

MAJOR TRAUMA | FOOT AND ANKLE SURGERY

Philosophy of Ankle Fracture Classification and Targeted Treatment

Understanding the injury and restoring useful function



Mr Peyman Bakhshayesh

MD, PhD, MBA

Consultant Major Trauma

Specialising in foot and ankle surgery

COMPLETE ILLUSTRATED EDITION | 17 OCTOBER 2026

COMPLETE ILLUSTRATED EDITION

Philosophy of Ankle Fracture Classification and Targeted Treatment

Mr Peyman Bakhshayesh, MD, PhD, MBA

Consultant Major Trauma, specialising in foot and ankle surgery

A clinical book connecting injury mechanisms, classification and diagnosis with targeted reconstruction, rehabilitation and the long-term consequences of ankle trauma.

This edition preserves and develops the author's seven supplied chapters, adds a foundation in functional anatomy and patho-biomechanics, expands the six-pattern framework, and brings the reasoning together through worked examples and practical records.

First complete illustrated edition • 17 October 2026

SCOPE AND PROVENANCE

About this edition

This book is written for clinicians, surgical trainees and readers seeking a detailed understanding of adult ankle trauma. It is a referenced narrative account of clinical judgement. Treatment decisions require assessment of the individual patient, current professional guidance and appropriate surgical training. Children, open injuries, vascular emergencies, neuropathic reconstruction and major pilon fractures require their specific pathways.

The author's practical voice and clinical philosophy have been retained from his supplied chapters and previous books. Personal techniques, developing hypotheses and established evidence are identified separately. The proposed Bakhshayesh six-pattern framework is described as a developing classification; the book does not claim independent validation or comparative superiority.

The original navy and gold cover artwork has been retained from Philosophy of Foot and Ankle Surgery. It is conceptual artwork, not a clinical anatomical reference. Eight new vector teaching diagrams explain decisions and relationships. Twelve clinical radiographic, fluoroscopic and CT images from the author's Drive archive illustrate observable morphology and reconstruction. No image is assigned to a particular proposed mechanism without supporting evidence.

Clinical images were converted into fresh, flattened images. Visible identifying information and source patient/study metadata are absent from the publication copies. Laterality, weight-bearing and orientation markers have been retained where useful. Source documents and raw clinical files are not embedded in the book. Captions state what can be seen without inventing patient history, follow-up or outcome. The worked scenarios in Chapter 9 are constructed teaching examples, separate from these images.

Sources were checked for this edition in October 2026. References provide direct links where available. The legal discussion is principally concerned with England and Wales; it should not be assumed to describe every jurisdiction. This publication does not imply endorsement by an employer, university, professional society or implant manufacturer.

© 2026 Mr Peyman Bakhshayesh. All rights reserved in the original author text and book design. Referenced works retain their respective rights.

NAVIGATE THE BOOK

Contents

About this edition	3
Preface	5
Introduction	6
Functional anatomy and patho-biomechanics	8
Chapter 1 Classification	16
Chapter 2 Diagnosis	22
Chapter 3 Timing of ankle fracture fixation	28
Chapter 4 Surgical planning for ankle fractures	36
Chapter 5 Rehabilitation after ankle fracture	43
Chapter 6 Post traumatic events and their treatment	52
Chapter 7 Medico legal aspects of ankle injuries	63
Chapter 8 The six pattern framework and targeted treatment	69
Chapter 9 Clinical reasoning through worked examples	75
Appendix A Practical records for the treating team	78
Appendix B Terms used in this book	80
A practical method for describing an ankle fracture	82
Illustration sources and interpretation	85
References	86

Preface

An ankle fracture must be understood before it can be treated well. The visible break is one part of an injury involving a loaded joint, its stabilising ligaments, the surrounding soft tissues and the person who depends on that limb. My purpose in writing this book is to connect these elements with the decisions we make in the emergency department, fracture clinic and operating theatre.

This book continues the approach developed in my writing on major trauma and foot and ankle surgery. I begin with the patient and the mechanism, then ask what treatment can realistically achieve. Restoring an image is valuable when it helps restore a stable, useful limb. Radiographic union, a technically satisfactory operation and meaningful functional recovery are related, but they are not interchangeable outcomes. The patient wants to stand, walk, work and return to a life that has been interrupted. [1, 2]

My experience in trauma and reconstruction has encouraged me to question descriptions that leave an important part of the injury unexplained. Weber and Lauge-Hansen remain useful systems. They give us a common language and help us anticipate associated injuries. Nevertheless, a familiar label must not stop us examining the posterior and anterior parts of the joint, the direction of talar displacement, or an impacted articular surface.

The particular concern developed here is the ankle fracture in which sagittal displacement is prominent and the observed morphology does not fit comfortably within the usual mechanistic sequence. Our study group has investigated these atypical injuries. In this book I develop a six-pattern framework around hyperflexion and hyperextension, each occurring alone or with pronation or supination. It is a developing clinical proposal. Its definitions, reliability and ability to improve decision making require further investigation; the value of a classification must be demonstrated rather than assumed. [3]

I also want to preserve a humane approach to examination. An injured ankle does not need repeated painful manipulation to prove that it is injured. It does need a careful assessment of the skin, circulation, sensation, associated injuries and position of the joint. Urgent treatment and diagnostic precision must support one another.

This book addresses adult ankle fractures, from classification and diagnosis through operative planning, rehabilitation and the consequences of injury. Children, open injuries, vascular emergencies and major pilon fractures require additional pathways beyond routine closed malleolar care.

Personal interpretation is identified as such. Published studies, conference findings and established guidance have different evidential weight. I regard that distinction as part of responsible surgical teaching: we should be able to explain both why we believe a treatment is appropriate and where uncertainty remains.

Mr Peyman Bakhshayesh

Introduction

Why ankle fractures deserve renewed attention

Ankle fractures are common orthopaedic injuries, but frequency does not make them simple. A short fall may produce an isolated lateral malleolar fracture, an unstable fracture-dislocation or a complex articular injury. The external event alone does not describe the damage. The position of the foot, movement of the leg, magnitude and direction of loading, bone quality and soft-tissue constraints all influence the resulting pattern.

The burden of injury also changes with the population. Historical studies described increasing low-trauma ankle fractures in older people, although subsequent trends have varied between age groups and countries. A Finnish national study of 118,929 operatively treated fractures from 1987 to 2019 found an increasingly older and more comorbid surgical population, with increased operative incidence among women over 70, despite levelling or declining trends in other groups. It would therefore be misleading to describe an uninterrupted increase in every population. The practical issue is the changing complexity of the people we treat. [4]

Body mass and falls deserve attention. A prospective study of older women associated ankle fractures with higher body mass index and previous falls. These associations do not establish the mechanism of every fracture, and ankle fractures should not all be equated with osteoporotic fragility fractures. [5] Similarly, diabetes is not a single risk category: neuropathy, vascular disease and other complications alter clinical assessment and treatment risk. Research comparing complicated and uncomplicated diabetes demonstrates the importance of these distinctions. [6]

In my proposed explanation of atypical injuries, impaired protective movement may be relevant. Neuropathy, poor balance, reduced coordination, alcohol or the effects of medication might change how the foot and leg behave during a fall. Higher body mass might alter the forces transmitted through the joint. These are hypotheses to investigate. Our preliminary fracture observations do not establish that any one of these factors causes a particular hyperflexion or hyperextension pattern.

Understanding the person and the damaged joint

My earlier books place the patient's story at the centre of treatment. In ankle trauma this means understanding previous walking ability, independence, occupation, activity, sensation, vascular health and the circumstances of the fall. A plan that assumes safe non-weight-bearing may be impractical for someone with poor balance or limited upper-limb strength. A technically ambitious reconstruction must be considered alongside tissue healing and the patient's ability to participate in recovery. [1, 2]

I regard the ankle as a functional relationship between the tibia, fibula and talus, supported by ligaments and surrounded by a vulnerable soft-tissue envelope. The fibula helps define the mortise; the medial structures resist displacement; the syndesmotic complex maintains the distal tibiofibular relationship. Anterior and

posterior fragments may affect the articular surface, ligament attachments and the containment of the talus. These structures must be considered together.

The first question is whether the joint and limb are threatened now. The second is what has failed. The third is how to restore and maintain an acceptable relationship while the tissues heal. I would then ask whether the proposed treatment offers a realistic route towards the patient's functional goals.

These questions remain useful whether the eventual management is a removable support, a cast, internal fixation or temporary external fixation.

Why the lateral image matters

The frontal images show important features of the mortise, medial clear space and fibular level. The lateral image contributes information that cannot safely be inferred from them: anterior or posterior talar translation, articular displacement and the relationship of the talus to the tibial plafond. When the ankle has been reduced before arrival, the earlier images and the reduction record can be particularly informative.

My emphasis on the lateral image is intended to strengthen complete assessment. Weber and Lauge-Hansen were not systems for using the anteroposterior image alone. Contemporary AO guidance explicitly requires a full radiographic assessment, including lateral and mortise views. The more precise criticism is that a short classification label may underdescribe a complex injury, especially when sagittal displacement, shear or impaction is substantial. [7, 8]

Lyndon W. Mason and colleagues in Liverpool have contributed to understanding posterior malleolar pathoanatomy and associated injuries. Stefan Rammelt and colleagues have described quadrimalleolar injuries, including the importance of an additional anterior component. Their work encourages us to examine morphology and associated instability rather than simply count fragments. It also provides a useful context for our own investigation of atypical fractures. [9, 10]

FOUNDATIONS

Functional anatomy and patho-biomechanics

An ankle fracture is a failure within a moving, load-bearing system. The fracture line is the part most readily seen, but its significance depends on the relationship between the talus, the tibial plafond, the fibula and the restraints that guide their movement. Before deciding where to place a plate, I want to understand which relationship has been lost, what is still functioning and what must be restored for this particular patient.

This requires three complementary descriptions. Anatomy tells us what has been damaged. Biomechanics explains how that damage may alter movement and loading. Biology tells us whether the tissues can tolerate the proposed treatment and how they may recover. A satisfactory plan needs all three. The following account concerns the adult ankle; it provides a foundation for classification and targeted treatment without assuming that a fracture label determines the operation.

The mortise: a relationship rather than a rigid socket

The distal tibial articular surface forms the roof of the ankle mortise. The medial malleolus and distal fibula provide its medial and lateral boundaries, while the anterior and posterior tibial margins contribute to containment. The talar dome sits within this arrangement. The articular surfaces distribute force through their shape, congruence and cartilage, and the ligaments limit displacement while permitting useful movement. The tibia carries the principal load into the talus; the fibula contributes both to load sharing and to the geometry of the mortise.

It is helpful to distinguish contact from containment. Contact describes which surfaces transmit compressive force at a particular instant. Containment describes the ability of the surrounding bone and ligaments to keep the talus in an appropriate relationship throughout movement. An apparently small marginal fragment may carry relatively little of the central weight-bearing surface but still matter because it forms a buttress or carries a ligament attachment. Conversely, an impacted central osteochondral fragment may have little effect on the external outline while substantially altering the bearing surface.

The talar dome is not a perfect cylinder and the mortise is not a fixed hinge. The anterior part of the trochlea is generally wider than the posterior part; its curvature and the surrounding constraints produce coupled motion. Accordingly, the joint relationship in dorsiflexion differs from that in plantarflexion. Anatomical variation and foot position also affect measurements. Souleiman and colleagues demonstrated position-dependent changes in three-dimensional distal tibiofibular relationships in intact cadaveric ankles. This supports consistent positioning when comparing scans rather than treating every small difference as pathological. [11]

Load transfer and the meaning of congruence

During standing and walking, the force transmitted through the ankle reflects body weight, acceleration and muscle activity. It cannot be understood from body weight alone. The location and direction of the force change through the gait cycle, as do the region of cartilage in contact and the contribution of the surrounding restraints. A joint that appears satisfactory while unloaded must also be capable of maintaining a useful relationship during the tasks for which the patient needs it.

Ramsey and Hamilton reported a marked reduction in contact area with a small imposed lateral talar shift in a dissected experimental model. Lloyd and colleagues subsequently reproduced a similar effect. These experiments explain why talar alignment deserves attention, but they are not a universal clinical calculator: a measured millimetre on an imperfect radiograph cannot be converted directly into a fixed percentage of future cartilage loss or an automatic indication for surgery. Experimental geometry, loading and tissue preparation differ from an individual injured ankle. [12, 13]

The practical objective is to reconstruct a congruent, stable articulation with appropriate length, rotation and alignment of its supporting structures. These features belong together. Fibular shortening may change the lateral boundary; rotation may alter its fit in the tibial incisura; an articular step may disturb local contact even when the mortise looks symmetrical. I therefore ask where the talus is, where it can move and what will happen to that relationship under the planned rehabilitation conditions.

Medial support: more than a medial malleolus

The medial malleolus and deltoid complex form an important restraint to abnormal talar movement. The deltoid has superficial and deep components with attachments extending towards the talus, calcaneus, navicular and spring ligament region. Detailed anatomical work demonstrates both consistent structures and variation in the appearance of individual bands. The phrase “deltoid injury” can therefore conceal different anatomical lesions. A medial malleolar fracture, an avulsion and a partial ligament tear need not have identical functional consequences. [14]

The remaining restraint matters as much as the damaged structure. Cadaveric work examining the posterior deep deltoid demonstrated preserved stability while that component remained intact in the tested model. The appropriate inference is that medial competence cannot be reduced to tenderness, bruising or one ligament label. It is not that an intact-looking posterior band guarantees stability in every combination of fracture, impaction and syndesmotic injury. Its significance must be interpreted within the entire injured joint. [15]

A vertical or oblique medial fracture also asks a different mechanical question from a small transverse avulsion. The former may represent a shear surface and may coexist with adjacent articular impaction. The latter may be a marker of tensile failure at an attachment. These are clues to inspect the images, not proof of the complete accident sequence. Restoration of the medial boundary requires attention to the joint surface and any interposed tissue as well as to the visible cortical line.

Lateral support: the fibula and lateral ligament complex

The distal fibula forms the lateral malleolus and participates in the mortise and distal tibiofibular articulation. Its length, rotation and position in the incisura should be considered separately. A fracture can look acceptably aligned in one projection while remaining rotated or translated in another. Reduction therefore requires more than closing a visible gap. It requires reconstruction of the relationship between the distal fragment, the talus and the tibia.

The lateral ligament complex includes the anterior talofibular, calcaneofibular and posterior talofibular ligaments. Their orientations and attachments differ, and their contribution changes with ankle and hindfoot position. The calcaneofibular ligament also links the fibula to the calcaneus, illustrating why ankle and subtalar behaviour cannot always be separated. Cadaveric studies of ligament forces and joint motion show that the restraints engage differently across positions; a ligament is not an equally tight cable throughout the range. [16, 17]

This has two implications for fracture interpretation. First, a lateral avulsion may be evidence of ligament-bone failure, not merely an incidental chip. Second, a restored fibula does not by itself prove that all restraints have recovered. The lateral side must be assessed in its reconstructed relationship with the medial structures, the tibial margins and the syndesmosis. The test of success is a coherent joint, not an isolated bone that looks straight.

The syndesmosis: controlled movement between tibia and fibula

The distal tibiofibular syndesmosis maintains the fibula within its relationship to the tibial incisura. Its principal components include the anterior inferior tibiofibular ligament, posterior inferior tibiofibular ligament, interosseous ligament and the deeper transverse posterior component. The interosseous membrane continues proximally and contributes to the tibia-fibula relationship. Normal syndesmotic behaviour includes small movements; pathological instability is excessive or abnormal movement under relevant loading, not simply the existence of any movement.

Three-dimensional assessment is essential conceptually even when the available investigation is two-dimensional. Diastasis describes separation, but the fibula can also be translated anteriorly or posteriorly, rotated or positioned at an inappropriate level. A single clear-space measurement cannot express all of these relationships. Foot rotation and sagittal position should be recorded where they materially affect interpretation, especially when comparing a postoperative study with the opposite ankle. Findings from intact cadaveric joints should not be mistaken for validated diagnostic thresholds in every injured patient. [11]

The syndesmosis is also part of a longer injury pathway. A painful ankle with a proximal fibular fracture is not two unrelated problems. Examination and imaging must account for the leg when the pattern raises concern for a Maisonneuve injury. Equally, a short distal fibular fracture does not exclude syndesmotic damage. The final assessment depends on the complete lesion and, when surgery is undertaken, on stability after the relevant bony relationships have been restored.

Anterior and posterior margins: articular surface, buttress and attachment

An anterior tibial fragment may involve the articular rim, the tibial attachment of the anterior syndesmotic ligament, or both. A fibular attachment fragment is a different structure even though the same ligament complex is involved. These distinctions matter because reduction must address the particular loss of surface, containment or ligament attachment. “Anterior fragment” is an observation that should begin further description, rather than conclude it.

The posterior malleolus likewise has several possible roles. A fragment may involve the posterior articular surface, the fibular incisura and the attachment of the posterior syndesmotic restraint. There may also be posteromedial extension, separate fragments, intercalary fragments or an impacted area that does not reduce simply by restoring the external rim. A percentage measured on one lateral image cannot fully communicate these features.

Gardner and colleagues combined clinical imaging with a cadaveric injury model and showed that posterior fragment fixation could restore substantial syndesmotic stability in that model. This provides a mechanical rationale for assessing the posterior component as a functional part of the injury. It does not establish that every posterior fragment requires fixation or that posterior fixation always removes the need for additional syndesmotic stabilisation. The reconstructed ankle still requires assessment. [18]

Define the movement before naming the mechanism

Sagittal descriptions must state the reference segment. Dorsiflexion of the foot relative to the tibia brings the dorsum of the foot towards the front of the leg. Plantarflexion moves the foot in the opposite direction. In a planted-foot event, the observer may instead describe the tibia advancing over the foot or moving backwards relative to it. These can describe the same relative motion from opposite observational perspectives. A useful account identifies which segment is regarded as fixed.

The terms hyperflexion and hyperextension appear in the proposed atypical-fracture framework developed in this book. They should not be silently equated with plantarflexion or dorsiflexion without an explicit convention. For clinical communication and research recording, I would add the unambiguous anatomical description, the reference segment and the observed talar displacement. Where the original event is uncertain, that uncertainty belongs in the description.

Rotation needs similar care: external rotation of the foot relative to the tibia is not the same verbal description as external rotation of the tibia over a fixed foot. Pronation and supination also describe coupled three-dimensional behaviour and should not be used as casual substitutes for any visible eversion or inversion. The initial foot position, applied force and final displacement are different pieces of information. They should be recorded separately whenever the evidence allows.

Rotation, shear, compression and tensile failure

A fracture pattern is the result of force interacting with geometry and tissue strength over time. Rotation can tension ligaments and generate spiral or oblique failure. Bending creates different conditions on opposite sides of a bone. Shear tends to displace one part along another, whereas compression may crush the subchondral surface or produce metaphyseal impaction. Tensile failure may occur through a ligament, at its attachment or through adjacent bone. Real injuries frequently combine these modes.

Consider a foot that remains caught while the body continues to fall. The loading direction may change as the knee, tibia and trunk move, and a structure that was initially restraining the talus may fail partway through the event. The final radiograph records the end of that sequence, possibly after spontaneous reduction or manipulation. It cannot reliably replay every stage. This is why a plausible mechanism should guide the search for missing injuries without overriding contradictory morphology.

Experimental work by Mait and colleagues found that ankle flexion altered the patterns and sequence of injury during forced external rotation. This supports attention to sagittal position as one contributor to injury formation. The study does not validate the six proposed atypical categories in this book. Their reproducibility and clinical utility require their own definitions, observer studies and outcome evaluation. Mechanistic plausibility is a reason to investigate a classification, not a substitute for its validation. [19]

Mechanical feature	What the images may show	Question for treatment
Tension or avulsion	A fragment at a ligament attachment	Which restraint is disrupted, and is the remaining joint stable?
Rotation or bending	Oblique or spiral failure, sometimes with injuries away from the ankle	What associated medial, posterior or proximal injury needs assessment?
Shear	A displaced articular or malleolar segment with an oblique or vertical fracture plane	What prevents translation along this plane after reduction?
Compression or impaction	Depressed subchondral bone, an intercalary fragment or comminution	Does the articular surface need direct reconstruction and support?
Combined loading	Features from more than one of the above	Which observed components determine the actual plan?

Dynamic stability and the conditions under which it is tested

Stability is a property of the injured system under stated conditions. The question is whether the talus remains acceptably related to the mortise during the loading and movement that treatment permits. An unloaded radiograph, a gravity-stress view, an assisted weight-bearing image and an intraoperative stress examination do not test the same conditions. Their findings should not be collapsed into one interchangeable number.

In a prospective study of selected Weber B fractures that were congruent on weight-bearing imaging, Gregersen and colleagues found comparable two-year outcomes in groups with different gravity-stress results when treated nonoperatively. This is evidence for a functional assessment in the population studied. It is not permission to load an unreduced fracture-dislocation, an uncertain complex articular injury or an ankle whose soft tissues or neurological condition make the test unsafe or unreliable. [20]

The patient also contributes to functional stability. Protective sensation, balance, muscle control and the ability to follow a mobilisation plan affect the demands placed on a healing joint. A radiographic construct and a rehabilitation instruction must therefore be designed together. “Non-weight-bearing” is not a mechanical solution if the person cannot perform it safely. Likewise, a strong construct does not eliminate biological limits imposed by skin injury or impaired healing.

The cartilage and soft-tissue injury continue after reduction

An articular fracture delivers an insult to cartilage and subchondral bone at the moment of injury. Subsequent incongruity and abnormal loading may add to that insult, but perfect-looking bone alignment cannot retrospectively undo the initial damage. In a prospective cohort with long-term follow-up, Stufkens and colleagues associated initial cartilage lesions with worse subsequent clinical and radiographic outcomes. The finding helps explain why union and acceptable reduction do not guarantee a symptom-free ankle. [21]

The depth of a cartilage lesion, its surface area, its location and the state of the opposing surface are distinct observations. A lesion extending through more than half the cartilage thickness is not the same as loss of more than half the joint surface. Nor should either measure become a universal definition of ankle osteoarthritis. Localised chondral damage, impingement and established joint-wide degeneration need separate descriptions so that the proposed treatment addresses the actual problem.

The skin, capsule, periosteum, tendons and neurovascular structures are part of the same injury. A displaced talus may threaten skin even when the fracture line itself appears straightforward. Swelling changes the environment for incisions and closure; scar can subsequently restrict excursion; a tendon can become displaced or trapped. These features are not secondary details to be considered after the bone. They influence urgency, approach, fixation strategy and rehabilitation from the beginning.

Why a pilon fracture is a different reconstructive problem

Malleolar injuries primarily involve the bony and ligamentous boundaries of the mortise, although they can include substantial articular injury. A pilon fracture centres on disruption of the distal tibial plafond, commonly with impaction, comminution and extension into the metaphysis. The talus may act against the plafond during axial loading. The distinction is about the reconstructive problem and injury morphology, not simply whether the incident was described as high energy.

There is an area of overlap. A posterior shear injury with impaction may be more complex than an ordinary posterior malleolar avulsion, and an apparently rotational injury can contain an important compression component. CT is particularly useful when plain films cannot explain the articular fragments and their relationships. In Tornetta and Gorup's prospective series of pilon fractures, CT frequently added information and altered operative planning. The study illustrates the value of understanding morphology before selecting an approach. [22]

Closed adult malleolar and syndesmotic injuries fall within the BOAST ankle-fracture standard, which explicitly excludes pilon fractures, open fractures and skeletally immature patients. This boundary matters: a routine malleolar pathway should not be applied automatically to a disrupted tibial plafond. The anatomy and soft-tissue injury must determine the appropriate specialist pathway and whether staged reconstruction is required. [23]

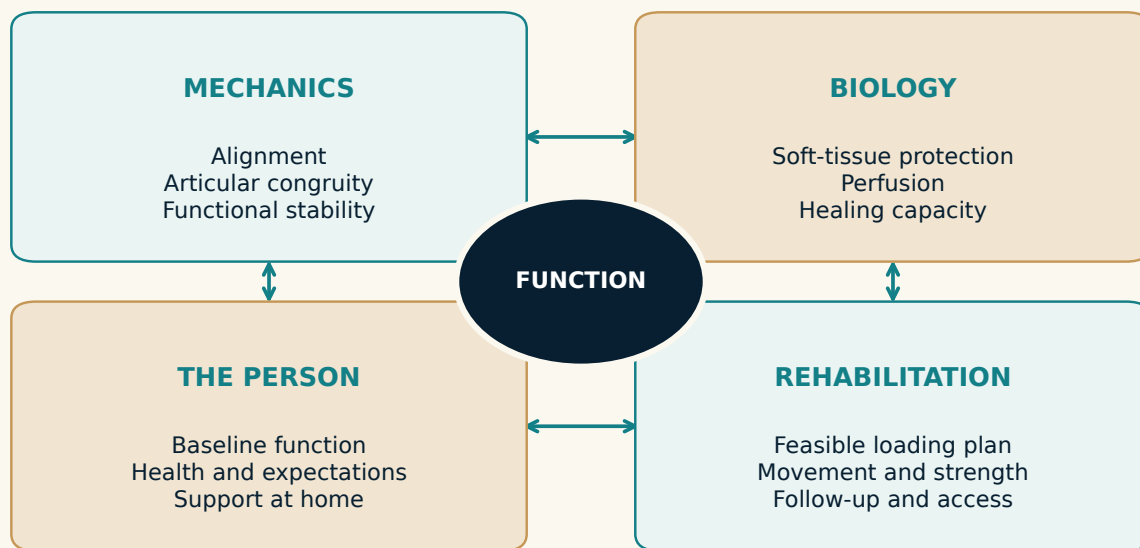
From understanding to a targeted plan

My practical sequence is to identify the threatened tissues, locate the talus, map the failed boundaries and describe the articular damage. I then ask which reductions are necessary to restore containment and contact, which restraints remain competent and what support will permit healing. Classification helps communicate this reasoning. It should remain accountable to the images and examination rather than forcing them into a preferred label.

