

## Fractures of the patella in children and adolescents

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Fractures of the patella in children and adolescents are rare injuries with particular characteristics. The aim of this study was an analysis of epidemiology, treatment strategy and outcome of this injury.

Between 1992 and 2006 all fractures of the patella in patients with an age  $\leq 16$  years were included in a case control study. Besides outcome analysis using the modified HSS knee score, radiological follow-up was evaluated.

During that time period, 23 children (6 girls, 17 boys) with patella fractures were seen in our institution; the incidence of patellar fractures was 0.44%. The average age was 12.4 years. The fractures mainly occurred during sports and leisure activities, followed by traffic accidents. Specific to children are avulsions of the lower or upper pole of the patella. Eleven children were non-operatively treated. Surgical techniques used were screw osteosynthesis, tension band wiring, transosseous suture, and refixation with biodegradable pins. In 7 cases an arthroscopy was performed in order to evaluate intraarticular lesions. Twenty-one children were recruited for a follow-up examination after an average of 40 months. A very good result was achieved in 16 cases and a good result in 5 cases. The radiological result at short term did not correlate with the clinical outcome. Patella fractures in children are a rare injury with a good short-term prognosis; long term outcome may significantly depend on the accompanying cartilage damage. In two cases an Autologous Chondrocyte Implantation was performed two years after the injury.

**Key words** : patella fracture ; children ; adolescent ; outcome ; treatment.

## INTRODUCTION

Fractures of the patella are rare injuries in children, with an incidence under 1% of all fractures in children (6). Stress loads result in less pressure and pulling forces in children than in adults because of the flexible soft tissue anchoring. The flexible stabilizing soft tissue structures allow for a high mobility of the patella that avoids mechanical stress peaks in accidents. Furthermore, the thick cartilage layer is acting as a buffer in case of direct impact. These anatomical characteristics protect the patella. Multicenter ossification of the patella starts at the age of 3 years, and fractures of the patella are usually not found before the children reach an age of 6 years (18,26).

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The different fracture types are caused by various accident mechanisms. Direct concussion presses the patella against the distal femur and leads to transverse or comminuted fractures. Distal or proximal avulsions that basically may be considered as bony tears of the quadriceps or patellar tendon are caused by sudden contraction of the quadriceps muscle in knee flexion. Lateral avulsions are rare, but should not be misinterpreted as the anatomical variant of a bipartite patella. Medial avulsions are a particular pathology associated with patellofemoral maltracking, medial patellar retinaculum and medial patellofemoral ligament (MPFL) ruptures and have been classified as patella fractures only when the bony avulsion was bigger than 1.5 cm in one dimension. Besides the refixation of the fragments, these injuries require additional procedures of medial stabilization such as MPFL suture, graft reconstruction or realignment with vastus medialis transfer in order to prevent recurrent dislocations (5).

A type of patella fractures, particular to children, is the sleeve fracture (34) where the small, eggshell-like bony fragment is dislocated with a larger soft tissue part which consists of cartilage, periosteum and retinaculum. This fracture type is frequently overseen, because its appearance on the lateral view is not spectacular and may sometimes only be recognized by the cranialization of the patella. When in doubt, MRI may clarify the situation (1). In order to correctly differentiate between fractures and anatomical variants, the normal ossification sequence should be known. Avascular osteonecrosis of the inferior patella pole known as Sinding-Larsen-Johansson disease (21) and the above mentioned bipartite patella should be taken in consideration when evaluating radiographs of the patella.

Surgery should be considered in case of secondary displacement during cast or brace treatment, in case of loss of active knee extension, and when a considerable step-off in the retropatellar joint surface is seen. In general the possibility of a successful remodeling of a step-off exceeding the local thickness of the articular cartilage is highly questionable (17). Only osteosynthesis with interfragmentary compression has proved to generate

bridging by hyaline cartilage at the location of fracture healing (22). Usually, the three basic radiographic views of the patella (knee AP and lateral, patella tangential) are sufficient. In case of patella dislocation an MRI is necessary in order to evaluate cartilage damage, osteochondral lesions, bone bruises and tears of ligaments such as the medial patellofemoral ligament (MPFL) (7).

