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EXTERNAL FIXATION OF THE TIBIA: REDUCTION AND MECHANICS

P.B.M.Thomas
University Hospital of North Staffordshire, UK

It is self-evident that tibial shaft fractures should be reduced as perfectly as possible. The reduction of tibial fractures tends to be best in those plated or nailed and worst in those treated by external fixation or plaster cast. This is because the plate or nail can assist in the reduction of the fracture: a conventional plate will pull the bone surfaces onto itself as the screws are tightened; the open technique can allow for the use of interfragmentary lag screws; the nail will automatically line up the medullary cavity as it passes across the fracture.

But plating of tibial shaft fractures carries a high risk of infection, and nailing can still allow angulatory malunions in metaphyseal fractures and tortional malunions at any level. The new generation of locking plates no longer assist the surgeon with reduction: for these the fracture must be perfectly reduced before the first screw is inserted.

Several devices have been developed specifically to assist in the reduction of tibial fractures: notable are the Bohler frame (1928), Anderson's "veritable fracture robot" (1934) and the device of Rheynders-Frederix (1992).

External fixation or minimal access internal fixation with locking plates will hold a good reduction but will not assist in its achievement. Most presently available external fixators have lockable joints which allow a fracture to be manipulated after the bone-screws are in place, but none of these fixators has any capacity for assisting the surgeon to gain a good reduction. The lockable joints in most external fixators are only used for the first hour or two of treatment: the period in the operating theatre when the fracture is manipulated and reduced. Once reduction is achieved, the joints are locked and must then remain locked for the whole of the rest of the treatment period; an average of 18 weeks for the tibial shaft. These lockable joints make the external fixator complex and costly. Lockable joints can come loose causing loss of fracture reduction and malunion.

We set out to develop a system in which the two mutually exclusive functions of reduction and external fixation of the tibia are separated.

By separating the two functions of reduction and fixation we have managed to improve the quality and reliability of reduction, and use a much simpler external fixator to hold the reduction. By eliminating the complex lockable joints of conventional monolateral external fixators we have managed to improve the mechanical properties of the fixator to optimise fracture movement for callus growth.

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Reduction of the fracture is achieved using the Staffordshire Orthopaedic Reduction Machine (STORM) (Fig 1). This is a device which is used in the operating theatre as a form of traction table within the sterile field. It is applied with tensioned wires in the proximal tibia and calcaneum, through which strong controllable axial traction can be applied, and torsion can be corrected. Two translation arms are then applied with one unicortical 4.5mm screw in each fracture fragment. These are used to pull the fracture fragments horizontally and vertically to fine-tune any remaining angulation or translation (Fig 2). Once a perfect reduction has been achieved, the fracture is fixed by whichever means are considered the most appropriate. The fracture may be nailed, fixed with a percutaneous locking plate or externally fixed.

The STORM device is now being used for pilon and plateau fractures, where its ability to help achieve a good reduction is useful for percutaneous screw, plate or fine-wire fixation. For plateau fractures the proximal tensioned STORM wire can be placed through the femoral condyles.

For the external fixation of shaft fractures we have developed a device utilising a titanium bar with optimised mechanical properties (the IOS fixator). It had been developed specifically for use with the STORM and must be applied to a perfectly reduced fracture (Fig 3). This fixator has no facility for adjustment of the fracture position, but none is required if the fracture is already nicely reduced. Because there are no adjustable elements, there is nothing that can come loose or cause a loss of reduction (Fig 4).

The fixator comes in two lengths. We studied 100 consecutive tibial fractures treated with external fixation at the University Hospital of North Staffordshire, measuring the fracture length and the distance required between the fixator bone-screws to span each fracture safely. We have found that 10mm is a safe distance from the nearest fixator bone-screw to the fracture. Adhering to this safe distance we have not seen infection pass from a fixator bone-screw to the fracture in over 300 exernally fixed tibial fractures. In the 100 fractures studied for length we found that 97% fitted between bone-screws separated by 110mm while 50% fitted between bone-screws separated by 70mm. With two lengths of fixator we are therefore able to accommodate most tibial shaft fractures. We find that very long oblique fractures are not suitable for monolateral external fixation, so the 3% which cannot be fitted between the bone-screws of the long IOS fixator are best treated with a circular frame arrangement.

I will discuss a set of principles for external fixation which, when adhered to, will maximise the healing potential of the fracture while minimising the risk of malunion and non-union. These principles are as follows:

Elastic return should be to the reduced position.

There should be no play.

The forces of weight-bearing should all act to reduce the fracture and not to distract it.

A symmetrical frame will tend to produce angulation & compression on weight-bearing.

An asymmetrical frame will tend to produce distraction & shear on weight-bearing.

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For monolateral fixators a symmetrical arrangement is one in which the centre of movement of the fracture is equidistant from the two sets of bone-screws. To achieve this in a fracture near to a joint the fixator must be short. The commonest fracture of the tibial shaft is at the junction of the middle and distal thirds, where a long fixator can only be placed asymmetrically. However, using a short fixator will allow the fracture to be placed symmetrically between the two sets of bone-screws thus optimising the movement of the fracture ends on weight-bearing (Fig 5).

