

## Calcaneal Fractures in Children

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**Summary:** Calcaneal fractures are rare in children but frequent in adults. We report 18 cases (20 feet) of pediatric calcaneal fractures before the distal tibial growth line closed to assess the characteristics of pediatric calcaneal fractures and reveal differences in treatment and prognosis between children and adults. Twelve (60%) of the fractures were extraarticular, a higher percentage than in adults, and only four (20%) were intraarticular fractures associated with displacement. One case

of avulsion fracture of the portion of the calcaneus where the Achilles tendon inserts, in which there was large displacement, and one intraarticular fracture were treated surgically. The outcome was good, including the surgical cases. One of the reasons that calcaneal fractures are considered rare in children is that they are missed, and thus care is required in making the diagnosis. **Key Words:** Avulsion—Calcaneus—Children—Extraarticular—Fracture—Intraarticular.

Calcaneal fractures in children were previously thought uncommon (4,5), but the frequency of reports of these fractures has been increasing (6,8). These fractures may be overlooked because initial radiographs are negative frequently (6,8–10), and the history of injury is not clear. However, the outcome is satisfactory with closed treatment (7), and surgery is seldom necessary. The purpose of this study was to characterize pediatric calcaneal fractures and to reveal differences in the diagnosis, treatment, and prognosis between children and adults.

### MATERIALS AND METHODS

The subjects of this study were patients with calcaneal fractures before the distal tibial epiphysis closed. They were treated in Keio University Hospital and its affiliated hospitals from 1983 through 1994. There were 18 patients (20 feet) in all, 12 boys and six girls. The injured side was the right side in six cases, the left in 10, and both in two. Age at the time of the injury ranged from 1 to 14 years (mean, 8.2). The cause of the injury was a fall from a height in 11 patients and a traffic accident or a simple fall in the other cases. In about half of the patients who were injured in a fall from a height (six patients, seven feet), the fall was from a relatively low height (<1 m) (e.g., from a table or a chair). Although a fall from a height was a common cause of injury, the same as in adults, the fractures were characterized by occurring as a result of relatively low-energy impacts.

We classified the fractures as types 1–6 according to

the Schmidt and Weiner system (8), which was the modification to Essex-Lopresti (3) classifications. Type 1 fractures are peripheral fractures and consist of the following five subgroups: (a) fractures of the tuberosity or apophysis, (b) fractures of the sustentaculum tali, (c) fractures of the anterior process, (d) fractures of the distal inferolateral aspect, and (e) small avulsion fractures of the body. Type 2 fractures are divided into two subgroups, A and B. Subgroup A consists of break fractures, and B, of avulsion fractures at the insertion of Achilles tendon. Type 3 are linear fractures not involving the subtalar joint. Type 4 are linear fractures involving the subtalar joint. Type 5 are compression fractures of the subtalar joint and are divided into (a) tongue type and (b) joint-depression type. Type 6 fractures are associated with significant bone loss of the posterior aspect with loss of the site of insertion of the Achilles tendon. Extraarticular fractures included types 1, 2, 3, and 6, and intraarticular fractures included types 4 and 5. In our series, type 3 fractures were the most common, occurring in six feet. There were five feet with type 1 fractures, one foot with a type 2 fracture, and a total with 12 feet with extraarticular fractures. A total of eight feet had intraarticular fractures, consisting of three feet with type 4 fractures with no displacement and five feet with type 5 fractures. There were no open fractures and no type 6 fractures.

### RESULTS

Seventeen of the patients (18 feet) were treated with immobilization in a cast below the knee or with a splint (Table 1). The patient who received surgical treatment had a type 2 avulsion fracture with displacement of the portion of the calcaneus where the Achilles tendon in-

