Consensus of the 10th Round Table Stratford upon Avon, June 2023

Professor Stefan Rammelt MD,
Amjad Sawah MD,
Dishan Singh FRCS (Orth),
James Tebby FRCS (Tr & Orth)

Ankle and hindfoot fractures

OrthoSolutions Group
Advancing Foot & Ankle Care

Consensus of the 10th Round Table Stratford upon Avon, June 2023

Course Facilitator:
Dishan Singh

Chairpersons:
Callum Clark
Mark Davies
Venu Kavarthapu
Jit Mangwani
Lyndon Mason

Hosted by:
OrthoSolutions Group

Distilled in this document are the thoughts and opinions, with consensus where possible, of 25 Orthopaedic Foot and Ankle Consultant Surgeons who gathered from across the United Kingdom, Germany and USA. A basis of invited lectures introduced open and frank discussion from which consensus was sought. The statements herein only represent those of individuals and no claim is made that they are irrefutable. All the percentage figures quoted represent the proportion of the surgeons present who voted on the subject in discussion.

Preface

The 1st Round Table meeting was held in Padua in June 2011 and, thereafter, rapidly became established in the foot and ankle calendar. There was a gap in the subsequent annual meetings due to the pandemic and the resumption of the meetings with our 10th meeting being held at Stratford upon Avon in June 2023 was well received. The meeting followed the usual unique format where all participants have an equal input to review the literature and present their individual experience on a topic - with ample time for an informal discussion of the subject in a relaxed setting. We then attempt where possible to reach a consensus to guide us.

This year, the theme was ankle and hindfoot fractures and this has reflected the change in practice in recent years. Our distinguished local participants had the privilege of an international perspective from Professor Stefan Rammelt from Dresden, Germany and Dr. Justin Kane from Texas, USA. James Ritchie delivered his usual fascinating historical lecture - this time on Medicine, Magic and Witchcraft in Shakespeare's England.

James Tebby and Amjad Sawah were responsible for recording opinions and capturing the essence of the debates. This booklet collates the literature review and the views of all those who participated. This booklet does not represent Level I evidence derived from prospective randomized controlled trials but represents the compilation of the combined experience of 25 British and international orthopaedic surgeons.

We have selected a short list of references to keep the booklet concise and easily readable.

I hope that you will find something of use and relevant to your own practice.

Dishan Singh MBChB, FRCS (Orth)
Consultant Orthopaedic Surgeon
Royal National Orthopaedic Hospital
Stanmore, UK (1995-2021)

August 2023

Summary of Sessions

Session 1 Assessment of Ankle Fractures

Chair: *Callum Clark*

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1.2	Assessment of stability	*Simon Clint*
1.3	Role of arthroscopy	*Devendra Mahadevan*

Session 2 Managing the Ankle Fractures

Chair: *Lyndon Mason*

2.1	Isolated lateral malleolar fractures - stability, treatment	*Robert Clayton*
2.2	Deltoid ligament injuries - conservative or surgical	*Anand Pillai*
2.3	Posterior malleolar fractures - when and how to fix	*Lyndon Mason*
2.4	Syndesmotic injuries - reduction technique and fixation	*George Smith*
2.5	Tillaux fragment, ant tib-fib ligament - direct or indirect fixation	*Stefan Rammelt*

Session 3 Calcaneal Fractures

Chair: *Jit Mangwani*

3.1	Which calcaneal fractures require fixation	*Paul Fenton*
3.2	Factors affecting outcome	*Jit Mangwani*
3.3	Which surgical approach - MIS vs Open, timing of surgery	*Callum Clark*
3.4	Subtalar fusion after calcaneal fracture - challenges and outcomes	*Claire Topliss*

Session 4 Talar Body Fractures

Chair: *Mark Davies*

4.1	Approach (single or double, osteotomies)	*Adam Lomax*
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4.5	Avascular necrosis - diagnosis and management	*Mark Davies*

Session 5 Specific Situations

Chair: *Venu Kavarthapu*

5.1	Acute ankle fracture in a diabetic patient (+/-neuropathy)	*Justin Kane*
5.2	Conservative or surgical in early Charcot hindfoot	*Venu Kavarthapu*
5.3	Early recognition of Charcot Arthropathy	*Dishan Singh*
5.4	Role of orthobiologics	*Vish Kumar*

General considerations

Given the current levels of pressure being felt by all workers in the NHS, the consensus group wanted to obtain some insight into the impact being had on the perceived level of care being provided in Orthopaedic units across the UK.

Consensus Questions on Orthopaedic practice

1. Does timely access to CT scanning (or lack thereof) have an effect on your management of patients?
   i. Always: 2 (12%)
   ii. Sometimes: 5 (29%)
   iii. Never: 10 (59%)

2. Does timely access to a trauma list compromise care for your patients?
   i. Yes: 14 (78%)
   ii. No: 4 (22%)

3. Do you feel delays to theatre affect your ability to train?
   i. Yes: 12 (71%)
   ii. No: 5 (29%)

4. Do you feel that these delays and impaired access to theatre are impinging on your elective workload?
   i. Yes: 10 (56%)
   ii. No: 8 (44%)

Session 1: Assessment of Ankle Fractures

Chaired by Callum Clark

1.1 Classification of Ankle Fractures

Andrew Kelly

Whilst criteria exist for the 'ultimate' classification system, regarding whether it is reproducible, affects management, aids communication and predicts prognosis etc. Often the over-looked but most important aspect of classifying ankle fractures has best been described by Stanley Boyd in 1896: "The most important divisions of fractures - simple, compound, complicated - are based upon the condition of the soft parts; less important varieties rest upon the conditions of the bone"[1].

When considering which classification to employ, even the simplest radiographic classification systems for ankle injuries, i.e., Weber A - C, can have significant intraobserver variability. This was even more so seen when being used by non-Consultant Orthopaedic and non-Orthopaedic colleagues. Intraobserver variability for Orthopaedic Consultants was only 93% at best compared to 60% in the lowest scoring other groups.

Understanding of the original intention of the system is also important, regardless of the classification systems current popularity. The Herscovici classification system of medial malleolar fractures (A-D)[2] was originally from a series of 57 fractures treated non-operatively. Further reviews of the system have shown nearly 20% of fractures are unclassifiable[3].

The use of the 1/3 rule for fixing posterior malleolar fractures seen on plain film has now been superseded and indeed, was related to a case series of less than 10 patients.

Even the somewhat revolutionary Lauge-Hansen Classification[4], with its focus of mechanism, progression of both bony and soft tissue injury, has been shown to be flawed. More modern studies have tried to replicate the injury patterns discussed and have failed to correlate to the original descriptions. Furthermore, videos of patients sustaining their injuries often show fractures sustained with a different mechanism to the one Lauge-Hansen described.

More of the interest of the consensus group, has been the use of CT imaging for generating a classification system of ankle fractures, more specifically those with a posterior malleolar injury. The main 3 of these classification systems have been reviewed (Haraguchi, BartoníčekRammelt and Mason-Molloy) for intra- and inter-observer variability. It was commented on that all three of these classifications are near identical aside from nomenclature and all are superior to plain film assessment of posterior malleolar classifications and thus the observer variability is more based on an inability to understand the classification.

More emphasis should be on the mechanism of the injury and the importance of morphology on outcome.

Future classifications may also come on a case-by-case basis with the development of Deep Learning Neural Network (DLNN) models that can assess fracture patterns and generate treatment suggestions. Such learning models have been shown to have high levels of success in other assessments including diagnosis of DDH using ultrasound[5].

Consensus Questions

1. All patients with a posterior malleolar injury should have a CT scan prior to surgery (unless emergent treatment prevents this)?
   i. Yes: 17 (89%)
   ii. No: 2 (11%)

2. When planning for surgical fixation of a suspected plafond injury, would you perform a pre-operative CT scan?
   i. Always: 16 (80%)
   ii. Usually: 4 (20%)
   iii. Seldom: 0
   iv. Never: 0

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1.2 Assessment of stability

Simon Clint

A stable ankle fracture can be defined as an injury where the talus remains undisplaced whilst being placed under physiological load. This is of importance, as those injuries shown to be stable do not require surgical intervention. Purely syndesmotic injuries without bony injury at the level of the ankle will be discussed later in this document and do not form part of this stability assessment session.

Assessment should always start with a visual inspection; clearly deformed injuries are almost certainly unstable and will require intervention. Further assessment is often taught to include palpation of the bony anatomy, including the proximal fibula and the medial aspect of the ankle.

Beware, however, that medial tenderness has been shown to have a poor correlation to deep deltoid incompetence with sensitivity and specificity percentages both in the 50s[1]. If palpating any part of the medial ankle, then focus on the posterior deltoid which has a been shown to be a better predictor of instability[2].

Plain radiographic assessment should traditionally consist of 3 weightbearing views (AP, Mortice and Lateral). Awake stress views and more tolerated hanging/gravity stress views have been shown to overestimate the number of patients requiring intervention when compared to weightbearing views (45% vs. 3.7%)[3].

No clinically relevant advantage has been shown with any other imaging modalities (MRI, CT or USS), when assessing ankle fractures for instability/need for intervention.

Operative assessment of instability rarely involves stress views at the beginning of the operation, unless being used to further confirm that invasive fixation is not required. The operative assessment of stability is much more focused on whether there is a syndesmotic component of the injury that requires stabilisation. Unexpected syndesmotic injuries have been seen in between 37% and 57% of patients during operative assessment, depending on initial injury pattern[4].

Many tests have been described for intraoperative assessment of syndesmosis stability including Cotton/Hook/Lateral stress test, External rotation test, Lateral view external rotation test tap test and dye (Chertsey) test. Most require open access to the syndesmosis in some way except the external rotation test which allows for comparison of the uninjured side. No consensus was formed during this roundtable as to which one of these tests is preferred.

