Outcome of Physeal and Epiphyseal Injuries of the Distal Tibia With Intra-Articular Involvement

Savvas P. Nenopoulos, MD, Vasilios A. Papavasiliou, MD, and Athanasios V. Papavasiliou, MD

Abstract: The authors reviewed 83 physeal and epiphyseal injuries of the distal tibia with intra-articular involvement. The children, aged 11 to 14 years, were treated in the authors' department during 1987 to 1999. Treatment was nonoperative for 72.25% (60/83) and surgical for 27.75% (23/83) according to specific indications. This gives the basis for a classification of these injuries. The main purpose of the study was to investigate the long-term results of these injuries according to a radiologic classification. The parameters considered were the patient's age, the mechanism of injury, and the possibility of growth deformities or functional disorders. They were studied relative to the long-term results, with a follow-up of 2 to 13 years. Regardless of treatment, varus deformity, ranging from 10 to 15 degrees in relation to the normal opposite leg, occurred in four cases. In only one case was there painful limitation of ankle joint movement; in two other children an overgrowth of the medial malleolus was detected, with no functional impairment.

Key Words: physeal injuries, distal tibia, intra-articular

(*J Pediatr Orthop* 2005;25:518–522)

Physeal injuries of the ankle joint constitute 11% of all physeal fractures.[1] Those with intra-articular involvement of the distal tibial epiphysis in children are the most problematic of ankle fractures.[2] Even though this injury is not rare, there is no single classification. For this reason, we studied our results and introduce a classification that helps not only in the method of treatment but also in estimating the results (Figs. 1 and 2).

MATERIALS AND METHODS

The total number of patients was 83 (41 girls, 42 boys). Their ages ranged from 11 to 14 years (Table 1). In 37 children, the right ankle was injured; the left was injured in 46. The mechanism of injury in almost all cases was the result of supination-inversion and/or external rotation of the ankle joint. Most of the patients were hurt while falling down stairs, tripping over a step, or slipping or falling while roller-skating or skateboarding (n = 50); the rest were hurt during sports (n = 19) and during a traffic accident or direct violence (n = 14). We used the following classification:

Group 1: Fractures of the medial malleolus region (n = 39). These were subdivided into two subgroups. **Group 1a:** Fracture-separations (Salter-Harris III or IV) of the medial part of the distal tibial epiphysis (n = 27). **Group 1b:** Fractures of the medial malleolus with or without fracture of the distal fibula (n = 12).

Group 2: Fracture-separations (Salter-Harris III) of the lateral portion of the distal tibial epiphysis (juvenile Tillaux type fractures) (n = 14).

Group 3: Fracture-separations of the distal tibial metaphysis-epiphysis in three dimensions (triplane) (n = 30).

The growth plates in all group 1 patients were open. Ten children in group 1a, four in group 1b, and four in group 3 also had a fracture of the distal fibula; in group 3, there was also one child with a fracture of the upper third of the fibula. One child in group 1a had multiple associated injuries, including a fracture of the talus and a fracture of the lumbar spine. One fracture in group 1a was open (Gustilo grade I).

All patients had AP and lateral radiographs of the injured ankle joint initially, and almost all also had oblique views taken. Only 17 patients with group 3 injuries (triplane) needed further imaging with CT to identify the nature of the fracture. CT was used only when the plain radiographs were not clear enough to allow planning for the management of the injury. In addition, this study influenced the process of treatment.

Treatment

Sixty ankles were manipulated and treated nonoperatively in a plaster splint. These patients were kept non-weight bearing for 6 weeks. Open reduction and internal fixation, either by Kirschner wires (n = 17) or screws (n = 3) or both (n = 3), was performed in the remaining 23 cases. Treatment in each group is listed in Table 2.

The criterion for surgical treatment was failure to achieve stable closed reduction with less than 2 mm of displacement of the fracture.[3–6] The K-wires or screws did not cross the growth plate unless the patients were near skeletal maturity. In some cases in group 3, to hold the distal tibial epiphysis in an acceptable position, the metaphysis needed fixation with screws (Fig. 3A, B).

