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Calcaneal Fractures: A Literature Review of Contemporary Treatment Strategies and Minimally Invasive Stabilization Using the Calcanail System

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ABSTRACT

Background

Calcaneal fractures are serious injuries, most commonly resulting from falls from height or road traffic accidents. Clinically, they present with severe pain, swelling, and an inability to bear weight on the affected limb.

Aim

The aim of this review is to present the current literature on calcaneal fractures and their minimally invasive stabilization using the Calcanail system. The available evidence indicates that the use of this technique reduces the risk of postoperative complications associated with the ORIF (Open Reduction and Internal Fixation) technique.

Material and methods

A systematic review of scientific literature was conducted. A systematic search was carried out in PubMed, GoogleScholar using keywords. Emphasis was placed on studies, randomized controlled trials, systematic reviews, and meta-analyses.

Results

The Calcanail technique allows for earlier surgical intervention compared with ORIF, as it does not require complete resolution of soft-tissue swelling. Its minimally invasive nature reduces soft-tissue trauma and enables treatment even in patients with persistent swelling or relative contraindications, with patient selection based on individual clinical assessment and risk of complications.

Conclusions

The use of the Calcanail intramedullary system for the treatment of displaced intra-articular calcaneal fractures is a minimally invasive surgical technique associated with a lower risk of postoperative complications compared with ORIF (Open Reduction and Internal Fixation).

The Calcanail system is characterized by a faster return to functional recovery and earlier restoration of limb mobility compared with traditional treatment methods.

KEY WORDS: calcaneus bone, fractures, Calcanail system

INTRODUCTION

In the 2000s, the treatment of calcaneal fractures relied primarily on conservative methods, largely due to concerns regarding complications associated with surgery. However, the unsatisfactory outcomes of conservative therapy led to a re-evaluation of the indications for surgery and its gradual adoption.

Recovery following surgery can be prolonged, and returning to pre-injury activity levels may not always be possible due to persistent pain and limited range of motion.

Complications associated with surgical treatment include soft-tissue injuries; superficial and deep wound infections, skin flap necrosis and delayed healing. Damage to the sural nerve is also possible. A turning point in the surgical management of calcaneal fractures was the introduction of minimally invasive techniques, which help reduce the risk of the aforementioned complications.

This study aims to present an overview of calcaneal fractures including their epidemiology, diagnosis and to discuss the advantages of minimally invasive stabilization using the Calcanail system.

EPIDEMIOLOGY

Calcaneal fractures are relatively rare and account for about 0.5–1% of all fractures in the adult population but make up approximately 60% of tarsal bone fractures.

Significantly displaced intra-articular fractures are usually associated with high-energy mechanisms, the most common of which include falls from height and jumping injuries. Road traffic accidents are also a significant cause of calcaneal fractures. These injuries most commonly affect car drivers involved in head-on collisions and

motorcyclists. During the impact, the foot is subjected to a sudden and forceful compression against the pedals or the ground, resulting in high axial loading of the calcaneus. It should also be emphasized that this type of injury may affect physically active individuals and athletes, particularly those participating in disciplines associated with substantial axial loading of the lower extremities, such as extreme sports and parachuting.

Calcaneal fractures most commonly affect younger individuals, particularly those between 20 and 39 years of age. Certain comorbid conditions, including diabetes mellitus, obesity and osteoporosis, may contribute to an increased susceptibility to fractures.

In the pediatric population, calcaneal fractures are considered uncommon.

MATERIAL AND METHODS

In the clinical assessment of a patient with suspected calcaneal fracture, a thorough medical history is essential to determine the mechanism of injury and to rule out associated injuries. It should be noted that approximately 10% of calcaneal fractures are bilateral. In addition, these injuries may be accompanied by lumbar spine fractures, which also occur in around 10% of cases.

The physical examination should always include an assessment of the vascular supply and neurological status of the affected limb. The presence of sensory disturbances, paresthesias, or severe pain that does not respond to analgesic treatment may indicate the development of compartment syndrome and requires particular diagnostic attention.