Open reduction and internal fixation of transverse fractures may be achieved using tension band wiring or osteosynthesis with lag screws. In case of sleeve fractures, transosseous sutures may restore knee extension. Fixation of osteochondral fragments or flake fractures and reconstruction of the joint surface is best achieved with biodegradable pins.

The aim of this study was the analysis of epidemiology, treatment strategy and outcome of this injury in children and adolescents. We wanted to find out whether fracture type and treatment strategy are different in young patients and in adults.

## MATERIALS AND METHODS

### Patients

Patella fractures in children are rare ; therefore, coverage of a long time period was necessary to include a sufficient number of patients for evaluation. Between 1992 and 2006 (15 years) all fractures of the patella in patients with an age  $\leq 16$  were included in a case control study. The patients were identified by scanning the patient's files for the ICD code S82.0 (International Classification of Diseases), and the catch words 'patella', 'fracture'. Epidemiologic data were obtained from the patient's records. Patella dislocations with osteochondral fragments were considered as patella fractures, when the size of the bony fragment exceeded 1.5 cm in one dimension.

### Outcome analysis

Outcome was evaluated by patient examination and questionnaire using the modified HSS knee score as described (4,23) after an average of  $40 \pm 31$  months (but at least 12 month following

injury). In addition, functional tests were performed and radiological follow-up was evaluated. Radiological result was evaluated as suggested elsewhere (4) by using the following categories : anatomical, retropatellar step-off ( $> 2$  mm), slight signs of gonarthrosis (subchondral sclerosis, slight narrowing of joint space, small osteophytes) (16), and advanced signs of gonarthrosis (severe narrowing of joint space, big osteophytes, subchondral cysts). In one patient the patella fracture occurred in association with a floating knee (distal fracture of the femur und fracture of the proximal lower leg), in another patient the fracture was associated with a spastic knee flexion contracture. Because of these complex situations both patients were excluded from the follow-up examination. There was no open fracture in this series. Functional tests included sports abilities, one-leg-stand, squatting and squat-walking, and lifting of the extended leg.

Two patients were treated by retropatellar autologous chondrocyte Implantation (ACI) (2,9,30). We used a matrix associated technique as previously described (24). The steps include 2-stage procedures with an initial cartilage biopsy, which is sent for chondrocyte culture, followed by cell implantation in a second stage operation. Implantation implies an arthrotomy with preparation of the defect sparing the subchondral bone plate, preparation of a collagen matrix (Chondro-Gide®, Geistlich Biomaterials, Wolhusen, Switzerland) with chondrocyte fixation, suture of the matrix within the defect, securing a watertight seal with fibrin glue, and wound closure. The amount of chondral damage was graded from 0 to IV based on the ICRS classification, decision making depending on size and depth of lesion has recently been published (27).

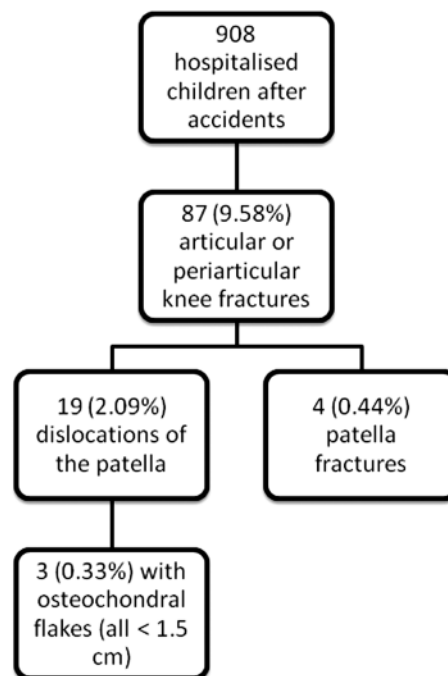
### Statistical Analysis

Data are expressed as mean  $\pm$  standard error of the mean. In groups with equal variances, data sets were analyzed using one-way analysis of variance. The direct comparison of individual score means was done by a Wilcoxon test. Significance was assigned where  $p < 0.05$ .

