

Philosophy of Calcaneal Fracture Fixation

Restoring the joint, rebuilding the heel, respecting the soft tissues



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Author's technique, early clinical experience and referenced evidence

EDITION AND SCOPE

A philosophy grounded in anatomy and experience

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Purpose and audience

This clinical teaching monograph develops my approach to calcaneal fracture reconstruction, particularly displaced intra-articular injuries with extension into the calcaneal body and posterior tuberosity. It is written for orthopaedic surgeons, trainees and other clinicians interested in the reasoning behind reduction and fixation.

Source of the technique

The technique and early experience draw on *A Novel Sinus Tarsi Approach and Standard Calcaneal Plate Application for Calcaneal Fractures*, a working manuscript by Tania Tanello, Ahmed Yousef and Peyman Bakhshayesh. Two manuscript versions were reviewed. The fuller results version supplies the aggregate series data reproduced in Chapter 9. A BOFAS email confirms receipt of an abstract submission in May 2025; it does not establish acceptance, presentation or journal publication. [1,2]

How to read the evidence

My preferred practice is identified as author experience or a technical proposal. Published comparative evidence is cited separately. This book is an authored educational publication, rather than a report of a newly completed trial. Missing outcome data have not been estimated or invented. The original manuscript remains an unpublished working source on the evidence available for this edition.

Clinical images were supplied by the author. Screen interfaces, timestamps and identifying monitor text have been excluded from the published figures. The demonstration images are not assumed to belong to the 2021-2023 study cohort. No radiographic measurements or Sanders grades are assigned from these photographed fluoroscopic views.

Clinical judgement

The operative description presumes specialist training, appropriate supervision and familiarity with the chosen implant. Fracture configuration, soft tissue viability, comorbidity and patient priorities determine the final treatment. Professional appointments do not imply institutional endorsement.

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The illustrations combine the author's operative photographs and fluoroscopic images with original teaching diagrams. Diagrams are explanatory schematics, not patient-specific anatomy or validated planning templates.

Central proposition

A limited skin incision can be combined with a comprehensive fixation strategy, provided that reduction, safe implant passage and the biological cost of the deeper dissection are judged independently.

ABOUT THE AUTHOR

Clinical practice, scholarship and surgical judgement

I am Mr Peyman Bakhshayesh, a Consultant Trauma and Orthopaedic Surgeon with a practice in major trauma, complex fracture reconstruction and foot and ankle surgery. My work at Leeds Teaching Hospitals includes major trauma care and elective foot and ankle surgery. I am Clinical Lead for General Trauma at Leeds General Infirmary and an Honorary Senior Lecturer at the University of Leeds.

After graduating from Shiraz Medical School, I completed orthopaedic training in Sweden and undertook further specialist training in Germany and the United Kingdom. My experience includes foot and ankle surgery, limb reconstruction, and pelvic, acetabular and hip surgery. My PhD at Karolinska Institutet examined clinical and radiological aspects of traumatic pelvic ring injury. My qualifications are MD, PhD and MBA. [25]

My published research includes trauma outcomes and CT-based three-dimensional methods of anatomical assessment. These interests inform a practical question that runs through this book: have we restored the useful anatomy of the limb, and have we done so in a way that gives the person a reasonable opportunity to recover?

Preface

A calcaneal fracture is more than a broken posterior facet. It can change the height, width, length and direction of the heel, the space available for the tendons, the relationship with the fibula and the ability to wear ordinary shoes. I therefore begin with the whole heel and the whole person.

I have considerable respect for the surgeons whose work established anatomical reconstruction and for those who demonstrated the morbidity of its exposure. My preference for a modified sinus tarsi approach grows from both lessons. I want the joint seen well enough to reduce it, the tuberosity controlled well enough to support it, and the skin disturbed as little as the reconstruction permits.

The seven-patient series in our archive is an early clinical experience. It supports an account of feasibility. It cannot answer every question about function, arthritis or comparative safety. Presenting that distinction is part of the philosophy, because a convincing operation must ultimately be judged by the patient's recovery.

Mr Peyman Bakhshayesh

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CHAPTER 1 | INTRODUCTION

The heel is a three-dimensional reconstruction problem

My starting point is to restore a heel that can support the body, clear the surrounding structures and fit into footwear. The posterior facet is central to that task, but it is not the entire task. A well-reduced facet above a shortened, widened or malaligned tuberosity is an incomplete reconstruction.

In a substantially displaced fracture, loss of height and length may accompany lateral wall expansion and varus or translation of the tuberosity. The consequences can include subfibular or peroneal impingement, altered loading, shoe-fitting difficulty and persistent pain. Subtalar cartilage damage and incongruity increase the risk of post-traumatic arthritis. Arthritis is not inevitable in every untreated fracture, and fixation cannot erase cartilage injury sustained at impact. [9,11]

The practical cost deserves attention. A person may be unable to return to a physically demanding occupation or may struggle to obtain suitable footwear. Buying mismatched shoe sizes is one possible consequence of a widened heel, not a universal requirement. I regard shoe fit and affordability as legitimate outcomes of treatment. I do not assume that most patients are financially disadvantaged; the individual circumstances should be established in conversation.

Four questions before choosing an implant

Question	Reconstructive objective
What happened to the joint?	Understand depression, rotation, comminution and cartilage injury.
What happened to the heel?	Restore useful height, length, width and tuberosity alignment.
What happened to the soft tissues?	Protect skin, perfusion, tendons, nerves and the heel pad.
What matters to this person?	Relate recovery to walking, shoes, work and independence.

My proposed solution is a modified sinus tarsi exposure with indirect reduction and passage of a standard anatomical lateral calcaneal plate. Its intended advantage is to separate access to the joint from the extent of skeletal support. This is a technical philosophy for selected reconstructable fractures, particularly those with extra-articular extension; it is not evidence that every calcaneal fracture requires this operation. [1]

CHAPTER 1 | HISTORICAL PERSPECTIVE

What the pioneers taught us

Modern reconstruction owes much to Roy Sanders and colleagues, whose CT-based work clarified articular fracture patterns and their prognostic importance. Their 1993 clinical series and subsequent long-term study remain important landmarks. Surgical treatment of the calcaneus, however, predates this work; it would be historically inaccurate to attribute the first operative fixation or the entire development of the lateral approach to one surgeon. [3,4,8]

Exposure and its biological price

The extensile lateral L-shaped approach permits broad inspection of the lateral wall, posterior facet and anterior calcaneus. Its value is access. Its potential cost is the disturbance of a vulnerable soft tissue envelope. Planning the flap, preserving its blood supply, allowing the tissues to recover and closing without tension are central to safe use. [13]

Allgöwer-Donati closure is relevant because it seeks to respect perfusion at the wound margin. A randomised study in ankle fracture surgery evaluated perfusion with this technique, but that anatomical setting does not prove a clinical advantage for every calcaneal incision. No suture technique compensates for ischaemic skin, excessive tension or an inadequately planned flap. [22]

A smaller approach opened a different question

The sinus tarsi approach provides direct access to the subtalar region through a shorter incision. It can be combined with screws, dedicated limited-approach plates, percutaneous fixation or other constructs. It was not confined historically to one proprietary plate. Exposure of the posterior body and primary fracture line remains limited, so indirect reduction may be necessary. [12]

In my practice, extra-articular extension is the reason to think beyond the small articular fragment. A short implant may not control the posterior tuberosity or support the plantar component required by a particular fracture. Conversely, some modern sinus tarsi implants do address these regions. The appropriate judgement concerns the actual plate footprint and screw paths, rather than a general assumption about all small plates. [1]

My interpretation

The important innovation is the combination of joint access, controlled indirect reduction and a construct that spans the components needing support. Incision length alone is an inadequate measure of how invasive an operation has been.

