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Tibial Tuberosity Fractures in Adolescents: Anatomo – Clinical Assessment and Treatment Results

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Abstract

Background: The objective of this study was to describe the anatomo-clinical, therapeutic aspect of TT fractures and the results.

Methods: This retrospective study was conducted over a period of 5 years (01 January 2018 to 01 January 2023) in the Paediatric Surgery Department of the Teaching Hospital and at theInternational clinic. The epidemiological- clinical, anatomopathological, therapeutic, and the results variables of TT fractures were studied.

Results: Data from 10 cases were included in this study. All patients were male, and their mean age was 14.3 years [range: 11-15 years]. All fractures occurred during sports activities through indirect mechanisms. Fractures occurred on both the left and right sides of the knee. We have compiled fractures of type IB (2 cases), type IIB (03 cases), IIIA (01 case), type IIIB (03 cases), and type IV (01 case). All patients underwent open reduction and osteosynthesis. No complications occurred in any of the patients, and their long-term results were satisfactory.

Conclusion: TT fractures are uncommon in adolescents; however, they are common in sports that involve jumping. The indications for treatment are based on the modified Ogden classification. These fractures have a good prognosis, with full recovery of function and activity after consolidation.

Keywords: Fracture, Tibial tuberosity, Adolescence

Introduction:

A fracture of the tibial tuberosity (TT) is a break in the continuity at the level of the apophysis of the conjugation cartilage of the proximal tibia and may even lead to its avulsion. It represents a form of rupture of the knee extensor apparatus [1]. TT fractures commonly occur in adolescent athletes at the end of their growth phase. However, its incidence has not been clearly determined in the literature [2]. In a study by Wendell et al., which was conducted in the United States in 2020, this injury accounted for 0.4–2.7% of epiphyseal fractures in children and 3% of all fractures of the proximal end of the tibia [3]. In Europe and South America, the proportion of ATT fractures in adolescents varies between 1% and 3% of all epiphyseal-metaphyseal injuries in adolescents [4]. Diagnosis is based on a standard radiograph of a swollen, painful knee in an adolescent. In well-equipped centres, computed tomography (CT) scans are performed to provide a detailed description of the fracture site. Magnetic resonance imaging (MRI) of the knee is sometimes necessary to detect associated lesions [5, 6]. Watson–Jones was the first to classify tibial tuberosity fractures into three types [7]. In 1980, Ogden et al. modified this classification system and included displacement and comminution [8].

TT fractures have been rarely reported in African populations, and only a few case series have been reported in the literature [9, 10, 11, 12].

Ignorance of this condition, which is mistaken for a simple knee contusion, results in delayed referral and inappropriate management of the lesion, which may affect the proximal tibial growth plate. This study aimed to determine the anatomo-clinical, therapeutic aspect of TT fractures and the results.

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Patients And Methods

This retrospective study was conducted over a period of 5 years (1 January 2018 to 1 January 2023) in the paediatric surgery department of the Teaching Hospital and at the international clinic. It included all the adolescents admitted to the emergency department for recent ATT fractures. Patients were admitted to the surgical emergency department and the emergency pool of the international clinic for knee trauma. After clinical examination, standard radiographs of the knee in anteroposterior and lateral views were obtained for all patients. The Ogden classification, modified by Ryu, was used. In the case of complex fractures, CT scans were used. Patients whose parents refused treatment and cases of neglected fractures were not included. The variables studied were as follows:

- Sociodemographic: Age, sex, and level of education
- Clinical: Place and circumstances of onset, mechanism and time of admission, history of Osgood–Schlatter disease, body mass index, side affected, knee volume, loss of active knee extension, patellar shock, associated lesions, etc.
- Anatomopathological: Type of fracture according to the Ogden classification modified by Ryu and Debenham
- Therapeutic: Therapeutic delay, approach, type of osteosynthesis, number of implants, type of immobilisation, etc.
- Evolutionary data: This was determined on the basis of whether complications had arisen (immediate [compartment syndrome, subcutaneous haematoma], secondary [skin necrosis, suppuration, secondary displacement], and late effects [genu recurvatum, callus, osteitis, stiffness, trophic disorders]), duration of immobilisation, time to consolidation, delay in removal of osteosynthesis equipmeand in resuming weight bearing and walking, restrictions in sports activities, and functional rehabilitation. Functional rehabilitation was determined based on the evolution of results over time using the knee pain assessment score (Anterior Knee Pain Scale (AKPS). It consists of 13 items based on anatomical and functional studies of the knee and comprises six sections corresponding to six activities associated with the knee (walking, running, jumping, climbing stairs, squatting, and sitting for prolonged periods with the knee bent) as well as symptoms such as lameness, amyotrophy, and oedema. The maximum score is 100, with lower scores indicating greater pain or disability. Scoring is hierarchical and uses different types of categorisations, including none, mild, and severe [13].

