

# Triplane fractures of the ankle

**Triplane fractures are fractures that occur in three planes. They occur in the adolescent population, with the ankle joint most frequently involved. Early recognition of the complex fracture pattern and appropriate treatment thereafter will maximize the chances of a favourable outcome.**

The distal tibial epiphysis is the second most common site of epiphyseal fractures. Of this group, 6–10% are so-called triplane fractures – fractures that occur in three planes (Figure 1). Triplane fractures classically occur between the ages of 10 and 18 years, and are more common in boys than girls. Because of their age dependency, they have been included in a group of ‘transitional fractures’ along with juvenile Tillaux fractures.

The most common site of a triplane fracture is the distal tibia, which is the injury that this article will concentrate on. They have, however, also been reported in the proximal tibia, distal radius, proximal phalynx of the hand and distal humerus.

## History

Triplane fractures were first described by Johnson and Fahl (1957) who investigated the patterns of epiphyseal ankle fractures in children. It was Marmor (1970), however, who recognized that this fracture had three planes:

- Coronal – through the posterior tibial metaphysis
- Transverse – through the physis

**Figure 1. A three-dimensional reconstruction of a triplane fracture showing three planes of fracture.**



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- Sagittal – through the distal tibial epiphysis.

The term triplane fracture was only coined in 1972, however, after case reports describing its operative fixation were published (Lynn, 1972).

## Mechanism of injury

The ankle is made up of two joints: the ankle joint and the subtalar joint. The ankle joint is the articulation of the talar dome, distal tibia and distal fibula. The subtalar joint is the articulation between the talus and calcaneus. It is the ankle joint that allows dorsal and plantar flexion, and the subtalar joint that allows internal and external rotation.

A triplane fracture is initiated after an external rotation force is placed on the ankle while the foot is in supination (Kärrholm et al, 1981). The force of deforming injury, the strength of the bones and ligaments, as well as the anatomy of the physis will determine what if any associated injuries exist in addition to the triplane fracture of the distal tibia.

But why does a fracture occur in three planes and not just one or two like all other fractures? The answer is the physis, and perhaps more importantly its closure. Closure of the distal tibial physis takes about 18 months and during this time, triplane fractures are said to occur more frequently, hence triplane fractures occur more frequently in adolescence. A literature review does not state the reasons why boys are affected more, but it is presumed to be because they are in general more physically active and thus tend to suffer injuries to all joints more frequently.

The classic story involving triplane fractures is that the physis begins to close centrally first then anteromedially, and finally posterolaterally (Kielger and Mankin, 1964; MacNealy et al, 1982). This pattern of fusion explains the unique nature of the triplane fracture where only the fused anteromedial part of the epiphysis is attached to the tibial shaft initially (Cooperman et al, 1978).

Although rarer, it is reported that triplane fractures can occur when the growth plate is still completely open (before 13–14 years of age). It is suggested that the presence of a hump in the growth plate 1 cm from the medial edge is able to stabilize the anteromedial part of the epiphysis in the same way as fusion of the medial plate does in older children, resulting in a two-part triplane fracture (Kielger and Mankin, 1964).

## Classification

Triplane fractures can be classified on the number of parts involved; namely two, three or four-part fractures.

The von Laer classification (1985) where fractures were deemed to be either type I (classic two-part fracture) or type II (classic three-part fracture) is outdated following the subsequent discovery of four-part fractures and other less common variants of fracture patterns.

The classic two-part fracture (*Figure 2*) arises when the medial epiphysis is closed. It starts with an intra-articular fracture in the sagittal plane extending through the anterior epiphysis followed by axial extension along the physal cartilage and finally fracturing in the coronal plane up through the posterior metaphysis. The result is a posterolateral fragment, consisting of the posterolateral epiphysis and posterior metaphysis that separates from the anteromedial epiphysis, which has remained attached to the tibial shaft (Cooperman et al, 1978; Dailiana et al, 1999).

The classic three-part fracture (*Figure 3*) arises when the central portion of the physis closes. The three fragments that result are a free anterolateral epiphyseal fragment similar to a Tillaux fracture, a fragment involving the rest of the epiphysis and the posterior metaphysis, and the main fragment corresponding to the rest of the tibial metaphysis and shaft.

The classic four-part fracture is rare. It is similar to the classic three-part fracture with additional fracture extension to the medial malleolus to create a separate medial malleolar fragment.

