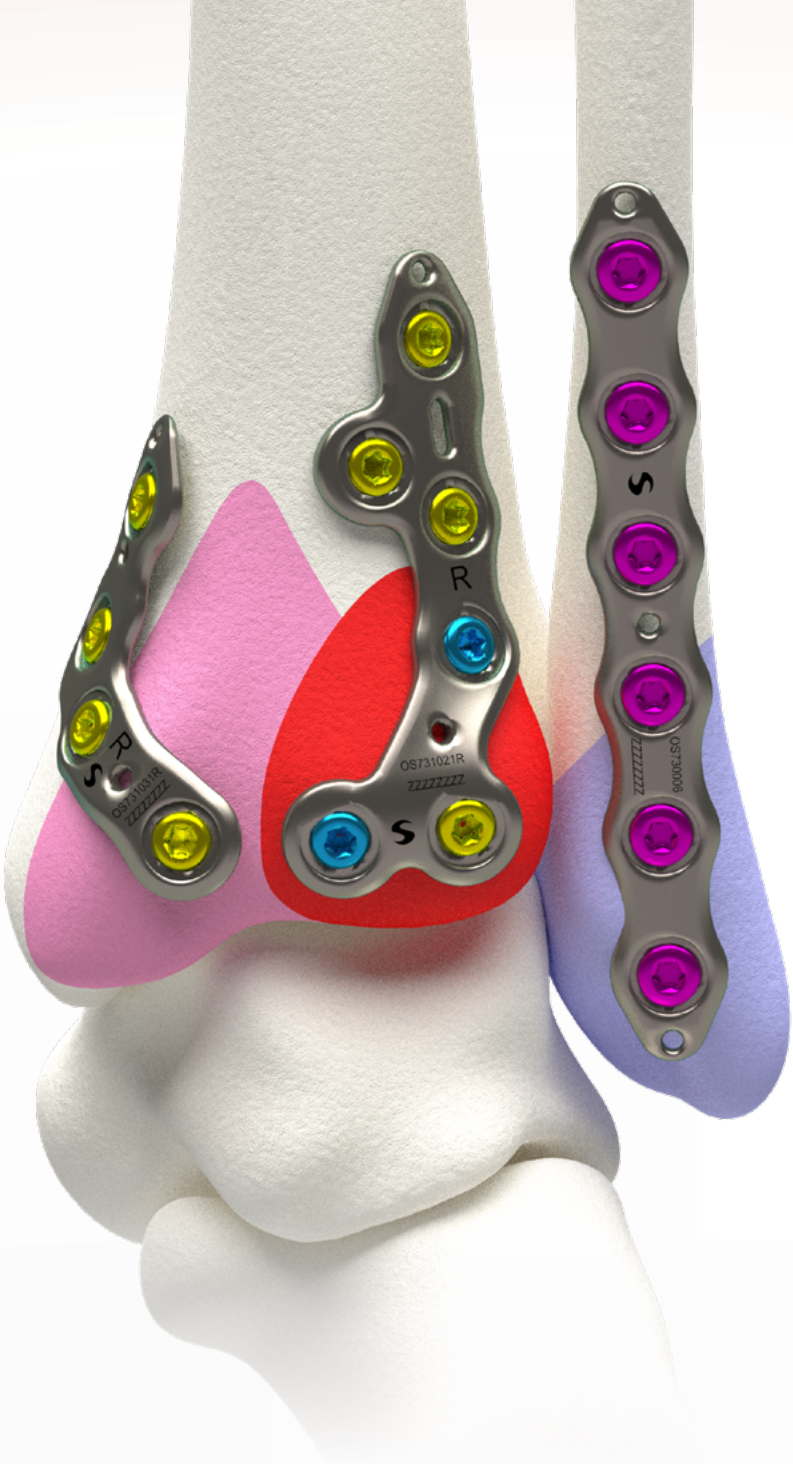

A Clinically Comprehensive Guide to the Management of Ankle Fractures: The Posterior Malleolar Fracture Patient Cohort.

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INTRODUCTION

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The posterior malleolus has two main functions in the stability of the ankle; preventing sagittal plane translation and horizontal plane rotation (figure 1 and table 1). [1] The larger fracture fragments are more important in preventing posterior talus displacement in the sagittal plane; however the smaller fragments have a greater importance in preventing talus rotation in the horizontal plane. Previous notions of percentage of articular surface dictating surgical intervention have been dispelled, with the importance now firmly understood to be due to fracture morphology (see classification below).[2]

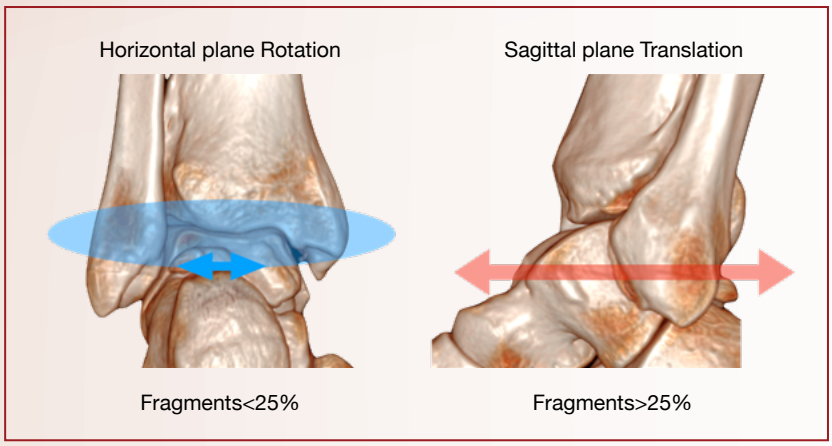


Figure 1

Movement	Direction	Stabilizer
Sagittal Axis Translation	Anterior	ATFL, Superficial deltoid
	Posterior	**Posterior malleolus**, PTFL, posterior deep deltoid, superficial posterior tibiotalar band.
Coronal Translation and Rotation	Medial	Medial malleolus, CFL, PTFL, in dorsiflexion. ATFL restricts with foot in plantar flexion
	Lateral	Fibular, AITFL, PITFL, IOL, posterior deep deltoid, anterior deep deltoid, superficial deltoid (tibiocalcaneal ligament)
Horizontal Axis Rotation	Internal and External rotation	**Posterior malleolus**, medial malleolus, fibular, ATFL, AITFL, PITFL, Anterior deep deltoid, posterior deep deltoid

Table 1

There are both clinical and anatomical studies also indicating the importance of the posterior malleolar fracture (PMF) in the management of syndesmosis injury. Gardner et al found that fixation of the posterior malleolus fragment rather than using a syndesmotic screw provided better rotational stability.[3] Miller et al looked at syndesmotic stability when patients are lying supine vs prone. They saw that positioning a patient prone to undertake ORIF of the PMF restored 97.9% of patient's syndesmotic stability. In comparison 48.3% of patients treated in the supine positioning required some form of additional syndesmotic stabilisation. [4] Fitzpatrick et al even found that the smaller fracture fragments had a greater determination on syndesmotic position than the larger fragments.[5]

However, it is important to note that not all PMF have injured syndesmosis. The injury of the syndesmosis is dependent on the mechanism of injury. Although we found in our classification paper in 2017 that 100% of avulsion type injuries had a syndesmosis injury on testing, only 49% of rotational Pilon's and 20% of axially loaded Pilon's had syndesmosis instability.[6] Further anatomical work by our group concluded this was due to the extensive expansion across the posterior tibia of the superficial component of the posterior inferior tibiofibular ligament.[7] Surprisingly, it was identified that the more extensive the bone injury, the lower the risk of ligamentous injury.
Thus, if the syndesmosis is injured, PMF fixation will improve its stability, however in the rotational and axially loaded Pilon it's not always injured. Percentage joint involvement of a PMF has no relevance to the syndesmosis injury. A further caveat is that on occasion, in high fibular fractures, fixation of the PMF does not control the anterior syndesmosis injury and thus a low threshold to undergo syndesmosis fixation should be kept even after PMF fixation in cases of high fibular fracture. Kohler et al showed in a biomechanical study that PMF fracture was not enough to stabilise high fibular fractures due to persistent anterior syndesmosis injury.[8]

CT

It is now recognised in the literature that a CT is required for PMF if you want to ascertain the extent of the injury. There are many publications in the literature showing the estimation of posterior malleolar fracture size to be very poor on a plain radiograph. [9-16] Any posteromedial involvement has a high chance of not being seen as the fracture line is not orientated correctly to view this. Meijer et al paper in 2015 found that the accuracy of measurement of posterior malleolar fracture size on lateral radiograph was only 22%.[14] Therefore, it is recommended to obtain a CT preoperative.

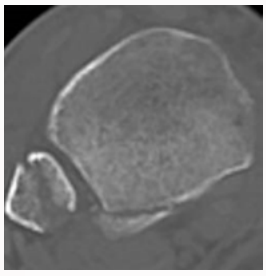
CLASSIFICATION

The PMF has long been known to be heterogenous, however percentage articular surface is still discussed as the defining factor. The original classification of the PMF was by Haraguchi et al, which attempted to distinguish the fractures further.[17] However, this has since been superseded by classifications by Bartonicek et al and by ourselves.[18, 19], which are indistinguishable apart from the Mason and Molloy identification of the Type 2A and 2B (Bartonicek type 2 and 3) being the same mechanism, but a minor and major variants of the rotational pilon (table 2) None of the classification systems use percentage as their defining factor.

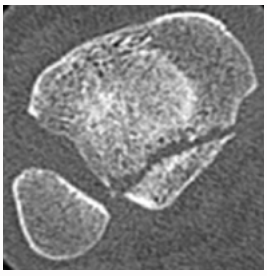
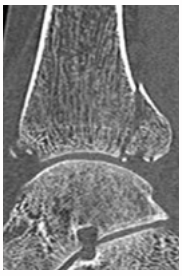
Mason and Molloy	Haraguchi et al	Bartonicek et al	Mechanism
Type 1	Type 3	Type 1	PITFL Avulsion
Type 2A	Type 1	Type 2	Rotational Pilon
Type 2B	Type 2	Type 3	
Type 3	Type 1?	Type 4	Axial loaded pilon

Table 2

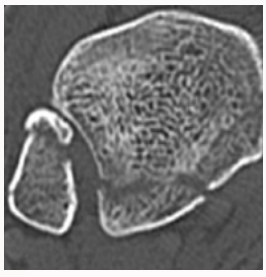
The Mason and Molloy classification type 2 subtype, the rotational pilon, have been validated by Xie et al who found the incidence of intraarticular impacted fragments to be consistent with the talus impaction on the tibial articular surface in rotation, unlike the avulsion type mechanism described by Haraguchi et al. [20] Studies using the historic Haraguchi classification either combined the Mason and Molloy type 2A and type 3 fracture patterns into the same group (often referring to them as small and large types) or did not include the type 3 at all. [21-23] Therefore, many have abandoned the use of the Haraguchi classification.



