Biomechanical comparison of non-bridging external fixation and volar plating of a comminuted fracture of the distal radius

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INTRODUCTION:

Intra-articular 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.[1] Traditional external fixation can provide stability through ligamentotaxis, but immobilization of the wrist joint is required.[2] Non-bridging external fixation, which allows for precise, fragment specific, multiplanar pin placement provides an alternative to locked volar plate fixation.

HYPOTHESIS:

Because of the ability to provide fragment specific, multiplane fixation pin placement, the NBX fixator should provide for better reduction, rigidity and strength of fixation comparable to a locked volar plate for a 5-fragment, intra-articular 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 (Nutek Orthop.), the matched pair was fixed with a locked volar plate and screws (Stryker Leibinger locking volar plate), VPS. Each forearm was held in a vise horizontally in 4 positions so that the hand hung by gravity in four directions: volar flexion (VF), dorsiflexion (DF), radial deviation (RD), and ulnar deviation (UD). A percutaneous screw was fixed in the third metacarpal at 50mm from the wrist axis of rotation so that a 10 N force applied perpendicular to the bone would create a 0.5 N·m torque to the wrist in each position. Each position was recorded by a fluoroscope (Insight, HOLOGIC Inc.), and analyzed using image analysis software (Image-Pro, Media Cybernetics Inc.) to measure the angle between the longitudinal axes of the 3rd metacarpal and the radius for ROM, as well as coronal (radial inclination, RI, and height, RL) and sagittal (volar tilt, VT) plane reduction parameters, Fig. 1. Finally each arm was loaded with a constant axial displacement rate until failure. Statistical comparisons were by t-test with Bonferroni correction for multiple comparisons.

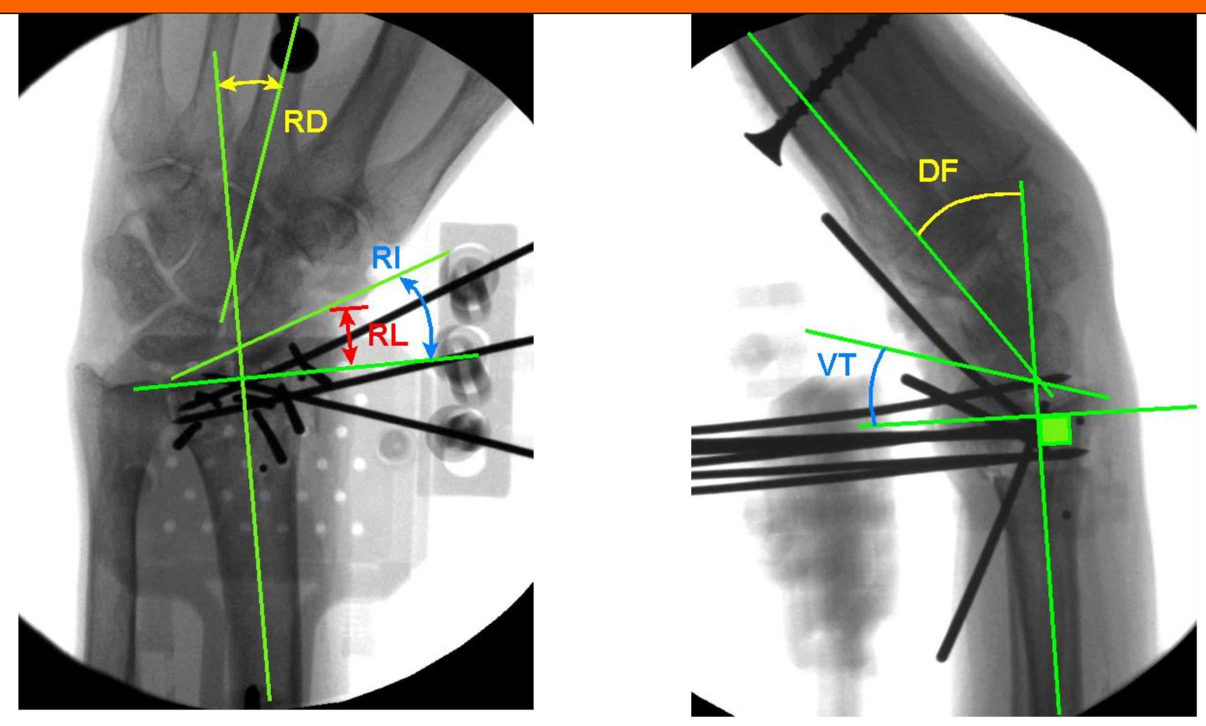

Figure 1 – Images of a wrist with NBX fixator applied to an OTA 23 C3.2 fracture. Measures of RD, RL, RT (left) and VT and DF (right) shown.

