J Orthop Sci (2003) 8:784–788
DOI 10.1007/s00776-003-0723-x

Journal of
Orthopaedic Science

Rotational injuries of the distal tibial growth plate

Savas P. Nenopoulos, Vasilios A. Papavasiliou, and At. V. Papavasiliou

Orthopaedic Paediatric Department, Aristotle University of Thessaloniki General Hospital "G. Gennimata," Thessaloniki, Greece

Abstract Nine rotational injuries of the distal tibial growth plate in combination with spiral fracture of the fibula were treated in our department between 1993 and 2000. The average age of the patients was 12 years. The injury was a result of sudden, forceful external rotation of the ankle and foot. Pain and slight swelling of the ankle and external rotation of the distal tibia of 20°–40° were present. Radiologically, irregularity and widening of the growth plate of the distal tibia were obvious. In all these cases we noted, on lateral views, the characteristic sign of an "open fish mouth," due to the changes in the shape of the physeal plate. The spiral fracture of the fibula was not obvious in all radiographic views. The treatment in all eight fresh cases was closed reduction and manipulation by reversing the mechanism of injury and long leg cast application in all nine cases (including the one neglected case) for 6–8 weeks. The final results were either excellent or very good in all nine patients after a mean follow-up of 6 years.

Key words Rotational · Injuries · Distal tibia · Physis

Introduction

Type I Salter-Harris injuries of the distal tibial physis are rare and are most often noted in neurologically impaired children or those subjected to child abuse.[3,8] Isolated fractures of the fibula in an immature skeleton are equally uncommon[3] and are usually associated with tibial fractures.

The combination of a rotational injury of the distal tibial epiphysis associated with spiral fracture of the fibula is not common. To the best of our knowledge this type of injury has not been adequately described in the relevant literature so far.

Offprint requests to: S. Nenopoulos, 1 K. Mitrousi Str, 546 46 Thessaloniki, Greece
Received: February 17, 2003 / Accepted: August 14, 2003

We present nine such patients with this rare injury. The four reported cases (known to us) of traumatic rotational displacement of the distal tibial epiphysis are presented without describing a fracture of the fibula.[1,5–7]

The purpose of presenting these nine cases is that this injury can be easily misdiagnosed. The reason is failure to identify the rotation of the epiphysis or the presence of a spiral fracture of the fibula. In all nine cases we noted a characteristic radiological sign at the injured distal tibial growth plate in the lateral view, an "open fish mouth" (Fig. 1a).

Material and methods

This series included nine children (eight boys, one girl) aged 11–14 years (mean 12 years). The right leg was affected in six patients (five boys, one girl) and the left leg in three boys (Table 1).

The mechanism of injury in all cases was sudden forceful violence that caused external rotation to the foot and ankle. The cause was stumbling while running ($M = 4$), an accident while playing football ($M = 3$), or a bicycle or skating accident ($M = 2$) (Table 1). All but one of the patients were examined soon after the accident. The exception was admitted 1 month later as a neglected case.

The initial clinical examination revealed pain and slight swelling of the ankle in all fresh ($M = 8$) cases. In seven patients pain and tenderness on palpation were also present in the distal third of the fibula, and in one of them these signs were noted in the upper third. Passive and active movements of the ankle joint were painful in all fresh cases, and all patients prior to attending the casualty department were able to bear weight on the injured side although with pain.

All patients displayed external rotation of the ankle and foot. The range of this rotational deformity compared to the normal side was 20°–40°.

Fig. 1. a Rotational injury of the distal tibial physis of a boy aged 13. Irregularity and widening of the growth plate is present in the anteroposterior radiograph. In the lateral view a spiral fracture of the distal fibula is just obvious, and we can also see the characteristic sign of an "open fish mouth" on the growth plate in the front. **b** Complete restoration without any deformity 6 years after the injury