The operation is one part of that plan. A useful reconstruction must remain compatible with tissue survival, mobilisation and the patient's goals. When I say that an ankle fracture should be understood before it is treated, I mean that the proposed treatment should answer a specific anatomical, mechanical and biological problem. The final explanation should be clear enough for a colleague to examine, for a trainee to learn from and for the patient to understand.

04 Four requirements for a useful reconstruction

The operation succeeds within a broader treatment system.



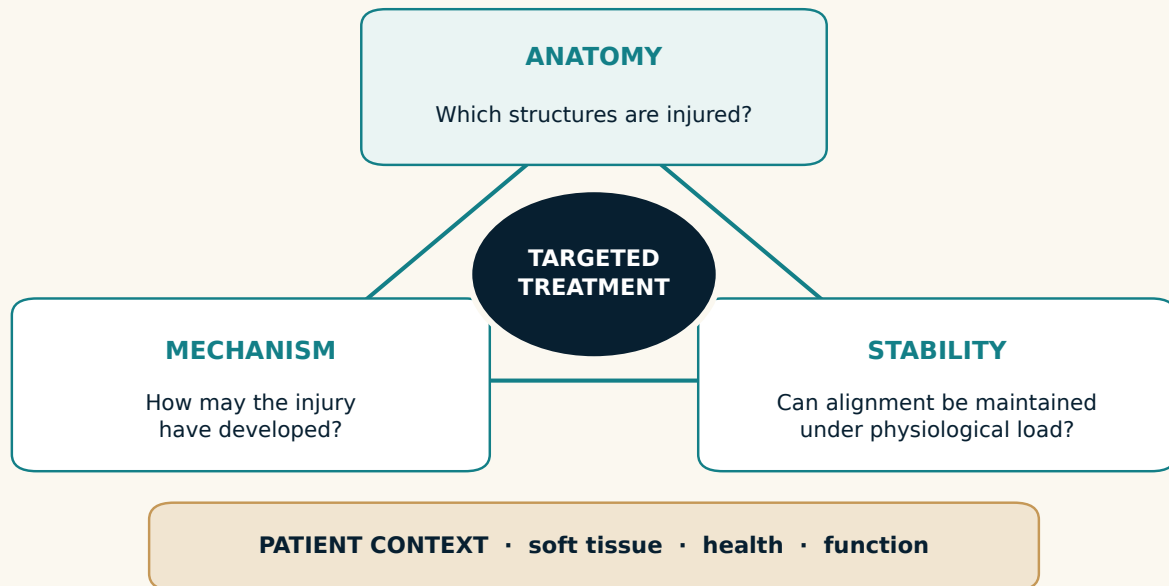
A technically sound construct must also permit an achievable recovery.

Teaching diagram 4. The author's treatment philosophy integrates mechanical reconstruction, biological preservation, the person's circumstances and a feasible rehabilitation pathway. The four domains influence one another; the intended outcome is useful function rather than radiographic appearance alone.

Chapter 1 Classification

01 Three descriptions, one treatment plan

A classification becomes useful when it answers a clinical question.



Use the descriptions together; none replaces examination and imaging.

Teaching diagram 1. Anatomy, mechanism and stability provide complementary descriptions of an ankle injury. Treatment also depends on the soft-tissue envelope, the patient's health, baseline function and achievable rehabilitation. This is a conceptual framework, not a validated scoring system.

What a classification should achieve

A useful classification allows clinicians to describe an injury consistently, anticipate what else may be damaged and communicate a treatment problem. It should also permit research groups to compare like with like. It becomes less useful when assigning the name replaces examining the injury.

I would judge a proposed system by several practical questions. Can different observers apply it reliably? Does it describe an important feature missed by existing systems? Does it help identify an unstable joint or a fragment that changes operative planning? Does it improve prediction or treatment sufficiently to justify additional complexity? A new name without these benefits adds vocabulary without improving care.

Three descriptions should therefore remain distinct. The anatomical description records what is broken and displaced. The mechanistic interpretation proposes how that happened. The assessment of stability asks whether the joint maintains an acceptable relationship under the conditions relevant to treatment. One does not automatically establish the others.

Weber classification

The Danis-Weber classification describes the fibular fracture level relative to the distal tibiofibular syndesmosis. Its strength is simplicity. Its limitation is that the fibular level does not provide a complete account of medial injury, posterior or anterior fragments, articular damage or functional stability. The following descriptions should be read with the whole radiographic series and examination. [2, 7, 8]

Type	Fibular level	The additional question
A	Below the syndesmosis	Is this truly isolated, with intact medial support and a congruent joint?
B	At the level of the syndesmosis	Is the mortise stable, and what medial, posterior or syndesmotic injury accompanies it?
C	Above the syndesmosis	What is the extent of syndesmotic and medial disruption, and is there a proximal fibular injury?

Weber A

An infrasyndesmotric transverse fracture can occur when a supination-adduction force places the lateral structures in tension. It is more accurate to describe failure of the lateral ligament-bone complex than to attribute every such fracture exclusively to the calcaneofibular ligament. Further loading can produce medial shear failure, often with a vertical or oblique medial malleolar fracture. [7]

When the injury is genuinely confined to the lateral side and the joint remains congruent and stable, supportive nonoperative treatment is usually appropriate. The support may be selected for comfort, protection and safe mobilisation. However, the letter A is not a certificate of stability. Medial injury, associated impaction and an atypical displacement pattern must still be considered. [2, 23]

Weber B

A transsyndesmotic oblique or spiral fibular fracture commonly accompanies a supination-external rotation pattern. Its clinical range extends from a stable injury to one with substantial medial or posterior disruption. A fracture line through the syndesmotic level does not tell us whether the entire stabilising system remains functional.

My central concern is whether the talus is appropriately centred beneath the tibia and whether that relationship can be maintained. The fibular fracture gap is not identical to talar displacement. A primary study by van den Bekerom and van Dijk demonstrated why these measurements should not be treated as interchangeable. Consequently, neither a universal 4 mm allowance nor a single small displacement threshold should replace assessment of the joint. [24]

Weight-bearing imaging can help assess selected isolated Weber B injuries when loading is safe and tolerable. It tests the relationship under physiological load; it does

not directly prove that every fibre of the deep deltoid ligament is intact. A prospective outcome study of weight-bearing-stable Weber B fractures found similar two-year outcomes despite differing gravity-stress results. This supports a functional approach in the studied population, not unrestricted loading of every ankle fracture. [20]

Weber C

A suprasyndesmotic fibular fracture raises concern for substantial syndesmotic and medial injury. Pronation-external rotation and pronation-abduction mechanisms can produce patterns in this group. The proximal fibula must not be forgotten simply because the patient describes pain at the ankle. [8]

The injury is not adequately explained by saying that the fibula has been squeezed upwards. Rotation, bending, translation and ligament failure may all contribute. An unstable mortise generally requires a strategy to restore and maintain alignment. The need for syndesmotic stabilisation is assessed in the context of the complete injury and the reconstructed ankle, rather than inferred solely from the letter C. [2, 8, 23]

Lauge-Hansen classification

Lauge-Hansen relates the initial foot position to the deforming force. The four commonly taught groups are supination-external rotation, pronation-external rotation, supination-adduction and pronation-abduction. Their sequences help the surgeon search for associated damage, while real injuries may combine forces or depart from the experimental pattern. Experimental work revisiting the system has also demonstrated limits to reproducing its classic mechanisms. [2, 25]

Pattern	Features to consider when examining the whole injury
Supination-external rotation	Anterior syndesmotic injury, an oblique fibular fracture, posterior injury and possible medial failure
Pronation-external rotation	Medial failure, syndesmotic disruption and a higher fibular fracture, with possible posterior involvement
Supination-adduction	Lateral tension failure and, with progression, medial shear injury
Pronation-abduction	Medial disruption, syndesmotic injury and bending failure of the fibula

Rotation and the frame of reference

The direction of rotation must always be related to a reference segment. In the conventional terminology, external rotation concerns the foot or talus relative to the leg. If the foot is planted while the tibia rotates internally, the relative motion can be described as external rotation of the foot with respect to the tibia. These accounts can describe the same relationship.

My concern about teaching the mechanism is therefore best addressed by making the reference frame explicit. It would be inaccurate to declare pronation-external rotation

a universally accepted naming error. The useful teaching question is what moved relative to what, and what structures failed as a result. [8]

The limits of reconstructing an event from its final image

The final position of a fracture is evidence of injury, not a recording of the entire event. The patient may have fallen, twisted, loaded the ankle again or undergone partial spontaneous reduction before imaging. Ligament failure changes the available motion as the injury progresses. A mechanistic interpretation should therefore remain open to revision when the history, CT morphology or operative findings do not fit it.

This is especially relevant to the lateral image. Anterior or posterior talar displacement is important, but by itself it does not prove a unique hyperflexion or hyperextension mechanism. It should prompt a fuller anatomical description and examination of alternative explanations.

Posterior and anterior malleolar morphology

Posterior malleolar injuries should not be reduced to a percentage of the articular surface. Mason and colleagues examined posterior fracture morphology and associated injuries, distinguishing patterns with different pathoanatomical characteristics. The practical lesson is to understand the fragment, its extension and the accompanying injury before deciding how it should influence reconstruction. [9]

Rammelt and colleagues described surgical fixation of quadrimalleolar fractures. In their usage, the fourth component is an anterior tibial tubercle fragment accompanying a trimalleolar injury; an anterior fibular rim fragment may constitute an equivalent pattern. The term describes morphology and does not establish a single mechanism for every case. [10]

For my purposes, these contributions reinforce the need to map the whole joint. A fibular label, a posterior-fragment label and a sagittal-instability description may each communicate something useful. They need not compete for exclusive ownership of the diagnosis.

A developing framework for atypical ankle fractures

Our group has examined fractures with anterior or posterior talar subluxation or dislocation on the lateral radiograph that were not satisfactorily classified within the Lauge-Hansen system. The 2025 conference abstract describes a retrospective 12-month single-centre cohort from 2022 to 2023, in which 70 fractures were classified as atypical, representing 20% of the reviewed cohort. The abstract stored with our research material reports the same percentage. [3]

I have also described an approximately 17% figure from our initial material. That author-reported estimate should be kept separate from the 70-case (20%) conference result until the underlying series and definitions have been reconciled. Neither figure should be presented as a population prevalence for all of Yorkshire. A single-centre retrospective sample reflects its referral pattern, inclusion criteria and classification decisions.

The abstract describes four combined mechanisms: hyperflexion-pronation, hyperflexion-supination, hyperextension-pronation and hyperextension-supination. The framework developed here adds pure hyperflexion and pure hyperextension as proposed categories. These additions should not be represented as six independently validated groups already established by that abstract. [3]

Terminology and the six proposed patterns

The labels below preserve the terminology of my developing model. Hyperflexion and hyperextension require an explicit anatomical convention before they can serve as reproducible classification terms. Until that convention is fixed, clinical records and research coding should state plantarflexion or dorsiflexion separately, identify the reference segment and record the observed direction of talar translation. The labels alone must not be used to prescribe a reduction manoeuvre or predict a particular fragment.

Proposed pattern	Intended conceptual distinction
Pure hyperflexion	A dominant sagittal mechanism, without a recognised pronation or supination component
Hyperflexion with pronation	The proposed hyperflexion mechanism with a pronation component
Hyperflexion with supination	The proposed hyperflexion mechanism with a supination component
Pure hyperextension	A dominant sagittal mechanism, without a recognised pronation or supination component
Hyperextension with pronation	The proposed hyperextension mechanism with a pronation component
Hyperextension with supination	The proposed hyperextension mechanism with a supination component

Pure should mean that no substantial additional component has been identified, rather than a claim that a real injury occurred in a mathematically isolated plane. Pronation and supination are composite movements and should not be treated as synonyms for a single coronal angle. Where the mechanism remains uncertain, a complete morphological description is preferable to forcing the case into one of the six labels.

Observation before explanation

I propose recording the sagittal finding first: anterior or posterior talar translation, whether the joint is subluxed or dislocated, and whether the image was obtained before or after reduction. CT can then define anterior and posterior fragments, impaction and articular extension. The coronal and rotational findings, syndesmotomic assessment and soft-tissue condition complete the description.

This sequence prevents a circular argument in which a fracture is called hyperflexion because it looks atypical, and then called atypical because it has been labelled

hyperflexion. The hypothesis must be tested against independently recorded observations. Injuries with substantial plafond impaction or a posterior pilon component also need appropriate distal-tibial classification and planning; an atypical ankle label must not conceal that distinction.

Neutralising the forces that threaten the reconstruction

My surgical principle is to identify the displacement tendency that remains after reduction and construct treatment to resist it. A fracture with prominent anteroposterior instability demands explicit assessment in that plane, alongside medial, lateral and rotational stability. The operation should address the actual fracture geometry, joint congruity, syndesmotic relationship and soft-tissue constraints.

This does not mean reproducing the injury force, selecting an approach from the category name alone, or inserting a syndesmotic device in every atypical case. The observed use of fixation in a retrospective series reflects both injury characteristics and local decisions. It is not a universal indication. The adequacy of reduction and residual instability remain the relevant clinical questions. [2, 3]

What must be established next

The next research step is an operational definition with illustrated criteria, followed by blinded observer assessment and external validation. Consecutive case inclusion, pre-reduction images where available, clear treatment of missing imaging and transparent exclusion of pilon injuries would improve interpretability. The six categories should be compared with a simpler description based on displacement and CT morphology to establish whether the additional terminology adds value.

The proposed associations with body mass, neuropathy, diabetes, impaired coordination, alcohol and medication also require measured data and suitable comparison groups. A classification becomes clinically persuasive when its reliability and consequences are demonstrated. Until then, the framework is an invitation to examine overlooked mechanics carefully and investigate them systematically.

Chapter 2 Diagnosis

Diagnosis begins with a clinical question

The diagnostic task is to identify the fracture, recognise immediate threats, define associated injury and establish what information is needed for a safe treatment plan. Seeing a fracture line answers only part of that task. In my practice, the history, examination and images must explain one another.

In high-energy trauma or a patient with multiple injuries, assessment follows the priorities of major trauma care. The ankle should not distract from a threat to life. In an apparently isolated injury, a brief history of the fall may still reveal collapse, a head injury or another problem requiring attention. [1, 2]

History

Ask when and how the injury occurred, whether the foot was planted or free, whether the patient recalls twisting or forced movement, and whether there was immediate deformity. Establish whether the ankle was reduced before arrival. Mechanistic recollections are useful but may be incomplete, particularly when pain, shock or intoxication affects recall.

Let the patient indicate the location of pain: lateral, medial, posterior, anterior or diffuse. Ask about pain in the foot, calf and knee, altered sensation, ability to bear weight immediately afterwards and any subsequent deterioration. Previous injury, surgery, deformity or arthritis may change the interpretation of the images.

The background history should establish baseline mobility and relevant medical conditions, especially diabetes with or without neuropathy, vascular disease, renal disease and previous problems with skin or wound healing. Medication, anticoagulation, allergies and circumstances affecting safe mobilisation also matter. I would document what the patient could do before the injury and what assistance is available at home. This connects the diagnostic assessment to a workable treatment plan. [2, 6]

Examination without unnecessary provocation

Inspection comes first. Expose enough of the limb to assess deformity, swelling, bruising, skin tenting, blisters and wounds. Consider whether a small wound could communicate with the fracture. The ankle must not be assumed closed solely because there is no large wound. Document the findings with sufficient detail for the next clinician to recognise change.

Record distal perfusion, palpable pulses where assessable, sensation and relevant motor function before and after manipulation or splintage. Pre-existing neuropathy must be distinguished from a new deficit where possible. Pain that appears unexpectedly mild in a neuropathic patient should not reassure the examiner about injury severity. [2, 6, 23]

My recommendation is to avoid repeated squeezing, forceful passive movement and painful stress manoeuvres in a suspected unstable fracture. Routine passive range-of-motion testing is not a necessary first step. Gentle, focused palpation remains useful when it answers a clinical question, including examination of the proximal fibula and other painful regions. The objective is a complete, proportionate examination with adequate analgesia, not repeated demonstration of tenderness. [2]

Skin compromise, impaired perfusion, a new neurological deficit, an open injury or concern about compartment syndrome requires urgent senior assessment. A pulse does not by itself exclude a serious pressure-related problem. Evolving symptoms should trigger reassessment even when an earlier examination was reassuring. [2]

CLINICAL PLATE A | THE COMPLEMENTARY RADIOGRAPHIC VIEWS



A, frontal and B, lateral images from the same distal tibial articular injury. The lateral view reveals marked sagittal displacement. A fibular-level label alone does not describe this injury. These are pilon-spectrum teaching images, not validated examples of one of the six proposed classes. Source: anonymised images from the author's clinical teaching archive.

Initial radiographs

Plain radiographs are the first imaging investigation for most suspected ankle fractures. Ottawa ankle and foot rules can help determine the need for radiographs in eligible patients; they do not classify a demonstrated fracture or establish its stability. They should not be used to exclude imaging when the examination is unreliable or when exclusionary conditions, including neuropathy, are present. [26, 27]

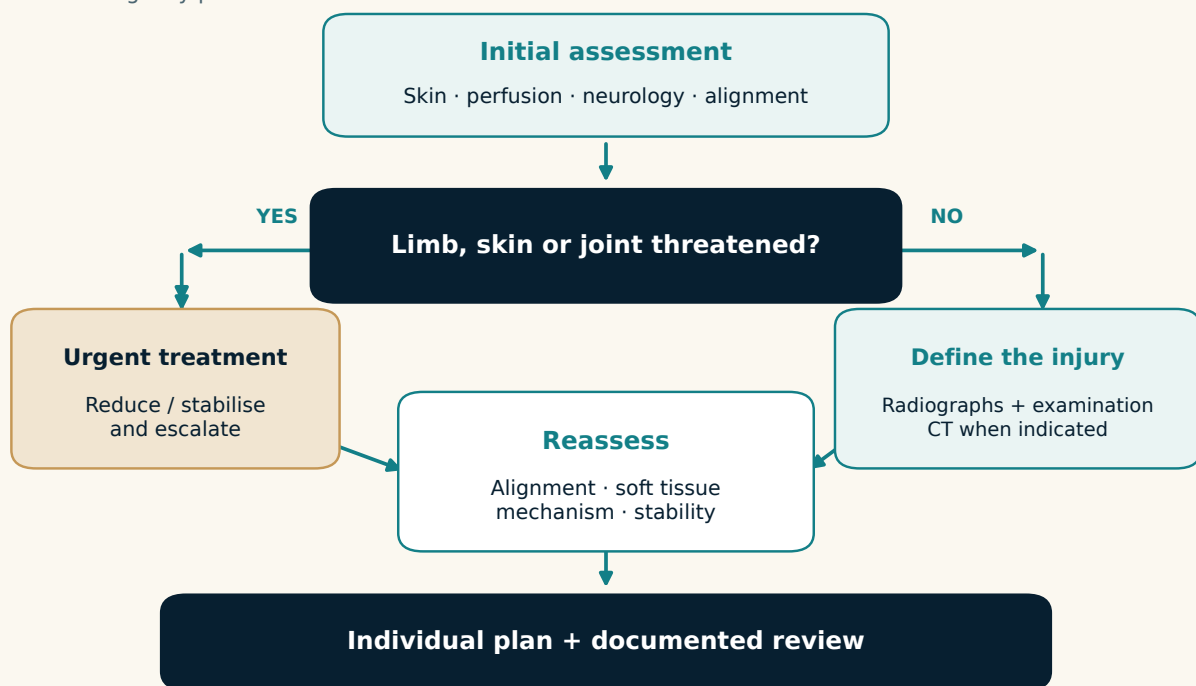
The standard assessment uses anteroposterior, mortise and true lateral views. Examine joint congruity, fibular length and rotation, medial injury, the syndesmotic

relationship, posterior and anterior fragments and any articular step or impaction. A technically poor view can create apparent widening or conceal displacement; image quality is part of interpretation. Image the whole leg when a proximal fibular injury is suspected, and other regions according to clinical findings. [2, 7, 8]

For the atypical injury considered in this book, I give particular attention to the first available lateral image. I record the position of the talus relative to the tibia and whether the posterior or anterior joint margin is involved. I then compare this with the frontal views. The lateral image is an additional source of understanding, not a substitute for the rest of the series.

03 Assessment starts with the threatened limb

Clinical urgency precedes detailed classification.



Repeat neurovascular examination after reduction and immobilisation.

Teaching diagram 3. A conceptual assessment sequence. Threatened skin, neurovascular compromise, dislocation and open injury demand urgent appropriate treatment and escalation. Reassess after intervention. Radiographs, selective CT and assessment of stability guide an individual plan; additional imaging must not delay necessary reduction. This diagram does not replace local emergency or open-fracture protocols.

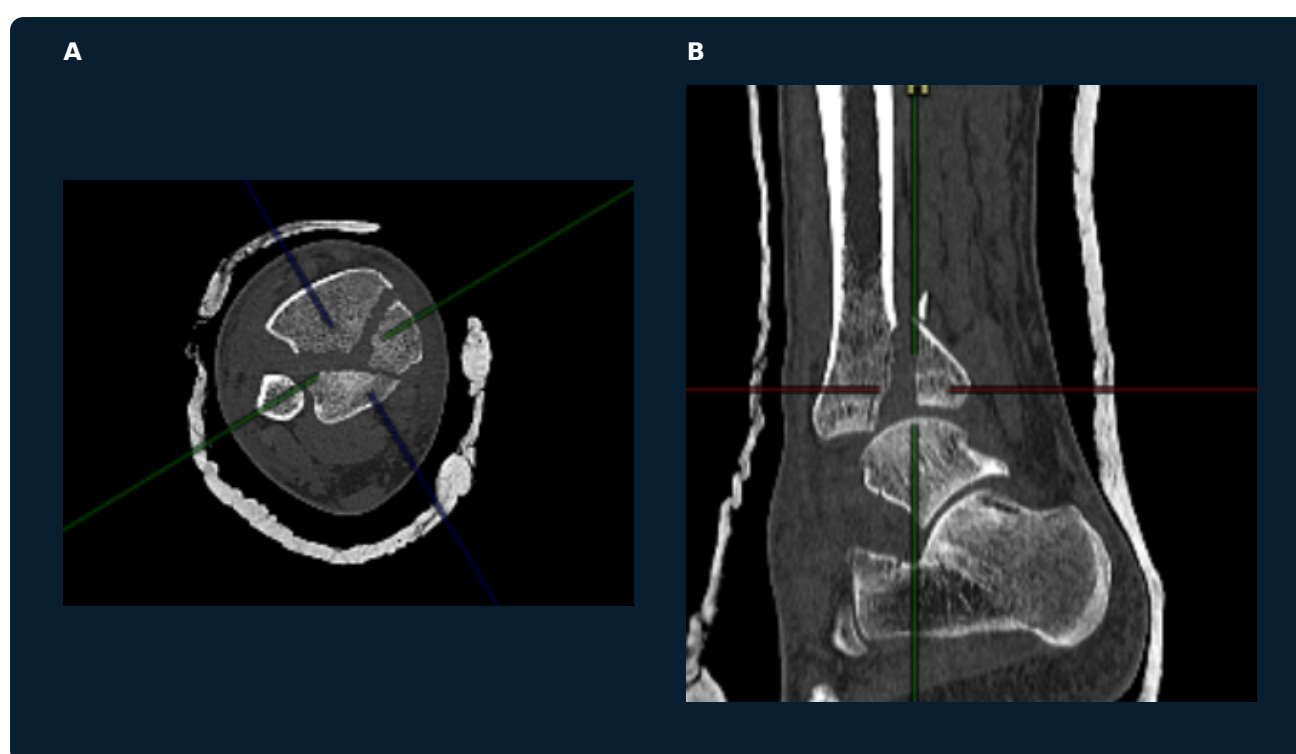
Reduction and reassessment

A clinically deformed ankle requires urgent reduction and splintage by appropriately trained staff with suitable analgesia or anaesthesia. Pre-reduction images are desirable when they do not introduce an unacceptable delay. Threatened skin or circulation may require treatment before imaging. Repeat the neurovascular examination and obtain post-reduction radiographs; document whether alignment is satisfactory. [23]

If reduction remains unacceptable, seek senior review promptly. Consider the quality of analgesia, the manoeuvre already attempted and a possible mechanical block, such as interposed tissue or an entrapped fragment. Repeated forceful attempts can add injury. A further controlled attempt, urgent operative reduction or temporary spanning external fixation may be appropriate, depending on the problem and tissue condition. External fixation is selective rather than an automatic response to one imperfect radiograph. [2, 23]

Splintage must accommodate swelling and preserve observation of the limb. Reassess comfort, skin pressure and neurovascular findings as the situation evolves. A radiographically reduced joint is only satisfactory if the position can be maintained without creating a new soft-tissue threat.