Study conducted at Aristotle University of Thessaloniki, General Hospital "G. Gennimata," Thessaloniki, Greece.

From University of Thessaloniki, General Hospital "G. Gennimata," Thessaloniki, Greece.

None of the authors received financial support for this study.

Reprints: Dr. Savvas Nenopoulos, Associate Professor of Orthopaedics, Aristotle University of Thessaloniki, 1 K. Mitrousi str, 546 46 Thessaloniki, Greece (e-mail: savanen@med.auth.gr).

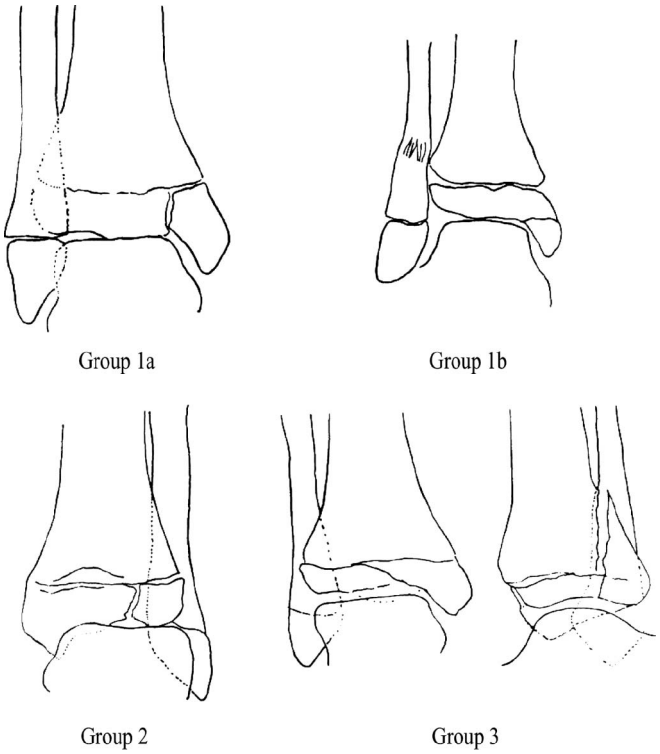

FIGURE 1. The three groups of our proposed classification.

RESULTS

Fifty-eight (67%) of the 83 patients were recently re-examined; the rest were lost to follow-up or declined to participate. The results are presented on the basis of our proposed classification. The range of follow-up was 2 to 13 years (mean 7 years) in group 1, 2.5 to 13 years (mean 9 years) in group 2, and 1.5 to 11 years (mean 6 years) in group 3. Fifty-seven of the 58 patients who were re-examined did not have any functional problems and could carry out their everyday activities and sports without any limitation.

Since we present cases with intra-articular fractures of the ankle joint, it is difficult to estimate the results because the postinjury period of time was not long enough. We may characterize the result as an "excellent" one at the time of examination, based on the functional parameters and the anatomy in comparison to the normal side.

In 4 of the 27 patients in group 1a, a varus deformity of 10 to 15 degrees developed; the rest had an excellent result so far after conservative or surgical treatment (Fig. 3C). One boy, age 11, with a group 1a injury who had nonoperative treatment developed varus deformity after 1 year (Fig. 4). Because of the deformity, corrective osteotomy was performed. The relapse of the deformity was detected 11 years later. During follow-up, no functional deficit was apparent. Three other patients with group 1a injury also developed a varus deformity 2 years after the injury, but with no sign of functional problems. These were a boy age 12 treated with internal fixation and a girl age 14 and a boy age 13 who had nonoperative treatment.