CHAPTER 2 | EPIDEMIOLOGY

An uncommon fracture with substantial consequences

Calcaneal fractures disproportionately affect working-age adults, although they also occur after lower-energy injury in older people. Falls from height and road traffic collisions are important mechanisms. Population studies should be distinguished from hospital-admission series, because their denominators and ascertainment differ. [5-7]

Study and population	Reported findings	Interpretation
Mitchell et al., Edinburgh, 1995-2005 [5]	697 patients; 752 fractures, including 55 bilateral injuries. Annual incidence 11.5 per 100,000; male:female frequency approximately 2.4:1.	A regional trauma population, not a global incidence estimate.
Humphrey et al., England, 2000/01-2016/17 [6]	62,858 adult hospital admissions. Mean annual incidence 10.5 per 100,000 men and 3.8 per 100,000 women.	Hospitalised adult injuries; does not include every community-treated fracture.
Zhu et al., Chinese national survey [7]	512,187 respondents; 59 people with 62 fractures in 2014. Incidence 11.5 per 100,000 person-years.	Survey-based ascertainment with a small number of fracture events.

Incidence is not prevalence

Incidence describes new injuries over a specified time. Prevalence describes the proportion of a population living with a condition at a point or over a period. A reliable single global prevalence of calcaneal fracture sequelae cannot be derived from these incidence studies. Persistent pain, deformity and arthritis may outlast fracture healing, so the burden of disability is not captured by counting new fractures alone.

Associated injury matters

In the Edinburgh series, falls from height accounted for 71.5% of injuries. Concomitant lower-limb injuries occurred in 13.2% and spinal injuries in 6.3%. These figures support a careful trauma assessment after high-energy mechanisms; they are not a reason to prescribe the same imaging to every patient regardless of examination and mechanism. [5]

In my assessment, occupation, access to rehabilitation, smoking, home circumstances and the ability to manage a period of restricted loading belong beside the injury pattern. They influence the practical treatment plan without defining a person’s worthiness for reconstruction.

CHAPTER 2 | OUTCOMES IN THE LITERATURE

Why the debate about surgery continues

Evidence about whether to operate and evidence about which surgical approach to use answer different questions. A technique that reduces wound complications compared with an extensile exposure has not thereby demonstrated superiority to good nonoperative care.

Evidence	Main finding	What it does not establish
UK Heel Fracture Trial, 2014 [15]	No symptomatic or functional advantage for ORIF at two years in the studied typical closed displaced fractures; complications were higher after surgery.	It does not settle every severe deformity or modern limited-approach reconstruction.
HeFT follow-up, 2021 [16]	At 60 months, no significant outcome difference; additional procedures in 10 ORIF participants versus 4 nonoperative participants.	Patients with significant deformity causing fibular impingement were excluded.
Cochrane review, 2023 [17]	12 trials, 1,097 participants. Possible functional benefit at 6-24 months; evidence judged low certainty.	A secure general advantage in return to work or later subtalar fusion was not established.
Li et al. randomised trial, 2016 [18]	64 patients. Wound complications 6.3% with sinus tarsi versus 31.2% with an extended lateral approach.	These are study-specific wound-event rates, not this author's infection rates.
Purdie et al. RCT meta-analysis, 2025 [19]	14 RCTs, 1,367 participants; less invasive techniques favoured for wound outcomes with comparable anatomical reduction.	It does not validate the exact standard-plate modification described in this book.

I interpret this evidence as a reason to improve selection, exposure and assessment of recovery. My preference for reconstructing suitable displaced fractures is consistent with a mechanical rationale, but its comparative benefit requires proper study. Small case series should not be used to dismiss randomised evidence.

Long-term prognosis also depends on injury severity. Sanders and colleagues found a greater need for later subtalar fusion among type III than type II fractures in their 10-20-year follow-up. That observation underlines the importance of initial cartilage and fracture damage, even after operative reconstruction. [4]

CHAPTER 3 | ANATOMY AND MECHANICS

Think beyond the posterior facet

The calcaneus transmits load between the talus and the ground while serving as an attachment for the Achilles tendon and plantar structures. The posterior facet articulates with the talus; the anterior process articulates with the cuboid. The sustentaculum tali is an important medial reference, although it should never be assumed to be perfectly intact or undisplaced without reviewing the CT. [9,26]

HEIGHT

Support below the talus

LENGTH

Posterior-to-anterior frame

WIDTH

Space for tendons and shoes

ALIGNMENT

Tuberosity under the leg

Reconstructive objectives; not an anatomical drawing.

The frame beneath the joint

My operative assessment treats the tuberosity and body as the frame beneath the posterior facet. The shape of that frame determines how the articular reconstruction sits under the leg. Rebuilding its outline also creates space for the surrounding tendons and reduces the chance of a mechanically troublesome widened heel.

The lateral wall lies close to the peroneal tendons. The sural nerve is vulnerable in lateral and posterolateral exposure. Medially, prominent screws or instruments can threaten the flexor hallucis longus and the neurovascular structures of the tarsal tunnel. These relationships matter during both reduction and plate placement. [9,12]

A plate is a means of holding a reduction; it is not proof that the reduction is correct. An anatomical outline can encourage the eye to accept a plausible silhouette while residual translation or rotation remains. For that reason, my final assessment returns to separate questions about the facet, the body and the tuberosity.

CHAPTER 3 | PATHOMECHANICS

From axial impact to a complex fracture

A common high-energy mechanism is axial loading through the talus into the calcaneus. Foot position, bone quality and the magnitude and direction of impact influence the fracture pattern. The talus creates articular disruption while displacement can propagate through the body, lateral wall and tuberosity. [11,26]

The contribution of tendon forces

In my teaching, the Achilles tendon helps explain superior displacement of a posterior fragment, while plantar attachments and the surrounding soft tissues influence how fragments remain tethered. Tibialis posterior contributes to hindfoot inversion or supination, but the final injury cannot be reconstructed simply from the pull of one tendon. The combined loading event and the position of the foot remain essential.

It is useful to imagine why a posterior fragment rises, why the lateral wall expands and why the heel may settle into varus. That mechanical reasoning guides reduction. It should not be turned into a new definition of Sanders classification: Sanders describes CT morphology, not a measured scale of supination energy. [3,27]

Articular and extra-articular components may coexist

The central problem addressed in this book is a displaced posterior facet together with extension into the body or tuberosity. A joint-only reduction can leave a poorly controlled posterior or plantar component. A body-only reduction can leave a depressed or rotated articular fragment. My strategy is to understand and control both before relying on the definitive construct. [1]

An important distinction

Sanders A, B and C are named positions of fracture lines on a defined CT section. They are not successive energy levels, and their presence does not prove a particular tendon-driven mechanism.

A useful operative plan therefore contains a description in words as well as a classification code: which part of the facet is displaced; whether the sustentacular reference is reliable; where the fracture exits; and how the body and tuberosity must move to restore the heel.