CLINICAL PLATE B | FROM PROJECTION TO FRAGMENT MAP



A, axial and B, sagittal CT slices from the same case as Plate A show the distal tibial fragment relationships and articular disruption. Source cross-reference lines are retained. CT morphology helps determine the required access and support; a single slice cannot establish the complete mechanism. Source: anonymised images from the author's clinical teaching archive.

CT and operative planning

CT is particularly valuable when plain images do not adequately define posterior or anterior fragments, articular impaction, complex fracture-dislocation or an atypical configuration. Multiplanar assessment helps map the fracture and clarify the question the surgeon needs to answer. CT does not replace assessment of skin, circulation or dynamic stability. [9, 10, 27, 23]

For an unstable displaced injury, preliminary reduction or temporary stabilisation may improve both safety and the value of the scan. Span, scan and plan is especially useful for selected complex injuries requiring a spanning frame, including pilon fractures. It

is not a requirement to externally fix every ankle before CT. Urgent treatment should not be postponed merely to obtain a more complete scan. [2]

In my planning, I ask which fragments restore the joint relationship, which surfaces are impacted, what access is needed and which incisions the skin can safely tolerate. Three-dimensional reconstructions may aid orientation, but the axial, coronal and sagittal sections remain essential. Imaging should lead to a specific operative question rather than become a collection of additional pictures.

Weight-bearing assessment in selected Weber B fractures

When an apparently isolated Weber B injury is not obviously unstable, weight-bearing radiographs can help determine whether the mortise remains congruent under load. They are obtained when safe and tolerable, with adequate loading and positioning. A partially loaded image should not be treated as definitive evidence of normal functional stability. [20]

The deep deltoid complex contributes to maintaining talar alignment, but the radiograph assesses the behaviour of the joint rather than visualising that ligament directly. Clinical findings, initial displacement and associated fractures remain relevant. If stability is uncertain, arrange timely review and repeat imaging rather than assuming that absence of visible displacement on one non-weight-bearing view establishes safety. [20, 23]

NICE recommends weight bearing as tolerated for nonoperatively managed unimalleolar fractures, with review within two weeks when stability is uncertain. That advice must be applied to the appropriate injury and patient. A gross fracture-dislocation, neuropathic ankle or major soft-tissue problem is not a routine candidate for a standing stability test. [26]

MRI as a targeted investigation

MRI is not routinely required to diagnose an obvious acute malleolar fracture. Its value is in answering a specific unresolved question, such as suspected osteochondral injury, ligament or tendon damage, an occult fracture, or persistent pain unexplained by initial radiographs. ACR guidance includes noncontrast MRI or CT as appropriate options in selected patients with persisting pain after negative initial films. [27]

MRI should not delay reduction or urgent stabilisation. Nor should its findings be presented as a precise forecast of future arthritis. Cartilage and soft-tissue abnormalities can inform diagnosis and discussion, but prognosis also depends on the initial injury, alignment, biology, complications and recovery.

Making the diagnostic record useful

I want the record to explain what has been found, what remains uncertain and what happens next. The next clinician should be able to understand both the condition of the limb and the reason for the treatment decision. A classification code alone cannot provide that continuity.

Domain	Information the record should communicate
Patient and event	Mechanism, timing, previous function, relevant comorbidity and any earlier reduction
Limb status	Skin and wounds, perfusion, sensation, motor findings and changes after intervention
Anatomy	All involved malleoli, fibular level, joint congruity and suspected associated injuries
Direction	Coronal and sagittal displacement, with pre-reduction findings preserved where available
Stability	What is established, what is uncertain and how further assessment will resolve it
Plan	Protection, permitted loading, additional imaging, review arrangements and escalation triggers

The final diagnostic synthesis should be an explanation of the injury in this patient. For a straightforward stable fracture, that explanation may be brief. For an atypical fracture-dislocation, it may require CT, senior review and staged care. The same principle governs both: establish enough understanding to act safely, protect what is vulnerable and keep the patient's future function in view.

Chapter 3 Timing of ankle fracture fixation

The decision begins with the patient and the injury

Timing is part of the treatment of an ankle fracture. The surgeon must decide when reconstruction will provide the best opportunity to restore anatomy while preserving the tissues that must heal around it. Swelling matters, but it is one part of a wider assessment. The fracture pattern, skin condition, physiological fitness, necessary imaging, anaesthetic preparation, surgical expertise and available resources all influence the decision.

My approach is to identify the earliest reasonable opportunity for safe definitive fixation and to organise care around that opportunity. If surgery must be deferred, the patient should have a protected, adequately reduced limb and a clear plan for reassessment. This continues the philosophy developed in my previous trauma writing: the extent of surgery should reflect the patient's capacity to tolerate it, and successful reconstruction depends on preparation and teamwork as well as technical execution. [2, 1, 28]

This chapter concerns predominantly adult ankle fractures for which an operative indication has been established. Stable injuries may be treated without fixation. Rotational malleolar fractures, fracture-dislocations, open injuries and tibial pilon fractures require different pathways. A timetable appropriate to a closed malleolar injury cannot simply be transferred to an open or high-energy plafond injury.

The opportunity for early fixation

In my experience, the first 24 hours often provide a useful opportunity to fix a closed ankle fracture before substantial swelling has developed. Many such injuries can be reconstructed and closed satisfactorily during this period. This is an observation from clinical practice, rather than a claim that every ankle fracture is suitable for immediate surgery. Tissue injury may already be severe at presentation, and an apparently manageable skin envelope can deteriorate over the following hours.

NICE recommends considering ankle fracture surgery on the day of injury or the following day. BOAST similarly recommends early fixation for most patients younger than 60 years with an unstable ankle mortise. Its ankle standard concerns closed injuries in skeletally mature patients and excludes pilon and open fractures. The age wording should not be interpreted as a reason to delay an otherwise suitable older patient. [26, 23]

Early surgery is appropriate when the patient can tolerate the procedure, the fracture has been understood, the required team and equipment are available, and the planned exposures and closure are acceptable. The ability to bring skin edges together is only one consideration: closure under excessive tension or over a damaged tissue bed may subsequently fail. An operation should not be rushed solely to remain inside a numerical target.

Conversely, the presence of some swelling does not automatically require postponement. The relevant question is whether the tissues at the proposed operative sites can tolerate the required operation. Delay should have a defined purpose, such as recovery of a compromised skin envelope, correction of an acute medical problem or completion of essential reconstruction planning.

Urgent treatment and definitive fixation are separate decisions

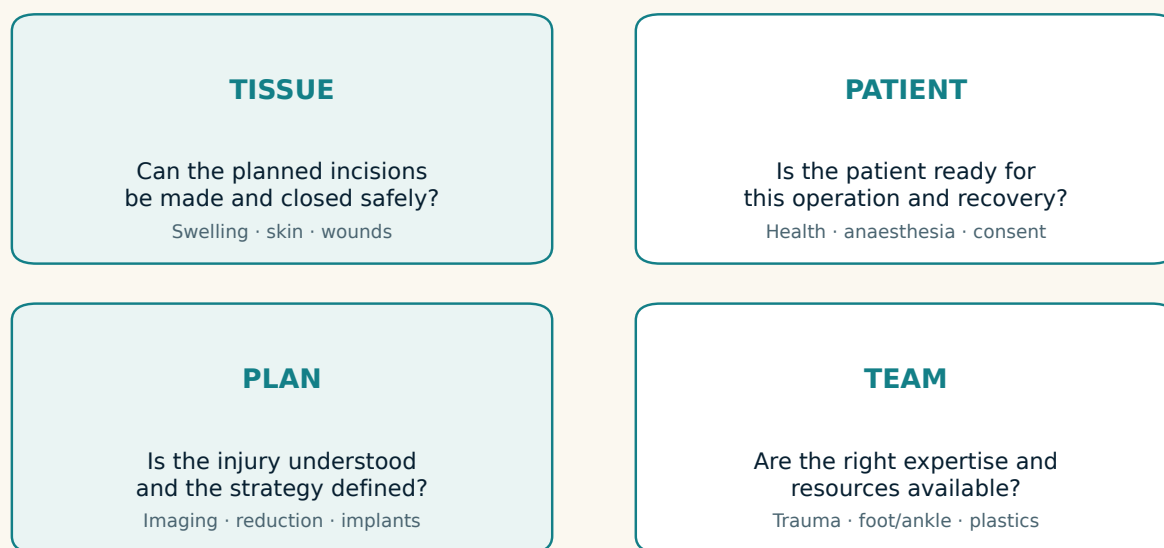
A deformed or dislocated ankle requires prompt reduction and splinting. Skin tenting, progressive neurological deficit or impaired perfusion increases the urgency. Document circulation and sensation before and after reduction and confirm the position radiographically. Imaging must not create an unacceptable delay in relieving a threatened skin envelope or restoring alignment. [23]

Persistent vascular compromise after reduction requires emergency assessment and intervention. Suspected compartment syndrome, an irreducible dislocation and an open contaminated injury also demand urgent senior action. These problems cannot be placed on a routine waiting list while swelling is observed. [2, 29, 30]

The initial intervention may be closed reduction, debridement, vascular treatment or temporary external fixation. Definitive internal fixation can follow when its requirements are met. A successful reduction is not the end of surveillance: displacement may recur, a splint may become tight, and the condition of the skin may change. The ongoing plan must specify who will reassess the limb and what findings will trigger escalation.

07 Four questions before definitive fixation

Readiness is a clinical judgement, not a universal waiting period.



Urgent threats require action; definitive fixation may require optimisation or staging.

Teaching diagram 7. Definitive fixation depends on soft-tissue condition, patient readiness, an adequate operative plan, and suitable expertise and resources. Urgent reduction, treatment of open injury and other time-critical actions are considered separately. No single elapsed-time threshold makes every ankle fracture safe for surgery.

Assessing the soft-tissue envelope

Assessment should include the whole ankle and the intended surgical corridors. Record the distribution of swelling, skin tension, abrasions, wounds, bruising, blisters and areas of pressure from displaced bone or splintage. Inspect the medial, lateral and posterior regions rather than relying on the appearance of one surface. Compare the findings with earlier examinations. A single description such as “swollen ankle” is insufficient to explain why surgery is safe or why it should wait. [2]

The wrinkle sign describes the return or presence of skin folds as tension decreases. A gentle pinch assessment, where suitable intact skin can be lifted between the thumb and index finger, may help the surgeon judge skin mobility and pliability. In this setting, these terms are more precise than “skin turgor”, which can also refer to hydration. Neither examination should damage fragile skin or a blister roof.

These signs support clinical judgement; they are not validated stand-alone clearance tests. A positive wrinkle or pinch finding does not establish normal microcirculation, exclude deep tissue injury or guarantee uncomplicated healing. Halvachizadeh and colleagues investigated objective measures of tissue stiffness and perfusion in a small prospective cohort, illustrating both the biological changes after injury and the limitations of purely subjective assessment. [31]

Ecchymosis helps identify the injured region, but bruising alone is not an automatic indication to postpone fixation. Its significance depends on the surrounding skin, the mechanism, the proposed exposure and whether the appearance is stable or deteriorating. Multiple incisions require particular attention to the intervening skin and to the cumulative effect of dissection. The number of incisions alone does not determine timing; their relationship to the zone of injury does.

Fracture blisters should be mapped in relation to planned incisions. Haemorrhagic blisters warrant particular caution. In Giordano and Koval's prospective series, wound-healing problems occurred in two patients whose incisions crossed blood-filled blisters. The study does not establish one universally superior blister-treatment method. Management should follow the treating team's wound-care pathway, with consideration of an alternative approach or postponement where the necessary incision would traverse compromised skin. A blister elsewhere on the limb does not automatically prohibit every possible procedure. [32]

What the timing studies show

The literature supports avoiding unnecessary delay, but it does not identify a universally safe hour or day for every patient. Most comparative evidence is observational. Patients who undergo later surgery often have more swelling, greater instability, medical problems or more complex injuries. These differences complicate any claim that timing alone caused an outcome.

Schepers and colleagues reported their original retrospective cohort of 205 surgically treated closed ankle fractures. Wound complications occurred in none of the 60 patients treated within one day and in 16 of 145 treated later. This finding supports making early fixation available, while selection and confounding prevent it from proving that all fractures would have benefited from immediate surgery. [33]

Pilskog and colleagues studied low-energy ankle fractures involving the posterior malleolus. Among 130 patients reviewed at follow-up, surgery after more than seven days was associated with poorer patient-reported outcomes, more pain and lower satisfaction. The study raises concern about prolonged delay, but seven days should not be treated as a universal biological cutoff or a reason to operate through an unsafe soft-tissue envelope. [34]

Penning and colleagues examined 447 ankle fracture-dislocations. After adjustment, fixation within 48 hours and delayed fixation after temporary cast or external-fixator treatment did not differ significantly in surgical-site infection or unplanned reoperation. This supports a selective approach: early fixation when feasible and appropriate temporary treatment when definitive surgery should wait. It does not establish equivalence for every injury pattern. [35]

Silva and colleagues prospectively studied 80 patients and did not detect an association between residual swelling, operative timing and wound complications. The study was underpowered, and surgeons selected when patients were ready; all operations followed some delay. These results do not justify operating immediately on severely swollen ankles. They do suggest that persistent swelling alone need not prolong waiting once expert assessment considers the tissues suitable. [36]

Taken together, these studies favour timely, individualised care. They offer no support for either routine delay in every patient or indiscriminate early fixation. The reason for waiting and the treatment provided during that interval are as important as the interval itself.

Fracture morphology, imaging and operative planning

An ankle fracture should be understood before it is reconstructed. Plain radiographs establish the initial pattern and alignment; CT can reveal information relevant to articular reduction and approach selection, particularly in complex posterior malleolar and pilon injuries. In Tornetta and Gorup's study of 22 pilon fractures, CT changed the operative plan in 14 cases. This is a planning benefit, not a justification for delaying urgent reduction or treatment of an ischaemic limb. [22]

Our work on atypical ankle fractures draws attention to patterns involving sagittal displacement and morphology that may not fit conventional rotational classifications. The Joumah-Bakhshayesh conference abstract supports careful assessment of such injuries and the potential need for combined approaches. It does not compare early with delayed fixation and should not be used as evidence for a particular timing threshold. [3]

Where CT, specialist review or additional equipment is needed, arrange these early and in parallel. The operative plan should account for the posterior plafond, impaction, fibular length and rotation, syndesmotic relationships, patient positioning and the sequence of approaches. A short, purposeful interval for essential planning in a protected limb can improve preparation. Repeated postponement because a necessary scan or implant was requested late is a different problem.

Complex injuries should be managed by surgeons with relevant ankle-trauma and reconstruction expertise. This may be a specialist foot and ankle surgeon, an orthopaedic trauma surgeon with the appropriate experience, or a combined team. The necessary competence matters more than a particular job title.

Pilon fractures and staged reconstruction

Pilon fractures combine injury to the weight-bearing tibial plafond with variable metaphyseal disruption and soft-tissue damage. A severely swollen, unstable injury may require ankle-spanning external fixation while the skin recovers and reconstruction is planned. The initial frame restores and maintains an acceptable relationship between the leg and foot; it is an active treatment stage with its own objectives. [2, 37]

The principle of “span, scan and plan” is useful when provisional spanning fixation is indicated. Pin placement should preserve subsequent operative approaches, implant paths and potential flap sites. Avoid excessive distraction, protect the heel and skin, and continue neurovascular assessment. CT after provisional reduction often makes the fragment relationships easier to interpret. CT timing should nevertheless follow the patient's actual needs; external fixation is not a prerequisite for every CT scan. [2, 22]

NICE specifies a definitive management plan and initial surgery within 24 hours for displaced adult pilon fractures. Initial surgery may be temporary or definitive. If the receiving hospital cannot provide this, transfer to an orthopaedic centre is recommended; wound complications require immediate transfer. These recommendations do not mean that every pilon fracture should undergo definitive open reduction and internal fixation within 24 hours. [30]

Sirkin and colleagues' staged series established an influential approach of initial stabilisation followed by reconstruction after soft-tissue recovery. Their observed waiting intervals should not be converted into a mandatory calendar. Some closed injuries become suitable earlier, others later; open injuries remain subject to current debridement and coverage requirements. Nor should routine initial fibular plating from a historical protocol be assumed necessary in every contemporary reconstruction. [37]

The decision to proceed should review the skin along every intended approach, healing of relevant blister beds, maintained alignment, patient fitness, imaging and available expertise. The team must also reconsider whether internal fixation, definitive external fixation or another strategy best matches the injury. Temporary treatment requires a named responsible team and a planned next assessment.

Open fractures: coordinated orthopaedic treatment

Open ankle fractures require a dedicated pathway. BOAST recommends specialist orthopaedic care for open long-bone injuries, with orthopaedic and plastic surgeons planning fixation and coverage together. Vascular expertise is added when the injury requires it. Administer intravenous antibiotics promptly, ideally within one hour of injury; align and splint the limb and protect the wound. [29]

Debridement is required immediately for highly contaminated wounds, including agricultural, aquatic or sewage contamination, or for vascular compromise such as compartment syndrome or arterial disruption causing ischaemia. It is required within 12 hours for other solitary high-energy open fractures and within 24 hours for other low-energy open fractures. Definitive closure or coverage should occur within 72 hours if it cannot be achieved during initial debridement. Definitive internal stabilisation should be performed only when definitive soft-tissue coverage can immediately follow at the same operation. [29]

Thus, the need to protect swollen tissues must be considered within the open-fracture pathway. It does not justify passive waiting for wrinkles before antibiotics, debridement or limb-saving treatment. Reconstruction and soft-tissue coverage should form one coordinated plan.

Medical readiness and practical preparation

"Patient availability" should include informed consent, anaesthetic readiness, relevant investigations and the practical ability to follow the proposed pathway. The surgeon should understand the patient's previous mobility, support at home, expectations and capacity to comply with restrictions. A technically successful fixation can still fail to deliver useful recovery if the wider plan is unrealistic. [2, 1]

Review diabetes and current glucose control, peripheral neuropathy, vascular disease, renal impairment, cardiopulmonary disease, frailty, nutritional concerns and smoking. Assess anticoagulant and antiplatelet use and agree a perioperative plan with the relevant team. Investigations should answer clinical questions: blood count, renal function, electrolytes, glucose and other tests are selected according to the patient, injury and anaesthetic requirements. Routine testing should not become an unexplained source of delay.

Acute physiological instability or a correctable serious medical problem may change the timing or extent of surgery. Anaesthetic and medical review should begin early, while reduction, soft-tissue care and imaging proceed. The aim is sufficient optimisation for the required procedure; waiting for every chronic condition to become ideal is often neither possible nor appropriate. In polytrauma, the overall injury burden and response to resuscitation take precedence over an isolated ankle timetable. [1]

During any delay, prescribe analgesia, elevation and appropriate splintage, and document the permitted mobility and weight-bearing plan. Consider venous thromboembolism and bleeding risks according to local policy. Arrange nursing, therapy and discharge support. If the patient waits outside hospital, reduction and skin condition must be suitable, with reliable review arrangements and clear instructions for increasing pain, pressure, numbness, colour change or other deterioration.

The surgeon, the service and the decision to proceed

Theatre capacity, surgeon availability, implants, radiography, anaesthetic support and postoperative care determine whether a plan can be delivered. These are genuine constraints, but they should be identified as organisational causes when they delay a clinically ready patient. A record that says “await swelling” should describe a soft-tissue finding, rather than conceal a lack of resources.

An MDT discussion can clarify a difficult fracture, assess the need for plastic or vascular input and agree the reconstruction sequence. Urgent decisions must not wait for the next scheduled meeting. Direct senior discussion, secure image review and early referral may be needed. Responsibility should remain clear during transfers and changes of team. [2, 1]

My practical approach is to review four questions together: Is the patient ready? Are the tissues suitable? Is the reconstruction understood? Can the service deliver it safely? When the answers are satisfactory, avoid unnecessary postponement. When one answer is unsatisfactory, identify the action needed, protect the limb and set the next review.

Table 3.1. Timing according to the clinical problem

Clinical situation	Immediate priority	Definitive fixation decision
Deformity, dislocation or threatened skin	Prompt reduction, protection and reassessment	Proceed or stage according to the post-reduction findings
Persistent ischaemia, suspected compartment syndrome or irreducibility	Emergency senior intervention	Integrated with the urgent limb-saving plan
Closed unstable malleolar fracture with suitable tissues	Complete preparation promptly	Aim for injury-day or next-day surgery when appropriate
Severe swelling or compromised incision sites	Maintain reduction; protect and reassess tissues	Operate when the necessary exposure and closure are acceptable
Displaced pilon fracture	Plan and initial surgery within 24 hours; temporary fixation if indicated	Reconstruct after tissue recovery and specialist planning
Open fracture	Antibiotics, debridement and orthoplastic pathway	Coordinate fixation with definitive cover
Acute medical instability	Resuscitate and treat the medical problem; protect the limb	Match surgery to physiological recovery

The table summarises the author's decision framework and the cited UK standards. It does not replace assessment of the individual injury. [2, 1, 26, 23, 29, 30]

The final record should explain the indication for surgery, current skin and neurovascular findings, imaging and operative plan, any reason for delay, interim protection, the responsible team and the review time. Timing is successful when it gives this patient a well-planned reconstruction with the best achievable conditions for healing and recovery.

Chapter 4 Surgical planning for ankle fractures

Understanding the injury before choosing the implant

Surgical planning begins with an explanation of what has failed. A familiar fracture label is useful, but it is not an operative plan. I want to understand the direction of displacement, the injured articular surface, the ligament attachments, the quality of the bone and the condition of the tissues through which the operation must be performed. I also want to know what the patient needs to achieve after surgery. These principles continue the patient-centred approach developed in my earlier foot and ankle writing. [2, 38]

Weber describes the level of the fibular fracture. Lauge-Hansen helps us anticipate associated injuries from the relationship between foot position and deforming force. The Mason-Molloy classification, developed by Lyndon W. Mason and colleagues, adds detail about posterior malleolar morphology and the injury as a whole. My proposed framework for atypical fractures draws attention to sagittal displacement and patterns that are incompletely described by conventional rotational categories. These descriptions can be used together; none should replace inspection of the actual images. [38, 3, 9, 39]

The Bakhshayesh framework remains a developing proposal rather than an independently validated classification. Our author-held abstract describes 70 atypical fractures, representing 20% of the reviewed series, and four combined mechanisms. The broader six-pattern discussion adds pure hyperflexion and hyperextension. Findings from that cohort, including frequent syndesmotic fixation, should not become an automatic instruction to use the same construct in every apparently similar injury. The reconstructed ankle still requires assessment of stability. [38, 3]

Planning around the patient

Chronological age is only one part of the decision. Previous independence, walking distance, occupation, sporting expectations, frailty, cognition and the ability to manage stairs may matter more than a birthday. A patient with weak upper limbs, impaired balance or a painful opposite leg may be unable to remain safely non-weight-bearing. That difficulty should influence the reconstruction and discharge plan before the operation, rather than becoming an unexpected problem afterwards.