Detailed imaging diagnostics, in turn, enable precise evaluation of the extent of damage, appropriate selection of the surgical treatment method, and, if necessary, planning of a staged treatment approach.

The diagnostic procedures most commonly used for patients with a suspected calcaneal fracture include:

X-ray imaging (radiography) - the primary and most frequently employed diagnostic imaging method, characterized by its widespread availability. It enables the assessment of high-density structures, particularly bone tissue, thereby playing a key role in the diagnosis and evaluation of calcaneal fractures.

Figure 1: X-ray of left calcaneus fracture
(https://www.physio-pedia.com/images/c/cf/Calcaneus-fracture-1.png)

Based on a lateral radiographic view of the foot, three types of calcaneal fractures can be distinguished according to the Guy Utheza classification, depending on the displacement of the posterior articular facet of the calcaneus.
Computed tomography (CT) - following an initial assessment, a CT scan is recommended. This method combines imaging technology with advanced computer processing to provide detailed cross-sectional views of the calcaneus. It can show the extent and extra- or intra-articular components of the fracture and hematoma along the sole of the foot (Mondor sign). Analysis of CT images should include scans in the coronal, sagittal, and transverse planes.

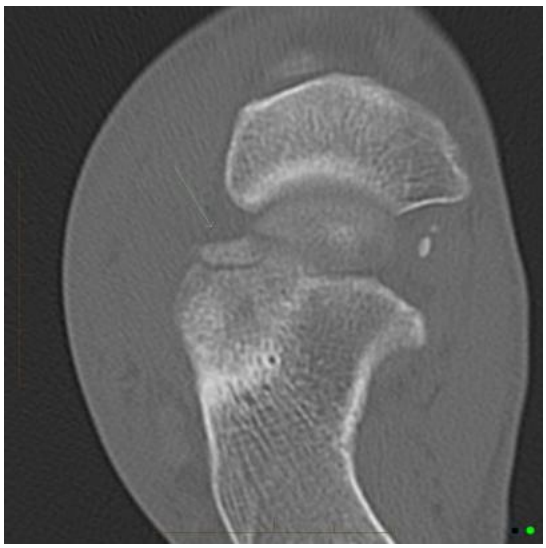

Figure 2: CT scan of anterior process of calcaneus fracture with soft tissue swelling
(https://www.physio-pedia.com/images/a/a7/Anterior-process-of-calcaneus-fracture.jpg)

CT in the coronal and axial planes plays an important role in the evaluation of intra-articular calcaneal fractures according to the Sanders classification. This classification is based on the number of fracture lines and the degree of displacement of fragments involving the posterior facet of the subtalar joint. It is essential for determining the most appropriate treatment strategy. Particular attention should also be paid to the assessment of the primary fracture line (main fracture line, fundamental fracture line), which represents the principal fracture cleft extending through the posterior articular facet of the calcaneus. This fracture line is created as a result of the combined effect of axial loading forces generated during a fall from height together with the additional destructive force exerted by the lateral process of the talus at the time of injury. The evaluation of the primary fracture line became fundamental to the development of the Utheza classification and its subsequent modification introduced by Goldzak.

UTHEZA CLASSIFICATION

Type I – vertical – The main fracture line may extend medially, resulting in the formation of a lateral fragment of the posterior articular facet of the calcaneus, which is subsequently displaced into a vertical position.

Type II – horizontal – The main fracture line may extend laterally, resulting in the formation of a medial fragment of the posterior articular facet of the calcaneus, which is subsequently displaced into a horizontal position.

Type III – mixed – The main fracture line most commonly extends centrally through the posterior articular facet of the calcaneus. The medial fragment containing the sustentaculum tali is displaced into a horizontal position, whereas the lateral fragment involving the articular surface is displaced into a vertical position.

SANDERS CLASSIFICATION

Type I – nondisplaced fractures, characterized by fragment displacement of less than 2 mm, regardless of the number of visible fracture lines.