Table 1. Profile of all cases

Sex	Age (years)	Cause of accident	Time from the injury to the correct diagnosis (days)	Method of treatment	Follow-up time (years)	Final results[a]
Boy	14	Stumbled while running	0	Internal rotation; long leg cast 8 weeks	9	Excellent
Boy	11	Sports accident (football)	2	Internal rotation; long leg cast 6 weeks	8.5	Very good, external rotation 10°
Boy	11	Stumbled while running	2	Internal rotation; long leg cast 8 weeks	8	Very good, external rotation 10°
Boy	12	Stumbled while running	4	Internal rotation; long leg cast 6 weeks	7.5	Excellent[b]
Girl	12	Bicycle accident	0	Internal rotation; long leg cast 6 weeks	7	Excellent[b]
Boy	13	Stumbled while running	0	Internal rotation; long leg cast 6 weeks	6	Excellent
Boy	11	Skating accident	30	Long leg cast 4 weeks	3	Very good, external rotation 15°
Boy	12	Sports accident (football)	2	Internal rotation; long leg cast 8 weeks	3	Excellent[b]
Boy	13	Sports accident (football)	0	Internal rotation; long leg cast 8 weeks	2	Excellent[b]

[a] Excellent: dorsiflexion of the ankle 20°–30°/plantarflexion 30°–50° without external rotation of the distal tibia; no leg length discrepancy; no disability due to the injury
[b] Premature closure of the physis

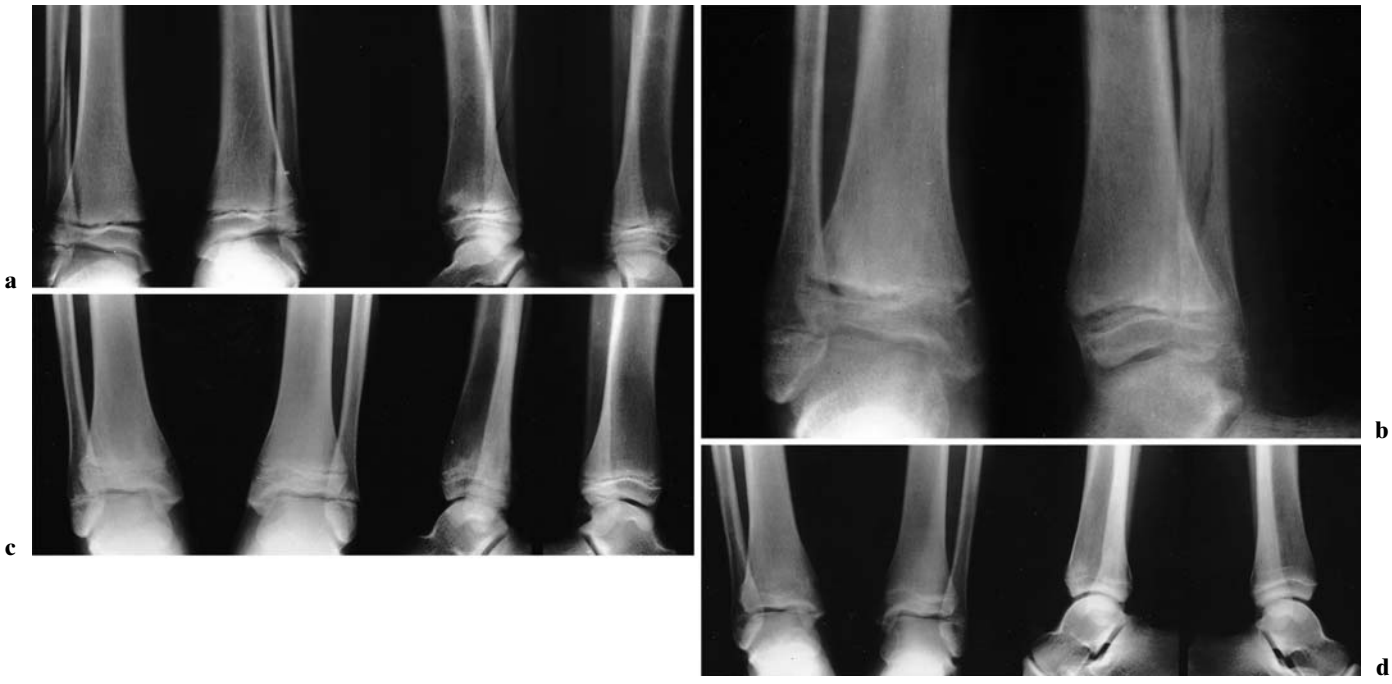

Fig. 2. **a** Rotational injury of the right distal tibial physis in a 13-year-old boy accompanied by a spiral fracture of the distal third of the fibula, seen on comparative radiographs in frontal and lateral views. The characteristic sign of "open fish mouth" is seen on the lateral view but not on the normal one. **b** After reduction, long leg cast immobilization, and removal of the cast. These radiographs were obtained 6 weeks after the injury. **c** Comparative radiographs after 6 months. **d** After 2 years these is early closure of the distal tibia growth plate and complete restoration without any deformity