Consensus Questions

1. In an ankle fracture with unknown stability, would you take the patient to theatre for an examination under anaesthetic (prior to any fixation)?
   i. Often: 0
   ii. Rarely: 3 (20%)
   iii. Never: 15 (80%)

2. The best intra-operative stress test to assess the syndesmosis after fracture fixation is?
   i. External rotation test only: 1 (5%)
   ii. Hook test only: 0
   iii. Both ER and Hook test: 14 (70%)
   iv. Open visualisation of the syndesmosis: (25%)

3. Should you always document that you have assessed the stability of the syndesmosis during ankle fracture fixation?
   i. Yes: 18 (100%)
   ii. No: 0 (0%)

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1.3 Role of arthroscopy

Devendra Mahadevan

Ankle arthroscopy at the time of fracture fixation is trending upwards, specifically in the Foot and Ankle Fellowship trained surgeons. This has led to an increase from 3.65 cases per 1000 (2010) to 13.91 cases per 1000 (2019).

Arthroscopy at the time of fracture fixation can aid the operating surgeon in 2 ways, it can help diagnose concurrent injuries and can help with assessment of fragment reduction. Studies looking at arthroscopy at the time of fixation have shown approximately 25% of Weber B and C fractures have osteochondral lesions and between 52% and 92% syndesmotic injuries for Weber B and C injuries respectively[1].

Systematic reviews looking into tradition ORIF vs Arthroscopically assisted internal fixation (ARIF) have failed to show any significant improvements in outcomes when incorporating arthroscopy. They have shown that ARIF has a longer surgical time than ORIF[2-4].

Overall, the benefits of arthroscopy at the time may not be of benefit to change clinical outcomes but more for diagnostic purposes. Aside from removing loose bodies, arthroscopy in this context allows for assessment of the joint surface and the performing of microfracture as required. It may allow the management of interposed soft tissue and for direst visualisation of the syndesmosis.
These potential benefits must be weighed against the potential risks of arthroscopy such as fluid extravasation (avoidable when dry scoping) and iatrogenic nerve injury.

Consensus Questions

1. How often do you use arthroscopy when fixing ankle fractures in adults?
    i. Always: 1 (5%)
    i. Often: 0
    ii. Rarely: 15 (79%)
    iii. Never: 3 (16%)

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Session 2: Managing the Ankle Fracture

Chaired by Lyndon Mason

2.1. Isolated lateral malleolar fractures - stability, treatment

Robert Clayton

A word of caution

The treatment of isolated lateral malleolar fractures in diabetic patient with polyneuropathy is not covered in this discussion.

Definitions

The treatment of isolated lateral malleolar fractures in diabetic patient with polyneuropathy is not covered in this discussion.

In distinguishing between isolated lateral malleolar fractures, it is crucial to recognize the two main categories:

- Undisplaced fractures, where no displacement is present, and
- Unstable fractures, which may either be displaced or have the potential to displace under physiological load.

How to diagnose potentially unstable fracture

The stability of potentially unstable fractures can be best assessed through a one week period of physiological loading (i.e. in a walking boot), followed by radiological reassessment under weight-bearing conditions[1, 2]. Ecchymosis and medial tenderness have been proven to be unreliable indicators of stability[3]. Stress views are painful and have the potential to overestimate instability[4]. MRI is not recommended for the assessment of stability[5].

Rationale for not fixing stable fracture

Studies have demonstrated that surgery is not superior to non-surgical management and can lead to a higher complication rate in isolated type B ankle fractures with no injury to the medial side[4, 6]. Functional protocols has demonstrated to be effective in detecting unstable injuries[7, 8]. Early rehab in important, although one shall be mindful of the importance of avoiding early inversion/eversion.

When and how to fix (clinical pearls)

Fracture fixation is generally recommended for radiologically displaced fractures on weight-bearing views following a one-week period of physiological weight bearing[1, 2, 4, 6].

It is important to be mindful of the peroneal tendons irritation that might be caused by a posterior placement of the fibular metalwork. Also, the metalwork profile is particularly important when dealing with the thin soft tissue envelop and in diabetic patients. Clinical bone quality assessment might be useful in deciding locking vs nonlocking fixation options.

Distal fibular nail fixation has higher complication rate compared to plate fixation and should be used with high degree of caution[9, 10].

Consensus Questions

1. In an **ankle fracture**, with **uncertain stability, weightbearing radiographs** should be done to test for stability
   Always: 18 (100%)
   Occasionally: 0
   Rarely: 0
   Never: 0

2. In a in a non-neuropathic **ankle fracture of uncertain stability**, where there are **concerns of medial ligament injury** (such as minimal displacement, medial bruising or tenderness), should the **repeat weightbearing radiographs** be done with the patient **in splintage or without a splintage**?
   In splintage: 2 (11%)
   Out of splintage: 16 (89%)

3. In **ankle fracture** of a non-neuropathic patient that is weight bearing **stable**, with a normal medial clear space and normal tibial plafond but a displaced fibula (2mm or less either shortening or rotation), the **treatment** of choice should be:
   Always surgical fixation: 0
   Sometimes surgical fixation: 9 (50%)
   Rarely surgical fixation: 8 (45%)
   Never surgical fixation: 1 (5%)

4. In an adequately **fixed ankle fracture** that **did not require syndesmotic fixation** in a compliant, young fit and healthy, non-neuropathic patient with good bone quality, **when** would **weight bearing** as tolerated be allowed:
   At 2 weeks: 18 (100%)

5. In an adequately **fixed ankle fracture** that **required syndesmotic fixation** in a compliant, young fit and healthy, non-neuropathic patient with good bone quality, **when** would **weight bearing** as tolerated be allowed:
   At 2 weeks: 13 (68%)
   At 6 weeks: 6 (32%)

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2.2. Deltoid ligament injuries - conservative or surgical

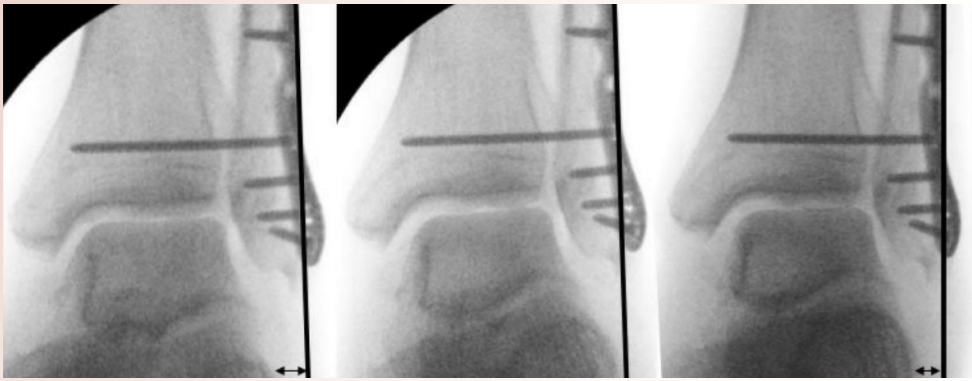
Anand Pillai

Introduction

40% of ankle fractures have deltoid injury[1]. Understanding the deltoid ligament complex anatomy is essential. This can be reviewed in the literature. There are 6 bundles (4 superficial resist hind foot eversion, 2 deep restraint external rotation of the talus), and variance exists[2]. Biomechanical investigation demonstrated the tibiocalcaneal band to be a main stabilizer[3]. The tension and length of each bundle can vary depends on ankle position[4].

Traditionally, rigid fixation of the syndesmosis has been assumed to allow the deltoid ligament to remain static while undergoing a healing response[5]. However, it is known that the syndesmotic screw does not ensure talar stability and that deltoid interposition can coexist even with acceptable reduction. Furthermore, valgus and external rotation stress can be positive even after syndesmotic fixation.

The best investigations for diagnosing deltoid injury are ultrasound (100% accurate), MRI and arthroscopy[6].



- No Deltoid repair
- No stress applied
- Lateral Fibular line does not bisect calcaneum

- Valgus stress applied
- Minimal medial clear
- Space opening
- Lateral Fibular line **does** bisect calcaneum

- Superficial Deltoid repair
- Valgus stress applied
- Lateral Fibular line does not bisect calcaneum

Deltoid repair in Ankle fracture

As previously mentioned, from a biomechanical point of view, the tibiocalcaneal ligament is essential for the stability of the ankle. Its sectioning has been demonstrated to decrease the tibiotalar contact area[3]. A recent study has

demonstrated ankle instability to be greatest when both deltoid and the syndesmosis are disrupted, and that stability incrementally improves with sequential syndesmotic fixation and deltoid repair[7]. It has been also found that isolated injury to either the superficial or deep deltoid can both equally lead to instability under axial rotational forces[8]. Further, deltoid disruption has been shown to lead to progressive flat foot deformity[9].

Available literature comparing deltoid repair vs no repair has shown better functional outcome and improved pain scores in the repair group[10, 11].
Also, papers comparing deltoid repair to syndesmotic screw fixation showed the repair to have decreased the postop MCS leading to more accurate syndesmotic reduction and less screw removal[12, 13].

A systematic review from 2022, which included 3 RCTs and 5 retrospective cohort studies, concluded that available studies appear to support deltoid repair although high-quality evidence guiding the treatment of deltoid ligament injury in acute ankle fractures is lacking[14].

Consensus Questions

1. In an adequately **fixed ankle fracture and repaired deltoid** ligament in a compliant, young fit and healthy, non-neuropathic patient with good bone quality, **when** would **weight bearing** as tolerated be allowed:
   At 2 weeks: 15 (79%)
   At 6 weeks: 4 (21%)

2. Prior to the evidence provided did you consider that **deltoid ligament stability** be **assessed and documented intraoperatively**?
   Yes: 4 (21%)
   No: 15 (79%)

3. **Prior to the evidence provided did you consider that the deltoid** ligament **should be repaired:**
   Always: 4 (21%)
   Usually: 1 (6%)
   Rarely: 12 (70%)

4. In regards to deltoid ligament injury, after the evidence provided, **would you change your practice**:
   Yes: 12 (60%)
   No: 8 (40%)

5. In a scenario where an **ankle fracture** has been **fixed** and a **deltoid injury is present**, what is your **usual procedure for splinting, regardless** of whether the **deltoid** injury is **treated or not**?

