ARTICULAR FRACTURES OF CALCANEUS

KAZIMIERZ RAPAŁA, ALEKSANDRA TRUSZCZYŃSKA

Józef Piłsudski Academy of Physical Education in Warsaw, External Faculty of Physical Education in Biała Podlaska, Department of Medical Rehabilitation, specialty Physiotherapy
Kierownik: prof. dr hab. K. Rapala

Intra-articular calcaneal fractures (ACF) result from high-energy injuries and belong to the most severe foot injuries. These fractures constitute an important diagnostic and therapeutic problem and long-term results of their treatment are often unsatisfactory, as compared to results of treatment of other fractures. The most serious fractures involve the talocalcaneal joint. Dislocation of fragments of the fractured calcaneus result in adverse changes in static-dynamic foot apparatus, impairing its function and normal walking. ACF, in particular its serious forms, apart from bone fragmentation and injury of its articular surface, result in injury of the soft tissues surrounding the calcaneus. Abnormally healed calcaneus with persistent changes in geometry has also an adverse effect on muscle triceps surae, impairing walking and function of the foot.

The aim of this paper is to present most important information of classification of fractures and therapeutic options in intra-articular calcaneal fractures, on the basis of extensive literature review and our own experience. This information may be useful for orthopedists and surgeons who treat such fractures. In the event of multiorgan trauma and multi-site injuries of the motor system, fractures of the calcaneus are commonly diagnosed and treated too late, when the patient starts walking after successful treatment of other serious injuries.

Patomechanism of calcaneal fractures

Fractures of the calcaneus occur during a fall from a height, with forces acting on the posterior articular surface of the calcaneus at different angles with regard to the ground (1).

Classification of fractures

Conventional Essex-Lopresti classification (2) is based on X-ray images and their analysis and includes two principle fracture subtypes:

1. tongue type (fig. 1A).
2. joint depression type (fig. 1B).

Experimental studies of the ACF were conducted by Thoren (3), Rąpała (4), Linda (5) among others.

Another modern classification, based on CT imaging, was proposed by Sanders et al. (6-9). They classified fractures of the calcaneus into four subtypes. This classification is based on degree of injury of the posterior facet, best seen on the projection going through the widest part of the talocalcaneal joint (fig. 2).

\[\text{– one fragment,} \]
\[\text{– two fragments,} \]
\[\text{– three fragments,} \]
\[\text{– four fragments.} \]

This classification also includes indications for treatment.

Using Essex-Lopresti classification (2), degree of dislocation of fragments can be assessed using a tuberoarticular angle proposed by Böhler (10) (fig.3).

Clinical signs and symptoms of ACF

Pain in the posteriori part of the foot is experienced and well as blurring of ankle contours caused by posttraumatic hematoma and blister-
Compartment syndrome (CS) occurs in 10% of fractures of the calcaneus. CS should be suspected in anyone with fracture of the calcaneus. Severe pain, neurological changes manifesting as tactile abnormalities are the early symptoms of CS. The pain becomes more severe during passive toe movements. If we suspect CS, internal pressure in the foot fascial compartment should be measured. Indications for fasciotomy include pressure difference versus healthy foot exceeding 30 mm Hg or then the difference between diastolic blood pressure and internal foot pressure is lower than 40 mmHg. Late foot CS manifests in half of the patients as clawed fingers – big toe to a smaller degree – and other deformations manifesting as rigidity and neurovegetative disorders. Immediate fasciotomy is indicated as management preventing ischemic contracture of the toes. The open reposition with internal fracture fixation should be performed. A skillful can also decide to perform primary fracture reposition and then proceed to fasciotomy. Fasciotomy is performed using a 6 cm medial incision with visualization of nervous-vascular bundle. CS-related problems were discussed by Myerson and Manoli (11), Bourne and Rorabeck (12) and Goldman et al. (13).