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TABLE 1. Calcaneus fractures in children

| Case/sex | Age (yr) | Side    | Type of fracture   | Schmidt and Weiner | Displacement | Treatment   | Outcome | Cause                        |
|----------|----------|---------|--------------------|--------------------|--------------|-------------|---------|------------------------------|
| 1/M      | 6        | L       | Joint depression   | 5B                 | Small        | Cast 3 wk   | Good    | Fall from 3-m height         |
| 2/M      | 14       | R       | Tuberosity         | 1A                 | None         | Cast 3 wk   | Good    | Bicycle                      |
| 3/F      | 5        | R       | Sustentaculum tali | 1B                 | None         | Splint 2 wk | Good    | Fall                         |
| 4/M      | 4        | R       | Joint depression   | 5B                 | None         | Splint 2 wk | Good    | Jump from table              |
| 5/F      | 11       | L       | Vertical           | 3                  | None         | Splint 3 wk | Good    | Fall                         |
| 6/M      | 5        | L       | Horizontal         | 4                  | Small        | Splint 2 wk | Good    | Pedestrian vs. bicycle       |
| 7/M      | 12       | L       | Anterior process   | 1C                 | Small        | Cast 3 wk   | Good    | Roller-skating accident      |
| 8/F      | 10       | R       | Tongue             | 4                  | Small        | Cast 3 wk   | Good    | Fall down stairs             |
| 9/M      | 9        | R       | Vertical           | 3                  | Small        | Cast 3 wk   | Good    | Jump from 1.5-m height       |
| 10/M     | 3        | L       | Vertical           | 3                  | Small        | Splint 1 wk | Good    | Jump from table              |
| 11/M     | 9        | R       | Avulsion           | 2A                 | Large        | ORIF        | Good    | Jump from 2-m height         |
| 12/F     | 10       | L       | Vertical           | 3                  | Small        | Cast 3 wk   | Good    | Fall                         |
| 13/M     | 1        | L       | Vertical           | 3                  | Small        | Splint 3 wk | Good    | Fall from table              |
| 14/M     | 6        | Bil (R) | Vertical           | 3                  | Small        | Cast 3 wk   | Good    | Pedestrian vs. bicycle       |
|          |          | Bil (L) | Horizontal         | 4                  | Small        | Cast 3 wk   | Good    |                              |
| 15/M     | 13       | Bil (R) | Joint depression   | 5B                 | Small        | ORIF        | Good    | Pedestrian vs. motor vehicle |
|          |          | Bil (L) | Tongue             | 5A                 | Small        | Cast 3 wk   | Good    |                              |
| 16/M     | 5        | R       | Sustentaculum tali | 1B                 | Small        | Splint 3 wk | Good    | Fall                         |
| 17/F     | 14       | R       | Tongue (severe)    | 5A                 | Small        | Cast 3 wk   | Fair    | Jump from 4th floor          |
| 18/F     | 10       | L       | Tuberosity         | 1A                 | Small        | Cast 2 wk   | Good    | Tripping                     |

M, male; F, female; L, left; R, right; Bil, bilateral.

serts in one foot, and a type 5 tongue-type fracture of the other foot, and both were treated with open reduction and percutaneous fixation with Kirschner wires. With the exception of one patient with an old fracture associated with cauda equina paralysis caused by a rupture fracture of the fifth lumbar vertebra, the results were favorable in all of the patients, including the patients treated surgically. There was no residual limitation of range of motion of the talocrural joint or subtalar joint, and there was no residual pain or deformity in any of the patients.

### Case descriptions

#### Type 1B

A 5-year-old girl (case 3) was injured in a fall and had a type 1B undisplaced fracture of sustentaculum tali that healed after 3 weeks of immobilization in a cast (Fig. 1A).

#### Type 1C

A 12-year-old boy (case 7) was injured while roller skating. A type 1C fracture of the anterior process of the calcaneus with calcaneonavicular coalition was observed on a radiograph. It healed without sequelae after 3 weeks of cast immobilization (Fig. 1B).

#### Type 2A

A 9-year-old boy (case 11) had a type 2A greatly displaced avulsion fracture at the insertion of the Achilles tendon when he jumped from a height of 2 m. Surgical reduction and internal fixation were achieved, and the outcome was good (Fig. 2A and B).

