Open Reduction and Internal Fixation of Intra-articular Calcaneal Fractures in Children

GUANG-RONG YU, PHD; HONG-MOU ZHAO, PHD; YUN-FENG YANG, PHD; JIA-QIAN ZHOU, MD; HAI-FENG LI, PHD

abstract

Calcaneal fractures are rare injuries in children and adolescents, and fractures with displaced intra-articular fracture patterns are even more rare. The purpose of this study was to report 9 intra-articular calcaneal fractures in 8 children (mean age, 12.6 years; range, 10-15 years) treated with open reduction and internal fixation (ORIF) and to examine cases reported in the literature to better define the classification characteristics and operational outcomes of this uncommon fracture. Preoperative radiographs and computed tomography scans were used to evaluate and classify the fractures. Clinical and radiographic examinations were performed at postoperative follow-up, and functional outcome was assessed with the modified American Orthopaedic Foot and Ankle Society (AOFAS) Ankle-Hindfoot score. Mean follow-up was 47 months (range, 21-72 months). Mean time to union was 9.2 weeks (range, 8-12 weeks). Mean modified AOFAS score was 65.2 points (range, 53-68 points). One foot experienced a minor complication.

After a systematic review of the literature, 4 studies with a total of 35 patients (37 fractures) were included. All fractures were caused by high-energy injuries. Based on the Essex-Lopresti classification, 40.5% (15/37) were tongue-type fractures and 59.5% (22/37) were joint depression-type fractures. Based on the Sanders classification, 62.2% (23/37) of fractures were 2 parts, 32.4% (12/37) were 3 parts, and 5.4% (2/37) showed comminution. No significant difference was found in classification information between children and adults. The authors concluded that the characteristics of intra-articular calcaneal fractures in children are similar to those in adults, and operative treatment of these fractures yields good results with few complications.

Drs Yu, Zhao, Yang, Zhou, and Li are from the Department of Orthopaedic Surgery, Tongji Hospital, Tongji University School of Medicine, Shanghai, China.
Drs Yu, Zhao, Yang, Zhou, and Li have no relevant financial relationships to disclose.
Correspondence should be addressed to: Guang-rong Yu, PhD, Department of Orthopaedic Surgery, Tongji Hospital, Tongji University School of Medicine, No. 389 Xincun Rd, Putuo District, Shanghai 200065, China (guangrongyu2002@163.com).
doi: 10.3928/01477447-20120525-27

Figure: Lateral radiograph showing a joint depression-type fracture of the calcaneus. The secondary calcaneal physis was not closed (A). Computed tomography scan showing that Bohler’s angle was decreased and the posterior subtalar joint surface was comminuted (B). Twelve-month postoperative lateral radiograph showing that the fracture had healed and that Bohler’s angle was normal (C).
Fractures of the calcaneus are common in adults but rare in children and adolescents, representing 0.005% of all pediatric fractures and 2% of all calcaneal fractures. Displaced intra-articular calcaneal fractures in the pediatric population are even more rare. Calcaneal fractures in children are most often the result of low-energy injuries, and the fractures are often minimally displaced or undisplaced. Several authors have reported satisfactory results of conservative treatment of undisplaced to minimally displaced calcaneal fractures in children, but the results of significantly displaced intra-articular calcaneal fractures treated nonoperatively have been less successful. The characteristics of intra-articular calcaneal fractures in children and outcomes of operative treatment are poorly described in the literature.

The purpose of this study was to report 9 intra-articular calcaneal fractures in 8 children treated with open reduction and internal fixation (ORIF) and to examine cases reported in the literature to better define the classification characteristics and operational outcomes of this uncommon fracture.

**MATERIALS AND METHODS**

The authors retrospectively studied the outcomes of operative treatment of calcaneal fractures in children in their institution between June 2004 and September 2008. All patients with a displaced, intra-articular calcaneal fracture treated with ORIF and open distal tibial physis were included (9 fractures in 8 patients).

All operations were performed by the same surgeon (G.-R.Y.), and the ORIF techniques used were similar in all aspects except the use of bone graft and the chosen fixation methods. The extended lateral approach, previously described for adults, was used in all feet. The full-thickness skin flap contains the sural nerve, peroneal tendons, and calcaneofibular ligament. Kirschner wires were introduced close to the joint into the talar body and neck to provide retraction of the superior skin flap. The objectives were anatomic reconstruction of the height, width, length, and articular surfaces. For patients whose secondary calcaneal physis was not closed, care was taken not to expose the area and no hardware was allowed through it. A small butterfly-shaped plate, designed by the same surgeon (G.-R.Y.), was placed on the lateral side of the calcaneus (Figure 1). When the secondary calcaneal physis was already closed and the calcaneal size allowed, a plastic calcaneal plate (Figure 2) or DePuy (Warsaw, Indiana) calcaneal plate was used. Bone grafts were used in 2 of 9 fractures for subchondral bone support. Fracture reductions were assessed with the use of intraoperative lateral and Harris and Broden view radiographs.