CHAPTER 3 | THE AUTHOR'S ORIGINAL SKETCH

Load pathways in the hindfoot

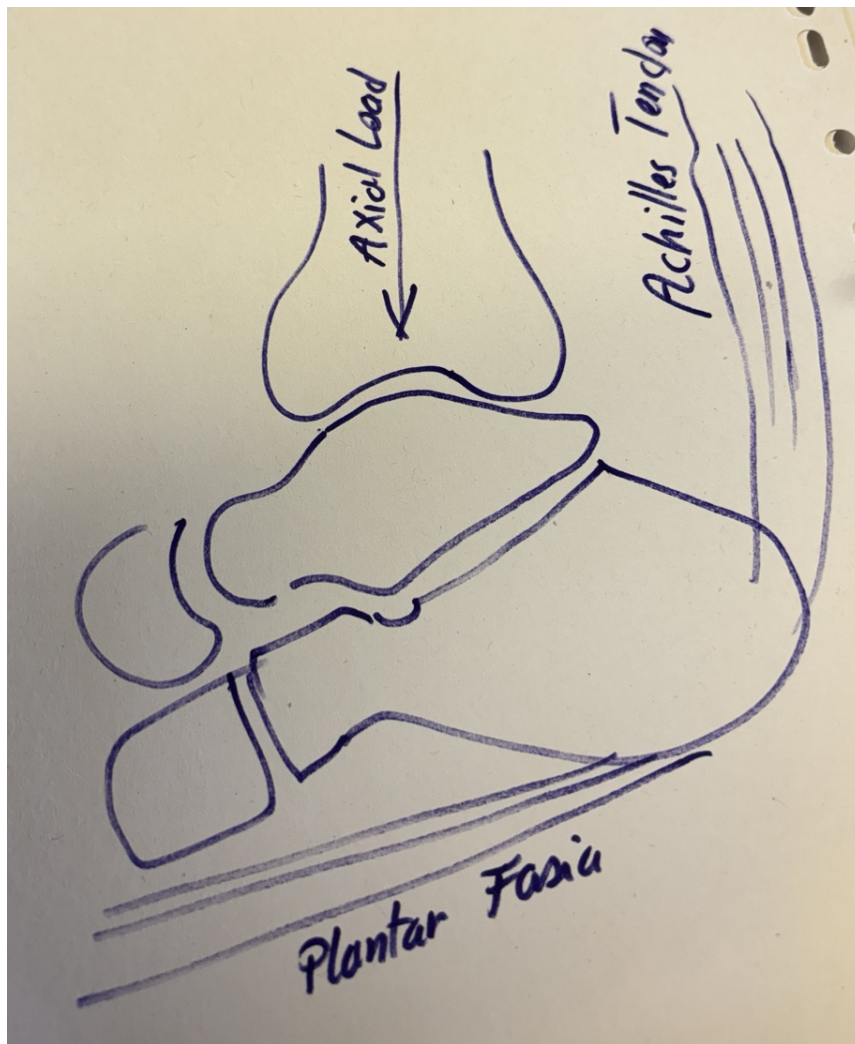


Figure 1. My original sagittal teaching sketch shows axial loading at the ankle and the relationships of the Achilles tendon and plantar fascia to the calcaneus. This is a conceptual drawing, not a patient-specific reconstruction or a quantitative stress model.

The sketch helps me explain why I consider the joint and the entire heel together. Axial impact acts through the ankle and hindfoot, while the surrounding tendon and fascial attachments influence fragment behaviour after the injury. The drawing shows those relationships without attempting to reproduce a particular fracture pattern.

The position of the foot, the direction and magnitude of impact, and bone quality remain important. Neither this sketch nor the tendon labels define the Sanders grade. The mechanism and CT morphology are complementary parts of the assessment. [1,3,11]

CHAPTER 4 | DIAGNOSIS

Examine the person, the skin and the fracture

Diagnosis usually begins with plain radiographs and is completed by early CT when an intra-articular injury or operative reconstruction is being considered. CT should answer the surgical questions raised by the injury rather than merely supply a classification label. [9,11]

Clinical assessment

Record the mechanism, timing, pain, ability to bear weight and relevant comorbidity. Examine the entire limb and inspect the plantar, medial, posterior and lateral skin. Document wounds, blanching, blisters, threatened posterior skin, distal perfusion and neurological findings. With a high-energy mechanism, assess for associated injuries through the appropriate trauma pathway.

Disproportionate or escalating pain, tense swelling or evolving neurological findings require urgent reassessment for compartment syndrome and other complications. An apparently acceptable radiograph is not a substitute for serial clinical observation.

Plain films

A true lateral calcaneal view shows depression, the posterior exit pattern and overall height and length. An axial or Harris heel view helps assess heel width and tuberosity angulation. AP and oblique foot views help evaluate the anterior calcaneus and calcaneocuboid region. Additional ankle images are obtained according to the injury and the operative question. [11]

CT as a map

Review multiplanar images for posterior facet step-off and gap, fragment rotation, comminution, sustentacular displacement, lateral wall blowout, calcaneocuboid involvement and extension into the tuberosity or plantar body. Describe possible tendon entrapment or subluxation and any suspicious relationship between the fracture and adjacent structures. [9]

For Sanders grading, use the appropriate semi-coronal section at the widest posterior facet, reconstructed perpendicular to the relevant talar facet orientation. Review the complete CT as well: one section does not represent the three-dimensional injury. [3,27]

My practical rule

The CT should allow me to name the fragments I must control, the reference I can trust and the direction of each required correction before making the incision.

CHAPTER 4 | RADIOGRAPHIC LANGUAGE

Angles are useful servants of anatomy

Measure or view	Definition and use	Limitation
Böhler angle	On a true lateral image, the angle between the line joining the highest posterior tuberosity to the highest posterior facet and the line joining the highest anterior process to that facet. Common reference range about 20-40 degrees; AO gives 25-40 degrees.	Reduced values suggest loss of height or facet depression; a normal value does not exclude every fracture. [9,11]
Critical angle of Gissane	Angle at the change in slope between the posterior facet region and the anterior process on the lateral view; commonly quoted about 120-145 degrees.	Definitions and projection affect values. Interpret with the actual fracture and CT rather than an isolated threshold. [9]
Calcaneal pitch	Inclination of the inferior calcaneal line relative to the supporting horizontal plane on an appropriately acquired lateral image; an adult reference is approximately 20-30 degrees.	A positioning-sensitive alignment measure; a non-weight-bearing intraoperative image is not directly interchangeable with a standing film. [10]
Heel axial view	Assesses width, tuberosity position and coronal alignment.	Rotation can conceal or exaggerate deformity; assess the clinical heel as well. [11]
Broden-type projections	Oblique fluoroscopic views used to inspect the posterior subtalar facet.	They supplement direct inspection and other views; they do not provide CT-equivalent assessment. [11]

The objective is restoration of useful anatomy, not the production of a normal number while another deformity is left behind. In a comminuted injury I document the direction and size of residual problems, as far as the available images permit.

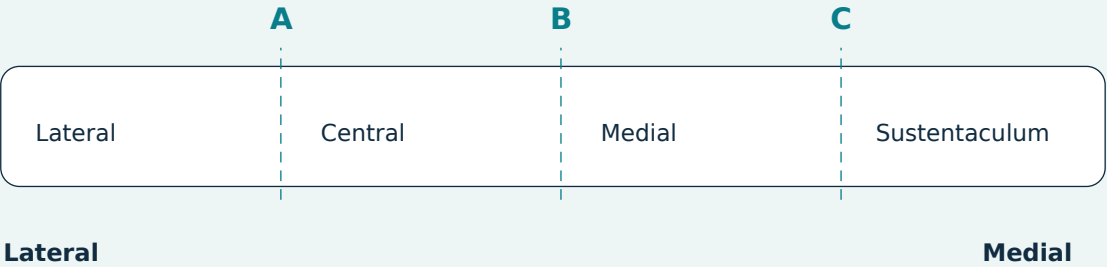
None of the fluoroscopic screen photographs in this edition is calibrated for formal angle measurement. They illustrate stages of the operation and the type of verification required. They are not used to certify perfect reduction or to infer CT-confirmed articular congruity.