#### Type 3

A 1-year-old boy (case 13) was injured in a fall from a table and had a type 3 undisplaced linear extraarticular

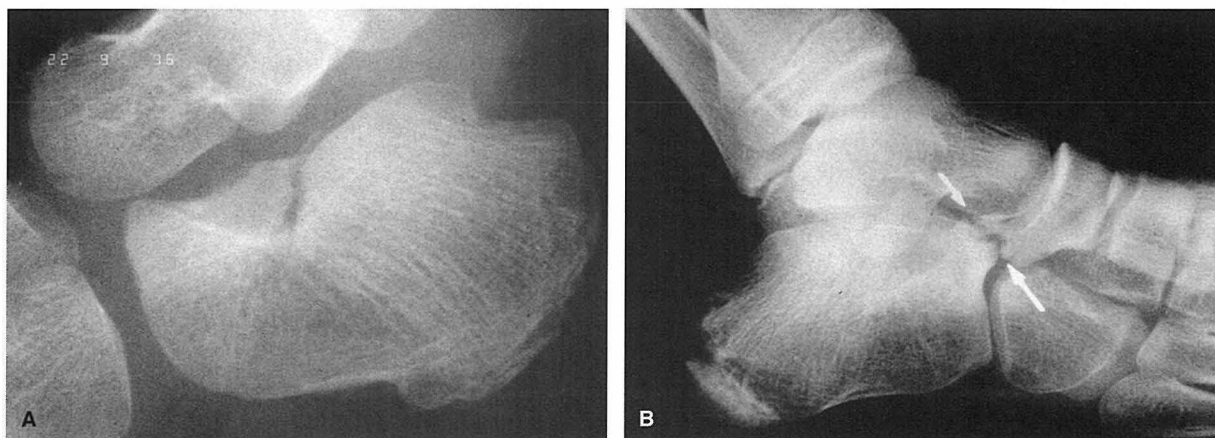
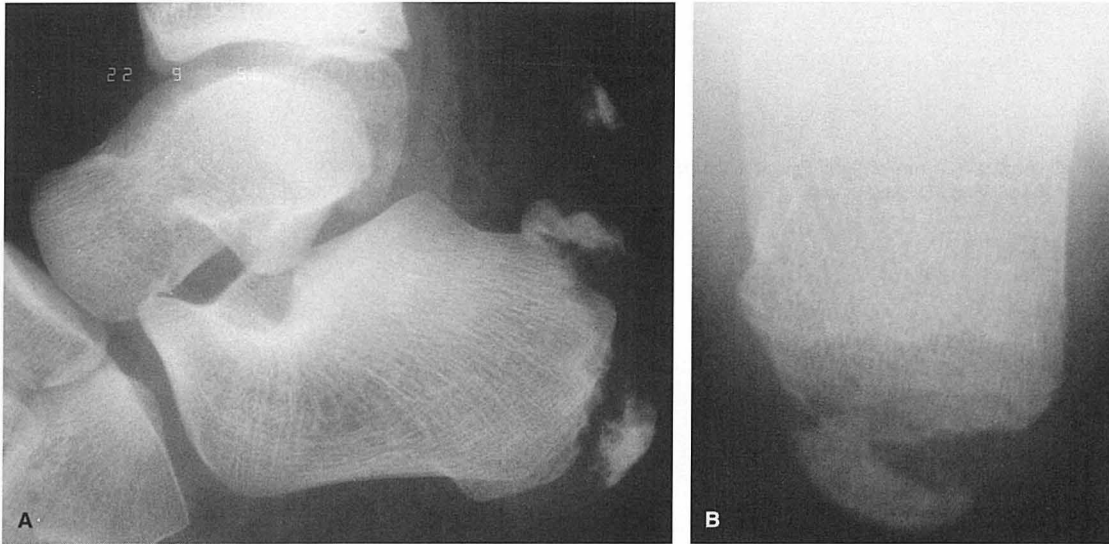


FIG. 1. A: Case 3, a 5-year-old girl, type 1B fracture of sustentaculum tali. B: Case 7, a 12-year-old boy, type 1C fracture of anterior process with calcaneonavicular coalition.



**FIG. 2.** Case 11, a 9-year-old boy, type 2A avulsion fracture of insertion of Achilles tendon. **A:** Lateral view. **B:** Axial view.

fracture that healed after 3 weeks of immobilization with a splint (Fig. 3A and B).

#### *Type 4*

A 10-year-old girl (case 8) fell down stairs and had a type 4 undisplaced intraarticular fracture. Her fracture healed without sequelae after 3 weeks of below-knee immobilization (Fig. 4A and B).