The postoperative rehabilitation protocol included active and passive range of motion exercises at the ankle and subtalar and Chopart’s joints and isometric and isometric exercises of the leg combined with continuous passive motion beginning on postoperative day 2. Patients were restricted to partial weight bearing in their own shoes for 6 to 8 weeks (depending on the severity of the fractures), and full weight bearing began when the fracture was seen as healed on radiographs.

Preoperative radiographs and computed tomography (CT) scans were reviewed, and each fracture was classified with the Essex-Lopresti and Sanders et al classification systems. Bohler’s angle was measured on pre- and postoperative radiographs. Each patient’s medical record was reviewed for injury mechanism, type of implant used, and postoperative complications. Functional outcome was assessed with the modified American Orthopaedic Foot and Ankle Society (AOFAS) Ankle-Hindfoot score, as described by Mora et al, at final follow-up (Table 1). The high score of this survey was 68 points, with 40 points for pain and 28 points for function; a higher score indicated a better outcome. The surveys were completed by the children or their parents.

A systematic review of the literature was performed to summarize the clas-
sification characteristics. A broad search of the English literature between January 1995 and December 2010 was conducted. MEDLINE and EMBASE databases were reviewed, and the terms child or pediatric or adolescent and calcaneal and fracture were searched in titles and Medical Subject Headings. A manual reference check of all accepted articles and recent reviews was performed to supplement the electronic searches. Inclusion criteria included: (1) pediatric calcaneal fractures treated with ORIF; (2) at least 5 cases reported; (3) use of the Sanders or Essex-Lopresti classification. Exclusion criteria included: (1) pediatric and adult cases combined; (2) patients treated with conservative methods; (3) multiple publications. The data of classification information were pooled to summarize the characteristics of pediatric displaced intra-articular calcaneal fractures and to compare them with the same fractures in adults.

The ratio differences were compared with the chi-square test. Statistical significance was set at \( P < .05 \). All statistical analyses were performed with SPSS version 17.0 software (SPSS Inc, Chicago, Illinois).

**Results**

Eight patients with 9 fractures were included (mean age, 12.6 years; range, 10-15 years) (Table 2). Mean follow-up was 47.4 months (range, 21 to 72 months). All patients had sustained high-energy injuries: 6 from a fall from a height and 2 from traffic accidents. Two patients also had other injuries: 1 had a vertebral fracture and a distal radius fracture and 1 had rib fractures and hemopneumothorax.

Based on Essex-Lopresti classification, 4 fractures were tongue-type and 5 were joint depression–type. Based on Sanders classification, 4 fractures were type II, 4 were type III, and 1 was type IV.

Mean time to union was 9.2 weeks (range, 8 to 12 weeks). Mean Bohler’s angle was 5.7° (range, –9° to 22°) preoperatively.
and 33.1° (range, 26° to 44°) postoperatively, with a mean improvement of 27.4° (P = .008). Mean modified AOFAS score was 65.2 points (range, 53 to 68 points). One wound breakdown occurred 10 days postoperatively, was treated with regular dressings, and healed 18 days later. No other perioperative complications occurred. At final follow-up, 1 patient reported mild pain and limitation of recreational activities.

Four previous studies of pediatric intra-articular calcaneal fractures treated with ORIF were found in the English literature, and 1 did not report classification information. The data of the remaining 3 studies and the current study were pooled (Table 3). A total of 35 patients with 38 fractures were included; 85.7% were boys. All patients had sustained high-energy injuries, except 1 whose mechanism was unknown. Based on Essex-Lopresti classification, 40.5% (15/37) of fractures were tongue-type and 59.5% (22/37) were joint depression-type. As reported by Ribbans et al, in an adult population, 53% (124/235) of fractures were joint depression–type and 35% (82/235) were tongue-type. Based on Sanders classification, 62.2% (23/37) of fractures in the current study were 2 parts (type II), 32.4% (12/37) were 3 parts (type III), and 5.4% (2/37) showed comminution (type IV). Sanders et al reported 65.8% (79/120) of type II, 25.0% (30/120) of type III, and 9.2% (11/120) of type IV intra-articular calcaneal fractures in adults. The current study compared classification information between children and adults and found no significant difference (Table 4).

