The Role of Soft Tissues in Rigidity of Fracture Fixation of Upper and Lower Extremities

Ouellette, E. Anne[1,2]; Elliott, Winston[3]; Latta, Loren[4,5]; Milne, Edward[5]; Lowe, Jason[6]; Kaimrajh, David [5]; Makowski, Anna-Lena[1]; Herndon, Eleanor[2]; Kam, Check[7]; Sawardeker, Prasad[8]

1. Physicians For The Hand, Coral Gables, FL, 2. Florida International University, Miami, FL, 3. University of Colorado, Boulder, CO, 4. University of Miami, Miami, FL, 5. Max Biedermann Institute for Biomechanics Research, Miami Beach, FL, 6. University of Alabama, Birmingham, AL, 7. Indiana Hand to Shoulder Center, Indianapolis, IN, 8. Allegheny General Hospital, Pittsburgh, PA

Introduction:
Combat injuries often involve open fractures with soft tissue deficits. Soft tissue compression (STC) in functional braces has been shown to provide rigidity and stability for most closed fractures, selected open fractures and can supplement some other forms of fracture fixation. But if the soft tissues are compromised, can an external splint or brace through STC provide adequate rigidity and stability either with, or without other forms of fixation?
This study was designed to evaluate the rigidity of different fracture fixation techniques when standardized “slot defects” in the soft tissues (ST) are used to simulate the soft tissue deficits both with simple fractures and bone defects.

Methods:
A simple, oblique fracture was created in 23 cadaveric femurs, 23 tibiae and fibulae, 22 humeri and 22 radii and ulnae of intact limb segments. The weight of each intact limb segment was measured. Cyclic axial loads (12 – 120N) were applied in compression for each progressive condition: intact limb, mid shaft osteotomy, a lateral 1/4 circumferential soft tissue defect, 1/3 circumferential defect and finally, 3 cm bone defect. (Figure 1) Cyclic axial loading was applied on an MTS model 858 MiniBionix II (MTS Corp., Eden Prairie, MN) aligned to the mechanical axis of the limbs. Limbs were randomly assigned to be stabilized by either plate and screw (PS), intramedullary rod (IR) or external fixation (EF). Testing with and without STC in a brace was performed after each condition. After the testing was completed all soft tissue was removed, the bone and the soft tissue weighed separately and the ratio of soft tissue to bone was calculated. ANOVA multi-variant analysis corrected for multiple comparisons was used to compare the axial rigidity between the different conditions tested.

