CASE REPORT

Use of Ilizarov Device to Gain Early Range of Motion in the Treatment of Pediatric Talus Body Fractures: A Series of Four Cases and Literature Review

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Abstract

Background: Talus fractures are rare in children but can lead to severe outcomes if untreated. The Ilizarov external fixator has been used in the treatment of a variety of lower extremity pathologies. The purpose of this study was to investigate the clinical outcomes of talus body fractures treated with the Ilizarov external fixator.

Case Presentation: Four male pediatric patients (age range, 5–11 years) with talus body fractures who were treated by open reduction and internal fixation combined with Ilizarov external fixator between November 2015 and April 2016 were reviewed. Mean follow-up period was 4 years (range, 4–5). Clinical outcome was evaluated using the clinical rating scale of the American Orthopaedic Foot and Ankle Society (AOFAS). All four patients achieved good to excellent results at the last follow-up. None of the patients developed avascular necrosis. One patient developed automatic fusion of tibiotalar joint.

Conclusion: Use of the Ilizarov external fixator to gain early range of motion is a valuable option for treatment of talus body fractures in children.

Key words: children; Ilizarov device; internal fixation; open reduction; talus body fracture

Introduction

Talus is the second largest tarsal bone that transmits the axial force. It articulates with the tibia and fibula supralaterally, the navicular bone distally, and the calcaneus inferiorly[1]. Talus fractures are uncommon, especially in children[2,3]. These account for approximately 1% of all fractures, and 3%–6% of all foot fractures[4]. Talus fractures are divided into two major types (talus body fractures and talus neck

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The Ethics Committee of Tongji Medical College, Huazhong University of Science and Technology (IORG No: IORG0003571) gave a final APPROVAL on 20/11/2019 for the study Retrospective Research of Surgical Methods in the Treatment of Fractures and Malformation in Children which was conducted by Xin Tang at Department of Orthopaedic Surgery, Union Hospital of Tongji Medical College, Huazhong University of Science and Technology.

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fractures) according to the anatomical site of the fracture. Talus body fractures account for 6%–23% of all talus fractures, and 0.1%–0.85% of all fractures[5].

The Ilizarov external fixator is a multipurpose modular procedure used for many kinds of post-traumatic ankle reconstruction[6]. It has been used for limb lengthening as its use allows the transmission of the axial force to the fixator rather than the bone[7]. Talus body fractures may potentially cause significant disability, and their rarity only adds to the importance of this disease. Thus, the application of the Ilizarov external fixator in talus body fractures is worth studying. The purpose of our study was to evaluate the use of the Ilizarov external fixator for talus body fractures in children.

Case presentation

This was a single-center case-series with prospective data collection. Children with talus body fractures who were

TABLE 1 Characteristics and postoperative information

Cases	Sex	Age	Sneppen Classification	Injury Side	Follow-up (year)	AOFAS Scores
1	M	11	II	R	4	93
2	M	9	V	L	4	93
3	M	5	II	R	4.5	97
4	M	11	V	R	5	97