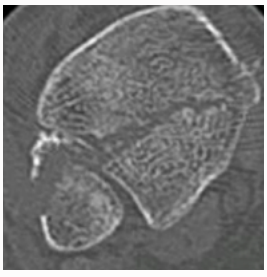
Type 1 PITFL Avulsion


Type 2A Rotational Pilon Minor



Type 2B Rotational Pilon Major



Type 3 Axially Loaded Pilon

PLANNING

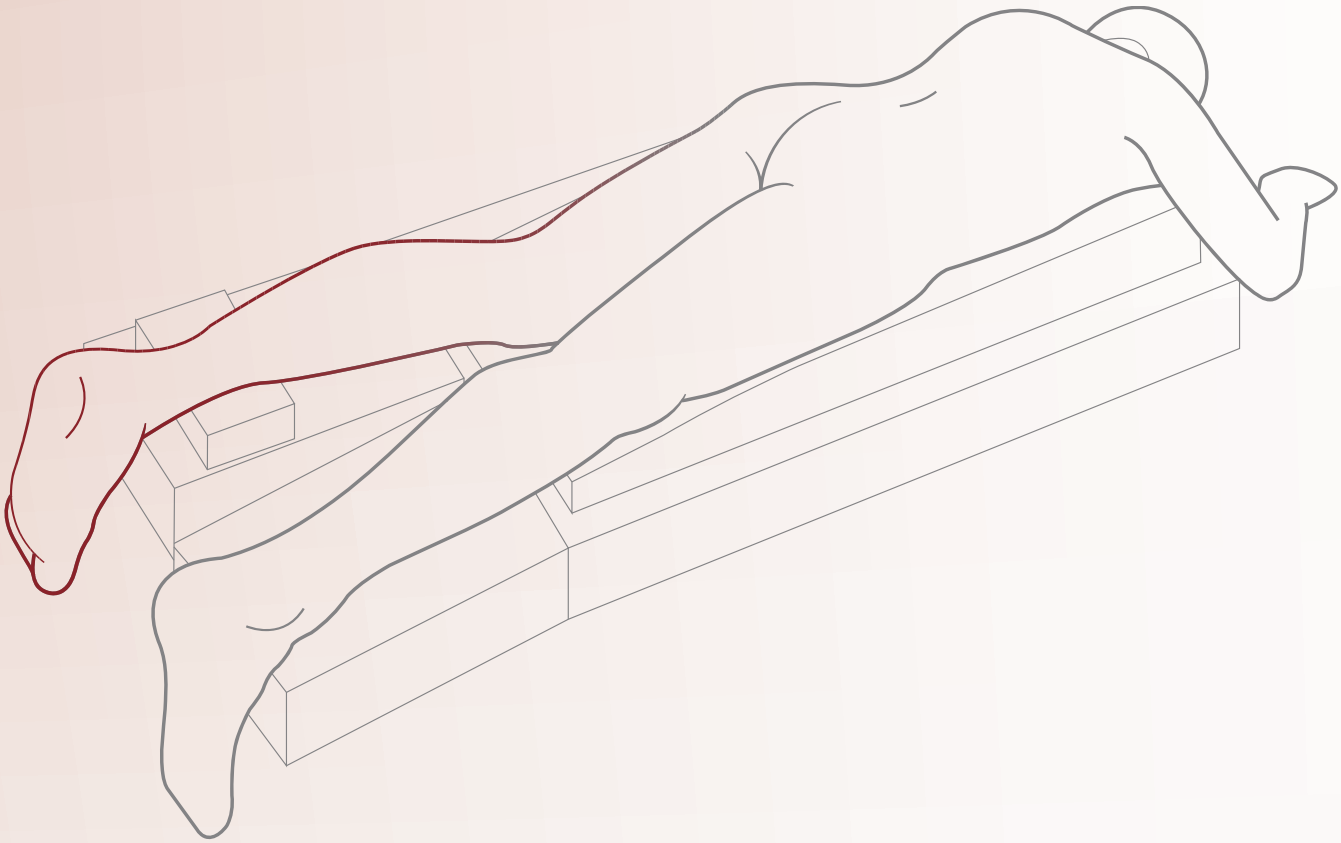
Access to CT is important when planning surgical intervention. Knowledge of the fracture pattern, including any die punch or comminution, will guide your approach. Our own work using a treatment algorithm based on the pathomechanic classification we published in 2017, resulted in a significant improvement in functional outcomes of all fracture types. This was published in 2019, with avulsion type fractures (type 1) undergoing syndesmotic fixation and Pilon fractures (rotational and axial loaded, 2A, 2B and 3) undergoing ORIF. [6, 24] The recent paper from the Royal London hospital showed very similar results to ours, using the same treatment theories as ours. [25] Many other papers over the last 4 years have also shown very good functional results using similar methods.

Our paper in 2020, discussed the use of a clock face on the indicating the requirement for different approaches. [26] The most common reason in the paper to not perform a posterolateral approach was a high or comminuted fibular.

THEATRE SET-UP

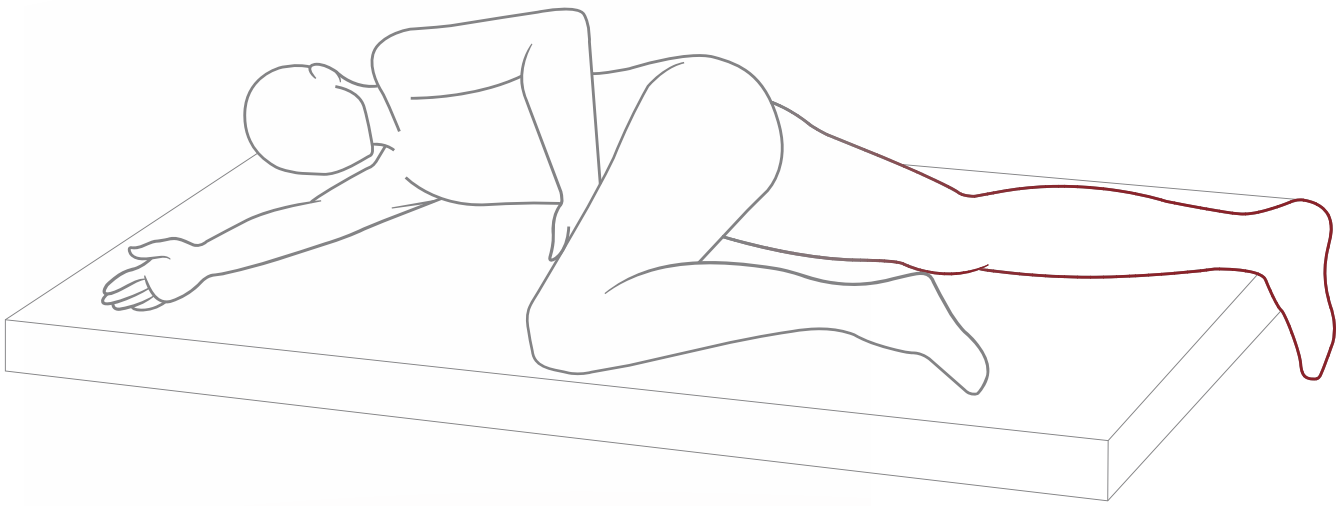
Fixation of the posterior aspect of the ankle is best completed with the ankle prone. Although other methods such as ‘figure of four’ or lateral are done regularly, our own personal experience with this is poor vision, and malreduction due to twisting the ankle to get a view of the fracture site. There are generally 2 setups that can be used consistently to achieve a prone position of the foot.

Full Prone



NB: Red leg indicates operating leg.

Recovery Position



NB: Red leg indicates operating leg.

POSTERIOR ANKLE SURGICAL APPROACHES

Posterolateral (PL)

The posterolateral approach is the most common utilised approach to posterior malleolar fractures; however, it is possibly the most difficult approach, gives lest access to the tibia and carries the greatest risk. As illustrated in the cross-section image in figure 1, there are 2 neurovascular bundles that are encountered in this approach, superficially the Sural nerve (SN) and short saphenous vein (SSV), and deep the peroneal artery (PA). Superficially, the SN/SSV will be encountered above the investing fascia and needs to be protected. The PA lies between the peroneal tendon sheath and the sheath for the flexor hallucis longus muscle belly/tendon. Thus, windows of access to the tibia and fibular should be separate as access from one sheath to the other risks injuring the PA.

Markup

For the posterolateral approach (PL) the skin incision is marked out half-way between the posterior edge of the fibular and the lateral edge of the Achilles tendon. The SN and SSV course should be estimated and drawn, typically leaving the lateral edge of the Achilles tendon approximately 7cm proximal to the intermalleolar axis (the line drawn between the distal tips of the medial and lateral malleoli), traversing obliquely to 7mm below the tip of the fibular.

Investing fascia

The SN and SSV are found and protected lying superficial to the investing fascia (figure 3). The investing fascia is opened revealing the fascia superficial to the flexor hallucis longus and peroneal compartments.

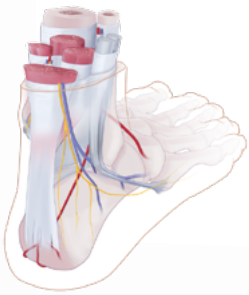


Figure 1

Figure 2

Figure 3

Figure 4

Tendon Sheaths

The sheaths of the flexor hallucis longus and peroneal compartments are opened longitudinally separately, to prevent damage to the peroneal artery which lies between the compartments figure 5. It is very important to not dissect between the compartments as the peroneal artery is relatively immobile due to the perforating peroneal artery transversing between the tibia and fibular, approximately 4cm proximal to the joint line.

Periosteum

Tibia

The next layer reveals the periosteum, Posterior inferior tibiofibular ligament (PITFL) and intermalleolar ligament. Care should be taken to elevate the periosteum and leave the deep PITFL footprint intact (figure 7 and 8).

Fibular

Regarding the fibular, the peroneal muscles are retracted medially to allow access to the base of the peroneal compartment (figure 9).

The fibular is approached through the base of the compartment, with periosteal elevation both medially and laterally. It should be noted that the peroneal artery is medial to the compartment and should be protected. (figure 10)

It is important to not deglove the skin outside the peroneal compartment as this can predispose to wound complications.

Fixation

The fracture pattern will dictate the choice of hardware to allow both reduction and maintenance of stability. The type 2A Volition™ ankle fracture plate is designed to be positioned easily through the PL approach, allowing access to the posterolateral tibia, and ensuring correct safe zone application so the hardware does not encroach on the incisura (figure 11).

Comminuted fibular fractures and high fibular fractures are better dealt with through a direct lateral approach than the PL approach, especially in situations where there is anterior comminution. In short oblique fractures of the distal fibular, a posterior plate is useful. The straight plate on the Volition set is designed to allow easy application using the screw in guide, and the multiple K wire holes enable positioning on the fibular which can otherwise be difficult due to the triangular shape of the posterior fibular (figure 12 and 13).

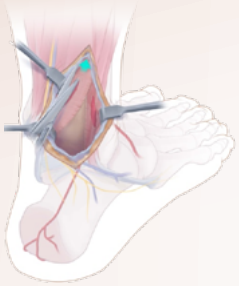


Figure 5

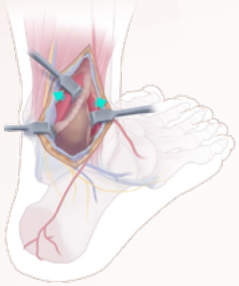


Figure 6

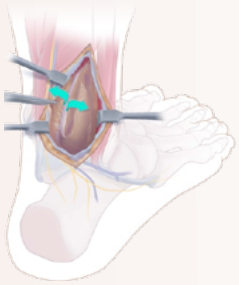


Figure 7

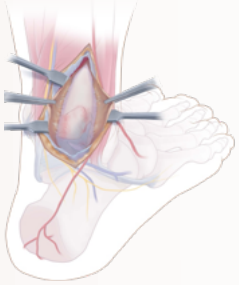


Figure 8

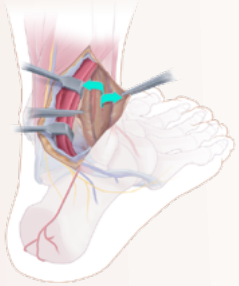


Figure 9

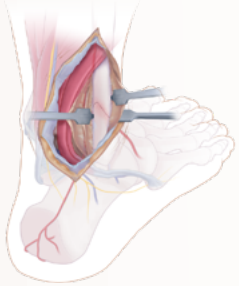


Figure 10

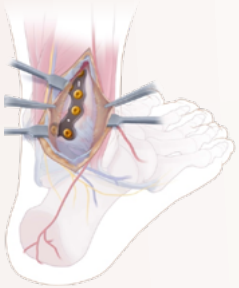


Figure 11

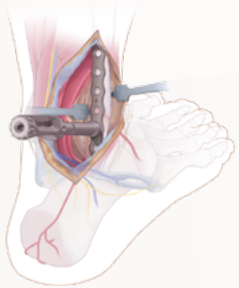


Figure 12

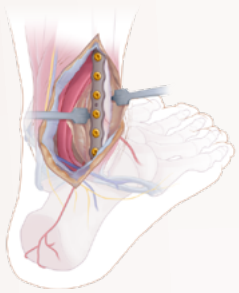


Figure 13

Posteromedial (PM)

As illustrated in the cross-section image in figure 1, the Tibial nerve and vessels neurovascular bundle lies between the flexor digitorum longus (FDL) tendon and the FHL tendon and muscle belly. The SN and SSV transverse from central to the lateral aspect of the ankle. Thus, window of access to the is lateral to FHL. This is the same deep window as the PL approach, however in cases where more of the tibia access is required, or access to the fibular is required through a direct approach (high fibular, comminuted fibular, large Wagstaffe, anterior syndesmosis instability etc) the PM approach is very useful. The skin bridge is adequate between the PM and the direct lateral approach to allow both to be used at the same time.