Type II – Two part fracture with one fracture line and is divided into three subtypes based on the side of the fracture line: lateral (IIA), central (IIB), or medial (IIC).

Type III – three-part fractures, involving two fracture lines that result in the formation of three bone fragments, including an additional fragment that is typically centrally located and depressed.

Type IV – comminuted fractures, characterized by the presence of four or more articular fragments.

GOLDZAK MODIFICATION OF THE UTHEZA CLASSIFICATION

Although the Utheza classification was introduced in French medical literature in the early 1990s, its complexity limited its widespread adoption outside France.

Based on three-dimensional volume rendering (3D VR) fracture analysis, Goldzak introduced a simplified modification of the Utheza classification by dividing calcaneal fractures into two

main types according to the location of the primary fracture line in relation to the posterior facet.

Type 1 includes fractures in which the posterior facet is displaced while maintaining its integrity as a single bone fragment. This anatomical pattern generally allows easier restoration of normal anatomy during reduction and is associated with a more favorable clinical outcome. Within this group, three subtypes are distinguished according to the location of the primary fracture line: medial (A), lateral (B), and lateral with an additional fracture line extending between the posterior facet and the sustentaculum tali (C).

Type 2 is characterized by a fracture line crossing the central portion of the posterior facet, resulting in double fragment displacement. This category is further divided into two subtypes: 2A, when a single fracture line crosses the posterior facet, and 2B, when two fracture lines involve the articular surface.

CALCANAIL SYSTEM

The Calcanail system is an innovative method for the surgical treatment of calcaneal fractures. One of the main advantages of this technique is its minimally invasive approach through the posterior calcaneal tuberosity, which helps reduce the risk of complications associated with the lateral approach.

The method utilizes a locking intramedullary nail that provides stable fixation and maintains the posterior articular surface of the calcaneus in the correct anatomical position following intrafocal reduction.

As a result, adequate stabilization can be achieved while minimizing soft-tissue damage.

OPERATIVE TECHNIQUE

Patient Positioning – Surgery is carried out with the patient placed in the lateral decubitus position, with the affected foot positioned beyond the edge of the operating table, allowing easier acquisition of lateral and axial calcaneal radiographic images.

Preparation of the surgical field – The skin is disinfected, the surgical field is draped, and the C-arm fluoroscope is positioned to obtain lateral and axial views of the calcaneus.

Identification of the entry point – Under fluoroscopic guidance, the entry point for the guidewire is identified on the posterior aspect of the calcaneal tuberosity.

Insertion and positioning of the guidewire – The guidewire is inserted through the calcaneal tuberosity into the central portion of the calcaneus, with its position verified in both fluoroscopic projections. Under fluoroscopic guidance, the wire is directed toward the posterior talar articular surface of the calcaneus in the lateral view, while in the axial view it should be positioned centrally within the calcaneal tuberosity. A Caspar distractor is applied using two pins placed in the calcaneal tuberosity and the lateral process of the talus. This creates a working tunnel that allows intrafocal reduction of the displaced fracture fragments using dedicated instruments, such as a curved elevator and a straight or curved tamp.

Fracture reduction – Closed reduction of the fracture fragments is performed using appropriate reduction instruments under continuous fluoroscopic guidance.

Creation of the intramedullary canal – The intramedullary canal is prepared using dedicated Calcanail reamers. This step facilitates nail insertion and enables elevation of the depressed posterior articular surface.

Calcanail implantation – The Calcanail intramedullary nail is inserted into the prepared canal along the longitudinal axis of the calcaneus. The implant is intended to support the reduced articular surface, while the proximal locking screw provides compressive fixation of the reduced calcaneal articular fragments.
Fragment fixation – The nail is locked with locking screws to ensure stable fixation of the fracture fragments.
Final assessment – Fracture reduction and implant positioning are evaluated under fluoroscopic control in both lateral and axial views.