Cast 6 weeks:	0
Boot without orthotics (arch support):	16 (89%)
Boot with orthotics (arch support):	2 (11%)
No splintage:	0

6. Prior to the evidence provided, did you fix the deltoid ligament in a Maisonneuve injury?

Always:	4 (23%)
Usually:	1 (6%)
Rarely:	12 (70%)
Never:	0

7. Would you **change your practice** regarding deltoid repar in a Maisonneuve injury **based on the evidence** presented in today's meeting?

Yes:	9 (50%)
No:	9 (50%)

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2.3. Posterior malleolar fractures - when and how to fix

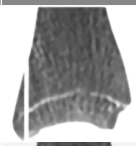
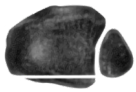
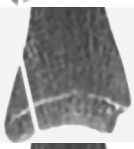
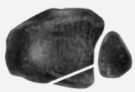
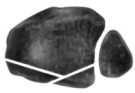
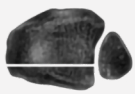
Lyndon Mason

What do we know in 2023

Our knowledge about posterior malleolus fixation has drastically changed from past times when outcomes were less than satisfactory[1, 2]. Today, CT scan is essential for accurate injury detection, nullifying the previous belief that the outcome was related to the joint's involvement extent[3-5]. The introduction of fragment-specific fixation techniques has significantly improved patient outcomes[6-8]. Additionally, several principles have been established for posterior malleolus fixation, including addressing the posteromedial prior to the posterolateral fragment, and adhering to a 'safe zone' during fixation[9].

Classification

There are 3 commonly used and noticeably similar CT-based classification systems, some of which also explored pathomechanisms associated with specific fracture morphologies[10-12].

Haraguchi	Bartoniceck	Mason	Sagital	Axial	Mechanism
3	1	1			PITFL avulsion
1	2	2a			Rotational impaction
2	3	2b			
	4	3			Axial load impaction

Do you never fix syndesmosis post PM Fixation?

Although there are evidence indicating the reduced need for syndesmotic stabilization with fixation of the posterior malleolus and that syndesmosis stability greatly improves following PM fixation[13-17], biomechanical studies demonstrated AITFL is the most important rotatory stabilizer both on internal and external rotation[18]. Furthermore, it has been shown that certain types of PM fractures do not have syndesmosis instability[19], and that larger PM fracture fragment are associated with less ligamentous injury[20]. Recent studies have clearly shown that fixing the PM fragment associated with high fibular fracture do not stabilize the syndesmosis[21, 22]

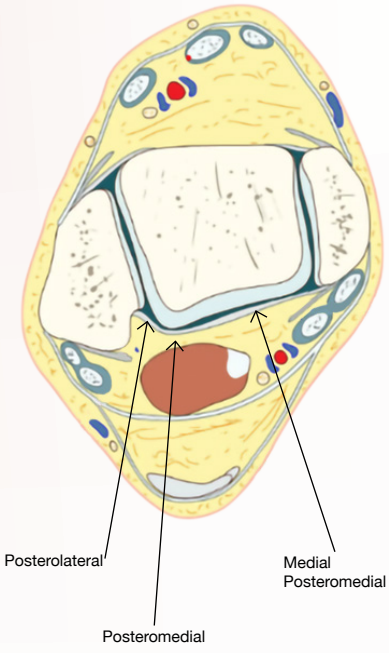
Is direct approach better than indirect?

Significant improvement in anatomical reduction and functional outcomes with direct approach has been shown by level 1, 2 and 4 studies[6, 8, 23], with recent systematic review affirming superior functional outcomes associated with the direct fixation technique[24]. Of note, malunion of PM, has been frequently seen with FHL entrapment.

What Approach?

Direct surgical approaches to the PM are described and can be revised. Although posterolateral approach seems to be the most popular among surgeons, evidence suggests the posteromedial fragment to be much easily accessible through the posteromedial or medial-posteromedial approach[25, 26]. Tailoring the surgical approach to the PM based on fragment morphology facilitates surgical access and allows for fragment-specific fixation.

There is a lack of evidence regarding whether to fix a minimally displaced or undisplaced 2A fracture (Mason-Molloy) or opt for syndesmosis fixation. However, direct fixation of a 2A fracture is recommended in the following scenarios: (1) when there is an incarcerated fragment, (2) in cases of incisura malreduction, (3) if a 2mm step is present, (4) when there is Tibialis posterior tendon incarceration, and (5) to aid in achieving the appropriate fibular length.



	Vision of PL Fragment	Vision of PM Fragment	Fixation of High or Comminuted Fibular	Access to Diepunch or Intercalary Fragment	Clear out of Fracture Soft Tissue
Easy	PL PM	MPM	MPM with DL PM with DL	MPM	MPM
Medium	MPM	PM		PM	PM
Hard		PL	PL	PL	PL

Consensus Questions

1. Following **posterior malleolus fixation** should you routinely then **screen** the **syndesmosis**?
   Always: 15 (83%)
   Usually: 3 (17%)
   Rarely: 0
   Never: 0

2. What **approach** do you typically utilize for **fixing** a fixable **posterior malleolar fracture** in a non-neuropathic patient with good bone quality?
   Direct reduction and PA fixation: 18 **(100%)**
   Direct reduction and AP fixation: 0

3. Should your **approaches** to the **posterior malleolus** be **individualized** based on fracture morphology on **CT** scan?
   Yes: 18 **(100%)**
   No: 0

4. Would you **routinely fix** an nondisplaced or minimally displaced 2A posterior malleolar fracture with no impaction or intercalary fragment?
   Always: 1 (6%)
   Usually: 2 (12%)
   Rarely: 13 (76%)
   Never: 1 (6%)

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2.4. Syndesmotic injuries - reduction technique and fixation

George Smith

Assessment of the Reduction

Reduction of the syndesmosis can be assessed by one of the following methods: visual examination, palpation, X-ray imaging, or arthroscopy. Visualizing the reduction of the syndesmosis can be best achieved at the anterolateral articular surface of the distal tibia to the anteromedial fibular articular surface[1]. Reduction by finger palpation appears to yield a comparable reduction to visualization, with a slight tendency towards posterior translation and external rotation of the fibula[2].

Several radiological parameters can be assessed, such as MCS (medial clear space), TFCS (tibiofibular clear space) on AP, and the posterior fibular line on lateral radiographs. Evidence has demonstrated that the AP radiograph is relatively poor at assessing malreduction of the syndesmosis, whereas the lateral radiograph is highly sensitive at detecting even minimal amounts of malreduction[3, 4].

Ankle arthroscopy has been employed for diagnosing syndesmosis injuries; however, there is limited evidence available, only at level 5, to support the arthroscopic assessment of syndesmotic reduction[5-8].

Clamping as reduction tool

When utilizing a clamp, it is crucial to be mindful of the clamp vector, which refers to the angle at which forces are applied through the connection between the tibia and the fibula. For optimal results, the clamp should be placed at the anterior third of the medial distal tibia[9, 10]. The glide path technique has been demonstrated to be simple and reliable in accomplishing the reduction without translating the fibula[11].

Fixation choices

Dynamic fixation of the syndesmosis has been shown to be clinically and functionally superior to static screw fixation, as demonstrated in a high-quality meta-analysis and RCT from 2020[12, 13]. However, from the patient's perspective, while dynamic fixation seems to provide a benefit that we can pick up scientifically, it does not necessarily seem to constantly reflect the noticeable clinical change experienced by the patient[14]. In terms of cost-effectiveness, the evidence between dynamic fixation and screw fixation is inconsistent and multifactorial[15-17].

Consensus Questions

1. Do you utilize a **lateral X-ray** in addition to an AP for **confirming the reduction** of the syndesmosis if you rely on radiographs instead of an open procedure?

Always:	14 (77%)
Usually:	1 (6%)
Rarely:	3 (18%)
Never:	0

2. In a non-neuropathic ankle fracture with good bone quality and **vertically stable fibula** (i.e. non Maisonneuve fracture, or fibula has been fixed), what method of fixation do you use for **syndesmotic fixation**:

Direct repair:	0
Direct repair with augmentation:	1 (6%)
Flexible fixation:	8 (44%)
Screw fixation:	9 (50%)
Combination of screw & flexible fixation:	0

3. In a non-neuropathic ankle with good bone quality **and vertically unstable fibula** (i.e. Maisonneuve fracture), what method of fixation do you use for **syndesmotic fixation:**

Direct repair:	0
Direct repair with augmentation:	0
Flexible fixation:	0
Screw fixation:	14 (78%)
Combination of screw & flexible fixation:	4 (22%)

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2.5. Tillaux fragment, ant tib-fib ligament - direct or indirect fixation

Stefan Rammelt

Introduction

The fracture of the Tillaux tubercle (Tuberculum anterior tibiae), also known as Chaput fragment, fourth or anterior malleolus (AM)[1], is the most frequently overlooked fracture around the ankle on plain radiographs[2-5], and is more prevalent among elderly patients[6]. Anatomically, the Tillaux tubercle provides insertion to AITFL. The most common mechanisms of Tillaux fragment fracture are syndesmotic avulsion through external rotation injury (SER 1, PER 2) or abduction injury with talar impaction against the tibial plafond (PAB 2)[7-9]. Depending on the fragment size, the reduction of the AM helps restore the anatomy of the incisura and substantially contributes to syndesmotic stability[10-14].

