

Open tibial fractures in children: are they really just little adults?



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Should open fractures in children be treated differently to those in adults? It is often thought that while anatomy might be similar, physiology might be different and a more cautious approach is taken with children following such trauma. National standards of care have been published, which include the care of children. The fact remains that the incidence of open long bone fractures in children is less than 10% than that seen in adults and as such, very few centres can declare an extensive experience.

We can reflect on a typical case example to illustrate standard management of open lower limb trauma in our centre, according to NICE Guidelines¹ and the BOA / BAPRAS Standards of Care², and discuss the evolution of orthoplastics management in this population.

Case Presentation

A 9-year-old boy was brought by ambulance to our Paediatric Major Trauma Centre (PMTC), having fallen two metres from a tree while on a camping trip. He sustained an open tibia fracture that was reduced under sedation at the scene by paramedics. On arrival at the PMTC, he was given prophylactic intravenous Co-Amoxiclav; his wound was inspected and photographed (Figure 1) prior to application of a saline-soaked gauze dressing and a plaster cast.

His foot was well-perfused with normal sensation. Plain X-rays confirmed a diaphyseal tibial fracture with some comminution (Figures 2 and 3). No other injuries were identified on clinical assessment and this was confirmed with a trauma CT series, including a CT angiogram. This is routine practice in our unit to assess the vascular anatomy of the limbs and to plan reconstructive options.



Figure 1: Open tibia fracture prior to application of a saline-soaked gauze dressing.



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Umraz Khan is a renowned plastic surgeon and has been undertaking extremity reconstruction for over 20 years. He has established and leads a world class orthoplastic service in Bristol where over 200 cases are managed each year. He has co-authored many leading articles as well as national guidelines in trauma and PJI.



Figure 2: Diaphyseal tibial fracture...

The next morning he underwent a first stage wound excision, extension and washout of the wound, with both consultant orthopaedic and plastic surgeons present. The guidelines recommend dual senior surgical input at this stage, as it allows thorough excision of compromised tissue in a planned fashion that enables preparation for future soft tissue management, but also allows for discussion of bony stabilisation options. Historically, there may have been a tendency to believe that the wound excision need not be as thorough as in adults, but this is not evidence-based. Degloved skin is assessed and is excised as it will take several days to fully declare, potentially leading to an exposed fracture and even metalwork³.



Figure 3: ...with some comminution.

At stage one, the comminuted bone fragment was loose and devitalised, so was removed leaving two-thirds remaining cortical contact. (Figure 4). A monolateral external fixator was applied in this case, along with a vacuum dressing (Figure 5). The choice of temporary stabilisation is down to the surgical preference of the orthopaedic and plastic surgical team, while bearing in mind the characteristics of the fracture and planned future definitive fixation.

The patient continued intravenous Co-Amoxiclav as an inpatient. He returned to theatre within 72 hours for definitive surgery in the form of further washout and debridement, redelivery of the bone ends, and exchange of the monolateral external fixator for a Taylor Spatial Frame (TSF-Smith and Nephew) and free flap soft tissue coverage (Figure 6).

When using a ring fixator for open fractures, combined pre-operative planning between orthopaedic and plastic surgery specialists is vital to ensure the frame can be partially deconstructed once applied to allow sufficient access for microvascular free tissue transfer. Where possible, we will position and prepare the patient so that our plastic surgery colleagues can begin harvesting the free flap, while orthopaedic surgeons complete the skeletal stabilisation, to minimise total anaesthetic time. >>



Figure 4: Comminuted bone fragment removed.

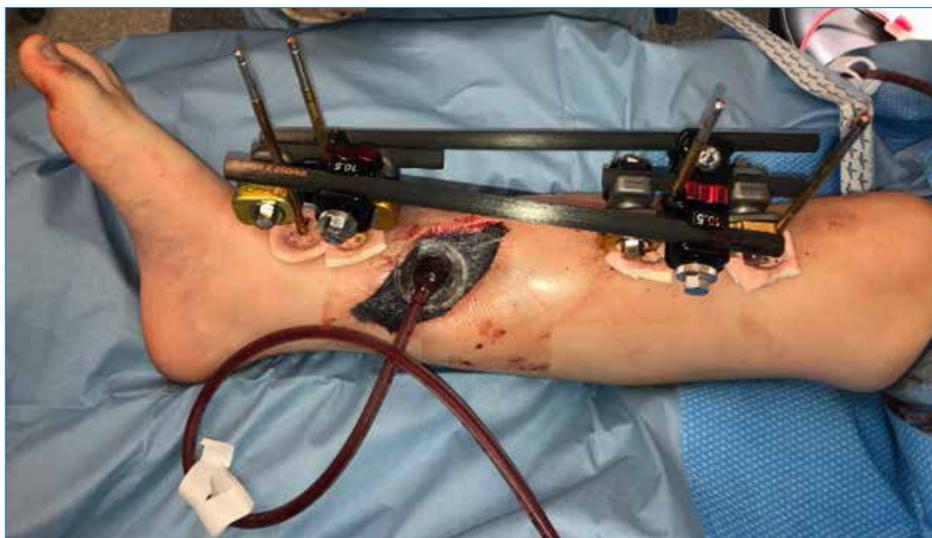


Figure 5: Monolateral external fixator applied, along with a vacuum dressing.