Other variants of fracture pattern exist and treatment is tailored to the exact configuration of injury.

## Clinical presentation

Patients with triplane fracture present acutely with a painful, swollen ankle following a twisting injury to the ankle. Weight bearing is not tolerated. Inspection may

**Figure 2. An illustration of the classic two-part fracture with a separate posterolateral fragment.**



**Figure 3. An illustration of the classic three-part fracture.**

show evidence of bruising, deformity, and blisters if there is a delay in presentation. The ankle will be tender to palpation, which is maximal over the fracture site. It is important to also palpate the entire fibula to assess clinically for a fracture there too. Palpation should not only be distal to assess for evidence of a lateral malleolus fracture, but also proximal to exclude a Maissonneuve fracture (Healy et al, 1996).

## Investigations

The first investigation of choice to identify a fracture is radiographs of the ankle; anteroposterior, mortise and lateral views should be requested. Further radiographs are then required based on clinical need.

Technically speaking, triplane fractures are Salter–Harris type IV fractures (Salter and Harris, 1963) in that they involve both the epiphysis and metaphysis. However, since the fracture extends in three different planes, the epiphyseal and metaphyseal fragments will not necessarily be evident on a single radiographic view. Indeed the Salter–Harris classification of the injury is likely to be different on the different views. Lateral radiographs (*Figure 4*) will tend to show either a Salter–Harris type II or IV injury, while anteroposterior radiographs (*Figure 5*) will show a Salter–Harris type III injury (Clement and Worlock, 1987).

Computed tomography (CT) scanning is now more widely available than before and the quality of imaging has also improved with the production of higher resolution images and the introduction of multiplanar and three-dimensional reconstruction. There are no formal guidelines regarding the use of CT imaging in triplane fractures, although it is proven that CT imaging with multiplanar reconstruction greatly facilitates assessment of the patterns of physal separation, fracture extension and detection of associated fibula fractures (Brown et al, 2004). Indeed the



**Figure 4.** A lateral radiograph of the ankle showing an apparent Salter–Harris type II fracture of the distal tibia.

improved identification of fibula fractures is important since they are believed to result from more severe rotational forces and may indicate a lower likelihood for successful closed reduction (El-Karef et al, 2000). As such, most units will favour routine use of CT to supplement the information given by plain radiographs.

## Management

### Emergency treatment

The entire patient should be examined initially. All suspected triplane fractures should be referred for an urgent orthopaedic opinion for a decision regarding non-opera-

**Figure 5.** An anteroposterior radiograph of the ankle showing an apparent Salter–Harris type III fracture of the distal tibia.



tive *vs* operative management. As with all fractures, any overlying open wounds need to be managed appropriately, the neurovascular status of the limb distal to the fracture should be assessed and documented, and evidence of other injuries must be looked for. Temporary stabilization with a plaster of paris backslab with the foot in a neutral position can then be applied.

### Aims of treatment

The aim of treatment is to correct the deformity and maintain the position in order to allow the fracture to heal. Treatment is dependent upon a number of factors including displacement, which can be used as a measure to split the fracture into the following groups:

- Undisplaced or minimally displaced
- Undisplaced or minimally displaced following closed reduction
- Displaced requiring open reduction and internal fixation.

Most two-part fractures can be managed with closed reduction alone while most three and four-part fractures will require open reduction and internal fixation. The methods of treatment as advocated by Cummings (2005) are outlined below.

### Undisplaced or minimally displaced

This group of fractures is defined as having less than 2 mm of displacement following the original injury and require no manipulation (*Figure 6*). The ankle is immobilized in a long-leg cast knee flexed at 30–40° and a CT scan of the ankle is ideally obtained after casting to ensure adequate position. A further CT scan should be performed at 7 days to ensure that there is no displacement. At 3–4 weeks, the cast can be converted to a below-knee, weight-bearing cast which is worn for another 3–4 weeks.

**Figure 6.** A three-dimensional reconstruction of a triplane fracture showing a minimally displaced fracture.



### Closed reduction

Where fractures are displaced beyond the acceptable limit, closed reduction under general anaesthesia is usually performed in the first instance. Axial traction is applied to the foot, which is placed in internal rotation if the fracture has a predominant lateral fragment or external rotation if the fracture has a predominant medial fragment. This is done under X-ray guidance and if adequately reduced, a CT scan can then be performed to confirm position. If this is adequate, the ankle is treated in the same way as an undisplaced fracture. What is important is that if a fracture displaces following adequate closed reduction, it is deemed unstable and a further closed reduction is unlikely to benefit the patient. In that scenario, open reduction and internal fixation is required (Rapariz et al, 1996).

