

Acetabular Fractures in Children: A Review of the Literature

Zlomeniny acetabula u dětí. Přehled literatury

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SUMMARY

Injury to the acetabular growth plate is rare. Accordingly, data on the incidence in the literature are controverse. Other difficulties include the clear definition of a pediatric acetabular injury.

The modified classification according to Salter-Harris described by Bucholz is used in immature patients.

The majority of these injuries can be treated conservatively. In severely displaced injuries or in the presence of intra-articular pathologies open procedures are recommended. The main long-term complication is the development of posttraumatic acetabular dysplasia which should be early detected by regular check-ups until the completion of growth.

Overall, the long-term results are satisfactory.

Anatomy of the triradiate cartilage

The growing acetabulum consists of the three primary ossification centers: the pubic, ischial and iliac centers. These confluence within the triradiate cartilage complex (39, 50), which normally fuses at the age of 16 to 18 years (50).

The growth plates lie between the three pelvic bones. They are composed of the nonarticular part medially (triradiate cartilage with three flanges between the three pelvic bones) and the classical cup-shaped articular acetabular hyaline cartilage laterally. Two thirds of this complex belong to the latter cartilage part (7, 39).

The greatest cellularity of these growth plates is found in the ilioischial flange (7, 39, 49), therefore, injury to this part can result in growth disturbances. Interstitial growth (height, dimension) and appositional growth (depth) and some periosteal growth are the main contributors in this complex, whereas the femoral head is responsible for development of the acetabular concentricity (7, 39, 50).

Several secondary ossification centers develop within the flanges of the acetabulum. The os acetabuli is the most common epiphysis of the superior pubic ramus contributing to the anterior wall of the acetabulum. Its

growth starts at 8 years of age and fuses by the age of 15 years. A superior epiphysis develops between 8 and 9 years and is fused by 18 years of age, whereas an ischial epiphysis appears between 9 and 10 years of age (7, 39, 50).

Epidemiology

Injuries of the pediatric acetabulum or triradiate cartilage are rare entities (3, 6–8, 16, 20, 25, 26, 29, 34, 36, 40, 43–45). Thus, the majority of early publications were only case reports (18, 34, 41, 48, 50).

Overall, the incidence of acetabular injuries within the group of pediatric fractures is reported to be between 0.03 and 0.3% (3, 45) and to be between 3.5% and 20.4% in pediatric patients with pelvic trauma (3, 6–8, 16, 20, 25, 26, 29, 32, 34, 36, 40, 43–45).

Even fewer patients sustain specific injury to the triradiate cartilage (7, 18, 21, 41).

Mechanism of injury

Most pediatric acetabular injuries are the result of a high energy trauma (1), whereas injury to the triradiate cartilage is most often due to direct injury (6, 7, 13, 23, 49).

The predominant injury mechanism is the motor vehicle accident (21, 22). More complex injury mechanisms can lead to combined pelvic ring and triradiate cartilage injury (23).

As in adults, lateral compression forces with forces through the femoral neck and head to the acetabular surface can lead to an acetabular injury or fracture (1, 31, 34).

Associated injuries

Pediatric acetabular fractures are associated with concomitant pelvic ring injuries, proximal femoral fractures or femoral shaft fractures, head trauma and multiple organ damage (47).

The rate of additional pelvic ring injuries can be found in up to 58.6% and femoral head dislocation can occur (21). The latter was found to result in less favourable long-term results (17). In a recent report, a combination of a triradiate injury and a traumatic epiphysiolysis of the femoral head was observed Pina-Medina et al. Additionally, acetabular fractures have been described as markers of significant bleeding (40, 48).

Diagnostics

Clinical evaluation generally does not differ from that of adults (ATLS) but must be focussed on possible concomitant intrapelvic lesions (35). Beside inspection of the undressed patient, mechanical stability testing of the pelvis and analysis of the peripelvic orificiae are mandatory. Especially, soft-tissue and bony injuries of the proximal femoral region should be suspected (22, 47).

Radiological evaluation of the traumatized acetabulum in young children is often difficult (13, 46, 49). An anterior-posterior pelvic x-ray is mandatory. Even with this single view several fractures cannot be detected. An os acetabuli might complicate the proper diagnosis (5, 12, 37). A follow-up x-ray after 2–4 weeks postinjury was recommended to detect secondary periosteal signs indicating an acetabular injury (35).

Oblique views (Judet-views) and Inlet- & Outlet views can confirm the diagnosis of an injury to the triradiate cartilage.