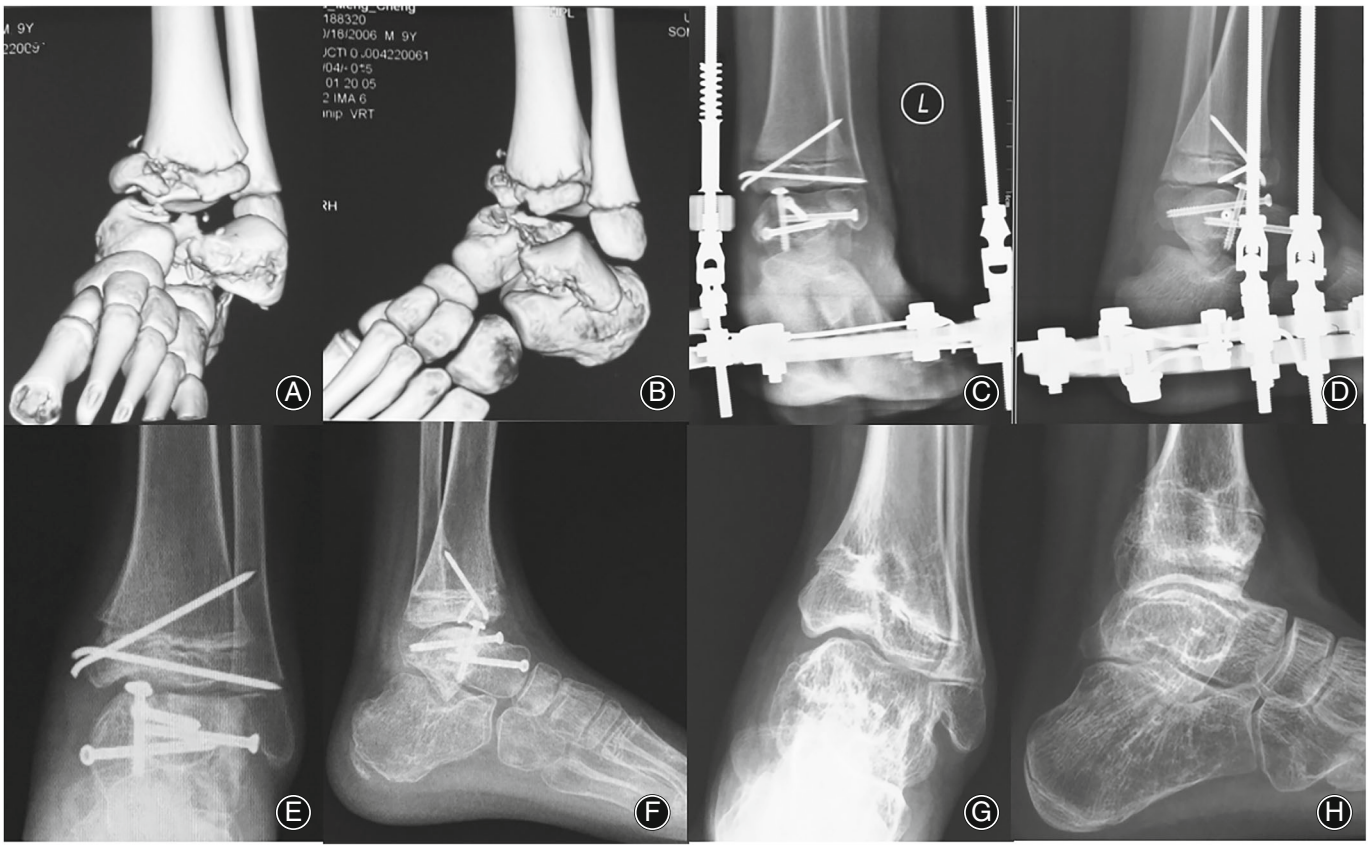

Fig. 1 Preoperative three-dimensional reconstruction of computed tomography images of a 9-year-old boy with Sneppen type V fracture of left talus body sustained after a fall (A, B). Postoperative anteroposterior (C) and lateral (D) X-ray views showing open reduction with combined screws and K-wires fixation with a Ilizarov frame to reduce the longitudinal pressure on left talus. Anteroposterior (E) and lateral (F) X-ray views at 5 months postoperative. The Ilizarov frame had been removed at 3 months after operation and talus fracture shows union with no signs of avascular necrosis. At 4 years after operation, anteroposterior (G) and lateral (H) X-ray views show a bone bridge of distal medial tibia with varus ankle; however, there are no signs of avascular necrosis or osteoarthritis after removal of the screws and K-wires at 10 months after surgery

treated using the Ilizarov external fixator at the authors' institute between November 2015 and April 2016 were included. The study was approved by ethical review board (No: IORG0003571) at the author's institution. Written informed consent was obtained from the parents of all patients.

Patients

All four patients were boys (left side: one patient; right side: three patients) (Table 1). The age of the patients at the time of operation was 5, 9, 11, and 11 years, respectively. The average time from injury to surgery was 4.3 days (range, 2–6 days). One patient had associated right calcaneal fracture and osteofascial compartment syndrome of the right lower leg. One patient had concomitant dislocation of the right ankle joint and subtalar joint. One patient had concomitant L2 vertebral fracture and right calcaneal fracture.