CHAPTER 5 | SANDERS CLASSIFICATION

A shared description of the posterior facet

Sanders classification is based on the number and location of displaced articular fragments on CT at the widest posterior facet. It is useful for communication and prognosis, but it is not a complete treatment algorithm. The term *intra-articular* is used throughout this book for involvement of the joint surface. [3,27]

POSTERIOR FACET: CONCEPTUAL CORONAL MAP



Line position, not energy level. Schematic only; not to scale. [3,27]

Type	Description
I	Nondisplaced or minimally displaced posterior facet, conventionally about 2 mm or less, irrespective of the number of fracture lines.
II	Two displaced articular parts with one principal fracture line: IIA, IIB or IIC.
III	Three displaced articular parts with two principal lines: IIIAB, IIIAC or IIIBC; central depression is common.
IV	Four or more articular fragments with three or more principal fracture lines and marked comminution.

Lines A and B project divisions of the talar posterior facet into lateral, central and medial regions; line C is at the medial edge of the posterior facet toward the sustentacular region. The letters locate lines, while the Roman numeral describes the displaced articular fragment pattern. [3,27]

Classification is sensitive to CT reconstruction and observer interpretation. I therefore add a written account of tuberosity displacement, body comminution and calcaneocuboid involvement. A Sanders grade alone does not indicate whether the proposed plate can control the entire injury.

CHAPTER 5 | THE AUTHOR'S ORIGINAL SKETCH

Visualising the A, B and C split positions

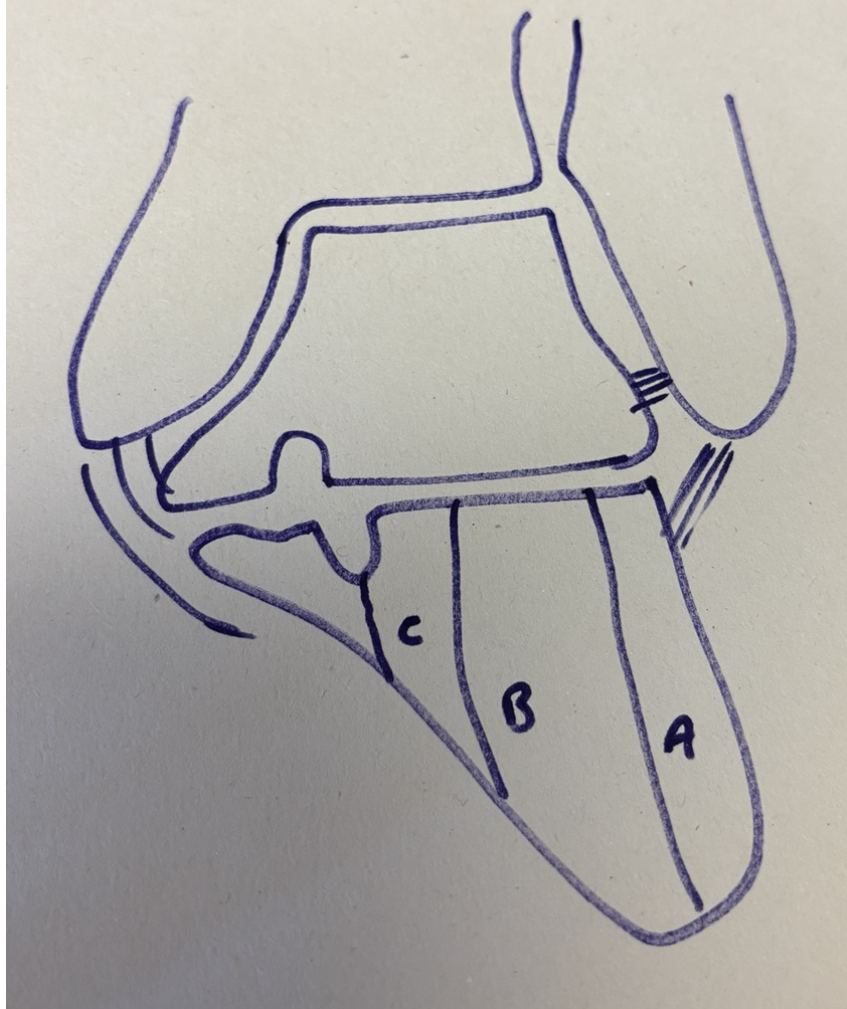


Figure 2. My freehand coronal teaching sketch uses A, B and C to illustrate potential split positions in the calcaneus. In this drawing the A side is on the reader's right and the C side on the left. It is a teaching aid, not a CT section or a formal grading template.

Read this drawing alongside the standard conceptual map on the preceding page. For Sanders classification, the letters locate fracture lines from lateral toward medial on the appropriate posterior-facet CT section. The Roman numeral reflects the displaced articular fragment pattern. [3,27]

My purpose in drawing the fracture lines is to make the geometry easier to discuss. Formal classification still requires the correctly reconstructed CT images and review of the entire injury, including its body and tuberosity extension.

CHAPTER 5 | COMPLEMENTARY SYSTEMS

A second description often answers the operative question

Essex-Lopresti

The correct name is **Essex-Lopresti**. Its familiar lateral radiographic distinction is between joint-depression and tongue-type patterns of intra-articular fracture. In the tongue-type pattern, the secondary fracture line exits posteriorly, leaving an articular fragment connected to a posterior tuberosity component. In the joint-depression pattern, the depressed posterior facet is separated from the posterior tuberosity. It should not be described simply as an extra-articular classification. [8,11]

The posterior skin must be examined immediately in a displaced tongue-type injury. The Achilles can pull the posterior fragment against the skin. Gardner and colleagues documented posterior skin compromise in 21% of their tongue-type fracture series, supporting early recognition and urgent relief of threatening displacement. This is different from waiting for swelling to settle before elective definitive fixation. [21]

Other classification languages

System	Main contribution	Use in this book
Böhler	Historical radiographic descriptions and emphasis on heel shape.	Historical context; Böhler angle is a measurement, not a substitute for a full classification.
Crosby-Fitzgibbons	CT grouping by displacement and comminution.	A complementary morphology-based description.
Zwipp	Considers the extent of osseous and joint involvement.	Encourages assessment of injury complexity beyond one facet.
AO/OTA	A broader coding framework for calcaneal fracture morphology.	Record the current applicable code separately from Sanders line letters.
Anatomical extra-articular description	Anterior process, sustentacular/body and tuberosity injuries outside the posterior facet.	State the actual anatomical component and its displacement.

These systems describe different aspects of an injury. I use them to clarify the problem, not to force every fracture into one operative pathway. Exact coding requires the relevant current classification reference; Sanders A/B/C must not be confused with AO/OTA A/B/C groups. [11,27]

CHAPTER 6 | INDICATIONS AND TIMING

The threshold starts a decision; it does not finish it

My practice favours anatomical reconstruction of a suitable displaced fracture when the expected benefit outweighs the risk. Posterior facet displacement or step-off greater than about 2 mm is an important trigger for specialist assessment, especially with loss of heel shape, impingement or malalignment. It is not, by itself, a universal requirement for surgery. [1,11,15-17]

Situation	Treatment reasoning
Nondisplaced or minimally displaced injury with maintained shape	Nonoperative treatment is often appropriate, with protection, observation and rehabilitation.
Reconstructable displaced facet and/or important heel deformity	Consider reduction and fixation in the context of soft tissues, fitness, expectations and expertise.
Intra-articular fracture with body or tuberosity extension	Plan support of the entire unstable pattern; this is the main setting for my standard-plate modification.
Sanders IV injury	Discuss reconstructability, cartilage injury and the alternatives of fixation, primary subtalar fusion or later fusion.
Open fracture, threatened posterior skin or acute neurovascular concern	Urgent assessment and appropriate emergency treatment; a staged strategy may be required.
Severe vascular compromise or unacceptable overall operative risk	Modify the plan or use nonoperative care; the aim remains a useful and safe recovery.