## RESULTS

Twenty-three patients with an average age of  $12.4 \pm 2.48$  years were included in the study. In 18 patients patellar fractures occurred as single lesions, 5 patients suffered from additional injuries. Twelve patients out of 23 were not able to actively extend the knee during their first presentation in the emergency department, correlating with the number of surgically treated children. In 15 cases an initial knee effusion was documented. Typically only the non-displaced fractures presented without a haemarthrosis.

In order to evaluate the incidence of patellar fractures a prospectively collected consecutive series of 908 hospitalised children between October 1992 and September 1996 (4 years) were analyzed (28). Eighty-seven children (9.6%) suffered articular or periarticular knee fractures (incl. distal femur and proximal tibia). Four children of 908 (0.44%) were treated because of a fracture of the patella (fig 1).



**Fig. 1.** — Overview of the incidence of patellar fractures in a consecutive series of 908 hospitalised children.

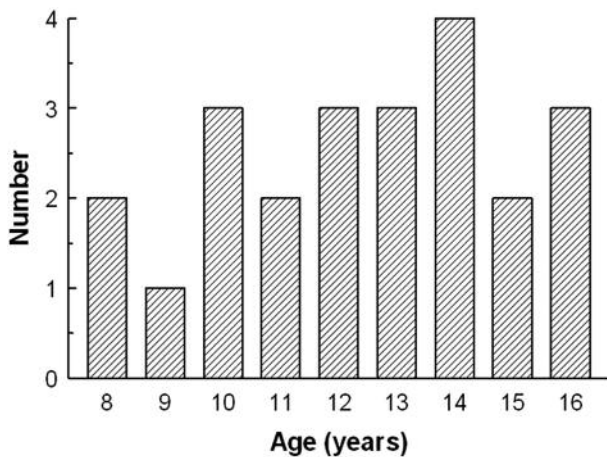


Fig. 2. — Age distribution of patients (≤ 16 years) with patella fractures. No fractures occurred in children younger than 8 years.

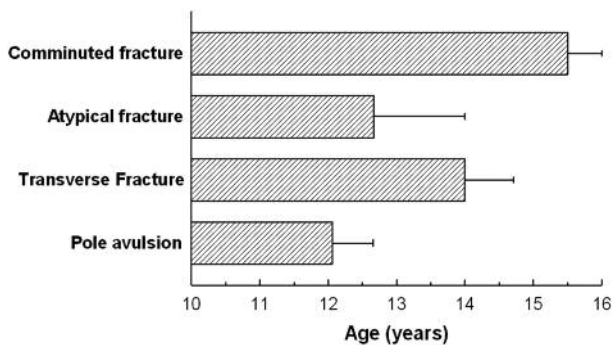


Fig. 3a. — Age dependency of fracture types. Atypical fractures mainly correspond to osteochondral avulsions. Statistically significant differences are indicated.

In the series of all registered patellar fractures (23) no injury was observed in children younger than 8 years (fig 2). The fracture type depended on age as pictured in figure 3a ( $p < 0.05$ ). Comminuted fractures were seen in adolescents, avulsions of the patella pole (fig 3b) were typically observed in younger children. Seventeen patients were boys and six patients were girls. Ten were treated on an outpatient basis ; 13 patients were hospitalised. The majority of accidents with patella fractures happened during leisure and sports activities ; direct contact caused patella fractures more often than forced hyperflexion of the knee. Eleven fractures were treated by immobilization in a cast or brace without operation, 12 patients were operated using tension band wiring, screw osteosynthesis, fixation with biodegradable pins or transosseous sutures. The time needed for operative stabilization was  $73 \pm 29$  min (range 42 to 132 min) ; intra-operative X-ray exposure ranged around 31 sec. No infections were noted after operative treatment, in one case an intraarticular effusion had to be aspirated without further complications. An additional arthroscopy for evaluation of cartilage damage was performed in 7 cases. In all operated children the cartilage damage was classified (multiple characterizations were possible). There was no cartilage damage in 3 cases (pole avulsions), 7 cases had cartilage cracks (grade I according to ICRS), 3 cases had cartilage contusion (grade II according to ICRS, accompanied in two cases by an

