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BIOMECHANICS OF ULNAR OSTEOTOMY FIXATION COMPARING 5 DESIGNS OF PLATES AND SCREWS

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INTRODUCTION:

Significant pain is a common symptom of protrusion of the distal ulna into the wrist joint following distal radius fracture. The most common surgical solution to this problem is to perform an ostectomy of the distal ulnar diaphysis and fix the bone in a shortened position. But non-union is a possible complication of this procedure. The senior author thus developed surgical instruments to create a precision ostectomy with improved rate of healing.[1] The conventional plate used for the fixation however has caused some problems because of it's bulk. It is the hypothesis of the investigators and designers that with the new technology of locking plates and screws, the size of the plate and screw can be reduced without reducing the rigidity or strength of fixation. To test this concept for this application a quantitative comparison was made of four new plate designs for fixation of a distal ulnar ostectomy.

METHODS:

All plates had a 2.7 mm lag screw applied across an oblique osteotomy in a 3rd generation Sawbones® composite tube with 2 standard 3.5 mm, non-locking screws on each side. The standard non-locking ulnar plate design had 2 - 3.5mm screws in the end holes (SP). All the other plate designs were low profile with 2.7 mm locking screws on the ends. Two of the low profile designs were stainless steel, one with fine threaded locking screws at each end (SF), the other with coarse thread locking screws (SC). Two of the designs were of Titanium alloy, one with fine thread locking screws (TF), the other with coarse thread locking screws (TC). Each osteotomy was created with a precision cutting fixture[1]. The preparation and fixation of each specimen was carried out by the senior investigator, a hand surgeon of more than 25 years experience. The tests performed are a four-point bend test with: 1) the plate on the tension side of the construct, 2) the plate on the lateral side of the construct, and, 3) an axial torque test. From the load/displacement graphs a structural bending stiffness (or effective cross-sectional stiffness) was computed as described in ASTM standard F382[2]:

EI = s2(L + 2c)(F/y)/12.

or... EI = s2(3L-4s)(F/y)/12.

Where: F/y = the slope of the elastic portion of the load-displacement curve s = the span from a load point to the nearest support c = the center span

L = the total span (c + 2s)

Each model was tested within the elastic range for bending in the 2 planes described above and in axial torque. After the elastic tests, 3 constructs were randomly picked for a single cycle destructive test in