Surgical Technique

All patients were placed in the supine position under general anesthesia on a radiolucent operating table. After open reduction, internal fixation was applied. In two patients, hollow tension screws were used for internal fixation. Kirshner wires were used in one patient. In one patient, both hollow tension screws and Kirshner wires were used. Bone graft was applied in one patient. The Ilizarov external fixator was applied after these fractures were identified as talus body fractures. Two of the fractures were Sneppen type II (shearing fractures), while the other two were Sneppen type V crush fractures (Figure 1(A),(B))[8]. The preoperative appearances and functional images of all patients, including three-dimensional reconstruction of computed tomography images and X-rays, were obtained. Because of the bulkiness of the frame, the wound was closed before the placement of the frame. Four rings were attached to one another with connecting rods (two tibial rings, one foot ring, and one forefoot ring) (Figure 2). The tibial segment and the foot segment were connected with two straight/flexure devices at the level of the ankle joint, so as to transmit the axial force through Ilizarov device and avoid pressure on the talus (Figure 1(C),(D)).

Postoperative Management

Parents were guided about pin-site care. Patients were monitored postoperatively with serial radiographs and clinical examination. Gentle ankle mobilization without weight bearing was allowed post-operation and the ankle range of motion was expected to restore to 80% at 3 weeks post-operation. Subsequently, rehabilitation exercises, such as weight bearing, were performed at the clinical department under the guidance of a rehabilitation doctor. The Ilizarov device was removed after 6–8 weeks when the radiological evidence of talus union was present (Figure 1(E),(F)). All patients were followed up for 4–5 years (4, 4, 4.5, and 5, average 4.4 years). At the most recent follow-up, the clinical rating scale of the American Orthopaedic Foot and Ankle Society (AOFAS) was used to assess clinical outcomes[9].

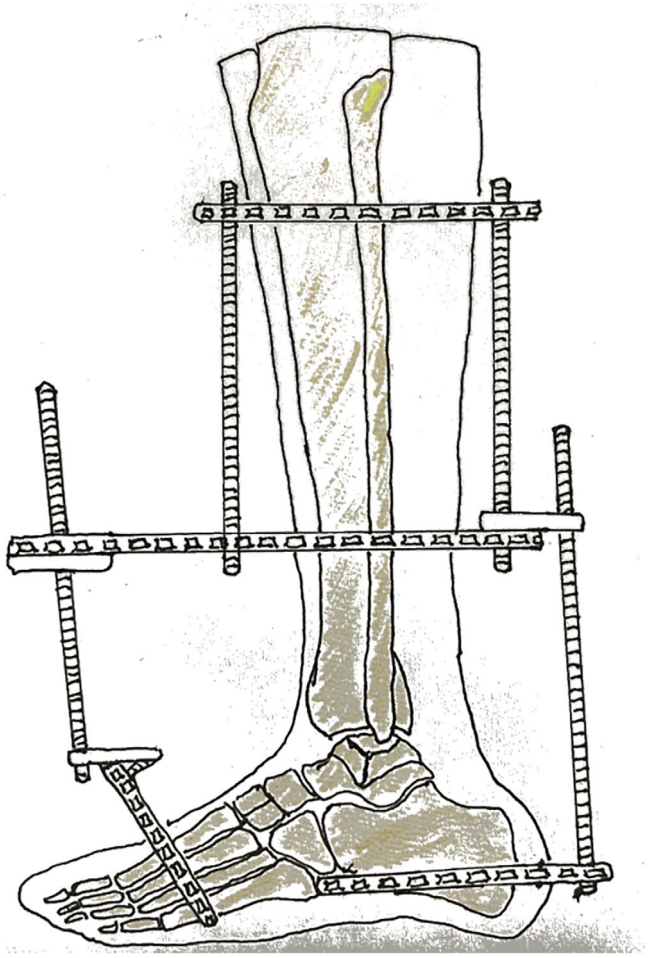

Fig. 2 A schematic illustration of the Ilizarov device. Four rings (two tibial rings, one foot ring, and one forefoot ring) were attached to one another with connecting rods

Results

None of the patients developed avascular necrosis. But the patient who suffered from multiple fractures including the vertebral fracture developed a bone bridge of distal medial tibia with varus ankle (Figures 1(G),(H) and 2). Thus, excision of the bone bridge was performed. One patient developed automatic fusion of the tibiotalar joint. According to the AOFAS rating scale, all four patients had good to excellent clinical results (Figure 3). The average total score was 95, ranging from 93 to 97 (individual scores: 93, 93, 97, and 97). (Table 1).