Injuries that accompany ACF include:
- fracture of thoracolumbar spine,
- fracture of tibia plateau,
- ankle fracture,
- fracture of other tarsal bones,
- transacetabulum fracture of the pelvis,
- open fracture.

Principles of management

Main principle of ACF management involves anatomical reposition of bone fragment with reconstruction of articular surface and stable fixation and early mobilization of foot joints. Traumatological practice demonstrates some fractures of the calcaneus and its facet that are so serious (e.g. four part fracture), that their reduction is difficult or impossible. In these exceptional cases attempts of fracture reduction may be abandoned and early functional management may be implemented. Such management ensures good movement in the foot joints at a cost of preservation of posttraumatic deformation of the posterior foot. When pain persists, later destructed joints may be subjected to arthrodesis.

Management options in the treatment of fracture of the calcaneus:
1) percutaneous fixation with K-wires of ACF without displacement,
2) percutaneous reduction of displaced ACF fragments and low invasive fixation with K wires,
3) operative reduction of displaced ACF fragments with percutaneous fixation with K wires,
4) operative reduction of displaced ACF fragments with fixation using a multiform plate and screws,
5) early or late arthrodesis of talocrural joint,
6) functional therapy.

Low invasive ACF fixation

This method involves fixation with a bundle of K-wires inserted from the side of the calcaneus tuber along with long axis of the calcaneus. Indications for such fixation include a fracture without displacement, fractures reduced with Steinman pin according to Westhues’ method (14, 15) and Essex-Lopresti’s method (2) as well as fractures reduced operatively (fig. 4).

This method may be used to reduce fractures of tongue type according to Essex-Lopresti classification or one and two part fractures according to Sanders classification. Active flexion and extension exercises in the talocrural joint and preservation of the fixation for 4 – 6 weeks with avoidance of weight bearing on the foot allow restoration of function within 6 months.

OPERATIVE TREATMENT

Operative reduction and stabilization with K-wires or multiform plate

Kocher lateral incision along the fibular muscles reveals lateral surface of the calcaneus. Displaced cartilageous-bony fragments of the posterior surface of talocalcaneous joint, after fragment reduction, are fixed with a bundle of K-wires or plate and screws (fig. 5, 6). Before fixation, defects can be filled with an allogenic frozen graft. Placement of very accurate adaptative sutures on the skin is required since perfusion of the skin in this region is poor. The sutures are removed after 3 weeks. Failure of operative treatment is usually caused by skin necrosis and secondary infection.
Arthrodesis of the talocalcaneal joint

Belief of many orthopedist that the injury of the talocalcaneal joint is permanent and pain caused by developing degenerative lesions is inevitable and these lesions will require arthrodesis of a painful joint later, is rationale behind such management. We must emphasize that success of early arthrodesis depends mainly on restoration of normal shape of the calcaneus and restoration of normal Böhler’s tuberointertubercular angle. This ensures lever arm of adequate length for the muscle triceps surae and efficient, normal walk. Percutaneous fixation of the talocalcaneal joint with a bundle of K-wires for 6 weeks and then immobilization in a walking plaster cast for another 6 weeks is sufficient to obtain full ankylosis.

Functional treatment

Functional treatment of ACF is a method based on assumption that adequately long avoidance of weight bearing of wedged bone fragments and early mobilization provide good motion in the foot joints. The following fractures may be treated with this method of treatment:
- nondisplaced
- multifragment four parts
- in patients above 65 years of age
- in patients with contraindications for surgical treatment (local or general)
Initial treatment:
1. P – rotection (posteriori insole),
2. R – est (rest),
3. I – ce (cooling),
5. E – levation (anti-edematous position),
6. M – edication (NSAID),