The mean follow-up duration was 34 ± 2 months [range :10 months and five years].

Data were analysed using Microsoft Office Excel. Qualitative variables are expressed as percentages, and quantitative variables are expressed as averages and limits with standard deviations.

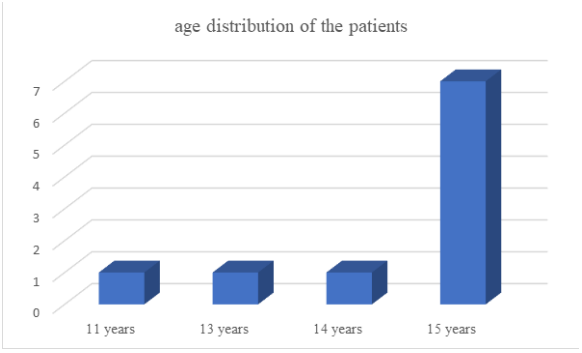

Figure 1 : Age distribution of the patients

Place of injury	Number of patients
Schools	4
Home	3
Sports ground	3
Total	10

Table 1: Distribution of patients according to the place of injury

Circumstances and mechanisms		Number of patients
Indirect mechanisms	Jumping	3
	Basketball	5
	High-jump event	2
Direct mechanisms	Direct impact	0

Table 2: Distribution of patients according to the circumstances of trauma

Physical signs	Number of patients
Swelling of the knee	8
Ecchymosis	4
Skin opening	0
Loss of active knee extension	10
Patellar shock	8

Table 3: Distribution of patients according to physical examination data

Results

1) Epidemiological data

From a total of 12 patients, we selected 10 who met the inclusion criteria.

We recorded 10 cases of TT fractures over the study period, which accounted for 0.90% of fractures, 2.66% of fractures of the lower limbs, and 19.42% of knee fractures. Of the 10 cases, four presented at the Teaching Hospital and six presented at the the international clinic. All patients were male, with a mean age of 14.3 years [range:11-15 years] (Fig.1). Most injuries occurred in schools (Table 1). Table 2 shows the circumstances and mechanisms of trauma. All fractures occurred during sporting activities, and the mechanism was indirect. The average admission time was 15 h [range: 45 min - 72 h] (Table 3).

2. Clinical examination data

Osgood–Schlatter disease was found in three patients. The body mass index of the patients is presented in Table 4, while the physical examination variables are depicted in Table 5. TT fractures occurred in both the right tibial tuberosity (five cases) and left tibial tuberosity (five cases). No cases of bilateral injury were noted.

3. Imaging work-up

All patients (n =10) underwent standard radiography of the knee (antero- posterior and lateral views; Fig. 2). The fracture types were classified according to the Ogden and Ryu classifications (Table 6). A CT scan of the knee was performed in one patient with a type IV fracture (n =1). An MRI of the knee was performed in one patient with a type IIIB fracture (n = 1) None of the patients had associated lesions.

4. Therapeutic data

All patients were treated surgically. The average time between the injury and intervention was 60 ± 3.2 h [range: 24 and 96 h]. All surgeries were performed as open-focus via an anterior approach to the knee (Fig. 3). The Types of osteosynthesis are depicted in Table 5. A crural pedal cast of the knee in extension was performed postoperatively in all cases (n =10). The surgical method was chosen depending on the type of fracture. Two types of method have been practiced in our patients: screwing (Fig. 4) and tension-band wiring (Fig. 5).

5. Evolutionary procedures

The average length of hospitalisation was 4 d [range, 2 - 6 d]. The mean time to return to weight-bearing was 6 ± 2 weeks [range: 5 - 7 weeks]. Of all patients, eight (80%) were able to walk again within six weeks, and eight patients with type IIB, IIIB, and IV fractures underwent functional rehabilitation. The average time to consolidation was six months (range: 4 - 7 months). Consolidation was achieved in all patients, and none of them had any restrictions in sporting activities after consolidation. The average time taken to remove the cast (duration of immobilisation) was 6.4 weeks [range: 6 -7 weeks]. The average time for the removal of the osteosynthetic material

Figure 2 : Right knee profile x-ray highlighting a type IIB anterior tibial tuberosity fracture according to Ogden classification.