Markup

The skin incision is made immediately medial to and parallel with the Achilles tendon and is extended proximally from the intermalleolar axis. The SN and SSV are not at risk during this approach. (figure 2)

Investing fascia

Care is taken to avoid the Achilles tendon paratenon. The investing fascia is opened longitudinally revealing the fascia superficial to the FHL (figure 3). Be careful not to deviate medially, as the neurovascular bundle is close initially. The space between the anterior aspect of the paratenon of the Achilles and the FHL sheath can be separated using a digital swipe. The Achilles paratenon is then retracted laterally.

Tendon Sheath

The FHL sheath is opened longitudinally, keeping as lateral as the exposure will allow you (figure 4). NB the neurovascular bundle is within this compartment anteromedial to FHL muscle and tendon and needs to be protected.

The muscle belly of Flexor Hallucis longus is retracted medially protecting the neurovascular bundle (figure 5).

Periosteum

The periosteum is opened and elevated both medially and laterally maintaining the deep PITFL footprint (figure 6 and 7).
The posteromedial approach exposes significantly greater tibia than the posterolateral approach.

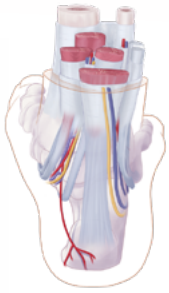


Figure 1

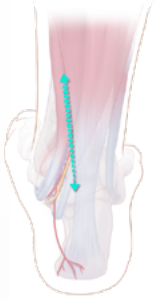


Figure 2

Figure 3

Figure 4

Figure 5

Figure 6

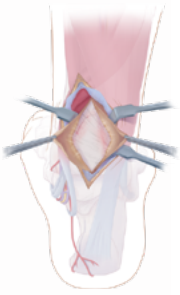


Figure 7

Fixation

The fracture pattern will dictate the choice of hardware to allow both reduction and maintenance of stability. Figure 8 shows the type 3 Volition™ fracture plate placed on a type 3 Mason and Molloy fracture type. The plate has 2 sizes to allow use in both the smaller and larger type 3 fracture patterns.

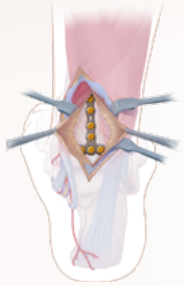


Figure 8

Medial Posteromedial (MPM)

As illustrated in the cross-section image in figure 1, the neurovascular bundle lies posterolateral to the flexor digitorum longus (FDL) tendon and anteromedial to the flexor hallucis longus (FHL) tendon and muscle belly. Thus, windows of access to the tibia should be utilised either anteromedial to the FDL tendon or lateral to the FHL muscle/tendon.

The MPM approach can either occur in front of the tibialis posterior (TP) or between the TP and FDL. The TP/tibia interval allows very good access to posteromedial fractures, especially if there is a medial extension, however the TP/FDL interval gives much better access to lateral extensions. For example, a Mason and Molloy type 3 fracture is preferably accessed through the TP/FDL interval than the TP/tibia interval.

The MPM approach is very useful in fracture patterns, where a die punch fragment needs to be accessed, as the PL and PM approaches do not allow visibility of the joint as the fragments are not readily mobilised to allow articular view. This is especially true of the PL approach, as the peroneal artery lies over the PITFL and therefore the lateral aspect of the posterior tibia talar joint and posterior incisura is inaccessible. The MPM can be performed with both the PL and direct lateral approach as the skin bridge is adequate.

Figure 1

Figure 2

Figure 3

Markup

The MPM approach is marked out either along the posteromedial edge of the tibia or up to 2cm behind it (thus in line with the fasciotomy line) as illustrated in figure 2.

This can be curved anteriorly in line with the TP tendon if, for example, an anterior collicular fracture is present and it is the surgeon's preference to access through the same incision rather than a separate anteromedial incision. If a proximal extension is needed, the medial fasciotomy line can be used, illustrating the safety and usability of the approach.

Investing fascia

The investing fascia is opened longitudinally (as per figure 3) exposing the tibialis posterior tendon sheath and FDL tendon.

Tendon sheath

The FDL tendon is usually visible below the investing fascia, with the neurovascular bundle posterolateral to the tendon. The tendon is retracted posterolaterally, protecting the neurovascular bundle as shown in figure 4.

To mobilise the TP tendon, the sheath is opened longitudinally (figure 5), but keeping the tough sheath as the tendon transverses the medial malleolar groove if possible.

The exposed tendon is protected and retracted laterally if the TP/tibia interval is required or anteromedially if the TP/FDL interval is preferred.

Periosteum

The periosteum is then elevated to expose the posteromedial tibia as illustrated in figure 7 and 8. The lateral extent of elevation should ensure the PITFL footprint is maintained.

Fixation

The fracture pattern will dictate the choice of hardware to allow both reduction and maintenance of stability. Figure 9 shows the 2B Volition™ ankle fracture plate placed on a 2B posteromedial fracture to allow reduction. The plate has been designed to protect the passing TB tendon.

Figure 4

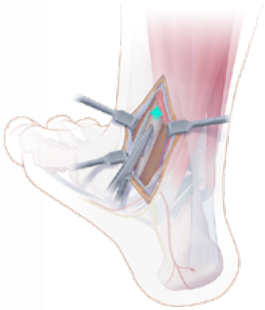


Figure 5

Figure 6

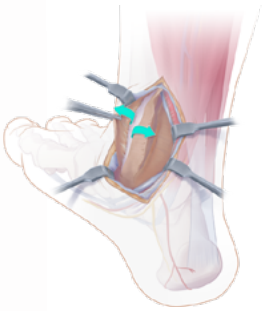


Figure 7

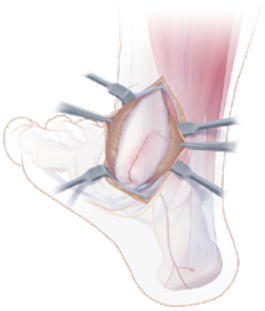


Figure 8

Figure 9

CASE EXAMPLE 1

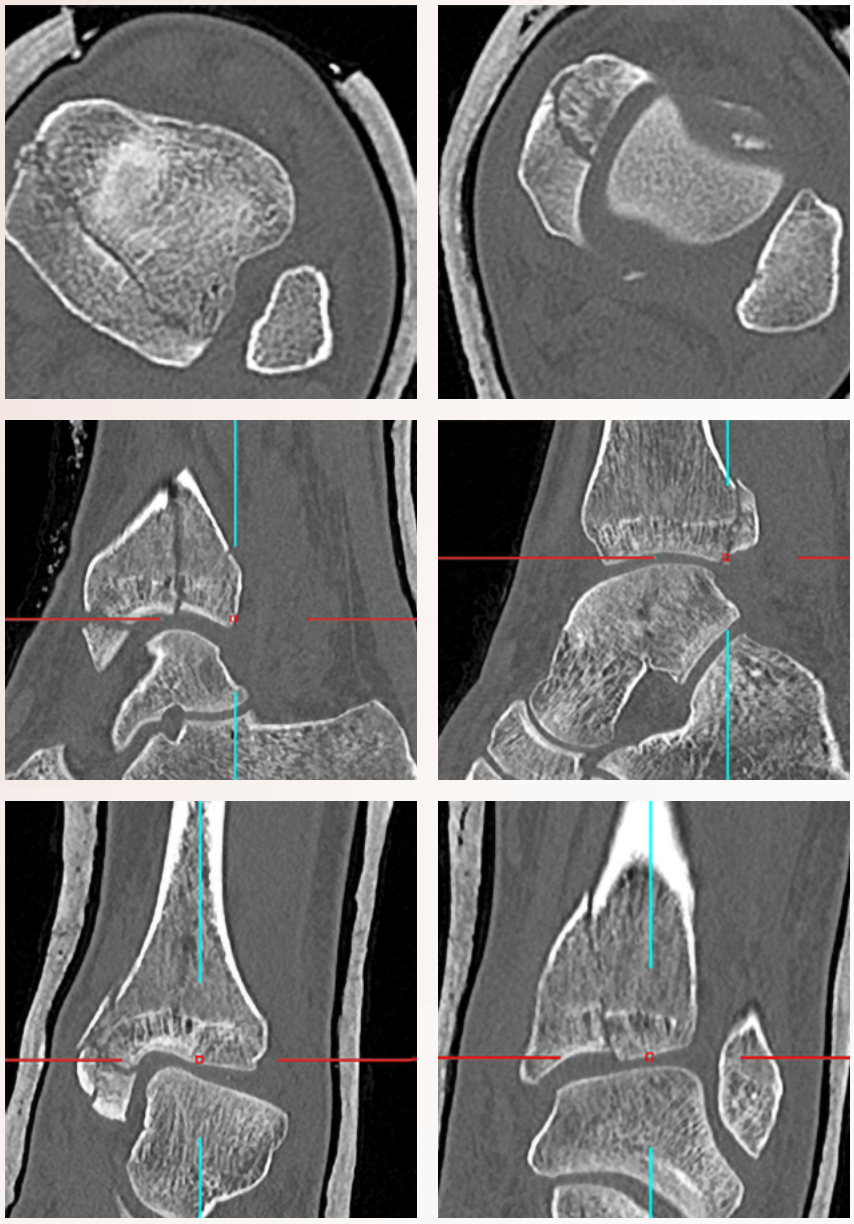
Fracture Type
Lauge Hansen – PER 4
Mason and Molloy – 2B
AO – 44B3.3

Soft-tissue (see appendix)
Closed fracture
Tscherne – C1

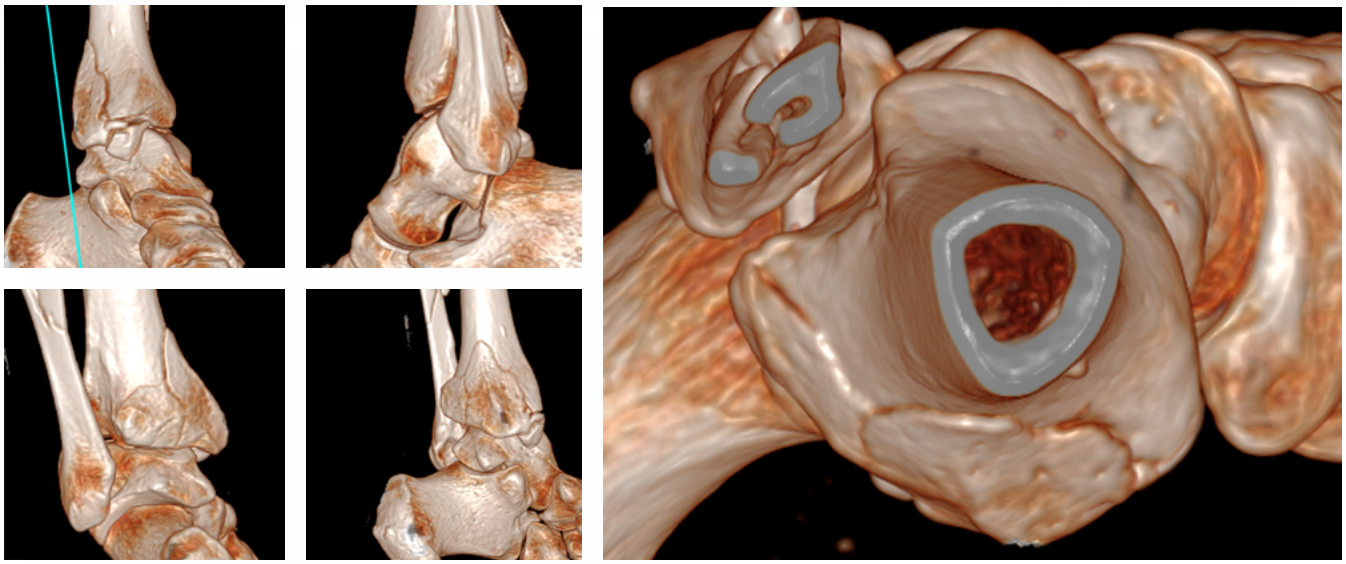
Specific Problems
Comminuted high fibular fracture, Type 2B PM fracture, anterior collicular fracture with multiple fragments. Syndesmosis injury.