Fig. 3. Normal radiograph of the distal tibia demonstrates the shape of the growth plate, which is not flat

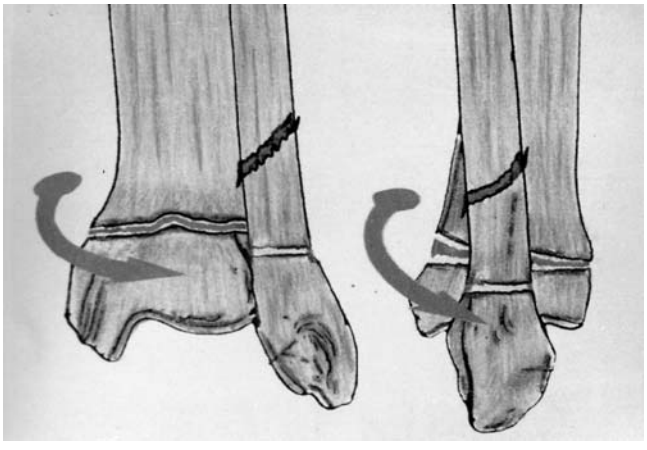

Fig. 4. Normal growth plate of the distal tibia, which is curved, and after rotation where the frontal side is opened

Anteroposterior and lateral radiographs of the injured ankle were obtained, as were some comparative ones. Careful examination of the radiographs revealed some irregularity and widening of the growth plate of the distal tibia. We also observed in the lateral view a characteristic disturbance of the anterior part of the growth plate, resembling an "open fish mouth" (Fig. 2a). This unique sign is caused by the shape of the growth plate of the distal tibia, which is normally slightly curved (Fig. 3) rather than being flat. After a rotational injury at the distal tibial epiphysis a gap analogous to the degree of rotation was observed (Fig. 4). An associated spiral fracture of the distal third of the fibula was present in seven cases; the other one was located in the upper third of the fibula.

Four of the eight cases were misdiagnosed as a "strain" or fracture of the fibula after their initial consultation. Only after the persistence of pain and their

Fig. 5. **a** Rotational injury of the left distal tibial physis in a 12-year-old boy accompanied by a spiral fracture of the distal third of the fibula. **b** Radiographs after successful closed reduction by reversing the external rotation, 2 days after injury. **c** Comparative radiographs in frontal and lateral views 3 years later. Note the complete restoration and early partial closure of the growth plate in the injured left ankle

reexamination (within 2–4 days after injury) was the correct diagnosis made of a Salter-Harris type I injury to the distal tibia with an associated fibula fracture. Rotation of 20°–25° of the ankle and foot was noted in the latter cases.

The treatment for all fresh cases consisted by manipulation, closed reduction (by reversing the mechanism of the injury), and long leg cast immobilization for 6–8 weeks (Fig. 2b). For the four cases misdiagnosed initially and treated as a "strain" or fracture of the fibula, after the correct diagnosis we followed the previous method of treatment, and reduction was accomplished after 2–4 days (Fig. 5a,b).

One patient, aged 11, attended our department 1 month after injury because of pain and his inability to bear weight fully. The clinical examination revealed 15° rotation of the affected distal tibia. The radiograph showed a periosteal reaction at the distal end of the tibia. The fracture of the distal end of the fibula was obvious only on the lateral view (Fig. 6). No attempt at manipulation or reduction was made in this patient, and he was treated with a long leg cast for 4 weeks.