In two patients with group 1b injuries, an overgrowth of the medial malleolus was seen. In these cases we did not detect any functional impairment. The only painful limitation in ankle joint movement was found in a boy with a group 2 injury

FIGURE 2. Classification of intra-articular injuries of the distal tibia. Group 1a: Fracture-separation Salter-Harris III or IV of the medial portion of the distal tibial epiphysis. Group 1b: Fracture of the medial malleolus (type 7 Ogden's mechanism injury) with fracture of the distal fibula. Group 2: Fracture-separation Salter-Harris III of the lateral portion of the distal tibial epiphysis (Tillaux-type fracture). Group 3: Fracture-separation of the distal tibial epiphysis-metaphysis, seen as Salter-Harris type III in the frontal radiograph and as Salter-Harris type II in the lateral view (triplane).

TABLE 1. Ages of Children With Physeal and Epiphyseal Injuries of the Distal Tibia With Intra-Articular Involvement

Age	11		12		13		14		Total
Boys	Group 1a	4	Group 1a	6	Group 1a	7	Group 1a	3	42
	Group 1b	2	Group 1b	2	Group 1b	1	Group 1b	–	
	Group 2	1	Group 2	–	Group 2	3	Group 2	4	
	Group 3	–	Group 3	1	Group 3	1	Group 3	7	
Girls	Group 1a	3	Group 1a	2	Group 1a	2	Group 1a	–	41
	Group 1b	–	Group 1b	3	Group 1b	1	Group 1b	3	
	Group 2	–	Group 2	2	Group 2	3	Group 2	1	
	Group 3	5	Group 3	7	Group 3	7	Group 3	2	
	Total	15	Total	23	Total	25	Total	20	83

Group 2 and 3 injuries often occurred nearly at the end of the development of the immature skeleton. In boys the peak was 1 year earlier than that of the girls.

who was 14 years old at the time of the injury; he had undergone an open reduction and internal fixation (with two K-wires and screws). Radiographs 2.5 years after the injury revealed a loose body present in the medial side of the ankle. This was probably a small osteochondral fragment detached from the articular surface of the distal tibia, not notable in the initial radiographs.

In group 3 injuries some minor abnormalities were noticed, but despite the seriousness and complexity of this injury, there were no functional problems. A slight external rotation of up to 5 degrees appeared in three children, a small angulation of the distal fibula of 10 degrees occurred in one child, a diluted lesion of the distal tibial metaphysis (4 years after removal of the screw) occurred in one child, and growth disturbance of the Harris line occurred in three children.

Concerning other parameters at the long-term follow-up, we did not notice any significant differences from the normal side. As far as the range of motion of the ankle deficit in dorsiflexion is concerned, 5 to 7 degrees was found in six patients. Leg length differences were 5 to 10 mm, as the patients were near maturity.

DISCUSSION

Intra-articular fractures of the ankle joint in the immature skeleton include fracture separations (Salter-Harris III and IV) of the medial part of the distal tibial epiphysis, fractures of the medial malleolus, fracture-separations (Salter-Harris III) of the lateral portion of the distal tibial epiphysis (juvenile Tillaux fractures), and triplane fractures. In the past two decades many authors have explored the nature and outcome of these injuries.[7–12]

The new imaging methods of diagnosis, including CT and MRI, have refined the radiographic diagnosis and enhanced the evaluation of complications.[13] They are indispensable aids to managing, identifying, and classifying the fracture.

