Acute Stabilization of a Leg with Fractures and Soft Tissue Injuries

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Introduction: A typical war injury includes an open fracture with soft tissue deficits (STD). Acute management of an open fracture typically includes splinting, bracing or external fixation (EF). But EF in the face of STD is often a single half pin frame avoiding the wounds, which is not a stable construct. Previous studies have shown that soft tissue compression (STC) in a tibial fracture brace can provide rigidity and stability to a fractured leg to supplement ORIF. But a fracture brace cannot be assembled over an external fixator and to accomplish STC and if there is STD it is not known if STC can be effective in providing this stability. No studies have addressed these issues.

Purpose: To measure the rigidity of legs with mid shaft fracture simulations stabilized by EF, with or without STC, with and without a STD.

METHODS.
Fresh frozen human cadaver legs had midshaft, oblique osteotomies of the tibia and fibula. Four EF half pins were placed in the tibia and joined with a 10 mm carbon fiber rod. A splint made of PVC struts, velcroe straps and soft cloth wrap was assembled around the pins and STC applied by tightening the struts, much like a bamboo Chinese splint, see figure. The limb was loaded both with and without the STC. Next longitudinal lateral STD's were created in the region of the fracture by removing first 1/4 of the soft tissue measured by circumference of the limb, then 1/3 of the soft tissue and finally with a 3 cm mid-shaft tibial defect. The loading steps were repeated with and without the STC for each condition. 26 legs were tested with an axial load aligned to the mechanical axis of the tibia. 19 additional legs were loaded in 3 point bending by supports fastened directly to the bone ends and a load applied through a universal joint connected through the skin directly into the distal end of the proximal bone fragment at the fracture site. Since each limb was tested for each condition, the relative change in measured stiffness, for each condition was expressed in % difference with vs. without STC, and compared by Student's t-test.

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Results: The increase in stiffness provided by the STC was more significant in bending than in axial loading, Table 1. Also, the contribution of the STC to bending stiffness was reduced as the soft tissue and bone defects increased, Table 1. For axial loading the differences provided by the TFB were far less and much more variable than for bending.

Discussion: As expected, STC was more effective in bending than in axial loading and the EF is good at providing length stability. Despite the loss of major portions of the soft tissue covering the fracture, STC did contribute to the stiffness of the limb. Bending in this study was in the sagittal plane, apex posterior. This was to simulate the role the STC might play in transporting a person with an open fracture of the tibia. The STC might also be helpful in providing compression on the wound packing to control bleeding. Conventional forms of braces are cumbersome to apply over an external fixator, but this "proof of concept" work demonstrated that STC can be an effective supplement to EF for severe open fractures using a simple splint that can be made from a "hand full" of materials.

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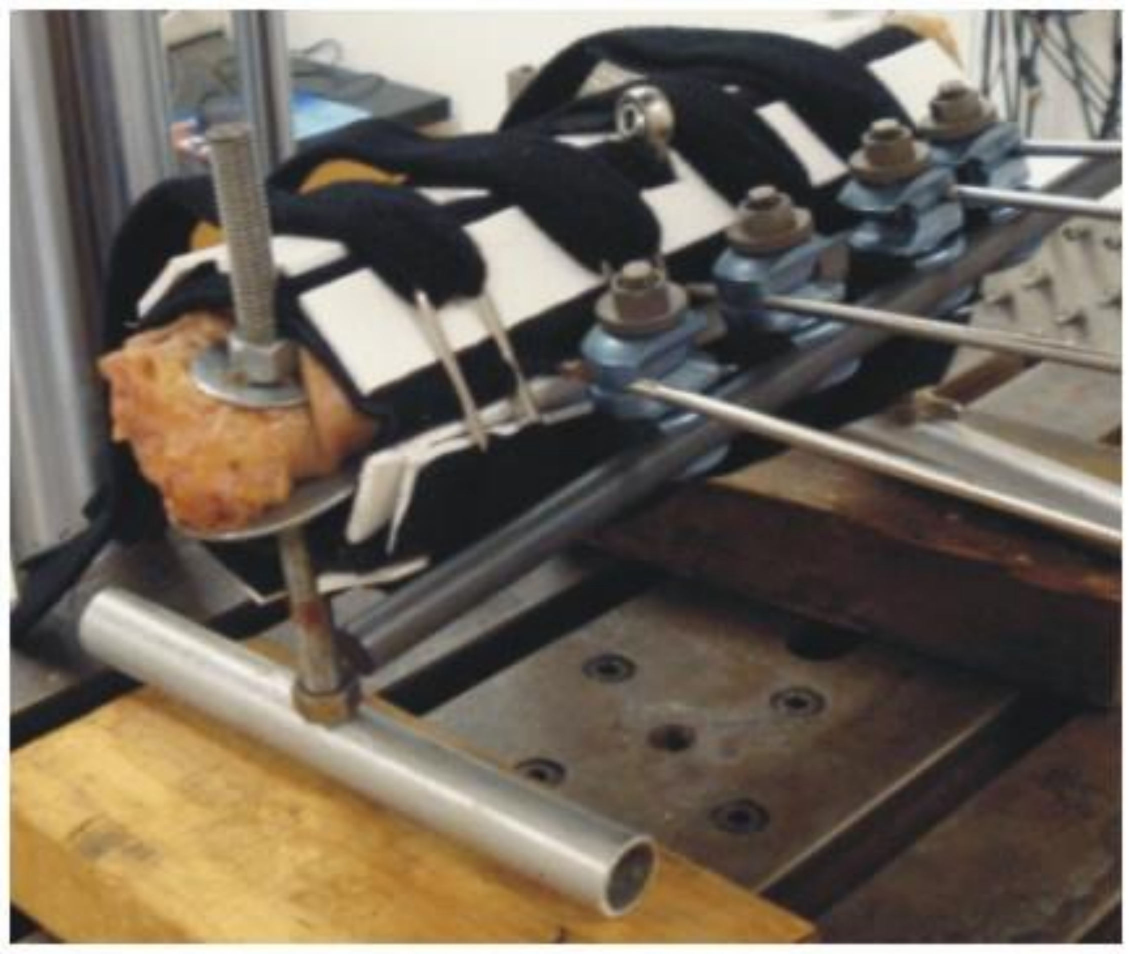

Figure: circumferential PVC struts apply STC around EF pins

Significance: The use of EF combined with a circumferential device which provides STC can help to safely transport a wounded soldier or a victim of a motor vehicle accident with an open tibial fracture and STD to a hospital for evaluation and definitive treatment.

Table 1 - % change in measured stiffness contributed by the splint vs. an external fixator alone

Intact				**¼ STD**				**3 cm tibial defect**			
Axial load		Bending		Axial load		Bending		Axial load		Bending	
Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
20.1%	40.9	63.1%	47.9	25.8%	49.6%	38.1%	47.5	52.1%	39.5	37.7%	71.1

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