

## Fracture of the Tibial Tuberosity in Adolescents

S. Vainionpää, O. Böstman, H. Päätiälä, and P. Rokkanen

Department of Orthopedics and Traumatology, Helsinki University Central Hospital, Topeliuksenkatu 5, SF-00260 Helsinki 26, Finland

**Summary.** Fracture of the tibial tuberosity is an uncommon injury and rarely occurs after closure of the proximal tibial epiphysis. Three cases of tibial tuberosity fracture over a period of 11 years were treated by open reduction, internal fixation, and immobilization for 6 weeks in plaster of Paris (1970–1980). The postoperative follow-up times were 5, 6, and 7 years. No subsequent deformities were detected. Two patients had secondary posttraumatic patella infera without any symptoms. All patients returned to normal activity. The results demonstrated that this injury in the adolescent knee heals without deformity of functional loss when adequate reduction and fixation of the fracture fragments have been achieved.

**Zusammenfassung.** Frakturen der Tuberositas tibiae sind selten und treten kaum nach dem Epiphysenschluß auf. Im Zeitraum von 11 Jahren (1970–1980) wurden drei Fälle von Tuberositastibiae-Fraktur operativ durch Reposition und interne Fixation sowie postoperative Immobilisation im Gips für 6 Wochen behandelt. Die Beobachtungszeiten waren 5, 6 und 7 Jahre. Sekundäre Deformierungen wurden nicht beobachtet. Zwei Patienten hatten eine symptomlose Patella infera posttraumatica. Es konnte keine Behinderung der Aktivität der Patienten festgestellt werden. Die Ergebnisse zeigen, daß diese Verletzung der Epiphysenplatte des wachsenden Kniegelenkes ohne Deformität der Tibia oder Funktionsverlust ausheilt, wenn eine adäquate Reposition und Fixation erzielt wird.

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Up to 55% of tibial growth originates in the proximal growth plate. Of all growth plate lesions, 0.5% are located in the proximal tibial growth plate. Fracture of the tibial tuberosity rarely occurs in adolescents.

*Offprint requests to:* S. Vainionpää, M.D. (address see above)

We found 89 such cases in the literature [1–8, 10, 11, 16, 17, 19–23].

### Etiology

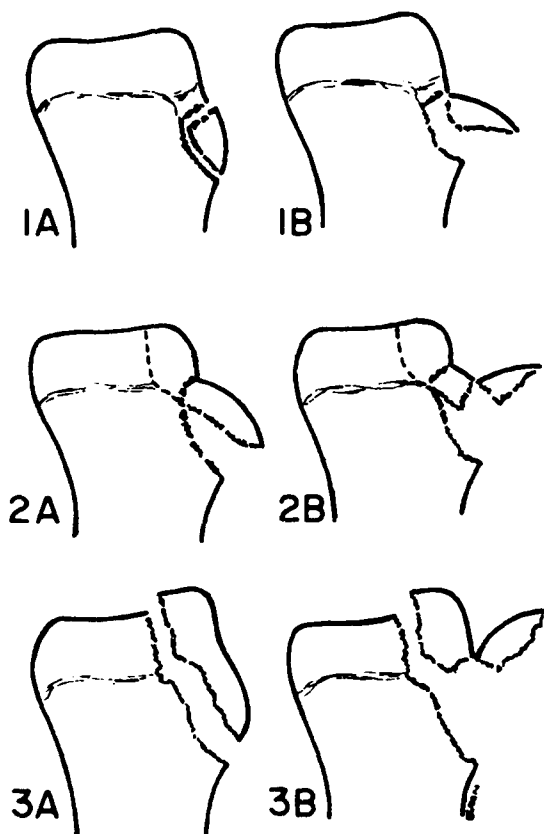
The development of the tibial tuberosity was studied by Ehrenborg and Lagergren [9] in dogs and by Ogden [18] in human fetuses and children of various ages killed in accidents or dying of a particular disease.

The secondary ossification center of the tibial tuberosity develops on average at the age of 11. The blood supply to the tibial tuberosity then differs from the normal circulation in the epiphyseal-metaphyseal region, since vascular communication occurs across the growth plate until the age of 10–12 years. Soon thereafter the secondary ossification center of the tibial tuberosity fuses with the proximal tibial center. Histologically, one can then distinguish in the growth plate of the tibial tuberosity predominant columnated tissue and a distal area of fibrotic cartilage. The tensile strength of the latter is clearly greater than that of the columnated tissue [18].

At the termination of growth, there is initial closure of the growth plate in the central proximal part of the tibia, and this then extends centrifugally. Lastly there is fusion of the tuberosity, which begins in the proximal part and proceeds in the distal direction. The columnated tissue is then replaced by tissue with greater tensile strength.

Fracture of the tibial tuberosity may result when the knee is flexed and the quadriceps muscle of the thigh is violently contracted. The damage arises distally and proceeds in the proximal direction. The low tensile strength of the columnated tissue contributes to the development of the lesion.

