

## CASE REPORT

# Lessons learnt from managing an avulsion fracture of the tibial tubercle extending into the tibial physis

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## SUMMARY

Acute avulsions of the tibial tubercle apophysis are uncommon, with reported incidence of 0.4–2.7% of all physeal injuries. In our case the extent of the injury was not realised at first presentation and initial internal fixation was attempted. At first outpatient follow-up, repeat radiographs indicated the fracture was not reduced and further CT imaging requested. The three-dimensional CT reconstructed images provide considerably more information on the fracture pattern and retrospectively these may have been helpful during the initial procedure. Therefore we would recommend obtaining a preoperative CT scan if extension of the fracture into the tibial physis is suspected. During the second procedure arthroscopy was tried to aid fracture reduction, but visualisation of the anterior articular surface under the anterior horns of the menisci was

difficult through the anterior portals with a standard 30° arthroscope and we further recommend having a 70° scope available to ensure optimal visualisation.

## BACKGROUND

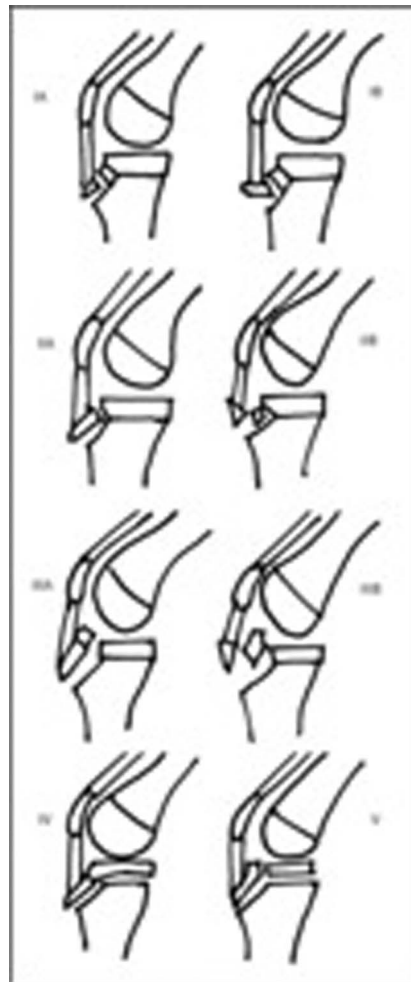
This is a rare presentation and the fracture pattern can be misleading. With the use of 3D CT reconstructions, the exact fracture configuration can be identified and understood.

In addition having the correct equipment available in theatre, in our case a 70° arthroscope would have increased visualisation of fragment making the reduction easier.

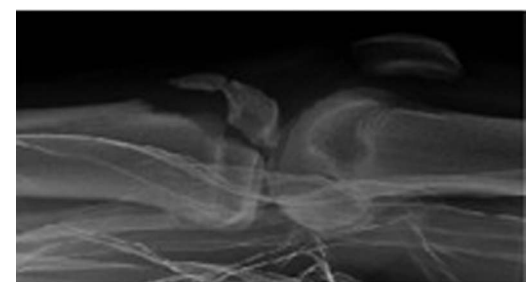
## CASE PRESENTATION

A 16-year-old boy presented to the emergency department with a painful, swollen left knee caused while playing football. He stated that he was playing as goal-keeper; the ball was in his hands and as he kicked to release the ball he landed on his non-kicking left leg in full extension. He immediately heard a crack and he was unable to bear weight. He had no previous injuries to his knees and no significant medical history.

Plain radiographs were taken showing an avulsion fracture at the tibial tuberosity with extension



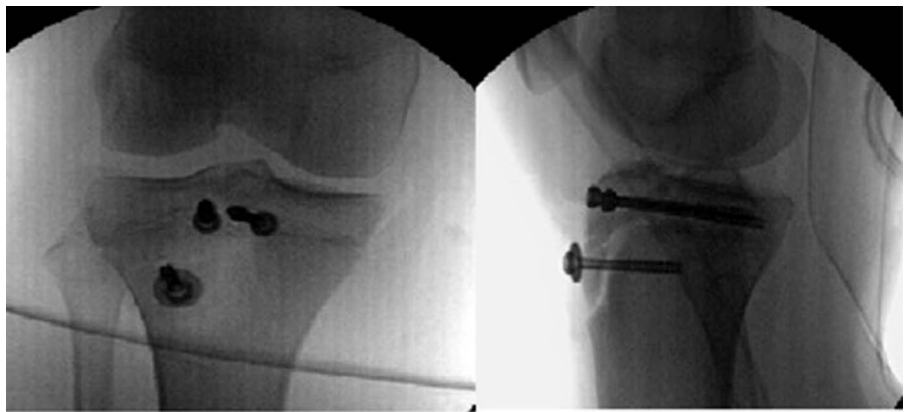
**Figure 1** Illustrations of the modified classification of tibial tuberosity fractures.