#### *Type 5*

A 13-year-old boy (case 15) with bilateral calcaneal fractures had a type 5A intraarticular fracture (Fig. 5A and B) on the left that was reduced manually and a type 5B (Fig. 5C and D) on the right fracture that was reduced

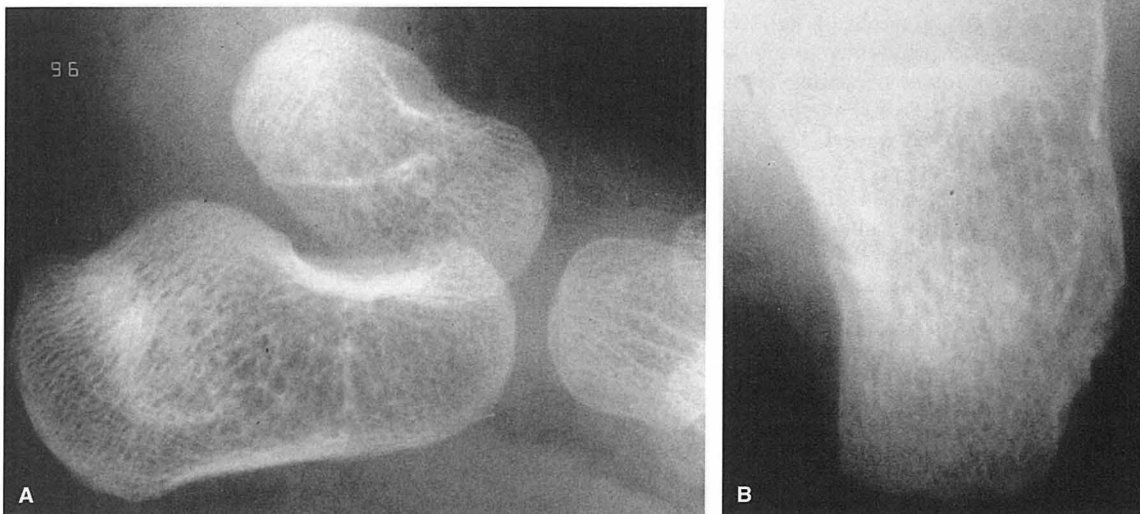
surgically and fixed percutaneously with Kirschner wires. Mild residual displacement of the posterior joint surface was observed on an axial view on the left side, but the fracture healed without sequelae.