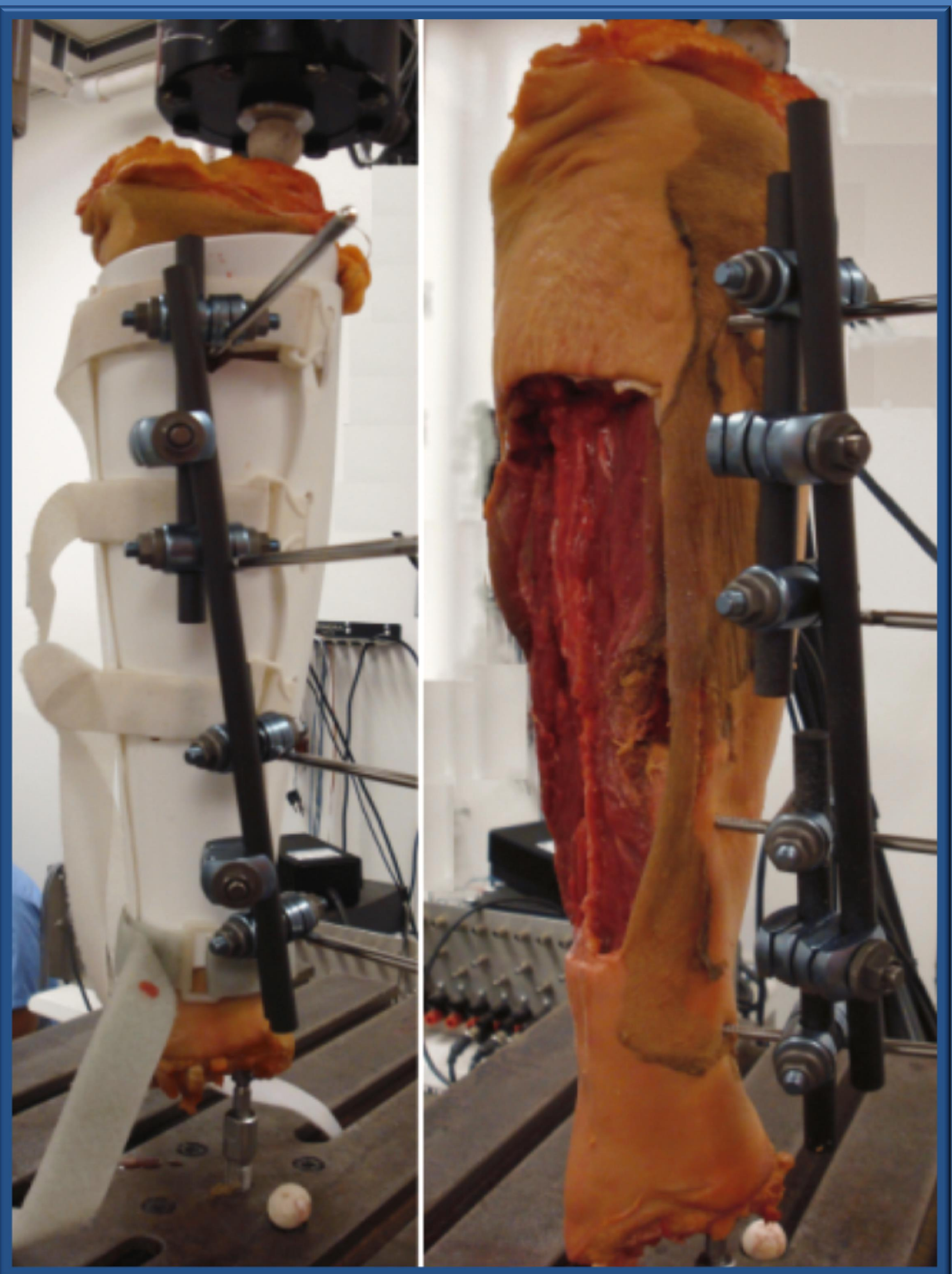

Figure 1.
A cadaver leg with STC and external fixator, left, and with fixator and soft tissue defect, right.

Results:
- Degree of soft tissue damage had no effect on axial rigidity for humerus or femoral FX regardless of fixation method
- 3 cm bone defect in femurs, tibias and humeri were best stabilized with IR
- 3 cm bone defect in forearms were best stabilized with PS
- Progressive ST defect = progressive loss in rigidity in forearms and legs, further accentuated by a bone defect
- The rigidity of IR and EF in legs ↓ 50% with bone defect
  - ➢STC restored 20% rigidity
- The rigidity of IR and EF in forearms ↓ 79% with bone defect
  - ➢STC restored 21% rigidity
- STC alone with fracture and intact soft tissues was not able to provide enough rigidity in the thigh or upper arm to test under load
- The forearms and legs were rigid enough to be tested with STC alone

Discussion/Conclusions:
Invasive types of surgical intervention provide the best rigidity and stability to fractures, regardless of the presence or size of a soft tissue defect. Apparently the increase in angulation of the limbs with progressive soft tissue defects allowed the STC in braces to improve the rigidity of the limbs even with the loss of soft tissue. In general, use of PS and IR and application of conventional types of braces to achieve STC is not practical in the field. EF, however, can be applied quickly and easily with a minimal of facilities in the field and can be applied in such a way that no foreign bodies end up in the contaminated wound. For injuries to the leg or forearm, supplemental support from STC with a splint or brace-like system could be effective.

Significance:
The rigidity of 3 types of fracture fixation with intact soft tissue (ST), then progressive ST defects and bone loss improved for two bone limb segments with ST compression in a brace, but not for one bone limb segments. The use of external fixators combined with fracture bracing can be applied quickly and facilitate transportation to a hospital for evaluation and treatment. Our future research involves improving fracture brace designs to a modular system with small components that can be assembled to fit the external fixators construct for acute management of forearm and lower leg injuries with and without soft tissue damage.

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Max Biedermann Institute for Biomechanics at Miami Beach

Physicians for the Hand

FIU Herbert Wertheim College of Medicine
Florida International University