**Figure 2** Initial radiographs of knee post injury.

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**Figure 3** Intra-operative films of fracture fixation using three cannulated screws.



of the fracture into the proximal tibial physis, which is seen in the paediatric due to the immature growth plate (figure 1). The patient underwent open reduction and internal fixation the following day. The fracture was exposed through a medial mini para-patellar approach with extra-articular visualisation of the fragments. Two 55 mm cannulated screws were used to fix the physis and one 45 mm cannulated screw the tibial tubercle. The intraoperative films are shown in figure 2. Postoperatively the patient was managed in a T-Rom brace, allowed to partially weight bear with the brace in full extension and was discharged on day 2.

The patient was seen routinely in the outpatient clinic a week later; he had been mobilising well with the aid of crutches and had experienced occasional pain from the knee. Repeat radiographs are shown in figure 3 and revealed displacement of the physal fragment. A CT scan was obtained the same day which confirmed displacement of the fracture and the three-dimensional (3D) reconstructions are shown in figure 4.

Owing to the intra-articular displacement the patient was admitted and underwent further surgery on day 10 postinjury. The previous medial para-patellar incision was extended and to assist visualisation medial and lateral arthroscopic portals were made. Separate tibial tubercle and anterior tibial articular fragments were found with peripheral detachment of the anterior horn of the lateral meniscus. The cannulated screws were removed, the anterior fragment reduced with arthroscopic assistance using a standard 30° camera and held with two screws. The tibial tubercle was fixed with a single screw and the anterior horn of the lateral meniscus reattached with vicryl. The reduction was checked both radiologically with image intensifier

and arthroscopically figure 5. Postoperatively the patient was mobilised non-weight bearing in a hinged brace blocked at 20° of extension to prevent loading the anterior tibial articular surfaces and at 70° flexion to prevent overloading the tibial tubercle. A further CT was obtained to check fracture reduction; the images are given in figure 6.

#### INVESTIGATIONS

Initial investigations included anteroposterior and lateral radiographs of the left knee in order to identify the injury. On routine follow-up, due to increasing pain repeat radiographs plus CT 3D reconstructions illustrating the exact fracture pattern and extension into the tibial physis leading to inadequate operative reduction and fixation. Repeat CT 3D reconstructions were taken after the second operation to ensure adequate reduction and alignment of articular surfaces had been achieved and maintained.

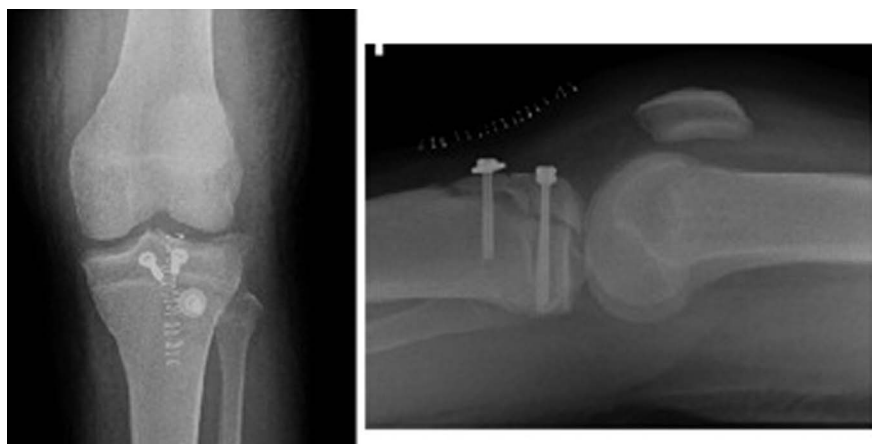
#### DIFFERENTIAL DIAGNOSIS

- ▶ Undisplaced avulsion of the tibial tuberosity
- ▶ Displaced fracture of tibial tuberosity with physis extension

#### TREATMENT

Initial treatment of this injury would follow basic orthopaedic principles of reducing the fracture, operative fixation in this case and early rehabilitation. Understanding the exact fracture pattern is key to providing the correct procedure. As there was intra-articular extension, it was imperative to achieve direct anatomical reduction with fixation. The use of the arthroscope greatly aided this procedure.