ADVANTAGES of the Calcanail system

- The developed reduction method minimizes the extent of the surgical intervention, which may help reduce the risk of postoperative complications.

- A bone fragment obtained during the creation of the surgical approach can be used as the patient's own bone graft.

- The reduction of displaced intra-articular fragments is facilitated by the use of a Caspar-type subtalar distractor, which allows for more effective manipulation at the fracture site.

- The technique enables the precise positioning of the locking nail at the correct height relative to the articular surface.

- Placing the bone graft into the implant's apertures supports the healing process.

ORIF

ORIF (*Open Reduction and Internal Fixation*) is a method of treating calcaneal fractures that involves surgical exposure of the fracture site, precise anatomical reduction of bone fragments, and their stabilization using implants.
Incisions for exposure of calcaneal fractures include medial, lateral, combined medial-lateral, and extensile lateral approaches, with the lateral approach being the most commonly used. Open reduction with LCP plate fixation allows for anatomical reduction, stable osteosynthesis and ex cel lent or good outcomes even in 80% of the cases. However, the procedure is relatively often associated with wound healing complications, skin necrosis or infections. The incidence of these problems has been estimated at 33% in retrospective studies and 16% in a randomised prospective study. To minimize wound healing complications and postoperative stiffness related to scar formation after ORIF via extensile approaches, the Calcanail technique has been introduced as a percutaneous and minimally invasive alternative, significantly reducing infection and wound complication rates while maintaining precise anatomic reduction.
The procedure also has numerous contra in dications (peripheral vascular disease, poorly controlled diabetes, significant comorbidities, nicotine use, poor soft-tissue condition, nondisplaced fractures, non-ambulatory patients, and poor compliance.).
Early ORIF is often limited by soft-tissue swelling. In open fractures, intravenous antibiotics and surgical debridement are required, with definitive fixation delayed until adequate recovery of the soft-tissue envelope. ORIF should ideally be performed within three weeks of injury, before early fracture consolidation, which can complicate anatomic reduction. Timing of

surgery should be based on soft-tissue condition, commonly assessed using the “skin wrinkle test.”
In the Calcanail system technique, there is no strict requirement to wait for complete resolution of soft-tissue swelling before surgery. Due to the minimally invasive approach and reduced surgical trauma, patients with persistent swelling may still be considered eligible for treatment. In addition, compared with traditional ORIF, the presence of certain relative contraindications (e.g., comorbidities or risk factors affecting soft-tissue healing) does not automatically exclude patients from the procedure. Instead, patient selection is made individually, based on clinical condition and the risk of complications.

POSTOPERATIVE CARE

week	CALCANAIL	
1	Ambulatory: - non-weight bearing with crutches	
2		
3	Walking: - protected weight bearing with 2 crutches Heel rest	
4		Begin physical therapy: - non-weight bear
5		
6	Walking in normal shoes: - begin subtler physical therapy	
7-15		

Figure 3: A table comparing return to function between the ORIF method and the Calcanail system.

The patient may begin mobilization immediately after surgery using crutches with no weight-bearing on the operated foot, provided that a pain-relieving foot brace is worn and wound healing is satisfactory during the first 15 days. Thereafter, the patient may begin partial weight-bearing using two crutches and a heel support for the following three weeks. After the fifth week, the patient can gradually transition to walking in normal shoes, and subtalar joint physiotherapy is initiated.
In ORIF treatment, the patient is immobilized for the first three weeks. Physiotherapy is initiated only thereafter, while non-weight-bearing ambulation with crutches is maintained for approximately three months.

CONCLUSIONS

The use of the Calcanail intramedullary system in the treatment of displaced intra-articular fractures is a minimally invasive therapeutic technique characterized by a low risk of complications.
It differs fundamentally from other techniques. The innovation lies both in the posterior surgical approach to the calcaneal tuberosity and in the method of reduction, which involves the direct application of reduction forces to the displaced bone fragments.

DISCLOSURE

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