Osgood-Schlatter's disease differs from fracture of the tibial tuberosity in that the changes in the former condition do not extend as far as the growth



**Fig. 1.** Types of injury to the tibial tuberosity [19]. (An illustration of this classification is presented by courtesy of the holder of the copyright.) *1 A* = The fracture is located below the junction of the ossification centers; *1 B* = the torn fragment is dislocated in forward and upward direction; *2 A* = the fracture is located at the junction of the ossification centers; *2 B* = the torn fragment is broken and dislocated; *3 A* the fracture extends as far as the joint; *3 B* = the torn fragment is broken and dislocated

plate. In Osgood-Schlatter's disease avulsion of the superficial layer of the secondary ossification center is involved [18, 19].

### Classification of the Fracture

In 1955 Watson-Jones put forward a classification which was supplemented by Ogden 25 years later. An illustration of this classification is presented by courtesy of the holder of the copyright (Fig. 1).

### Patients and Methods

During the period 1970–1980 three tibial tuberosity fractures in adolescents were treated operatively at the Department of Orthopedics and Traumatology. A follow-up study was performed in 1983, comprising subjective results and functional recovery. The factors examined were the range of motion of the knees, the diameter of the thigh 10 cm above the medial joint space, hydrops, length difference of the limbs, and possi-

ble deformity of the tibial tuberosity. The normal limb was used as control.

Radiological examination comprised a-p and lateral views and tangential exposure of the patella in 20° flexion [14]. The measurements obtained from the radiographs were height index of patella (length of patella/length of patellar ligament; normal value 0.8–1.2 according to Insall and Salvati [12], Insall et al. [13], the lateral patellofemoral angle [14], and possible lateral displacement of patella [15]. In addition, the shape of the tibial tuberosity was studied. The normal limb was used as control. The strength of the quadriceps muscle of the thigh was measured using a dynamometer with the patient in half sitting position and supported, the hip joint in 90 degrees and the knee joint in 30 degrees of flexion in both limbs separately and finally as a combined value.

### Case Reports

#### Case 1

The patient was a 13-year-old previously healthy boy. On Jan. 12, 1978, he injured his right knee on the springboard while practising high jump. Examination at the emergency department revealed definite hydrops in the knee, and active extension of the knee joint failed. Radiologically, a typical 2 B fracture of the tibial tuberosity was diagnosed. The torn fragment was reduced and fixed with a screw and unresorbable sutures (Supramid) carried through bore holes. The knee was mobilized after 6 weeks in plaster of Paris and the screw was removed 8 weeks later. A superficial infection after the second operation healed in 2 weeks. At follow-up examination performed on March 28, 1983, the knee was asymptomatic and did not prevent athletic activities.

Preoperative radiographs showed a traumatic patella alta condition (see Table 1). At follow-up, secondary patella infera and deformity of the tibial tuberosity were observed on the injured right side. To the left the position of the patella was normal (see Table 1).

#### Case 2

On July 19, 1977, a 14-year-old previously healthy boy sustained a 1 B type fracture of the tibial tuberosity to the left in connection with high jumping. The torn fragment was fixed with a screw and two Kirschner wires, which were removed after 8 months. At follow-up on March 28, 1983, the knee was asymptomatic, and the range of motion and amount of muscle tissue and muscular strength were normal. Radiologically, the shape of the tibial tuberosity and the position of the patella were normal (see Table 1).

#### Case 3

The patient was a previously healthy 14-year-old girl. During physical training on Oct. 6, 1978, she fell from the beam when

**Table 1.** Type of lesion and position of patella (LP/LT)

Case no	At time of injury			At follow-up	
	Type of lesion	Side of lesion	Height index of patella	Right	Left
1	2 B	Right	0.7	1.3	0.9
2	1 B	Left	0.8	1.0	1.0
3	1 B	Left	0.7	0.8	1.3

her left foot gave way. Radiological examination showed a 1 B type fracture of the tibial tuberosity. The tibial tuberosity was fixed with a screw carried from above the torn fragment through the patellar ligament. The screw was removed 1 year later. At follow-up on April 15, 1983, the knee was asymptomatic and the range of motion was normal. A circumferential difference of 0.5 cm showed a loss of thigh muscle to the left, the strength of the left quadriceps was 85 kp as opposed to 105 kp to the right, and the combined strength was 185 kp. Pre-operative radiographs showed traumatic patella alta to the left. At follow-up, secondary patella infera was observed in the injured knee. The position of the right patella was normal (see Table 1). Tangential views of the patella showed nothing noteworthy.

## Discussion

Fracture of the tibial tuberosity due to indirect violence sustained by individuals aged 11–16 years occurs after fusion of the proximal part of the tibia and the ossification center of the tibial tuberosity has taken place. The capacity of the tibial tuberosity to resist traction forces is then reduced, because the columnated region in the growth plate of the tibial tuberosity extends almost to the distal level of the entire tuberosity. Ogden [19] found that Osgood-Schlatter's disease predisposes to fracture of the tuberosity. None of our patients showed any signs of Osgood-Schlatter's disease in either limb. In none of them did the lateral joint angle of the patellofemoral joint show any tendency towards medial opening, which is considered typical of recurrent subluxation of the patella [14], nor could any lateral dislocation be demonstrated in the patellofemoral joint. Two patients showed secondary asymptomatic patella infera.