**Figure 4** Routine radiographs at one week which suggest redisplacement of fracture.



**Figure 5** CT 3-D reconstructions confirming fracture displacement.



### OUTCOME AND FOLLOW-UP

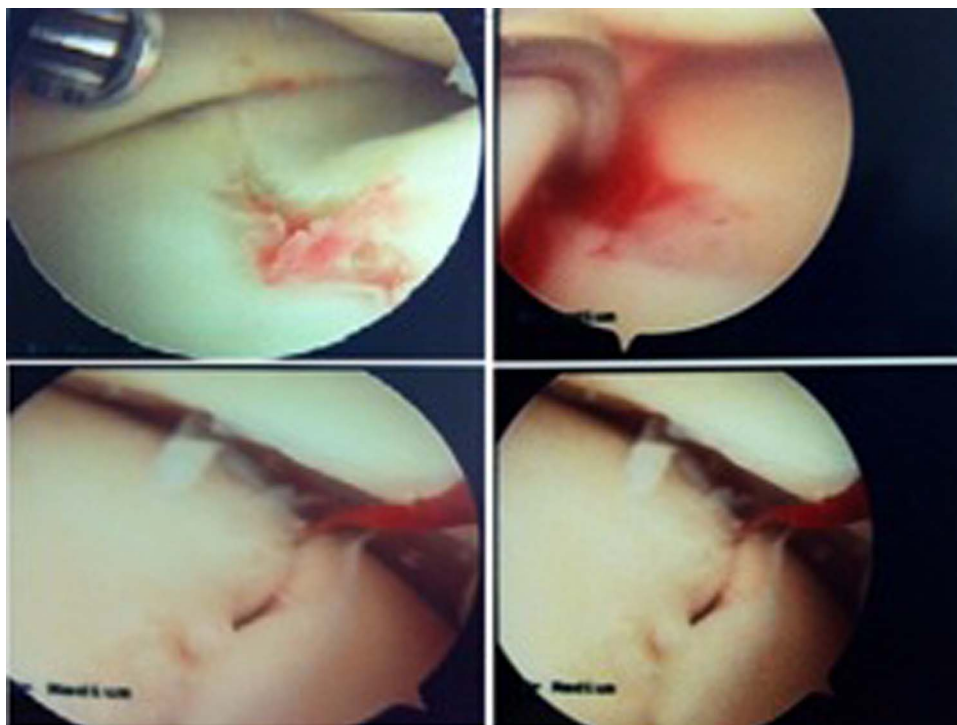
With this mechanism and fracture pattern, there is a high risk of compartment syndrome. There were no signs of this in the immediate postoperative period. The patient was discharged non weight bearing with no complications and seen routinely in paediatric fracture clinic. At 2 weeks he remained pain free; at 7 weeks radiographs showed adequate healing and he was able to bear weight and began physiotherapy in a T-ROM brace. At 6 months, the patient was completely pain free and back to his regular sporting activities with full range of movement in the left knee. He planned to have the screws removed.

### DISCUSSION

Acute avulsions of the tibial tubercle are uncommon, with reported incidence of 0.4–2.7% of all epiphyseal injuries.<sup>1 2</sup> Some authors have explained this low incidence by the lack of direct ligament attachments to the proximal tibial epiphysis.<sup>3–5</sup>

Importantly the collateral ligaments attach to the tibial metaphysis so sparing the epiphysis from any varus or valgus stress.<sup>6 7</sup> The physis of the tibial tuberosity is composed primarily of fibrocartilage and fibrous tissue, with bone being added to the anterior portion of the tibial metaphysis by membranous bone formation.<sup>8 9</sup> The development of the tibial tubercle shows progression from this fibrocartilage to columnar cartilage and begins proximally.<sup>10 11</sup> These structural features would be an adaptation to the strong tensile forces exerted in this region.<sup>8</sup> At this development stage the tubercle is at highest risk of fracture and correlates with an age of between 13 and 16 years.<sup>6 12 13</sup>

Two mechanisms for avulsion fractures have been proposed: a powerful contraction of quadriceps during extension, as seen in jumping or rapid passive flexion of the knee against contracted quadriceps, as seen in landing after a jump or fall.<sup>14</sup> Originally these injuries were classified by Watson-Jones into three types; in type I a small fragment is avulsed from the tubercle, type II occurs when the whole tubercle is avulsed and in a type III