RESULTS: The average loss of radial inclination due to fracture was 16.6º ± 7.2 for the arms with NBX and 11.2 º ± 5.5 for arms with VPS fixation. The average loss of radial length was 5.4 mm ± 4.0 for NBX, and 4.6 mm ± 2.3 for arms with VPS. The average loss of volar tilt was 28.0 º ± 12.3 for NBX and 24.7 º ± 15.7 for arms with VPS. The average restoration of radial inclination achieved for the NBX group was 13.8 º ± 4.8; and 6.3 º ± 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 º ± 12.4 for NBX and 14.0 º ± 13.5 for VPS, Fig. 2. Only the restoration of radial length was not statistically different between NBX and VPS.

The ROM was slightly less for the NBX group after fixation, with volar and dorsiflexion statistically significantly (SS) reduced. After VPF, the ROM was increased to a SS degree in both volar and dorsiflexion.

With axial load to failure the VPF was SS stiffer and stronger than NBX: 343.7 ± 138.4 vs. 159.7 ± 118.8 N/mm and 2152 ± 1023 vs. 925 ± 445 N , Fig.3.

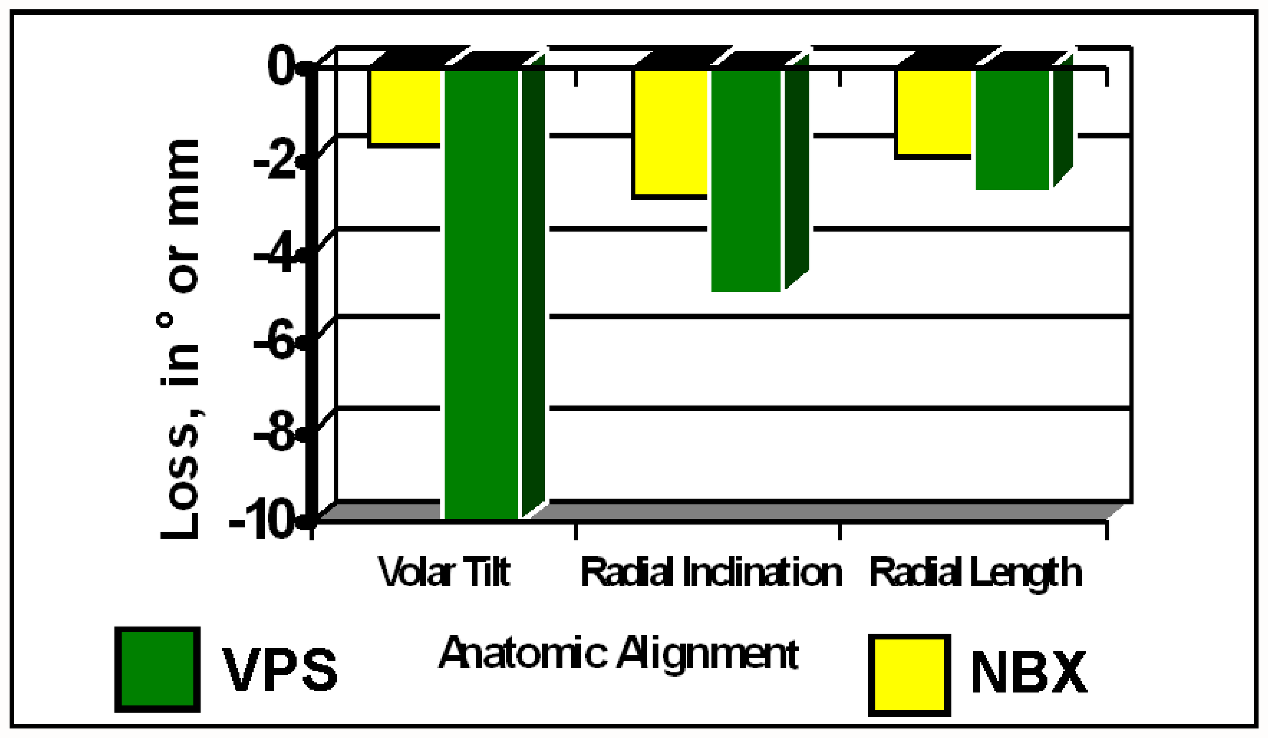

Figure 2 – Anatomic restoration was better achieved by NBX than by VPF for this OTA 23 C3.2 fracture simulated in cadavers.