Figure 3 : Anterior approach view

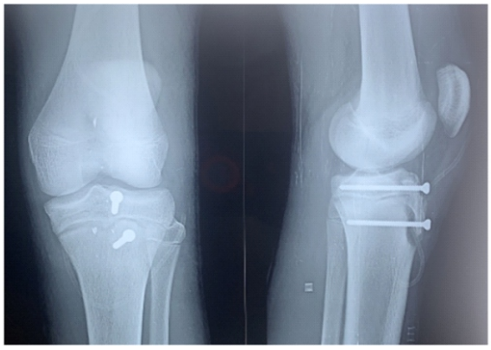

Figure 4 : Left knee radiography post osteosynthesis by screwing (face (A) and profile (B) incidences)

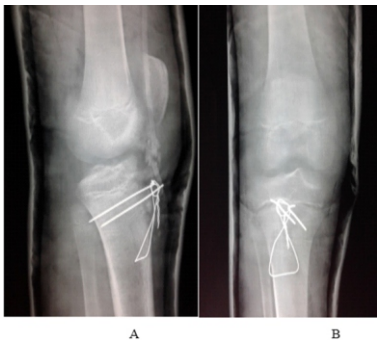

Figure 5 : Left knee radiography post osteosynthesis by bracing (profile (B) and face (B) incidences)

Type	IA	IB	IIA	IIB	IIIA	IIIB	IV	Total
Number of patients	0	2	0	3	1	3	1	10

Table 4: Distribution of patients according to the Ogden classification type modified by Ryu

Type of fracture / Type of treatment	IB	IIB	IIIA	IIIB	IV	Total
Osteosynthesis by screwing	2	0	0	2	0	4
Osteosynthesis by tension band wiring	0	3	1	1	1	6

Table 5: Distribution of the type of treatment according to fracture type

Results	Asymptomatic patients	Moderate disability (score 14 to70)	Very symptomatic patients (score 7 à 14)	Total
Number of patients	10	0	0	10

Table 6: Distribution of the patients according to functional results

was 12 ± 2, 1 months [range: 9 -18 months]. None of the patients developed complications. The postoperative functional results for our patients are reported in Table 6 (Table 6). All 10 patients were followed up for a long time according to the clinical criteria. The mean follow-up duration was 34±2 months [range:1 months].

Discussion

TT fractures are rare. The small number of cases in our study also confirms the epidemiological reality of this trauma, which is limited to a few clinical cases in the literature [6, 13, 14]. These fractures occur predominantly in adolescent males. They occur at the end of cartilage growth, generally between 13 and 16 years of age [12, 15, 16]. This exclusivity of male cases was also reported by Jennifer et al. in a series of 56 patients [17]. This result may be due to the earlier closure of the proximal tibial apophysis in girls [5, 6]. Sports activities resulting in a sudden contraction of the quadriceps are the main cause of this trauma. The contracted quadriceps pull the tibial tuberosity under the patellar tendon while landing with the knee in flexion [18, 19]. The force of contraction of the quadriceps is greater in boys than in girls; therefore, males are at a greater risk of injury [6, 18, 20]. Basketball, high jump, football, and sprinting are the sports most frequently associated with this type of trauma [21, 22, 23]. In a series of 19 patients, Frey et al. observed 18 boys with an indirect fracture occurring after a sports accident, particularly basketball [24]. Three patients had a history of Osgood–Schlatter disease. This is a factor favouring the occurrence of avulsion fractures of the TT. This association remains frequent; however, no causal link has been established [18].

In the current study, the diagnosis of avulsion fractures of the TT was made after the patients underwent standard radiography (anteroposterior and lateral views) of the knee. This examination is performed as the first line of investigation and provides the best indication of the size and displacement of the fragment [6]. However, CT and MRI scans of the knee can also be useful. A CT scan of the knee is useful for more accurate visualisation of the extent of the fracture, particularly in forms with posterior or intra-articular extension, and for assessing the degree of comminution [7]. MRI can be used to diagnose associated soft tissue injuries (of the ligament, tendon, or meniscus); however, its cost remains a limiting factor [6, 7]. In our series, there were as many injuries on the right side as on the left, which differs from the literature, which reports a predominance of left knee injuries [5, 24, 25]. According to some authors, at the time of the trauma, when the knee is in extension or 30° of flexion, the apophysis is torn without involving the epiphysis. However, when the flexion is >30°, both structures are damaged (intra-articular injury) [23]. In 50% of the cases, this is a type III fracture [10]. We have not noted any associated lesions in our series. In the literature, these associated injuries are dominated by rupture of the patellar tendon, avulsion of the quadricipital tendon, meniscal tears, cruciate ligament injuries, and compartment syndrome following injury to the soft tissues or the anterior tibial recurrent artery [26, 27, 16]. In terms of treatment, all of the patients in our study underwent open-focus surgery with an anterior medial approach to the knee. The type of treatment depends on the classification and displacement of the fracture [28]. The open approach is recommended for more severe forms with significant displacement or when soft tissue interposition makes closed reduction difficult. It also allows