Mobilization was started when acute pain related to the injury subsided. In the first period, passive exercise was implemented, aimed at reduction of the risk of secondary displacement and prevention of involvement of fibular muscles by the developing scar. During this time, active exercise are recommended only for toes. After 7-10 days scope of exercise was expanded to include active exercise involving talocrural joint. With resolution of edema and pain reduction, activity of exercise was increased and walking with crutches, with avoidance of weight bearing was recommended. After 4-6 weeks resistance exercises were implemented. Walking with dosed weight bearing started after finding X-ray signs of bone union – on average after 10-12 weeks. This management promoted soft tissue healing and provided good foot mobility and elasticity. Injury of non-skeletal structures surrounding the calcaneus result in unsatisfactory treatment results. Early mobilization promotes resorption of the postrauomatic hematoma, impairs formation of periarticular and intraarticular adhesions and prevents compression of the synovial bursae of fibular tendons by the scar. This is the principle cause of pain after ACF. It is better to leave a deformed foot while preserving its mobility than preserve relatively good shape of the posterior foot at a cost of joint stiffness and pain.

DISCUSSION

The literature on ACF is very extensive. In our country this problem was predominantly studied by Łukasik, Rąpała and others (16-21).

ACF treatment is difficult and long-term effects not universally are satisfactory. This is related to irregular structure of the calcaneus and difficulties related to restoration of its anatomical shape. Good treatment results can be expected when a physician has knowledge on mechanisms of the injury and classification of fractures. Essex-Loprestii classify fractures into two subtypes: tongue type and joint depression type that suggest recommended management. Fractures of tongue type can be managed non-operatively, with a percutaneous Steinman pin, according to method reported by Westhues (15) and Essex-Loprestii (2), while fractures of joint depression type should be managed operatively. Palmer (22) in his paper from 1948, recommended operative treatment for fractures of joint depression type. Essex-Loprestii (2) believed that multi-fragment fractures of the calcaneus in patients over 50 years of age should be treated only with functional methods. Recommendations prepared by Essex-Loprestii (2) are still valid and have their proponents (20, 21, 23, 24). Long term results of treatment of closed ACF range from 85 to 95%. Sanders et al. (7) presented very convincing long term results of ACF treatment. He presented results of operative treatment of 120 fractures of the calcaneus fixed with a multi-shape plate. He assessed treatment results on a 100% Maryland scale and with X-ray and CT imaging. The results are presented in a tab. 1.

58 very good and good results (86%) per 79 treated type II fractures should be noted. Very good and good results were obtained in 21 fractures (60%) per 30 three-fragment fractures. Only one good result was obtained per 11 treated type IV four-fragment fractures. Sanders provides an interesting observation on the learning curve within four years. Good treatment results, initially 27%, were 84% after four years. According to Sanders, patient

<table>
<thead>
<tr>
<th>Typ złamania / Fracture type</th>
<th>Bardzo dobry / Very good</th>
<th>Dobry / Good</th>
<th>Zadowalający / Satisfactory</th>
<th>Zły / Poor</th>
<th>Ogółem / Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>II</td>
<td>23</td>
<td>35</td>
<td>8</td>
<td>13</td>
<td>79</td>
</tr>
<tr>
<td>III</td>
<td>7</td>
<td>14</td>
<td>3</td>
<td>6</td>
<td>30</td>
</tr>
<tr>
<td>IV</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>8</td>
<td>11</td>
</tr>
<tr>
<td>Ogółem</td>
<td>30</td>
<td>50</td>
<td>13</td>
<td>27</td>
<td>120</td>
</tr>
</tbody>
</table>
with type IV fractures can expect unsatisfactory treatment results, irrespective of experience of a surgeon. In such cases primary subtalar arthrodesis should be considered. Experience in treating such serious fractures, is gained only after performance of more than 20 operations.