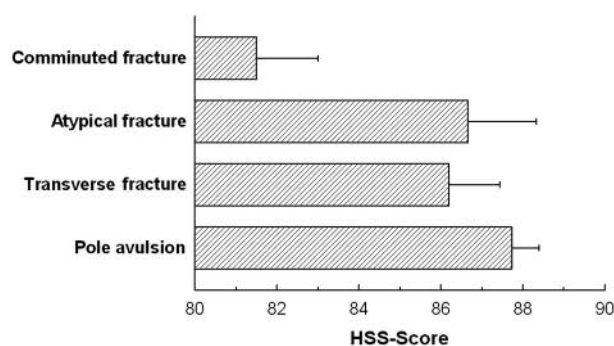


Fig. 3b. — Lateral views of the knee showing different types of pole avulsions. a : displaced upper pole ; b : lower pole without displacement ; c : sleeve fracture.

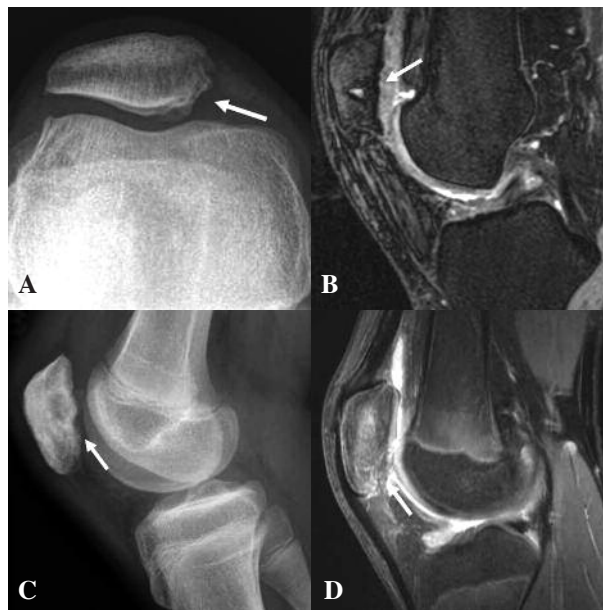


impression in the subchondral bone layer), and two cases had subchondral bone exposed and a partial shearing off of cartilage layer (grade III and IV according to ICRS, sleeve fractures). The average time until the patients could go back to school was 2.4 weeks, full weight bearing was possible after an average of 33.5 days, and sport activities were possible after an average of 18 weeks. Knee function was evaluated using the HSS knee score. In 16 cases a very good and in 5 cases a good result was found after an average of 40 months. The mean HSS knee score was  $86.6 \pm 3.1$  points [80-90]. There was no statistical relation between fracture type and outcome, but the functional result tended to be worse in comminuted fractures (fig 4). The type of chosen therapy did not influence the post-operative outcome: non-operative cases reached an average score of  $85.67 \pm 0.78$  versus  $87.33 \pm 1.06$  in operative cases (n.s.). Residual functional deficits were found in 3 cases. Five patients reported a recurrent knee effusion. In two patients a retropatellar step-off and in two further patients slight signs of gonarthrosis (doubtful narrowing of joint space as suggested by Kellgren and Lawrence) were observed. The radiological outcome score did not correlate with the HSS score:  $85.73 \pm 0.81$  with abnormal radiological findings vs.  $88.33 \pm 1.67$  with anatomical restitution (n.s.). We found full stability of the ligaments in every case undergoing a follow-up examination. No patella dislocation or signs of meniscal tears were found. Range of motion after reaching full weight bearing was  $-0.4^\circ \pm 1.4^\circ$  extension and  $114.6^\circ \pm 24.4^\circ$  flexion.

Accompanying cartilage damage is supposed to be a decisive factor for long time prognosis (fig 5). MRI scans of the knee were performed because of persisting complaints in 6 cases showing a significant cartilage lesion in 4 cases. Two of these patients were treated by a retropatellar Autologous Chondrocyte Implantation (ACI) as previously described (24). Both patients were seen at one year follow-up, showed proper graft integration on MRI and had reached full sports activity. MRI in the acute situation was performed 3 times, when injury mechanism or complaints indicated additional injuries such as cartilage damage or rupture of ligaments.



