (12–157 months).

The average subjective Visual Analog Scale pain score at follow-up was  $42.7 \pm 35.7$  (0–87 points). The patients were rated by the examiner as having no pain in 28.3%, mild pain in 29.9%, moderate pain in 23.9% and severe pain in 17.9%.

The mean Merle d'Aubigné score was  $15.4 \pm 2.8$  points (6–18 points) with 31.3% of patients with a perfect functional result, 25.4% with a good, 28.4% with a moderate and 14.9% a poor functional outcome.

A persistent nerve deficit was observed in 15 patients (22.4%): two patients had slight sensoric deficits involving the lateral cutaneous femoral nerve and the peroneal part of the sciatic nerve; 9 patients had motoric deficits of the sciatic nerve (M3) and four patients had functionally disturbing deficits of the peroneal and/or tibial part of the sciatic nerve (M1, M2).

At follow-up 35 patients (52.2%) had no post-traumatic osteoarthritic changes of their hip joint (Fig. 2). 12 patients had mild changes (17.9%), 10 patients (14.9%) had moderate arthritis and 10 patients had severe joint destructions (14.9%). Overall, femoral head necrosis grade III and IV were present in 7 patients (10.4%), heterotopic ossification grade IV in one patient. In 10 patients, after an average of 43 months postinjury, a total hip replacement was necessary. Thus, a joint failure was diagnosed in 32.8% of the patients.

There was a significant correlation between the clinical (functional) and the radiological result ( $p < 0.05$ , chi-square test).

Considering only patients with anatomically reconstructed hip joints (postoperative gap/step: 0–1 mm) with a complete follow-up ( $39.6 \pm 32.2$  months (12–144 months),  $n = 49$ ) the following results could be observed:

32.7% of these patients complained of no, 28.6% of mild, 18.4% of moderate and 20.4% of severe pain. The mean Merle d'Aubigné score was  $15.4 \pm 2.9$  points (6–18 points), with 34.7% having a perfect, 24.5% a good, 26.5% a moderate and 14.3% a poor functional result. Disturbing nerve damages (M1–M3) were present in 16.3% of these patients.

Post-traumatic arthrotic changes grade III or IV developed in 26.5% of these patients. A joint failure was present in 32.7%. Overall, 30.6% had total hip replacement.

Comparing patient groups with a joint failure and no joint failure, patients developing a joint failure were significantly more likely to present with an acetabular comminution zone (50% vs. 6%, Fisher's exact test,  $p < 0.001$ ). Other parameters showed no significant difference between these two groups.

## DISCUSSION

Associated transverse and posterior wall fractures are common acetabular fractures with an expected incidence of approximately 17% (7).

Nevertheless, there are only few epidemiological data of this fracture type or long-term results. To our knowledge, no study is dealing with this fracture type.

Letournel reported an incidence of this fracture type of 19.5% (9). Overall, he reported on 183 of these fractures with a sex ratio (m/f) of 2.4:1. An existing preoperative nerve lesion was present in 21.3% of his cases. 32.8% of these fractures had a central femoral head dislocation and 63.9% a posterior dislocation. In four cases intraarticular fragments were reported.

117 of his patients were stabilized operatively within three weeks. In 90 cases (76.9%) the Kocher-Langenbeck approach was used, in 13.7% the extended iliofemoral approach, in six cases the ilioinguinal approach and in two cases a combined dorsal-ventral approach was chosen.

An anatomical joint reconstruction was achieved in 67.5% of these cases.

Clinical and radiological results were available for 101 patients (follow-up rate: 86.3%). 64.4% of patients had an excellent result (Merle d'Aubigné score), 9.9% a good, 8.9% a moderate and 16.8% a bad result. Thus, the frequency of good to excellent clinical results was 74.3%. Radiologically, there were 49.5% perfect results. Femoral head necrosis was reported in three cases. 33.7% of his patients developed post-traumatic osteoarthritis. 3 patients (3%) showed mal-union of the fracture.

In a collective of 262 operatively treated acetabular fractures reported by Matta et al. 60 had an associated transverse and posterior wall fracture (22.9%) (10).