The assessment includes diabetes and its complications, protective sensation, vascular disease, smoking, renal disease, nutrition, bone quality, previous surgery and the patient's medication. Diabetes with intact sensation and satisfactory circulation differs substantially from diabetes complicated by neuropathy, ulceration or ischaemia. An implant cannot compensate for unrecognised loss of protective sensation or a failing soft-tissue envelope. [23]

Document skin integrity, wounds, perfusion, sensation and motor findings, including changes after reduction. Open injury, threatened skin, persistent neurovascular

compromise and an irreducible dislocation alter the urgency and the team required. The principles of urgent reduction and tissue protection are developed in Chapter 3. Definitive fixation should follow a plan that the patient can tolerate and the available team can deliver.

Mapping the fracture in three dimensions

Assessment should include AP, mortise and true lateral radiographs. CT is particularly useful when posterior or anterior malleolar involvement, impaction, comminution or unusual talar translation changes the reconstruction. Multiplanar CT sections remain essential even when three-dimensional reconstructions are available. The scan should answer practical questions: where is the articular step, what is impacted, which fragment contains the incisura, and what must be exposed to restore the joint? [9, 39]

An anterior fragment must be named accurately. A Wagstaffe-Le Fort fragment arises at the fibular attachment of the anterior inferior tibiofibular ligament; a Tillaux-Chaput fragment arises at its tibial attachment. A larger anterior plafond or rim fracture may represent a different reconstruction problem. Posterior fragments also vary in their articular contribution, medial extension, impaction and relationship to the posterior inferior tibiofibular ligament. Fragment size alone does not describe these differences. [9, 39, 10]

Complex articular impaction and posterior or anterior plafond patterns require a surgeon with appropriate ankle-trauma expertise. That may be a foot and ankle surgeon, a trauma surgeon with relevant experience, or a combined team. Planning should include patient positioning, fluoroscopic access, the sequence of reduction, instruments, possible bone-void management and an alternative strategy if the expected reduction cannot be achieved.

Choosing approaches that permit reduction

An approach is selected to show the structure that needs reconstruction while respecting the injured skin and its blood supply. The most convenient incision is not necessarily the most useful one. Previous wounds, blisters, scars and the relationship between multiple incisions may change the plan. The following table is a planning guide rather than a mandatory approach algorithm. [39, 10]

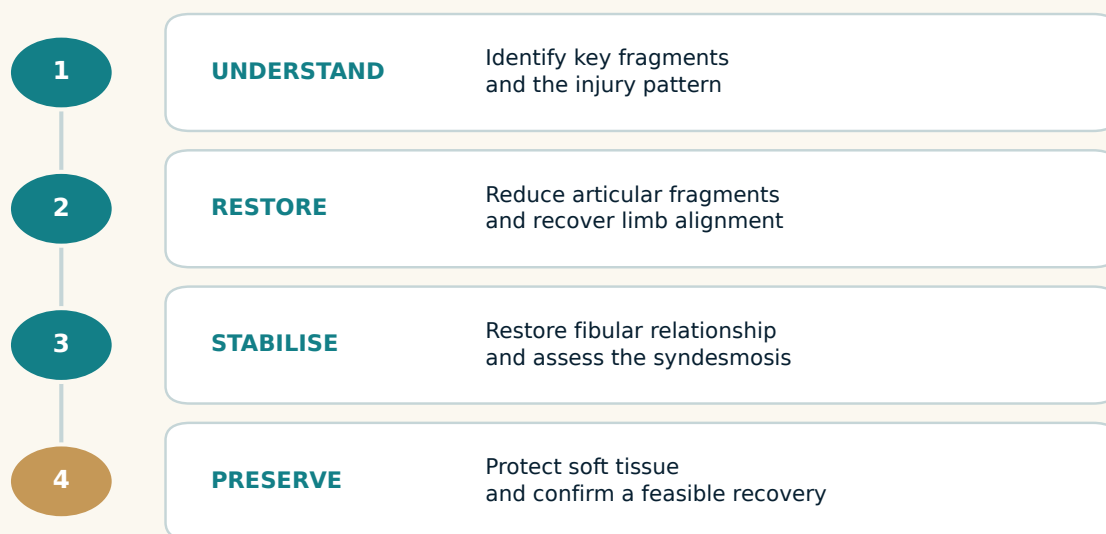
Table 4.1 Common approaches and their principal targets

Approach	Principal target	Planning consideration
Lateral	Fibular length, rotation and fracture reduction	Plate position and local soft-tissue coverage
Medial	Medial malleolus and medial joint margin	Shear, impaction, comminution and deltoid-related instability
Posterolateral	Posterolateral tibial fragment and posterior fibula	Fragment access, patient position and protection of local nerves and tendons
Posteromedial or modified posteromedial	Posteromedial extension and posterior tibial fragments	Neurovascular protection and access to the actual fracture plane
Anterior or anterolateral	Anterior rim, Chaput region and selected plafond fragments	Anterior neurovascular structures, tendons and the available skin envelope

Mason and colleagues reported a CT-directed treatment series in which posterior fracture type influenced the chosen exposure. It supports morphology-based planning, but a Level IV series cannot establish that one incision is superior for every fracture within a category. Combined approaches may be necessary when a single corridor does not permit control of all relevant fragments. [39]

08 Reconstruction is a sequence of objectives

The exact sequence depends on the fracture morphology and approach.



Confirm reduction and stability; let morphology guide exposure and fixation.

Teaching diagram 8. Operative planning links recognition of key fragments to restoration of articular congruity and alignment, assessment and restoration of the fibular-syndesmotic relationship, and preservation of the soft-tissue envelope. The ordering shown is conceptual, not a prescribed universal fixation sequence.

Anatomical reduction in every plane

The talus must be appropriately centred beneath the tibial plafond. Restoration includes fibular length and rotation, the medial relationship, the posterior and anterior joint margins, and the distal tibiofibular articulation. An acceptable-looking frontal image can coexist with posterior translation, sagittal incongruity or fibular malrotation. I therefore regard the lateral image as an essential part of the reduction assessment, with equal attention to technical image quality.

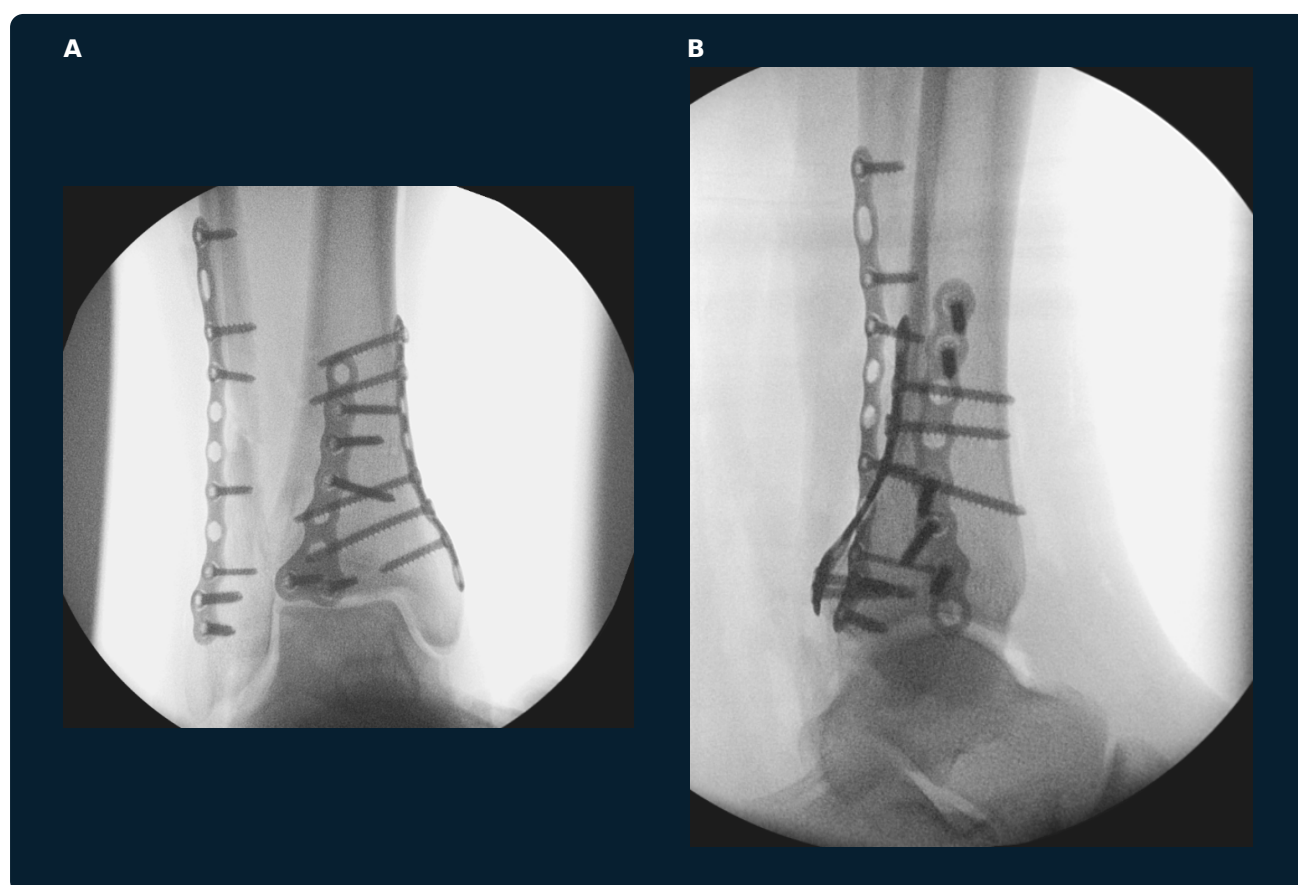
On the mortise image, examine talar tilt and shift, medial clear space relative to the superior joint space, fibular alignment and syndesmotic relationships. Shenton-type continuity and the dime sign are useful adjuncts when assessing fibular length. Radiographic assessment of length is sensitive to projection, and image rotation can conceal shortening. These signs should therefore be interpreted alongside the other reduction findings. There is no reliable universal instruction to make both gutters exactly 4 mm. Normal medial clear-space measurements vary with technique and individual anatomy. [40, 41]

A true lateral should show near-superimposition of the talar dome profiles, with the expected distal fibular overlap behind the distal tibia. These are image-quality checks, not proof of anatomical reduction. The surgeon must separately assess anterior or posterior talar translation, posterior plafond congruity and the position of the

fragments. Cartilage is not directly visualised on a plain radiograph; an apparent bone-to-cartilage boundary should not be used as the sole criterion for a perfect lateral image.

After reconstruction, reassess the syndesmosis and stabilise residual instability when indicated. Confirm reduction with appropriate fluoroscopic views and direct assessment where exposure allows it. Residual rotation, translation or articular incongruity can alter loading and contribute to later arthritis. Equally, anatomical reduction cannot undo cartilage damage sustained at the moment of injury. Good reconstruction improves the conditions for recovery; it does not guarantee a normal joint indefinitely.

CLINICAL PLATE C | ORTHOGONAL CHECKS AFTER FIXATION



A, frontal and B, lateral fluoroscopic views show plate-and-screw reconstruction in the case illustrated in Plates A and B. The images demonstrate construct configuration and orthogonal alignment checks. They do not establish union, long-term stability or functional outcome. Source: anonymised images from the author's clinical teaching archive.

Selecting fixation for the reduction achieved

The one-third tubular plate remains useful for appropriate fracture patterns. Its limitations should be understood in comminution, poor bone or configurations requiring stronger buttress support. Locking compression plates and anatomically contoured plates offer different screw trajectories, fragment capture and fixation options. Their value depends on how they meet the mechanical needs of the individual fracture.

Available designs include lateral and posterior fibular plates, medial malleolar hook constructs and posterior tibial plates aimed at posteromedial or posterolateral fragments. Choice follows the fracture, the intended mechanical function and tissue coverage. A posterior buttress plate serves a different purpose from a neutralisation plate protecting interfragmentary compression. Excessive implant prominence, unnecessary dissection or unsuitable screw placement can undermine an otherwise reasonable construct.

In osteoporotic bone, selected fibula pro-tibial screws can obtain additional purchase in the tibia and augment the construct. A synthetic-bone experiment found greater resistance to rotational failure with this technique, but mechanical testing does not establish clinical superiority or universal permission for immediate loading. These screws enhance fixation; they do not bypass or offload the tibiotalar joint. [42]

My governing principle is that reduction is primary and fixation maintains the reduction. An anatomical plate does not turn a malreduced fracture into an anatomical reconstruction. The shape of the metalwork must never become the standard against which the patient's anatomy is judged.

Frailty and alternative treatment strategies

For a frail person who cannot manage prolonged offloading, the question is which treatment offers a stable, plantigrade limb with an achievable route back to transfers and walking. Options may include augmented internal fixation, selected tibiotalarcalcaneal hindfoot nailing, specialist frame treatment or close contact casting. These are not all salvage procedures, and they do not have interchangeable indications.

A hindfoot nail crosses the ankle and subtalar joints and sacrifices motion while spanning them; formal fusion may or may not be intended. It can be useful in selected low-demand patients, but the functional trade-off, wound risk and potential complications need explicit discussion. It is distinct from a fibular nail, which stabilises the fibula without spanning the hindfoot joints. Evidence from selected elderly cohorts should not be generalised to fit, active older adults. [43]

Close contact casting follows controlled reduction, usually under anaesthesia with imaging, and requires trained application and surveillance. In the AIM trial, 620 adults aged 60 years or older had comparable six-month functional outcomes with close contact casting or surgery. Casting produced more radiographic malunion, whereas surgery produced more wound problems. Maintaining reduction and detecting skin pressure or recurrent displacement remain central responsibilities. [44]

Temporary ankle-spanning external fixation protects alignment and soft tissues when definitive reconstruction must wait. A circular frame may be selected as definitive treatment for particular complex injuries. Neither option should be prescribed simply because the patient is elderly. The decision follows the fracture, tissues, physiology, available expertise and rehabilitation needs.

Completing the operative plan

The postoperative plan should also state whether further implant-related procedures are anticipated. Routine removal of a syndesmotic screw is not required solely because it is present. The RODEO randomised trial supported on-demand removal, with fewer removal-related complications than a routine-removal strategy. Symptoms, infection, reduction, construct-specific concerns and informed discussion may still justify removal in an individual patient. [45]

Before surgery, the plan should identify the fragments requiring reconstruction, the order of reduction, approaches, implant requirements, anticipated difficulties and postoperative loading strategy. Consent should address realistic benefits, alternatives, wound problems, infection, nerve symptoms, thromboembolism, stiffness, loss of reduction, further surgery and post-traumatic arthritis in relation to the actual patient.

The operation note should explain what was reconstructed, how syndesmotic stability was assessed, what remains vulnerable and which rehabilitation restrictions follow. A statement such as 'routine ankle protocol' is inadequate when the patient has an impacted plafond fragment, compromised wound or unusual fixation. Surgical planning is complete only when the next team can understand how to protect the reconstruction and help the patient recover.

Chapter 5 Rehabilitation after ankle fracture

Recovery begins with the treatment plan

The purpose of ankle fracture treatment is to restore a useful limb. Bone union and a well-aligned radiograph are important milestones, but they do not by themselves restore walking confidence, calf strength, balance or independence. Rehabilitation must therefore begin with the initial treatment decision and continue through recovery of daily function. My published patient guidance makes the same distinction between a stable, well-aligned ankle and the later recovery of movement, strength and activity. [2, 46]

In my usual postoperative approach, the first two weeks provide an opportunity to protect the wound and manage swelling, using a backslab, cast or selected boot according to the tissues and construct. At approximately two weeks, the patient returns for wound assessment, removal of sutures when appropriate, review of alignment and a decision about loading and movement. This is a practical pathway, not a biological rule that every ankle must remain non-weight-bearing for exactly fourteen days.

Some adequately stabilised injuries can load earlier; other injuries require longer protection. Rehabilitation also begins before ankle exercises are permitted: safe transfers, walking-aid training, maintaining movement elsewhere in the limb and planning support at home should not wait for suture removal. The task is to protect what needs protection while avoiding unnecessary loss of function.

Why stability matters during weight bearing

Load passes through the tibial plafond and talus into the hindfoot and forefoot during standing and gait. The ligaments and syndesmosis maintain the relationships that allow those articular surfaces to transmit load. They resist rotation and translation and help preserve congruity as the ankle moves. The fibula also contributes to the function of the mortise. It is therefore misleading to say that loading simply bypasses the ankle ligaments.

The important clinical distinction is between an unstable injury and an ankle whose stability has been restored sufficiently for the proposed activity. A well-fitted boot can support the limb and limit movement, but it cannot compensate for unrecognised instability, inadequate fixation, threatened skin or an insensate foot. Pain can help guide activity in a sensate patient; it cannot be relied upon to protect a neuropathic ankle.

Early walking may reduce the practical burden of immobilisation and facilitate function. Its safety depends on the combined condition of the reduction, fixation, soft tissues, sensation and patient. This explains why a loading prescription must follow the operation actually performed rather than the fracture name alone.

What the evidence supports

The WAX trial randomised 561 adults in 23 NHS hospitals to weight-bearing from two or six weeks after ankle fracture surgery. Four months after randomisation, mean Olerud-Molander Ankle Scores were 65.9 and 61.2 respectively; the adjusted difference was 4.47 points, with a 95% confidence interval of 0.58 to 8.37. Early loading was non-inferior. One or more complications occurred in 16% and 14%, with no statistically significant difference. This does not prove that every individual complication has identical risk. [47]

WAX excluded patients without protective ankle sensation, those treated with a hindfoot nail and people unable to consent or adhere to the trial. The protocol required clinician suitability for early loading and protected the first two postoperative weeks. It provides strong support for a two-week reassessment pathway in eligible patients, while leaving immobilisation and exercise decisions to the treating team. [47, 48]

The INWN trial, published in 2025, compared walking in a boot from postoperative day one with six weeks of non-weight-bearing in a cast in 160 patients. It found better early function and similar complication rates with immediate protected loading. Its protocol excluded plafond fractures, Gustilo III open injuries, polytrauma and injuries expected to have inadequate fixation, among other exclusions. The intervention also differed in support and mobilisation, so the findings concern a care strategy rather than loading alone. [49, 50]

These trials strengthen the case for early loading after appropriate fixation. They do not establish unrestricted loading for every ankle fracture, every neuropathic patient or every salvage construct. A trimalleolar fracture or syndesmotic fixation is not automatically a reason for six weeks without loading, but the particular reconstruction must be considered. Where uncertainty remains, document the reason for protection and the reassessment that will resolve it.

BOAST recommends loading for most surgically treated malleolar injuries unless fixation, neuropathy or soft-tissue concerns justify restriction. Its ankle standard excludes pilon and open injuries. [23] In practice, the evidence supports asking why loading must be restricted in this patient, rather than assuming that all patients require the same delay.

Writing a usable rehabilitation prescription

The 2024 BOAST terminology distinguishes Non Weightbearing, Limited Weightbearing and Unrestricted Weightbearing. It discourages ambiguous terms such as partial or touch weight-bearing and restrictions expressed as percentages or kilograms. Document the affected limb, reason for restriction, permitted activities or distances, duration, aids, support and review arrangements. Review the prescription at follow-up. [51]

For an appropriate patient, a practical instruction might be: 'Unrestricted weight-bearing in the prescribed walking boot, using crutches or a frame as required and within comfort. No running or jumping. Remove the boot only for the activities authorised in the written plan.' This is an example of wording, not a prescription for

every patient. Unrestricted loading does not mean that the patient must immediately walk without aids or undertake unrestricted sport.

When protection is needed, the instructions should specify what the patient can actually do. Permission for supported bed-to-chair transfers differs from permission to walk around the home. A plan that cannot be followed safely requires reassessment, including the aids, home environment and care support available. The patient and carers should be able to repeat the essential instructions in their own words.

The first two postoperative weeks

The immediate priorities are a protected wound, acceptable swelling, adequate analgesia and safe mobility. Check the fit of the splint or boot and protect the heel and other pressure points. A backslab may accommodate early swelling; a boot is useful only when its fit and removal instructions are suitable for the wound, patient and fixation. A cast that becomes tight, painful, wet, damaged or unexpectedly loose needs review.

Elevation is used to help control dependent swelling, with the leg supported comfortably and without sustained pressure on the heel. Dressings and wounds should remain protected according to the operating team's instructions. Patients should not soak an unhealed wound or apply creams beneath the dressing. Ice, if advised, must be wrapped and used cautiously; impaired sensation or circulation makes unsupervised cooling inappropriate.

Analgesia should permit rest and the agreed mobilisation programme without obscuring a deteriorating clinical picture. New severe pain should not simply trigger an increase in medication. Opioid-related sedation, constipation and falls risk may interfere with rehabilitation. Medication choice should account for renal function, anticoagulants and the patient's other conditions.

Physiotherapy and occupational therapy should address transfers, walking aids, stairs, toileting and access to the home. Encourage suitable knee and hip movement, quadriceps activation and toe movement when compatible with the injury and support. Ankle movement begins only when authorised; the presence of a removable boot does not by itself confer permission to exercise without it. Sleep, nutrition, glycaemic control and smoking cessation support also belong to the recovery plan.

The two week review

Two weeks is a useful review point because it brings together wound healing, the patient's early experience and a fresh decision about mobilisation. Sutures are removed only when the wound is ready; a calendar date does not override skin condition. Examine all incisions, the heel and boot or cast contact areas. Look for drainage, wound separation, erythema, blistering and pressure injury, as well as the expected postoperative swelling.

Reassess circulation, sensation, pain, medication and the ability to transfer and walk with the prescribed aids. Review the operative findings and any restrictions related to the syndesmosis, impaction, bone quality or additional repairs. Where radiographs are

obtained, inspect the mortise and lateral alignment and compare with the postoperative baseline. Imaging schedules may vary, but new symptoms, deformity or concern about stability should prompt appropriate investigation.

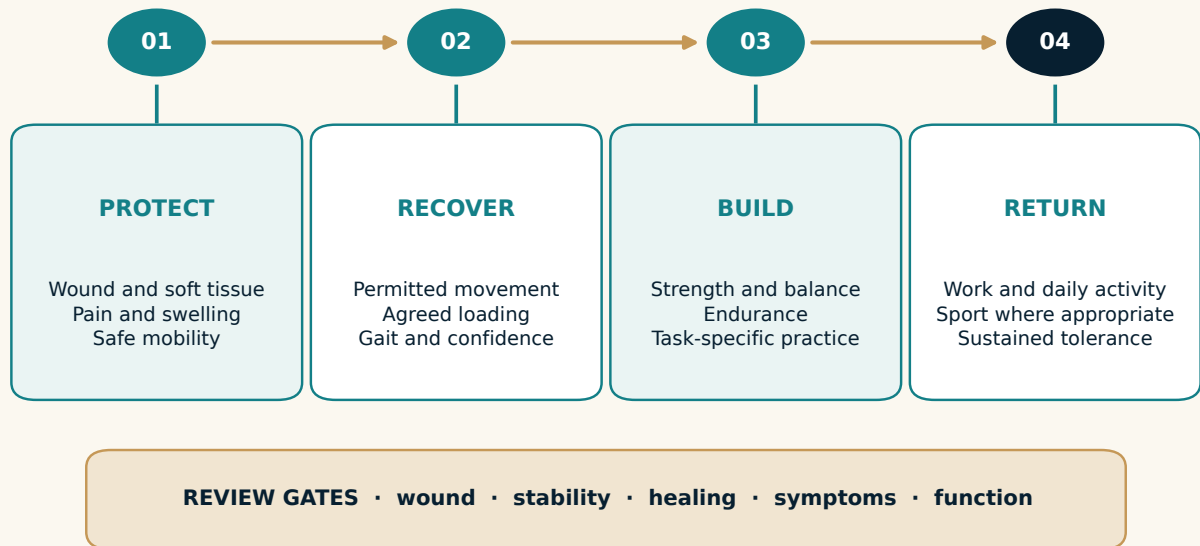
Table 5.1 Questions before advancing loading or movement

Domain	Finding that supports progression	Reason to pause and reassess
Reconstruction	Maintained alignment and a construct judged suitable for loading	Loss of position, uncertain fixation or an incompletely supported articular injury
Wound and skin	Satisfactory healing and a support that does not threaten the skin	Drainage, separation, pressure damage or substantial tissue compromise
Sensation and circulation	Protective sensation and adequate perfusion	Neuropathy, ischaemia or a new neurovascular change
Symptoms	Pain and swelling compatible with expected recovery	Escalating pain, new deformity, disproportionate swelling or systemic illness
Practical safety	Safe transfers and use of aids, with a plan the patient understands	Falls risk, inability to follow restrictions or inadequate support at home

When the review is satisfactory, my preferred pathway is usually to introduce or continue walking in a supportive boot within comfort, with aids as required, and begin the authorised range-of-movement programme. If a particular structure remains vulnerable, specify what is restricted and when it will be reviewed. A normal-looking X-ray alone does not establish that a wound or neuropathic foot is safe to load.