Classical radiographic signs of an acetabular fracture can be (46):

- displacement of growth plates
- disruption of the iliopectineal line
- intraarticular effusion (ultrasound evaluation, Fig. 1)
- a positive capsule sign
- asymmetric tear drop

Data from the literature found a rate of 22%–80% missed injuries on primary x-rays (7, 10, 22, 44). Therefore, in all suspected cases acetabular evaluation a CT-scan is recommended (1, 7, 19, 21, 23, 33, 46, 50). The main advantage is the more frequent detection of osteochondral injuries (19).

A MRI is recommended in all further unclear situations, in clinical suspicion of an inverted labrum or an intra-articular osteochondral fragments or suspected closure of the triradiate cartilage.

For long-term evaluation, follow-up x-rays are recommended to detect significant growth disturbances (4).

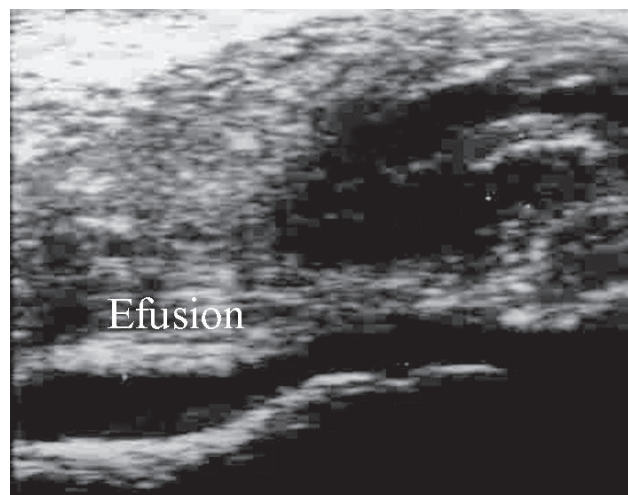


Fig. 1. Longitudinal ultrasound examination of the hip joint, showing intraarticular effusion as an indirect sign of possible acetabular injury.

Classification

Several authors described pediatric acetabular classifications (1, 24, 50). The most useful classification of injuries of the acetabulum in the immature group of patients (open triradiate cartilage) was proposed by Bucholz (7). This classification evaluates the injury in relation to the triradiate cartilage. Analogue to the Salter-Harris-classification he distinguishes between three injury types:

- type I: epiphysiolysis of one part of the triradiate cartilage
- type II: epiphysiolysis with a bony fragment
- type V: crush injury to the growth plate

Injury to the triradiate cartilage with or without metaphyseal involvement can arise from shearing forces, due to forces on the ischial bone, the pubic bone or the proximal femur. These injuries are the most common types (15, 28) and have a relatively good prognosis and normal growth in the majority of cases (7, 42). Often, an additional injury of the pelvic ring can be observed (6). The second variant involves a crush injury of the triradiate cartilage (type 5 according to Salter) with a poor prognosis and risk of development of a premature closure due to a medial osseous bridge.

The classification of Letournel is often not feasible in young children, but in the transient age group of children (12–14 years) many fractures can be classified with this classification (7, 31).

Treatment options

The main goal in treating pediatric patients with acetabular injury is an absolute anatomic reduction (4, 50) without creating further injury to the blood supply of the triradiate cartilage.

Conservative treatment was advocated as the treatment of choice in these injuries (6, 24). The treatment options differ from functional to plaster and traction therapy. In stable, undisplaced fractures, bed rest, early physiotherapy and partial weight bearing after one week was favored, whereas in unstable, displaced fractures, a six week trac-

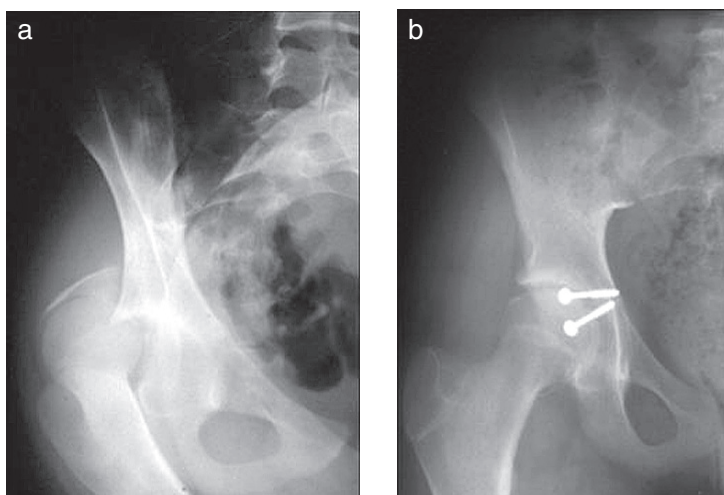


Fig. 2. A displaced injury of a posterior wall fragment in a 13-year-old girl (a) was fixed by screw osteosynthesis via Kocher-Langenbeck approach (b).

tion therapy followed by non weight bearing for an additional six weeks was proposed (1). Others recommended supracondylar traction for 3–4 weeks, followed by 2–4 weeks bed rest after anatomic reduction (4) or application of a pelvic cast for 3–4 weeks in stable injuries (28).