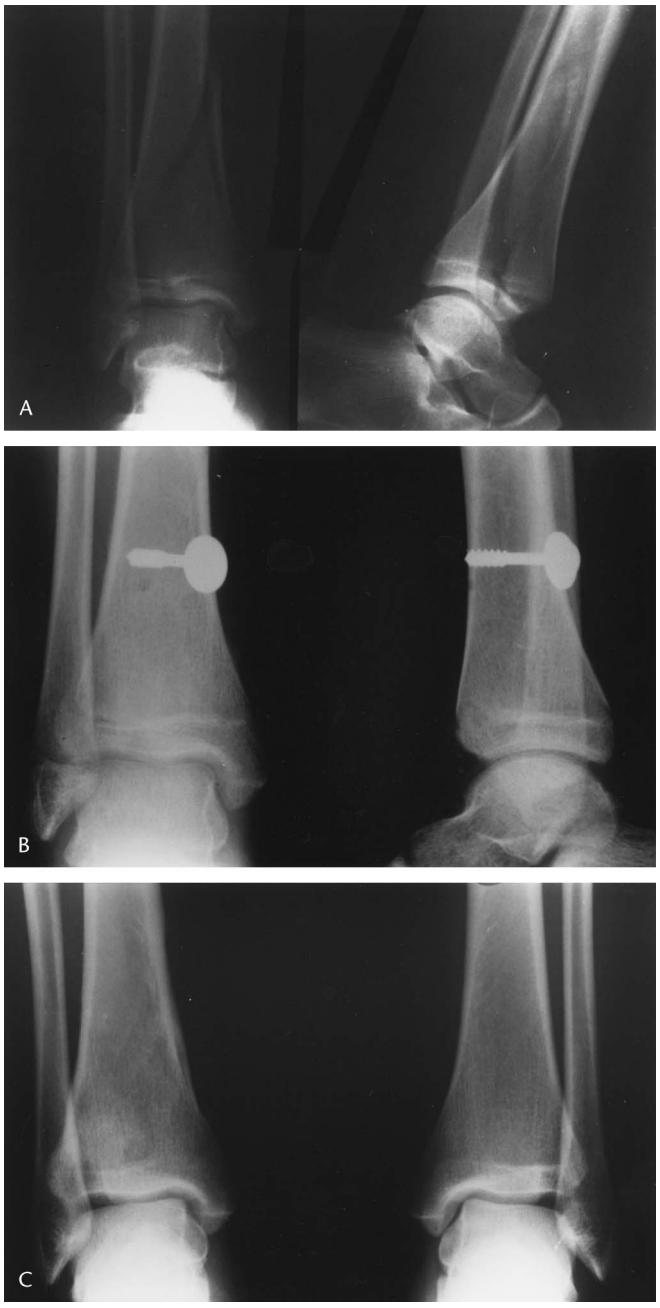

FIGURE 3. A, Group 3 injury (triplane) in a girl age 13. B, Radiographs 8 weeks after open reduction and fixation to the metaphysis with a screw. The fracture is well healed in good position. C, Comparative radiographs 5 years later show a normal appearance of the injured right ankle.

TABLE 2. Treatment of Physeal and Epiphyseal Injuries of the Distal Tibia Based on Proposed Classification

Group	Nonoperative Treatment	Operative Treatment
Group 1a	16	11
Group 1b	7	5
Group 2	12	2
Group 3	25	5

