EXTERNAL FIXATION ACROSS THE ANKLE

**Antoci, V; *Voor, MJ; **Antoci Jr, V; *Roberts, CS  
*University of Louisville, Louisville, KY, USA; ***Jefferson University, Philadelphia, USA.  
E-mail: viantoci@hotmail.com

External fixation is commonly used during distal tibia realignment osteotomies, distraction osteogenesis, and fractures treatment (1, 2). A frame extension across the ankle helps to prevent joint contractures(2), joint subluxations(3), and increases fixation stability (4). The effect of spanning of the ankle on the biomechanics of external fixation to our knowledge has not been studied. The purpose of this study was to evaluate and to compare the mechanical stability of external fixation with and without ankle spanning fixation using a foot plate in an in-vitro model of distal tibia osteotomy/fracture.

MATERIALS AND METHODS

A laboratory investigation was performed to evaluate the mechanical behavior of external fixation of distal tibia osteotomy/fracture using a fixator with and without a foot plate. Ten fresh frozen lower extremities (five pairs) with a simulated distal tibia osteotomy/fracture were stabilized with an Ilizarov hybrid fixator with and without a foot plate. The fixation technique followed the manufacturer’s recommendations. Each specimen was fixed with an Ilizarov hybrid fixator (Smith and Nephew, Memphis, TN) with half-pins proximally fixed with Rancho® cubes and wires distally both with and without ankle spanning with an Ilizarov foot plate (Smith and Nephew, Memphis, TN). All specimens were loaded using a servohydraulic load frame (MTS Bionix 858, Minneapolis, MN, U.S.A.). The proximal end of the prepared specimen was fixed to the test frame. The force was applied to the foot through a flat bar placed under the metatarsal heads. The load was applied incrementally from 0 to 25, 50, 75, 100 N and then back to 50 and 0 N. We chose not to study higher loads because patients usually do not bear any more weight than this during the first 3 weeks after surgery. Relative interfragmentary motions (vertical and horizontal translations, and rotation) were measured. Three repetitions of each test were performed for each specimen with and without a foot plate. The mean values of the three trials for each specimen were used in our comparison. These values were then grouped by fixator design (with and without a foot plate) and statistical analysis was performed as a paired t-test to compare the different frame constructs. Secondary statistical analysis was used to determine if there was any effect from testing the foot plate first or second on the specimens. For this analysis the left and right foot from each cadaver were considered as a pair and a t-test: paired two sample for means was used. A probability value of less than 0.05 was considered indicative of a significant difference between fixator constructs.

RESULTS

The vertical displacement measured at the center of the distal fragment under load with the foot plate was such that the bone fragments became closer together (± 0.83 ± 0.64 mm). Loading of specimens without the foot plate, however, resulted in distraction of the distal fragment (2.57 ± 0.97 mm). The difference was statistically significant (p<0.05). The horizontal displacement of distal fragment with (1.12 ± 0.98 mm) was not significantly different from the motion without (1.19 ± 1.23 mm) a foot plate and was in the anterior direction in both cases. Loading of the construct with the foot plate caused sagittal plane angulation of the fragments with the fracture gap opening anteriorly (–1.15 ± 0.61 deg.). Conversely, loading of the construct without a foot plate resulted in sagittal plane angulation of fragments with the gap opening posteriorly (4.49 ± 0.45 deg.). These motion differences between constructs with a foot plate and without a foot plate were found to be statistically significant (p<0.05). There were no statistically significant differences between left and right feet for any kind of displacement. Thus, there was not a statistically significant difference between the order of testing the construct with a foot plate and the construct without it (p>0.05).

DISCUSSION

Our data show a biomechanical advantage to the addition of a foot plate to span the ankle joint in external fixation of distal tibia osteotomies/fractures. The addition of a foot plate significantly decreased osteotomy/fracture site vertical displacement and angulation in the sagittal plane, but did not affect horizontal displacement or shear at the osteotomy/fracture site. We attribute the identical horizontal displacement in both models (with and without the foot plate) to the rigidity of the peritalar tensioned olives wires in both constructs, which prevented significant shear.

The use of external fixation is currently popular for peritalar distal tibia fractures (1, 3, 5), deformity correction and bone lengthening (2, 3). It is known that the mechanical characteristics of a specific external fixator are the major factor in determining the biomechanical environment at a fracture site and, hence, affect the healing process (3, 4). Under external fixation, fluctuating stress induced by unstable fixation and the associated osteotomy/fracture gap movement is an important contributing factor in pin-tract loosening and infection, nonunion and malunion (3). Pugh et al. (4) mentioned that the incidence of nonunion and delayed union is greater when devices with inadequate stiffness are used. Our data suggest that fixators with ankle spanning using foot plates increase the mechanical stiffness of external fixation of peritalar distal tibia osteotomies/fractures. When the peritalar fragment is small (like in our experimental model) it is difficult to achieve two or more levels of fixation. The use of a foot plate with ankle spanning is an optimal method to improve the mechanical stiffness of external fixation.

External fixation is commonly used in the treatment of high-energy fractures of distal tibia (1, 3, 4, 5). Barbieri et al. (5) reported on a series of 34 tibial plafond fractures (75% were high energy) treated using a hybrid external fixator without spanning the ankle joint. They reported 15% pin tract infections, 9% nonunions, and 9% loss of reduction necessitating revision of the frame. Anglen (1) also reported a series of 34 distal tibia fractures treated using hybrid external fixators without spanning the ankle joint. He reported 21% nonunions, particularly, 83% of these nonunions were at the diaphyseal-metaphyseal junction. Maffulli et al. (2), reviewing 240 patients undergoing distraction osteogenesis for congenital, post-traumatic, or postinfective lower limb length discrepancy, concluded that spanning the ankle joint with a foot plate could prevent joint contractures and subluxations when lengthening percentage exceeds 15.

Our mechanical data suggests that non-ankle spanning external fixation of peritalar distal tibia osteotomies/fractures in trauma, deformities correction, and lengthening is relatively not a stable configuration. Fixators with ankle spanning using foot plates increase the mechanical stiffness of external fixation peritalar distal tibia osteotomies/fractures.

REFERENCES


52nd Annual Meeting of the Orthopaedic Research Society  
Paper No: 0204