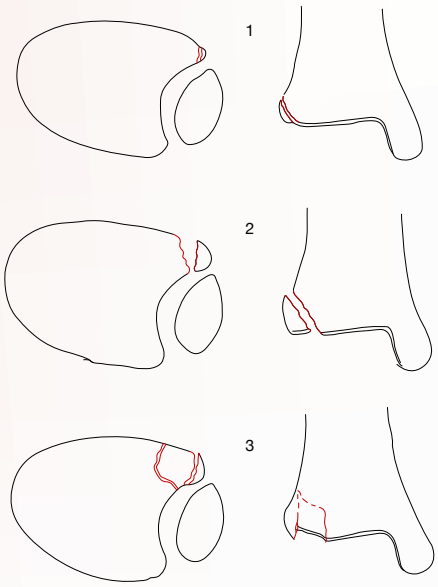
Classification[6]

Pathoanatomically AM fracture can be subtyped into:

- Type 1: Avulsion fracture (frequent in PER > SER)
- Type 2: Intraarticular fracture - extends into the incisura and joint surface
- Type 3: Plafond impaction fracture (frequent in PAB)

Treatment recommendation

- Type 1:
  - Undisplaced: generally, no fixation needed
  - Displaced: fixation with suture anchor[15]
- Type 2:
  - Undisplaced: generally, no fixation needed
  - Displaced
    - ORIF[16]
    - Arthroscopically assisted fixation can be considered for isolated fractures[17, 18]
- Type 3: ORIF with disimpaction[16]



Outcome

Recent evidence demonstrated that a differentiated treatment protocol tailored to dislocation, size, incisura involvement and joint impaction leads to favourable outcomes in complex malleolar fractures involving the AM[14]. The existing literature reports similar findings, though based on small series.[17-21]. Excellent results have been reported for open or percutaneous (arthroscopically-assisted) fixation of isolated AM fractures[15, 16, 19]. On the other hand, overlooked AM fractures may lead to persistent ankle incongruity with the subsequent need for surgical revision[20-23].

Consensus Questions

1. Would you **routinely CT** injuries that have an indication of an **anterior malleolar fracture**?
   Always: 11 (69%)
   Usually: 5 (31%)
   Rarely: 0
   Never: 0

2. Would you **routinely fix** avulsion injuries to **anterior malleolus**?
   Always: 0
   Usually: 18 **(100%)**
   Rarely: 0
   Never: 0

3. Would you **routinely fix** avulsion injuries to **anterior malleolus with tibial plafond impaction injury**?
   Always: 16 (94%)
   Usually: 1 (6%)
   Rarely: 0
   Never: 0

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Session 3: Calcaneal Fractures

Chaired by Jit Mangwani

3.1. Which calcaneal fractures require fixation? *Paul Fenton*

Calcaneal fracture treatment poses a challenge for surgeons, requiring careful decision-making. The complexity arises not only from the difficulty of applying existing evidence to individual patients, which may often not provide straightforward solutions, but also due to the high rate of complications and the variable, unpredictable journey to recovery.

Most of calcaneal fracture fall into a grey area where the decision making process needs to be tailored to individual patients. The assessment of the injury should place special focus on soft tissue injury, while also considering fracture pattern, patient factors (comorbidities, functional needs, etc.), and surgeon-related factors and bias. The treatment aims for timely return to function, pain control, a foot that fits into a shoe, minimal complications, joint reduction, and cosmetically acceptable results.

Fracture types and their operative management

Tuberosity avulsion

Requires emergency treatment to avoid skin necrosis[1]. Several methods can be used for fixation (i.e. screws, tension band, etc.).

Tongue type

Depending on displacement, might also require emergent treatment[2]. Modified Essex Lopresti technique can be utilized for reduction[3].

Joint depression type

Commonly associated with high-energy trauma and frequently observed in challenging patients. Historically, the lateral extensile approach has been utilized to address these injuries[4], however, the sinus tarsi approach has been associated with fewer wound healing complications and is becoming the preferred approach for these injuries[5].

Open Displaced Intraarticular Calcaneal Fractures (DIACF)

Relatively uncommon and historically associated with higher rate of complications. Higher degrees of injury usually require plastic intervention.

There is limited high-quality evidence on the best way to treat these injuries. Several techniques are described (i.e. multiple K wires, external fixation, etc.), with most involving some form of lateral approach and another plastic approach[6]. In the absence of a good level of evidence, one should return to the principle that skeletal stability is a key part of reducing infection rates in open fractures[7].

If soft tissue reconstruction is needed, a good way to address the injury involves a staged approach with medial external fixation followed by lateral fixation combined with soft tissue reconstruction in a single setting.

Sustentacular fractures

Relatively rare, often a high-energy injury in younger patients, calcaneal fractures lead to displacement of the middle facet, disrupting the mechanics of the subtalar joint. The evidence is based on case series, and generally, it is accepted that displaced fractures are an indication for fixation. The approach and surgical technique can be reviewed in the literature[8].

Column injuries

Can be dealt with initially with ex-fix or bridge plate from medially[9]

Which DIACF needs fixation

Definitive indications for fixation

- Open fracture needing soft tissue reconstruction
- Fracture dislocation through posterior facet[10]

Relative indication for fixation

- Peroneal impingement
- Height/width/axial deviation
- Articular reduction

Factors in decision making Smokers, Age, sex, work compensation[11-13]

Pearls - approaches for fixation of DIACF

There are two common approaches that can be reviewed in the literature.

1. **Lateral extensile approach**
   It is crucial to have a deep understanding of the angiosomes theory, upon which this approach is based[14, 15]. If poorly executed, not respecting the angiosomes, or utilized in patients with inappropriate characteristics[16, 17], the lateral extensile approach has been associated with a high wound complications rate[18].

2. **Sinus tarsi approach**
   Most surgeons are moving away from the routine use of the extended lateral approach in favour of the sinus tarsi approach due to reduced incidence of wound complications and favourable functional outcome[3, 5, 19-21].

The evidence is clear on that the rate of wound problems is lower with minimally invasive approaches[19-21].

Consensus Questions

1. Have the results of the **UK Heel Fracture Trial** changed your thinking process and practices since published?
   Yes: 7 (39%)
   No: 11 (61%)

2. Following **calcaneal fracture fixation** when would full weight bearing as tolerable be allowed?
   2 weeks postop: 0
   4 weeks postop: 0
   6 weeks postop: 14 (78%)
   8 weeks postop: 3 (18)
   12 weeks postop: 1

3. Do you agree or disagree that a **non-neuropathic** patient with a **calcaneal tuberosity avulsion fracture** and potentially **threatened soft tissue** requires **emergency intervention**?
   Agree: 18 **(100%)**
   Disagree: 0

4. The preferred **method of fixation** in a **high velocity tuberosity avulsion fracture** in an adult?
   Screws: 13 (72%)
   Tension band technique: 5 (28%)
   Soft tissue repair: 0
   Plate: 0

5. What is the preferred **method of fixation** in a **tuberosity avulsion fracture** in **osteoporotic bone** in an adult?
   Screws: 3 (15%)
   Tension band technique: 9 (45%)
   Soft tissue repair: 2 (10%)
   Plate: 6 (30%)

6. Do you agree or disagree that in a **displaced intraarticular fracture** of the calcaneus, a **CT** investigation should be conducted for further assessment of fracture morphology?
   Agree: 18 (100%)
   Disagree: 0

7. **Displaced sustentaculum tali** fracture need open reduction and internal fixation
   Always: 4 (22%)
   Usually: 14 (78%)
   Rarely: 0
   Never: 0

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3.2. Factors affecting outcome

Jit Mangwani

Introduction

The calcaneum is the most common tarsal bone to fracture. The most common mechanism of injury is either a fall from height or motor vehicle collision. The majority of these injuries are intra-articular with approximately one in 5 being an extra-articular fracture[1, 2]. Extra-articular fractures generally tend to be of low-energy. Males between 30-50 year old are affected in 90% of the cases. Associated injuries are common, 1 in 10 patients with fractured os calcaneum has a spine fracture and one in four has a contralateral limb injury.

Historically, the outcome from this injury and treatment have been reported to be incredibly bad. The goal of treatment, from a surgeon's point of view, is to restore anatomy. From the patient point of view the goal is to achieve pain free, functioning hindfoot which fits into shoes.

Factors affecting outcome

Factors affecting outcome of calcaneal fracture are intensively studied in the literature. It is sometimes conflicting. This section is an attempt to simplify this complex area focusing on outcome of intraarticular fractures.

Age & sex: patient age over 50 seems to be an approximate cutoff for a less favourable outcome especially with coexisting comorbidities. Female sex seems to have somehow better outcome compared to male[2-4].

Smoking: smoking seems to affect outcome tripling the infection rate[5, 6].

Diabetes: targeted perioperative diabetes management seems to positively affect postoperative outcome and complication rate[7].

Anatomical reduction: biomechanical studies have shown that even small step-offs of 1 mm-2 mm in the posterior facet of the subtalar joint were associated with a significant load redistribution at the subtalar joint. However, clinical relevance and effect on outcomes still uncertain[8, 9].

Polytrauma vs isolated injury: the literature suggests similar outcome[10].

Institutional fracture load: the literature suggests exponential increase in infection rate with decreasing institutional fracture load[11].

Outcome literature overview

There are 2 RCTs which showed operative treatment for DIACF is not superior to nonoperative treatment, with 5x higher chance for subtalar fusion in patient treated nonoperatively and higher risk for complication with operative treatment. Operative treatment seems to have some benefits at 8-12 years[12, 13].

The Heel Fracture Trial in the UK has also demonstrated no difference in the outcome between operative and nonoperative treatment, although it has been heavily criticised for its selection bias[14, 15].

With the MIS fixation and sinus tarsi approach becoming popular, evidence continues to emerge. Available evidence sees MIS as a promising option. Also, sinus tarsi approach appears to have lower complication rates, better functional scores and shorter operative duration compared to extensile lateral approach, although a meta-analysis from 2020 found no difference in any outcome measure between the two approaches[16].