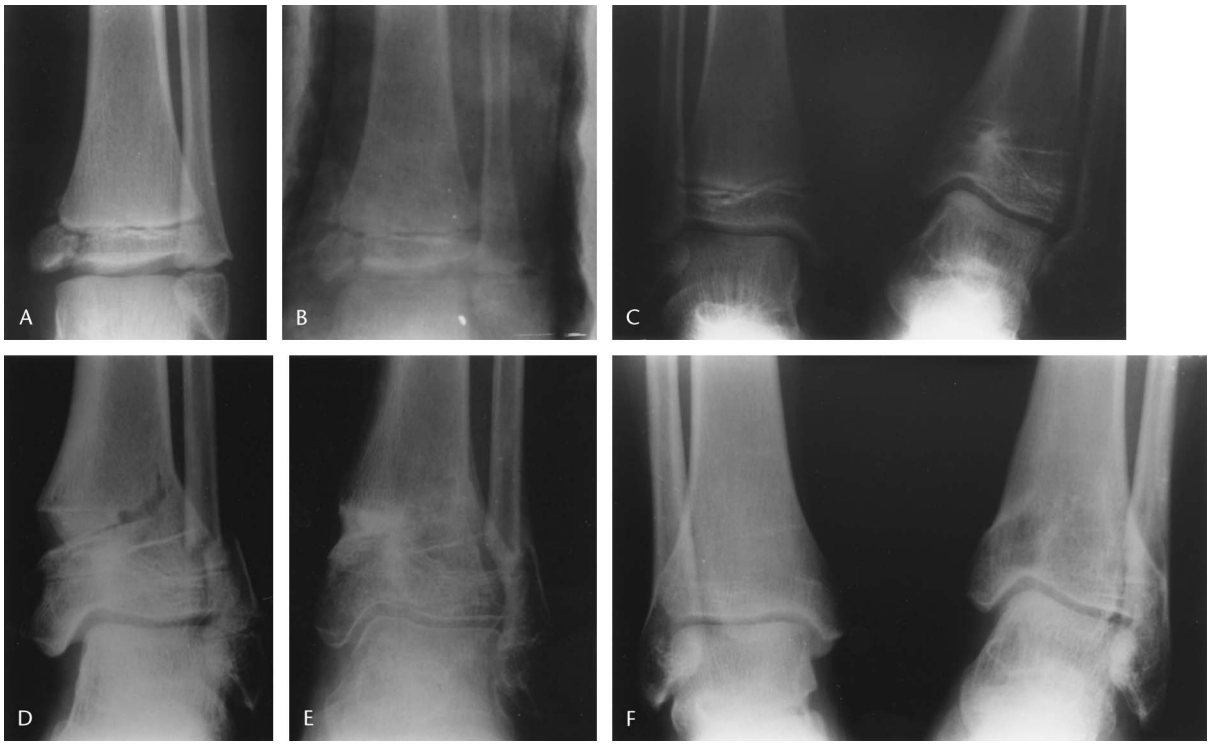

FIGURE 4. A, Group 1a injury in a boy age 11. B, Immobilization in the cast. C, Varus deformity of 12 degrees 1 year later in a comparative frontal radiograph. Osseous bridge and growth arrest in the medial portion of the growth plate are observed. Corrective osteotomy (D) and healing (E). F, Comparative frontal radiograph 10 years after the osteotomy; varus deformity of 15 degrees is present again.

Most epiphyseal fractures of the ankle joint can be classified according to the Salter-Harris classification.[14] The triplane fracture, first described by Marmor,[15] was categorized as extra-articular and intra-articular based on a CT scan examination.[16] The latter is a group 3 injury according to our classification and belongs to type IV in the Salter-Harris classification. This is in agreement with Ogden's findings.[17] Shin et al,[11] in a study of five intramalleolar triplane fractures of the distal tibia with 3D-CT, identified three fracture patterns: intramalleolar, intra-articular fracture at the junction of the tibial plafond and medial malleolus; intra-articular fracture of the medial malleolus; and extra-articular intramalleolar fracture.

The group 2 and group 3 injuries in this study often occurred after partial closure of the physis as a result of normal maturation (Table 1).

The long-term results were surprisingly good in most cases after correct nonoperative or operative treatment. This conclusion is in agreement with many papers dealing with this subject.[18–20]

The fractures in more of the group 3 (triplane) injuries were undisplaced, so few required operative treatment. It is well known that we may have growth disturbance of the distal tibial physis, an angular deformity, and late degenerative changes when a displacement of more than 2 mm persists after reduction.[3–6,17] Most were older children (near maturity), so this explains why they had few growth disturbances.

We stated that compression forces in some group 1a injuries (Salter-Harris III or IV) may also cause damage to the growth plate (Salter-Harris V); medial bridge is formed, leading to early angular deformities in the younger patients (see Fig. 4). As for the relapse of the varus deformity after corrective osteotomy in the 11-year-old patient, it was necessary to do an epiphysiodesis on the remaining open ipsilateral physis of the distal tibia and fibula.

After physical and radiographic examination, no signs of degenerative changes of the ankle joint were noticed. Only one patient with a group 2 injury was found to have painful limitation of ankle range of movement due to a loose body that was detected on plain radiographs.