Investigation

Pre-operative x-rays. AP and lateral views.



Pre-operative CT scan. Transverse, sagittal, and coronal slices.



Pre-operative rendered CT scan views.

Planning Comments

Approaches were planned to allow confident reduction of the high fibular and syndesmosis, which is more predictable through a direct lateral approach. The comminution posteromedial (PM) and medial fragments were best approached through the MPM incision. However, the small PL fragment meant that a percutaneous approach was needed to place the screw. The reduction and view of screw entry can still be obtained through the MPM approach, however. The MPM incision can be curved anteriorly along the tibialis posterior course, to allow access to the anterior collicular fracture and comminution. Due to the size of the fragments, fixation of these were accomplished with headless screws.

Theatre Set-up

Recovery position.

Approach

Lateral and medial posteromedial (MPM)

Intra-operative comments

Approaches were planned to allow confident reduction of the high fibular and syndesmosis, which is more predictable through a direct lateral approach. The comminution posteromedial (PM) and medial fragments were best approached through the MPM incision. However, the small PL fragment meant that a percutaneous approach was needed to place the screw. The reduction and view of screw entry can still be obtained through the MPM approach, however. The MPM incision can be curved anteriorly along the tibialis posterior course, to allow access to the anterior collicular fracture and comminution. Due to the size of the fragments, fixation of these were accomplished with headless screws.

The large posteromedial fracture fragments were easily reduced and fixed with a Volition™ 2B plate. The fragment was brought to the joint line and was fixed using K-wires before placement of plate. The posteromedial fracture fragment was fixed before the posterolateral fragment. This staged process is vital to prevent medial fragment escape. The fibular comminution was bridged using a long fibular plate and the buttress fragment was fixed with a lag screw. When tested, the anterior syndesmosis remained rotationally unstable, so a syndesmosis screw was placed.

Intra-operative x-rays. AP and lateral views.

Post-surgery protocol
2 weeks NWB in a back slab. Conversion to Vacuum cast boot at 2 weeks to allow full weightbearing. Wean out of boot at 6 weeks.


6-week post-operative, weight bearing x-rays. AP and lateral views.

CASE EXAMPLE 2

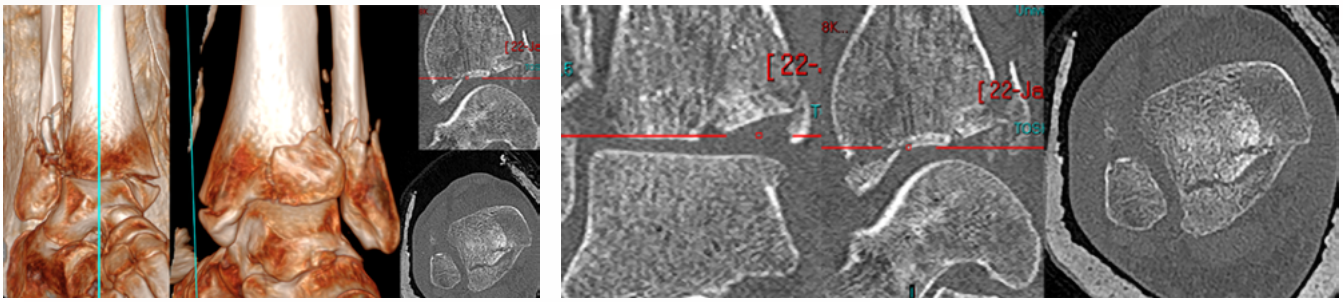
Fracture Type
Lauge Hansen – PAB 3
Mason and Molloy – 2A
AO – 44B3.3

Soft-tissue (see appendix)
Closed fracture
Tscherne – C1

Specific Problems
Short comminuted fibular fracture, Type 2A posterior malleolar fracture, anterior collicular fracture. Die punch fragment posteromedial aspect. Avulsion posteromedial of intermalleolar ligament.

Investigation


Pre-operative x-rays. AP and lateral views.



Pre-operative CT scan. Coronal, sagittal, and transverse slices.

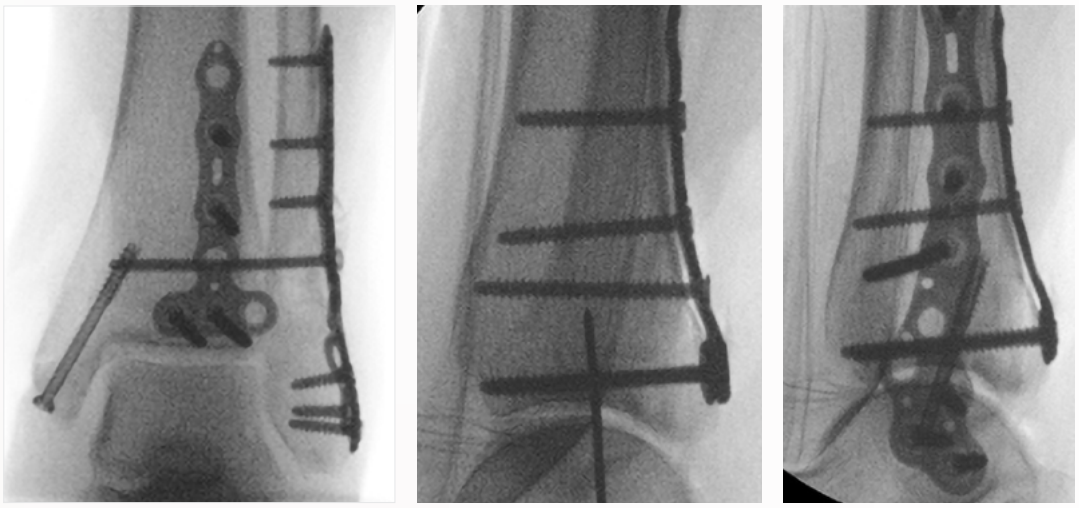
Planning Comments
Due to the posteromedial (PM) die punch fragment, it was important to plan access to the die punch. There was also a need to ensure the comminuted fibular fracture can be accessed and reduced appropriately.

Theatre Set-up
Recovery position.

Approach
Lateral and medial posteromedial (MPM).

Intra-operative comments
Approaches were planned to allow confident reduction of the fibular comminution. This is more predictable through a direct lateral approach, plus the need to access to the die punch fragment, it was appropriate to enter through the bed of tibialis posterior. Therefore, a lateral and MPM approach was the best option in this complex case. The MPM approach can be curved anteriorly along the tibialis posterior course, to allow access the anterior collicular fracture.

The MPM approach allowed for full visualisation and open access to the posterolateral fragment fracture plane, this enabled ease to reduce the die punch with a small osteotome. A K-wire was inserted to give initial, accurate positioning before application of plate. The posterolateral fragment was then reduced and fixed with the Volition™ type 3 plate, which fitted best for this case. Note, the most lateral distal screw in the Volition™ type 3 plate was not used here, as this would encroach on the incisura. The initial buttress screw in the Volition™ type 3 plate was removed following fibular fixation, to allow syndesmosis fixation.



Intra-operative x-rays.
AP & lateral views.

Post-surgery protocol
2 weeks NWB in a back slab. Conversion to Vacuum cast boot at 2 weeks to allow full weightbearing.
Wean out of boot at 6 weeks.

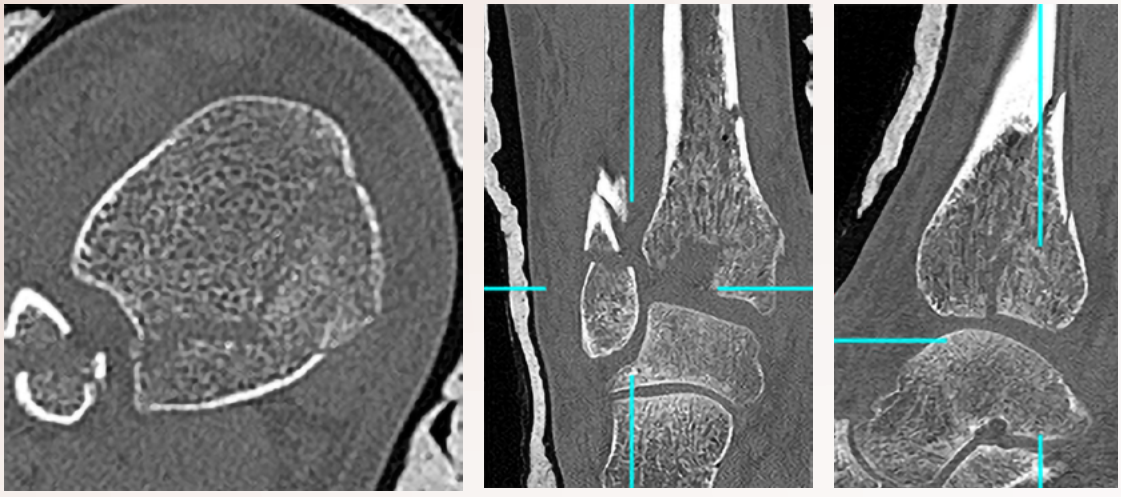
CASE EXAMPLE 3

Fracture Type
Lauge Hansen – SER 4
Mason and Molloy – 2B
AO – 44B3.3

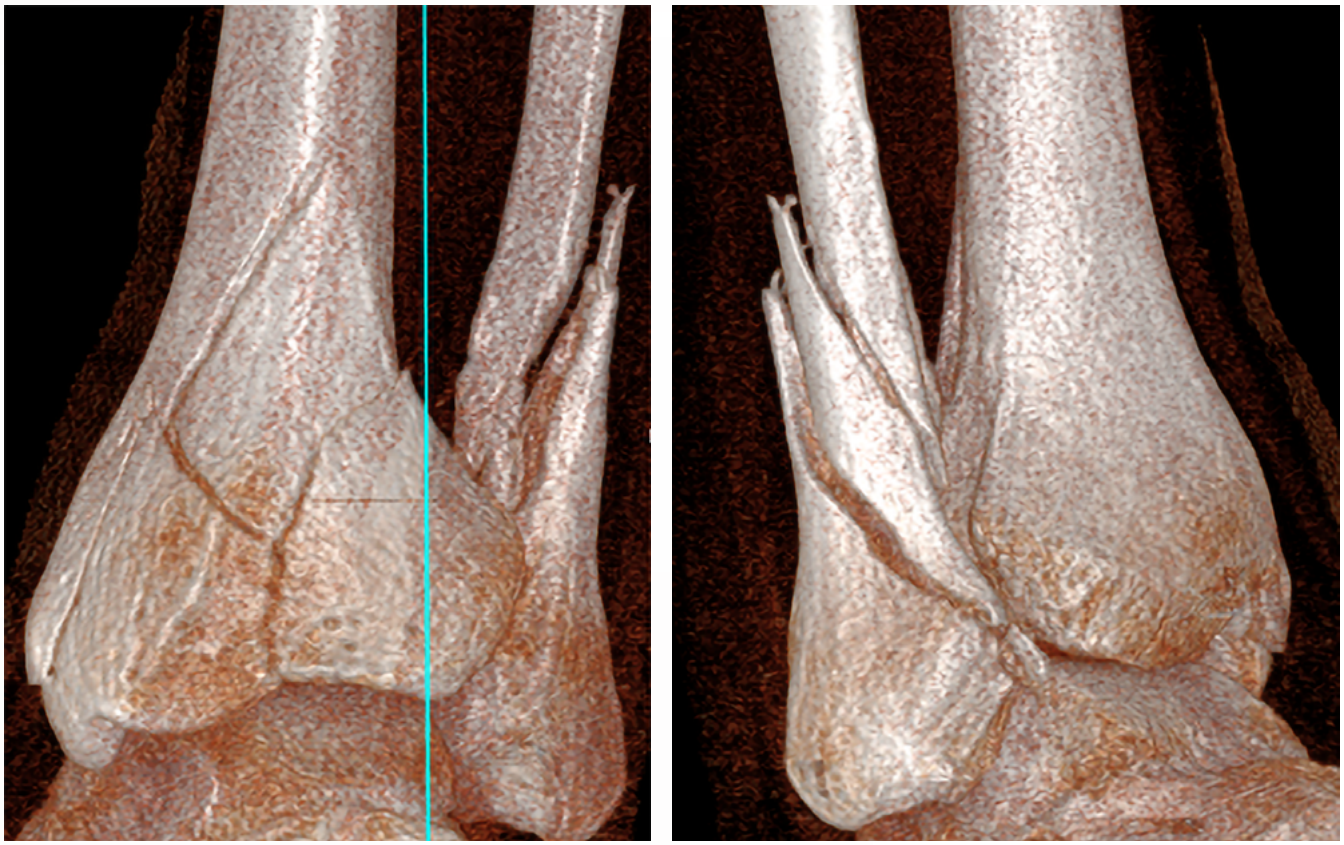
Soft-tissue (see appendix)
Closed fracture
Tscherne – C1

Specific Problems
Comminuted and segmental fibular fracture. Type 2B posterior malleolar fracture, with large 2A and 2B fractures with separate proximal fragment. Medial malleolus had sagittal split. Posteromedial die punch fragment present.

