

Pediatric and adolescent intra-articular fractures of the calcaneus

Marcel Dudda, Christiane Kruppa,
Jan Geßmann, Dominik Seybold,
Thomas A. Schildhauer

Department of Surgery, University
Hospital Bergmannsheil, Ruhr-University
of Bochum, Germany

Abstract

Calcaneal fractures in childhood are very rare, whereas particularly intra-articular displaced fractures are not typical in skeletally immature children. Various techniques of osteosynthesis have been described. This study aimed to determine clinical and radiological outcome after surgical treatment of intra-articular calcaneal fractures. Fourteen intra-articular fractures of the calcaneus were included in this retrospective study. Eleven children (2 girls and 9 boys) aged 6-16 years (average age 11.5 years) underwent surgical treatment. One child sustained a Type II open fracture of both calcanei. All injuries occurred after a high-energy trauma; 3 patients had multiple additional fractures. The clinical and radiological postoperative follow up was an average 44 months. In 4 cases, a reduction through a minimally invasive approach and fixation with K-wires or screws could be achieved. Eleven fractures were treated with open reduction and internal fixation with plate osteosynthesis, K-wires or screws. In one case with open fractures of both heel bones, an additional external fixator was applied. The surgical treatment approach adopted enabled the pre-operative Böhler's angle (average 16°) to be improved to an average 30°. In all cases, except for the patient with open fractures, a good functional result and outcome could be achieved. In calcaneal fractures in childhood, anatomical reduction is the determining factor, as in fractures in adults, whereas the surgical technique seems to have no influence on clinical outcome in children. The wound healing problems that have often been described were not observed in this age group.

Introduction

Calcaneal fractures in childhood are still rare and have been estimated in literature at approximately 0.005-0.41%.^{1,2} They are probably the most common fracture of the tarsus in children.³ But the incidence of these fractures

may be greater than estimated in literature because of misdiagnosis or occult fractures.⁴⁻⁸ The rate of delayed diagnosis of pediatric calcaneal fractures is estimated at 27-55%.^{3,7-9} Stress or occult fractures are very rare but have been reported in the recent literature.⁵ The high percentage of cartilage and poorly perceived bone aggravates the diagnosis of these injuries in plain X-rays.¹⁰ In the past, scintigraphy was used to determine fractures if plain X-rays were negative,^{10,11} but today this is usually replaced by magnet resonance imaging (MRI).¹²⁻¹⁶

In children aged 9 months-3 years, these fractures are called toddler's fractures of the calcaneus.^{5,17} Most studies of calcaneal fractures in childhood are small case series or case reports,^{5,17-21} and most of the fractures have been reported as non-displaced.^{6,11} The first case series was published in 1969 by Thomas *et al.* who reported on 5 children with calcaneal fractures.²² Like in adults, in most cases the mechanism of injury is a fall from a height or a motor vehicle accident.^{8,23,24} But differences in age are reported. In children under the age of ten years, the fracture can occur through falls from low heights, and in children over the age of ten years, fractures are reported to be more common from falls from greater heights.⁸ Some studies showed an excellent outcome for pediatric calcaneal fractures with non-surgical treatment.^{7-9,18,21} An increasing number of intra-articular calcaneal fractures are being

Correspondence: Marcel Dudda, Department of Surgery, BG-University Hospital Bergmannsheil Bochum, Bürkle-de-la-Camp Platz 1, 44789 Bochum, Germany.
Tel. +49.234.3020 - Fax: +49.234.6956.
E-mail: marcel.dudda@ruhr-uni-bochum.de

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reported in children and surgical treatment is recommended.^{4,25} Several authors reported that both intra- and extra-articular fractures were treated conservatively and no dysfunction was observed.^{3,5,7-9,18,21} Surgical treatment with open reduction and internal fixation is increasingly recommended in the literature.^{9,21,25,26}