joint exploration and the search for and treatment of associated lesions [19, 29, 30]. Several approaches may be used. Some authors have recommended the anterior approach, which allows perfect reduction of the fragments and direct access to the fracture site [31, 18, 19]. Others have opted for a medial parapatellar approach to the knee to avoid cutting the infrapatellar nerve threads of the saphenous nerve. Indeed, some cases of scar neuroma and infrapatellar hypoesthesia have been reported when using the anterior approach [19]. Bauer et al. used the anterior approach in 12 patients, with the occurrence of infrapatellar hypoesthesia in two patients [19]. Osteosynthesis may be performed by bracing or screw fixation, with or without a washer. The choice and number of implants used depend on the patient's age, type of fracture, and size of the avulsed bone fragments [31]. We have not used washers during screw osteosynthesis. The use of a washer can lead to late rupture of the patellar ligament by a process of devascularisation through compression at its insertion on the TT, which may lead to premature epiphysiodesis [31]. In a series of 18 adolescent footballers, Ares et al. described an open-focus surgical technique using two parallel screws: one proximal and one distal to the physeal [32]. The advantage of this technique is that it avoids damage to the cartilage, thereby preserving growth. In addition, the choice of unicortical or bicortical fixation (i.e. screw fixation involving the anterior cortex only or the anterior and posterior cortices) is open to debate. The study by Alexander et al., which compared these two techniques, demonstrated that unicortical fixation offers significant stability and results equivalent to those of bicortical fixation, and the associated neurovascular risks can be avoided [33]. They concluded that bicortical fixation does not confer a significant mechanical advantage over unicortical fixation, even for displaced Watson–Jones type III fractures. This is because unicortical fixation avoids crossing the posterior cortex and damaging the vascular and nerve structures posteriorly. Although this risk is rare, it does exist [13]. Postoperatively, the patients were immobilised with either a knee brace or crural pedal cast with the knee in extension. Post-operative protocols in the literature show a preference for immediate post-operative immobilisation and early weight bearing [34]. In contrast, Behery et al. prefer immobilisation of the knee in extension for the first week and suggest early mobilisation of the knee [34]. Follow-up radiographs were taken at three and six weeks, and the cast was removed if consolidation was satisfactory [35]. Post-operative management was straightforward in our patients, and no postoperative complications were observed. In the literature, complications occur in 28% of the cases. TT fractures with intra-articular involvement or posterior metaphyseal components are the most common complication. Refracture may also occur, especially type III and IV fractures [6]. The most common post- operative complication is bursitis [6]. In their study, Pretell et al. observed that 56% of the patients developed bursitis, 7% of whom subsequently had their hardware removed [6]. Genu recurvatum is found in patients aged <11 years due to premature closure of the anterior physeal [15]. In our study, the long-term results were good, with all patients returning to sports activities. The average time to return to weight-bearing was 6 ± 2 weeks. Frey et al., in their series of 19 patients, found an average time to return to sporting activities of 3.9 months [16]. Pretell et al. reported that 98% of patients resumed their activities within an average of 22.3 weeks, and 97% regained normal knee range of motion, regardless of the fracture type. In our study, the average consolidation time was six months (range: 4 and 7 months). The results of the longest follow-up period were satisfactory. The assessment score used was the AKPS score, which is based on anatomical and functional studies of the knee. It is easy to use in children [36]. TT avulsion fractures in children have a good prognosis, with complete recovery of knee mobility [12, 21].

Conclusion

Avulsion fractures of the TT are uncommon. They occur in adolescents during sports involving jumping. The therapeutic challenge remains, and the type of treatment depends on the modified Ogden classification. All patients in our series were treated surgically. Numerous methods of osteosynthesis have been described. However, screw fixation and pinning with bracing are the most commonly used methods for treating these fractures. The aim of the treatment is to restore the function of the knee extensor apparatus, and complications are rare. The prognosis is good, with full recovery of function and activity after consolidation.

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Declaration of patient consent : The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient has given the consent for his/ her images and other clinical information to be reported in the journal. The patient understands that his/ her names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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