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PRELIMINARY REPORT OF A COMPRESSION TECHNIQUE TO APPLY TENSION TO SLIDING BONE GRAFTS IN TIBIAL SHAFT FRACTURES

R. J. Minns & P. L. Frank

University of Durham, Durham, and Hope Hospital, Salford, Lancs, U.K.

A new compression device is described that applies tension to sliding bone grafts on the medial aspect of the tibia in tibial shaft fractures. The mechanical aspects of the operation are outlined and the advantages and disadvantages of the system discussed. There have been no complications and rigidity has been obtained in two clinical cases. Mechanical tests in bending and torsion show that rigidity can be obtained without breaking the graft.

Key words: tibial shaft fractures; grafting; rigidity; reduction; fracture fixation

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Sliding bone grafts for the treatment of tibial shaft fractures have been used during immobilization (Holden 1973); however, it is well known that applying tension across the fracture site by compression plating decreases the time to full union due to the increased rigidity this system affords (Anderson 1965, Harris 1965, Müller et al. 1970, Lettin 1965). Applying tension to sliding bone grafts was therefore considered, as this may very well add rigidity to a well-established treatment for delayed or non-union. The existing Müller compression device, however, is unsuitable for use with sliding bone grafts since the protruding lip on the movable leg stands clear of the surface and will not pass through the hole made in the cortex of the graft. A new device was designed which would allow tension to be applied to a sliding bone graft, resulting in compression at the fracture surfaces.

Description of device

The device consists of a fixed leg 8.0 cm in length and a movable leg which is pivoted by means of a small hinge at the top. Approximately a third of the way up the fixed leg a ¼ inch U.N.F. screw passes through a slot in the movable leg and is screwed through the fixed leg at right-angles. A large movable knob is situated on the screw to allow the movable leg to rotate about the hinge, a weak spring causing the two legs to stay apart. The lip on the movable leg is positioned below the level of the bone surface so as to engage into a hole drilled in the sliding graft. Figure 1 is a view of the compression device.

Mechanical aspects of the operational techniques

To obtain a greater surface area of contacting bone, the graft should be sawn

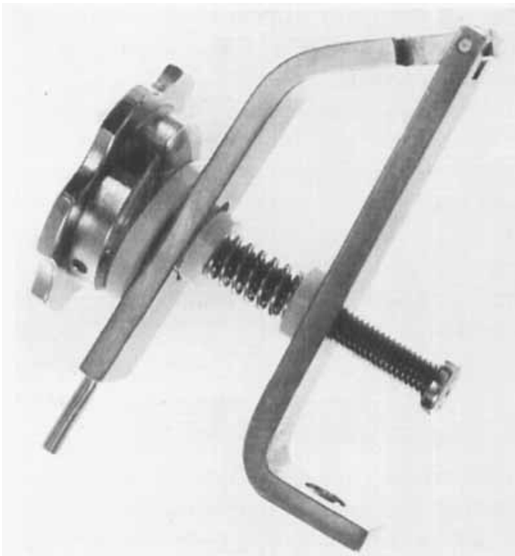
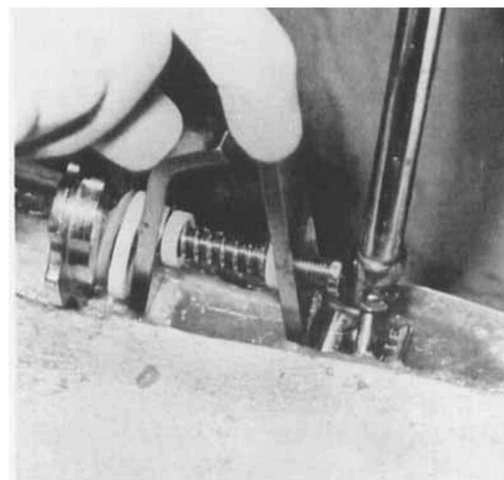


Figure 1. General view of the compression device, designed for the technique described.

from the medial aspect of the tibial shaft such that it is slighly tapered (by approximately 1–2 mm) and the section should also be tapered towards the bone centre (see Figure 2). The graft should be reversed and one screw located distally to the compression device until the graft surface is level with the existing bone. The graft is now secured to the distal fragment by both shear and compressive forces at the sawn surfaces. A 4 mm diameter hole is then drilled in the graft approximately 10–15 mm from its