05 Rehabilitation progresses by criteria

Stages overlap; loading and movement follow the individual treatment plan.



Early wound review is commonly around 2 weeks; progression is not a fixed-date prescription.

Teaching diagram 5. A staged conceptual rehabilitation pathway. Early review addresses wound and soft-tissue recovery, frequently around two weeks. Subsequent progression depends on the fixation or non-operative plan, stability, healing, symptoms and function. The diagram does not prescribe a universal period of non-weight-bearing or a return-to-sport date.

A staged pathway from protection to function

The following timetable describes an uncomplicated, adequately stabilised malleolar fracture. It is a clinical framework synthesising the author's approach and the evidence above, not a single trial protocol. Progress depends on reassessment and functional milestones. Patients with complex injuries may remain in a stage longer or follow a different pathway entirely.

Table 5.2 Typical rehabilitation stages after suitable ankle fixation

Stage	Main work	Progression criteria
Operation to about 2 weeks	Wound protection, swelling control, safe transfers and prescribed mobility	Tissues remain safe; pain is manageable; planned wound review completed
About 2 to 6 weeks	Authorised loading in support, gentle ankle movement and walking practice	Maintained alignment, healing wound and improving tolerance
Around 6 weeks onward	Reassess healing; begin boot weaning when appropriate; increase strength and balance work	Clinical and imaging findings support reduced protection; safe gait in footwear
About 8 to 12 weeks	Build walking endurance, stairs, calf strength and control	Acceptable symptom response and improving movement and function
About 3 to 4 months onward	Work-specific and selected recreational progression	Adequate healing and functional readiness for the intended demand
Later recovery	Higher-demand sport and management of persisting deficits	Task-specific assessment rather than elapsed time alone

Boot weaning is a transition, not a single event. Once approved, begin with short periods in supportive footwear in a safe setting and increase exposure according to gait, symptoms and confidence. Some patients continue the boot for longer walks initially. Avoid abandoning the support simply because six weeks have passed or continuing it indefinitely because the ankle still feels unfamiliar. A walking aid can remain useful while gait improves.

After an increase in activity, some transient aching or swelling may occur. Persistent deterioration, a worsening limp or symptoms that remain substantially above the usual level by the next day should prompt reduction of the activity and, when needed, clinical review. This response-based approach is a practical pacing aid, not a substitute for investigating a complication.

Movement strength and balance

Once wound and reconstruction restrictions permit, start gentle active dorsiflexion and plantarflexion in a comfortable range. Additional inversion, eversion and rotational exercises should follow the treating team's instructions, particularly after associated ligament or syndesmotic procedures. Avoid forceful stretching through pain or attempting to recover the full range in one session. Short, repeated sessions are often easier to tolerate than a prolonged exercise period.

As healing permits, progress from active movement to resistance and functional loading. A therapist may introduce resistance-band exercises, supported weight shifts, sit-to-stand practice and bilateral heel raises before more demanding single-leg work.

Calf endurance, control during stair descent and the quality of push-off are useful treatment targets. These examples require adaptation to the patient's healing and abilities; they are not an immediate postoperative exercise sheet.

Balance training develops from supported standing to narrower stance, controlled single-leg balance and later uneven-ground or task-specific work. Support must be close enough to prevent a fall. Walking practice should address step length, foot clearance, heel contact and push-off, rather than simply increasing distance despite a marked limp. The knee, hip, opposite limb and trunk should also be considered when gait remains abnormal.

Record progress using repeatable measures: walking distance and aids, ankle movement, calf performance when safe, balance and patient-reported function. The weight-bearing lunge test can help quantify functional dorsiflexion once loaded testing is appropriate. A consistent measure, such as the Olerud-Molander Ankle Score, complements the patient's own goals. No single score or strength percentage should be treated as a universal clearance threshold. [52]

Matching physiotherapy to need

Every patient needs understandable advice and a route to help. Not every uncomplicated fracture requires a prolonged course of supervised physiotherapy. The EXACT trial randomised 214 patients after immobilisation and found no additional improvement in activity limitation or quality of life from supervised exercise plus advice compared with advice alone. Its findings support thoughtful allocation of therapy rather than routine treatment intensity for everyone. [53]

Targeted supervision remains appropriate when the patient has persistent stiffness, weakness, impaired balance, fear of falling, an abnormal gait, frailty, complex reconstruction or demanding occupational or sporting goals. A home programme should be demonstrated, achievable and reviewed. If recovery stalls, first determine whether the problem is adherence, insufficient support, excessive activity or a complication needing investigation; simply adding more exercises may miss the cause.

Adapting the pathway for higher risk patients

Diabetes requires assessment of protective sensation, perfusion, glycaemic control and skin condition. In neuropathy, pain is an unreliable warning, and frequent skin checks and a more protective specialist plan may be necessary. A patient with Charcot risk, ulceration or vascular compromise should not enter a routine pain-guided early-loading pathway. Smoking, poor nutrition and renal disease may also alter healing and the intensity of follow-up.

Osteoporosis and frailty create a tension between fixation concerns and the harm of immobility. The aim is an achievable prescription matched to the construct, not a restriction that the patient repeatedly breaks because it is impossible. Coordinate orthogeriatric support, falls assessment, medication review and appropriate bone-health evaluation after low-energy injury. A frame or hindfoot nail requires its own instructions for loading, wound or pin-site care and surveillance.

Posterior malleolar fixation and syndesmotic stabilisation are not, by themselves, universal exclusions from early rehabilitation. The relevant questions are whether the reconstruction is stable and whether additional articular or soft-tissue injuries impose restrictions. Weight-bearing and movement are separate permissions. Neither a syndesmotic screw nor a suture-button device should be used as a shorthand for an entire rehabilitation programme.

Open fractures, major plafond impaction, flap coverage, infection, polytrauma and additional tendon or ligament repairs may require different milestones. These patients should follow a coordinated plan shared by the surgeons and rehabilitation team. Evidence from standard malleolar fracture trials should not be transferred to them without considering the important differences. [48, 50]

Preventing and recognising complications

Assess venous thromboembolism and bleeding risk at presentation and after changes in mobility or treatment. NICE advises considering LMWH or fondaparinux for lower-limb immobilisation when thrombosis risk exceeds bleeding risk. Duration follows individual assessment and local policy; the advice to consider stopping beyond 42 days is not a universal six-week prescription. Early walking does not remove the need for risk assessment. [54]

Patients need clear escalation instructions. Sudden severe pain, a cold or discoloured foot, rapidly worsening numbness or concern about a dangerously tight cast requires urgent assessment. Wound discharge, separation, spreading redness or fever needs prompt review by the treating service. New calf pain or swelling should be assessed urgently for possible thrombosis; chest pain or breathlessness warrants emergency help. These symptoms should not be managed by simply reducing exercise. [46, 55]

Persistent pain deserves an explanation. Consider infection, loss of reduction, delayed union, symptomatic hardware, tendon irritation, instability, osteochondral injury or post-traumatic arthritis according to the findings. Disproportionate pain with sensory, temperature, colour or sweating changes may suggest complex regional pain syndrome and warrants timely assessment. Continuing rehabilitation and investigating the cause should be coordinated rather than treated as competing choices.

Return to work driving and sport

Return to work depends on the tasks required, transport and the ability to accommodate elevation, breaks and reduced walking. Desk-based work may be feasible earlier than prolonged standing, climbing ladders or carrying loads on uneven ground. A phased return or temporary modification of duties can provide a useful bridge. The decision should be expressed in functional terms rather than as one date for every occupation.

Driving requires the ability to enter and control the vehicle and perform an emergency stop safely without pain, hesitation or impairment from medication. A cast or walking boot can interfere with control. The side injured, vehicle transmission and current restrictions all matter. Obtain advice from the treating team and insurer; permission to bear weight does not automatically establish fitness to drive. [55]

Sport should progress from lower-demand conditioning to walking endurance, then running, landing, direction changes and sport-specific activity when suitable. Before higher-impact activity, assess healing, joint symptoms, motion, strength, balance and confidence. Do not authorise running simply because a patient can walk in a boot. Persistent swelling after exercise, recurrent giving way or inability to control a single-leg task should guide further assessment and rehabilitation.

Swimming waits until the wound is fully healed and access to the pool is safe. Cycling and other lower-impact exercise can be introduced when the patient's motion, loading permissions and safe transfers allow it. Rehabilitation goals should reflect the individual: independent shopping and safe stairs may be more important than running, while an athlete may need prolonged work beyond comfortable daily walking.

Healing time and the measure of success

Patients benefit from separating wound healing, fracture union and full functional recovery. Uncomplicated fractures commonly show substantial bone healing over the first six to eight weeks, although complex injuries and impaired biology can take longer. Clinical assessment and imaging, where appropriate, determine whether protection can be reduced; the calendar alone does not establish union. [55]

Three to four months is a useful review point for meaningful functional improvement in many patients, but it should not be described as complete recovery for all ankle fractures. Stiffness, swelling, endurance and confidence can continue to improve for six to twelve months or longer. In a prospective cohort after ankle fixation, only about half of respondents had regained their prefracture activity level at one year, despite substantial overall improvement. This illustrates the difference between healing and full recovery, rather than predicting an individual patient's outcome. [52]

The final assessment should ask whether the patient can do what matters to them, whether symptoms are improving and whether any remediable problem remains. A good radiograph is valuable, but the patient lives with the function of the ankle. My aim is to combine a sound reconstruction with a clear, achievable rehabilitation plan and timely intervention when recovery does not follow the expected course.

Chapter 6 Post traumatic events and their treatment

Looking beyond post traumatic arthritis

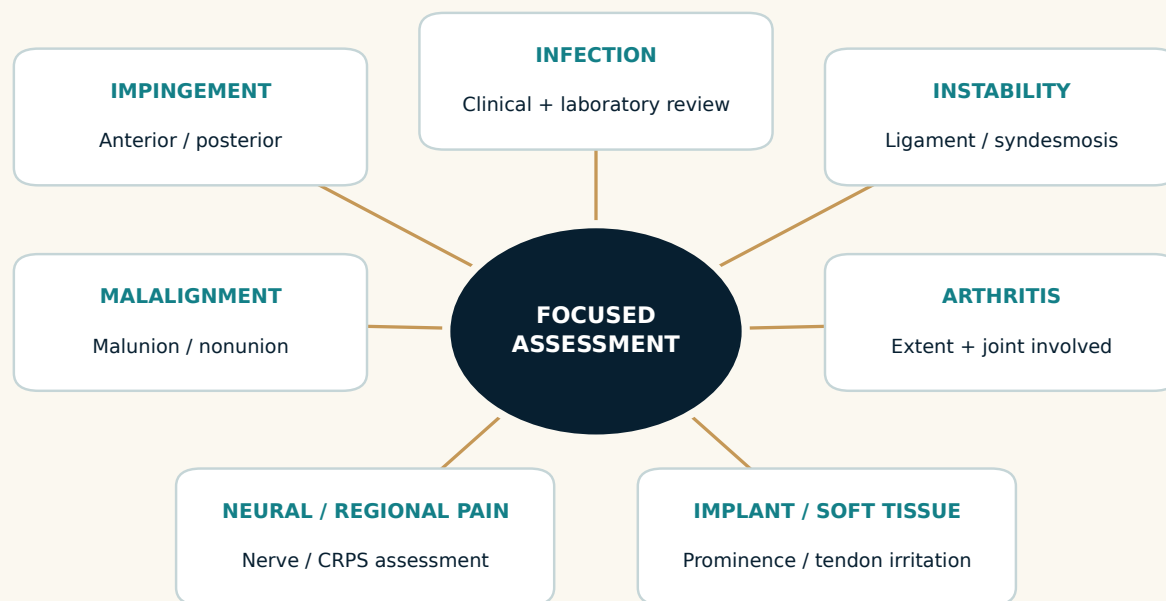
I prefer to discuss post-traumatic events, or sequelae, rather than place every painful ankle under the heading of post-traumatic arthritis. A fracture may unite while the patient continues to experience stiffness, swelling, painful restriction of movement or difficulty returning to work. The explanation may be focal impingement, scar formation, an osteochondral lesion, altered alignment, syndesmotic pathology, prominent metalwork or degeneration of the joint. More than one problem may coexist.

This distinction matters because the treatment follows the cause. A patient with a painful anterior osteophyte and substantial preservation of the joint surface should not automatically enter the same pathway as someone with widespread tibiotalar cartilage loss. Equally, removing an osteophyte from an extensively arthritic joint may leave the principal source of pain untreated. My earlier foot and ankle writing emphasises this connection between the location of symptoms, the mechanics of the limb and what the patient hopes to recover. [2, 56]

I sometimes use the expression edge arthritis to describe painful marginal osteophytes around a joint whose central articulation remains comparatively preserved. It is a descriptive expression in my clinical teaching, not a recognised diagnostic classification. The formal diagnosis should identify the actual problem, such as anterior bony impingement with limited degenerative change. Arthritis is not universally defined by damage to more than 50% of the cartilage. Depth, distribution, joint-space loss, subchondral change, alignment and symptoms all contribute to assessment; percentage involvement alone does not establish severity or an indication for surgery.

06 Persistent pain: identify the source

Pain after a fracture is not synonymous with diffuse ankle arthritis.



History + examination + targeted imaging; several pain generators may coexist.

Teaching diagram 6. A differential framework for persistent post-traumatic ankle pain. Consider impingement, infection, instability, malalignment or impaired union, arthritis, neural or regional pain syndromes, and implant or soft-tissue irritation. Categories are not mutually exclusive and are not mapped to specific anatomical pain locations. Investigation should follow the clinical question.

Finding the source of persistent symptoms

The history should establish whether pain occurs at the end of movement, throughout weight bearing, over an implant, around a tendon or at rest. Ask about locking, giving way, swelling, numbness and sensitivity to light touch. The course of recovery is important: a stiff but improving ankle is different from one with increasing pain, a new deformity or recurrent wound discharge. Review the original injury, reduction, fixation, rehabilitation and any subsequent operations.

Examination connects those symptoms with gait, alignment, movement, tenderness, stability, skin condition, sensation and circulation. Record dorsiflexion and plantarflexion explicitly. The everyday words hyperflexion and hyperextension can be interpreted differently and should not substitute for anatomical terminology.

Observe the hindfoot and neighbouring joints as well as the tibiotalar articulation. A restriction that matters greatly to a roofer may be missed if assessment is limited to level walking in the consulting room.

Weight-bearing radiographs, when appropriate, help assess alignment, joint space and the relationship of the tibia, fibula and talus. CT is useful for osteophytes, bony bridging, malunion, articular incongruity, bone loss and the position of implants. MRI may clarify cartilage, osteochondral injury, synovitis, tendons and ligaments, although

metal artefact can limit interpretation. Neither CT nor MRI should be treated as a perfectly accurate map of the percentage of surviving cartilage. Imaging must answer a clinical question and be interpreted alongside examination. [57]

Persistent symptoms also require consideration of nonunion, infection, instability, neuropathic pain and complex regional pain syndrome. Infection may be indolent; unexplained deterioration or concerning findings require investigation before an injection or reconstructive operation. An image-guided local anaesthetic injection can sometimes help localise pain, but its response is one part of the assessment, not an infallible diagnostic test.

Anterior and posterior impingement

Anterior impingement may result from a tibial or talar osteophyte, scar tissue or synovial thickening that becomes painful during dorsiflexion. Posterior symptoms may arise during plantarflexion from posterior bony or soft-tissue impingement. Tendon pathology and other causes of posterior ankle pain must be considered before assuming that the visible bone is responsible. A radiographic spur without matching symptoms does not, by itself, require removal.

Initial treatment may include modification of the provoking activity, appropriate footwear, physiotherapy and a plan to improve strength and movement without repeatedly forcing a mechanical block. Where symptoms remain limiting, the lesion is well localised and the remaining joint is suitable, arthroscopic or limited open debridement can be discussed. Arthroscopic burrs or an open osteotome technique can remove an offending prominence. The approach depends on the site, size, associated pathology, previous scars and the surgeon's experience.

The aim is to relieve the specific obstruction while protecting cartilage, tendons, nerves and stabilising structures. Removal should be controlled; excessive bone resection can create another problem. Patients need to understand the risks of nerve injury, infection, residual stiffness, recurrent impingement and incomplete pain relief. Debridement is more predictable when the main problem is impingement and joint preservation is substantial; long-term studies show that associated arthritis influences the result. It should not be presented as a way to reverse diffuse osteoarthritis. [58]

Distal tibiofibular synostosis

Injury and healing around the distal tibiofibular syndesmosis can produce heterotopic ossification or a complete bony bridge between the tibia and fibula. Damage to the anterior or posterior inferior tibiofibular ligaments, bleeding, injury to the interosseous tissues and local surgical trauma may contribute. Partial calcification and a true synostosis should be distinguished on imaging.

Many patients tolerate this finding well. Published follow-up after ankle fracture fixation has found that substantial ossification or synostosis may have little effect on overall functional outcome. Its presence should therefore not automatically be taken as the cause of pain or an indication for surgery. [59]

Symptoms may become more apparent when a patient needs exceptional ankle performance, but age or sporting ambition alone does not justify resection. Assess whether restriction or pain is reproducibly attributable to the bridge, and whether malreduction, arthritis, instability or another lesion offers a better explanation. A young athlete with an incidental synostosis may need no intervention; a symptomatic older patient may still merit specialist assessment.

Resection is a selective reconstructive decision. The surgeon must consider the original syndesmotic injury and the stability that will remain after removal of the bridge. Risks include recurrence, persistent pain, neurovascular injury and destabilisation of the distal tibiofibular relationship. Releasing the bones does not guarantee restoration of normal physiological motion, and associated instability may require treatment. The objective is a useful, comfortable ankle rather than an anatomical change on CT alone.

CLINICAL PLATE D | ASYMMETRIC JOINT SPACE

IMAGE



A weight-bearing frontal radiograph shows asymmetric tibiotalar joint-space narrowing and marginal bony change. The distribution of remaining joint space and whole-limb alignment matter in planning. The cause, pain severity and treatment indication cannot be inferred from this image alone. Source: anonymised images from the author's clinical teaching archive.

Treating established ankle arthritis

Where the principal problem is established post-traumatic osteoarthritis, management should begin with the patient's priorities and the options that remain realistic. Activity modification, appropriate footwear, bracing, strength and balance work, weight management where relevant and suitable analgesia may reduce symptoms. Physiotherapy should work within the mechanical limits of the joint. A painful block is not overcome simply by applying more force.

Nonoperative treatment can be successful even when imaging is abnormal. Conversely, a patient may have unacceptable disability without the most dramatic radiographic appearance. The plan should record what is being tried, the intended benefit and when its effect will be reviewed. In selected patients with asymmetric disease and correctable deformity, realignment or another joint-preserving procedure may be considered by an experienced team. Such treatment requires an assessment of the viable joint surface and the whole limb; it is not appropriate for every arthritic ankle. [56, 60]

Corticosteroid injections

In my practice, targeted corticosteroid injection may be arranged through radiology, or in private practice with sonographic support. Imaging guidance is particularly useful when access is difficult or precise localisation matters. The intended benefit is symptom relief, sometimes sufficient to support rehabilitation or defer a larger operation. It is not restoration of the damaged joint surface.

NICE describes intra-articular corticosteroid benefit in osteoarthritis as short term, commonly two to ten weeks, while ankle-specific high-quality evidence remains limited. The 2026 AAOS ankle guideline treats corticosteroid injection as a consensus option for short-term relief. The general NICE estimate should not be read as a guaranteed duration for an individual ankle. [61, 60]

A repeated-injection strategy must be reviewed rather than prescribed indefinitely. I may consider further injections when previous treatment has given worthwhile benefit and the patient's circumstances favour continued symptom management. However, three or four injections every year is not a universal safe regimen. Repetition depends on the preparation, interval, prior response, diabetes, skin and tissue risks, infection risk, cumulative exposure and any planned surgery. Local policies often limit frequency and require spacing. Lack of meaningful benefit is a reason to reconsider the diagnosis and plan. [62]

PRP and bone marrow aspirate concentrate

I have used platelet-rich plasma and bone marrow aspirate concentrate in selected patients with ankle symptoms. This is a statement of my practice; it does not establish effectiveness. The explanation given to patients must distinguish a biological rationale, a favourable uncontrolled report and benefit demonstrated against a suitable comparator.

For ankle osteoarthritis, the PRIMA randomised trial involving 100 participants found no significant benefit of PRP over saline in its principal outcome at 26 weeks. Follow-up to 52 weeks did not establish a clinically important advantage. Consistent with this evidence, the 2026 AAOS guideline advises against routine PRP use for symptomatic ankle osteoarthritis. It would therefore be inaccurate to describe PRP as a proven way to improve ankle cartilage function or regenerate cartilage. [60, 63, 64]

BMAC is a concentrate of bone marrow constituents, not a purified or expanded stem-cell preparation. Evidence from treatment of focal osteochondral lesions, often combined with another operation, cannot establish the effectiveness of an isolated injection for diffuse ankle arthritis. A reliable disease-modifying or cartilage-restoring benefit in ankle osteoarthritis has not been established. Harvest-site morbidity, procedural risks, costs, uncertainty and alternatives require explicit discussion. [65]

These limitations cannot be reduced to a disagreement with NHS England or NICE. Evidence, regulatory status, local governance, commissioning and insurance cover are separate questions. Private availability or insurer authorisation does not establish clinical benefit. Any proposed use requires indication-specific justification and clear consent; eligibility for funding must be checked individually.

Hydrogel and other injectable products

The term hydrogel does not identify a single treatment. Products differ in composition, persistence, intended use and evidence. Hyaluronic acid and an injectable polyacrylamide hydrogel should not be treated as interchangeable. Arthrosamid's manufacturer information concerns symptomatic knee osteoarthritis. Its knee evidence does not demonstrate benefit or establish an indication for post-traumatic ankle arthritis. The relevant problem here is chronic joint disease after fracture, not treatment of the acute fracture itself. [66]

Ankle use of a product intended for the knee requires scrutiny of its instructions, evidence and governance. Patients seeking to avoid surgery still need a clear explanation of the uncertain benefit and long-term consequences.