Subtalar arthroscopy has been used for DIACF with described benefits, yet no available literature comparing outcome.

Consensus Questions

1. For **acute displaced intraarticular calcaneal fracture,** the **commonly** used **approach** for fixation is:

Lateral extensile approach:	4 (21%)
Sinus tarsi approach:	13 (68%)
Percutaneous approach:	2 (10%)
Arthroscopic assisted percutaneous approach:	0

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3.3. Which surgical approach - MIS or Open, timing of surgery?

Callum Clark

The goals of calcaneal fracture surgery are to restore the congruity of the joint surface, to restore the shape of the calcaneum, and to achieve stable fixation. The focus here will be on 3 methods of minimally invasive calcaneal fracture fixation: Percutaneous reduction and screw fixation (PRIF), Arthroscopic-assisted reduction and internal fixation (ARIF), and Sinus Tarsi Approach (STA).

Percutaneous reduction and screw fixation (PRIF)

Small incisions made and used for reduction instruments and screws. Surgical techniques are described[1] and are aligned with those used in ORIF aiming to restore the body fragments, unhook it from the sustentaculum fragment, restored alignment, restore the articular segment.

Arthroscopic-assisted reduction and internal fixation (ARIF)

The incorporation of arthroscopy aims to enhance visualization of the posterior facet and subtalar joint, in an attempt to improve the accuracy of articular reduction. Surgical technique can be reviewed in the literature[2, 3].

Sinus Tarsi Approach (STA)

Initially described by Essex Lopresti[4], is increasingly being used for fixing even more complicated fractures[5].

There is no high-quality evidence on percutaneous and arthroscopic techniques[6]. However, the evidence on sinus tarsi approach is expanding, including 7 meta-analysis, all pointing in the same direction. The sinus tarsi approach has much lower rate of wound complications, lower operative time, similar fracture reduction and no difference in calcaneal shape compared to extensile lateral approach with shorter time to surgery and length of stay hospital[7-17].

Evidence comparing plate versus screws fixation with sinus tarsi approach demonstrated no difference in maintenance of reduction[18]. Nailing technique has also been described and can be reviewed[19].

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3.4. Subtalar Joint Fusion after Os Calcis Fracture

Claire Topliss

Subtalar joint osteoarthritis is common after calcaneal fractures. Fusion aims to restore the calcaneal height, shape and alignment. The technique and approach should be tailored to the individual patient respecting soft tissue envelope, existing metalwork and bony anatomy etc.

Indications for subtalar fusion include malunion, reduced calcaneal height, lateral impingement, anterior ankle impingement due to dorsiflexion of the talus with subluxation of the talonavicular-calcaneocuboid joint, varus heel, pain-related issues, nonunion, infection, and AVN with collapse.

It has been demonstrated that initial ORIF restores calcaneal shape, alignment and height and facilitates STJ fusion[1]. The bony sequelae of Os Calcis fractures can be divided into malunion, non-union and additional AVN or sepsis.
The specific treatment rational of each condition can reviewed in the literature[2].

Arthroscopic STJ fusion can be used for cases without malunion[3], and has been reported to be an effective alternative to open fusion[4]. In situ fusion can be done[5], however without consideration of the deformity at hand, it might not be adequate treatment and could lead to poor outcome[6]. Bone block fusions is technically demanding procedure but can provide good outcome also in terms of returning to normal pedobarography distribution[7-9]. Shaped titanium wedges have also been used with acceptable results[10].

Variables predicting fusion when we're going to do in situ fusion are: Böhler angle less than 0, Sanders type 4 fracture classification, workers' compensation cases, and patients treated non-surgically[11]. Predictors of worse outcomes are smoking, complications after fusion, infection, high energy trauma, ipsilateral injury, parallel screw configuration, and used freeze dried iliac crest[12, 13].

Consensus Questions

1. For **posttraumatic subtalar arthritis** following calcaneal fracture **in situ fusion** should be performed

Always:	0
Usually:	9 (47%)
Rarely:	10 (53%)
Never:	0

2. The **preferable approach** for **subtalar fusion** in posttraumatic arthritis utilizing **bone block arthrodesis technique** is
   Posterolateral approach: 16 (89%)
   Extended lateral approach: 2 (11%)

3. The **preferable material** for **distraction arthrodesis** of the subtalar joint
   Iliac crest: 12 (65%)
   Allograft: 1 (5%)
   Bone substitute: 0
   Metal mesh: 3 (15%)
   Lateral wall: 1 (5%)
   Combination: 1 (5%)

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Session 4: Talar Body Fractures

Chaired by Mark Davies

4.1. Which surgical approach? *Adam Lomax*

When planning for the fixation of talar body fractures, the primary concern will often be the preservation of blood supply, not just to the talus itself but also to any skin bridges that will arise from multiple incisions. In order to achieve a good reduction of talar body fractures, a good understanding of the normal anatomical shape of the talus is required. This is especially so when dealing with these high energy injuries that often have comminution and impaction of fracture fragments.

Up-to-date studies with Gadolinium-Enhanced MRI have shown that a substantial portion of the talar body blood supply enters posteriorly, primarily from the posterior tibial artery as the medial/posterior medial aspect[1].

Planning for these surgeries is paramount and CT imaging is mandated. It is useful to understand how open wounds can be extended and to think about reconstructive options and potential future interventions when planning approaches. Numerous surgical approaches are described and can be revised. Understanding the access given by each approach to the talar body will help with this planning. This has been reviewed by at least two papers[2, 3].

Anteromedial: Only gives access to anteromedial portion of the talus (mean 25%).

Medial Malleolar Osteotomy: 100% access to the medial aspect of the talar dome from anterior to posterior but only approx. 50% across the talus coronally and unable to reach midline posteriorly.

Anterolateral: 24-28% average access only to the anterolateral aspect of the talar body.

Lateral transligamentous approach[4]: All of the talar body accessible except a residual 22.7% posteromedial zone.

Fibula osteotomy: 43% access to talar dome. 100% of lateral aspect anterior to posterior, but not to the midline posteriorly.

Posterolateral/Posteromedial: 12% and 13% of the respective surface accessible. Can be used as a supplementary approach for screw access. Postero-central area remains inaccessible.

Using the above information as a road map to combine approaches should allow access to the majority of talar body injuries.

Consensus Questions

1. Would you always get a CT scan for a suspected or known talar body fracture?
   i. Yes: 18 **(100%)**
   ii. No: 0

2. Should the definitive fixation of a talar body fracture be performed by a Foot and Ankle surgeon rather than a general trauma surgeon?
   i. Yes: 18 **(100%)**
   ii. No: 0

3. In body/neck fractures, do you use the 2 standard anteromedial and anterolateral (AO) approaches?
   i. Always: 2 (10%)
   ii. Sometimes: 14 (74%)
   iii. Never: 3 (16%)

4. Do you tailor your approaches to the pathoanatomy of the fracture?
   i. Yes: 20 **(100%)**
   ii. No: 0

5. If performing a medial malleolar osteotomy, would you routinely extend your osteotomy across to include the plafond?
   i. Yes: 10 (59%)
   ii. No: 7 (41%)

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4.2 Methods of internal fixation

Bakur Jamjoon

Talar fractures are often high energy injuries, they may be part of a polytrauma scenario and there may be significant soft tissue concerns associated with these injuries. These factors may play a role when deciding what sort of fixation method is acceptable for any given fracture. It is important to remember that the inherent shape, and the significant coverage of the talus in cartilage, play a role in the optimum function of the joints surrounding the talus.

Open fractures and those with joint dislocation require emergent reduction and wound management. For the injuries where this is not the case, more recent studies have shown that a delay to surgery for soft tissue optimisation does not cause further complications and that complications that arise are more related to the severity of the original injury[1, 2].

Headed Screws: Usually used cannulated threaded screws for maintaining reduction/position, partially threaded to compress fragments. Most useful when inserted posterior to anterior when dealing with a posterior body fracture. Can be used in neck fractures and buried to allow free movement of the talonavicular joint.

Headless Screws: Versatile option for fixing multiple different talar fractures, especially those that are intraarticular fragments. Often supplemented with other fixation modalities when reconstructing the talar body back onto the neck.

If a dual screw only construct is selected then, if possible, a parallel, posterior to anterior construct has been shown to have the best results biomechanically compared to cross screws or AP screw constructs[3].

Unilateral Plating: Useful for head/neck comminution. Can be used in a tension band technique, especially when used laterally in conjunction with a single screw. Helpful when trying to avoid compressing into varus/valgus in comminuted fractures.

Bilateral Plating: Useful when there is comminution on both the medial and lateral aspects of the talus.

Arthroscopic/minimally invasive: Some evidence is available for the use of arthroscopy, Hu et al have shown some good results, however the majority of their cohort had minimally displaced injuries[4].

Consensus Questions

1. In a closed, fracture-dislocation of the talar body, should an urgent, sub-specialist consultation be sought?
   i. Yes: 18 **(100%)**
   ii. No: 0

2. How often would you undertake an immediate post-operative CT after talar body fixation?
   i. Always: 2 (10%)
   ii. Sometimes: 12 (60%)
   iii. Never: 6 (30%)

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4.3 Managing malreduction/malunion

Stefan Rammelt

Malunion of even 1-2mm of the talus can have a significant impact on a patient's outcome. Even minimal articular incongruity can cause a significant increase in joint loading learning to early osteoarthritis. Furthermore, malaligned fractures will lead to abnormal and restricted movements to adjacent joints that can have a knock-on effect further down the foot. All of these factors combined can lead to severe disability from malreduced/malunited fractures of the talus.