A smaller incision does not abolish soft tissue risk

For an extensile lateral exposure, wait for a receptive soft tissue envelope and use return of skin wrinkles as one guide. With a limited sinus tarsi approach, earlier surgery may be possible when swelling is modest and the skin is healthy. Marked swelling, blisters, ischaemia or tension at the intended incision remain reasons to defer definitive exposure or choose a staged plan. [12-14]

There is no safe universal calendar day. The first priority is to recognise exceptions requiring urgent reduction, particularly threatened posterior skin. The second is to select the time at which the chosen definitive approach can be performed safely.

CHAPTER 6 | SEVERE INJURIES AND CONSENT

Sanders IV is a discussion, not an exclusion

I do not exclude a fracture from reconstruction solely because it is Sanders IV. In selected cases, a limited exposure may allow restoration of heel shape with less skin disturbance than an extensile approach. That is a preference derived from my experience; a small incision does not make severe cartilage damage disappear. [1]

For an unreconstructable subtalar surface, primary fusion is a reasonable alternative to discuss. A small randomised multicentre trial of Sanders IV injuries compared ORIF with ORIF plus primary subtalar arthrodesis. It does not provide a simple universal answer, and the decision must consider the patient's needs, the actual articular damage and the implications of later surgery. [20]

Discuss the recovery that the person will live through

My consent discussion addresses the possibility of persistent pain and stiffness, post-traumatic arthritis, footwear difficulty, loss of function and delayed return to work despite satisfactory bony healing. Operative risks include wound problems, infection, nerve symptoms, tendon irritation, malreduction, fixation failure and further surgery. The comparison includes an active nonoperative care plan, not an absence of care.

Smoking cessation, diabetic control, nutritional status, medication, vascular assessment where appropriate and the ability to follow the loading plan may change the balance of risk. Age alone does not decide the treatment. The patient should understand why fixation is proposed in this particular fracture and what remains uncertain.

The question I want answered

Can the reconstruction restore a mechanically useful heel at an acceptable biological cost, and is the expected recovery consistent with this patient's priorities?

Define the limits before starting

The operative plan should include what would justify changing the exposure, modifying the construct or moving to a staged strategy. Maintaining a very short incision is not a worthwhile goal if it requires blind dissection, unsafe instrumentation or acceptance of an avoidable deformity.

CHAPTER 7 | THE AUTHOR'S TECHNIQUE

Positioning and fluoroscopy come before incision

The following describes my preferred modification, supported by the technical account in our manuscript and the additional details dictated for this edition. It is not the standard sinus tarsi approach in every unit. [1]

Lateral positioning

I position the patient in a supported true lateral decubitus position, with the injured side uppermost and the lateral hindfoot accessible. Protect the dependent limb, bony prominences and peripheral nerves. Arrange the leg and radiolucent table so that the heel is clear of obstructing supports and the C-arm can obtain the required projections without compromising sterility or stability.

Before preparing the limb, rehearse a true lateral calcaneal image, the planned oblique or Broden-type subtalar views and a heel axial view. Positioning that yields a convenient lateral image but prevents axial assessment is inadequate. An ankle AP or mortise view may be added when it answers a relevant question; it does not replace the facet-specific projections.

View to rehearse	Question it must answer
True lateral calcaneus	Height, length, posterior facet contour, tongue/body relationship and plate profile.
Oblique / subtalar projections	Facet congruity and the relationship of subchondral screws to the joint.
Heel axial	Width, tuberosity translation and varus or valgus alignment.
Additional ankle or foot views	Associated injury, calcaneocuboid region or an implant trajectory that remains uncertain.

Preparation

Anaesthesia is agreed with the anaesthetist; my usual practice uses general anaesthesia with an appropriate regional block. Use antibiotic prophylaxis according to the local policy, a documented tourniquet plan when appropriate, and standard skin preparation and draping. Tourniquet pressure and duration are individual clinical decisions, not fixed prescriptions in this monograph.

Mark the planned incision and identify the structures and safe corridors before working. The accompanying photographs show the operative hindfoot field. They do not show a complete patient setup and should not be treated as proof of whole-body positioning.

CHAPTER 7 | OPERATIVE FIELD

Access through the sinus tarsi



Figure 3. Author-supplied operative view of the lateral hindfoot exposure. The field illustrates access and retraction, not a complete positioning setup.



Figure 4. The incision shown beside a ruler. Perspective prevents a precise incision-length claim from this photograph.

I use a sharp sinus tarsi incision directed from the tip of the fibula toward the fourth metatarsal base, with its exact length and orientation adapted to the joint and fracture. Protect the sural nerve and peroneal tendons. The defining modification is preparation of a corridor that can accommodate a standard lateral anatomical plate. [1,12]

The photographed field is presented as a technical illustration. Identifying and unrelated screen content has been removed by framing; the operative anatomy has not been generatively redrawn.

Respect the depth of the exposure

A limited skin opening can conceal extensive deeper dissection. Tendon mobility, flap perfusion and atraumatic implant passage require the same attention as the appearance of the skin incision.

CHAPTER 7 | SOFT TISSUE CORRIDOR

A short incision with a deliberate deep plan



Figure 5. Detailed view of the lateral exposure and instruments. Individual nerves and tendon boundaries cannot be reliably identified from this photograph alone.

In my modification, the peroneal sheath is released as required and the tendons are mobilised with the protective soft tissue layer. The sural nerve is protected within that layer rather than subjected to unnecessary traction or skeletonisation. This differs from assuming that the usual limited exposure already permits free access to the whole lateral wall. [1]

I develop a controlled plane along the fractured lateral wall, extending only as far as required from the calcaneocuboid region toward the posterior calcaneus. The intended pouch must allow smooth plate passage without catching, compressing or trapping a tendon. A fresh sharp blade is used when needed for controlled dissection; repeated blind cutting beneath the tendons is not the principle.

The release is limited by the soft tissues, their vascular supply and the reduction required. I avoid treating the phrase “liberal release” as permission to strip every fragment. Where passage or reduction cannot be made safe through this access, I change the plan. [1,12]

CHAPTER 7 | ADDITIONAL OPERATIVE VIEWS

Seeing the field during manipulation



Figure 6. An additional view of the operative hindfoot, showing the lateral exposure, retractors and an instrument approaching the posterior heel region. The photograph cannot establish the precise internal instrument position.



Figure 7. A wider view during manipulation, with the surgeon's hands and instruments around the heel. The image illustrates operative access and handling; it does not show the patient's full lateral positioning setup.

These views complement the earlier photographs of the incision and soft tissue corridor. They help explain how access to the joint can be combined with manipulation of the posterior component while maintaining a limited skin exposure.

The surface view and fluoroscopic view answer different questions. Seeing an instrument near the heel does not by itself establish a safe deep trajectory or confirm articular reduction. Those judgements depend on the operative examination, protected access and the relevant imaging. [1]

Use the views together

A photograph illustrates the field and the way it is handled. Fluoroscopy and direct joint assessment are still needed to judge the position of the bone, the instruments and the fixation.