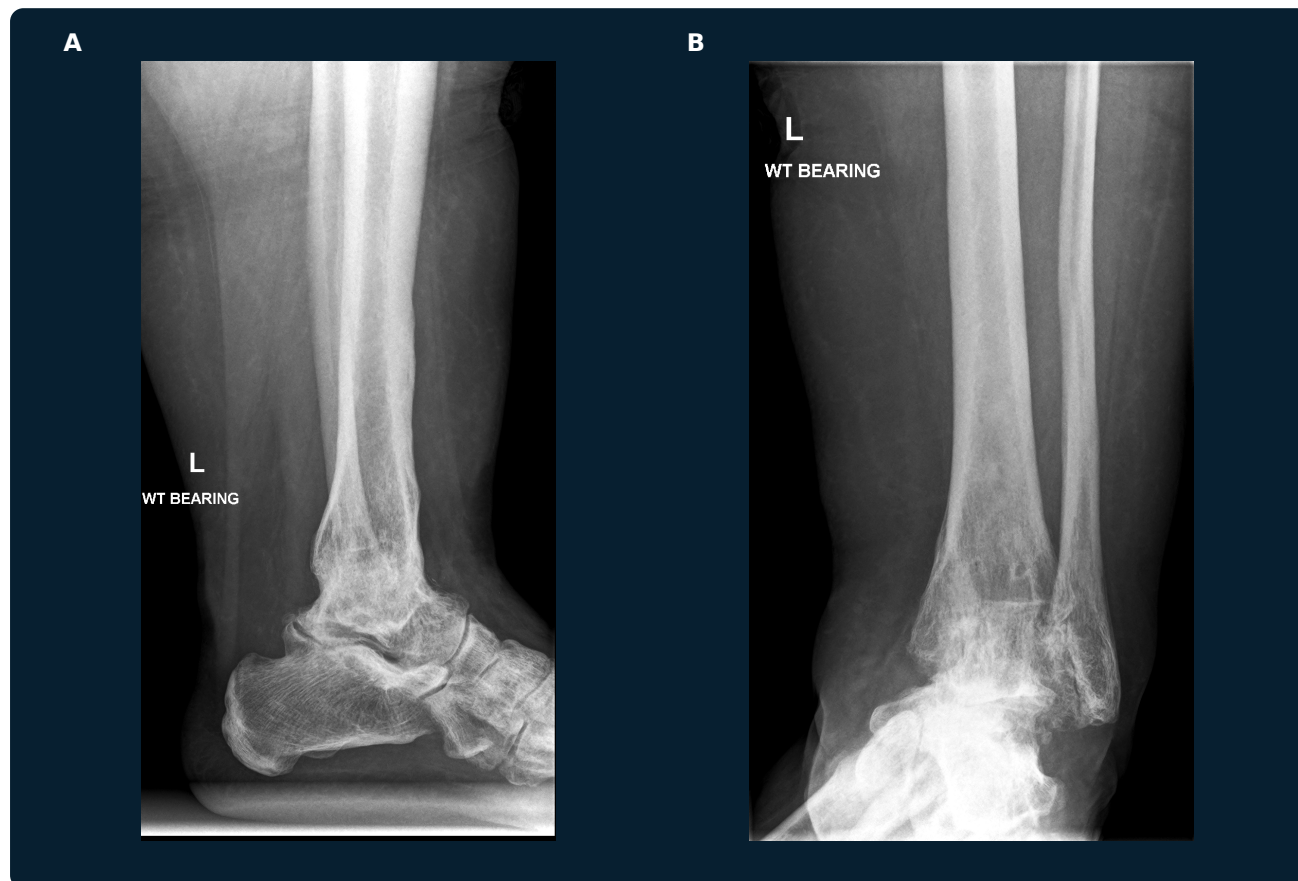
When fusion or replacement enters the discussion

Surgical discussion becomes appropriate when a clearly identified joint problem continues to cause unacceptable pain and loss of function despite reasonable treatment, and when an operation offers a proportionate prospect of improvement. The decision includes the patient's expectations, health, soft tissues, vascular and neurological status, bone stock, alignment, adjacent joints and ability to complete recovery.

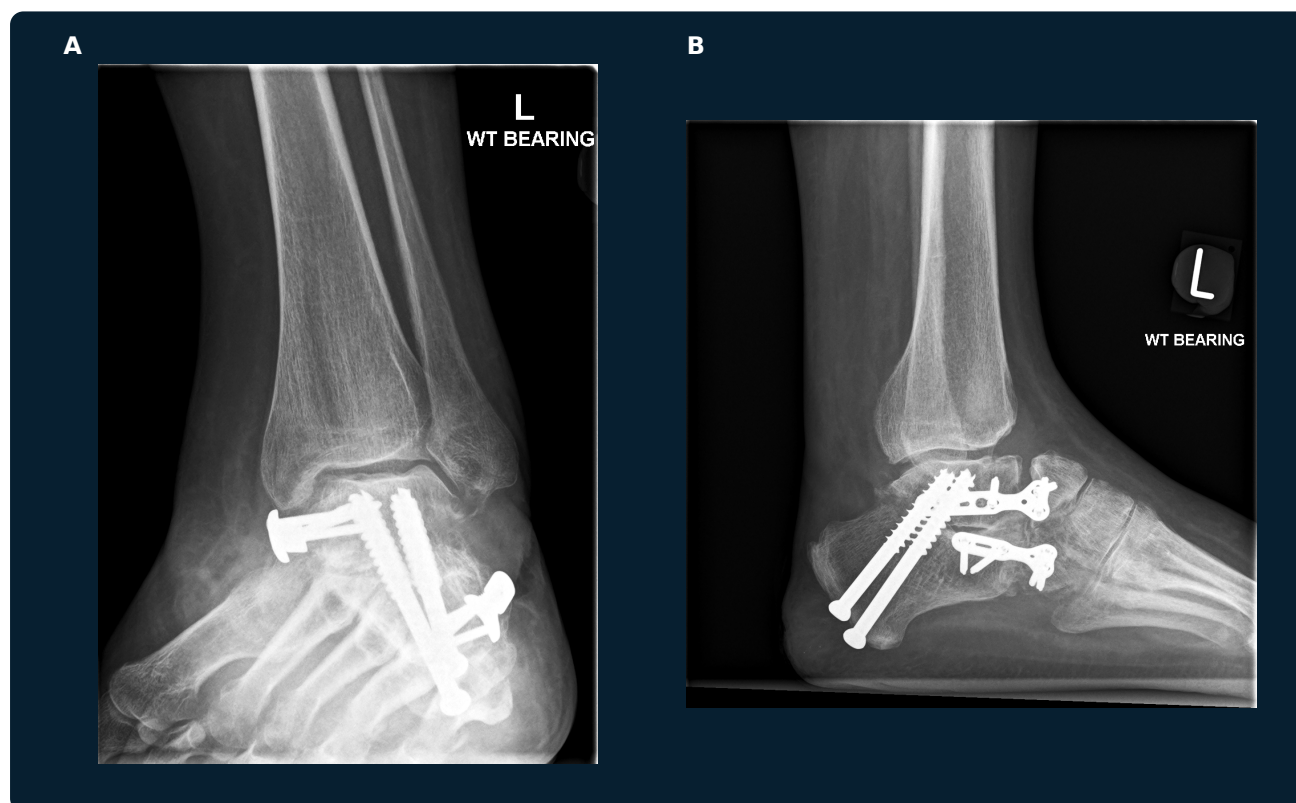
In my consultations, pain around seven out of ten and a patient's description of function below half of their previous level may prompt a more detailed conversation about reconstruction. These are personal discussion prompts, not validated thresholds or a surgical mandate. If a formal outcome measure is used, its name and scoring direction must be recorded. A score of 50 on one scale does not necessarily mean 50% of normal function, and surgery should never follow from the number alone.

Complex cases benefit from collegial review. A regional ankle arthritis or reconstruction meeting, where available, can bring fusion and replacement expertise to the same discussion. Such review can be especially useful after previous surgery, substantial deformity, compromised bone or disagreement about the best option. Local arrangements vary; this is not a single mandatory national referral pathway.

CLINICAL PLATE E | REMODELLING AND THE CLINICAL HISTORY



A, lateral and B, frontal weight-bearing views show extensive distal tibial and talar remodelling with loss of normal joint definition. The images alone cannot distinguish an intended fusion, spontaneous ankylosis or another chronic process. Operative history, clinical findings and adjacent joints remain essential. Source: anonymised images from the author's clinical teaching archive.

CLINICAL PLATE F | KNOW WHICH JOINTS WERE RECONSTRUCTED

A, frontal and B, lateral weight-bearing views show hindfoot and midfoot hardware beneath a retained tibiotalar joint. These are not examples of the author's ankle-fusion technique described below. They illustrate why the anatomical level of reconstruction must be identified when interpreting persistent ankle symptoms. Source: anonymised images from the author's clinical teaching archive.

Ankle fusion and my reconstructive approach

Ankle arthrodesis aims to create a stable, plantigrade, comfortable limb by obtaining union between the tibia and talus. It sacrifices tibiotalar motion. Remaining movement comes from other joints, and patients must understand the implications for squatting, uneven ground, footwear and activities requiring substantial ankle excursion. Risks include nonunion, malunion, infection, wound problems, metalwork symptoms, persistent pain and possible later symptoms in adjacent joints.

There are several ways to achieve fusion. Depending on deformity, bone loss, skin condition and previous surgery, surgeons may use arthroscopic preparation, open approaches, screws, anterior or other plate constructs, external fixation, or intramedullary fixation. A tibiotalocalcaneal nail includes the subtalar joint and is a different functional proposition from an isolated tibiotalar fusion. Preserving a useful subtalar joint remains an important consideration.

The technique I describe in my practice uses lateral and anterior access. A fibular osteotomy allows the fibula to be mobilised and rotated approximately 90 degrees to assist exposure. The remaining articular cartilage is removed and the underlying bone is prepared to promote fusion, including controlled perforation or feathering of the subchondral surface. This is preparation of bone after cartilage removal, rather than microfracturing retained cartilage as a cartilage-repair procedure.

I use a lateral tubular plate in combination with an anterior locking plate to provide fixation in different planes. This describes my preferred construct in selected circumstances; it is not a comparative demonstration that this method is superior to other accepted techniques. Alignment, apposition, compression where appropriate, biological viability and protection of the soft tissues remain more important than the name of a plate. The osteotomy and fibular position must be incorporated into the healing and stability plan.

One intention is to preserve useful anatomy and bone stock for possible future reconstruction. Conversion of a fusion to replacement can be considered in carefully selected patients, but it is a complex revision procedure. Preservation of the fibula alone cannot guarantee that conversion will be feasible or advisable. It depends on the eventual anatomy, bone stock, soft tissues, adjacent joints and specialist assessment. A patient should consent to fusion as a potentially permanent operation, not as an assured temporary step before replacement.

Total ankle replacement

Total ankle replacement aims to reduce pain while preserving some tibiotalar movement. It does not recreate an uninjured ankle or guarantee the motion needed for demanding manual work. Suitability depends on the clinical problem, deformity and its correctability, bone stock, ligament balance, soft tissues, circulation, sensation and the patient's expectations. Infection and serious neurovascular compromise require particular attention. Revision risk and the consequences of implant failure should be discussed from the outset.

My practice includes Stryker ankle systems selected for the individual reconstruction. Infinity is a total ankle replacement system; Inbone provides a modular stemmed construct, and Invision is designed for revision reconstruction. Prophecy provides patient-specific preoperative planning and surgical guides. It is not itself a custom ankle implant. Current product indications, compatible components, local availability and surgeon training must govern use. These names describe different tools, not evidence that one system suits every ankle. [67, 68, 69, 70]

The TARVA randomised trial compared replacement and fusion in patients aged 50 to 85 who were considered suitable for either operation. Both groups improved at one year, and the overall primary comparison did not establish a statistically significant advantage for replacement. Complication profiles differed. A post hoc analysis favoured fixed-bearing replacement, but this exploratory finding does not establish superiority for every implant or patient. These findings support a balanced discussion; they do not prove lifetime equivalence or remove the importance of patient selection. [71]

Preserving movement is a worthwhile goal, but it is only one component of success. A patient with a technically satisfactory replacement may remain dissatisfied, while another with a sound fusion may be very pleased with pain relief and walking ability. The explanation may involve residual pain, expectations, other joints, nerve symptoms, strength or the demands of work. We should assess the person rather than assume that the operation with more movement must produce greater satisfaction.

CLINICAL PLATE G | THREE DIMENSIONAL GEOMETRY**IMAGE**

A CT surface rendering shows global foot-and-ankle geometry and substantial remodelling. Surface views supplement multiplanar CT; they do not define cartilage health, instability or the pain generator. This image is not presented as an example of implant loosening. Source: anonymised images from the author's clinical teaching archive.

Pain after replacement and the limits of static imaging

Pain following replacement requires a systematic assessment. Possible causes include infection, impingement, malalignment, instability, periprosthetic fracture, adjacent-joint disease, tendon or nerve pathology, and loosening. Serial radiographs may show migration or progressive lucency. CT can identify bone loss, component position, fractures and other structural abnormalities; selected MRI techniques may help assess soft tissues. Static imaging remains useful even when it does not fully explain symptoms.

A normal or inconclusive image does not exclude every mechanical problem. Conversely, a lucency or inflammatory change does not by itself prove that a component is mechanically loose. This creates an important research question: can movement of an implant relative to its supporting bone be measured more reliably under controlled conditions?

A research ambition for CT based motion analysis

My interest in this question builds on collaborative CT research in pelvic fracture measurement, femoral symmetry and lower-limb rotational assessment. Work with Henrik Olivecrona, Lars Weidenhielm and other colleagues provided a foundation for thinking about three-dimensional measurement beyond a single static radiograph. The pelvic studies include a cadaveric model and a prospective clinical series. Anatomical symmetry and deformity studies should, however, be distinguished from direct tests of prosthetic loosening. [72, 73, 74, 75]

CT registration can compare the position of defined structures between scans. Migration over time and displacement induced during a controlled examination are different measurements. Hip studies have investigated inducible displacement for detecting loosening, while radiostereometric analysis has measured migration and inducible displacement of ankle components. These studies support investigation of the concept, but they do not validate a new stress-CT test for every ankle replacement. [76, 77]

My proposal is to investigate whether paired, radiation-optimised CT examinations under standardised, tolerable loading or controlled plantarflexion and dorsiflexion can detect clinically relevant movement at an ankle implant-bone interface. Forced extreme movement should not be assumed necessary or safe. The analysis must distinguish normal prosthetic articulation, whole-limb repositioning and measurement error from movement of a component relative to its own supporting bone.

This remains an ankle-specific research ambition. A 2026 scoping review of inducible displacement CT identified important validation gaps and did not establish an ankle diagnostic pathway. A numerical threshold from another joint cannot simply be transferred to the ankle. Excess movement may suggest failure of fixation, but its significance requires validation against clinical follow-up and appropriate reference standards. [78]

An initial programme should establish repeatability and precision, define the loading protocol, control metal artefact and radiation exposure, and test the method in well-characterised groups. Analysis should be blinded where possible and account for infection, implant design and time since surgery. Subsequent studies should examine whether the measurements improve diagnosis and decisions beyond existing care. Commercial support must be declared and the analysis remain independent. I would welcome future collaboration with imaging scientists, academic colleagues and manufacturers, including Stryker; this is a proposed collaboration, not an established agreement.

The purpose of reconstruction

Our ambition is to restore anatomy, comfortable movement and meaningful activity. Current treatments involve compromises. Careful technique, good instruments and collegial support help us pursue that goal, while honest expectations and continued rehabilitation remain essential to the patient's recovery.

Chapter 7 Medico legal aspects of ankle injuries

When an ankle fracture changes a life

An ankle fracture can be a life-changing event even when the wound heals and the bone unites. The patient may continue to struggle with standing, stairs, uneven ground, footwear, driving or sleep. The effect on employment depends on what the job actually requires. An electrician working close to the floor, a carpenter kneeling and squatting, and a roofer moving across a sloping surface may all need movements that are unnecessary in a sedentary role.

The distinction between radiographic recovery and practical recovery is central to my approach. The orthopaedic assessment should explain what the person can do, what remains difficult and why. A united fracture is an important finding; it is not a complete description of the patient's future needs.

Medico-legal work can help a court or compensating body understand those consequences. Its value depends on accurate, independent evidence. The expert does not become an advocate for a particular financial result, and a sympathetic account of hardship must still distinguish injury-related limitations from other causes. This continues the approach developed in my medico-legal handbook. [79]

Treatment and expert evidence have different purposes

The treating team assesses the patient, offers care and supports recovery. An expert witness answers the questions within their instructions and expertise, using the available evidence and explaining its limitations. The same clinician may hold relevant factual knowledge from treatment, but any proposed expert role requires consideration of conflicts, independence and the distinction between factual and opinion evidence.

For civil proceedings in England and Wales, CPR Part 35 gives an expert an overriding duty to help the court on matters within their expertise. That duty takes precedence over obligations to the person instructing or paying them. Practice Direction 35 requires an objective, independent account, including material that may detract from the opinion. Different procedures apply in Scotland and Northern Ireland and must be checked for the relevant case. [80, 81]

GMC guidance applies to medical witness work and requires honesty, competence and clarity about the basis and limits of evidence. Experts should identify relevant conflicts, keep their knowledge current and avoid addressing matters beyond their expertise. Where further records or another specialty are required, the report should say so. [82]

Establishing the history and the evidence

A useful report begins with a clear chronology: the accident, initial symptoms, assessment, reduction, imaging, operative treatment, complications, rehabilitation and subsequent progress. Identify the documents reviewed and those still missing. Original radiographs and CT images can be important where morphology, alignment or timing is disputed; a written radiology report is not always enough to answer those questions.

The patient's account, contemporaneous records and the expert's findings should remain distinguishable. For example, a patient may describe being unable to squat, while examination demonstrates restricted dorsiflexion and pain during a partial squat. These findings support a functional explanation. They do not independently prove how long the restriction has existed or that every difficulty is attributable to the index injury.

Establish pre-injury function with the same care as current disability. Ask about earlier fractures, ankle symptoms, arthritis, diabetes, neuropathy, previous surgery, work restrictions and other conditions affecting mobility. Record the work pattern, sport and domestic responsibilities before the event. A person who had radiographic degeneration but no symptoms presents a different causal question from someone already limited by painful arthritis.

Documentation should also address medication, aids, footwear, treatment response and help received from others. Where reported limitations and observed findings differ, describe the discrepancy fairly and consider pain variability, fatigue, fear and the setting of examination. A single clinic observation does not reproduce a full working day.

Translating the injury into functional consequences

The report should connect an anatomical finding to a task. Restricted dorsiflexion may interfere with squatting or descending stairs. Pain during prolonged loading may limit standing or carrying. Reduced balance may affect ladders and uneven surfaces. Loss of confidence can also influence activity, and psychological consequences may need assessment by an appropriate specialist.

Measured movement, gait, tenderness, swelling, strength, sensation and relevant imaging should be recorded in reproducible terms. A recognised patient-reported outcome measure can complement the assessment, but does not replace it. Document the instrument and scoring direction, and avoid presenting a score as an automatic percentage of disability or earning loss.

Table 7.1 Connecting work demands with clinical assessment

Work or daily task	Relevant ankle demand	Evidence to record
Squatting or low-level electrical and carpentry work	Dorsiflexion, balance and tolerance of sustained positions	Observed movement, pain, duration and possible task adaptation
Roofing, ladders and uneven ground	Balance, reliable foot placement and load control	Gait, stability, endurance and occupational safety assessment
Prolonged standing, lifting or carrying	Weight-bearing tolerance and endurance	Time or distance tolerated, swelling, rest needs and recovery afterwards
Driving	Safe pedal control and emergency response	Side injured, vehicle and transmission, medication, restrictions and appropriate driving advice
Stairs, household work and caring responsibilities	Repeated loading, movement and confidence	Home layout, assistance, aids and specific tasks that cannot be completed

These are prompts for individual assessment, not automatic conclusions about fitness for a job. Workplace observation, occupational therapy or vocational assessment may be needed where the consequences are disputed or technically complex.

Causation and the possibility of clinical negligence

An accident-related injury claim and an allegation of negligent treatment ask different questions. In an injury claim, the expert may be asked what damage the event caused and what consequences are likely to follow. In a clinical negligence claim, the questions may also concern an alleged breach of duty and whether that breach caused additional harm. The expert should answer the actual instructions and identify the factual assumptions on which an opinion depends.

An adverse result does not, by itself, establish negligence. Arthritis may develop after a severe articular injury despite appropriate reduction and treatment. Infection, stiffness or nonunion may be recognised complications, although the management of their risk and response can still require examination. NHS Resolution expressly distinguishes a disappointing outcome from negligent care. [83]

The standard of care should be assessed in the clinical circumstances and against the standards applicable at the time of treatment, rather than solely against later knowledge or guidance. [82]

Where a delay, malreduction or another alleged error is relevant, separate the consequences of the original injury from any additional consequences attributed to the alleged breach. Explain the counterfactual: what outcome would probably have occurred with the alternative care being considered? Avoid assuming that earlier or technically different treatment would necessarily have prevented arthritis.

The report should identify pre-existing disease, subsequent injuries and other plausible contributors. If the injury aggravated or accelerated an underlying condition, explain the evidence and the uncertainty about the likely course without the event. Do not invent a precise acceleration period simply because a calculation would be convenient. Legal tests and disputed facts are ultimately for the court; clinical opinion should make its reasoning transparent.

Prognosis and future treatment

Prognosis should be expressed in a way that distinguishes what is likely, what is possible and what cannot yet be judged. Severity of the original cartilage injury, residual alignment, infection, healing, neurological status, other joints and the trajectory of recovery all matter. The risk of later arthritis is not the same as certainty that the patient will require fusion or replacement.

Removal of metalwork may improve symptoms when there is a convincing local implant-related problem, but it cannot be assumed to relieve pain arising from the joint itself. Discuss refracture, wound and nerve risks, persistent symptoms and the possibility that removal provides little benefit. The indication should be made clinically, rather than included routinely as an anticipated operation in every report.

The same discipline applies to debridement, injections, fusion and replacement. Explain the current indication, alternatives, expected benefit, principal risks, rehabilitation and likely implications for work. The limitations of PRP, BMAC and other injections set out in Chapter 6 also apply to expert evidence. A treatment should not become an unquestioned future cost merely because it is offered privately.

Neither fusion nor replacement guarantees restoration of pre-injury activity. A technically successful procedure may still leave restrictions that matter to a manual worker. Where further surgery is only a possibility, state the factors that would lead to it and the uncertainty about timing. Distinguish treatment recommendations from costings, and identify which costs require contemporary quotations or evidence from other experts.

Rehabilitation and support after discharge

Recovery planning should consider physical, psychological, social and vocational needs. For people with complex rehabilitation needs after traumatic injury, NICE guidance supports coordinated assessment and planning across those domains. Physiotherapy, occupational therapy, pain management and psychological support may each have a role. A written plan should identify the goals, responsible clinicians and review points. [84]

The Rehabilitation Code provides a framework for early consideration of rehabilitation in personal injury claims. Appropriate rehabilitation can be explored while legal issues remain unresolved. The clinical need for support and the legal question of who ultimately bears the cost should not be confused. [85]

The charity referred to in my teaching is Day One Trauma Support, which originated in Leeds and also works with major trauma services including Aintree in Liverpool. It

offers practical and emotional support, help navigating financial and legal concerns, and peer support. Its role should not be described as exclusively short term: support may continue beyond hospital discharge according to need and service availability. Referral and eligibility should be checked with the charity. [86]

Charitable assistance complements statutory services, rehabilitation and legal advice. It does not guarantee compensation or replace a properly assessed long-term care plan. Some people require assistance with transport, domestic activities, dependants or navigating benefits while the orthopaedic recovery remains incomplete.

Returning to work and adapting a career

Return to work is not always an all-or-nothing decision. A phased return, shorter periods of standing, altered tasks, suitable footwear, rest opportunities or a temporary change of role may help. The clinician should describe functional restrictions clearly enough for occupational health and the employer to consider practical arrangements, while recognising that workplace safety requires its own assessment.

In Great Britain, an employer may have duties to make reasonable adjustments where the Equality Act 2010 applies. An ankle injury does not automatically meet the statutory definition of disability; the effect, severity and expected duration require consideration. Occupational advice should be tailored to the person and role rather than assume entitlement or a particular adjustment. [87]

Access to Work may offer additional support for eligible people whose health condition or disability affects employment, subject to its rules. It does not replace the employer's duty to make reasonable adjustments. These possibilities should be considered before assuming that continued symptoms necessarily require permanent withdrawal from work. [88]

For some patients, the original occupation will remain impractical despite treatment and adaptation. Retraining, redeployment or a different career may then be needed. Ill-health retirement is a separate decision governed by the relevant employment and pension arrangements. The orthopaedic expert can explain prognosis and functional limitations, but should not treat retirement or a particular pension entitlement as an automatic consequence of ankle pain.

Compensation and financial needs

Patients may need legal advice about a personal injury claim, an employer's liability claim, a relevant insurance policy or another potential route. The route depends on the circumstances and applicable legal or contractual requirements. There is no universal UK workers' compensation payment for every work-related ankle fracture. Industrial Injuries Disablement Benefit is a separate statutory scheme for eligible people and has its own assessment and eligibility rules. [89]

Medical evidence may inform the assessment of treatment, aids, rehabilitation, care, adaptations and occupational limitations. Solicitors and, where needed, other experts consider the legal basis and valuation of loss. The surgeon should explain the clinical need and uncertainty without promising recovery of a particular sum.

Keep a clear distinction between help actually received, support currently required and future assistance that may become necessary. Similarly, an inability to resume one particular job is not synonymous with complete inability to earn. The evidence may need to address transferable skills, realistic alternative roles, retraining and the labour-market context through suitable vocational expertise.

Patients should obtain timely legal advice about relevant deadlines and routes. A textbook chapter cannot determine limitation dates, insurance coverage or benefits entitlement for an individual case. These questions depend on facts and rules beyond the orthopaedic examination.