77% of patients were stabilized via the Kocher-Langenbeck approach and 22% with the extended iliofemoral approach. An anatomical reduction was achieved in 80% of the patients, a near anatomic reduction in 17% and 3% had non-anatomical joint reconstruction. According to the Merle d'Aubigné score a functionally perfect result was found in 35%, a good in 35%, a moderate in 8% and poor in 22%.

Mears et al. reported on 55 transverse and posterior wall fractures, of which 74.5% had anatomical and 20% near anatomical reduction (13). 5.5% had a non-anatomic joint reconstruction.

All patients were followed (100%) and Harris Hip Score (8) showed 69% good to excellent clinical results.

Data from the 1<sup>st</sup> German Multicenter Study group pelvis reported an incidence of 7.2% for this fracture type (36/503 cases) (17). In 28 patients the fracture was stabilized surgically (77.8%). The Kocher-Langenbeck approach was used in 20 patients, the ilioinguinal approach in 3 patients, an extended approach in 4 patients and a combined dorso-ventral stabilization in one patient. The postoperative quality of reduction was evaluated as anatomic in 82.1% and as near anatomic in 17.9%.

Due to lack of differentiation between surgical and non-surgically treated patients, no clear data were available on the long-term outcome after surgical treatment.

Zinghi et al. found an incidence of this fracture type of 20.8% (21). The majority of the 58 patients were men. The rate of preoperative nerve deficits was 2.8%.

All patients were stabilized surgically. Three iatrogenic nerve injuries were reported (2.8%). Two patients developed deep hip joint infections (1.9%). Heterotopic ossifications of Brooker grade III and IV {Brooker, 1973 #19} were found in 7.5% and interestingly 23.6% of these