Classification of malunions[1]

Type I	Malunion and/or joint displacement
Type II	Nonunion with joint displacement
Type III	Types I/II with partial AVN
Type IV	Types I/II with complete AVN
Type V	Types I/II with septic AVN

Management principles

Type IV and V scenarios, with complete avascular necrosis (AVN) will be discussed separately in this document. The management malunions and non-unions are of similar importance and as such the principles and methods will overlap. The Zwipp & Rammelt classification[3] links both scenarios into the type IIs and IIIs. As such there will be overlap in this section with that of the next section looking purely at non-unions. For these type I - III injuries, the aim should be for anatomic reconstruction. This should be undertaken as early as possible and should also aim for joint preservation. Osteotomy through the site of malunion should be used and has not been shown to increase the size of known AVN or create new areas of AVN[2].

Limitations to reconstruction include, poor patient compliance and poor bone or cartilage quality leading to progression of arthritis. Surrounding joints can be assessed at the time of reconstruction and only those with degeneration should be fused at that stage.

Outcomes

As mentioned, in type I - III patients, progression of AVN is not usually seen. Patients will often develop arthritis after reconstruction but often at similar rates to those that are fixed anatomically at initial presentation. Of the patients that progress to have arthritic pain, some will need secondary fusions, in the series by Rammelt et al., this was in the order of 15%[2].

Patients have significant improvements in their functional scores after reconstruction, reflecting again the significant disability that patients suffer with a mal or non-united talar fracture.

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4.4 Managing non-union

Rod Hammett

Whilst most of this chapter focuses on talar body fractures, it is important to remember other peripheral injuries to the talus, especially as they have high levels of non-union with just minimal levels of displacement.

Lateral process: Non-union rate of 60% in non-operatively managed patients and malunion leads to subtalar osteoarthritis[1, 2].

Posterior process: If the fragment is larger enough then fixation is recommended in fragments with >3mm displacement, this helps to avoid impingement due to malunion. Non-operatively treated patients have also been found to have a lower return to pre-injury activity rate[3, 4].

Risk factors for non-union: For central/body fractures, the generic risk factors for non-union are present, including high energy injury, pre-existing diabetes, open fractures, presence of infection etc. Delayed diagnosis and failed operative management can also lead to non-unions.

Investigation of non-union: CT (weightbearing if available) to confirm diagnosis, weightbearing plain films otherwise to look at alignment. MRI will help when looking at the vascularity of the fracture fragments. Blood tests will be useful for investigating infection and for looking at overall bone health/bone biology.

Planning of reconstruction: Approaches for reconstruction are based on those mentioned for acute fixation and are dictated by fragment position. As for all non-union surgery, fibrous pseudarthrosis should be excised and autologous graft is preferred to restore anatomy. Joint restoration can be visualised either with distraction openly or with (dry) arthroscopy. Insufficient data exists to comment on the role or requirement of vascularised bone graft. Any pre-planned fusion surgery must deal with the existing non-union and any malalignment whilst dealing with the arthritis.

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4.5 Avascular Necrosis - diagnosis and management

Mark Davies

When looking at AVN of the talus, this session will focus on the diagnosis and management of post-traumatic AVN, this constitutes the cause for 75% of all cases. The authors, however, recognise that several different factors represent the other 25%, such as corticosteroids, excess alcohol, hyperlipidaemia, anti-viral therapy, chemo/radiotherapy, thrombophilia, diabetes and SLE. Many cases are also idiopathic. The diagnosis and investigation of the other causes are not discussed here.

For the diagnosis of post-traumatic AVN it is first important to have idea of the history of the injury, previous scars and surgical management, the presence of deformity and presence of any global vascular issue affecting the limb.

Initial weightbearing plain film radiography offers insight into numerous factors including the presence of sclerosis, mal or non-union, collapse and arthrosis. However, as previously discussed, CT scanning also offers this information but with the added benefit of 3D reconstruction for planning. It is also useful to scan the unaffected contralateral foot, especially when looking at custom implants for treatment.

MRI has limited use, especially if there is metalwork in situ from previous fixation. There may be the classical presence of serpiginous lines, best shown on T1 views that surround bone necrosis.

Staging of AVN is universal and the Ficat classification is easily and accurately applied when considering the talus. More important than staging, is the extent of the AVN, partial AVN can be treated by retaining the vascularised parts of the talus, whereas global AVN will require a treatment strategy that involves the whole talus. If there is arthrosis of the adjacent joints, then this too will need addressing.

Treatment strategies

Non-operative management with non-weightbearing (NWB) or patella tendon bearing casts are likely to have poor compliance given the extended time periods that are involved with some papers quoting over 6 months of NWB to achieve best results. Furthermore, the outcomes of patella bearing casts are wildly divergent in the literature, between 90% and 30% good/excellent outcomes[1, 2].

Extracorporeal shockwave (ECSW) therapy was assessed against physio alone in 34 patients by Zhai et al. Of those treated non-operatively, 45% went on to have surgery, however, the rate was just 3% of those treated with ECSW[3].

Operative, joint sparing, procedures are similar to those used in other areas of AVN. For the early Ficat stages, a 4mm drill can be used for core decompression. A large percentage will have improvement (75%) but roughly 30% will go on to have collapse and 11% went on to have fusion surgeries. Some studies report good outcomes with autologous graft, both vascularised and non-vascularised. The data itself is quite heterogenous and therefore difficult to draw a solid conclusion from.

Salvage surgery for these patients has traditionally been with arthrodesis. Improving options in arthroplasty now mean that total ankle replacement may be beneficial. There are now a growing number of options for patient specific partial or total talus replacement.

Partial AVN

This will depend on which part of the talus remains unaffected. If the body is healthy then ankle arthrodesis can be performed or flat cut ankle replacement. Tibiocalcaneal fusion with or without lengthening can used if the talar head remains. Bulk allograft and now custom cages can be used with fixation to maintain height. Results for tibiotalocalcaneal arthrodesis with bulk allograft have serious shortcomings with rates of non-union as high as 50%[4] and even those with higher union rates having below knee amputation (BKA) rates as high as 7.5%[5]. Early results with custom cages for treating numerous causes of significant bone loss (failed total ankle replacement, AVN, post-traumatic bone loss and non-union) appear better but still have complications such as persistent pain (10%), BKA (<5%) and septic non-union (25% - in neuropathic patients)[6, 7].

Global talar AVN

Bulk allograft and custom cages for pantalar fusions are options for this scenario but concerns remain about getting avascularised bone to go to union. In the absence of surrounding joint disease the latest focus is to consider total talar replacement (TTR).

Total talus replacement

The concept of replacing part of or all the talus with an articulating implant is not new. Harnroongroj & Harnroongroj published their experience of pegged talar replacements from 1974 to 2011. They were treating numerous conditions including bone tumours, AVN and fractures. Their follow up range was 10 - 36 years and they revised just 15%, including for tumour recurrence[8]. The Taniguchi team from Japan presented data from 1990-2006 using an initially pegged then non-pegged ceramic replacement, concluding the recommended use of the TTR implant even if the talar neck and head are preserved[9]. The author's preferred material is now Titanium Nitride (TiN), 3D printed from patient scans. These implants have been further modified to include surface that can be grafted to incorporate either talonavicular joint (TNJ) fusion or sub-talar joint (STJ) fusion. Ankle replacement on the tibia side in conjunction with total talus replacement also offers an option for talar AVN associated with ankle arthritis. The Sheffield group have performed a systematic review of 9 studies with a total of 115 patients, this showed a cumulative incidence of failure for total talar replacements at 0.1% (95% CI 0.0-4.9%) and a significant improvement in functional outcomes in 70% of patients[10].

In conclusion, total talus replacement may provide a reliable, better tolerated option for these difficult scenarios, compared to bulk allograft and Ilizarov frame fusion and lengthening.

The below table is an adapted/suggested management protocol for these patients (modified from[11]).

Type	Features	Treatment Options	
		Active, Reliable Patients, No Symptomatic Arthritis	Noncompliant Patient, Comorbidities, Arthritis
I	Malunion with joint displacement	Osteotomy, secondary reconstruction, and internal fixation with joint preservation Custom partial resurfacing/ replacement or osteochondral allograft	Corrective fusion of the affected joint(s)
II	Nonunion with displacement		
III	Types I/II with partial AVN		
IV	Types I/II with complete AVN	Necrectomy, (vascularized) bone grafting, corrective fusion Total talus replacement	
V	Types I/II with septic AVN	Redical debridement(s), bone grafting, corrective fusion 'Tumour" resection and orthoplastic reconstruction, 3D-printed cage reconstruction	

Consensus Questions

1. What is your current practice for the management of talar body AVN?
   i. Bulk allograft: 0
   ii. Frame and lengthening: 4 (30%)
   iii. Blair fusion and internal fixation: 0
   iv. Cage reconstruction: 9 (70%)

   Addendum: 7 members of the group would use a custom cage but do not have that option available.

2. In the absence of arthrosis, would you consider the use of total talus replacement for the treatment of global AVN?
   i. Yes: 19 **(100%)**
   ii. No: 0

   Addendum: 7 members of the group would use a custom cage but do not have that option available.

3. In the absence of arthrosis, would you consider the use of total talus replacement for the treatment of global AVN?
   i. Yes: 16 (69%)
   ii. No: 2 (11%)

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Session 5: Specific Situations

Chaired by Venu Kavarthapu

5.1. Acute ankle fractures in patients with complicated diabetes

Justin Kane

12% of patients with ankle fractures will be diabetic and unless there is a change in current trends, this number is likely to continue rising. The traditional dogma for these patients, especially those with complicated diabetes, is that they do badly with surgery. They have high rates of complications, 26-47% compared to 15% in non-diabetics. They are also known to have high rates of surgical site infections[1]. They have the highest odds ratio for amputation[2] and are more likely to undergo secondary interventions.

The true difficulty with these patients is that they do worse with non-operative management. They have a 21-fold OR for complications and any secondary intervention has a 100% complication rate[3].