## DISCUSSION

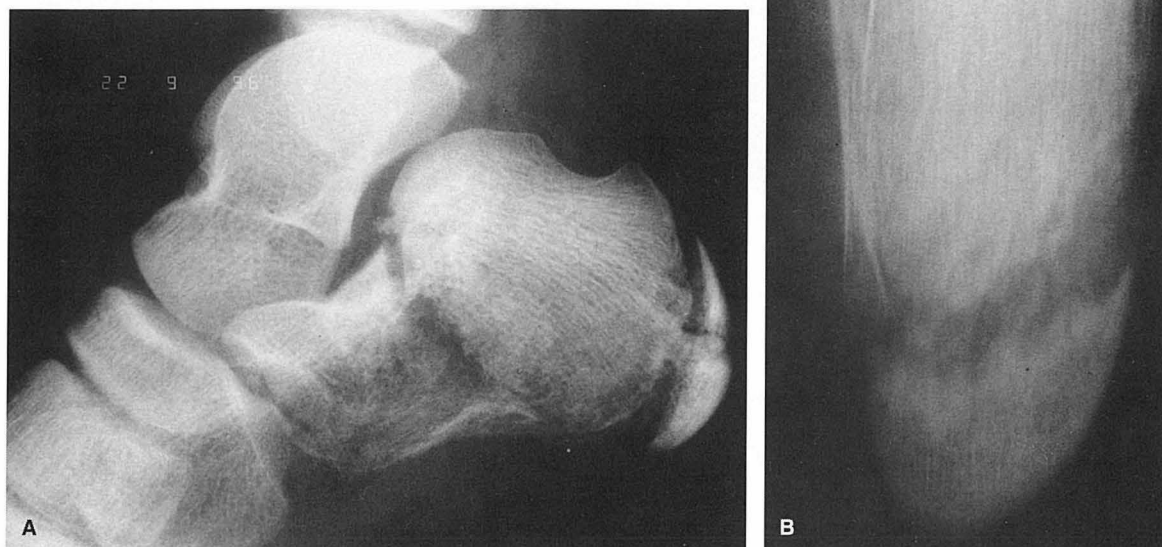
### Definition of child

We did not define "child" in terms of chronologic age but according to whether the distal tibial epiphysis had closed, and the result was  $\leq 14$  years. Schmidt (8) reported a 19-year-old patient as a child. However, because they reported that extraarticular fractures were more

**FIG. 3.** Case 13, a 1-year-old boy, type 3 linear fracture not involving the subtalar joint. **A:** Lateral view. **B:** Axial view.



**FIG. 4.** Case 8, a 10-year-old girl, type 4 linear fracture involving the subtalar joint. **A:** Lateral view. **B:** Axial view.



common at age  $\leq 14$  years than in adults, it seems that they considered patients  $\leq 14$  years to be children. Schantz and Rasmussen (6) considered patients age  $\leq 15$  years to be children. Thus 14 or 15 years would seem to be a convenient dividing line between “adult” and child when considering the characteristics of pediatric calcaneal fractures.

#### **Incidence of pediatric calcaneal fractures**

Calcaneal fractures used to be considered much rarer in children than in adults. Jonasch (4) reported that pediatric calcaneal fractures accounted for 0.005% of all fractures in children, a lower percentage than pediatric talus fractures, and a mere 1/400 of the 2% in adults, whereas Landin (3) reported a very low rate of 0.41/10,000 population at ages  $\leq 17$  years. Nevertheless, Schmidt and Weiner (8) (56 cases) and Schantz and Rasmussen (6) (78 cases) reported rather large series, and we collected 18 cases over a period of  $\sim 10$  years. Thus, although rare, calcaneal fractures are sometimes encountered clinically.

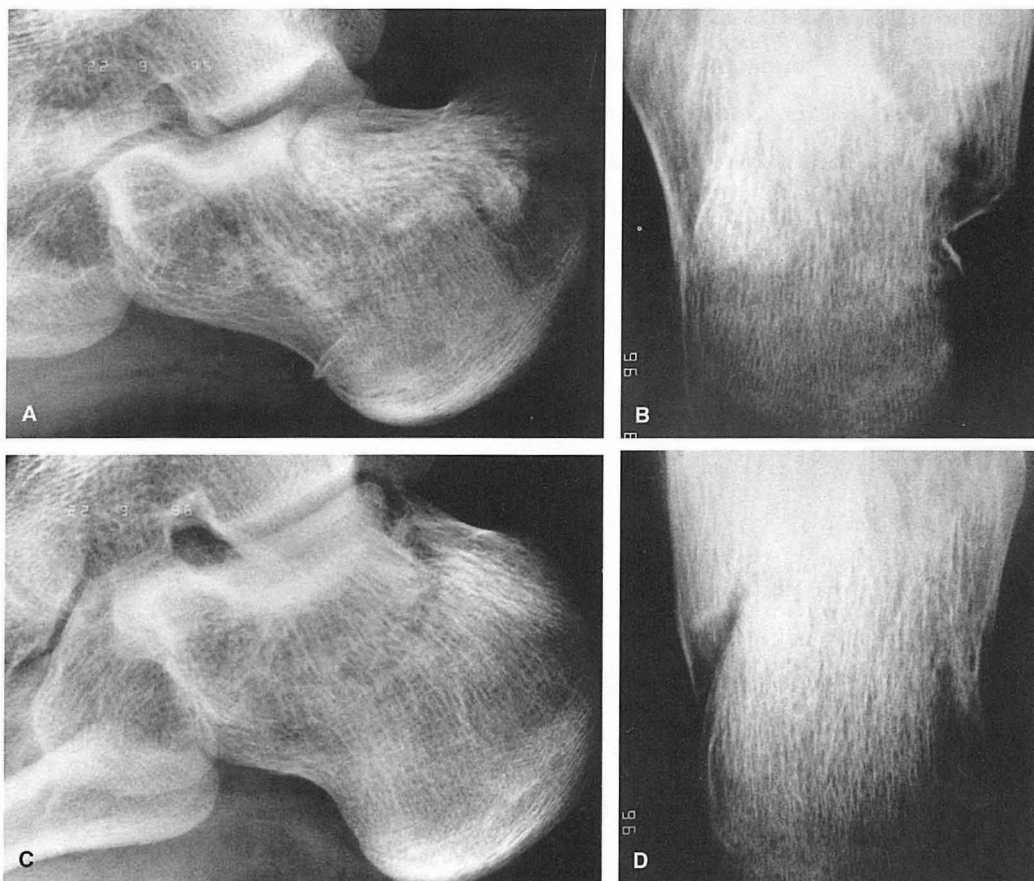
#### **Reasons for the rarity of calcaneal fractures**