**Figure 6** Intra-operative arthroscopic images of fracture and its reduction.

**Table 1** Modified classification of tibial tuberosity (TT) fractures

Types	TT	Epiphyseal portion (EP)
IA	Fracture minimally displaced	No disruption
IB	Fracture displaced anteriorly and proximally	No disruption
IIA	Fracture at junction of TT and EP	No disruption
IIB	Fracture comminuted and displaced proximally	No disruption
IIIA	Fracture into joint line with EP as composite unit	Disrupted
IIIB	Fracture comminuted and displaced proximally	Disrupted
IV	Fracture extension transversely through proximal tibial physis with displacement of fracture fragment	Disrupted

injury, the fracture extends across the proximal physis into the knee joint.<sup>15</sup> This classification was modified by Ogden with subdivision into groups A and B according to the level of comminution and displacement.<sup>11</sup> A type IV was described by Ryu and Debenham when the fracture extended posteriorly through the physis<sup>16</sup> and type V was added by McKoy and Stanitski with a combination of IIIB and IV giving rise to a Y-shaped pattern.<sup>17</sup> These classifications are illustrated further in table 1 below and figure 7.

Early literature on these cases focused on associated soft tissue injuries including; patellar or quadriceps avulsion, collateral or cruciate ligament ruptures and meniscal injuries.<sup>18–21</sup> A number of case reports and series have described the association between tibial avulsion fractures with proximal bony injuries.<sup>22–25</sup> Owing to the presence of fibrocartilage at the tibial tuberosity, physeal injury is uncommon in young children; however, during adolescence the fibrocartilage is gradually replaced with columnar cartilage and is at increased risk of injury. When they occur these fractures usually propagate along the physeal extension beneath the tibial tuberosity so displacing the tibial epiphysis and tuberosity as one unit.<sup>11</sup>

Tibial tuberosity fractures with physeal extension tend to be unstable making maintenance of an adequate reduction difficult.<sup>6</sup> Fractures mostly result in anterior, anterolateral or anteromedial displacement of the epiphysis and physis relative to the metaphysis.<sup>1</sup> Open reduction and internal fixation is recommended whenever the physis is severely displaced or comminuted, that is, in types IIB, IIIA, IIIB and IV.<sup>17</sup> The surgical aim must be to restore both the extensor mechanism and the congruency of the knee joint. In the case reports described the

majority of the cases reported are fixed using cannulated screws.<sup>22–25</sup>

In our case the extent of the injury was not realised at first presentation and internal fixation was attempted with an extra-articular approach and without further investigations. Unfortunately the fracture was found to be displaced 1 week postoperatively and the patient had to undergo further surgery to correct this displacement. This report highlights the role CT can play in these cases. The two 3D reconstructed images provide considerably more information on the fracture pattern than the plain radiographs. We would recommend obtaining a preoperative CT scan if extension of the fracture into the tibial physis is suspected. This allows appreciation of the fracture configuration prior to surgery and aids planning of the reduction and fixation methods. This use of CT imaging in complex fracture patterns is also recommended by other authors.<sup>26</sup> During the second operation, arthroscopy was used to ensure accurate fracture reduction, an approach recommended previously.<sup>25</sup> We had difficulty visualising the anterior articular surface under the anterior meniscal horns with a 30° scope. A 70° arthroscope would have helped tackle this difficulty and should have allowed the surgeon to visualise the anterior joint surface more easily. In type III injuries the tuberosity fracture propagates into the anterior tibial physis and the ability to see this area intra-operatively allows the surgeon to confirm fracture reduction. We would recommend that before attempting fixation of these injuries a 70° arthroscope is available to ensure optimal reduction.

### Learning point

Tibial tuberosity fractures with extension into the tibial physis are rare, and appreciating fracture patterns from plain radiographs alone may be difficult. We recommend the following in order to achieve direct anatomical reduction:

- A pre-operative CT scan with 3D reconstructions to fully appreciate the fracture configuration;
- Use of an arthroscope intraoperatively to aid and confirm the accuracy of reduction.

**Competing interests** None.

**Patient consent** Obtained.

**Provenance and peer review** Not commissioned; externally peer reviewed.

**Figure 7** CT 3-D reconstructions confirming satisfactory reduction.



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