Overall, congruent reduction with a closed conservative treatment concept is difficult and often impossible to achieve (22). Therefore, operative stabilization is proposed when anatomic reduction is not possible by closed means (4).

Accepted indications for operative stabilization of acetabular injury in children are (1, 4, 7, 11, 15, 22, 27, 28, 49, 50):

- fractures with >2 mm displacement of the weight-bearing articular surface
- hip joint instability (Fig. 2)
- posterior wall fractures involving more than 50% of the articular surface
- incarcerated fragments

Presently, only 1.5% of children were treated surgically in the recent German multicenter study (20), whereas others reported an osteosynthesis rate between 15 and 45% (16, 27, 40, 44).

Treatment options include resorbable transosseous sutures (4), single screw osteosynthesis, K-wire fixation or plate osteosynthesis (1, 4, 22, 24, 28, 44).

Heeg et al. reported on a rate of 81.3% anatomic congruency after open reduction and internal fixation (21).

Postoperatively, non-weight bearing for 4–8 weeks without (28) or with additional traction is recommended (22).

Von Laer proposes further weight bearing dependent on clinical impairments (pain) (28). However, Heeg permits partial weight bearing for an additional six weeks, followed by full weight bearing after three months (22).

Mortality

Data on mortality after acetabular injury in children was only reported in one study. A low rate of 1.5% deaths was reported (25).

Outcome

However, only few reports focus on the long-term outcome of these injuries (7, 17, 18, 23, 30, 41, 47, 49).

Heeg et al. performed several excellent analyses on pediatric acetabular trauma (21–23).

First they reported on six cases at an average of eight years after trauma. After radiographically detected Salter-Harris type I or II injuries, no growth disturbances were observed and an excellent functional result was reported. In both type V injuries, an acetabular dysplasia developed and resulted in operative correction (23). In a further analysis of 23 acetabular injuries in children, the clinical and radiological result was analysed according to the Harris Hip Score. Following conservative treatment, the results were encouraging. Salter-Harris type V injuries had poor results. Overall, patients with an acetabular displacement of less than 2 mm, stable posterior

fracture-dislocations and Salter-Harris type I and II triradiate cartilage fractures had better results. Less favourable results were seen in type V triradiate cartilage fractures and in comminuted fractures. Overall, functional results were superior to radiological results (22).

Recently, Heeg, in a multicenter study, analysed 29 patients up to 16 years of age with an acetabular fracture (21). Ten of these patients were adolescents (15 or 16 years of age) and were predominantly (n=7) treated by open reduction and internal fixation. Of the remaining “real” children, five were treated operatively with two having major long-term sequelae like avascular necrosis of the femoral head and ankylosis of the hip joint. In the non-operative group, no acetabulum specific growth disturbances were reported.

Stäubli et al. in a follow-up analysis of eight former children 20 years after trauma found a rate of 50% medial callus bridge formation with moderate or severe acetabular dysplasia (47).

COMPLICATIONS OF TREATMENT

Prognosis

Several late sequelae after pediatric acetabular injuries are described in the literature:

- development of posttraumatic acetabular dysplasia (1, 4, 6, 7, 12, 13, 15, 23, 30, 41, 47, 49)
- posttraumatic femoral head necrosis (1, 13, 17)
- leg length discrepancies (6)
- postraumatic arthrosis (12, 17)
- As a rare complication Torode reported on a hip joint ankylosis (48).

One of the main risks after acetabular injury is the development of an acetabular dysplasia (Fig. 3). Severe damage to the triradiate cartilage can result in its premature closure with the often observed consequence of acetabular dysplasia, which affects approximately 5% (range, 0–11%) of patients with acetabular fractures (23, 49).

After acetabular fractures in immature patients the rate of premature closure of the triradiate cartilage or secondary dysplasia is reported to be approximately 31% (range: 0–55%) (7, 8, 21, 29, 34, 43).

Periarticular ossifications due to small bone or chondral fragments, injury of chondral vessels (7), development of an osseous bridge on the triradiate cartilage (46) or ossification of haematoma (41) may be etiologies of acetabular dysplasia. The natural course is still unclear. Present data are only available from experimental studies. In animal models, fusion of parts of the triradiate cartilage lead to an age-related development of acetabular dysplasia (14, 18). Isolated fusion between the ilium and pubis showed only minimal growth disturbances, whereas fusion of the ilio-ischial part lead to 100% dysplasia (14). Several authors confirmed these experimental results by clinical observations (10, 13, 41, 49).