CHAPTER 7 | REDUCTION STRATEGY

Rebuild the foundation before locking the construct

Reduction begins with an understanding of the reliable reference fragment, usually the medial sustentacular region after checking its position on CT. The posterior facet, tuberosity and anterior component are then related to that reference. My sequence is adjusted to the actual pattern; it is not a rigid order for every fracture. [1]

Elevating the depressed facet

When lateral access is sufficient, I elevate and derotate the articular component through the sinus tarsi exposure, checking the visible joint surface and fluoroscopy. With extension into the body and plantar component, my described adjunct is a small separate heel access for an elevator beneath the depressed fragment.

The manuscript describes use of the broad blunt surface of a Langenbeck retractor to distribute the elevating force. Access should exploit an appropriate fracture corridor rather than create an unnecessary defect through intact bone or the load-bearing heel pad. The plantar soft tissues and medial structures must be protected. This is a specialised, case-dependent manoeuvre and not a routine instruction to puncture the sole. [1]

Elevation is controlled and observed. If a mallet is used, taps are minimal and directed, with repeated checking of the instrument position and fragment response. Force is stopped if resistance or the trajectory is unexplained. A broad instrument does not prevent over-elevation, cartilage penetration or injury to unseen structures.

Controlling the posterior component

An additional small posterolateral access just anterior to the Achilles may assist controlled tuberosity manipulation. My manuscript describes a ball-spiked reduction clamp to reduce the elevated posterior component. The objective is to recover heel height and length while bringing the tuberosity beneath the reconstructed facet; protect the Achilles, sural nerve and skin from the instrument and clamp points. [1]

Reduction must be observable

Direct inspection, tactile information and more than one fluoroscopic projection should agree. When the views disagree, resolve the discrepancy before placing definitive screws.

CHAPTER 7 | FLUOROSCOPIC DEMONSTRATION

Indirect elevation and provisional control



Figure 8. Lateral fluoroscopic photograph with an instrument projected beneath the posterior calcaneal region during reduction. The image demonstrates an operative stage, not a measured final result.



Figure 9. Provisional wire fixation after manipulation. The projected trajectory illustrates temporary control; safe depth and extra-articular position require assessment in additional views.

I use temporary wires to maintain the reconstructed relationship while judging height, length and joint position. Oblique caudocephalad wires from the calcaneus toward the talus may be used for temporary transarticular stabilisation in selected cases. Such wires deliberately cross the joint and must be recognised as temporary reduction aids, with a documented removal plan. [1]

Check every wire and instrument against the relevant anatomy and other projections. A satisfactory lateral silhouette alone cannot establish that the posterior facet is congruent, that a wire is safely positioned or that tuberosity translation has been corrected.

What these images can show

They illustrate the sequence and tools used. They cannot supply an audited reduction grade, a calibrated angle or the eventual functional outcome.

CHAPTER 7 | FLUOROSCOPIC CORRELATION

Relating the instrument to the posterior calcaneus

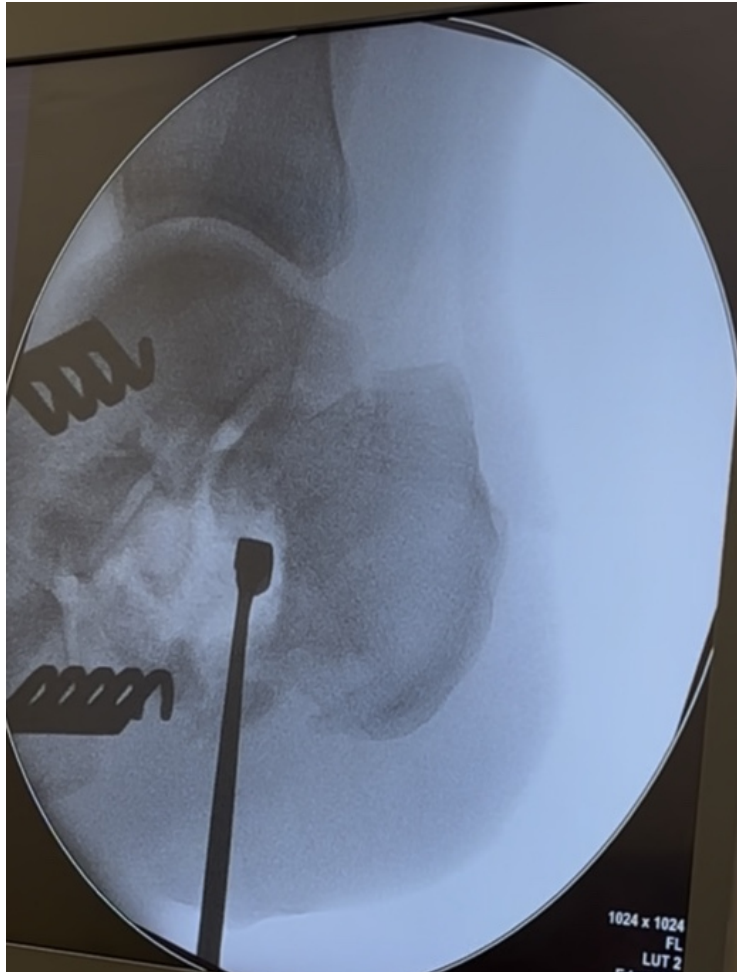


Figure 10. A de-identified crop from the additional monitor photograph shows the same reduction-stage projection as Figure 8 from a different screen framing. An instrument is projected beneath the posterior calcaneal region. The monitor photograph is oblique and is not used for calibrated measurements.

The skin photographs describe the field; this image shows how a reduction instrument relates to the bony projection. Reviewing both is useful for teaching the indirect manoeuvre described in this chapter, while recognising the limitations of a single image.

This is a further illustration of an operative stage already represented in the book, not an additional patient or a separate outcome. It does not prove instrument depth, CT-confirmed joint congruity, or final alignment. The identifying monitor text and unrelated screen content have been removed from the published crop.

CHAPTER 7 | PLATE APPLICATION

Use the plate to support an achieved reduction

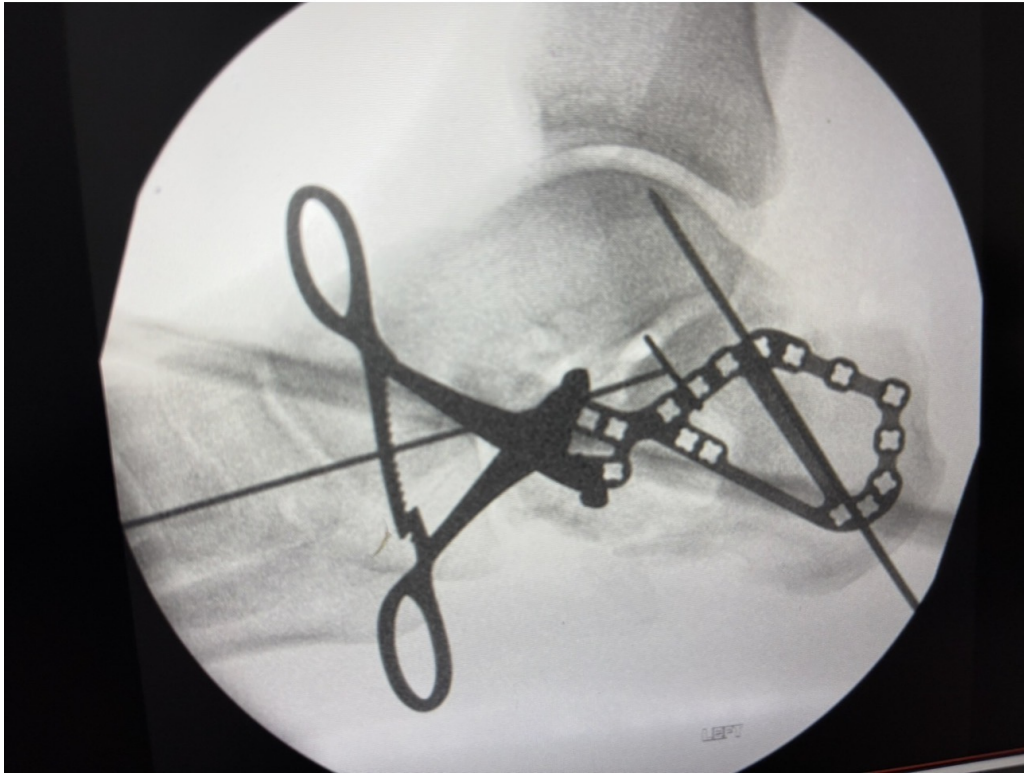


Figure 11. A standard lateral calcaneal plate is provisionally positioned with wires and a clamp. This stage precedes definitive screw fixation.