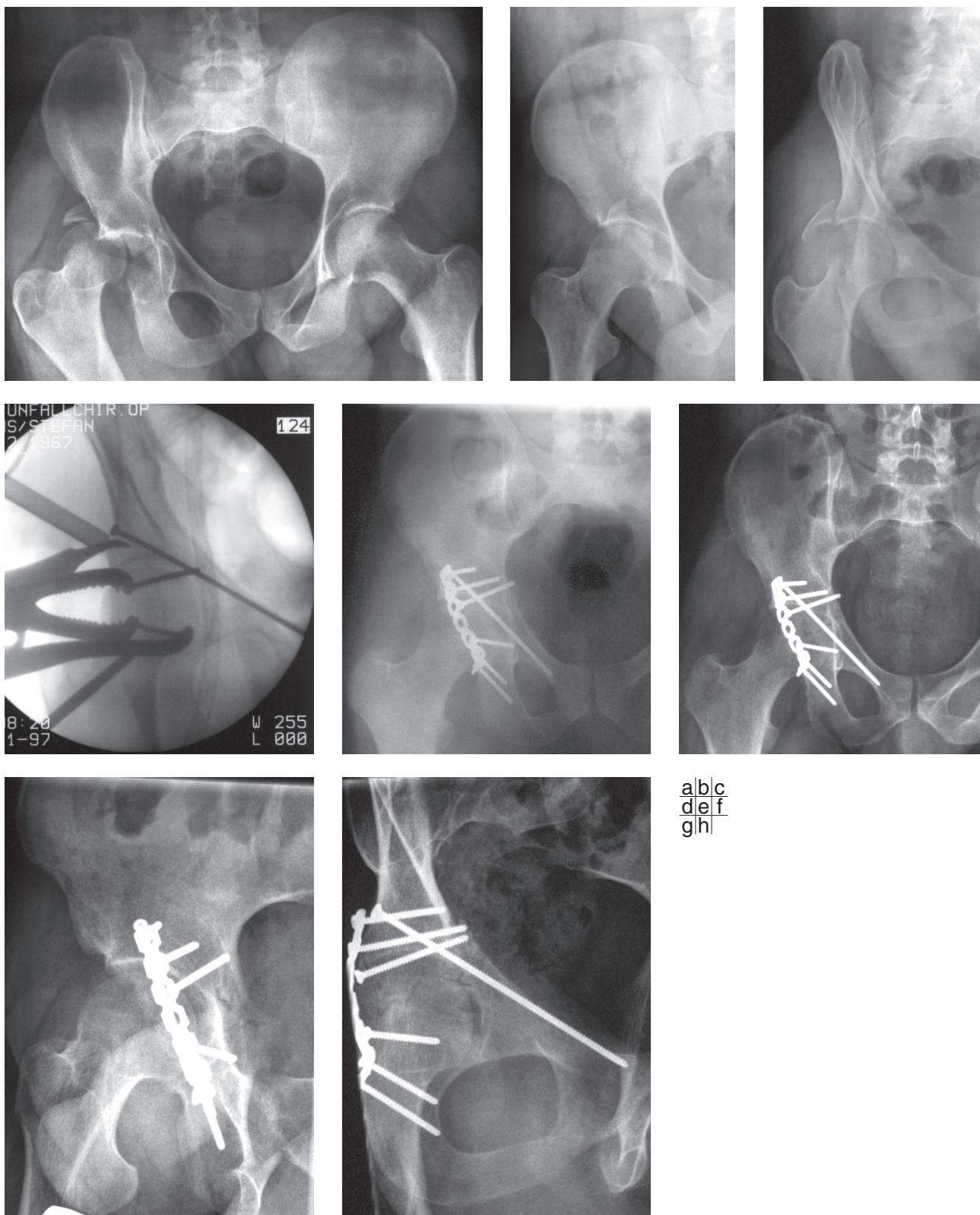


Fig. 2. Clinical example of a transverse/posterior wall fracture treated with plate and screw osteosynthesis via the Kocher-Langenbeck approach with a congruent reconstruction of the joint. The a.p.-view (a) shows the typical postero-superior fracture dislocation with a displaced posterior wall fragment and a juxta-tectal transverse fracture component. After reduction the ala-oblique view (b) shows a congruent joint with a minor displaced transverse fracture, the latter confirmed on the obturator oblique view (c). Intraoperatively, reduction of the transverse component was performed with a Faraboeuf-clamp (d). Postoperatively, anatomical reconstruction was achieved (e) with posterior plate fixation of the transverse fracture in addition to an anterior column screw. The posterior wall fragment was fixed with to isolated screws. The long-term result after 39 months shows a congruent joint in the a.p. (f), ala (g) and obturator oblique views (h) with anatomical joint healing. The old fracture line is still somehow visible.

Tab. 1. Relevant epidemiological data in operatively treated transverse/posterior wall fractures

	Incidence	Age	Sex m:f	Side r:l	High energy-trauma	Additional injuries	Primary nerve deficit
Letournel, n = 183	19.5%	n.e.	2.4:1	n.e.	n.e.	n.e.	21.3% 39
Matta, n = 60	22.9%	n.e.	n.e.	n.e.	n.e.	n.e.	n.e.
Zinghi, n = 106	20.8%	n.e.	n.e.	n.e.	n.e.	n.e.	n.e.
Pohlemann, n = 36	7.2%	n.e.	n.e.	n.e.	n.e.	n.e.	n.e.
Gänsslen, n = 104	10.6%	35.5	3.7:1	72:32	98	73	20.2%
<b>Overall</b>	<b>15%</b>	<b>36.5</b>	<b>3:1</b>	<b>rechts</b>	<b>&gt;90%</b>	<b>70.2%</b>	<b>10–15%</b>

Tab. 2. Overview of perioperative data in transverse/posterior wall fractures

	OR time	Approach				Duration of operation	Blood loss
		ilioinguinal	Kocher-L	extended	combined		
Letournel, n = 114	0–21d	6	90	16	2	n.e.	n.e.
Matta, n = 60	0–21d	0	46	14	0	n.e.	n.e.
Pohlemann, n = 28	n.e.	3	20	4	1	n.e.	n.e.
Gänsslen, n = 102	9.9d	0	94	4	4	190min	855ml
<b>Overall</b>	<b>10d</b>	<b>3%</b>	<b>82.2%</b>	<b>12.5%</b>	<b>2.3%</b>	<b>190min</b>	<b>855ml</b>