In conclusion, we have classified intra-articular fractures of the distal tibial epiphysis in young patients into three groups. They were treated nonoperatively or operatively based on this classification. The affected side during the last re-examination appeared to be normal in all but five cases. All four cases with growth deformities were group 1a, probably suggesting that group 1a injuries are more vulnerable to growth deformities. In addition, the remodeling process at this age and over a period of time makes a clinically good restoration possible.

REFERENCES

1. Tachdjian MO. *Pediatric Orthopedics*, vol. 4, Philadelphia: Saunders, 1990:3302.
2. Rang M. *Children's Fractures*. Philadelphia: JB Lippincott, 1983:312.
3. Beaty JH, Linton RC. Medial malleolar fracture in a child. A case report. *J Bone Joint Surg [Am]*. 1988;8:1254–1255.
4. Cooperman DR, Spiegel PG, Laros GS. Tibial fractures involving the ankle in children. The so-called triplane epiphyseal fracture. *J Bone Joint Surg [Am]*. 1978;60:1040–1046.

5. Dias LS. Fractures of the distal tibial and fibular physes. In: Rockwood CA, Wilkins JKE, King RE, eds. *Fractures in Children*, Vol. 3. Philadelphia: JB Lippincott, 1984:1029–1032.
6. Spiegel PG, Cooperman DR, Laros GS. Epiphyseal fractures of the distal ends of the tibia and fibula. A retrospective study of 237 cases in children. *J Bone Joint Surg [Am]*. 1978;60:1046–1050.
7. Cass JR, Peterson HA. Salter-Harris type IV injuries of the distal tibial epiphyseal growth plate, with emphasis of those involving the medial malleolus. *J Bone Joint Surg [Am]*. 1983;65:1059–1070.
8. Dias LS, Giegerich CR. Fractures of the distal tibial epiphysis in adolescence. *J Bone Joint Surg [Am]*. 1983;65:438–444.
9. Karrholm J, Hansson LI, Laurin S. Computed tomography of intra-articular supination-eversion fractures of the ankle in adolescents. *J Pediatr Orthop*. 1981;1:181–187.
10. Rapariz JM, Ocete G, Gonzalez-Herranz P, et al. Distal tibial triplane fractures: long-term follow-up. *J Pediatr Orthop*. 1996;16:113–118.
11. Shin AY, Moran ME, Wenger DR. Intramalleolar triplane fractures of the distal tibial epiphysis. *J Pediatr Orthop*. 1997;17:352–355.
12. Wilkins KE. Changing patterns in the management of fractures in children. *Clin Orthop Rel Res*. 1991;264:140–149.
13. Rogers LF, Poznanski AK. Imaging of epiphyseal injuries. *Radiology.* 1994;191:297–308.
14. Salter RB, Harris WR. Injuries involving the epiphyseal plate. *J Bone Joint Surg [Am]*. 1963;45:587–621.
15. Marmor L. An unusual fracture of the tibial epiphysis. *Clin Orthop Rel Res*. 1970;73:132–135.
16. Jarvis JG, Mc Intyre WMJ, England RE. Computerized tomography and the triplane fracture. In: *Behavior of the Growth Plate*. New York: Raven Press, 1988:165–174.
17. Ogden JA. *Skeletal Injury in the Child*. Philadelphia: Lea & Febiger, 1982: 596–598, 839–841.
18. Denton JR, Fischer SJ. The medial triplane fracture. Report of an unusual injury. *J Trauma*. 1981;21:991–995.
19. Ertl JP, Barrack RL, Alexander AH, et al. Triplane fracture of the distal epiphysis. Long-term follow up. *J Bone Joint Surg [Am]*. 1988;70:967–976.
20. Tinnemans GM, Severijnen VM. The triplane fracture of the distal tibial epiphysis in children. *Injury.* 1981;12:393–396.