Rąpała (20) obtained good results in 83%, satisfactory in 10%, poor in 7% out of 30 patients treated using Westhause or Palmer method and low invasive fixation with 4 K-wires. He had a good result in 70%, satisfactory in 14% and poor in 16% out of 150 fractures treated with various methods. Poor results in this study were caused by treatment of these fractures using a plaster cast. Poor results were obtained in 50% out of 33 fractures in this group. Therefore a decision was taken to abandon foot immobilization in a plaster cast. Assessment of long term results of ACF treated using non-operative and operative methods does not universally depend on the precision of reduction. Buckley et al. (25) assessed results of 371 fractures in 307 patients. After 2 years of follow-up, they did not find any differences between operative and non-operative treatment. The groups were reanalyzed and results of non-operative treatment in women and uninsured patients proved to be better. Among uninsured patients, better results were found in younger patients, performing light work, with small degree of loss of Böhler angle and displacement of articular surface no more than 2 mm. Progress in aseptic, antibiotic therapy, implementation of new implant generation (thin titan plates) as well as progress in skin reconstructive surgery made surgeons more eager to proceed with operative treatment of all ACF with displacement. Number of published papers on plate fixation exceeds number of papers on other treatment methods (26-29). Number of approaches to the fractured bone were reported. Lateral Kocher approach is the most common however vascularization of the skin in this region is poorer and therefore the skin is at higher risk of wound necrosis. Reynolds medial approach was predominantly reported by Bourdaux (30, 31). Authors of this paper do not have their own experience in using this medial approach and this approach did not gain much popularity. Operative treatment carries higher risk of infection. Inflammatory complications in the operative treatment are found in 1.8% of operated cases. Such rate of infective complications is reported by Bernirschke and Kramer (32). Inflammatory complication rate in the material of these authors, in open fractures of the calcaneus, was 7.7%, while Aldrige et al. (33) had as much as 11% complications. Amputation below the knee was required in two out of 19 treated cases of open calcaneus fractures due to chronic heel inflammation.

Computerized classification of calcaneal fractures according to Sanders et al. (7) had a significant effect on operative treatment of ACF. This classification facilitates making proper decision with regard to the treatment method. The discussion between proponents of fixation of reduced fragments continues. Whether to stabilize the fragments with a multi-shape large plate, low-invasively – with a small plate or screws or percutaneously with a bundle of K-wires from the calcaneal tuber? The latter method is low invasive and safe. The authors of this paper and others (34 – 37) recommend this method of fixation as a simple and effective method, since K-wires can be easily removed in the event of infection. Recently more papers were related to this problem. Low invasive fixation and external fixation are especially indicated for the treatment of open fractures (38-46).

Some orthopedists-trauamtologists recommend primary arthrodesis of the destroyed talocalcaneal joint, believing that degenerative changes are the principal cause of late complaints after intra-articular fractures of the calcaneus (47-52). Polish authors, Gągała,
Dudek and Modrzewski (53) are proponents of open ACF reduction with concurrent talocalcaneal arthrodesis. Assessing 73 calcaneal fractures, they recommend rejection of good Westhues method and proceeding with primary arthrodesis. We cannot fully share such radical suggestion because pain after ACF not universally results from destroyed talocalcaneal joint. Furthermore, Sanders’ studies showed that two- and three-fragment fractures, reduced and fixed using operative methods, gave good results. Clinical observation suggests that syndesmosis between talus and calcaneus is not universally painful. Various approaches (lateral, posterior) as well as various degrees of arthrodesis were reported in the literature. Should only talocalcaneal joint undergo arthrodesis or Chopart joint, too? We believe that with acute fractures, arthrodesis of talocalcaneal joint is simpler, while in the event of late arthrodesis, additional arthrodesis of Chopart joint is more justified due to co-dependent movement mechanics in these joints. Lack of motion in the talocalcaneal joint will result in overload of the Chopart joint.