Discussion

The reported incidence of talus fractures in children and adults is 0.01%–0.08% and 1.3%, respectively[10]. However, the increasing participation of children in high-impact

Fig. 3 At 4-year follow up after surgery, mild varus of left ankle is observed (A, B), with moderate restriction of left ankle joint flexion (C, D)

sports is likely to lead to an increase in the incidence of talus fractures in children[11]. Three out of four patients in this case series had associated injuries adjacent to the talus, such as calcaneal fractures. Similar results have been reported in a previous study[4]. All four patients were under the age of 12 years. Smith *et al.*[12] suggested that children are less vulnerable to displaced talus fractures because of the thick periosteum and abundant malleable cartilage. Eberl *et al.* compared the talus fractures in children aged <12 years with those in adolescents (age > 12 years) and concluded that adolescents sustained more severe fractures[13].

Although all four patients in this series showed good to excellent clinical results, outcomes of talus fracture are not always good. Rather than muscular or tendinous attachments, two-thirds of the talus surface is covered with articular cartilage[14]. The talus is supplied by the posterior tibial artery, the dorsalis pedis artery, and the perforating peroneal artery[1]. Ebraheim *et al.*[15] found less favorable outcomes of crush fractures of the talar body, open fractures, and talar neck fractures. Vallier *et al.*[5] found that comminuted fractures were also related to worse outcomes. Sneppen *et al.*[9] concluded that subluxation and articular damage to the subtalar and talotibial joints may contribute to poor prognosis. Sneppen type II (shearing fractures) fractures were reported to be associated with diagnostic and treatment delay because of the rarity, thus leading to poor outcomes[16]. Avascular necrosis refers to ischemia-induced bone death. This may result from lack of post-traumatic hyperemia reaction in the talus, or the missed initial diagnosis of fractures[1]. The reported incidence of avascular necrosis ranges from 0% to 66%[17,18]. Compared with talus neck fractures, talus body fractures are associated with a greater risk of avascular necrosis[17,19]. This is because of the presence of an anastomotic ring around the inferior neck of the talus, formed by

the canal artery and the tarsal sinus artery. In contrast, talus body has only limited intraosseous anastomosis of the artery[20]. Even though non-displaced talus body fractures can be dealt with using conservative treatment, the great majority of displaced fractures require surgery. The surgical intent is mostly about restoration of the articular surface and alignment, both in children and adults[4,13]. Traditional surgery such as open reduction and internal fixation is indicated in most of the cases[2–4], but most patients may develop osteonecrosis or post-traumatic arthritis[5,21].

The use of Ilizarov device has been reported in other fractures[6,7]. A key advantage of the Ilizarov external fixator is that it transmits the axial force preventing pressure on the limbs during the healing. Thus, its use allows early weight-bearing[22]. No association between fracture types and clinical outcomes was found in our series. One patient developed a bone bridge of distal medial tibia with varus ankle. Another patient developed automatic fusion of tibiotalar joint. None of the cases developed avascular necrosis. However, this may be attributable to the small number of patients in our series. A relatively low incidence of avascular necrosis was also observed by Eigafy[23]. This may be attributable to early anatomical reduction and stabilization of the fracture. In this case series, good functional results were achieved with use of Ilizarov device for the treatment of talus body fractures, as assessed by AOFAS rating scale.

Conclusion

Another limitation of our study is the lack of comparison between the Ilizarov external fixator and other modes of internal or external fixation. Thus, although the outcome of our application was good to excellent, we can only suggest the Ilizarov external fixator as a valuable option for talus body fractures in children.

Authorship declaration

All authors listed meet the authorship criteria according to the latest guidelines of the International Committee of Medical Journal Editors, and all authors are in agreement with the manuscript.

Author contributions

Qi Li and ShuJuan Chu were involved in data collection and follow-up assessments. Xin Tang and WenQi Liu were responsible for literature search, study design. WenTao Zhu and ShuJuan Chu drafting the manuscript. WenQi Liu and Xin Tang finalized the manuscript.

Financial disclosure

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