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PHYSEAL INJURIES OF DISTAL FEMUR IN CHILDREN

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Abstract

Epiphyseolysis, i.e. separation of physis, is a specific injury that occurs in the immature skeleton of children. Some sites of occurrence tend to be very frequent, whereas others are rather rare. The latter include epiphyseolysis of the distal femur epiphysis. In this retrospective study, we present treatment results achieved by long-term application of a uniform diagnostic and therapeutic procedure at the Department of Paediatric Surgery, Orthopaedics and Traumatology of the Faculty Hospital in Brno, Czech Republic (KDCHOT FN Brno). The period of 11 years provided a collection of 31 patients who were given complex treatment at our department. The data was obtained from the Hospital Information System AMIS H (NIS AMIS H). The treatment method combined a conservative approach making use of a spica cast with percutaneous mini-invasive osteosynthesis using Kirschner wires or cannulated screws, depending on the type of epiphyseolysis and the level of dislocation. All patients underwent a control examination based on a uniform protocol. The group of patients treated conservatively exhibited no complications. In the group where osteosynthesis with Kirschner wires was applied, five serious clinical complications were observed. The group treated with osteosynthesis with cannulated screws showed one complication out of a total of two cases.

In terms of our treatment algorithm, complete healing without complications occurred in 25 patients (81 %), with the percentage of complications being slightly lower than that published in international retrospective studies. Based on long-term observation, our method can thus be recommended as standard treatment for this type of femoral injury in children.

Key words

Epiphyseolysis, Distal femur, Children

Abbreviations used

KDCHOT, Department of Paediatric Surgery, Orthopaedics and Traumatology; FN, Faculty hospital; CT, Computed tomography; MRI, Magnetic resonance imaging; SH,Salter–Harris; LCP, Locking compression plate; LISS,Less invasive stabilisation system

INTRODUCTION

Epiphyseolysis in the distal femur epiphysis in children is not a frequent injury (*Fig. 1*). At the distal end of the femur, supracondylar fractures tend to occur more often. Epiphyseolysis can be divided into several categories that are based on the original Salter-Harris classification (*Tab. 1*).

Table 1
Salter–Harris classification

SH Type	Description	Note
Type I	Fracture line goes through the hypertrophy zone of the physis.	
Type II	Fracture line goes through the physis and the metaphysis.	Type II is the most common type of Salter-Harris fracture.
Type III	Fracture line goes through the physis and the epiphysis.	Type III fractures rarely result in significant deformity; therefore, they have a relatively favourable prognosis.
Type IV	Fracture involves all 3 elements of the bone: The fracture passes through the epiphysis, physis, and metaphysis.	
Type V	Compression or crush injury of the epiphyseal plate with no associated epiphyseal or metaphyseal fracture.	This fracture is associated with growth disturbances at the physis. Initially, the diagnosis may be difficult, and it is often made retrospectively after premature closure of the physis is observed. In older teenagers, the diagnosis is particularly difficult.
Rare types of Salter-Harris fractures		
Type VI	Injury to perichondral structures.	
Type VII	Isolated injury to the epiphyseal plate.	
Type VIII	Injury to the metaphysis, with a potential injury related to endochondral ossification.	
Type IX	Injury to the periosteum that may interfere with membranous growth.	

X-ray examination in two basic projections is a sufficient diagnostic method. If in doubt, CT scans can be added. To prove bone bridge formation, MRI is the most suitable imaging method. The treatment consists in open or closed reduction and subsequent fragment retention by means of plaster fixation or osteosynthetic material.

Between 1997 and 2007, 46 patients with a physeal injury in the distal femur were treated at KDCHOT FN in Brno. In case of fragment dislocation and instability of epiphyseolysis, our department prefers osteosynthesis with Kirschner wires which are inserted transphyseally and percutaneously following accurate repositioning (*Fig. 2*). The goal of this retrospective study was to verify the results achieved through

the application of our treatment scheme. The results will be used to formulate therapeutic standards, and they can serve as guidance in case of doubts as to the optimal diagnostic and therapeutic procedure resulting from rare occurrence of this type of injury.

Fig. 1
Epiphyseolysis in the distal femur epiphysis in a 12-year-old girl on X–ray examination

Fig. 2
Osteosynthesis with K-wires which are inserted transphyseally after the repositioning of epiphyseolysis SH II on X-ray examination

METHODS

The assessment of the results was preceded by forming a set of patients. This was defined in terms of their age (0–19 years), diagnosis (SH I-VI epiphyseolysis of the distal femur epiphysis), and the fact that the patient had undergone complex treatment at our department between 01/01/1997 and 31/12/2007. A total of 46 patients constituted the set.

The next step included acquiring information from the medical records as to what treatment and subsequent rehabilitation had been applied. Information on each patient was supplemented with post-injury and follow-up X-ray findings, the treatment method, the necessity and length of rehabilitation, and the occurrence of complications. We obtained complete data from 38 patients.

In case of fragment dislocation and instability of epiphyseolysis, our department prefers osteosynthesis with Kirschner wires which are inserted transphyseally and percutaneously following accurate repositioning. In case of a non-dislocated fracture, a spica cast is the method of choice. The established treatment and follow-up algorithm, the verification of which is the goal of this study, is as follows:

Epiphyseolysis of distal femur

non-dislocated – a spica cast; X-ray check-up on days 3, 10, 28, 32, and then during months 2 and 3; spica cast removal after 5 weeks;

dislocated – SH I, SH II – repositioning; transfixation by K-wires; a spica cast; X-ray check-up on days 3, 10, 28, 32, and then during months 2 and 3; spica cast removal after 5 weeks; wire extraction during month 3 post surgery;

- SH III, SH IV – repositioning; transfixation by K-wires; in case of persistent fragment distraction following repositioning 1–2 cannulated tension screws; a spica cast; X-ray check-up on days 3, 10, 28, 32, and then during months 2 and 3; metal extraction during month 3 post surgery; spica cast removal after 5 weeks.