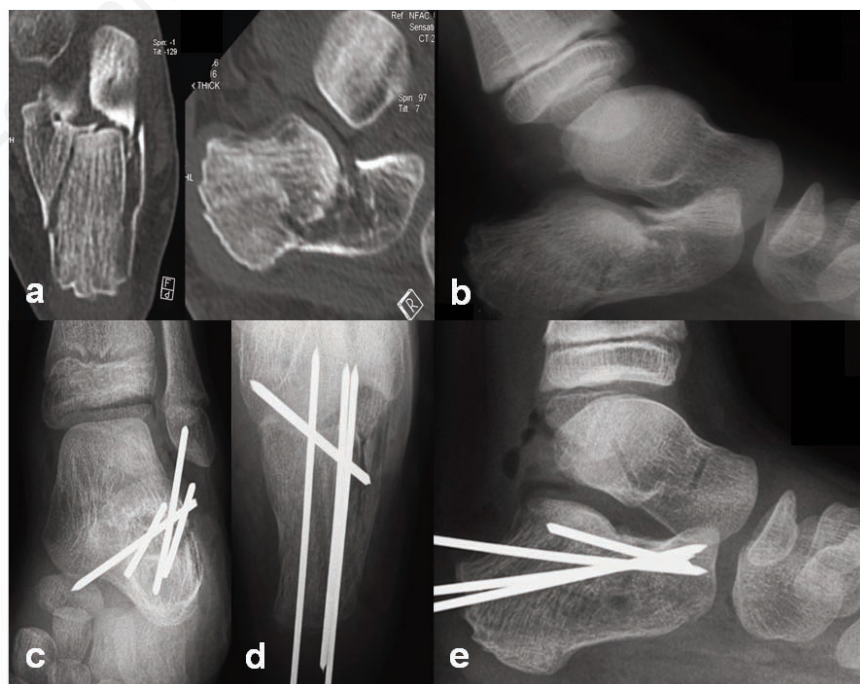


Figure 1. Eight-year old boy after a fall from a height of 3 meters. K-wire osteosynthesis. Pre-operative Böhler's angle 9°, postoperative 35°. a) and b) pre-operative, c-e) postoperative.

Table 1. Fracture types and treatments.

	Sex	Age	Trauma	Side	Essex-Lopresti classification	Sanders classification	Treatment
1	F	7	Jump 4 m	L	JD	II c	Open reduction, screw + K-wires
2	M	13	Fall 5 m	R	JD	III c	Open reduction + plate osteosynthesis
3	M	7	Jump 1.5 m	R	JD	III b	Percutaneous K-wires
4	M	16	Motorcycle	R	TT	I	Percutaneous K-wires, additional external fixator, fasciotomy for compartment release
5	F	15	Fall	B	R+L: JD	R: IV; L: II b	1: R + L external fixation 2: R plate osteosynthesis, L: K-wires 3: R subtalar arthrodesis 7 mos after trauma
6	M	15	Jump 2 m	R	JD	III b	Percutaneous K-wires
7	M	16	Jump 3 m	L	TT	II a	Open reduction + plate osteosynthesis + additional screw
8	M	9	Jump 3 m	R	JD	I	Open reduction + K-wires
9	M	8	Fall 3 m	B	R+L: JD	R: II c; L: II b	L: open reduction + K-wires R: close reduction + K-wires
10	M	16	Jump	L	TT	III b	Open reduction + plate osteosynthesis
11	M	6	Fall 11 m	B	R+L: JD	L: III b; R: II b	L: open reduction + plate osteosynthesis R: K-wires

M, male; F, female; m, meters; R, right side; L, left side; B, bilateral; JD, joint-depression fracture; TT, tongue type fracture.

Schneidmüller *et al.* aimed to restore articular surface through surgery to prevent early arthritis, and the restoration of lengths and width of the calcaneus to rebuild the arch of the foot.²⁷ The purpose of this study was to determine early mid-term results and outcomes of surgically treated intra-articular pediatric calcaneal fractures.

Materials and Methods

Fourteen surgically treated intra-articular fractures of the calcaneus in 11 children were included in this retrospective analysis. Mean age was 11.5 years (range 6-16 years). The fractures were presented in 2 girls and 9 boys.

All injuries were the result of high-energy trauma. In 3 cases, patients had multiple additional fractures after a fall from a significant height. According to the Essex-Lopresti classification, fractures were classified into joint depression and tongue type,²⁸ and, in addition, into the CT classification according to Sanders (Table 1).^{29,30}

Eleven fractures were joint depression fractures; 3 fractures were tongue type fractures. One child sustained a Type II open fracture of both calcanei. All other fractures were closed. Average postoperative clinical and radiological follow up was 44 months (range 5-63).