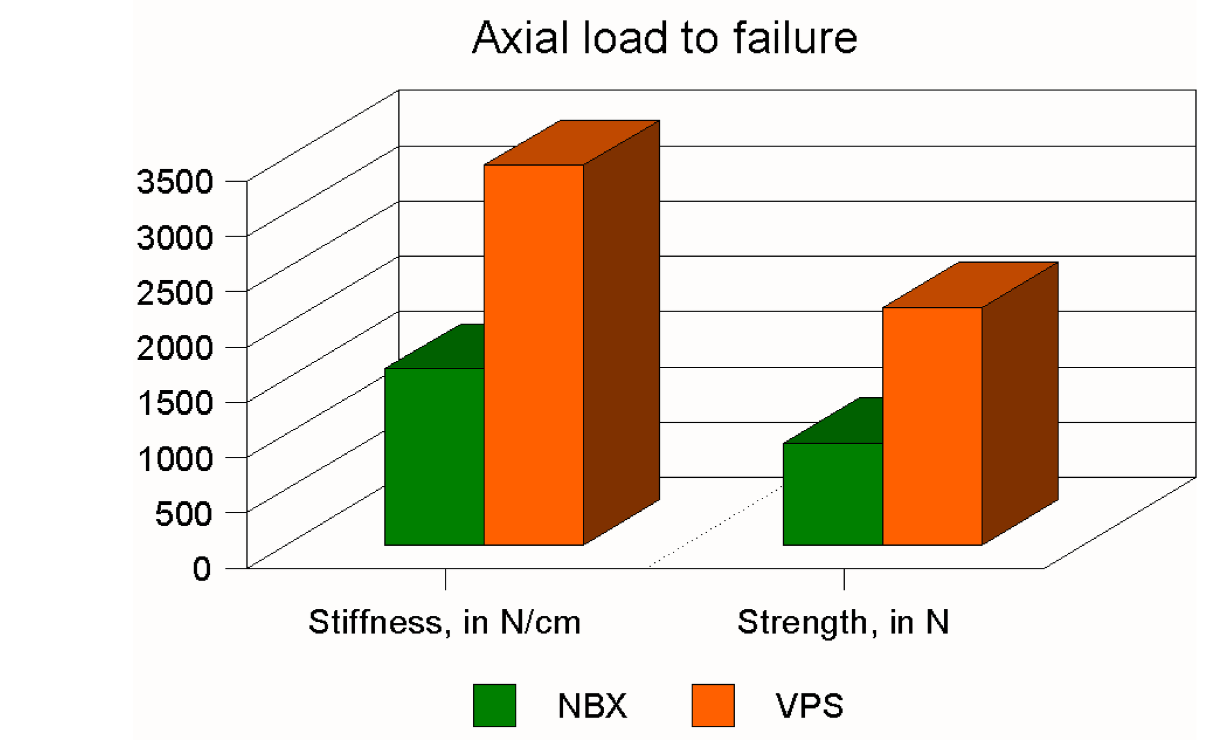

Figure 3 – Axial load was applied at a constant rate of displacement along the entire forearm until failure was recorded. VPS was stiffer and stronger than NBX.

DISCUSSION & CONCLUSION: This preliminary biomechanical study shows that excellent restoration of volar tilt, radial inclination, and radial height of simulated intra-articular distal radius fractures can be achieved with NBX with multiplanar fragment specific capability. In our study, VPS fixation showed higher ultimate load to failure compared to NBX. But both had far stronger than 200 N, the expected load of ADL. There was also increased combined range of motion of the radiocarpal, midcarpal, and carpometacarpal joints in all planes with VPS constructs compared to intact wrists and to the NBX constructs. This difference in motion may be due to a combination of tethering of the soft tissues, and possibly of the extensor compartments, by the pins in the NBX construct, and to dissection of soft tissues required for VPS fixation.

Limitations of this study include the small sample size, lack of measurement of intraarticular gapping and step-off, and the inability to measure interfragmentary motion. However, we were able to establish a baseline biomechanical profile and reduction capability with this new device, in comparison to locked volar plating, the most widely used method of fixation for intra-articular distal radius fractures.

REFERENCES:

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2) Schmelzer-Schmied, N, et al, (2008), Int. Orthop., [ePub]

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