Pre-operative x-rays. AP and lateral views.



Pre-operative CT scan. Tranverse, coronal, and sagittal slices.



Pre-operative rendered CT scan views.

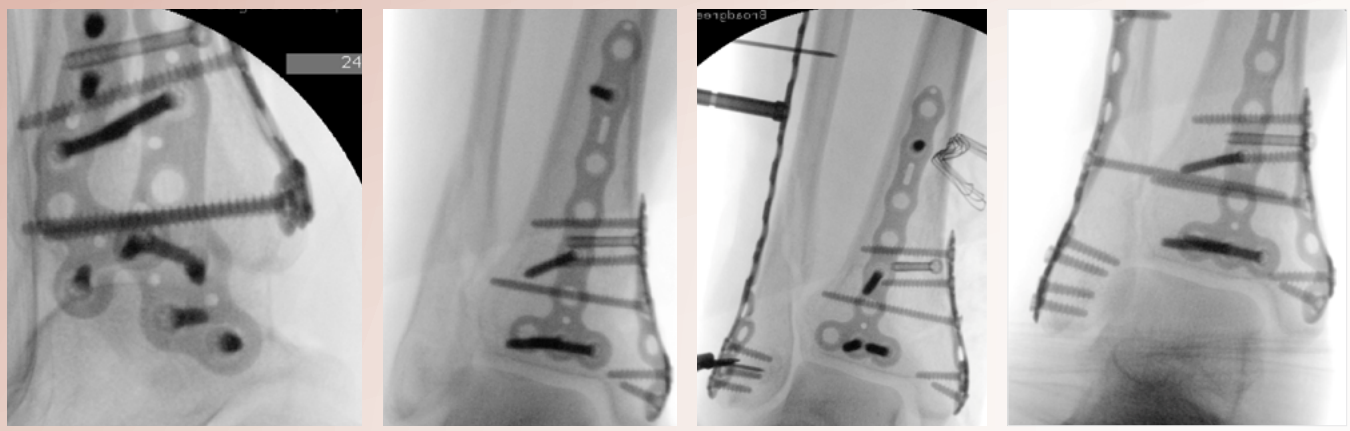
Planning Comments
The 2B fracture pattern and comminuted medial wall needed medial access to allow posterior malleolar reduction and fixation. The approach needed to be extensile to allow reduction of proximal fragment. Additionally, there was a small die punch fragment posteromedially. The comminution needed approaching through the direct lateral position. A posterolateral (PL) approach in this case would hinder reduction.

Theatre Set-up
Recovery position.

Approach
Lateral and medial posteromedial (MPM).

Intra-operative comments
Approaches were planned as stated above. Even though this was a 2B pattern, due the proximal comminution and medial wall split meant that a large Volition™ type 3 plate and medial plate was used. This was the most appropriate option to allow reduction and fixation of the main fragments. The posterolateral and posteromedial fragments were brought to the joint line and provisionally fixed with K-wires. The Volition™ type 3 plate was then used to fix the fracture in place. The medial plate was used to reduce and fix the medial wall split.

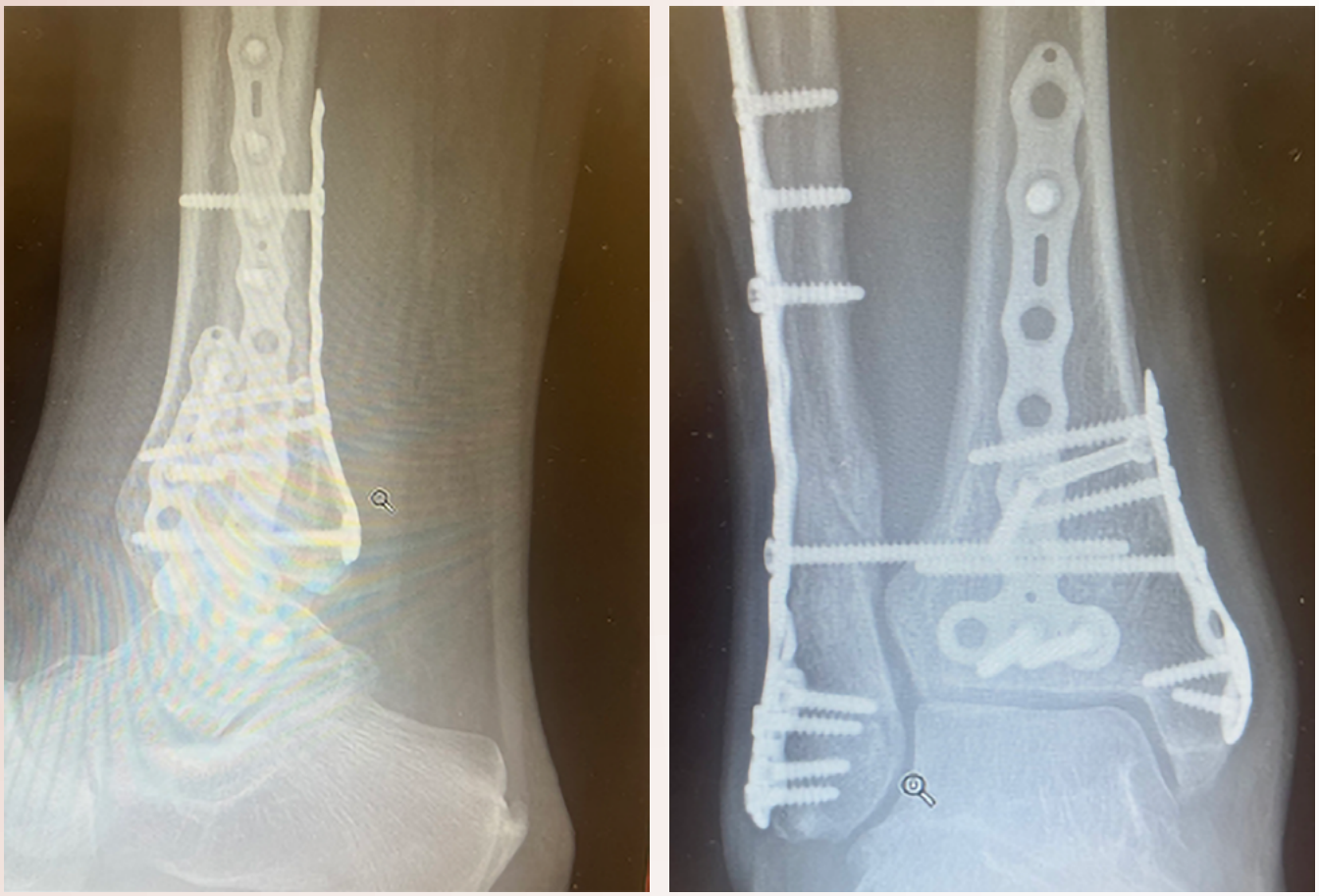
The fibular fracture was segmental. The fibular was initially fixed distally and was then pulled using a pointed clamp to achieve length and rotation correction. The use of the specific oblong hole designed on the anatomical lateral fibula plate assisted in this staged correction. The anatomical lateral fibula plate was then fixed proximally.
The anterior syndesmosis was screened and was unstable on rotation. A screw was used to fix the syndesmosis in the usual fashion.



Intra-operative x-rays. AP and lateral views.

Post-surgery protocol

2 weeks NWB in a back slab. Conversion to Vacuum cast boot at 2 weeks to allow full weightbearing. Wean out of boot at 6 weeks.



6-week post-operative x-rays. AP and lateral views.

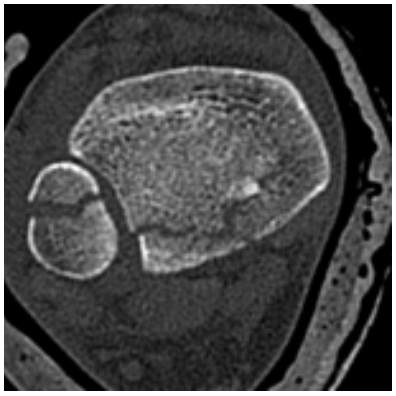
CASE EXAMPLE 4

Fracture Type
Lauge Hansen – SER 4
Mason and Molloy – 2B
AO – 44B3.3

Soft-tissue
Closed fracture
Tscherne – C1

Specific Problems
Oblique fibular fracture. Type 2B PM fracture, with large 2B and small 2A fractures.


Pre-operative x-rays. AP and lateral views.

Pre-operative rendered CT scan view. Pre-operative CT scan. Transverse slice.

Planning Comments
The 2B fracture pattern need medial access to allow posteromedial (PM) reduction first. Additionally, there was a small die punch fragment posteromedially. The fibular could be approached through posterolateral (PL) or direct lateral position.

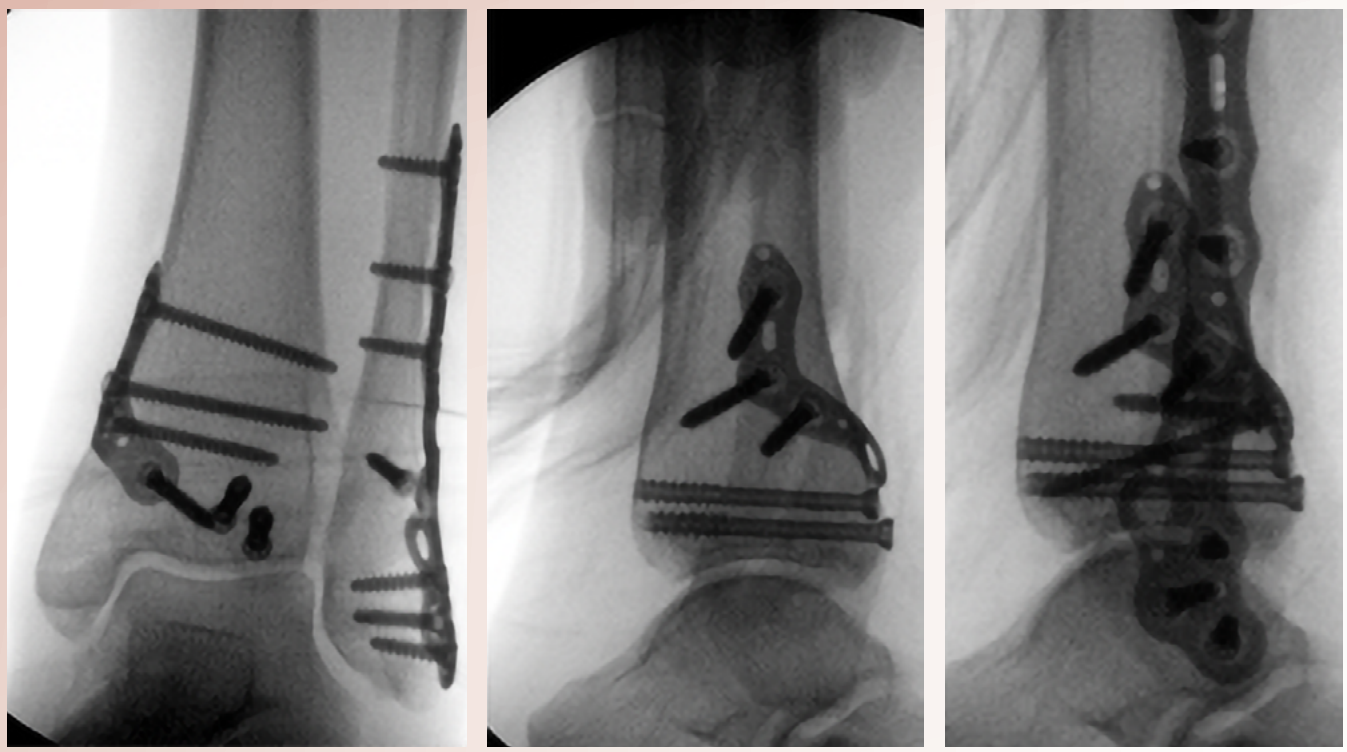
Theatre Set-up
Recovery position.