Results

Depending on the condition of the soft tissue, surgery was performed after an average six days. In 4 cases, reduction through a minimally invasive approach and fixation with K-

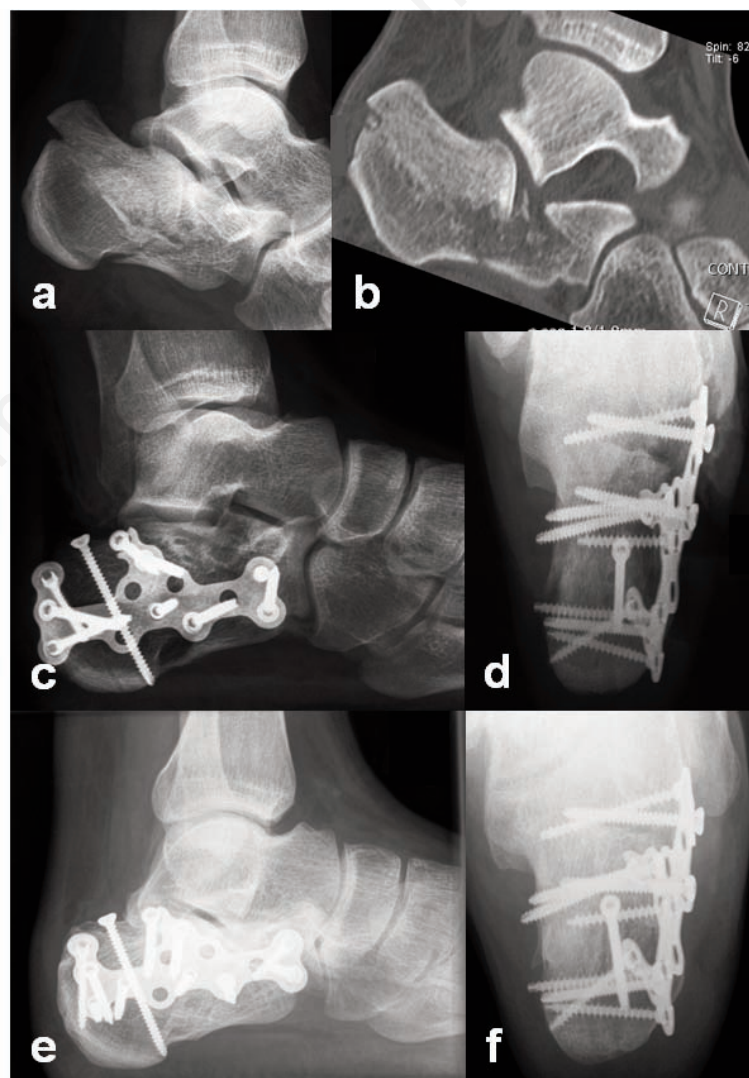


Figure 2. Sixteen-year old boy after jumping from a height of 3 meters. Surgical treatment with plate osteosynthesis and additional screw. Pre-operative Böhler's angle 0°, postoperative 20°; a) and b) pre-operative; c) and d) postoperative; e) and f) 12-month follow up.

wires or screws could be achieved. In 11 patients, open reduction and internal fixation with plate osteosynthesis, K-wires or screws was performed (Figures 1-3). In the case with open fractures of both heel bones, an additional external fixator was applied. In one case after a motor vehicle accident, a fasciotomy of the foot due to a compartment syndrome was performed and an additional external fixator was applied to protect the soft tissue. The wound was partially closed four days and completely closed nine days after trauma. No post-operative complications, such as infections or wound healing disorders, were observed.

This analysis involved 11 joint depression fractures and 3 tongue types. According to Sanders, there were 2 Type I, 6 Type II, 5 Type III and one Type IV fracture.

The surgical treatment approach adopted enabled the pre-operative Böhler angle (average 16°) to be improved to an average 30°. With the exception of the patient with open fractures, a good functional and clinical outcome was observed in all cases at follow up. All patients were free of pain and had a normal range of motion in the subtalar joint. Gait was not impaired. No secondary arthrosis has been observed until now. So far, no patient has required orthopedic shoes.