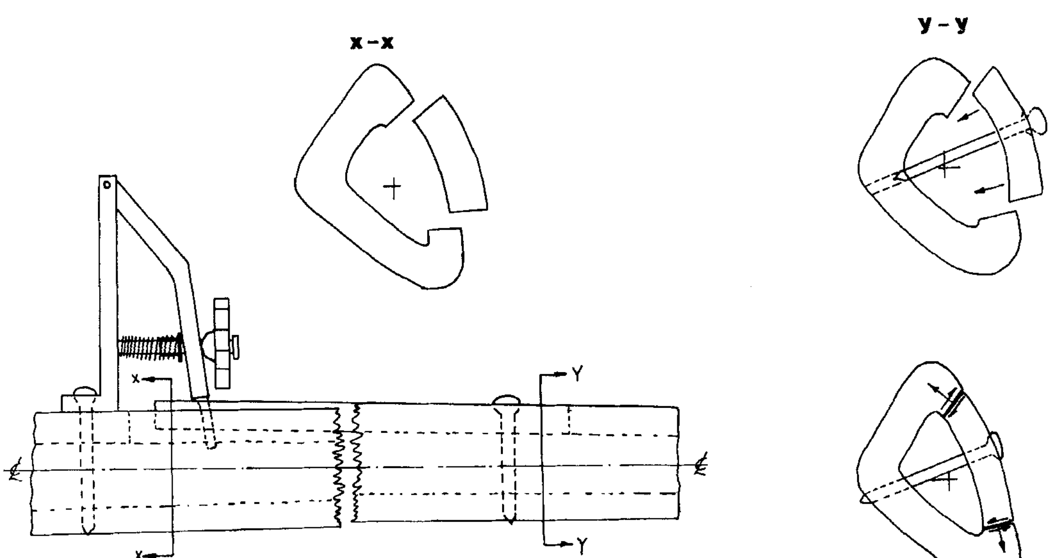


Figure 2. Lateral sketch of the tibia with the sliding bone graft in position before the application of compression at the fracture site. The cross sections show the position of the graft in the distal and proximal ends of the shaft. Photograph shows device in position just before compression is applied.

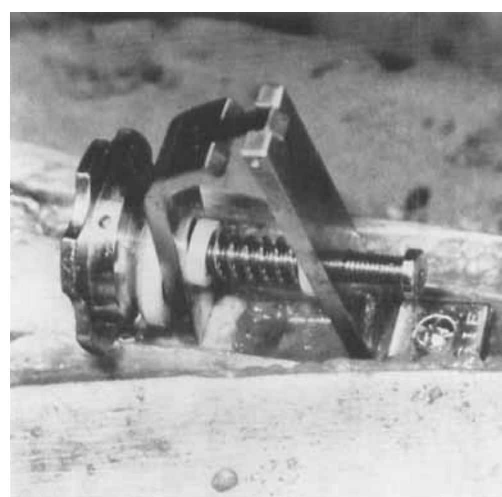
end to locate the lip on the movable leg of the compression device. The compression device is then attached by a 4 mm bone screw in the fixed leg and the graft should be raised above the bone surface so that on applying compression the two fracture surfaces approach each other with the opposite cortex contacting first so that equal compression will be applied when finally tightened (see Figure 2). Figure 3 shows the situation just prior to removal of the compression device. The two screws in the proximal fragment are angled towards the fracture so that when the compression device is removed, the tension in the graft is taken by these screws and will also bring the graft towards the centre of the bone (see section X–X, Figure 3) as there is now a slight gap due to the reverse taper.

Clinical experience

One of us (P.L.F.) has had the opportunity to insert two sliding bone grafts and they have withstood the tension without difficulty and compression was applied at the same time to the fracture site. The grafts have become incorporated and none of the screws used for fixation of the graft have had to be removed. The compression device described allowed the compression to be performed quickly without the use of additional equipment, as with other compression devices normally used for compression plating, the long stem allowing good purchase within the hole in the graft. The length of the stem also ensured that tension was applied parallel to the shaft of the bone, consequently causing even compression around the fracture cortex, and not compression at an angle that would tend to open the graft and possibly break it.

Mechanical studies

Seventeen left tibiae were tested in bending and torsion to evaluate the effect of antero-medial plating on mechanical



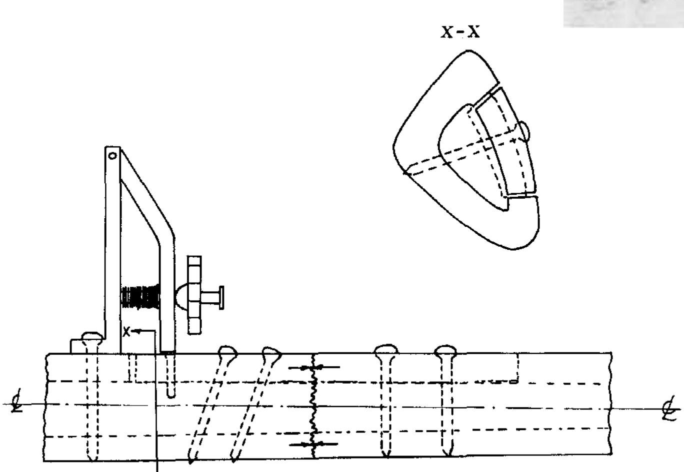


Figure 3. Position of the two tibial components after the application of compression just prior to removal of the device.