Preparing a useful and defensible report

A report should allow another reader to follow the reasoning from the injury and records to the opinion on current function and future needs. Practice Direction 35 sets out formal requirements, including the expert's qualifications, material instructions, relevant literature, the basis of the opinion, any range of opinion and the required declarations. Use the current applicable wording and jurisdiction-specific requirements when preparing a report. [81]

For an ankle injury, the essential clinical sequence is the pre-injury baseline, the event, treatment and complications, the present diagnosis, functional consequences, causation, prognosis and reasonable future options. The conclusions should answer the instructions directly and state what additional evidence could change the opinion. Record review dates where prognosis remains uncertain rather than manufacture finality prematurely.

Confidential information must be handled securely and disclosed appropriately. Reports should contain relevant information and avoid unnecessary personal detail. If new evidence changes a material opinion, the expert should explain and communicate the change through the appropriate process. Accuracy is more valuable than defending an earlier conclusion simply because it has already been written. [82]

The final responsibility

The final responsibility after an ankle fracture extends beyond fixation. We should help the patient understand what has happened, what treatment can still achieve and what adaptation may be necessary. Some will return to their former life; others will need a different way of working or living. Good surgery, rehabilitation, practical support and independent expert evidence can each contribute, but their roles must remain clear.

For me, the measure of success is a patient who has the best achievable function, a realistic understanding of the future and access to appropriate support. The surgeon's task is to combine technical judgement with that wider responsibility, from the first assessment to the long-term consequences of the injury.

Chapter 8 The six pattern framework and targeted treatment

02 The author's six-pattern framework

Descriptive terminology for atypical ankle fracture patterns

	PURE	+ SUPINATION	+ PRONATION
HYPERFLEXION	Pure hyperflexion Proposed extension	Hyperflexion supination Combined pattern	Hyperflexion pronation Combined pattern
HYPEREXTENSION	Pure hyperextension Proposed extension	Hyperextension supination Combined pattern	Hyperextension pronation Combined pattern

Schematic taxonomy only. Anatomical motion conventions require explicit definition.

Teaching diagram 2. The six categories requested by the author are pure hyperflexion, hyperflexion-supination, hyperflexion-pronation, pure hyperextension, hyperextension-supination and hyperextension-pronation. The two pure categories are shown as proposed extensions. No motion arrows are used, and hyperflexion/hyperextension are not equated with plantarflexion/dorsiflexion in this diagram. Define the convention and demonstrate reproducibility before treating the expanded framework as validated.

The purpose of the framework

My interest in atypical ankle fractures began with injuries whose important features were not adequately communicated by a familiar rotational label. In these injuries the lateral view may show substantial anterior or posterior talar displacement, while CT reveals a combination of rim fragments, shear and impaction that changes the reconstruction. The purpose of the proposed Bakhshayesh framework is to make us look more carefully at that problem. A useful classification should improve the explanation of an injury and the quality of the plan.

This chapter brings the six requested patterns into one clinical framework: pure hyperflexion, hyperflexion with supination, hyperflexion with pronation, pure hyperextension, hyperextension with supination and hyperextension with pronation.

The four combined patterns appear in the preliminary conference work. The two pure categories are proposed extensions developed in this book. The framework is not yet a validated replacement for Weber, Lauge-Hansen, CT morphology or direct assessment of stability. [3]

The terms hyperflexion and hyperextension are retained from my developing work. The available source manuscripts do not settle a reproducible anatomical convention for them. For this reason, every clinical or research description should also state plantarflexion or dorsiflexion explicitly, identify the segment moving relative to the other, and record anterior or posterior talar translation as an independent observation. This is especially important when the leg moves over a planted foot. No reduction manoeuvre, expected fragment or surgical approach should be inferred from the label alone.

What the preliminary research can tell us

The conference abstract reports a retrospective 12-month series from 2022 to 2023 in which 70 fractures, representing 20% of the reviewed cohort, were classified as atypical. Its practical signal is that sagittal displacement and unusual morphology deserve attention in a substantial subgroup of the cases reviewed. It does not establish how frequently these injuries occur in the general population, how reliably independent observers classify them, or whether classification-guided surgery improves outcomes. The separate author-reported estimate of approximately 17% should not be merged with the conference result without reconciling the underlying series. [3]

The reported use of syndesmotic fixation, CT and combined approaches reflects the injuries and decisions in that series. A high treatment frequency is not a treatment indication. An atypical ankle should not receive a syndesmotic device merely because another cohort commonly received one. After reconstructing the bony injury, the surgeon must establish whether residual instability remains and choose fixation appropriate to the observed problem.

The author's earlier conceptual manuscript suggests that some atypical patterns may occur when the foot is not firmly fixed to the ground. That is a mechanistic hypothesis. The final fracture image cannot establish whether the foot was free, planted, trapped or sequentially loaded during the event. History, pre-reduction imaging, experimental work and carefully recorded operative findings are needed before such a hypothesis becomes a reproducible explanation. [90]

Pure hyperflexion

The intended distinction is a dominant sagittal injury without a recognised substantial pronation or supination component. Pure does not mean that an injury has been proved to occur in one mathematical plane. It means that the additional components have not been identified to the standard used in that assessment. The category therefore needs a documented basis and an explicit allowance for uncertainty.

The first task is to record the observed talar position on an adequate lateral image, including whether that image preceded reduction. The second is to map the anterior

and posterior tibial margins, articular depression, incisura, fibula and medial structures. If the fracture has an important weight-bearing plafond component, it must be described and managed as a distal tibial articular injury as well as considered within this proposed framework. A pure category does not imply that the syndesmosis or medial restraints are intact.

Treatment follows the actual instability. A rim fragment that contributes to containment, a depressed articular surface and a displaced fibula pose different reconstruction problems. The choice between nonoperative care, direct reduction, buttress fixation, another fixation construct or temporary spanning fixation depends on those findings and the tissues. The label should sharpen the examination of sagittal stability; it should not conceal another plane that also needs treatment.

Hyperflexion with supination

This category combines the proposed sagittal mechanism with a supination component. Supination is a composite position and movement; it is not simply an inward tilt measured on one frontal radiograph. A description should separate the observed coronal alignment, rotational relationship, medial injury and lateral injury before adding a mechanism interpretation.

An asymmetric joint surface, marginal impaction or shear may require direct visualisation, but none is a mandatory feature established for this category. CT should identify the fragment that blocks reduction, the fragment that supports the talus and the relationship of the fracture to the syndesmotic incisura. The operation is planned around those structures. A small visible fragment may be important because of its articular or ligament-bearing role, while a larger fragment may be stable after another component is restored.

In my earlier positioning proposal, a floppy-lateral arrangement with the injured side down was considered for hyperflexion-supination injuries. This is an author-described option, not a universal rule. Its use requires a clear target, acceptable pressure protection, a workable anaesthetic plan and reliable fluoroscopy. The condition of the skin and the required approaches may justify another position. No limb should be placed on an injured surface simply to conform to a classification. [90]

Hyperflexion with pronation

The proposed pronation component asks us to examine a different combination of coronal and rotational findings alongside the sagittal injury. Pronation should be described in its anatomical context rather than used as shorthand for every medial clear-space abnormality. Medial failure, fibular injury and syndesmotic disruption require their own assessment; their severity cannot be read from the category name.

The practical question is whether one exposure can achieve the necessary articular and fibular reconstruction or whether more than one corridor is required. A posterior or medial component that remains malreduced after fibular fixation needs explicit attention. Conversely, the presence of a posterior fragment does not by itself mandate a posterior incision. The sequence should be chosen from CT morphology, reduction opportunities and the soft-tissue envelope.

The author's earlier proposal describes floppy-lateral positioning with the injured side up for selected hyperflexion-pronation injuries. This may provide useful access when it matches the planned reconstruction. It remains a positioning preference requiring case-by-case judgement. The operative plan should explain why that position improves access, how pressure and rotation are controlled, and how the team will verify the joint in every relevant plane. [90]

Pure hyperextension

Pure hyperextension is the second proposed sagittal category without a recognised substantial pronation or supination component. As with pure hyperflexion, it is an extension of the developing framework rather than a separately validated group in the preliminary four-pattern abstract. Its name must not be converted into a presumed direction of talar translation or a predetermined anterior fracture pattern.

The injury map should include the anterior and posterior margins, central plafond, any impacted osteochondral fragment, the fibula and the syndesmosis. An injury with significant axial impaction or metaphyseal disruption may belong primarily within a pilon reconstruction pathway. Classification should never delay recognition of that distinction or encourage a routine malleolar operation for a more extensive articular problem.

The author's conceptual manuscript suggests supine positioning and established pilon approaches for selected hyperextension injuries. The useful principle is access to the demonstrated pathology. Supine positioning is not obligatory if the essential reduction target lies elsewhere or if the tissues favour another corridor. Definitive fixation may be immediate or staged according to the biological and mechanical requirements described in Chapter 3. [90]

Hyperextension with supination

This combined category adds a supination component to the proposed hyperextension mechanism. The description should establish how much of the interpretation comes from the history, pre-reduction images or the final morphology. If the sagittal category is uncertain, it is better to record uncertainty than to produce a confident but non-reproducible label.

Targeted treatment asks which part of the ankle remains unsupported after reduction. Is there a marginal shear fragment, articular depression, loss of fibular length, a displaced medial component or residual syndesmotic instability? These findings may coexist, but no fixed sequence of failure is established for this proposed pattern. The reconstruction must restore the support and containment that the particular injury has lost.

The plan should anticipate whether direct reduction of the articular component is needed before closing the surrounding ring. Premature fixation of one fragment can make another harder to reduce. The decision is made from fragment relationships and access, not from a single preferred order applied to every supination-labelled injury. Fluoroscopic checks should include a true lateral view and an assessment of the reconstructed mortise.

Hyperextension with pronation

This category combines the proposed hyperextension mechanism with pronation. It should prompt a deliberate review of the medial structures, syndesmotic relationship, fibular injury and sagittal containment while retaining the distinction between suspicion and observation. It does not establish that all four structures have failed, nor that all require separate implants.

A combined approach may be appropriate when different fragments cannot be controlled adequately from one corridor. Such a plan must account for the distribution of bruising, blistering, open wounds, vascular status and the skin bridges between incisions. If exposure and safe closure cannot be achieved, temporary stabilisation and staged reconstruction may be the more coherent treatment.

The definitive test of the proposed framework is whether it helps the team identify and solve those problems more consistently. The category is useful when it improves the questions asked of the CT scan and the operation. It becomes unhelpful when it gives an impression of certainty that the evidence does not support.

A common treatment method across all six patterns

The six labels sit within one practical method. First protect the limb and restore a threatened joint relationship. Next describe the injury without relying on a mechanism label: skin, circulation, sensation, talar position, articular injury, fibular length and rotation, medial support and syndesmotic relationship. Then identify the structures whose reduction or stabilisation changes the result. Finally choose the position, approach, sequence and construct that address those structures within the patient's biological and functional limits. [23]

The method should include a plan for difficult reduction. Interposed tissue, an incarcerated fragment, unrecognised rotation or an impacted articular segment can prevent the desired relationship. Repeated force without understanding the obstacle risks additional injury. A changed approach or direct visualisation may be necessary. A reconstruction that is satisfactory on one projection still requires assessment on the others.

The final record should explain what was observed, what was reconstructed and what remained stable or unstable after each important step. It should state the permitted weight-bearing and movement, the reason for any restriction and the intended review. This links classification to treatment and treatment to recovery. A classification has achieved little if it does not improve that chain of reasoning.

How the framework should be tested

A useful validation study requires written operational definitions and anonymised exemplar images agreed before the main observer exercise. Independent readers should classify consecutive cases without knowing treatment or outcome. Both agreement and disagreement matter. Difficult images, missing pre-reduction views and cases that cannot be classified should be reported rather than silently excluded.

The study should compare the six-pattern model with established systems and with a simpler morphology-and-displacement description. Reliability is necessary but not sufficient. Researchers should ask whether the additional label improves surgical planning, predicts relevant outcomes or identifies a subgroup that benefits from a different strategy. Surgeon preference and referral complexity can influence treatment, so treatment frequency cannot serve as the only evidence of usefulness.

The proposed associations with body mass, neuropathy, diabetes, coordination, alcohol and medication need measured exposures and suitable comparators. These hypotheses must not become assumptions about an individual patient. The research aim is a more accurate and useful classification, not the defence of a name regardless of the findings.

Chapter 9 Clinical reasoning through worked examples

How to use these examples

The following examples are constructed teaching scenarios. They are not additional patients from the author's series and are not linked to the radiographs reproduced elsewhere in this book. Their purpose is to demonstrate the sequence of reasoning. No fictional outcome, treatment response or prevalence estimate is offered as clinical evidence.

An isolated fibular fracture with uncertain stability

A patient presents with an apparently isolated Weber B fracture. The first assessment records the skin, circulation, sensation, medial symptoms and any proximal fibular tenderness. The mortise appears congruent on the initial non-weight-bearing films. That image is reassuring, but the fibular level alone does not settle functional stability. The next question is whether the injury is sufficiently isolated and comfortable for a planned weight-bearing assessment under the local pathway.

If a satisfactory weight-bearing study shows a stable mortise in an appropriate patient, nonoperative treatment can be discussed with clear support, loading and follow-up instructions. If the joint is incongruent, the patient cannot provide a meaningful loading study, or associated injury changes the problem, the team needs further assessment. The decision is based on the joint and the person, not an arbitrary allowance for the fibular gap. The record explains why the injury is regarded as stable or unstable and what would trigger reassessment.

A reduced fracture dislocation with an overlooked posterior component

A patient arrives after emergency reduction elsewhere. Current frontal images look acceptable, but the original lateral film shows marked sagittal displacement. CT identifies a posterior articular fragment and impaction that were not obvious on the initial mortise view. The earlier image remains important because successful reduction has changed the appearance without undoing the original injury.

The treatment plan identifies whether the posterior fragment contributes to the incisura, articular surface or talar containment, and whether the depressed area needs direct reduction. The approach and sequence follow these relationships. If the morphology overlaps a posterior pilon injury, that must be named and planned accordingly. After bony reconstruction, the syndesmosis is assessed rather than assumed to be stable or unstable from the label. This example illustrates why complete imaging and preservation of the pre-reduction record matter.

An older person who cannot manage non weightbearing

An older adult with an unstable fracture has poor balance and insufficient upper-limb strength to use crutches safely. A plan requiring prolonged non-weight-bearing may not be deliverable. Before choosing a construct, the team considers pre-injury independence, cognition, skin, sensation, circulation, home arrangements and the assistance available. Physiotherapy and occupational therapy contribute to the decision at the beginning.

Options may include conventional fixation, selected augmented constructs, close-contact casting within an appropriate trained pathway, or selected hindfoot-nail strategies. These options have different consequences for joint preservation, wounds, alignment and later function. Chronological age alone does not select the treatment. The proposed plan should explain how the patient will transfer, reach the toilet, manage stairs and protect the limb. A technically stable reconstruction achieves its purpose only when the recovery plan can be followed.

Diabetes with loss of protective sensation

A patient with diabetes reports little pain despite a displaced ankle injury. Examination identifies reduced protective sensation. Absence of pain must not be mistaken for a minor injury or used to judge safe loading. The team assesses perfusion, skin, previous ulceration, renal disease, glucose management and the possibility of neuropathic instability.

This patient cannot be assumed to match the populations in trials that excluded absent protective sensation. Treatment requires a risk-specific fixation, protection and surveillance strategy, often with specialist diabetic foot or vascular input. The loading prescription must be explicit, and the patient or carers need practical instructions for skin inspection and urgent contact. In this setting, classification explains only part of the problem; the biological and neurological context may dominate the risk of failure.

Persistent pain with preserved joint space

Several months after union, a patient experiences pain at terminal dorsiflexion and difficulty descending steps. The initial question is where the symptoms arise. Examination and imaging may identify an anterior osteophyte and a mechanical block while much of the joint remains preserved. Other causes, including malalignment, instability, tendon symptoms, infection and neuropathic pain, still need consideration.

The finding does not justify labelling the entire ankle as end-stage arthritis. Treatment begins with a plan appropriate to the actual pain generator, including activity modification and rehabilitation within the mechanical limits of the joint. Selected patients may be considered for targeted debridement or another joint-preserving procedure after assessment. The expected benefit is relief of a defined problem, not restoration of a completely normal ankle. A fusion or replacement discussion belongs to a different clinical question when the joint disease warrants it.

The patient whose work requires more than ordinary walking

A patient has united fractures and can walk on level ground but remains unable to climb ladders, squat or carry loads across uneven surfaces. A routine clinic note stating that the patient is mobile does not capture the occupational consequences. Assessment should identify the job tasks, movement and balance demands, endurance, pain pattern, medication effects and realistic opportunities for modified work.

Clinical rehabilitation and independent medico-legal assessment have different purposes but both benefit from an accurate functional description. An expert should separate the patient's account, contemporaneous records, observed findings and opinion. Prognosis should state the reasons for uncertainty and the conditions under which future treatment might be considered. There is no need to promise lifelong recovery or lifelong incapacity when the evidence supports neither. Clear explanation is more valuable than false precision.

Appendix A Practical records for the treating team

A concise injury description

Record the side and injury date in the clinical record, the mechanism as reported, and the timing of each examination. Describe open or closed status, threatened skin, perfusion, sensation and motor findings before and after reduction. Identify pre-reduction and post-reduction images. Record the fibular fracture level and morphology, medial injury, anterior and posterior components, articular impaction, talar translation and syndesmotic findings. Add an established classification and, where useful, a provisional atypical-pattern label with its uncertainty.

In a public teaching figure, remove the clinical identifiers and exact dates. Keep only the imaging information needed to understand the teaching point. A figure caption should not imply a mechanism, operation, follow-up interval or outcome that the source does not establish.

The operative planning note

The note should identify the main reduction targets, why each matters, the intended patient position and the approaches that provide access. State the anticipated sequence, provisional fixation, definitive construct options and the method of checking articular and syndesmotic reduction. Include the soft-tissue plan, any need for orthoplastic input, the alternatives if reduction or closure is unsafe, and the postoperative loading and wound-review plan.

Document the patient's relevant priorities and the discussion of reasonable alternatives. The consent conversation should relate material risks to the patient and the proposed treatment rather than reproduce a generic list without context. Where an author-specific technique or developing strategy is being considered, explain the evidence and alternatives accurately.

The rehabilitation prescription

Specify the limb, Non Weightbearing, Limited Weightbearing or Unrestricted Weightbearing status, and the clinical reason. State the boot, cast or other support required; whether and when it may be removed; the permitted movement; walking aids; practical activity limits; and the next review. Avoid a percentage or kilogram instruction that the patient cannot apply reliably. Changes should be communicated to the patient, nursing team and therapists. [51]

Progression follows wound condition, fixation and fracture stability, symptoms, function and the treating team's assessment. Include advice about increasing pain, new numbness, colour change, wound discharge, fever, calf symptoms or breathlessness and how urgently to obtain help. Review VTE and bleeding risk through the appropriate local pathway. A review date without a usable plan for the intervening days is incomplete care.

A research record for the proposed classification

A prospective dataset should keep the proposed label separate from the observations used to assign it. Record availability and quality of pre-reduction views, actual talar translation, CT morphology, impaction, associated fragments, observer confidence, competing classifications and unclassifiable cases. Define pilon inclusion or exclusion in advance. Record treatment decisions and outcomes independently of the observer classification wherever practical.

Patient-centred outcomes should include pain, function, return to meaningful activity, complications and further procedures, with a prespecified follow-up schedule. Radiographic union alone is not sufficient. Any future comparison should account for injury severity, comorbidity, referral patterns and treatment selection. A transparent negative finding can improve a classification as much as a favourable one.

Appendix B Terms used in this book

Morphology

The observed shape, location and relationship of injured structures. Morphology describes the fracture and associated damage without claiming to reconstruct the entire injury event.

Mechanism

An explanation of how forces and relative movement produced an injury. It may be supported by the history and images but often remains partly inferred.

Stability

The ability of the injured or reconstructed ankle to maintain an acceptable relationship under the conditions relevant to treatment. Stability must be considered with the permitted loading and soft tissues.

Syndesmosis and incisura

The syndesmosis is the distal tibiofibular ligament complex. The incisura is the tibial groove accommodating the distal fibula. Correct fibular length, rotation and position matter alongside the condition of the ligaments.

Tillaux Chaput and Wagstaffe Le Fort fragments

These terms refer respectively to bony injuries at the tibial and fibular attachments of the anterior inferior tibiofibular ligament. They should not be used interchangeably with every anterior plafond fracture.

Pilon and posterior pilon patterns

Pilon injuries involve the weight-bearing distal tibial articular surface with variable impaction and metaphyseal disruption. Some posterior-dominant patterns overlap rotational ankle injuries, making a detailed description more useful than a contested label alone.

Impingement and edge arthritis

Impingement describes painful contact or entrapment of structures during movement. Edge arthritis is the author's descriptive term for symptomatic marginal osteophytes with relative preservation of the central articulation; it is not a universally validated stage of osteoarthritis.

Synostosis

A bony bridge between the tibia and fibula. Its importance depends on symptoms and functional consequences, not its appearance alone.

Arthrodesis and arthroplasty

Arthrodesis aims for bony fusion across a joint. Arthroplasty replaces the joint surfaces with an implant construct. Both involve compromises and require patient-specific assessment.

Proposed classification

A structured hypothesis that requires clear definitions, reproducibility and clinical validation. In this book the six-pattern Bakhshayesh framework is presented in that developing form.

APPENDIX C

A practical method for describing an ankle fracture

A useful fracture description should allow a colleague who has not yet seen the images to understand the urgent problem and the questions that remain. It should be sufficiently structured to prevent omissions but sufficiently short to support a decision. The following method is a teaching framework. It complements local documentation requirements and does not replace examination or review of the original images.

1. Begin with the person and the immediate condition

State the injured side, skeletal maturity, relevant baseline function and the main treatment constraints. Record whether the injury is open or closed, whether the ankle is deformed or reduced, and the condition of the skin, circulation and sensation. Distinguish observed findings from assumptions: “sensation not reliably assessable because of pre-existing neuropathy” is more useful than an unsupported “neurovascularly intact”. Document examination before and after reduction. Urgent reduction of a threatened ankle should not wait for an elaborate classification exercise. [23]

2. Identify the information on which the description rests

Say which images are available and whether they precede or follow manipulation. Identify the mortise and lateral views, any additional leg imaging and any CT examination. Mention limitations that could change interpretation, such as an oblique lateral image, obscuration by a cast or incomplete coverage of a suspected proximal injury. A normal-looking post-reduction image does not erase the significance of a documented fracture-dislocation. Retain the earlier images as part of the injury account.

3. Put the talus at the centre

Describe the talus relative to the tibial plafond in the coronal and sagittal planes. Is it centred, translated, tilted, subluxed or dislocated? Specify the direction. Describe obvious rotation when supported by the available views, but do not claim precise rotational measurement from an inadequate projection. If the apparent relationship changes between unloaded and weight-bearing images, record the loading conditions and the actual finding. “The mortise remains congruent on the available weight-bearing view” is more precise than asserting that every ligament is intact.

4. Map every bony component

Describe the fibula by level, configuration, displacement, shortening, rotation and comminution where these can be assessed. Then describe the medial, posterior and anterior tibial components separately. Include avulsion fragments and state their attachment or anatomical location when identifiable. For posterior injury, record posterolateral and posteromedial involvement, extension into the incisura and any separate articular fragments. A count of malleoli is useful shorthand, but it should follow the anatomical account rather than replace it.

5. Describe the joint surface and soft tissues

Record an articular step, gap, depressed surface, intercalary fragment, loose fragment or subchondral comminution if present. Keep measurements linked to the image and plane from which they were obtained. State when cartilage itself has not been assessed. Note soft-tissue findings that affect treatment, including blistering, skin threat, an open wound or suspected tendon displacement. Avoid describing a surface as normal merely because the available radiographs cannot show its damage.

6. Separate anatomy, proposed mechanism and stability

After the morphology, give a conventional classification when it can be applied confidently. Add the proposed mechanism as an interpretation, with uncertainty where appropriate. If using the atypical-fracture framework, state the category and the actual sagittal movement or displacement being described. Use plantarflexion or dorsiflexion with an explicit reference segment; do not ask the reader to infer what hyperflexion or hyperextension means. Finally, state whether stability is demonstrated, clearly lost or remains uncertain, and on what evidence that judgement rests.

7. Translate the description into decisions

The concluding statement should identify what the description changes. Does the joint require urgent reduction? Is further imaging needed to define an articular fragment? Is specialist reconstruction required? Can a congruent position be maintained nonoperatively, or is operative stabilisation being considered? State any uncertainty that must be resolved before choosing the definitive treatment. The purpose is to make the reasoning inspectable, not to make a provisional opinion sound final.