Approach
Lateral and medial posteromedial (MPM).

Intra-operative comments
Approaches were planned to allow easy reduction and fixation of the fibular through a direct lateral approach. Gaining access to the PM and PL fragments, the interval between tibialis posterior and FDL was most sensible. This also allowed access to the die punch fragment.

Using the MPM approach allowed visual access to open the fracture planes and attempt reduction of the die punch fragment. The PM fragment was then accurately reduced and positioned using a K-wire. A secondary K-wire was used to accurately reduce and position the PL fragment. The Volition™ 2B plate was applied to the PM fragment to provide lateral and anterior compression and assurance that the tibialis posterior was not impinged. Two screws were used to fix, compress, and stop rotation to the PL fragment.

The fibular was reduced with a lag screw before plate application. The syndesmosis was screened and was stable.



Intra-operative x-rays. AP and lateral views.

Post-surgery protocol

2 weeks NWB in a back slab. Conversion to Vacuum cast boot at 2 weeks to allow full weightbearing. Wean out of boot at 6 weeks.

6-week post-operative x-ray. AP view.

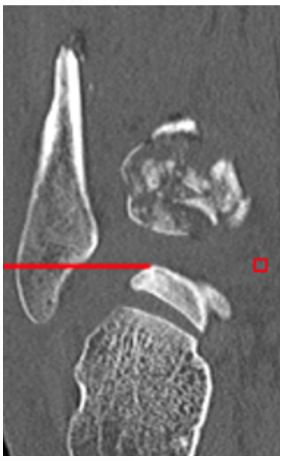
CASE EXAMPLE 5

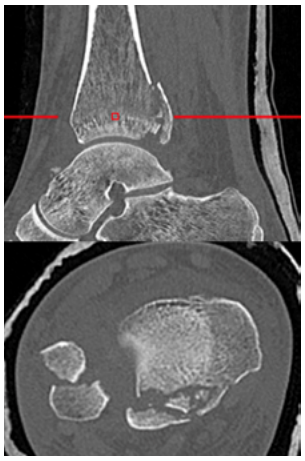
Fracture Type
Lauge Hansen – SER 4
Mason and Molloy – 2A (with additional PM comminution)
AO – 44B3.3

Soft-tissue (see appendix)
Closed fracture
Tscherne – C1

Specific Problems
Long comminuted fibular fracture with very large Wagstaffe fragment. Type 2A posterior malleolar fracture and anterior collicular fracture. Die punch fragment posteromedial aspect with posteromedial comminution.

Pre-operative x-rays. AP and lateral views.





Pre-operative CT scan.
Transverse, sagittal, and coronal slices.

Pre-operative CT scan. Transverse, sagittal, and coronal slices.

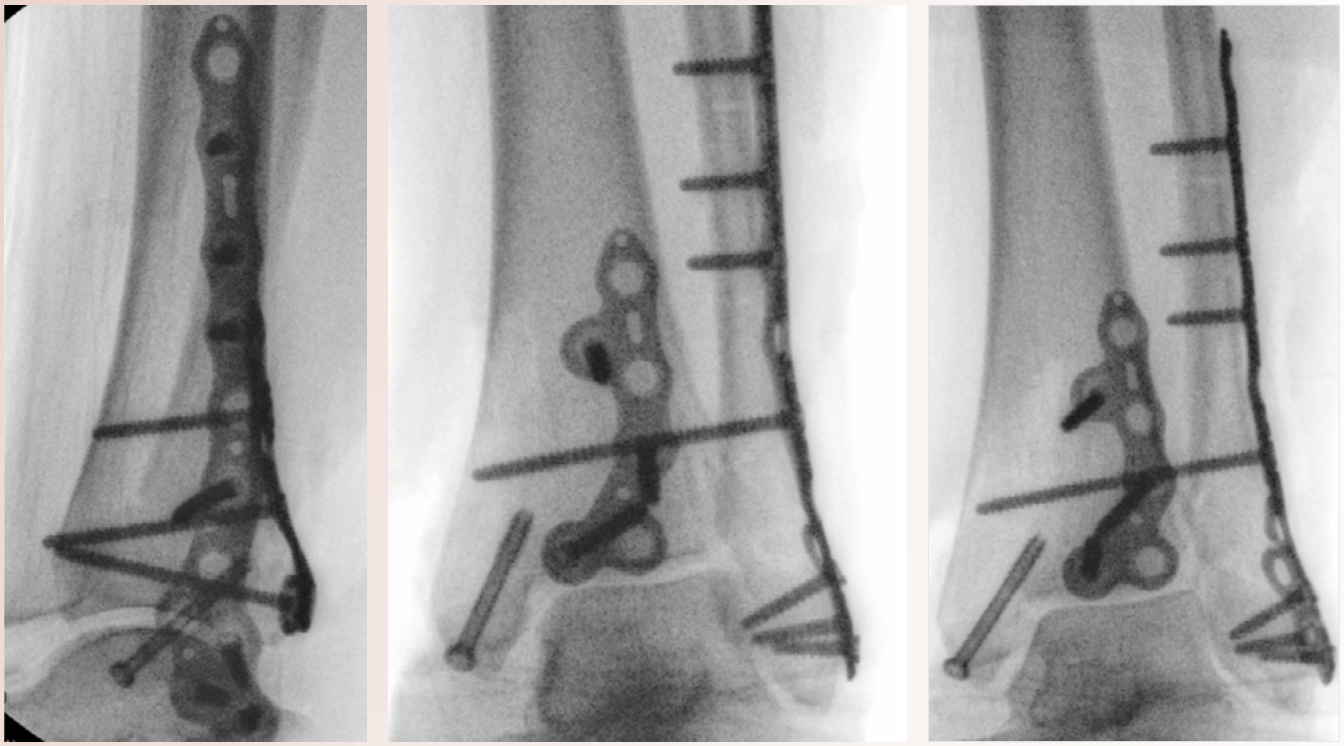
Planning Comments
Due to the posteromedial die punch fragment and comminution, there was a need to gain posteromedial access. A lateral approach was also required, to ensure the comminuted, fibular fracture with a large Wagstaffe fragment can be accessed and reduced appropriately.

Theatre Set-up
Recovery position.

Approach
Lateral and medial posteromedial (MPM).

Intra-operative comments
Approaches were planned to allow confident reduction of the fibular Wagstaffe fragment which is possible through a direct lateral approach. Needing access to the die punch and posteromedial comminution access the bed of tibialis posterior was most reasonable. Therefore, a lateral and MPM approach is easiest in this case. The MPM can be curved anteriorly along the tib post course to allow access the anterior collicular fracture.

The MPM approach allowed access to open the posterolateral fragment fracture plane to reduce the die punch with a small osteotome. A K-wire was inserted to give initial, accurate positioning before application of plate.
The posterolateral fragment was then reduced and fixed with a Volition™ type 2A plate, which fitted best in this case.
The Volition™ 2A plate allowed a locked screw to be inserted above the die punch fragment and act as a raft.
Note: The Volition™ 2A plate has a medial screw proximally, this allows easier access to screw through the MPM approach.



Intra-operative x-rays. AP and lateral views.

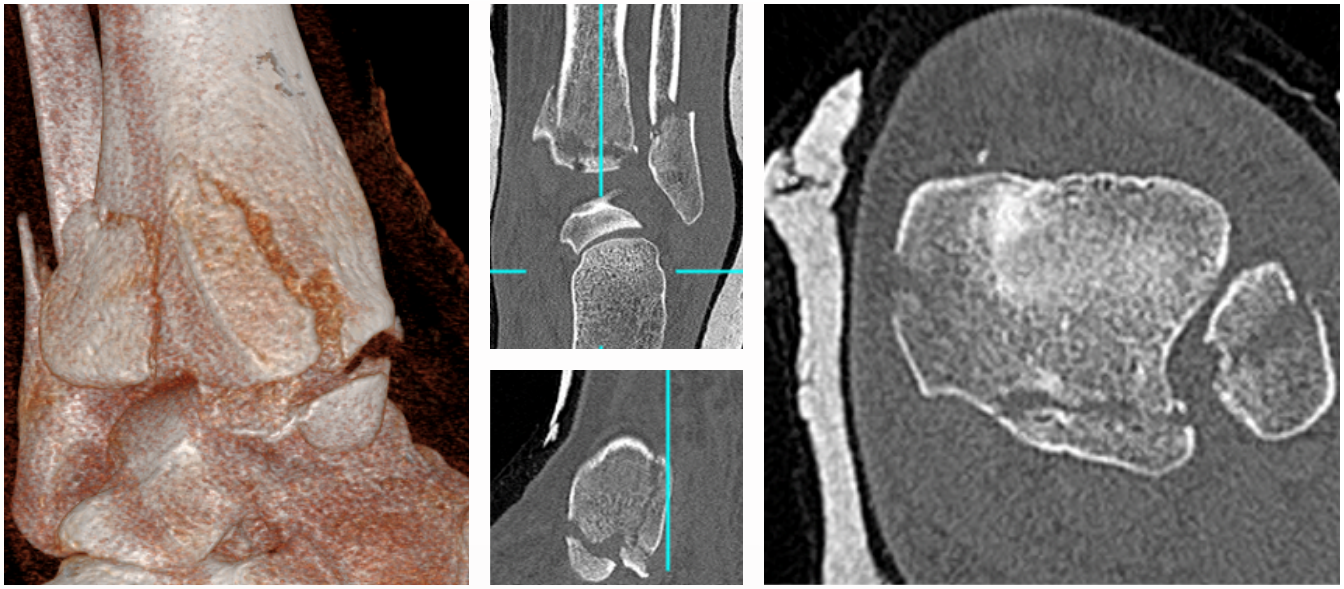
Post-surgery protocol
2 weeks NWB in a back slab. Conversion to Vacuum cast boot at 2 weeks to allow full weightbearing.
Wean out of boot at 6 weeks.

CASE EXAMPLE 6

Fracture Type
Lauge Hansen – SER 4
Mason and Molloy – 2B
AO – 44B3.3

Soft-tissue
Closed fracture
Tscherne – C1

Specific Problems
Oblique comminuted fibular fracture. Type 2B fracture, anterior collicular fracture medially.



Pre-operative rendered CT scan views and standard pre-operative CT scan views. Transverse, sagittal, and coronal slices.

Planning Comments
Due to the posteromedial die punch fragment and comminution, there was a need to gain posteromedial access. A lateral approach was also required, to ensure the comminuted, fibular fracture with a large Wagstaffe fragment can be accessed and reduced appropriately.

Theatre Set-up
Recovery position.