Blount [1] and Deliyannis [7] stated that fracture of the tibial tuberosity involves the risk of genu recurvatum and recommended conservative treatment. Watson-Jones [23] also recommended conservative treatment in all types of fracture of the tibial tuberosity. So far no case of tibial tuberosity fracture alone resulting in genu recurvatum has been reported. Ogden [19] was of the opinion that fracture of the tibial tuberosity caused by indirect violence cannot lead to recurvatum. On the other hand, if a direct force operating in the axial direction causes a compression injury of Salter V type in the proximal tibial growth plate, genu recurvatum may result.

Today, a return to normal of the anatomical conditions is considered very important in fractures of the tibial tuberosity. Conservative treatment is feasible mainly in 1 A and sometimes in 2 A type fractures. If torn soft tissues prevent exact reposition, operation is mandatory in these cases also. With conservative treatment, radiological controls are recommended immediately after reposition and 1, 3, and 6 weeks after injury. Six week's immobilization in plaster of Paris is considered sufficient.

As operative treatment, fixation with a screw is recommended or, as an alternative, the use of two Kirschner wires and tension wire bandage. No growth disturbances have been described in connection with operative treatment of fractures of the tibial tuberosity.

## References

1. Blount WP (1955) Fractures in children. Williams & Wilkins, Baltimore, p 175
2. Becker D (1983) Abriss der jugendlichen Tuberositas tibiae-Typisierung und Therapieempfehlungen einer Fall-demonstration. *Z Orthop* 121:320–323
3. Bowers KD (1981) Patellar tendon avulsion as a complication of Osgood-Schlatter disease. *Am J Sports Med* 9:356–359
4. Brandesky G, Salen G (1961) Die Fractur der Tuberositas Tibiae. *Chirurg* 32:517–519
5. Christie MJ, Dvonch VM (1981) Tibial tuberosity avulsion fracture in adolescents. *J Pediatr Orthop* 1:391–394
6. Clarke HO (1935) Discussion on fracture of the tibia involving the knee joint. *Proc R Soc Med* 28:1035–1050
7. Deliyannis SN (1975) Avulsion of the tibial tuberosity: Report of two cases. *Injury* 4:341–344
8. DePalma AF (1954) Diseases of the knee. Lippincott, Philadelphia London Montreal, pp 207–209
9. Ehrenborg G, Lagergren C (1961) The normal arterial pattern of tuberositas tibiae in adolescents and growing dogs. *Acta Chir Scand* 121:500–512
10. Gill JG, Chakrabarti HP, Becker SJ (1983) Fractures of the proximal tibial epiphysis. *Injury* 14:324–331
11. Hand WL, Hand CR, Dunn AW (1971) Avulsion fractures of the tibial tubercle. *J Bone Joint Surg [Am]* 53:1579–1583
12. Insall J, Salvati E (1971) Patella position in the normal knee joint. *Radiology* 101:101–105
13. Insall J, Goldberg V, Salvati E (1972) Recurrent dislocation and the high-riding patella. *Clin Orthop* 88:67–69
14. Laurin CA, Levesque HP, Dussault R, Labelle H, Peides PJ (1978) The abnormal lateral patellofemoral angle. A diagnostic roentgenographic sign of recurrent patellar subluxation. *J Bone Joint Surg [Am]* 60:55–60
15. Laurin CA, Dussault R, Levesque HP (1979) The tangential X-ray investigation of the patellofemoral joint. X-ray technique, diagnostic criteria and their interpretation. *Clin Orthop* 144:16–26
16. Levi JH, Coleman CR (1976) Fracture of the tibial tubercle. *Am J Sports Med* 4:254–263
17. Mayba II (1982) Case report. Avulsion fracture of the tibial tubercle apophysis with avulsion of patellar ligament. *J Pediatr Orthop* 2:303–305
18. Ogden JA, Southwick WO (1976) Osgood-Schlatter's disease and tibial tuberosity development. *Clin Orthop* 116:180–189
19. Ogden JA, Tross RB, Murphy MJ (1980) Fractures of the tibial tuberosity in adolescents. *J Bone Joint Surg [Am]* 62:205–215
20. Schwarzkopf W, Ahlers J, Kirschner P (1980) Abrisse und Fracturen der Tuberositas tibiae. *Unfallheilkunde* 83:360–365
21. Schönbauer HR (1957) Brüche der Tuberosita tibiae. *Monatsschr Unfallheilkd* 60:83–88
22. Unglaube H (1955) Ein Beitrag zur Abrissfraktur der Tuberositas tibiae. *Zentralbl Chir* 80:1372–1375
23. Watson-Jones (1955) Fractures and joint injuries. Livingstone, Edinburgh London, pp 785–788

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