Summary of complications defined according to Ogden (1):

post-injury angulation
shortening of femur
development of porosis in distal femur
limitation of knee and hip movement
redislocation
resurgery
damage to neural vascular plexus

The following conditions were regarded as successful treatment: complete healing of epiphyseolysis without significant angulation (less than 5°) (1, 2), difference in length less than 1 cm (1) compared to the unaffected femur and absence of any other complications. All patients were treated and observed according to the above-described scheme. The data was collected by means of NIS AMIS H and a system for saving and sharing X-ray documentation (PACS). The last clinical examination of patients including movement examination of the surrounding joints was performed during month 3 post injury. The final number of patients from whom information on therapeutic results and existing complications could also be obtained was 31.

RESULTS

The set of 31 patients consisted of 16 boys (52 %) and 15 girls (48 %), with an average age of 11.9 years (ranging from 2 to 16 years). Postnatal epiphyseolysis was not documented and thus not included in our set. Most cases included SH II epiphyseolysis (26–84 %), SH I epiphyseolysis was found in 3 patients (10 %), and SH III epiphyseolysis was found in 2 patients (6 %).

Eleven patients (36 %) sustained a non-dislocated fracture which was treated at our outpatient department with a spica cast. In 18 patients (58 %), percutaneous

transfixation by Kirschner wires was conducted following repositioning and in 2 patients (6 %) (SH III epiphyseolysis in both cases) osteosynthesis with a tension screw was performed. Open reduction was not necessary in any of the cases.

In the group where the conservative approach had been applied no complications were encountered. The group treated with osteosynthesis with Kirschner wires exhibited 4 cases of clinically significant angulation (*Fig. 3*) and 2 cases of significant shortening (in 1 case it occurred in combination with post-surgery angulation), reaching a total of 5 complications (28 %). The group where osteosynthesis with cannulated screws had been used showed clinically significant angulation in 1 out of 2 cases (50 %). To sum up, after introducing our treatment algorithm complete healing without complications occurred in 25 patients (81 %).

Fig. 3
Angulation (valgoid deformity) of the distal femur after epiphyseolysis on X-ray examination

DISCUSSION

The growth zone of the distal femur is responsible for 70 % of bone growth and for 40 % of longitudinal growth of the lower extremity (*1*). That is why the treatment of injuries in this area is of great importance. The most frequent causes of injury in children mainly include sports and traffic accidents. Postnatal epiphyseolysis of the distal femur is considered a separate issue and was not included in our set (*3*). One of the reasons is the fact that this type of injury is usually treated directly at the delivery room and, if without complications, the intervention of a paediatric traumatologist is not required in the acute or follow-up phase. The healing capacity of the neonatal

skeleton is very good. However, some authors refer to frequent growth and angular deformities following postnatal injuries of the distal growth zone. Neer recorded in his work a 42% incidence of lower limb growth discrepancy (*4*), Cassebaum and Patterson reported on 25% incidence (*5*). Our experience in cooperation with the departments of neonatology and paediatric orthopaedics is different.

Diagnostics usually poses no difficulty, with the exception of type I epiphyseolysis. In our view, the reason why this type of injury exhibits very low occurrence is that it is problematic to diagnose and X-ray images tend to be evaluated as false-negative. However, this fact does not in any way diminish the dangers of type I epiphyseolysis, which are very serious. In the other cases, X-ray examination was performed in two projections. In case of post-injury growth disturbance or clinically significant angulation, magnetic resonance was used in all 6 cases where the existence of a bone bridge in the area of the growth zone had been proved.

A bone bridge is the most unfavourable complication in physeal injuries. As a result, a large number of experiments were conducted, aiming to eliminate the risk of its formation. Our experimental study, similarly to some international studies, explores the possibility of using mesenchymal stem cells to prevent bone bridge formation in the site where the metal material traverses through the growth plate. The experiments were preceded by widespread use of autologous fat to fill the defect in the growth plate (*6*).

Bone bridge treatment currently consists in correction (osteotomy, external fixation, filling the defect with autospongioplastic material, growth arrest induced in the unaffected limb by means of hook nails in the physis, etc.). A modern, though still experimental, approach that would deal with the cause is available. It includes bone bridge excision and filling the defect with alternative tissue (autologous chondrocytes (*7*), mesenchymal stem cells(*6*)).

Most international sources describe a similar therapeutic scheme that we apply at our department (*1, 8*). It can be modified by using an external fixator which is preferred by some authors (quote) mainly for its reliability and quick application. It is definitely indicated in case of open epiphysiolysis. Considering the site, i.e. the growth plate, the use of a condylar splint, LCP of the LISS type or a retrograde femoral nail has to be excluded. In type II and type IV epiphysiolysis with an extensive metaphyseal fragment, the use of a Prevot rod could be discussed. Long-term results are not yet available for applying this method in this indication, as it is used only rarely.

CONCLUSION

Our diagnostic and therapeutic procedure applied in the treatment of epiphysiolysis in the distal femur epiphysis provides long-term satisfactory results in 81 % of the patients. The percentage of complications that we recorded is slightly lower than that published in similar retrospective studies. Based on long-term

observation, our method can thus be recommended as standard treatment for this type of femoral injury in children.

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