Studies of the authors (54, 55) demonstrated that late complaints result from narrowing of the canal through which tendons of the fibular muscles go. Scar hyperplasia on the lateral side of the heel or uneven surface of the calcaneus irritate synovial bursae of these

Fig. 8. Computer tomography of both feet. Multi-fragments fracture of both calcanei including posterior talocrucalis joint’s surface of. Subluxation in right talocalcaneus joint (author’s own collection)

Fig. 9. A photograph of feet and shanks. When the patient was standing on his toes, shape of posterior feet and outline of Achilles tendons were normal. Photograph shows functional result of patient B.Z. after 3 years Good result in Maryland scale (author’s own collection)
tendons and induce pain. We believe that primary arthrodesis of the talocalcaneal joint, without anatomical reconstruction of the bone shape, is difficult, because cartilageous-bony fragments of the posterior facet are small and dislocated to the inside of the calcaneal shaft. Removal of the articular cartilage from them is not an easy task. The authors of this paper believe that unless the thalamus, where the posterior facet is located, is reconstructed, functional effect of therapy will be unsatisfactory. Therefore it is better to operatively reconstruct shape of the calcaneus and its facet, and only then perform secondary arthrodesis of the talocalcaneal joint, after careful confirmation that the source of pain is in the destroyed joint.

Functional therapy

Functional therapy is indicated in the event of very serious calcaneal fractures. This management accepts lack of reduction and union of displaced bone fragments but enables restoration of elastic and mobile foot (1, 56, 57, 58). When pain persists, operative arthrodesis of painful joints or late reconstruction of deformed calcaneus is performed in quite good anatomical conditions.

Foot immobilization in a plaster cast in multi-fragment fractures should unequivocally be abandoned. This results in clear disadvantage and adverse effects. Following several weeks of immobilization, the foot is rigid and compartment syndrome accompanying serious fractures facilitates hammer-like toe position.

Calcaneal fractures are serious foot injuries that should be well diagnosed and treated only in the inpatient setting.

At the end of our paper we would like to present a practical illustration of treatment of a complicated calcaneal fracture.

A 34-year old hang-glider underwent calcaneal fractures during an unfortunate landing. These fractures were treated almost with all the above described methods – we present a brief summary with clinical imaging documentation.

Management

1. Operative reposition of displaced right calcaneus and fixation with K-wires passed through the calcaneus and peripheral part of the tibia. Direct traction was attached to the calcaneal tuber to restore length of shortened right calcaneus and eliminate angular displacement.
2. An attempt of percutaneous reposition of the articular surface of left calcaneus (not completely successful) with adequate manual correction of varus displacement of the calcaneus. Operative reposition was risky due to not completely healed skin wound.
3. Reposition of the right talocalcaneal joint and fixation with K-wires.
4. Functional therapy at any stage of the treatment of right and left calcaneus.
5. Functional and radiological result after 3 years. No pain, normal walking, the patient skis and returned to his previous athletic activities.

Summary

1. Intra-articular calcaneal fractures belong to high-energy fractures, which are characterized by fragmentation of the posterior facet and significant destruction of the structure of cancellous calcaneus.

2. Injury of the posterior facet in most of the fractures has the same and approximate pattern reported by Essex-Lopresti as a tongue type fracture or joint depression type fracture.

3. Tongue type dislocation can be reduced using Westhues method while depression type fractures should be treated operatively.

Sanders in his classification provided that one-fragment and multi-fragment nondisplaced fractures should be treated nonoperatively. Two- and three-fragment fractures require operative treatment and stable fixation, while in four-fragment fractures primary arthrodesis of the talocalcaneal joint or functional therapy is indicated.

4. Fragment fixation can be performed using low invasive methods, by passing a bundle of K-wires from the side of the calcaneal tuber or operatively, with a plate and screws from lateral approach. Both methods fulfill criteria of stable osteosynthesis.

5. Functional therapy is a therapy of choice in non-displaced fractures and in fractures which are difficult or impossible to reduce as well as in fractures reduced and fixed stably.

REFERENCES


Received: 25.08.2009 r.
Adress correspondence: 05-400 Otwock, ul. Konarskiego 13