The reason calcaneal fractures are rare in children seems to be that, in addition to children's feet having a larger cartilage component and much greater resilience, fractures tend not to occur because of the relative strength of the bones in their feet in relation to body

weight. There were also many patients with incomplete fractures that were extraarticular and unassociated with displacement, and the tendency for such fractures to be missed appears to be another reason for the low incidence in children.

#### **Characteristics of fracture types**

Extraarticular fractures were more common among our cases than intraarticular fractures (60 vs. 40%). Schmidt and Weiner (8) described the differences according to age as follows: At age  $\leq 7$  years, intraarticular fractures are quite infrequent, but they are relatively common in the  $\geq 15$ -year-old group, the same as in adults, with 8–14 years intermediate between the two. Certainly when both boys and girls reach the age  $\geq 15$  years, they differ from children and exhibit the same characteristics as adults, because their tarsal bones are mature. However, all our patients were children 14 years of age or younger, and the mean age at the time of injury of the children with both intraarticular and extraarticular fractures was 8.3 years, with no difference in age. In our patients, intraarticular fractures seemed to be mostly the result of falls from a height, and the differences in fracture types were suspected of being the result of the impact at the time of the injury. The reason intraarticular fractures in children, at 30%, were less common than the  $\sim 60\%$  in adults seems to be the reciprocal relationship



**FIG. 5.** Case 15, a 13-year-old boy with bilateral fractures. **A:** Lateral view of type 5A, tongue-type compression fracture of the subtalar joint, and axial view on the left (**B**). **C:** Lateral view of type 5B, joint-depression-type compression fracture. **D:** Axial view on the right.

between the strength of the articular cartilage and the cortical bone of the tuberosity area. On the contrary, de Beer (2) reported nine fractures in eight patients aged from 18 months to 12 years (mean, 6 years) and described that intraarticular fractures predominated [six (66%) of nine fractures].

#### Missed cases

The majority of calcaneal fractures in children are incomplete fractures without displacement, and in many cases, the fracture line cannot be seen at the time of diagnosis. The fracture was missed at the time of the initial examination in 44% of our cases, 55% of Schantz and Rasmussen (6), 44% of Wiley and Profitt (10), and in 27% of Schmidt and Weiner (8). Thus if the clinical manifestations, such as swelling, tenderness, and trouble walking, are severe, radiographs should be taken 2 weeks later even if no fracture is detected on the films at the time of the initial examination. Fracture lines on radiographs 2 weeks later are obvious in adults because of bone atrophy around the fracture line, and they are often detected in children because the healing callus begins to ossify. Moreover, because fracture lines are sometimes not visualized because of the angle of view, views in three different directions are necessary, a lateral view

of the calcaneus, a sagittal axial view, and Anthonen's view (1), and depending on the case, tomography should also be performed.

Bone scintigraphy, computed tomography (CT), and magnetic resonance imaging (MRI) also are useful, but because the prognosis of fractures without displacement, which are difficult to diagnose, is favorable, there is no need to resort to using them.

#### SUMMARY

Good results can be obtained by treating calcaneal fractures without displacement by immobilization with a splint or a cast. However, we think that surgical therapy should be performed in displaced avulsion fractures of the portion of the calcaneus where the Achilles tendon inserts and in intraarticular fractures in which displacement is present, even though the patients are children.

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