CASE REPORT

Rehabilitation of simultaneous bilateral epiphysal fracture of proximal tibia in adolescent

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SUMMARY

Simultaneous and bilateral epiphysal fracture of the proximal tibia is an extremely rare injury, with only 23 cases reported in the literature. In this paper, we present a 15-year-old adolescent with a simultaneous and bilateral epiphysal fracture of the proximal tibia in sport context (trampoline jump). He underwent surgical repair with bilateral closed reduction and internal fixation, followed by outpatient rehabilitation programme during 4 months. There was a good functional outcome, without limitation in activities of daily living and with resumption of amateur sports activity. Since there are no guidelines described for this pathology, the authors suggest a rehabilitation protocol for bilateral epiphysal fractures of the proximal tibia that underwent surgical treatment previously and in which there were no complications in the acute phase.

BACKGROUND

Fractures of the proximal tibial epiphysis in adolescents are uncommon and include 0.4%–2.7% of all epiphysal fractures.^{1–5} According to the literature, bilateral simultaneous fractures are even more unusual, with about 23 cases described in the last 60 years.^{5–6} This is probably due to the presence of the lateral collateral ligaments of the knee which prevent the direct transmission of valgus and varus forces to the tibial epiphysis, conferring high stability.^{1–9}

The proximal tibia has two ossification centres, the epiphysis and the anterior tubercle. The proximal tibial epiphysis fuses from a posteromedial to anterolateral direction, while the tubercle fuses from a proximal to distal direction. Closure of the proximal tibial epiphysis and union between the epiphysis and tubercle centres occur commonly in girls between 10 and 15 years of age and in boys between 11 and 17 years of age.^{10–11}

The type of epiphysal fracture depends mostly on the age, due to the complex ossification sequence of this anatomical region.^{12–13} Before the tibial tubercle fusion, its avulsion can occur due to tensile forces exerted through the quadriceps femoris. After the fusion, these forces may cause separation of the growth plate from the proximal epiphysis which is not yet closed.^{5–9}

There are several mechanisms of injury reported in the literature, namely by direct trauma (motor vehicle accident) and during sports activities. In the later, it may occur after abrupt contraction of the patellar tendon during extension of the lower limb

(jump's take-off phase), after contraction of the quadriceps tendon with fixed tibia or after passive flexion of the knee with contraction of quadriceps femoris (jump's reception phase).⁷ In this context, most of the cases described in the literature occur in the context of acrobatic gymnastics, basketball, volleyball, athletics and soccer.⁵

The extent and severity of the fracture are directly related to the degree of knee flexion at the time of the fracture. As soon as the degree of flexion of the knee is below 30°, only tibial tubercle avulsions tend to occur. Above 30° of flexion, avulsion usually appears associated with epiphysal fracture.⁵

Surgical intervention followed by a rehabilitation programme is the most frequently reported treatment in the literature, although strict guidelines for the treatment of this pathology are not yet defined.

CASE PRESENTATION

A 15-year-old male adolescent was carried to the paediatric emergency department by an ambulance with two paramedics, with sudden and intense bilateral knee pain after the take-off phase of a trampoline jump, in amateur sports context. He reported impossibility of assuming the orthostatic position due to pain and bilateral deformity of knees. He had no significant medical or surgical history, including joint or bone pathologies. No previous clinical symptoms of Osgood-Schlatter disease were reported.

The orthopaedic emergency team made the initial evaluation and investigations. At physical examination, he had bilateral knee joint swelling, with knees held in a semiflexion position of approximately 90° to the left and 30° to the right and impossibility of active extension; the attempts of passive extension caused severe pain. No nerve or vascular changes were identified by peripheral neurological examination and lower limb pulse palpation, respectively.

INVESTIGATIONS

Bilateral X-ray of the knees showed bilateral epiphysal fracture of the proximal tibia, classified as Salter-Harris type II on the left and Salter-Harris type IIIB on the right (figures 1 and 2).

TREATMENT

Approximately 12 hours after the fractures, he was submitted to surgical treatment. The orthopaedic emergency team of the paediatric hospital performed the intervention. He underwent bilateral closed reduction and internal fixation with two

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Figure 1 A radiograph of the right knee revealing the presence of a fracture classified as type IIIB in the Salter-Harris classification—lateral view.

anterior–posterior cannula screws on the right and with three screws on the left. Bilateral immobilisation with long leg cast in full extension position was applied during 6 weeks, without weight-bearing.

