Biomechanical Comparison between Volar Plate Fixator (VPF) and Non-Bridge External Wrist Fixator System (NBX)

INTRODUCTION: Comminuted distal radius fractures with 5 or more bone fragments are difficult to reduce and stabilize with current ORIF techniques because screw placement and purchase is difficult in the small intra-articular fragments of often osteoporotic bone. External fixation can provide stability through ligamentum tarsi but immobilization of the wrist joint is required. Non-bridging external fixation which allows for precise, multiplanar pin placement provides an alternative to volar plate fixation.

HYPOTHESIS: Because of the ability to provide multiaxial fixation and accurate pin placement, the NBX fixator should provide better reduction and comparable rigidity of fixation to a volar plate for a 5-fracture distal radius fracture.

METHODS: Using a biopsy needle, 1.5 mm stainless steel balls were implanted in the distal radius of 5 fresh pairs of human cadaveric upper limbs to track bone fragments by radiographic images. A simulated 5-part distal radius fracture was created with an osteotome, guided by a fixture to produce consistent size and shape fragments to simulate an OTA 23 C3.2. One arm was randomly fixed with the NBX fixator, the matched pair was fixed with a volar plate and screws (VPS). Fluoroscopic images were recorded at the extremes of passive volar-dorsiflexion range of motion (ROM) and radial-ulnar deviation ROM, (Fig. 1).

Finally, each arm was loaded with an axial force at a constant displacement rate until failure. A percutaneous screw was fixed in the third metacarpal at 50mm from the head of radius so that a 10 N force applied perpendicular to the bone would create a 0.5 Nm torque to the wrist. The arm was set in a vise horizontally in 4 positions so that the hand hung by gravity in four directions for each specimen: in the direction of the palm (volar flexion), the back of hand (dorsiflexion), the thumb (radial deviation), and the little finger (ulnar deviation). In each position the torque of 0.5 Nm was applied to the wrist Each position was imaged by using fluoroscope (Insight, HOLOGIC Inc.), and the images are analyzed by image analysis software (Image-Pro, Media Cybernetics Inc.) to measure the angle between the extension line of metacarpal bone of the middle finger and that of radius for ROM, (Fig. 1).

RESULTS: The average loss of radial tilt due to fracture was 16.6° ± 7.2 for the NBX and 11.2° ± 5.5 for VPS arms. The average loss of radial length was 5.4 mm ± 4.0 for NBX, and 4.6 mm ± 2.3 for VPS arms. The average loss of volar tilt was 28.0° ± 12.3 for NBX and 24.7° ± 11.2 for VPS arms. Initial displacement was slightly less for the VPS group, but it was not statistically significant (SS). The average restoration of radial tilt achieved for the NBX group was 13.8° ± 4.8; and 6.3° ± 4.7 for VPS; radial length: 3.4 mm ± 3.7 for NBX and 1.9 mm ± 1.0 for VPS; volar tilt: 26.3° ± 12.4 for NBX and 14.0° ± 13.5 for VPS. Only the restoration of radial tilt by NBX was SS better than VPS. But pairing R/L, the relative restoration of radial length and volar tilt were SS better for NBX, (Fig. 2).

The ROM was slightly less for the NBX group after fixation compared to ROM before fracture. ROM with volar plating increased after surgery, (Fig. 3).

The peak axial load for NBX was 925 N ± 445; for VPS 2152 N ± 1023. VPS strength was SS better than NBX.

DISCUSSION: The decrease in ROM after NBX fixation was clearly a matter of soft tissues tethered by the percutaneous pins and blockage of dorsiflexion by the fixator. The increase in ROM for the VPF group is not clear, but may be due to the increased soft tissue dissection necessary for the surgery. The improved anatomic reduction for the NBX fractures was probably due to the reduction device that comes with the NBX fixation system. No such aid was available for the VPF group. Also, the screws in the VPF plate were fixed in position, whereas the pins in the NBX could be aligned more accurately to each fragment.

CONCLUSION: NBX has minimal effect on ROM, provided adequate restoration of alignment that was at least as good as VPS for this 5 part fracture model. Load to failure was more than twice as high for the volar plate.


ACKNOWLEDGEMENTS: This work was performed at the Max Biedermann Institute for Biomechanics at Mt. Sinai Medical Center, Miami Beach, FL and supported by Nutek Orthopaedics, Inc.