Domain	Minimum useful statement
Person and tissues	Baseline function, relevant comorbidity, skin, circulation and sensation
Joint position	Talar relationship to the tibia in both major radiographic planes
Bony injury	Fibular, medial, posterior and anterior components
Articular injury	Step, gap, impaction and fragment relationships, with imaging limitations
Stability	What was tested, under which conditions, and what was found
Interpretation	Classification and proposed mechanism, separated from direct observations
Plan	Immediate action, unresolved question and next decision

A worked teaching example

The following is an invented teaching example, not a patient record: “Closed ankle fracture in a skeletally mature adult who previously walked independently. Initial lateral imaging shows posterior talar subluxation. Following reduction, the talus is centred on the available mortise and lateral views. There is an oblique transsyndesmotomic fibular fracture, a medial malleolar fracture and a posterior tibial fragment. CT demonstrates extension of the posterior fragment into the incisura and a separate impacted articular fragment. The skin is swollen but has no documented open wound; circulation and sensation are recorded before and after reduction. This is a complex malleolar injury with articular impaction. The posterior morphology and reduction strategy require specialist planning; syndesmotomic competence must be assessed in the reconstructed ankle.”

The value of this account is not its length. It communicates a sagittal displacement, the response to reduction, the complete bony pattern and a specific reconstructive question. Calling the injury “Weber B” or “trimalleolar” alone would omit information that changes planning. The example also avoids claiming a witnessed mechanism from the fracture pattern and avoids declaring the syndesmosis normal simply because the reduced mortise looks satisfactory.

A final discipline: record change over time

An injury description should evolve as information becomes available. The emergency account prioritises threat and reduction. CT may refine the morphology. Surgery may clarify tissue interposition, cartilage injury and residual instability. Follow-up establishes whether the position and function are being maintained. Date these changes and preserve the distinction between the original finding and a later interpretation. This creates a better clinical record and a more trustworthy foundation for audit, research and medico-legal explanation.

IMAGE RECORD

Illustration sources and interpretation

Clinical Plates A-C contain six anonymised images from one author-held distal tibial articular-fracture planning document: two radiographs, two CT slices and two fluoroscopic fixation views. Their purpose is to demonstrate how different projections and CT morphology inform reconstruction. They are not an atlas validating the six atypical categories.

Plate D contains one weight-bearing radiograph from the author's archive. Plate E contains two views demonstrating extensive remodelling. Plate F contains two views of a hindfoot and midfoot reconstruction. Plate G contains one surface-rendered CT image from an author-held ankle-revision planning document. No patient names, dates, hospital numbers, accession numbers, source-file labels or source DICOM tags are reproduced.

The clinical images were reproduced as flattened publication copies. Marginal interface fragments were cropped where necessary; source DICOM images were rendered with a global contrast window and appropriate monochrome inversion. Anatomy was not generated, reconstructed or altered with generative tools. The captions deliberately avoid unsupported mechanism or outcome claims. GMC guidance distinguishes anonymised radiographs from identifiable recordings. [91]

The eight teaching diagrams are original vector graphics prepared for this edition. They are conceptual explanations of reasoning, not patient images or validated biomechanical simulations. The cover reuses the conceptual navy-and-gold artwork from the author's Philosophy of Foot and Ankle Surgery.

Teaching diagram	Subject
1	Three descriptions, one treatment plan
2	The author's six-pattern framework
3	Assessment starts with the threatened limb
4	Four requirements for a useful reconstruction
5	Rehabilitation progresses by criteria
6	Persistent pain: identify the source
7	Four questions before definitive fixation
8	Reconstruction is a sequence of objectives

LINKED SOURCES

References

References are numbered in order of first citation. Author manuscripts and conference research are distinguished from peer-reviewed studies and official guidance. URLs were checked during preparation where accessible; a linked source does not imply endorsement of this book. Clinical and legal sources should be read within their stated scope.

- 1.** Bakhshayesh P. Philosophy of Major Trauma. Revised illustrated edition. October 2026. Author educational book. [Read source](#)
- 2.** Bakhshayesh P. Philosophy of Foot and Ankle Surgery. Complete illustrated edition. 14 October 2026. Author educational book, including Chapter 8 Foot and Ankle Trauma. [Read source](#)
- 3.** Jumah A, Bakhshayesh P. Identifying and Managing Atypical Ankle Fractures Beyond the Lauge-Hansen Classification System. BOFAS Scientific Meeting 2025. Poster P20, detailed abstract p77. Preliminary conference research. [Read source](#)
- 4.** Happonen V, Kröger H, Kuusmin M, Sund R. Ankle fractures in Finland: 118,929 operatively treated between 1987 and 2019. Acta Orthop. 2022;93:327-333. doi:10.2340/17453674.2022.2071. [Read source](#)
- 5.** Hasselman CT, Vogt MT, Stone KL, Cauley JA, Conti SF. Foot and ankle fractures in elderly white women: incidence and risk factors. J Bone Joint Surg Am. 2003;85(5):820-824. doi:10.2106/0004623-200305000-00008. [Read source](#)
- 6.** Wukich DK, Joseph A, Ryan M, Ramirez C, Irrgang JJ. Outcomes of ankle fractures in patients with uncomplicated versus complicated diabetes. Foot Ankle Int. 2011;32(2):120-130. doi:10.3113/FAI.2011.0120. [Read source](#)
- 7.** AO Surgery Reference. Infrasyndesmotoc lateral isolated fracture. Adult trauma, malleoli. [Read source](#)
- 8.** AO Surgery Reference. Suprasyndesmotoc multifragmentary fibula, medial injury, with or without posterior fracture. Adult trauma, malleoli. [Read source](#)
- 9.** Mason LW, Marlow WJ, Widnall J, Molloy AP. Pathoanatomy and associated injuries of posterior malleolus fracture of the ankle. Foot Ankle Int. 2017;38(11):1229-1235. doi:10.1177/1071100717719533. [Read source](#)
- 10.** Rammelt S, Bartoníček J, Kroker L, Neumann AP. Surgical fixation of quadrimalleolar fractures of the ankle. J Orthop Trauma. 2021;35(6):e216-e222. doi:10.1097/BOT.0000000000001915. [Read source](#)
- 11.** Souleiman F, Heilemann M, Hennings R, et al. Effect of weightbearing and foot positioning on 3D distal tibiofibular joint parameters. Scientific Reports. 2022;12:9357. [Read source](#)
- 12.** Ramsey PL, Hamilton W. Changes in tibiotalar area of contact caused by lateral talar shift. Journal of Bone and Joint Surgery American. 1976;58(3):356-357. [Read source](#)
- 13.** Lloyd J, Elsayed S, Hariharan K, Tanaka H. Revisiting the concept of talar shift in ankle fractures. Foot & Ankle International. 2006;27(10):793-796. [Read source](#)
- 14.** Campbell KJ, Michalski MP, Wilson KJ, et al. The ligament anatomy of the deltoid complex of the ankle: a qualitative and quantitative anatomical study. Journal of Bone and Joint Surgery American. 2014. [Read source](#)
- 15.** McCormack DJ, et al. Role of the posterior deep deltoid ligament in ankle fracture stability: a biomechanical cadaver study. World Journal of Orthopedics. 2022;13(11):969-977. [Read source](#)

- 16.** Clanton TO, Campbell KJ, Wilson KJ, et al. Qualitative and quantitative anatomic investigation of the lateral ankle ligaments for surgical reconstruction procedures. *Journal of Bone and Joint Surgery American*. 2014. [Read source](#)
- 17.** Bahr R, Pena F, Shine J, Lew WD, Engebretsen L. Ligament force and joint motion in the intact ankle: a cadaveric study. *Knee Surgery, Sports Traumatology, Arthroscopy*. 1998;6(2):115-121. [Read source](#)
- 18.** Gardner MJ, Brodsky A, Briggs SM, Nielson JH, Lorich DG. Fixation of posterior malleolar fractures provides greater syndesmotic stability. *Clinical Orthopaedics and Related Research*. 2006;447:165-171. [Read source](#)
- 19.** Mait AR, Forman JL, Nie B, et al. Propagation of syndesmotic injuries during forced external rotation in flexed cadaveric ankles. *Orthopaedic Journal of Sports Medicine*. 2018. doi:10.1177/2325967118781333. [Read source](#)
- 20.** Gregersen MG, Robinson HS, Molund M. Concomitant unstable and stable gravity stress tests on weight-bearing stable Weber B ankle fractures treated nonoperatively: a 2-year outcome study. *J Bone Joint Surg Am*. 2023;105:1435-1441. [Read source](#)
- 21.** Stufkens SAS, Knupp M, Horisberger M, Lampert C, Hintermann B. Cartilage lesions and the development of osteoarthritis after internal fixation of ankle fractures: a prospective study. *Journal of Bone and Joint Surgery American*. 2010;92:279-286. [Read source](#)
- 22.** Tornetta P III, Gorup J. Axial computed tomography of pilon fractures. *Clin Orthop Relat Res*. 1996;(323):273-276. doi: 10.1097/00003086-199602000-00037 [Read source](#)
- 23.** British Orthopaedic Association. BOAST: The Management of Ankle Fractures. August 2016. [Read source](#)
- 24.** van den Bekerom MPJ, van Dijk CN. Is fibular fracture displacement consistent with tibiotalar displacement? *Clin Orthop Relat Res*. 2010;468(4):969-974. doi:10.1007/s11999-009-0959-7. [Read source](#)
- 25.** Michelson J, Solocoff D, Waldman B, Kendell K, Ahn U. Ankle fractures: the Lauge-Hansen classification revisited. *Clin Orthop Relat Res*. 1997;(345):198-205. [Read source](#)
- 26.** National Institute for Health and Care Excellence. Fractures (non-complex): assessment and management. NG38. Recommendations 1.2.2 and 1.4.1-1.4.2. [Read source](#)
- 27.** American College of Radiology. ACR Appropriateness Criteria: Acute Trauma to the Ankle. Revised 2020. [Read source](#)
- 28.** Bakhshayesh P. Ankle fractures; Pilon fractures. Professional patient guides, prepared 10 October 2026. Related author material consulted for continuity of explanation. [Read source 1](#) · [Read source 2](#)
- 29.** British Orthopaedic Association. BOAST: Open Fractures. December 2017; orthoplastic-centre definition updated November 2019. [Read source](#)
- 30.** National Institute for Health and Care Excellence. Fractures (complex): assessment and management. NG37. Updated 23 November 2022; especially recommendations 1.2.27-1.2.34. [Read source](#)
- 31.** Halvachizadeh S, Pfeifer R, Kalbas Y, Schuerle S, Cinelli P, Pape HC. Assessment of alternative techniques to quantify the effect of injury on soft tissue in closed ankle and pilon fractures. *PLoS One*. 2022;17(5):e0268359. doi: 10.1371/journal.pone.0268359 [Read source](#)
- 32.** Giordano CP, Koval KJ. Treatment of fracture blisters: a prospective study of 53 cases. *J Orthop Trauma*. 1995;9(2):171-176. doi: 10.1097/00005131-199504000-00014 [Read source](#)
- 33.** Schepers T, de Vries MR, van Lieshout EMM, van der Elst M. The timing of ankle fracture surgery and the effect on infectious complications; a case series and systematic review of the literature. *Int Orthop*. 2013;37:489-494. doi: 10.1007/s00264-012-1753-9 [Read source](#)

- 34.** Pilskog K, Gote TB, Odland HEJ, et al. Association of Delayed Surgery for Ankle Fractures and Patient-Reported Outcomes. *Foot Ankle Int.* 2022;43(6):762-771. doi: 10.1177/10711007211070540 [Read source](#)
- 35.** Penning D, Tausendfreund J, Naryapragi MA, et al. Timing of Fracture Fixation in Ankle Fracture-Dislocations. *Foot Ankle Spec.* 2026;19(4):368-382. First published online 5 October 2024. doi: 10.1177/19386400241273105 [Read source](#)
- 36.** Silva AM, Franco H, Walsh TP, Hohuynh A, Platt S. Preoperative Ankle Swelling and the Effect On Postoperative Wound Complications Following Ankle Fracture Surgery. *Foot Ankle Orthop.* 2025;10(3):24730114251342252. doi: 10.1177/24730114251342252 [Read source](#)
- 37.** Sirkin M, Sanders R, DiPasquale T, Herscovici D Jr. A staged protocol for soft tissue management in the treatment of complex pilon fractures. *J Orthop Trauma.* 1999;13(2):78-84. doi: 10.1097/00005131-199902000-00002 [Read source](#)
- 38.** Bakhshayesh P. Philosophy of Ankle Fractures. Supplied opening chapter manuscript. 17 October 2026. Incorporated and expanded in this edition.
- 39.** Mason LW, Kaye A, Widnall J, Redfern J, Molloy A. Posterior Malleolar Ankle Fractures: An Effort at Improving Outcomes. *JB JS Open Access.* 2019;4(2):e0058. doi:10.2106/JBJS.OA.18.00058. [Read source](#)
- 40.** Jackson NJ, Root KT, Nichols JA, Reb CW. Image Rotation Alters Apparent Fibula Length: An Evaluation of Talocrural Angle, Shenton Line, and Dime Sign. *Foot Ankle Int.* 2024;45(3):236-242. doi:10.1177/10711007231221991. [Read source](#)
- 41.** Murphy JM, Kadakia AR, Irwin TA. Variability in radiographic medial clear space measurement of the normal weight-bearing ankle. *Foot Ankle Int.* 2012;33(11):956-963. doi:10.3113/FAI.2012.0956. [Read source](#)
- 42.** Okoro T, Teoh KH, Tanaka H. Fibula pro-tibia vs standard locking plate fixation in an ankle fracture saw bone model. *World J Orthop.* 2021;12(8):548-554. doi:10.5312/wjo.v12.i8.548. [Read source](#)
- 43.** Georgiannos D, et al. Fragility fractures of the ankle in the elderly: Open reduction and internal fixation versus tibio-talo-calcaneal nailing: Short-term results of a prospective randomized-controlled study. *Injury.* 2017. [Read source](#)
- 44.** Willett K, Keene DJ, Mistry D, et al. Close Contact Casting vs Surgery for Initial Treatment of Unstable Ankle Fractures in Older Adults: A Randomized Clinical Trial. *JAMA.* 2016;316(14):1455-1463. doi:10.1001/jama.2016.14719. [Read source](#)
- 45.** Sanders FRK, Birnie MF, Dingemans SA, et al. Functional outcome of routine versus on-demand removal of the syndesmotic screw: a multicentre randomized controlled trial. *Bone Joint J.* 2021;103-B(11):1709-1716. doi:10.1302/0301-620X.103B11.BJJ-2021-0348.R2. [Read source](#)
- 46.** Bakhshayesh P. Ankle fractures: patient information and recovery guide. Prepared 10 October 2026. [Read source](#)
- 47.** Bretherton CP, Achten J, Jogarah V, et al. Early versus delayed weight-bearing following operatively treated ankle fracture (WAX): a non-inferiority, multicentre, randomised controlled trial. *Lancet.* 2024;403:2787-2797. doi:10.1016/S0140-6736(24)00710-4. [Read source](#)
- 48.** Bretherton CP, et al. Protocol for the Weight-bearing in Ankle Fractures (WAX) trial: a multicentre prospective non-inferiority trial of early versus delayed weight-bearing after operatively managed ankle fracture. *BMC Musculoskelet Disord.* 2021. doi:10.1186/s12891-021-04560-7. [Read source](#)
- 49.** Khojaly R, Rowan FE, Shah V, et al. Immediate Weight-Bearing Compared with Non-Weight-Bearing After Operative Ankle Fracture Fixation: Results of the INWN Pragmatic, Randomized, Multicenter Trial. *J Bone Joint Surg Am.* 2025;107:1423-1438. doi:10.2106/JBJS.24.00965. [Read source](#)

- 50.** Khojaly R, et al. Is postoperative non-weight-bearing necessary? INWN Study protocol for a pragmatic randomised multicentre trial of operatively treated ankle fracture. *Trials*. 2021. doi:10.1186/s13063-021-05319-0. [Read source](#)
- 51.** British Orthopaedic Association. BOASt Mobilisation and weightbearing after orthopaedic surgery and musculoskeletal injury. August 2024. [Read source](#)
- 52.** Ramadi A, Beaupre LA, Heinrichs L, Pedersen ME. Recovery and Return to Activity 1 Year After Ankle Fracture Managed With Open Reduction and Internal Fixation: A Prospective Longitudinal Cohort Study. *Foot Ankle Orthop*. 2022. doi:10.1177/24730114221091806. [Read source](#)
- 53.** Moseley AM, Beckenkamp PR, Haas M, Herbert RD, Lin CC. Rehabilitation After Immobilization for Ankle Fracture: The EXACT Randomized Clinical Trial. *JAMA*. 2015;314(13):1376-1385. doi:10.1001/jama.2015.12180. [Read source](#)
- 54.** National Institute for Health and Care Excellence. Venous thromboembolism in over 16s: reducing the risk of hospital-acquired deep vein thrombosis or pulmonary embolism. NG89, recommendations 1.11.1 and 1.11.14. [Read source](#)
- 55.** NHS. Broken ankle. Patient guidance on treatment, recovery and seeking help. [Read source](#)
- 56.** Bakhshayesh P. Ankle arthritis. Practice patient information and recovery guide. Prepared 10 October 2026. [Read source](#)
- 57.** Royal National Orthopaedic Hospital. A Patient's Guide to Ankle Arthritis. Assessment, treatment and expectations. [Read source](#)
- 58.** Tol JL, Verheyen CP, van Dijk CN. Arthroscopic treatment of anterior impingement in the ankle. *J Bone Joint Surg Br*. 2001;83(1):9-13. doi:10.1302/0301-620X.83B1.10571. [Read source](#)
- 59.** Droog R, Verhage SM, Hoogendoorn JM. Incidence and clinical relevance of tibiofibular synostosis in fractures of the ankle which have been treated surgically. *Bone Joint J*. 2015;97-B(7):945-949. doi:10.1302/0301-620X.97B7.34460. [Read source](#)
- 60.** American Academy of Orthopaedic Surgeons. Management of Ankle Osteoarthritis Evidence-Based Clinical Practice Guideline. Adopted 4 June 2026. [Read source](#)
- 61.** NICE. Osteoarthritis in over 16s diagnosis and management. NG226. 2022. Recommendation 1.4.10 on corticosteroid injections. [Read source](#)
- 62.** University Hospitals of Morecambe Bay NHS Foundation Trust. Ultrasound Guided Steroid Injections in the Radiology Department. Patient information. [Read source](#)
- 63.** Paget LDA, Reurink G, de Vos RJ, et al. Effect of Platelet-Rich Plasma Injections vs Placebo on Ankle Symptoms and Function in Patients With Ankle Osteoarthritis. *JAMA*. 2021;326(16):1595-1605. doi:10.1001/jama.2021.16602. [Read source](#)
- 64.** Paget LDA, Reurink G, de Vos RJ, et al. Platelet-Rich Plasma Injections for the Treatment of Ankle Osteoarthritis. *Am J Sports Med*. 2023;51(10):2625-2634. doi:10.1177/03635465231182438. [Read source](#)
- 65.** Vannini F, Filardo G, Altamura SA, et al. Bone marrow aspirate concentrate and scaffold for osteochondral lesions of the talus in ankle osteoarthritis: satisfactory clinical outcome at 10 years. *Knee Surg Sports Traumatol Arthrosc*. 2021;29(8):2504-2510. doi:10.1007/s00167-021-06494-y. Combined surgical series, not injection-alone evidence. [Read source](#)
- 66.** Contura Orthopaedics. Arthrosamid Instructions for Use. October 2025. Manufacturer intended use for symptomatic knee osteoarthritis. [Read source](#)
- 67.** Stryker. Infinity with Adaptis Technology. Manufacturer product information. [Read source](#)
- 68.** Stryker. Inbone Total Ankle System. Manufacturer product information. [Read source](#)

- 69.** Stryker. Invision Total Ankle Revision System. Manufacturer product information. [Read source](#)
- 70.** Stryker. Prophecy Preoperative Navigation Alignment System. Patient-specific planning and surgical guides. [Read source](#)
- 71.** Goldberg AJ, Chowdhury K, Bordea E, et al. Total ankle replacement versus ankle arthrodesis for patients aged 50-85 years with end-stage ankle osteoarthritis: the TARVA RCT. Health Technol Assess. 2023;27(5):1-80. doi:10.3310/PTYJ1146. [Read source](#)
- 72.** Bakhshayesh P, Olivecrona H, Weidenhielm L, Enocson A. A New CT Based Method for Post-operative Motion Analysis of Pelvic Fractures. 3D Research. 2019;10:7. doi:10.1007/s13319-019-0217-z. [Read source](#)
- 73.** Lundin N, Olivecrona H, Bakhshayesh P, Gordon Murkes L, Enocson A. Computed tomography micromotion analysis in the follow-up of patients with surgically treated pelvic fractures: a prospective clinical study. Eur J Orthop Surg Traumatol. 2023;33:3143-3151. doi:10.1007/s00590-023-03542-w. [Read source](#)
- 74.** Bakhshayesh P, Sandberg O, Kumar V, Ali A, Enocson A. Volume fusion of CT images to measure femoral symmetry. Surg Radiol Anat. 2020;42:635-639. doi:10.1007/s00276-019-02389-3. [Read source](#)
- 75.** Bakhshayesh P, Ihediwa U, Sandher S, Vris A, Heidari N, Enocson A. A novel technique to assess rotational deformities in lower extremities using CT-based motion analysis. Sci Rep. 2021;11:21123. doi:10.1038/s41598-021-00532-y. [Read source](#)
- 76.** Sandberg O, Carlsson S, Harbom E, et al. Inducible displacement CT increases the diagnostic accuracy of aseptic loosening in primary total hip arthroplasty. Acta Orthop. 2022;93:831-836. doi:10.2340/17453674.2022.5240. [Read source](#)
- 77.** Dunbar MJ, Fong JW, Wilson DA, Hennigar AW, Francis PA, Glazebrook MA. Longitudinal migration and inducible displacement of the Mobility Total Ankle System. Acta Orthop. 2012;83(4):394-400. doi:10.3109/17453674.2012.712890. Radiostereometric analysis. [Read source](#)
- 78.** ter Wee MA, Dobbe JGG, Kievit AJ, et al. Inducible displacement CT for implant loosening detection: a scoping review on methods, validation, and challenges. Acta Orthop. 2026. doi:10.2340/17453674.2026.45512. [Read source](#)
- 79.** Bakhshayesh P. Principles of Medicolegal Activity in the UK. First edition. 14 October 2026. Author website and book overview. [Read source](#)
- 80.** Ministry of Justice. Civil Procedure Rules Part 35 Experts and Assessors. In particular rules 35.3 and 35.10. England and Wales. [Read source](#)
- 81.** Ministry of Justice. Practice Direction 35 Experts and Assessors. In particular paragraphs 2.1-2.5 and 3.1-3.3. England and Wales. [Read source](#)
- 82.** General Medical Council. Providing witness statements or expert evidence as part of legal proceedings. Updated 13 December 2024. [Read source](#)
- 83.** NHS Resolution. Advice for clinicians on responding to clinical negligence claims. 10 July 2026. Section 8. [Read source](#)
- 84.** NICE. Rehabilitation after traumatic injury. NG211. 18 January 2022. Guidance for complex rehabilitation needs. [Read source](#)
- 85.** Ministry of Justice. Pre-Action Protocol for Personal Injury Claims. Paragraphs 4.1-4.5 on rehabilitation and the Rehabilitation Code. [Read source](#)
- 86.** Day One Trauma Support. Our Story and About Day One. Service history, purpose and continuing support. History | Services [Read source 1](#) · [Read source 2](#)
- 87.** GOV.UK. Reasonable adjustments for workers with disabilities or health conditions. [Read source](#)

88. Department for Work and Pensions. Access to Work: get support if you have a disability or health condition. [Read source](#)

89. Department for Work and Pensions. Industrial Injuries Disablement Benefit Eligibility. [Read source](#)

90. Bakhshayesh P. A biomechanical classification of the Partial Articular Pilon or Atypical ankle fractures. Author-held conceptual manuscript, undated. Consulted 17 October 2026. Unpublished proposal.

91. General Medical Council. Making and using visual and audio recordings of patients. Anonymised recordings, paragraphs 10-12. Current online guidance consulted 17 October 2026. [Read source](#)