Between the 1st week to 6th week, due to bilateral long cast immobilisation, the patient only used wheelchair for ambulation, and he stayed at home, with recommendations regarding

Figure 2 A radiograph of the left knee revealing the presence of a fracture classified as type II in the Salter-Harris classification—lateral view.

Figure 3 A radiograph of the knees after surgical intervention—anteroposterior view.

hip and ankle active mobilisation exercises and transfer precautions to avoid falls.

After this period, he underwent radiological control which revealed good consolidation and alignment of the fractures (figures 3, 4 and 5).

At the 7th week postinjury, the patient was referred for physical and rehabilitation medicine (PRM) consultation. At that time, his weight was 54 kg, height 161 cm, with a body mass index of 20.8 which was appropriate for his age and height (72nd percentile). At physical examination, he presented mild joint effusion in the right knee, bilateral knee pain at static contraction of the quadriceps femoris, marked bilateral atrophy of quadriceps femoris and calf muscles, stiffness of knees with a range of motion (ROM) of 10°–20° in the left knee and 0°–20° in the right knee, reduction of knee extensor strength bilaterally. He was unable to stand in orthostatic position. He did not

Figure 4 A radiograph of the right knee after surgical intervention—lateral view.

Figure 5 A radiograph of the left knee after surgical intervention—lateral view.

Figure 6 A radiograph of the right knee at 16th week postinjury—lateral view.

present pain during rest, but exuberant pain to passive flexion, classified as 8/10 on the numeric pain scale.

Between PRM evaluation and the beginning of the rehabilitation programme, he had indication to start weight-bearing with support during transfers and to start walking with two crutches as tolerated.

The patient started an outpatient rehabilitation programme at the 8th week postinjury and 2 weeks after cast removal. He already started gait training with two crutches. In the first 2 weeks of the programme, the daily sessions aimed pain control, improvement of soft tissue healing, beginning range of movement exercises and muscle strength. He underwent scar massage, bilateral patellar mobilisation, active and active-assisted knee mobilisations from 0° to 90°, isometric quadriceps femoris and calf muscles strengthening, open kinetic chain proprioceptive training and gait training with two crutches. If he presented pain at the end of the sessions, static ice was applied. At 10 weeks postinjury, he started active and active-assisted mobilisation of the knees with ROM of 0°–120°, concentric dynamic quadriceps femoris and calf muscle strengthening, gait training without crutches and closed kinetic chain proprioceptive training. At 12 weeks after the injury, he progressed in active and active-assisted mobilisation of knees with ROM of 0°–140°, maintained concentric dynamic quadriceps femoris and calf muscle strengthening, gait training and closed kinetic chain proprioceptive training with progressive difficulty. During the following weeks, he proceeded to eccentric dynamic muscle strengthening and running training with progressive intensity and difficulty.

The patient benefited from psychological and educative support regarding his medical condition. A first psychological evaluation was made at the 7th week postinjury in the rehabilitation department. He showed no symptoms of kinesiophobia, catastrophisation, anxiety or negative thoughts about pain or disability. He showed fear related to mechanism of injury (trampoline sports). He underwent monthly psychological support session which ended at the end of the rehabilitation programme.

There were no complications during the rehabilitation programme.

OUTCOME AND FOLLOW-UP

After 16 weeks postinjury, the patient presented no pain, he regained muscle strength completely and had a limitation of ROM at 10° in the right knee flexion, with functional repercussion only in activities that required knee hyperflexion. He did not present any limitation in the activities of daily living and had no need of crutches or other assistive devices during gait.

Bilateral X-rays showed good consolidation (figures 6 and 7).

He had no signs or symptoms of growth disturbances, and no deformity or leg-length discrepancy were present.

He resumed physical exercise at school in a progressive way, but he did not return to trampoline activities due to psychological factors.

DISCUSSION

This case report presents similar aetiological characteristics to those mentioned in the literature.⁵ Predisposition to this kind of fractures has been reported in individuals with Osgood-Schlatter disease,¹³ osteogenesis imperfecta¹⁴ and vitamin D deficiency¹⁵ which did not occur in our case.

Conventional radiography is the first choice modality in the diagnosis of epiphyseal proximal tibial fractures. MRI can be helpful in the detection of fracture radiographically occult, especially in those subjects with suspected bilateral involvement. For preoperative surgical planning, preoperative CT may be helpful.