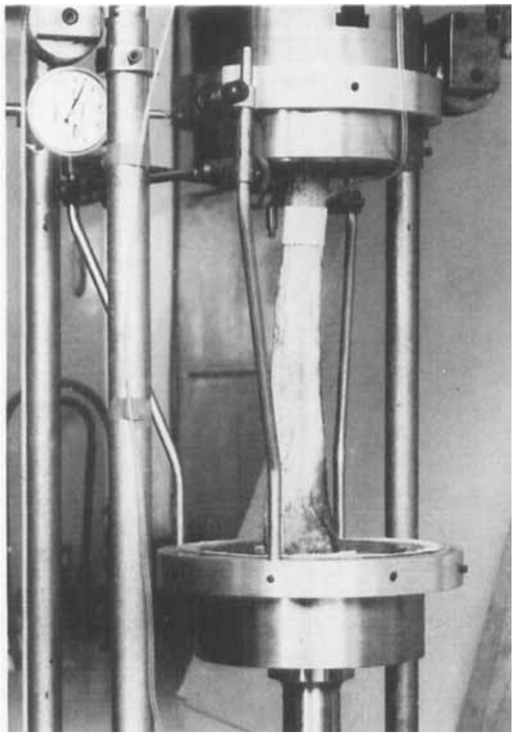


Figure 4. General view of the mechanical testing rig showing a tibia undergoing bending in the antero-posterior plane.

rigidity. The technique of specimen preparation and testing procedures is described in Minns et al. (1975). Bending was applied in the antero-posterior plane using the equipment shown in Figure 4, the deflections being recorded by a dial gauge situated at the distal end of the tibia. Torsion was applied about the shaft axis as shown in Figure 5, two dial gauges recording angulation about the axis. Three further tibiae were tested in which sawn, artificially produced mid-shaft fractures were reduced by sliding bone grafting, the sliding graft being sawn from the antero-medial aspect.

The bending and torsional stiffnesses of the tensioned sliding bone graft are low (see Tables 1 and 2) compared to metal on-lay plates. It may be true that a bending moment on the shaft introduced by tension applied to the graft using the

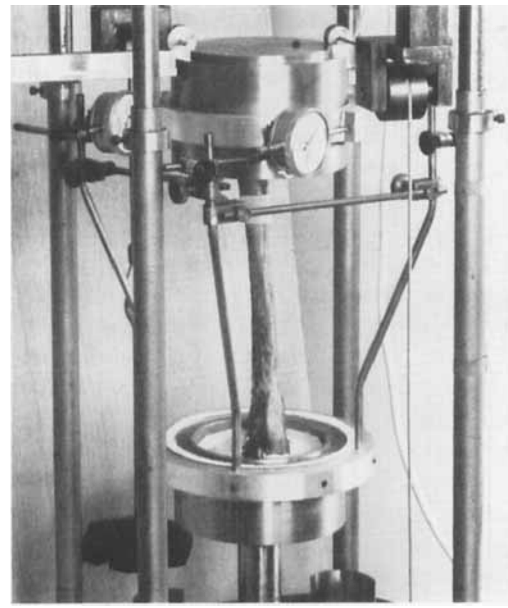


Figure 5. View of the mechanical testing rig showing a tibia undergoing a torsion test.

Table 1. Results of bending tests on 17 tibiae used in conventional plating studies and three tibiae subjected to bending after experimentally applying a sliding bone graft to compress the two fractured surfaces. The fracture was artificially produced by a saw cut. (Units are Newton-metres/millimetre deflection.)

	Intact		Plated	
	A/P	M/L	A/P	M/L
Mean of 17 tibiae	6.16	3.72	3.09	1.69
Sliding bone grafts	5.07	3.42	0.65	0.40

Table 2. Results of torsion tests on the 17 control plated tibiae and the three sliding bone grafted tibiae. (Units are Newton-metres/degree angulation.)

	Intact	Plated
Mean of 17 tibiae	4.40	1.96
Sliding bone grafts	2.72	1.71

device, placed within a cortex, is smaller than the one produced by a plate, placed on the subcutaneous side, but the bone is many times less strong under bending than the currently available implant materials. The torsional stiffness would be expected to be very much lower than that obtained in plated tibiae because the torsional strength of the bone as a circular tube is many times reduced by the fact that the circumference of the bone is slit open (Brooks et al. 1970). However, some torsional rigidity can be obtained very close to plated tibiae even when applying a tensile stress to the bone below its fracture strength, possibly because the graft becomes continuous with the cortex at any section. Obviously the technique is limited to fractures that have a sufficient length of graft available to accommodate four screws: probably it must be longer than 15 centimetres.

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Correspondence to: R. J. Minns, Department of Engineering Science, University of Durham, South Road, Durham, DH1 3LE, U.K.