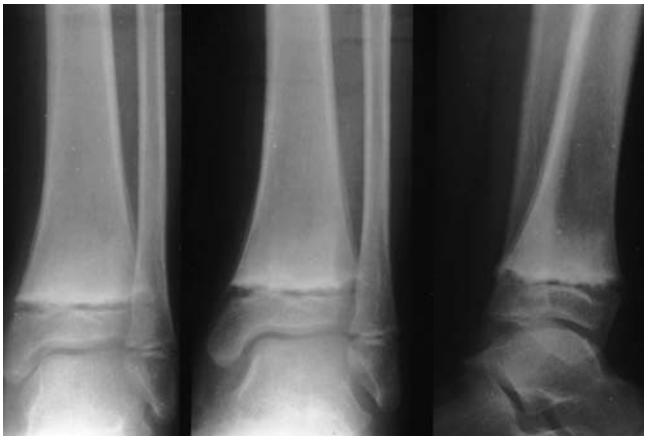

Fig. 6. Periosteal reaction to the distal tibia in an 11-year-old boy, with rotational injury of the distal tibial physis who was examined as a neglected case for the first time 1 month after the accident. Spiral fracture of the distal third of the fibula is just obvious in the lateral view

Results

During the last year all patients were assessed clinically and radiologically. The follow-up ranged from 2 to 9 years (mean 6 years).

Physical examination included movement of the ankle joint to check for the existence of rotation or other deformity of the distal part of the tibia compared to the normal one and leg length discrepancy. Total ankle joint range of movement was normal in all cases (dorsiflexion 20°–30°, plantarflexion 30°–50°). External rotation of 10°–15° was present in three patients, who were those who were initially misdiagnosed. The length of the tibia and femur in all cases was normal compared to that of the noninjured ones. All patients could walk and carry out their work without limitation or pain.

In the comparative radiographs of the tibia and ankle, in the frontal and lateral views we noted four cases of early closure of the distal growth plate of the tibia (Fig. 2c,d). No other deformities were present, and complete restoration was accomplished.

Discussion

Type I Salter-Harris injuries of the distal tibial physis do occur but are exceptional.[9] Rotational displacement of the lower tibial epiphysis can be accompanied by a spiral fracture of the fibula on the lower or upper third. It is important to have a radiograph of the entire tibia and fibula to rule out a high fibula fracture.[4] Furthermore, if the rotation is trivial, oblique views may

be necessary so the fracture of the fibula is made evident.

Plain film radiography often underestimates the extent of the injury in children with physeal fractures. A Salter-Harris type I physeal injury of the distal tibia when undisplaced or minimally displaced may be difficult to identify radiographically.[2] The initial rotation at the time of accident should be more than the rotation seen on the radiographs because the fibula is plastic enough to twist without breaking.[3,7]

Rotational injury of the distal tibial epiphysis and spiral fracture of the fibula indicates significant rotation of the distal tibial epiphysis (in our study up to 40°). The radiological sign called "open fish mouth" on the lateral view of the distal tibia in association with the mechanism of injury should raise high suspicion for an associated fibula fracture and thus significant rotational deformity, which requires manipulation, correction, and immobilization.

No permanent damage to the growth plate was noted with these injuries, which generally healed without any significant deformity when treated, and the patients had complete restoration of function (Figs. 1b, 2d, 5c). No leg length discrepancy occurred, although premature closure of the distal tibial physis was observed in four cases. The reason is thought to be that premature closure occurred at a periadolescent age.

References

1. Broock GJ, Greer RB. Traumatic rotational displacements of the distal tibial growth plate. J Bone Joint Surg Am 1970;52:1666–8.
2. Cameron HU. A radiologic sign of lateral subluxation of the distal tibial epiphyses. J Trauma 1975;15:1030–1.
3. Crawford AH. Fractures and dislocations of the foot and ankle. In: Green NE, Swiontowski MF, editors. Skeletal trauma in children. vol 3. Philadelphia: Saunders; 1994. p. 455.
4. Dias LS. Fractures of the distal tibial and fibular physes. In: Rockwood CA, Wilkins KE, King RE, editors. Fractures in children. vol 3. Philadelphia: Lippincott; 1984. p. 1025.
5. Henke JA, Kiple DL. Rotational displacement of the distal tibial epiphysis without fibular fracture. J Trauma 1979;19:64–6.
6. Lovell ES. An unusual rotatory injury of the ankle. J Bone Joint Surg Am 1968;50:163–5.
7. Nevelos AB, Colton CL. Rotational displacement of the lower tibial epiphysis due to trauma. J Bone Joint Surg Br 1977;59:331–2.
8. Ogden JA. Skeletal injury in the child. New York: Springer-Verlag; 2000. p. 1045–6.
9. Rang M. Children's fractures. 2nd edn. Philadelphia: Lippincott; 1983. p. 309.