Figure 6a: Taylor Spatial Frame.



Figure 7a: Solid union.



Figure 7b: No deformity.

For this case, the frame was applied in the supine position and then augmented laterally with Ilizarov rods before removal of the medial three struts and the medial half of the rings. The patient was then turned to the lateral position (injured side down) to allow access to both the posterior tibial vessels and elevation of a scapular free flap. The flap was anastomosed to the posterior tibial artery (end to side) and its vena comitans (end to end). Once free tissue transfer has been completed, the TSF was reconstructed and the lateral Ilizarov rods removed.

The patient was then treated on the high dependency unit as per our department free flap protocol. This involves a period of four days'

bed rest under a warming blanket with fluid balance monitoring via a urinary catheter. Nursing staff are trained to monitor the flap regularly for signs of vascular compromise. The patient has their first change of dressing on day five and is allowed to mobilise non-weight bearing initially. The majority of our patients will be discharged on day seven.

Our patients are then followed up in a specialist orthoplastics multi-disciplinary clinic, their pin site care is managed and maintained in clinic and with local district nursing input, and they are monitored until soft tissue healing and union has occurred. This child went on to have solid union at the fracture site, no bony deformity, and soft tissues as shown (Figure 7).

Enneking functional outcome scores are collected for all our patients throughout their recovery.

Choice of soft tissue coverage

The choice of flap reconstruction is dependent on surgeon preference, but also patient factors. In our centre, we have found that free fasciocutaneous flaps afford better functional outcomes than local flaps⁴. Local flap options may also be compromised by the zone of trauma. We prefer to use fasciocutaneous flaps rather than muscle flaps, as we find post-operative monitoring more reliable, and the skin flap is easier to re-raise for secondary



Figure 6b: Free flap soft tissue coverage.

surgery (namely removal of metalwork). Although the anterolateral thigh flap (ALT) is our most commonly used flap in adult open tibial fractures, we use the scapular flap most commonly in children, as it has extremely consistent and reliable vascular anatomy compared to the perforator-based ALT flap. However, the patient must be placed in a lateral (or prone) position to raise a scapular flap.

Acute shortening or intentional deformation of tibial fractures has been described, in order to allow direct primary closure and later slow deformity correction with programmed hexapod fixation⁵.

Although these techniques avoid the need for microsurgical reconstruction, they require extended periods in ring fixators, multiple procedures and associated morbidity. We have not needed to use these methods, but could perhaps consider them in the unlikely event that flap coverage was not possible or unsuccessful.



Figure 8: Versatility of modern locking plates.

Choice of fixation

The choice of skeletal fixation will depend on patient age, fracture configuration and associated soft tissue injury. In the child with significant growth remaining, our preferred options are external fixation with a hexapod device or internal fixation with extra-physeal plates. TSF fixation has been shown to have good outcomes in high energy open fractures of the tibia in children with a low complication rate⁶.

Hexapod fixators are commonly used as definitive treatment for paediatric open lower limb trauma in our department, and our practice is to use a combination of hydroxyapatite-coated half-pins and trans-osseous wires to obtain at least two points of fixation above and below the fracture zone. The advantage of this form of fixation is stability, and the ability to easily monitor the soft tissues. In cases where bone loss has occurred or there is imperfect reduction, the frame can be programmed to potentially correct for this once



Figure 9: Adult medullary nails.

the soft tissues are adequately stable. It also means the physes are not violated in any patient with sufficient growth remaining.

Modern locking plates are very versatile and occasionally the soft tissue defect resulting from injury and initial debridement provides adequate exposure for plate fixation without the need for further incisions, while also remaining extra-physeal (Figure 8). When combining this with robust free tissue coverage, we have had no issues with infection, metalwork failure or non-union.

When treating an older child with minimal remaining growth and sufficient tibial canal diameter, there is the option of using adult intra-medullary nails (Figure 9). Violating the tibial tubercle apophysis with an adult nail can cause later recurvatum deformity, which can be difficult to correct and is therefore best avoided if doubt remains as to the patency of the physis.

Titanium elastic nails can also be considered, but have historically been associated with high complication rates, particularly in older, heavier children with unstable fracture configurations^{7,8}. The triangular cross section of the tibia makes their insertion technically challenging and prominence of metalwork can be an issue, leading to a higher rate of further surgery when compared to other forms of fixation. The use of end caps can increase their indication and in many units – particularly in Europe – these implants are widely used with good effect.

Summary and conclusion

The management of open lower limb trauma in children in the UK is still evolving. Unlike in adults where the guidelines are well-accepted and largely followed, in children the nature of their developing skeleton could mean there is a belief that their outcomes are inherently better than adults due to favourable biology, and the more limited choice of physis-friendly implants can influence management.

We ascertain that in cases of severe open trauma in children, the management should still be guided by the severity of the soft tissue injury, the nature of the fracture, respect for open physes and to a lesser extent, the societal circumstances of the child. An orthoplastics approach is vital to address all of these factors, to achieve a healed fracture with stable soft tissues and no deep infection, thereby allowing the child to return to their pre-injury level of activity. We have previously demonstrated that timely and comprehensive orthoplastics management of children with open tibial fractures can result in high union rates, low infection rates and excellent functional outcomes⁹. ■

References

References can be found online at www.boa.ac.uk/publications/JTO.