From the Orthopaedic standpoint, the diagnosis of complicated diabetes has traditionally been focussed on the presence of peripheral neuropathy/a numb foot. However, Orthopaedic surgeons are notoriously bad at diagnosing peripheral neuropathy and are often using inaccurate or insensitive techniques to look for neuropathy. To that extent, this booklet will use the terminology of complicated diabetes and will consider it to be present in any patient that is presenting with signs of end-organ disease. This includes patients, not just with proven neuropathy, but also those with vascular disease, chronic kidney disease (CKD), retinopathy, in addition to an elevated HbA1c. It is likely that these changes will start to happen within 10-15 years of onset of diabetes, bearing in mind that during a large section of this timeframe the patient may not have been diagnosed with these complications.

In patients with uncomplicated diabetes, the recommendation would be to treat as per the rest of the population with the guidance set out earlier in this booklet. If treating these patients non-operatively, then consider closer monitoring, remembering that ankle fractures can lead to Charcot and that progression of deformity can be limited to <10% if caught early but will be 100% if left until 3 months[4].

Peri-operative factors

When operating on patients with complicated diabetes, there are several factors that one should look to optimise either pre-operatively or in the immediate post-op timeframe. Glycaemic control should ideally be below 70. Dietician involvement whilst as an inpatient should be considered in those with elevated HbA1c levels. Critical limb ischaemia is an independent factor for surgical complications and ankle-brachial index, or transcutaneous oxygen pressure (TcPO2) measurements should be obtained for these patients. Patients with CKD may have low Vitamin D, which should be replaced. Further assessment of the patient's nutritional status can be achieved looking at blood markers such as prealbumin.

Open reduction and Internal fixation

A low threshold should be applied to treating these patients in the same way that Sammarco et al describes treating patients with Charcot. That involves the use of "superconstructs", with fixation beyond the zone of injury, with the strongest fixation that is tolerated by the soft tissue envelope and whereby fixation maximises the mechanical function of the patient. For internal fixation, this is often best achieved with tib-pro-fib constructs as shown.

If internal fixation is performed without multiple tib-pro-fib screws but syndesmosis stabilisation is required, then locking screw fixation, rather than non-locking or tightrope fixation should be used[5].

External fixation

For patients with a poor soft tissue envelope that is not amenable to internal fixation, external ring fixators can be applied. The use of olive wires as part of the construct can also provide a powerful tool for fragment reduction in displaced injuries. External fixation can also be used in conjunction with internal fixation in patients that are likely to be non-compliant. Beware of patients have developed cerebral neuropathy[6] from their diabetes who may appear to understand post op instructions to non-weight bear but may in fact be non-compliant.

Primary arthrodesis

In the presence of complicated diabetes, there is a significant risk that a patient undergoing ankle fusion for fracture will undergo Charcot of the subtalar joint below. Therefore, along the lines of superconstructs, the recommendation for fusing would be a tibiotalocalcaneal (TTC) fusion. This would be the recommended management for injuries that are severely comminuted, especially those having intraarticular involvement. TTC is recommended for patients with delayed presentation, given that increasing deformity is likely to have already begun. Although joint movement is sacrificed, patients treated with TTC have been shown to have fewer complications, shorter hospital stays and have no increase in functional decline compared to ORIF[7].

Consensus Questions

1. Do you pre-operatively plan to use tib-pro-fib fixation principles in patients with uncomplicated diabetes?
   i. Always: 0
   ii. Sometimes: 11 (consensus)
   iii. Rarely: 0
   iv. Never: 0

   Addendum: Many attendees felt unable to commit to this consensus due to the number of other factors that co-exist with these patients.

2. In the presence of an appropriate energy ankle fracture, in a patient with uncomplicated diabetes, would you extend your period of immobilisation to 3 months?
   i. Always: 3 (15%)
   ii. Sometimes: 14 (70%)
   iii. Never: 3 (15%)

3. In patients with low energy (osteoporotic) ankle fractures and uncomplicated diabetes, would you plan to use tib-pro-fib fixation?
   i. Always: 9 (53%)
   ii. Sometimes: 8 (47%)
   iii. Never: 0

4. In patients with low energy (osteoporotic) ankle fractures and uncomplicated diabetes, would you extend your period of immobilisation to 3 months?
   i. Always: 5 (33%)
   ii. Sometimes: 9 (60%)
   iii. Never: 1 (7%)

5. In patients with closed Pilon fractures, in the presence of complicated diabetes without known severe peripheral vascular disease, would you treat these patients non-operatively in a cast due to concerns about complications?
   i. Always: 0
   ii. Sometimes: 11 (58%)
   iii. Never: 8 (42%)

6. In patients with closed Pilon fractures, in the presence of complicated diabetes without known severe peripheral vascular disease, would you treat these patients with a hindfoot nail, in preference to tib-pro-fib internal fixation?
   i. Always: 2 (11%)
   ii. Sometimes: 15 (83%)
   iii. Never: 1 (6%)

7. If performing a hindfoot nailing for the above scenario, would you formally prepare the subtalar joint?
   i. Always: 8 (42%)
   ii. Sometimes: 11 (52%)
   iii. Never: 0

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5.2 Conservative or surgical management in early Charcot hindfoot

Venu Kavarthapu

In the acute phase of Charcot neuroarthropathy (Eichenholtz Stage 1) the patient has already had their initial trauma (often trivial) and they are now in the process of an uncontrolled inflammatory reaction. The aims of treating a patient at this stage are to achieve timely resolution of inflammation, prevent progression of deformity thus preventing ulceration and then to prevent the recurrence of Charcot.

Medical management

Several novel treatments have been tried to medically manage Charcot including anti-resorptive medication, recombinant parathyroid hormone, RANKL antibodies, low-intensity ultrasound, and electric/magnetic stimulation. None however have managed to show any improvement in the previously mentioned goals.

Non-operative Orthopaedic management

The gold standard for treating stage 1 Charcot is offloading. This is achieved in a total contact cast (TCC). A TCC will rapidly reduce the oedema in the lower leg and ankle. TCC will also help prevent fragmentation and progression of deformity. To be most effective, the patient should be non-weight bearing in their TCC. In some healthcare systems and in particularly hot areas, a full TCC cast (with weekly changes) may be too cumbersome to the patient and the healthcare service. In that scenario a walking boot or air type boot will still be helpful, but the patient will take longer to improve.

Stage 0

With the judicious use of a TCC in Eichenholtz stage 1, the patient can progress swiftly through the stages, to stage 3 (Consolidation). Hopefully, this will occur with little or no deformity. However, if the pathology is diagnosed in stage 0 (Pre-radiographic) Charcot and the patient placed into a TCC early, then there is an opportunity to divert the disease from progressive Charcot changes and never develop through to stage 1.

Deformity at stage 1

Typically, a patient would be guided through to consolidation and if at that time there was deformity at risk of ulceration then surgical intervention with reconstruction or exostectomy can be performed.

If a patient's Charcot process/inflammation is severe enough with severe bone fragmentation and instability, then the deformity can lead to a 'foot at risk' status whilst the patient is still in stage 1. It is important that the care of these patients is coordinated through a diabetic foot MDT comprising not only of a Diabetologist, Podiatrist and Orthopaedic Surgeon, but also a Vascular Surgeon, Plastic Surgeon, Orthotist, Microbiologist and Radiologist.

Surgical Management

The Kings' group have published their evolving results and are now achieving predictable results in these patients, if there is durable long-segment rigid internal fixation with optimal bone opposition. The midfoot Charcot reconstruction involves utilisation of medial and lateral column 'beams' and locking plates, with improved surgical outcomes. Similatly, better results have been published when treating hindfoot Charcot, even in the absence of infected ulcers, with a one-stage TTC nail. Wedge or rhomboid resections of the bones is performed to correct the deformity. To achieve good approximation, bone fragmentation found at surgery should be removed and flat cuts made that fit well together. The use of bulk allograft to fill structural defects has not been shown to be helpful and does not incorporate in the presence of Charcot. Bone resections to correct the deformity results in limb shortening, however this is beneficial for the reduction in soft tissue tension allowing tension free wound closure and reduced surgical complications. Conversely, trying hard to keep the limb length and placing the soft tissues under tension leads to a higher rate of complications. Further predictors for metalwork failure were also identified in hindfoot nail reconstructions- failure to achieve isthmus fit, an incompetent medial malleolus and the lack of an additional calcaneo-tibial screw being used. If all three of these markers were present, there were no episodes of metalwork failure[1].

Timing of surgery

Reduction of swelling is paramount to being able to operate on patients in this scenario with a foot at risk. For this to happen quickest, the patient should be admitted for elevation, be non-weight bearing and be in a suitable plaster. Swelling can be reduced very quickly with this process and takes 8 days on average. Another endpoint to guide timing is when the temperature of the skin of the affected leg is within 2 degrees centigrade of the contralateral limb. This time in hospital can also be used for smoking cessation if required and for better glycemic control. Due to the acute nature of intervention in these patients, the relatively slow process of lowering the patients HbA1c can be put aside, although optimum control of blood sugar as an inpatient and moving forward is required.

Hindfoot Charcot with active infection

Even in patients with failed previous debridement, with talar resorption and on-going infection in the hindfoot can be treated with limb salvaging surgery. The King's group have published their two-stage reconstructive approach with the key principles of; elimination of infection, correction of deformity and stable fusion[2]. First stage includes aggressive 360 debridement, procurement of bone samples, filling of defects with antibiotic eluding material and temporary stabilisation, either external fixation (if tolerated) or buried wires. The patient is optimised by the multi-disciplinary team over the next 6-8 weeks, and then if inflammatory markers remain within normal limits, a second stage can be performed. Second stage reverts to the same principles of good opposition of fragments and rigid fixation. Supplementary external fixation is not usually required.