**Fig. 4.** — Fracture type and outcome (no statistical association, but a trend towards a worse functional result in comminuted situations)



**Fig. 5.** — Part A and B as well as part C and D show pairs of conventional X-ray and MRI showing cartilage damage after patella fractures (arrows). A (tangential view) and B (corresponding MRI) 4 years after injury (lateral patella facet). C (lateral view) and D (corresponding MRI) 1 year after a sleeve fracture. Both patients complained of stress induced knee pain.

## DISCUSSION

Our study confirms that fracture of the patella in children and adolescents is a rare injury, which may be due to the special anatomic characteristics of the knee in children (6). Our results are confirmed by the data of the Federal Statistical Office of

Germany ([www.gbe-bund.de](http://www.gbe-bund.de)). The incidence of all patella fractures treated in Germany ranged between 10.331 and 12.967 cases per year in the period from 2000 to 2008, with a proportion of children under 15 years ranging between 2.34% and 3.11%. This appears to be slightly higher compared to our data and is probably caused by the higher portion of outpatient treatments in the group of children since data of the Federal Statistical Office account for both in- and outpatient treatments. As also noticed in our series, patella fractures in children less than 5 years of age are extremely rare: the proportion ranged between 0.00% and 0.07%. Traffic accidents as the first cause for these fractures in children were surpassed by leisure activities. This may be triggered by the growing popularity of modern sport activities such as inline skating or skate boarding (10). The typical configuration of this fracture in younger children is a pole avulsion (26). The principles of treatment are similar to adults. They include reconstruction of the extensor mechanism and anatomical restoration of the joint surface (29). In our patients different techniques of osteosynthesis such as tension band wiring (12), screw osteosynthesis (32), fixation with biodegradable pins (20) or transosseous sutures were used (31). Usually, the goal of surgical treatment is early functional rehabilitation (15); the type of surgical treatment depends on fragment size and localization. Partial or total patellectomy has been recommended by some authors (18) for displaced, comminuted patellar fractures. Serious objections against patellectomy have been described (12) and the tendency now is that the patella should be saved even in the case of fractures with multiple fragments. In our series reconstruction was possible in every case. Functional after-care with passive or assisted knee mobilisation is not possible when transosseous sutures were used as in case of sleeve fractures. Sutures require after-care with brace immobilization (14). The number of fractures needing operative repair is lower in children compared to adults: a high number are non-displaced fractures, and the flexible and strong soft tissue anchoring in children protects the patella. Patellar fractures without relevant displacement may be

immobilized using a brace for 4 weeks. A radiological check following a week is suggested; in our study we had one case of secondary displacement which necessitated open reduction and internal fixation. The sleeve fracture is a special form of patella fractures in children that should be recognized early as a dislocated small bony fragment with a larger soft tissue part consisting of cartilage, periosteum and retinaculum (1,8,11,13). Usually, this fracture type is associated with loss of active knee extension and requires operative refixation (3,14) as was done in the two cases of our series. Generally, a good or very good functional result may be expected (6); this could be confirmed by our results within the first 4 years after injury.

Shortcomings of our study are the limited number of cases and the variety of operative techniques used. Long-term outcome is supposed to be highly influenced by the accompanying cartilage damage (25). In case of internal fixation, arthroscopy may be helpful and may add diagnostic information as to long-term prognosis (32). Acute arthroscopic intervention is rarely necessary or possible. Joint aspiration and evacuation of a haemarthrosis protects the cartilage and relieves postoperative pain. In case of recurrent knee effusion, persisting pain and functional complaints after patella fractures in childhood, we recommend MRI to evaluate possible cartilage lesions. In a previous study we have shown that preoperative radiographs in acute haemarthrosis of the knee in children failed to identify osteochondral fractures in 36% of cases. Injuries of the anterior cruciate ligament are also associated with acute haemarthrosis and may be overlooked because clinical examination is difficult in children who are in pain (19). Therefore, MRI or in doubt even arthroscopic evaluation is strongly recommended in obscure traumatic knee with haemarthrosis, which always reflects a major injury to the knee. In case of significant cartilage damage surgical repair depending on the location, extent and depth of the injury, and autologous chondrocyte implantation should be considered (33).

Disturbances of patella growth were not observed in this series and have not yet been described in literature (6).

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