Tab. 3. Overview of the reduction quality in transverse/posterior wall fractures

	Anatomic 0–1 mm	Near anatomic 2–3 mm	Non-anatomic > 3 mm
Letournel, n = 117	79	n.e.	n.e.
Matta, n = 60	48	10	2
Mears, n = 55	41	11	3
Pohlemann, n = 28	23	5	0
Gänsslen, n = 104	79	15	10
<b>Overall</b>	<b>74.2% (270/364)</b>	<b>16.6% (41/247)</b>	<b>6.1% (15/247)</b>

Tab. 4. Overview of functional and radiological long-term results after operative treatment of transverse/posterior wall fractures

	Merle d'Aubigné				Posttraumatic changes III+IV°	Femoral head necrosis
	18	16–17	13–15	<13		
Letournel, n = 101	65	10	9	17	34	3
Matta, n = 60	21	21	5	13	n.e.	n.e.
Zinghi, n = 106	58	25	7	16	n.e.	n.e.
Gänsslen, n = 67	21	17	19	10	20	7
<b>Overall</b>	<b>49.4%</b>	<b>21.9%</b>	<b>12%</b>	<b>16.7%</b>	<b>32.1%</b>	<b>6%</b>

patients developed an algodystrophic syndrome. Posttraumatic femoral head necrosis developed in 11.3%, acetabular necrosis in 7.5% and post-traumatic arthrosis in 11.3%.

The clinical result using the Merle d'Aubigné score showed a rate of excellent and good functional results in 78.3% of the patients, with 58 patients having an excellent and 25 a good result. 7 patients had moderate and 16 severe functional limitations.

In summary, based on present available data from the literature and on the basis of the presented data the following conclusions can be made (see table 1–4).

#### Epidemiological data (table 1):

- the incidence of associated transverse and posterior wall fractures is about 15%
- the mean patient age is between 30 and 40 years
- males are predominantly injured
- high energy trauma as the cause of injury can be observed in > 90%

- the incidence of associated injuries is > 70%
- the rate of primary nerve damage (especially sciatic nerve lesions) is approximately 20%

#### Perioperative details (table 2):

- the majority of patients is treated operatively within 3 weeks after trauma
- standard approaches were the Kocher-Langenbeck approach (> 80%) and extended approaches
- in 70% a combined plate and screw fixation was performed
- a mean operative time of 3 hours can be expected
- a mean intraoperative blood loss of 900–1000 ml can be expected

#### Quality of reduction (table 3):

Approximately 75% anatomical reductions can be expected after operative treatment of associated transverse and posterior wall fractures. Near anatomical reductions

are observed in about 16% and non-anatomical reductions in about 6%.

#### Long-term results (table 4):

- 49.4% perfect functional results can be expected
- 21.9% good functional results can be expected
- 12% moderate functional results can be expected
- 16.7% poor functional results can be expected
- overall, 71.3% good and perfect functional results can be expected
- a rate of 32.1% posttraumatic arthritic changes can be expected
- a rate of 6% posttraumatic femoral head necrosis can be expected

A clear dependency between the quality of reduction and the long-term results can be stated for this fracture type. Additionally, fracture-related factors (additional pathologies) as the extent of the primary displacement, the extent of involvement of the acetabular roof with any existing comminution zones (13), the number and location of intraarticular fragments (10) and concomitant lesions of the femoral head (10) are also indicators of poorer long-term results.

This additional pathologies are now increasingly in the interest of long-term evaluation after acetabular fractures. Only the quality of reduction can be influenced surgically, whereas fracture classification, fracture-related pathologies and additional associated injuries (e.g. nerve damage) are given.

Only the presence of a comminuted acetabular area especially in the area of the acetabular roof was the only prognostic factor in the present study for associated transverse and posterior wall fractures of the acetabulum for a poor radiological and functional outcome.

#### CONCLUSION

Associated transverse and posterior wall fractures are common acetabular fracture types and are the result of high energy trauma in the majority of patients. Therefore, significant injury to the acetabular cartilage and additional local injuries are often observed. With open reduction and internal fixation anatomical or near-anatomical joint reconstruction is possible > 90% of patients. In contrast, the long-term result shows only 56.7% functionally perfect or good results and a high rate of posttraumatic degenerative changes with 1/3 developing joint failure within few years after trauma. An additional acetabular comminution zone seems to be of prognostic value.

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