### Open reduction and internal fixation

If after closed reduction, the fracture exhibits displacement of 2 mm or more then open reduction and internal fixation is needed (Ertl et al, 1988). The surgical approach depends on fracture pattern and it is important to know that surgery itself carries certain pitfalls. The presence of swelling can lead to difficulty in closing wounds as well as fracture blisters, which may in turn become infected. Furthermore, there may be evidence of comminution of the fracture at the physis, which can affect growth. Management in the operating theatre is by clearance of the fragments and insertion of a fat plug into the void. When patients present 1 week following injury, callus may be present that prevents opposition of a healthy physis. In these instances, the callus is best debrided to allow opposition and a fat plug again used to insert into the defect, a modification of the Langenskiöld procedure (Langenskiöld, 1975).

For a typical two-part fracture, an anteromedial or anterolateral approach which allows direct visualization of the fracture is required. The fracture is reduced and where there is doubt over the reduction, fluoroscopic examination is performed (McGillion et al, 2007). Cancellous screws are then placed to hold the fracture.

Fractures with three or more parts require greater exposure to achieve adequate hold and stabilization. For a typical three-part fracture, the Salter–Harris type II fragment is tackled first and provisionally fixed to the distal tibia through the metaphyseal fragment. The Salter–Harris type III fragment can then be reduced and fixed to the stabilized type II fragment.

Fractures with four or more fragment are naturally more complex and require additional steps. In a manner similar to three-part fractures, the Salter–Harris type II or IV fragment can be fixed to the distal tibia through the metaphysis before the Salter–Harris type III fragment is attached.

After operative reduction, patients can be treated in a short-leg cast for 6–8 weeks with weight bearing allowed at 3–4 weeks.

### Prognosis

The overall outcome from triplane fractures is good if they are managed correctly with most patients experiencing no long-term functional deficits. Complications that can arise include persistent pain, swelling and degeneration, growth plate disturbance and compartment syndrome.

Of these complications, compartment syndrome and disturbances to the growth plate are difficult to avoid. They are usually, although not always, the consequence of the primary injury rather than the result of an iatrogenic act such as manipulation or surgery. However, it is important to watch for them.

Despite the fact that triplane fractures are epiphyseal injuries, growth plate disturbance is uncommon. Of all occurrences of premature physal closure, triplane fractures constitute only 21% of cases. This low occurrence is because the injury usually occurs when the physis is already closing so there is little growth potential left. It should not be assumed, however, that patients closer to physal closure are less likely to suffer from premature physal closure with its subsequent limb length discrepancy (Barmada et al, 2003).

Compartment syndrome is a rare complication. When described in triplane fractures, patients have complained of pain and swelling at the ankle that was a great deal more severe than would be expected in an immobilized fracture, decreased sensation in the first web space, weak toe extension and severe pain on passive flexion of the toes, especially in the extensor hallucis longus (Mubarak, 2002). Treatment is immediate surgical decompression, although permanent damage can arise when there are delays in recognizing that the disease process is occurring.

By far the most common complication of a triplane fracture is persistent pain, swelling and degenerative joint changes which occur long term in one in three patients. The biggest factor accounting for this is displacement of 2 mm or more of the fracture in the primary weight bearing area of the ankle, which explains why fractures with significant displacement are openly reduced and fixed. However, even when the fracture is adequately reduced, these symptoms are not necessarily prevented (Ertl et al, 1988).

### Conclusions

Triplane fractures result from a twisting injury to the ankle in the adolescent patient. The type of epiphyseal injury exhibited will be different on different radiographic views because of the complex fracture configuration of extension in three planes. Accurate diagnosis and prompt orthopaedic input increases the likelihood of a successful outcome. **BJHM**

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Conflict of interest: none.

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## KEY POINTS

- High suspicion of triplane fractures is needed for epiphyseal injuries of the distal tibia.
- Plain X-rays are essential for diagnosis while computed tomography can add information to help with a decision on appropriate treatment.
- Anatomical reduction and stabilization is required to prevent long-term complications.
- Growth plate injuries and compartment syndrome must be watched for.