I introduce an appropriately sized standard anatomical lateral plate through the prepared corridor and check its relation to the posterior facet, tuberosity, anterior calcaneus and peroneal tendons. The plate must sit in a suitable plane without undue pressure on the skin or tendons. [1]

A small number of nonlocking cortical screws can be used selectively to draw suitable fragments toward the plate and restore lateral wall width. This “pull-home” effect is a reduction tool, not a justification for uncontrolled compression. It can distort the heel or displace a fragment if the plate is malpositioned or the medial reference is unreliable.

I reassess the joint and heel after each meaningful change. Only when the relationship is satisfactory do I complete the planned locking fixation. Locking screws retain the relationship present at insertion; they do not automatically create compression, restore length or correct an already malreduced tuberosity.

CHAPTER 7 | CONSTRUCT DESIGN

Three regions need reliable purchase

My practical minimum is an intended two screws in the tuberosity, two in the subarticular region and two in the anterior component toward the calcaneocuboid region. This “two-two-two” pattern is an author preference for regional capture, not a validated universal minimum or an instruction to place six screws regardless of fracture size. [1]

AUTHOR'S REGIONAL CAPTURE PLAN

TUBEROSITY



2 intended screws

SUBARTICULAR



2 intended screws

ANTERIOR



2 intended screws

A planning preference, not a validated universal minimum. [1]

The fracture, bone quality, plate design, screw paths and achieved fixation determine whether that plan is sufficient or even appropriate. A screw counted in a region is useful only if it captures a meaningful fragment with adequate purchase and does not enter a joint or endanger medial structures.

Conventional and locking screws do different jobs

Conventional screws may help bring selected bone to the plate; fixed-angle or variable-angle locking screws provide angular support within the permitted design. I use the manufacturer's current instructions for screw compatibility, trajectories, drilling guides, torque and any allowed plate contouring. Components from different systems are not assumed to be interchangeable.

Newer anatomical plates can offer a range of locking options from several manufacturers. This book evaluates a reconstructive strategy, rather than a particular company. It does not claim that one plate is superior, nor that every standard lateral plate can be safely inserted through every sinus tarsi exposure.

Before completion

Confirm the actual fragment capture, screw length, tendon clearance and joint clearance. A visually pleasing plate outline and a sufficient screw count are not substitutes for these checks.

CHAPTER 7 | FIXATION IMAGES

Progression toward definitive fixation



Figure 12. Lateral fluoroscopic view during plate fixation. Additional projections are required to assess screw purchase and joint clearance.



Figure 13. A later lateral fluoroscopic view of the plate-and-screw construct. A separate projected wire is visible; this is not used to assert removal of every temporary aid.

The images show how the standard lateral plate can span the tuberosity, subarticular region and anterior calcaneus. They do not demonstrate that this exact construct is adequate for every configuration or that every screw is extra-articular.

My completion assessment uses the lateral image for heel shape and implant profile, oblique subtalar projections for the facet and subchondral region, and a heel axial view for width and tuberosity alignment. Any uncertain screw trajectory is resolved before closure.

Temporary means temporary

Reconcile the wire and instrument count, document the removal or intended retention of temporary stabilisation, and save the relevant completion images. Do not infer the completed count from an isolated photograph.

CHAPTER 7 | A KNOWN TECHNICAL LIMITATION

Tuberosity translation must be judged separately



Figure 14. Axial fluoroscopic photograph of the calcaneus and fixation. This projection is particularly relevant to heel width and tuberosity alignment, but the supplied photograph is not sufficient for a quantitative deformity assessment.

One difficulty in my experience is residual medial translation of the tuberosity. It may persist despite a satisfactory lateral view and despite attempts to draw the bone toward the plate. This observation should be distinguished from the more familiar problem of varus: translation and angulation are different deformities. [1]

I therefore inspect the clinical heel and repeat a properly aligned axial projection before committing to the final construct. If translation remains unacceptable, I revisit the reduction rather than assume that another cortical screw will correct it. A cortical screw can narrow the heel without necessarily restoring the tuberosity to its correct position beneath the talus.

The goal is a useful three-dimensional relationship: facet reduction, length and height, appropriate width and tuberosity position. The supplied image illustrates the reason for checking the axial plane; it is not labelled as proof of perfect or imperfect alignment in that individual patient.

CHAPTER 8 | CLOSURE AND AFTERCARE

A reconstruction must survive its soft tissues

Before the skin is closed

Release excessive retraction, inspect the soft tissue corridor and ensure that the peroneal tendons are free to glide. Check the wound, haemostasis and skin tension; release the tourniquet when clinically appropriate to assess perfusion and bleeding. If tendon sheath or retinacular structures have been released, consider their restoration according to the exposure and the stability of the tendons.

Close in a manner that protects the wound edges and avoids strangulating sutures. Allgöwer-Donati-type principles may be useful where appropriate. The closure must fit the tissue condition; it is not a substitute for avoiding excessive tension or for changing a plan that has compromised perfusion. [13,22]

An individual postoperative plan

Elevation, a protective dressing or splint, analgesia and a clear wound-review arrangement are central. Give explicit advice on increasing pain, wound discharge, fever, loss of sensation or perfusion and other symptoms that warrant prompt reassessment. Document thromboprophylaxis according to the local protocol and the person's risk assessment.

The loading prescription must reflect fixation stability, comminution, bone quality, associated injuries and the ability to follow the plan. A standard plate or locking screws alone do not justify immediate unrestricted weight bearing. The retrieved case series does not provide a uniform postoperative loading protocol, so none is attributed to that cohort.

Movement and protection

I balance protection of the reconstruction and the skin with prevention of avoidable stiffness and deconditioning. Ankle and subtalar motion are introduced when the wound and fixation permit. A boot may facilitate selected stages, but its fit, pressure points and timing require review rather than automatic use in every patient.

Recovery is part of the operation

A technically successful fixation is only one stage. The patient needs a practical plan for mobility, home support, wound review, rehabilitation and the return to shoes and work.

CHAPTER 8 | FOLLOW-UP AND COMPLICATIONS

Measure function as carefully as the radiograph

My follow-up questions concern wound healing, pain, sensation, swelling, tendon symptoms, walking, footwear and the ability to resume meaningful activity. Radiographs address healing, maintenance of shape, implant position and any evolving concern. Persistent focal pain or uncertainty about a screw or the joint can justify further assessment and selected CT.

Problem to recognise	Clinical implication
Wound breakdown or infection	Assess promptly, distinguish superficial from deep involvement, and plan treatment around both soft tissues and fixation.
Sural symptoms or peroneal irritation	Examine distribution, tendon glide, instability, local scarring and possible implant prominence.
Persistent widening, translation or varus	Relate symptoms and shoe fit to a clinical and radiographic assessment of malunion.
Joint pain and stiffness	Consider cartilage injury, incongruity, post-traumatic arthritis and adjacent causes; union alone does not establish a painless joint.
Disproportionate pain with sensory, vasomotor or sudomotor changes	Consider complex regional pain syndrome through an appropriate clinical assessment; avoid labelling all postoperative pain as CRPS.
Loss of reduction or implant failure	Assess the cause, stability, infection risk and the role of revision or a salvage procedure.