There is no consensus in the literature regarding the classification of these fractures. The existing classification systems are limited to one type of fracture region (tibia tubercle, tibia spine or epiphysis), not taking into account all fracture patterns, in anterior–posterior and mid-lateral planes.^{6,7}

An epiphyseal fracture of the proximal tibia classification (table 1) was first described by Watson and Jones in 1955 and initially involved three types of fractures.² Subsequently, Odgen

Figure 7 A radiograph of the left knee at 16th week postinjury—lateral view.

et al suggested an addendum to this classification, with the addition of two subtypes.¹⁶ More recent modifications were suggested, with the addition of two other subtypes.^{17 18} In 1963, Salter and Harris reported a new classification of epiphyseal fractures based on histological and epiphyseal anatomy concepts.^{19 20} In the apophysis fractures of the tibial tubercle, the use of the Odgen, Tross and Murphy classification prevails.¹⁸

The majority of fractures reported in the literature were classified as Watson-Jones type III. However, the lack of a standardised classification may result in an underestimation of the actual incidence of these fractures.

Table 1 Epiphyseal fractures of proximal tibia classification

Watson and Jones classification (modified)	
Type I	Fracture of the secondary ossification centre near the insertion of the patellar tendon.
Type II	Fracture that propagates to the junction with the primary ossification centre.
Type III	Fracture extending posteriorly through the primary ossification centre.
Type IV	Fracture through the entire proximal epiphysis.
Type V	Periosteal avulsion of the secondary ossification centre.
Odgen classification	
Subtype A	Aligned and non-comminuted fracture.
Subtype B	Misaligned or comminuted fracture.
Salter-Harris classification	
Type I	Complete separation of epiphysis and metaphysis.
Type II	Fracture line between the epiphysis and the metaphysis but with presence of a metaphyseal fragment near the epiphysis.
Type III	Complete separation of epiphysis and metaphysis associated with epiphyseal fracture.
Type IV	Fractures extending from the metaphysis, through the growth plate and involving the epiphysis.
Type V	Compressive fractures of the epiphysis.

Surgical intervention followed by a rehabilitation programme is the most frequent treatment reported in the literature, although there are no treatment guidelines for this condition.

As it is a rare condition, there is still controversy in the literature regarding surgical treatment of this kind of fractures. Some authors suggest that closed manipulation and percutaneous pinning should be the best option whereas others propose closed manipulation.²¹ To this date and to our best knowledge, there is no evidence-based medicine data to prefer one technique to another. Long cast immobilisation in full extension position is recommended during 4–6 weeks, for this kind of fractures, treated surgically or conservatively.^{2 7 21}

Frey *et al*²² described a possible treatment algorithm. These authors suggest conservative treatment with long-leg cast immobilisation during 4–6 weeks for Watson-Jones type IA, IB and IIA fractures; osteosynthesis and long-leg cast immobilisation during 4–6 weeks in Watson-Jones type IIB, IIIA, IIIB and IV fractures; and separate treatment of the epiphyseal fracture and the fracture of the metaphysis, followed by long-leg cast immobilisation during 4–6 weeks in Watson-Jones type V fractures. However, we found no data about the validation of this algorithm.

All cases described in the literature, whether treated surgically or treated conservatively, involved long cast immobilisation in full extension during 4–6 weeks. Similarly, all cases reported rehabilitation programme after cast removal. However, the type of exercises or procedure was not clarified, and the authors did not find any rehabilitation protocol described in the literature.

We propose a rehabilitation protocol (table 2) for bilateral epiphyseal fractures of the proximal tibia that had undergone surgical treatment previously and in which there were no complications in the acute phase. This protocol was based on general concepts about fracture healing and rehabilitation, a case report of rehabilitation of tibial tuberosity avulsion²³ and in the experience of our team in the management of the reported case.

The rehabilitation protocol must integrate different types of exercises accordingly to the tissue healing phases. In acute phase, only static strengthening and open chained proprioceptive training are appropriate. These kinds of exercises are important to prevent muscle atrophy, usually seen after surgery and immobilisation. As both legs are affected, gait training will have to be slowly and pain free progressive, with weight-bearing exercises addressing both legs and avoiding unbalance between them. Subsequently, it is important to introduce closed kinetic chain exercises and concentric/eccentric strengthening that are functionally more similar to real activities of the patient's daily living. In all phases, it is important to maintain optimal ROM of the non-involved articulations and prevent atrophy of proximal and distal musculature. In the last phase of the rehabilitation protocol, it is very important to address exercises to improve neuromuscular coordination and resumption of sports activities, in order to avoid sports-related injuries.²³