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5.3 Early recognition of Charcot Arthropathy

Dishan Singh with Alastair Bint and Julia Gray

The clinical and cadaveric description by Charcot in 1868 of neuroarthropathy in tertiary syphilis was of swollen, painless deformed joints at the later stages of the of the arthropathy. Bony destruction, fragmentation, joint subluxation and bony remodeling were considered radiographic hallmarks of the disease and Eichenholtz in 1966 described 3 stages of progressive radiological abnormalities[1].

In 1990 Shibata et al introduced the term Eichenholtz stage 0 to describe a clinical stage of swelling, warmth and instability in leprotic neuroarthropathic ankles which preceded changes seen on plain radiographs, a stage which has subsequently been variously referred to as Eichenholtz stage 0, clinical stage, acute stage or inflammatory stage[2]. Sella et al in 1999 applied the term to diabetic neuro-arthropathy with Eichenholtz stage 0 referring to a warm swollen foot characterized by normal plain radiographs and a positive technetium 99 bone scan; they also commented that all patients who presented in the later stages of Charcot neuroarthropathy recalled a warm swollen foot prior to deformity and suggested that patients with CN diagnosed and treated in the early stages did not develop deformities[3].

Further studies have appeared to suggest a window of opportunity when initial abnormalities of Eichenholtz grade 0 CN would not progress to bone and joint destruction, and sequential disabling deformity, when management of the active grade 0 CN is instituted by offloading the foot as early as possible at the time of osteoclastic activity[3-7].

The National Institute for Care Excellence (NICE) in the United Kingdom in 2015 addressed the issue in clinical guideline (CG10) on diabetic feet[8]. It stated:

> *Charcot arthropathy: Investigation*
>
> *1.7.1 Be aware that if a person with diabetes fractures their foot or ankle, it may progress to Charcot arthropathy.*
>
> *1.7.2 Suspect acute Charcot arthropathy if there is redness, warmth, swelling or deformity (in particular, when the skin is intact), especially in the presence of peripheral neuropathy or renal failure. Think about acute Charcot arthropathy even when deformity is not present or pain is not reported.*

Delayed diagnosis of acute Charcot neuropathic osteoarthropathy (CN) of the foot and ankle in diabetic patients persists in spite of the NICE guidelines NG19 produced in 2015 and designed to aid prompt recognition and encourage urgent referral to a diabetic multidisciplinary team in order to prevent foot and ankle deformity, ulceration, infection and extremity amputation.

In a review of the records and legal documents of 28 patients (average age 51, range 22-73) who have started legal proceedings for a delayed diagnosis of CN since 2015 it was found that the condition was often initially misdiagnosed as cellulitis, gout, deep venous thrombosis or a sprain, with an average delay of 19 weeks (range 2.5-74).

Diagnosis	1st Presentation	2nd	3rd Presentation
	n(%)	n(%)	n(%)
Cellulitis	12 (42.9)	9 (32.2)	2 (7.1)
Sprain	6 (21.4)	2 (7.1)	0
Deep vein thrombosis	3 (10.7)	5 (17.9)	4 (14.3)
Gout	1 (3.6)	1 (3.6)	2 (7.1)
Arthritis	3 (10.7)	1 (3.6)	1 (3.6)
Oedema	2 (7.1)	2 (7.1)	3 (10.7)
Other	1 (3.6)	3 (10.7)	3 (10.7)
No diagnosis	0	3 (10.7)	6 (21.4)

Further review of the records to look at clinical features at initial presentation of a Charcot arthropathy were:

Swelling	28 (100%)	0 (0%)
Foot	15	
Lower Leg	1	
Both	12	
Redness	17 (60.7%)	11 (39.3%)
Warmth	10 (35.7%)	18 (64.3%)
Neuropathy	13 (46.4%)	15 (53.6%)
Ulcer	2 (7.1%)	26 (92.9%)
Deformity	2 (7.1%)	26 (92.9%)

The main factors identified in failure to recognize Charcot arthropathy at initial presentation were: a failure to consider CN because it is assumed to be rare, to be painless, to give rise to symptoms only in the foot and to always be associated with pre-existing dermal neuropathy. We also believe that the NICE Guidelines are poorly worded as they imply that all the features of warmth, redness and swelling should be present at initial presentation

We suggest that further research is needed into the presenting features of acute CN which distinguish CN from more common conditions, and an education campaign would then be required to translate clear evidence-based guidelines into clinical practice.

Consensus

There was unanimous agreement that the committees of the British Orthopaedic Foot and Ankle Society should discuss how to encourage NICE to produce more evidence-based and clearer guidelines on the diagnosis of Charcot arthropathy.

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5.4 Role of orthobiologics

Vish Kumar

The use of 'natural' products that can be used in a number of conditions and injuries, both in isolation or as a supplement to other treatment, has created much industry-led interest over the last decade or so.

The majority of published evidence for these substances refers to their use in elective procedures, with little information being available for their application in acute fractures. Orthobiologics can be useful in the presence of bone loss and poor vascularity, both of which can be seen in severe fractures. These substances can be osteoconductive, osteoinductive or osteogenic in their use.

The following Orthobiologics may have a role in acute fractures.

Bone Morphogenetic protein (BMP)

These proteins are part of the TGF - β supergene family and work by attracting mesenchymal stem cells (MSCs). There are 7 different proteins, with recombinant (rhBMP) 2 and 7 being used most widely. RhBMP - 2 has been shown to have benefits when used in open tibial fractures, reducing the risk of infection and increasing wound healing[1].

Platelet Derived Growth Factors (PDGF)

Also act to signal MSCs along with other angiogenic factors to encourage new bone and vascularity to be formed. They are often used in conjunction with a bone structure alternative, i.e. Tri-calcium-phosphate (TCP). Some studies have suggested this combination works as well as autograft. They have been shown to achieve good union rates in hindfoot arthrodesis procedures[2].

Platelet Rich Plasma (PRP)

Derived from autologous blood which is centrifuged. PRP is then removed from the sample and injected directly into the area of use. PRP contains some of the substances already discussed including PDGF, as well as cytokines and other growth factors. Its usefulness has been shown predominately in soft tissue problems. Further investigation into its use for healing in acute fractures will be required.

Bone Marrow Aspirate Concentrate (BMAC)

Harvested from one of a number of sites including tibia or calcaneum, but normally from the pelvis, of which the PSIS has been shown to give the greatest harvest of MSCs. The ASIS can also be used. Specific kits are available to

improve the quality of the harvest. The presence of red blood cells in the harvest does limit the potential use with intraarticular injuries. Further downsides include donor site pain. BMAC may be useful in high risk patients and has been shown to decrease complications in diabetic patients, although this was in a cohort of non-unions rather than acute fractures[3].

Demineralised Bone Matrix (DBX)

DBX is the most popular of the allografting options and is used in approximately 20% of all bone grafting procedures. There is a heterogenicity to the production and evaluation of DBX. It can be offered to the surgeon as wedges or anatomically optimise blocks, it is also available as smaller chips as a void filler. Often it is bare but can be offered with other adjuncts attached. Often DBX is mixed during a procedure with one of the aforementioned orthobiologics. Lareau et al had a 100% return to play outcome when using DBX and BMAC together in Jones' fractures in NFL players[4].

Bone graft substitutes

Many variations are available, some containing antibiotics too. The main three are calcium sulphate (CS), calcium phosphate (CP) and tricalcium phosphate (TCP). The majority of studies, especially in the F&A world, are for the use of these injectable grafts in the operative management of calcaneum fractures as a void filler. Results are variable and are often multi-factoral, especially given the different approaches used to treat these fractures that have been discussed previously in this booklet.

Complications

There is little mentioned about the potential complications of these substances, and this is likely to be due to underreporting rather than orthobiologics being entirely innocuous. The introduction of something foreign into the body will always carry more risk than not doing so. Complications reported mainly focus on localised inflammatory response, often difficult to distinguish from infection.

Conclusion

The challenge will be to obtain good level evidence for differing injuries, especially given the heterogenicity of formulations and administration when considering trial protocols. Orthobiologics may be used in the future both as a standalone agent or as part of operative intervention for acute fractures. Initially their use may be best directed to high-risk cases as there is not currently enough data to support widespread use on all fractures.

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Notes

Notes

Convened participants of the 2023 Round Table Meeting

Callum	Clark	Heatherwood & Wexham Park Hospitals
Robert	Clayton	NHS Fife
Simon	Clint	Cheltenham General Hospital
Mark	Davies	Northern General Hospital, Sheffield
Paul	Fenton	Queen Elizabeth Hospital, Birmingham
Rod	Hammett	Taunton & Somerset NHS Foundation Trust
Bakur	Jamjoon	RNOH, Stanmore
Justin	Kane	Orthopaedic Institute of North Texas, USA
Venu	Kavarthapu	Kings College Hospital
Andrew	Kelly	Musgrove Park Hospital, Taunton
Vish	Kumar	Wye Valley NHS Trust
Adam	Lomax	Leeds Teaching Hospitals NHS Trust
Devendra	Mahadevan	Royal Berkshire NHS Foundation Trust
Jit	Mangwani	University Hospitals of Leicester
Lyndon	Mason	Liverpool University Hospitals NHS Foundation Trust
Anand	Pillai	University Hospitals South Manchester, Wythenshaw
Stefan	Rammelt	University Hospital Carl Gustav Carus, Dresden, Germany
James	Ritchie	Maidstone & Tunbridge Wells NHS Trust
Amjad	Sawah	Liverpool University Hospitals NHS Foundation Trust
George	Smith	Norfolk & Norwich University Hospital
James	Tebby	Northern General Hospital, Sheffield
Claire	Topliss	Morriston Hospital, Swansea

OrthoSolutions Group

Advancing Foot & Ankle Care

OrthoSolutions Limited,West Station Business Park,
Spital Road, Maldon, Essex. CM9 6FF, United Kingdom

T: +44 (0) 1621 843599
F: +44 (0) 1621 858953

E: sales@orthosol.com
W: www.orthosol.com