A NEW MINI EXTERNAL FIXATOR FOR SEVERE HALLUX VALGUS TREATMENT
A BIOMECHANICAL STUDY

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Introduction

- Symptomatic hallux valgus > more than 130 surgeries
- *Proximal crescentic metatarsal osteotomy* of 1st metatarsal was firstly described by Mann and popularized in the last twenty years.
- *The most difficult step in this operation is the fixation of the osteotomy.***
- *We designed a mini external fixator* in order to gain better biomechanical properties and better bone healing with percutaneous crescent shaped osteotomy.


Our mini external fixator

- made of Titanium (Ti6Al4V); it weighs 37.2 grams with the sizes of 31.5 mm wide, 57.5 mm height, 17 mm thickness.
- can be lengthened up to 10 mm with help of the distraction device.
- can be bent up to 25° for both sides to correct the deformity with the help of the proximal swivel clamps.
- applied to metatarsal bone with 2 proximal and 3 distal 2.5 mm Schanz pins. *(All of these Schanz pins oriented convergent to the axis of the metatarsal with the angled pin holes of the fixator)*
Introduction

- The purpose of our biomechanical study:
  To compare the stability of conventional screw fixation and our newly design mini external fixator.
Material & Method

- 18 composite cortical bone models of 4th generation metatarsals
  (Sawbone, Pacific Research Laboratories, Vashon, WA)
- A crescentic proximal osteotomy; 10 mm distal to the proximal end of the bone model with a power crescentic oscillating saw thickness of 1 mm, and a 10 mm radius (Aesculap GC 554 Inox 16, Aesculap-Werke AG, Tuttlingen, Germany)
- 9 metatarsals fixed with our mini external fixator
- 9 metatarsals fixed with headless compression screws (Acutrac, Acumed, Beaverton, OR)
Material & Method

Mechanical Testing

- “MTS 858 Mini Bionix 2” universal dynamic test system
- Dynamic, axial and torsional loading capacity of the system was 100Hz, 25kN and 200Nm, respectively
- axial compression
- distraction and bending
- measurements recorded by a “MTS Multipurpose Testware”
- Displacement measured by a “static optical camera and 3D correlation system”
- Construct stiffness and the amount of interfragment angulation were calculated on the 1st, 10th, 50th, 100th, 200th, 300th… and 1000th load cycles.
Results

- Dorsal angulation of 10 degrees was defined as failure.
- The mean failure cycles of screw group was 556 (456-823).
- The mean failure cycles of mini EF group was 997 (621-1204).
  
  *mini EF group was statistically stable* (p<0.001).

- All of the screw constructs in screw group showed failure before completion of 1000 load cycles. (3 constructs failed between 400th and 500th load cycles, 4 constructs failed between 500th and 600th load cycles, 1 construct failed between 700th and 800th load cycles, and 1 construct failed between 800th and 900th load cycles)
- Two of nine mini-EF constructs failed before completion of 1000 load cycles. Both of them failed between 600th and 700th cycles. Only one of the mini-EF construct failed after 1200 cycles whereas 4 mini-EF constructs showed failure between 1000th and 1100th, 2 mini-EF constructs showed failure between 1100th and 1200th cycles.
- Construct stiffness of mini EF group was statistically better than screw group at 10th(p:0.05), 400th(p:0.003), 500th(p:0.014), 700th(p:0.05), 800th(p:0.001), 900th(p:0.004), and 1000th(p:0.011) cycles.

- Statistical significance was set as p<0.05. Paired, Mann-Whitney tests were used to determine the significance of differences in the number load cycles before failure with dorsal angulation > 10 degrees at each cyclic load interval.
Discussion

- Ideal proximal osteotomy should provide rigid stability, prevent dorsal malunion and allow early weight bearing

- Our newly design mini external fixator provided superior osteotomy stability comparing to screw fixation. According to these encouraging results, this device can be applied safely and provide early weight bearing in the post operative rehabilitation period

- To our knowledge this is the first biomechanical report that uses the external fixator and compares with screw in the treatment of hallux valgus

- Mini external fixator can be good alternative for the treatment of metatarsus primus varus deformities with satisfactory biomechanical properties and the advantages of lengthening, shortening, and further deformity correction options. However this results should be supported with clinical studies.