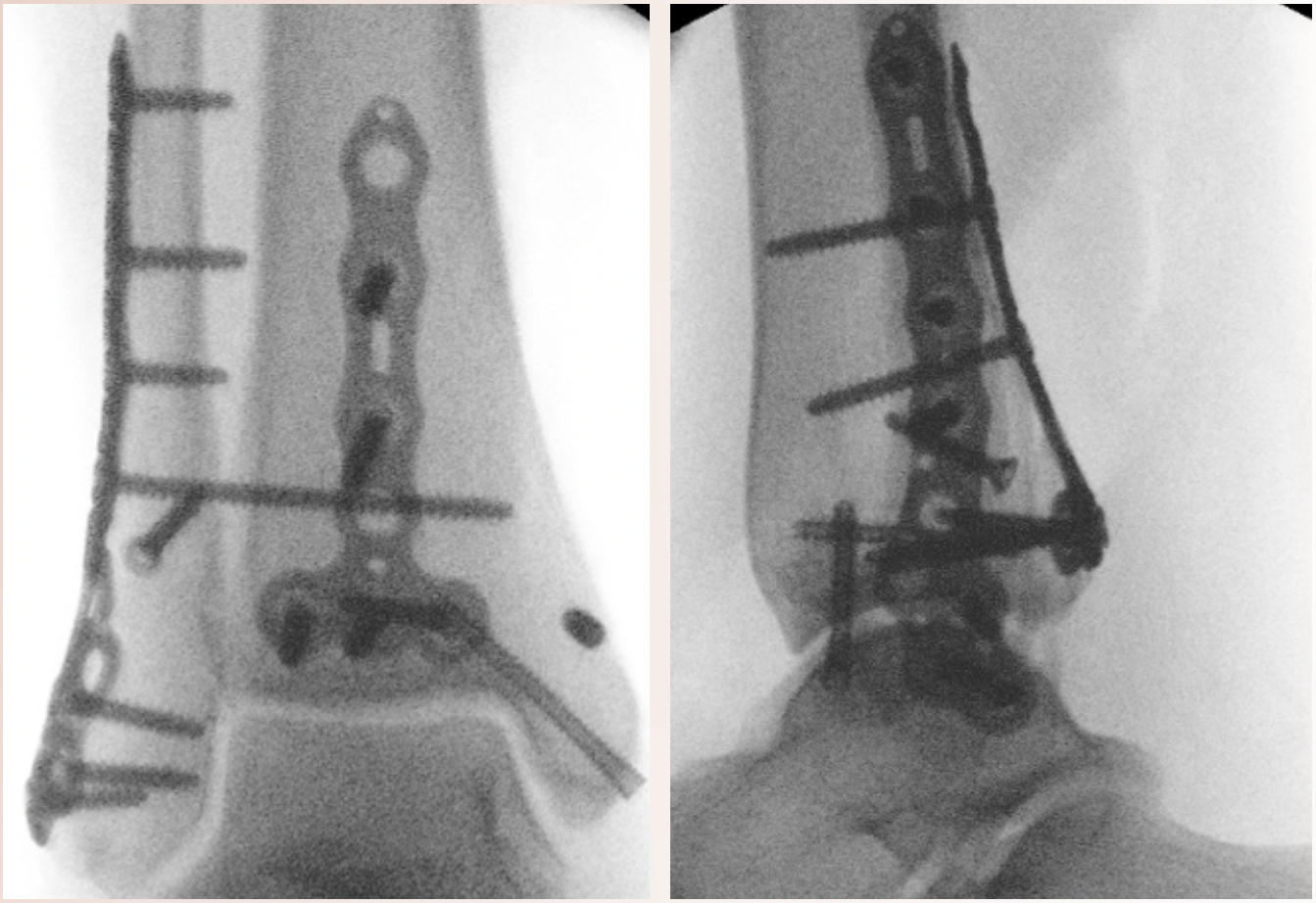
Approach
Lateral and medial posteromedial (MPM).

Intra-operative comments

Approaches were planned to allow confident reduction of the fibular through a direct lateral approach.
Needing access to the posteromedial and posterolateral fragments, the interval between tibialis posterior and FDL was most sensible. Therefore, a lateral and MPM is easiest in this case. The MPM can be curved anteriorly along the tib post course to allow access the anterior collicular fracture.

The MPM approach allows access to reduce the posteromedial fragment. A K-wire was inserted to give initial, reduction and accurate positioning of the fragment. The same process was then repeated to accurately reduce the posterolateral fragment. The Volition™ type 3 plate was used as it gave the most coverage of the 2 fragments best in this case. An additional headless screw was inserted to ensure reduction and rigid fixation of both fragments.

The fibular was reduced using a standard lag screw technique before plate application. The anterior collicular fracture was reduced and fixed with a small headless screw. The syndesmosis was screened and presented as unstable, so was fixed with x1 screw.



Intra-operative x-rays. AP and lateral views.

Post-surgery protocol

2 weeks NWB in a back slab. Conversion to Vacuum cast boot at 2 weeks to allow full weightbearing.
Wean out of boot at 6 weeks.

CASE REPORTING TEMPLATE

Fracture Type (see appendix)
Lauge Hansen
Mason and Molloy
AO

Soft-tissue (see appendix)
Tscherne

Specific Problems
Discuss any problems you foresee. Comminution/diepunch/small medial mal etc

Investigation
(Xray/CT)

Planning
What aspects of the fracture pattern are important in the planning for this case

Soft-tissue (see appendix)
Position of the patient and why?

Approach
What approaches used and why?

Intra-operative comments
Any specific comments regarding surgery

Post-surgery protocol
What was your post-surgery protocol and why?

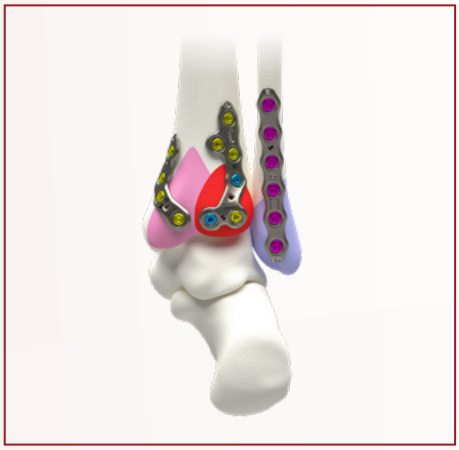
VOLITION™ PLATE ADVANTAGES

Volition™ Lateral anatomical fibular plate

- The twist from anterior (distal) to posterior (proximal) on the plate give several advantages listed below:
  - Preferential placement of syndesmosis fixation from posterolateral to anteromedial
  - Distal anterior fixation allows assessment of PM reduction and fibular reduction on lateral radiograph as there is no metal work obscuring the posterior plafond.
  - By moving incision 1cm anteriorly from lateral malleolar prominence it allows access to anterior incisura to confirm syndesmosis reduction.
  - Wagstaff suture holes - Suture holes are in the average position of a Wagstaff fragment to allow AITFL repair.
  - Fibular lengthening - a proximal oblong hole allows lengthening of the fibular by distal fixation with screws and then traction applied through plate. This allows 5mm of lengthening.

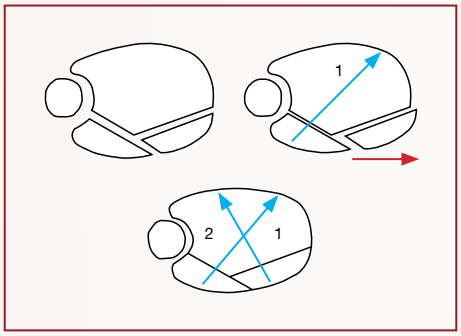
Volition™ Type 2A plate

- Anatomically designed for correct placement for typical 2A fracture patterns.
- Medialisation of the distal end of plate helps obtain safe zone distal position. Thus, preventing the risk of hardware in the incisura.
- Plate placement optimisation - a proximal oblong hole allows initial buttress of fracture and ability to move plate to optimal position.
- Access from the medial approach, if desired - medial hole allows plate application from medial posteromedial approach.



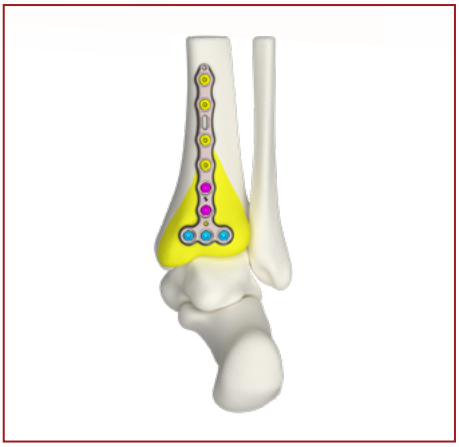
Volition™ Type 2B plate

- Anatomically designed for correct placement for typical 2B fracture patterns.
- Unlike other posteromedial plates on the market, the plate does not occupy the average fracture line but the fragment itself.
- Allows correct force application to reduce type 2B medial fracture with lateralisation and anterior force.



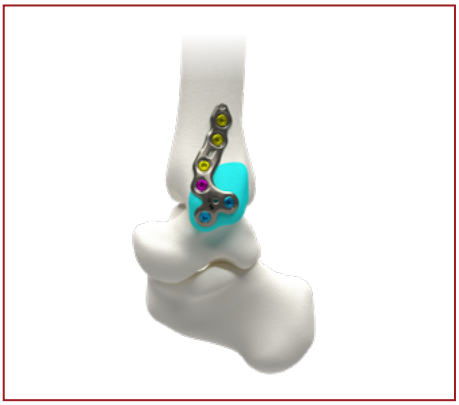
Volition™ Type 3 plate

- Anatomically designed for correct placement for typical type 3 fracture patterns.
- Designed to typically be located between incisura safe zone and tibialis posterior sheath.
- Plate placement optimisation - a proximal oblong hole allows initial buttress of fracture and ability to move plate to optimal position.
- Tibialis posterior protection - the plate aims to stay outside of the tibialis posterior sheath.
- Angular placement of screws to optimally incorporate the plafond position.



Volition™ Medial malleolus plate

- Anatomically designed for correct placement for typical medial wall blow out fractures. Specifically, it arches anteriorly due to the typical location of blowout within the medial malleolus.
- Plate can be placed directly on the medial wall or be placed more distally to obtain home run screw on anterior collicular fracture.
- Plate placement optimisation - an oblong hole allows initial buttress of fracture and ability to move plate to optimal position.



Volition™ Straight fibular plate

- Can be used as a utility plate on the tibia.
- Multiple K-wire holes allows initial placement of plate prior to screw fixation and to allow easier maintenance of plate positioning.
- When used on the posterior fibular, the screw in guide allows ‘joy sticking’ of the plate into the optimal position (figure 2).

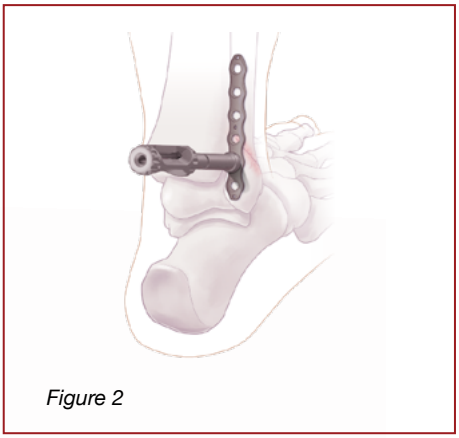


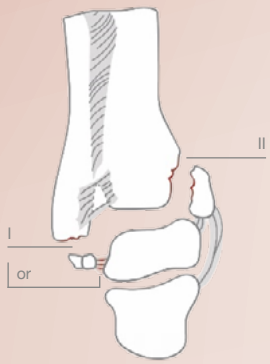
Figure 2

YOUR NOTES:

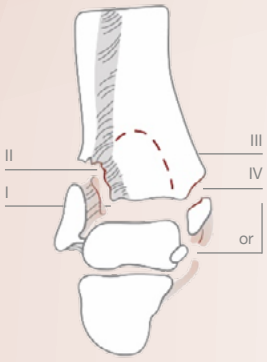
YOUR NOTES:

Classifications

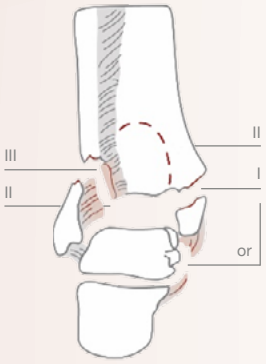
Lauge-Hansen



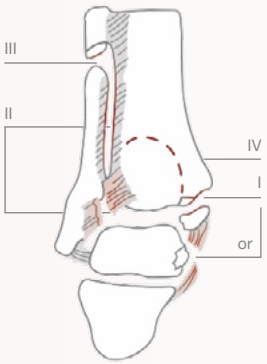
Supination-adduction:
Stages I-II



Supination-external Rotation:
Stages I-IV

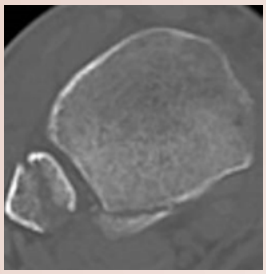


Pronation-abduction:
Stages I-III

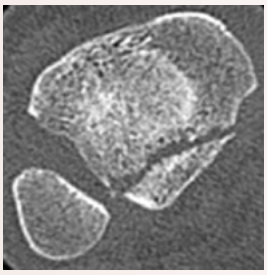


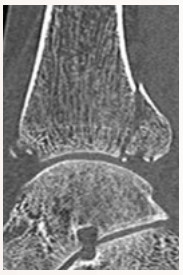
Pronation-external Rotation:
Stages I-IV