Outcomes worth recording

For future evaluation I would record a validated patient-reported foot and ankle measure alongside a calcaneal-specific functional assessment, pain, shoe fit, work status and reoperation. If the AOFAS ankle-hindfoot score is used, recognise that it combines clinician and patient components and is not a purely patient-reported measure.

Report baseline injury severity, time from injury, treatment and rehabilitation as well as the outcome score. A return-to-work result without occupation or follow-up duration is difficult to interpret. The absence of infection is encouraging, but it cannot stand in for an assessment of function or the later development of arthritis.

CHAPTER 9 | THE CENTRE’S EARLY EXPERIENCE

Our early clinical series

Our working manuscript describes seven patients treated in a UK level-one academic major trauma centre between February 2021 and August 2023 for intra-articular calcaneal fractures with extra-articular extension. The treatment combined a modified sinus tarsi approach, indirect reduction and a standard lateral calcaneal plate. [1]

Item	Reported information
Number and period	Seven patients; February 2021 to August 2023.
Age	Mean 39.14 years; range 27-60 years.
Mechanism	Three jumps from height, two high-energy road traffic collisions and two falls from height.
Laterality	One patient bilateral, one right-sided and five left-sided. The number of fractures actually operated on is not reconciled in the results.
Time to surgery	Mean nine days.
Wound course	One patient with a slight wound ooze; no clinically recorded surgical-site infection in the reported series.
Radiographic course	The manuscript describes satisfactory healing, without recorded screw loosening or plate breakage on clinic radiographs.
Risk context	Two patients were described as having a smoking history with associated alcohol and drug misuse; the source records advice to abstain.

Read the denominator carefully

The source uses seven patients and also reports one bilateral injury. It does not state clearly whether both heels in that person received the described operation. This edition therefore reports the patient count and avoids inventing an eight-fracture operative denominator.

No patient names, dates of birth or identifiers from the research working documents are reproduced. The operative demonstration images supplied for this book are not linked to a row in that cohort, and should not be counted as additional study cases.

CHAPTER 9 | OUTCOMES AND THEIR LIMITS

Encouraging observations, incomplete functional data

Domain	Evidence available for this edition
Surgical-site infection	The fuller manuscript reports no clinically recorded infection among seven patients and notes one minor wound ooze. This is a reported series observation, not an independently audited risk estimate.
Neuropraxia and CRPS	For this book the author reports that no major neuropraxia or complex regional pain syndrome was observed. The retrieved manuscript does not provide a structured neurological or CRPS assessment or its follow-up window.
Sanders IV injuries	The author reports experience including some type IV injuries. The manuscript's Sanders distribution is incomplete, so the number and outcomes of this subgroup cannot be supplied.
AOFAS or other functional scores	The fuller results section does not supply a completed AOFAS value. No mean, distribution, preoperative comparison or improvement can be calculated.
Follow-up and final reduction	A defined follow-up duration, independent CT reduction grades, return-to-work results and later fusion/reoperation data are not supplied.
Healing and implants	Satisfactory healing and no recorded screw loosening or plate breakage are described; an audited union rate or time to union is not available.

These observations are consistent with technical feasibility and an encouraging early wound course. They do not establish superior safety, elimination of neuropraxia or CRPS, prevention of arthritis, or effectiveness for every calcaneal pattern. The absence of an event in a small uncontrolled series does not mean that the underlying risk is zero.

The next study should answer a specific question

A prospective evaluation should define eligibility, patient and fracture denominators, baseline CT pattern, comorbidity, operative details, complications and follow-up. Independent assessment of reduction and validated functional outcomes should accompany pain, shoe fit, work, reoperation and subsequent arthrodesis. A comparison group and adequate follow-up are needed before claiming comparative benefit.

CHAPTER 10 | DISCUSSION AND CONCLUSION

A limited approach with comprehensive support

My preferred strategy combines a modified sinus tarsi incision, careful mobilisation of the lateral soft tissues, direct and indirect reduction, and standard anatomical lateral plating. Its principal intended application is the reconstructable displaced intra-articular calcaneal fracture with extension into the body or tuberosity. [1]

I regard the articular surface and the extra-articular frame as connected responsibilities. I want to recover heel length and height, reduce widening, restore a useful relationship beneath the talus and protect the tissues that make the reconstruction viable. A comprehensive plate may help capture regions beyond the direct view, but only if safe passage and adequate reduction have already been achieved.

What I propose

I propose considering this combination across a broad range of suitable displaced patterns, including selected Sanders IV injuries, rather than excluding reconstruction because a limited articular exposure appears too small for the entire fracture. The incision, indirect reduction manoeuvres and implant footprint must be planned together.

What the present evidence supports

Our early series describes feasibility and an encouraging wound course. Published evidence supports the potential wound advantages of less invasive approaches compared with extensile lateral exposure. Neither body of evidence proves the superiority of this exact modification to all alternative techniques or to nonoperative treatment. [1,18,19]

Nonoperative management remains appropriate for many minimally displaced injuries and for people whose risk-benefit balance favours it. Primary subtalar fusion remains an option when the joint cannot be reconstructed usefully. The choice should be explained in terms of the particular fracture and the particular person. [11,17,20]

My concluding principle

Restore the joint and the heel together. Use the least soft tissue disturbance that permits a safe, observable and mechanically adequate reconstruction. Judge success by the person's recovery as well as by the plate and the radiograph.

A new philosophy becomes useful when it makes our decisions clearer and our results more honestly measurable. For this technique, the next step is a defined prospective record that can test the mechanical reasoning against pain, function, footwear and long-term recovery.

TEACHING SUMMARY

Ten questions to take into theatre

Before surgery	At reduction and fixation
1. Have I assessed the patient and the whole injury?	6. Are the facet, body and tuberosity reduced in three dimensions?
2. Is the posterior skin threatened, or is there an open injury?	7. Can the plate pass without trapping or compressing the tendons?
3. What does the complete CT show beyond the Sanders grade?	8. Do the screws capture the planned regions and clear the joints?
4. Are the soft tissues receptive to this exposure?	9. Have I checked width, translation and varus on an adequate axial view?
5. Can I obtain all required fluoroscopic views before incision?	10. Are the wire count, closure and individual aftercare plan complete?

Working glossary

Posterior facet: the major posterior subtalar articular surface.

Sustentacular fragment: the medial reference fragment, whose position must still be checked.

Tuberosity or tuber: the posterior heel component; “tail” is informal terminology.

ORIF: open reduction and internal fixation.

STA / ELA: sinus tarsi approach / extensile lateral approach.

Step-off: mismatch in articular surface height; distinct from a gap.

Translation: a shift of a fragment; distinct from angular deformity.

CRPS: complex regional pain syndrome.

Illustration record

Figures 1-2 reproduce my original hand-drawn teaching sketches. Figures 3-7 are author-supplied operative photographs. Figures 8-14 are author-supplied fluoroscopic photographs, including a de-identified crop from the additional monitor view. Screen interfaces, identifying monitor text and unrelated thumbnails have been excluded. No generative change was made to bone, instruments or fixation.

The three additional teaching schematics illustrate reconstructive dimensions, Sanders fracture-line positions and regional screw capture. They are original diagrams, not copied patient images, not to scale and not a substitute for imaging or manufacturer instructions.

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