The prognosis of this kind of fracture is favourable, both in patients treated surgically and in patients undergoing conservative treatment. The majority have no sequelae in terms of range of movement and functionality.⁷ Complications are rare, the most frequent being the posterior compartment syndrome, meniscal or cruciate ligament injury and patellar tendon calcification.^{6 24} The possibility of premature closure of the epiphysis and deformity of the tibia has also been described.⁷ In the case reported, there were no complications at 16th week postinjury, but late complications cannot be excluded. Ideally, the follow-up should be maintained until the patient reaches adulthood, to exclude the occurrence of long-term complications, namely

Table 2 Rehabilitation protocol for bilateral epiphyseal fractures of the proximal tibia

Week	Aim	Details	Frequency of sessions
0–2 weeks after immobilisation	<ul style="list-style-type: none"> ▶ Decrease pain and inflammation. ▶ Improvement of soft tissue healing. ▶ Improvement of ROM. ▶ Improvement of muscle strength. 	<ul style="list-style-type: none"> ▶ Static cryotherapy. ▶ Elevation of lower limbs. ▶ Remodelling scar massage. ▶ Patella passive mobilisation. ▶ Active and active-assisted mobilisation of the knees between 0° and 45°. ▶ Quadriceps femoris and hamstrings static strengthening. ▶ Dynamic strengthening of the remaining lower limb muscle groups. ▶ Open kinetic chain proprioceptive training. ▶ Progressive weight-bearing. 	Daily
3–4 weeks	<ul style="list-style-type: none"> ▶ Improvement of ROM. ▶ Improvement of muscle strength. ▶ Improvement of neuromuscular coordination. 	<ul style="list-style-type: none"> ▶ Active and active-assisted mobilisation of the knees between 0° and 90°. ▶ Quadriceps femoris and hamstrings concentric strengthening. ▶ Balance training in dynamic orthostatism. ▶ Gait training with two crutches. ▶ Open kinetic chain proprioceptive training. 	Daily
5–6 weeks	<ul style="list-style-type: none"> ▶ Improvement of ROM. ▶ Improvement of muscle strength. ▶ Improvement of neuromuscular coordination. 	<ul style="list-style-type: none"> ▶ Active and active-assisted mobilisation of the knees between 0° and 120°. ▶ Quadriceps femoris and hamstrings concentric strengthening. ▶ Gait training without assistive devices. ▶ Closed kinetic chain proprioceptive training. 	Daily
7–8 weeks	<ul style="list-style-type: none"> ▶ Improvement of ROM. ▶ Improvement of muscle strength. ▶ Improvement of neuromuscular coordination. 	<ul style="list-style-type: none"> ▶ Active and active-assisted mobilisation of the knees between 0° and 140°. ▶ Quadriceps femoris and hamstrings concentric strengthening. ▶ Gait training without assistive devices. ▶ Closed kinetic chain proprioceptive training with progressive difficulty. 	Daily
9–12 weeks	<ul style="list-style-type: none"> ▶ Improvement of neuromuscular coordination. ▶ Improvement of cardiovascular endurance. 	<ul style="list-style-type: none"> ▶ Quadriceps femoris and hamstrings concentric and eccentric strengthening. ▶ Progressive aerobic training. ▶ Run training with progressive difficulty and intensity. ▶ Closed kinetic chain proprioceptive training with progressive difficulty. 	Three times a week
13–16 weeks	<ul style="list-style-type: none"> ▶ Resumption of sports activity. 	<ul style="list-style-type: none"> ▶ Progression of specific sports training according to functional tests results. 	Three times a week

ROM, range of motion.

premature closure of the epiphysis which can be assessed with metric radiographic study of lower limbs.

Learning points

- ▶ Bilateral epiphyseal fractures of proximal tibia are very rare fractures that occur mainly in adolescents in sport context.
- ▶ There is still a lack of a unified classification of this kind of fractures.
- ▶ The majority of cases undergo surgical intervention followed by rehabilitation programme, with a good prognosis.
- ▶ The authors suggest a rehabilitation protocol in order to make the functional rehabilitation of these patients more objective and systematic.

Contributors All authors have contributed to the writing and editing of this case report. PF identified the case and initially examined the patient in physical and rehabilitation medicine consultation. JP did the construction of the case report and elaborated the rehabilitation programme protocol suggested in the article. JP and SO did the literature review and text adjustments. JPP and PF guided the areas of discussion and made grammatical and syntax adjustments. All authors approved the final version.

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