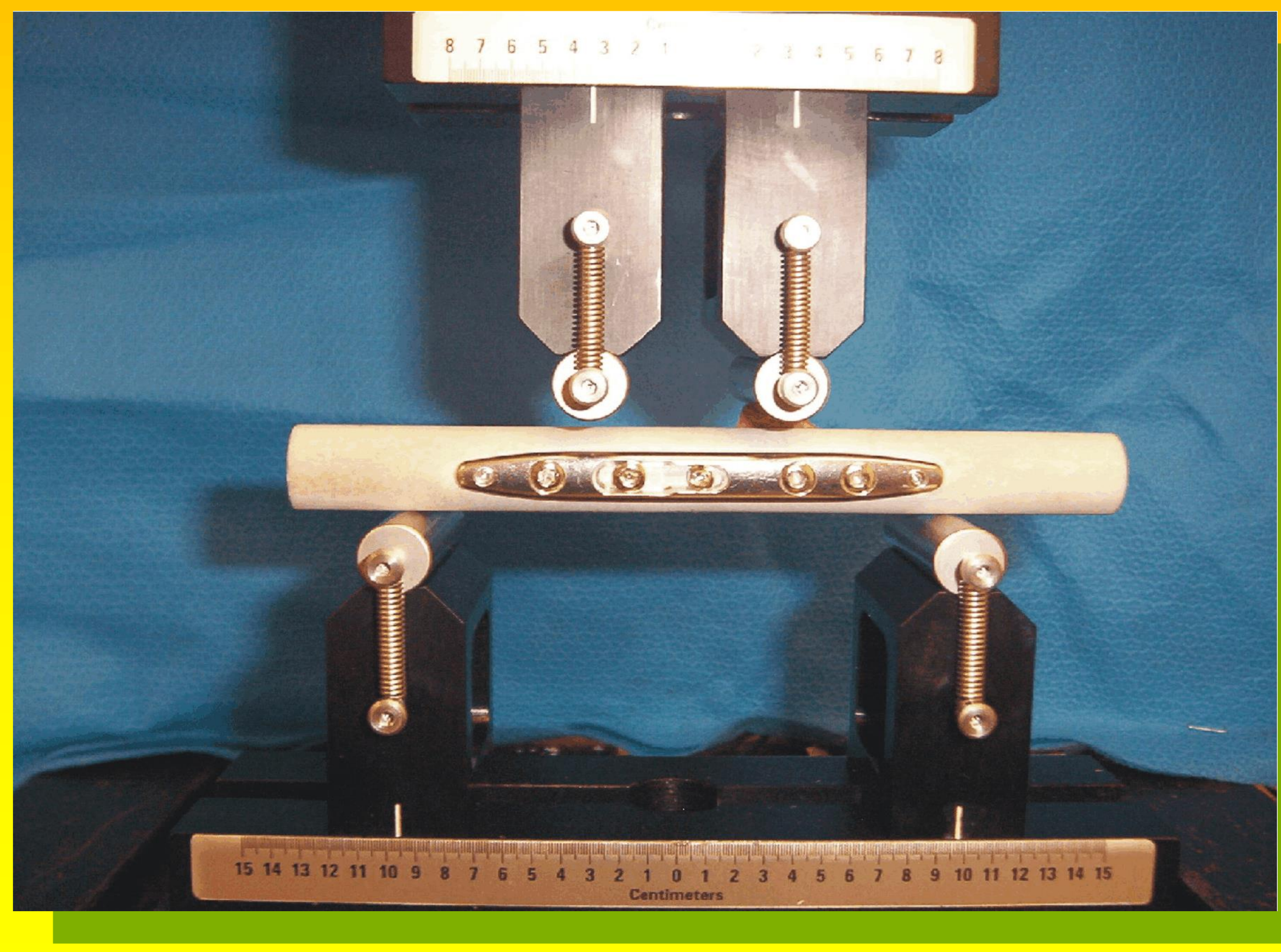

Figure 1 – Out of plane 3-pt bend test

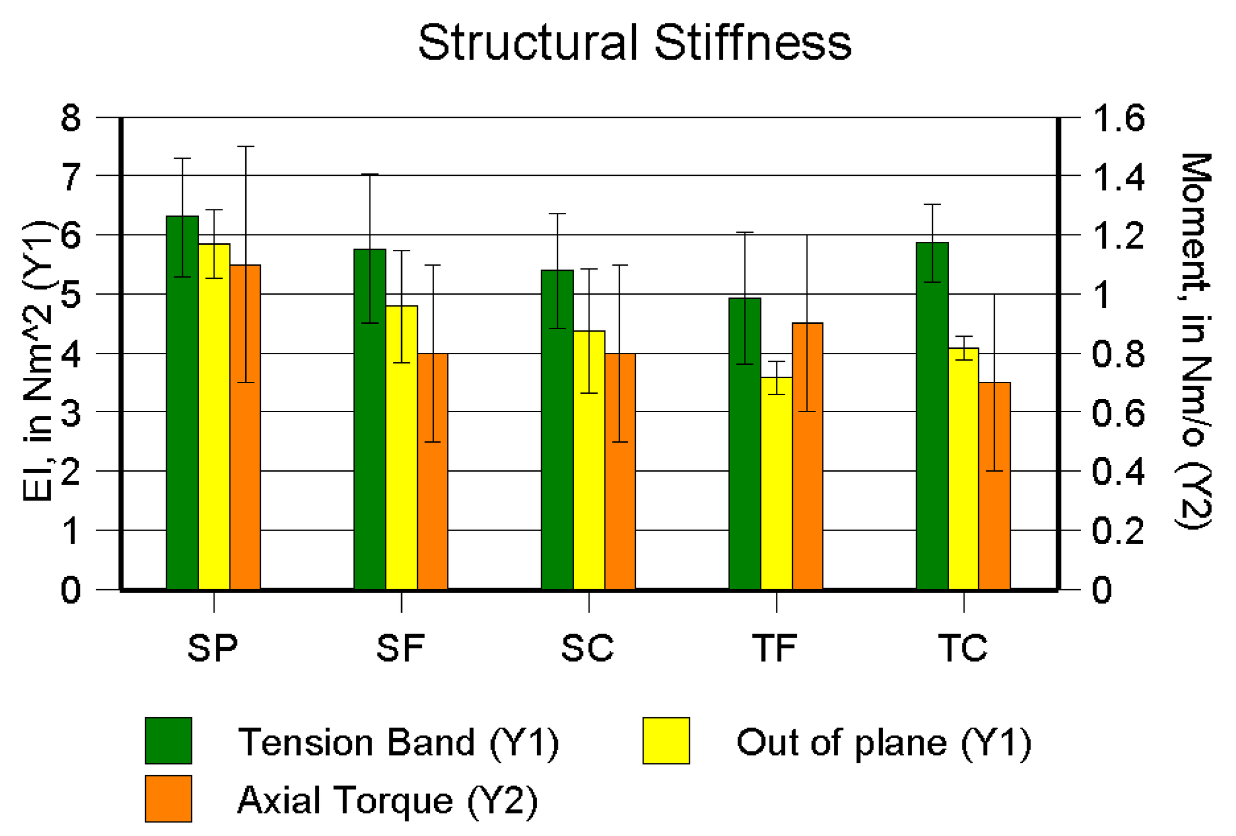

Figure 2 – Structural Stiffness measured in Bending and torsion

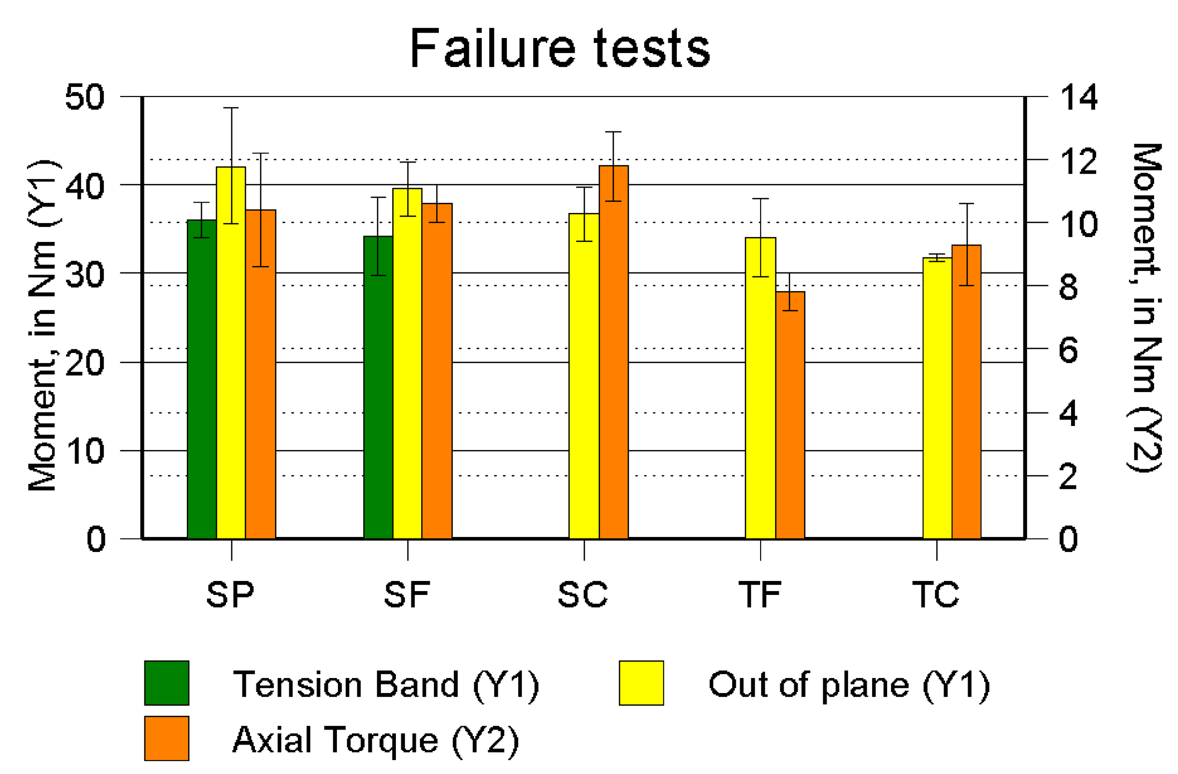

Figure 3 – Bending and Torsional Strength Tests

one of the loading modes to define the strength of the construct. For each test, failure was defined as the point at which the load-deflection curve became very non-linear and a plastic deformation was observed. All devices were compared to the SP values using an ANOVA multiple comparison test employing the Bonferronni correction factor for multiple comparisons in ProStat software, v. 3.5.

RESULTS:

The only statistically significant reduction of stiffness compared to SP in the tension band mode was for the TC, ($P < 0.02$) see Figure 2.

However, all the low profile plate configurations had statistically significant reductions in rigidity compared to SP in out of plane bending: SF, $P < 0.002$; SC, $P < 0.016$; TF, $P < 0.001$ and TC, $P < 0.001$. In axial torque, all the low profile plate and screw constructs were less rigid than the SP, but only the TF was statistically significantly less, $P < 0.044$. There was no statistically significant differences in bending tests to failure for any of the low profile plates when compared to the SP, see Figure 3. But there were statistically significant differences in torsion for TC and TF.

DISCUSSION:

Utilizing a locking screw at the end of a low profile plate provided similar strength and rigidity of fixation to a conventional plate of larger profile and larger screws. Titanium alloy provided no advantage over stainless steel designs.

REFERENCES:

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2)Standard specification and test method for metallic bone plates, F382-08, ASTM, Conshohocken, PA, 2003.

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