Discussion

Conservative treatments of calcaneal fractures in childhood are discussed by many authors in the literature, also for intra- and extra-articular fractures.^{3,5,7-9,18,21}

Schmidt *et al.* had the highest number of pediatric calcaneal fractures with 59 children, but 37 were extra-articular for which non-surgical treatment is usually recommended.³ The highest number of intra-articular fractures was reported by Wiley in 1984: 34 fractures in 32 children. Involvement of the posterior subtalar joint was common and occurred in 28 fractures.⁸ Schantz *et al.* reported that, in contrast to adults, intra-articular fractures of the calcaneus in children constitute less than half of all calcaneus fractures. He reviewed 80 calcaneal fractures in 78 children over 30 years.⁶ Mora *et al.* assembled data of 23 calcaneal fractures in childhood; 2 underwent surgical treatment. The largest number of conservatively treated patients had good functional results during the short-term (1-14 months) and long-term (2-8 years) follow up. Four patients had mild disorders and changes in radiological findings.⁴

A study, including a long follow up, of 19 calcaneal fractures was published by Brunet *et al.* Fourteen intra-articular were treated conservatively without reduction in a brace or cast. The patients were able to walk on flat ground

without any problems. No orthopedic shoes were necessary; 2 patients required wide shoes, one was not able to walk in high heels. The radiographic findings showed a reduction in the Böhler angle in 4 cases.¹⁸

Surgical treatments are also reported in literature. Voigt *et al.* reported a 13-year old boy with a calcaneal fracture, joint depression type, who was treated by open reduction and an internal plate fixation. The 1-year follow up showed a mild reduction in the range of motion and limitations in taking part in sporting activities.³¹

In one case report published by Frank *et al.*, one pediatric tongue type fracture was treated with open reduction and K-wire fixation, while the other calcaneus showed an extra-articular fracture and was treated conservatively. Both fractures healed with little limitation to the

range of motion.¹

Pickle *et al.* reported a group of 7 pediatric intra-articular calcaneal fractures surgically treated with internal fixation. Mean age was 13 years, and 4 tongue type and 3 joint depression fractures were presented. Follow up was 30 months. All patients were free of pain and had a normal range of motion in their tibiotalar joints; 5 had little limitation in the range of motion of the subtalar joint. No complications were reported.²⁵

Surgical treatment with open reduction and internal fixation is increasingly recommended in the literature.^{9,21,25,26} Furthermore, achievement of anatomic reduction of these fractures to prevent degenerative joint disease is recommended.³²

If the disruption of the three subtalar facets is less than 4 mm, and the posterior gap in



Figure 3. Fifteen-year old boy after a jump from a height of 2 meters. Surgical treatment with screw osteosynthesis. Pre-operative Böhler's angle 25°, postoperative 30°. a) and b) Pre-operative; c) and d) postoperative; e) and f) 1-year follow up.

tongue type fractures is less than 1 cm, non-surgical treatment is recommended.³³ Schneidmüller *et al.* suggested: i) reconstruction of the joint alignment, width and length of the calcaneus; ii) physiological axis; and iii) arms of lever as the three treatment goals for pediatric calcaneal fractures.²⁷

With regard to the CT classification of Sanders, we found the Type II fractures did not lead to early or mid-term arthrosis of the subtalar joint; however, the Type IV fracture does.^{29,30} In our study, we noticed a good functional outcome of our patients without signs of secondary arthrosis except in the Type IV fracture. Due to surgical treatment, we could improve the Böhler angle by an anatomical degree although the assessment of Böhler's angle in childhood as a proportion of fracture dislocation is limited due to the immature bone and the high proportion of cartilage.^{18,27}

A limitation of the study is that 50% of the patients were over ten years of age and a long-term follow up to evaluate eventual onset of arthritis is needed.

In agreement with other authors, we suggest reconstruction of the joint alignment as the main treatment goal in pediatric and adolescent intra-articular calcaneal fractures to achieve a good functional outcome and to avoid secondary arthrosis.²⁷

Conclusions

In calcaneal fractures in childhood and adolescence, anatomical reduction is the determining factor, as in fractures in adults, whereas the surgical technique seems to have no influence on the clinical outcome in children. The wound healing problems that have often been described were not observed in this age group.

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