**DISCUSSION**

Pediatric calcaneal fractures are rare injuries, and intra-articular fractures are even more rare. Children’s feet have a larger cartilage component and a relative strength of the bones in their feet in...
relation to body weight. Moreover, the increased elasticity of the pediatric skeleton and cartilage result in less stress on the calcaneus.\textsuperscript{4,6} Treatment of pediatric calcaneal fractures is often nonoperative, yielding satisfactory results for many reasons: The majority of injuries result from low-energy trauma; strong pediatric calcaneal subchondral bone resists significant fracture displacement; and, in children, the lateral process of the talus is small and the posterior subtalar facet is parallel to the ground, and the injuring force through the lateral process of the talus is distributed throughout a wider area than in adults.\textsuperscript{1,12,15} The characteristics of high-energy pediatric intra-articular calcaneal fractures are poorly described in the literature. The conservative treatment of this type of fracture results in unsatisfactory outcomes.\textsuperscript{7,8}

Based on the results of the current study, children exposed to high-energy trauma sustained displaced intra-articular fracture patterns similar to those found in adults. No statistical differences were found in calcaneal fracture classification information between children and adults. Comparative studies in adults have reported that patients with intra-articular calcaneal fractures managed nonoperatively reported significantly lower satisfaction scores and higher postoperative arthrosis rates than those treated with ORIF.\textsuperscript{16} No published studies compare the results of operative and nonoperative treatment of intra-articular calcaneal fractures in the pediatric population, which may be because of the much lower incidence in this population. The similar characteristics of fracture classification in children and adults indicates that closed methods make it difficult to achieve anatomic reduction of the articular surface, so operative treatment may be a better choice.

The few existing studies on the operative treatment of pediatric calcaneal fractures reported better outcomes and a lower complication rate compared with those reported in the adult population.\textsuperscript{12,14,17,18} Petit et al\textsuperscript{12} reported 10 excellent results in 12 patients, 1 with mild pain and slight limitation of daily activities, 1 with moderate daily pain and limitation of recreational activities, and 3 experiencing 4 minor complications. Two other studies with a total of 16 pediatric intra-articular calcaneal fractures treated with ORIF reported no perioperative complication.\textsuperscript{13,14} In the current study, 1 patient scored <65 points on the modified AOFAS scale (53 of 68 points); he lost points due to reporting occasional pain and limitation of recreational activities and some difficulty on uneven terrain, stairs, and ladders. One patient experienced a minor complication that was successfully treated before discharge.

The results of the current study and previous studies demonstrate that significantly displaced intra-articular calcaneal fractures in children can be treated successfully with ORIF. Calcaneal deformity in children may remodel with time, and the long-term functional results may be good even with some radiological abnormalities, such as a slight reduction in Bohler’s angle or degenerative changes in the subtalar joint.\textsuperscript{3} No studies were found that supported complete remodeling of posttraumatic articular incongruence in children. Poor results of conservative treatment are still being reported. The current authors agree with Sandermann et al\textsuperscript{2} and Petit et al\textsuperscript{12} that the best possible reduction of the subtalar joint may lead to the best possible results and few complications in displaced intra-articular calcaneal fractures. Displaced intra-articular calcaneal fractures should be treated with open reduction to restore the anatomy.

The published studies on ORIF treatment of pediatric intra-articular calcaneal fractures have the same limitations as the current study. They are retrospective reviews with a small number of cases; this may be due to the rarity of the injury. However, the limited results offer some useful information to the surgeon with regard to the treatment of pediatric intra-articular calcaneal fractures. Long-term comparative studies regarding operative vs nonoperative treatment of pediatric intra-articular calcaneal fractures are needed.

### Table 4

<table>
<thead>
<tr>
<th>Sanders Type</th>
<th>Essex-Lopresti</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Tongue</td>
</tr>
<tr>
<td>Children, % (n/N)</td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>62.2</td>
</tr>
<tr>
<td>II</td>
<td>32.4</td>
</tr>
<tr>
<td>III</td>
<td>5.4</td>
</tr>
<tr>
<td>P</td>
<td>.683</td>
</tr>
<tr>
<td>Adults, % (n/N)</td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>65.8</td>
</tr>
<tr>
<td>II</td>
<td>25.0</td>
</tr>
<tr>
<td>III</td>
<td>9.2</td>
</tr>
<tr>
<td>P</td>
<td>.313</td>
</tr>
</tbody>
</table>

### References