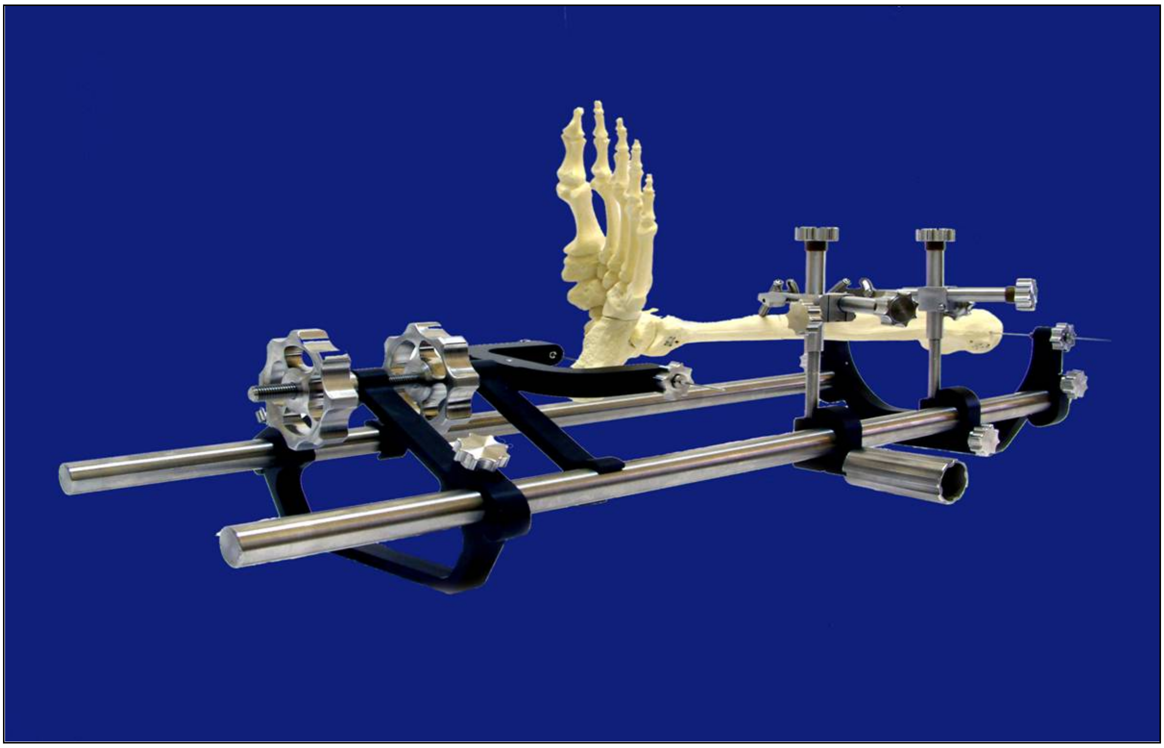

Fig 1: The STORM reduction device

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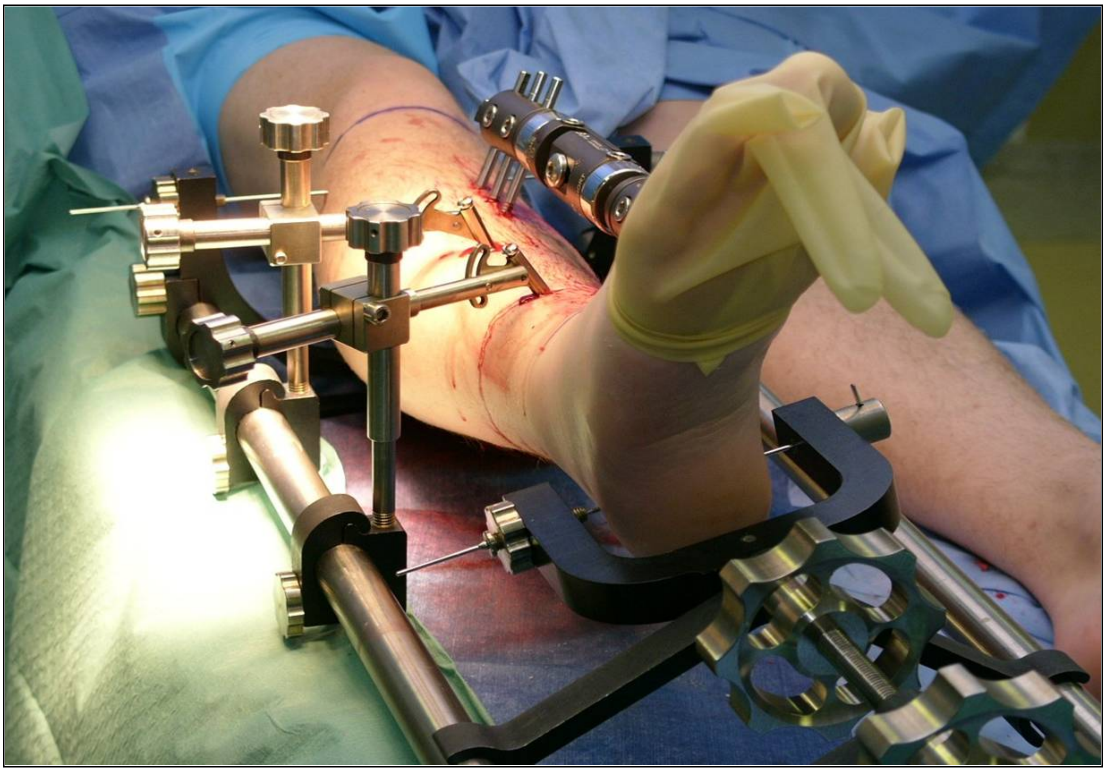

Fig 2: The STORM device used to apply an Orthofix External Fixator

Fig 3: The reduction achieved using the STORM and fixed with the IOS fixator

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Fig 4: The IOS fixator.

Fig 5: Symmetrically placed distal tibial fracture held with the short IOS fixator.