Mason and Molloy

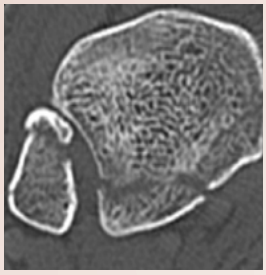


Type 1 PITFL Avulsion

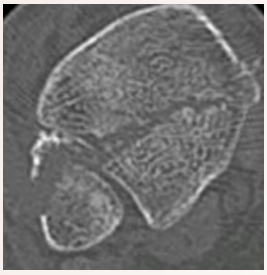




Type 2A Rotational Pilon Minor

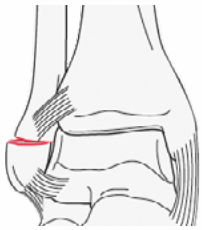


Type 2B Rotational Pilon Major

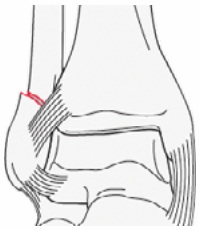


Type 3 Axially Loaded Pilon

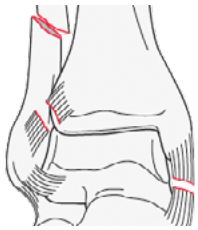
Tibia/fibula, malleolar segment, **transsyndesmotic fibula fracture** 44B



Tibia/fibula, malleolar segment, **transsyndesmotic fibula fracture** 44B



Tibia/fibula, malleolar segment, **suprasyndesmotic fibula fracture** 44C



44A

Types: Tibia/fibula, malleolar segment, **Infrasyndesmotic fibula injury** 44A

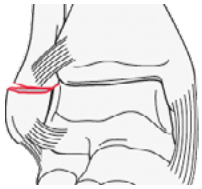
Group: Tibia/fibula, malleolar segment, Infrasyndesmotic, **isolated fibula injury** 44A1

Subgroups:

Rupture of the lateral collateral ligament 44A1.1

Avulsion fracture of the tip of the lateral malleolus 44A1.2

Transverse fracture of the lateral malleolus 44A1.3

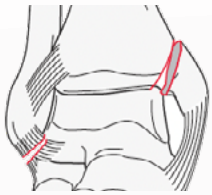


Qualifications *are optional and applied to the fracture code where the asterisk is located as a lower-case letter within rounded brackets. More than qualification can be applied for a given fracture classification, separated by a comma. For a more detailed explanation, see the compendium introduction.*

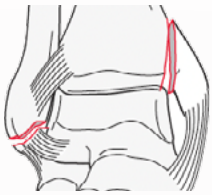
Group: Tibia/fibula, malleolar segment, Infrasyndesmotic fibula injury **with a medial malleolar fracture** 44A2

Subgroups:

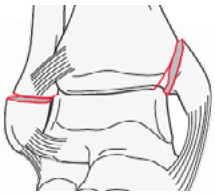
Rupture of the lateral collateral ligament 44A2.1



Avulsion fracture of the tip of the lateral malleolus 44A2.2



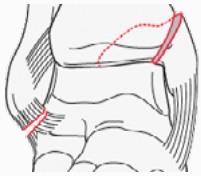
Transverse fracture of the lateral malleolus 44A2.3



Group: Tibia/fibula, malleolar, Infrasyndesmotic fibula injury **with a posteromedial fracture** 44A3

Subgroups:

Rupture of the lateral collateral ligament with a posteromedial fracture 44A3.1



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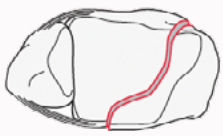
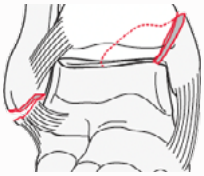


p

Avulsion fracture of the tip of the lateral malleolus with a posteromedial fracture 44A3.2



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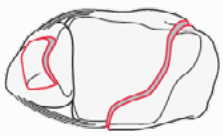

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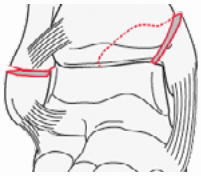
Transverse fracture of the lateral malleolus with a posteromedial fracture 44A3.3



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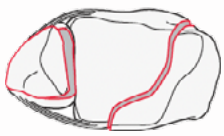


p

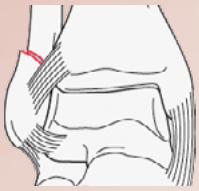
44B

Types: Tibia/fibula, malleolar segment, **Transsyndesmotic fibula fracture** 44B

Group: Tibia/fibula, malleolar segment, Transsyndesmotic, **isolated fibula fracture** 44B1

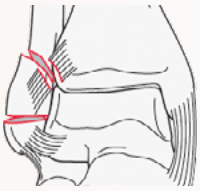
Subgroups:

Simple fibula fracture 44B1.1*



With a rupture of the anterior syndesmosis 44B1.2*

Wedge or multifragmentary fibula fracture 44B1.3*

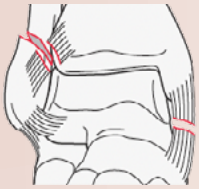


*Qualifications:
n Tillaux-Chaput tubercle fracture
o Wagstaffe-Le Fort avulsion fracture
u Syndesmosis unstable

Group: Tibia/fibula, malleolar segment, Transsyndesmotic fibula facture **with a medial injury** 44B2

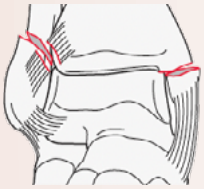
Subgroups:

With a rupture of the deltoid ligament and anterior syndesmosis 44B2.1*

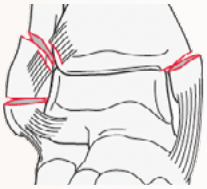


*Qualifications:
n Tillaux-Chaput tubercle fracture
o Wagstaffe-Le Fort avulsion fracture
u Syndesmosis unstable

With a medial malleolus fracture and a rupture of the anterior syndesmosis 44B2.2*



Wedge or multifragmentary fibula fracture with medial injury 44B2.3*

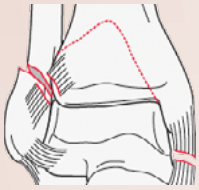


*Qualifications:
r Rupture of deltoid ligament
s **Fracture of medial malleolus**
u Syndesmosis unstable

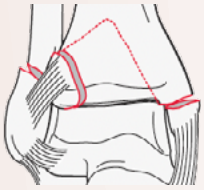
Group: Tibia/fibula, malleolar segment, **Transsyndesmotic fibula facture with a medial injury and fracture of the posterolateral rim (Volkmann's fragment)** 44B3

Subgroups:

Simple with a deltoid ligament rupture 44B3.1*



Simple medial malleolus fracture 44B3.2*



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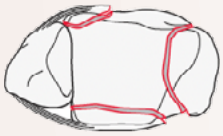
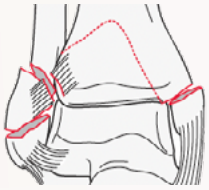


p

Wedge or multifragmentary fibula fracture with a fracture of the medial malleolus 44B3.3*



*Qualifications:
n Tillaux-Chaput tubercle fracture
o Wagstaffe-Le Fort avulsion fracture
u Syndesmosis unstable

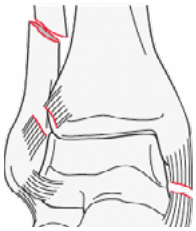
44C

Types: Tibia/fibula, malleolar segment, **suprasyndesmotic fibula injury** 44C

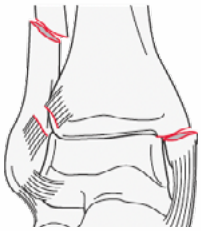
Group: Tibia/fibula, malleolar segment, suprasyndesmotic, **simple diaphyseal fibula fracture** 44C1

Subgroups:

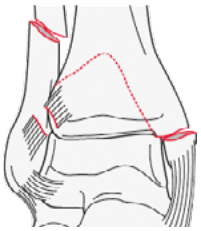
With a rupture of the deltoid ligament 44C1.1*



With a fracture of the medial malleolus 44C1.2*



With a medial and a posterior malleolus fracture 44C1.3

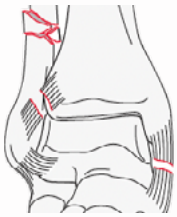


*Qualifications:
t Syndesmosis stable
u Syndesmosis unstable

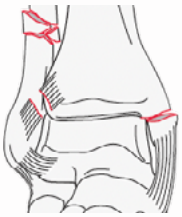
Group: Tibia/fibula, malleolar segment, suprasyndesmotic, **wedge or mutlifragmentary diaphyseal fibula fracture** 44C2

Subgroups:

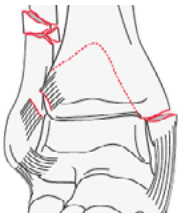
With a rupture of the deltoid ligament 44C2.1*



With a fracture of the medial malleolus 44C2.2*



With a fracture of the medial malleolus and posterior malleolus 44C2.3*

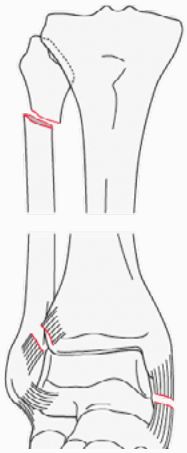


*Qualifications:
t Syndesmosis stable
u Syndesmosis unstable

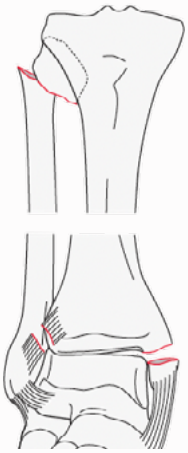
Group: Tibia/fibula, malleolar segment, suprasyndesmotic, **proximal fibula injury** 44C3

Subgroups:

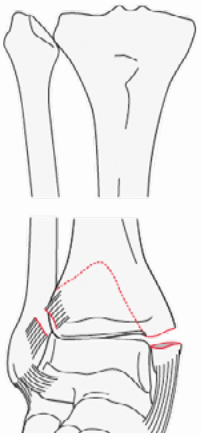
With a medial side injury 44C3.1*



With shortening and a medial side injury 44C3.2*



With a medial side injury and posterior malleolus fracture 44C3.3*



*Qualifications:
p Fibula neck fracture
q Proximal tibio-fibular joint dislocation
r Rupture of deltoid ligament
s Fracture of medial malleolus

Soft-tissue

Table 1. Tscherne classification for closed fractures

Grade	Energy	Typical fracture pattern	Typical soft-tissue damage
C0	Low	Spiral	None to minimal
C1	Mild to moderate	Rotational ankle fracture-dislocations	Superficial abrasion/contusion
C2	High	Transverse segmental complex	Deep abrasions; impending compartment syndrome
C3	High	Complex	Extensive skin contusion; myonecrosis; degloving; vascular injury; compartment syndrome

Table 2. Tscherne classification for open fractures

Grade	Typical fracture patterns/injuries	Typical soft-tissue damage
O1	Fractures resulting from indirect trauma (eg, AO A1-2)	Skin laceration; none to minimal
O2	Fractures resulting from direct trauma (eg, AO A3; B, C)	Skin laceration; circumferential contusion; moderate contamination
O3	Comminuted fractures; farming injuries; high-velocity gunshot wounds	Extensive; major vascular and/or nerve damage; compartment syndrome
O4	Subtotal and complete amputations	Extensive; major vascular and/or nerve damage

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