Typical radiographic sings of posttraumatic acetabular dysplasia are (46, 49):

- pelvic asymmetry
- coxa parva (acetabular dyslasia with a small femoral head)
- lateral subluxation of the femoral head
- lateral extension and widening of the tear drop figure/quadrilateral plate (7)
- joint incongruence
- reduced Center-Edge-Angle (47, 49)
- growth disturbances of the proximal femur (7, 30)

The time intervall between the injury of the triradiate cartilage and the development of an acetabular dysplasia was 12.4 years in average (47).

Treatment of symptomatic posttraumatic dysplasia consists of different periacetabular osteotomies and/or intertrochanteric osteotomies (4, 7, 13, 46, 49).

For early detection of possible complications, x-ray evaluation of the pelvis is recommended annually until adulthood (35).

All other complications and especially their treatment are reported rarely in the literature. Recently, a case was reported where a secondary osteoarthritic change developed at the site of an acetabular fracture and a hip resurfacing arthroplasty was performed at the age of 25 years (2).

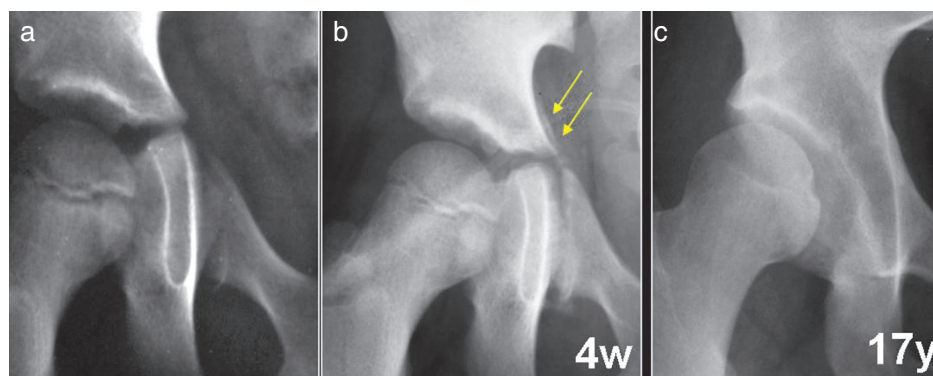


Fig. 3. 6-year-old boy with a lateral compression injury to the pelvis. The a.p.-view of the hip shows an injury to the upper pubic ramus (Salter-Harris Type I). After 4 weeks some periosteal ossification is visible (b) indicating an involvement of the triradiate cartilage. Follow-up examination after 17 years shows development of acetabular dysplasia with typical radiological signs (c).

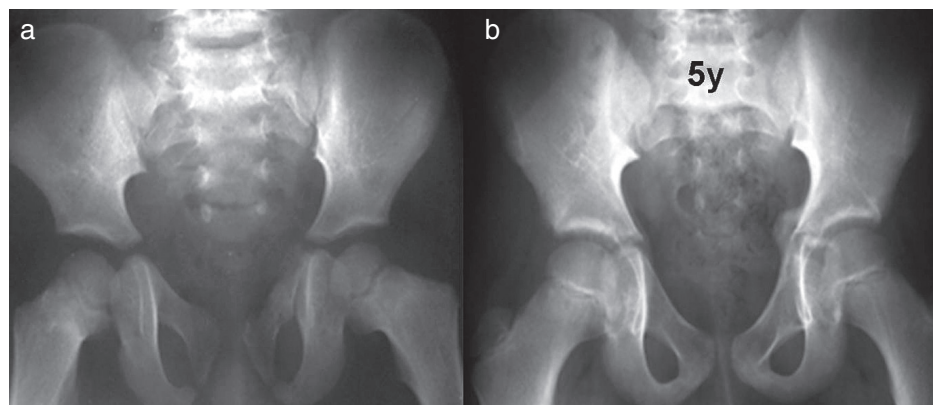


Fig. 4. A left Salter-Harris type II injury (a) lead to development of an osseous bridge at the medial triradiate cartilage (b).

Additionally, development of an osseous bar (Fig. 4) can lead to resection with no further abnormalities (9, 38).

Conclusion

Acetabular injuries in the pediatric trauma group are still rare injuries and no standardized treatment concept can be recommended. The most important first step is to diagnose such an injury, as still many of these injuries can be overlooked. Adequate radiographic evaluation is necessary in all suspected cases. Frequent re-evaluation of all children with significant pelvic trauma is recommended until growth arrest to detect late sequelae of their injury.

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