Are 3.5mm Plates and Screws Ideal Forearm Fixation? Biomechanical Analysis of Diaphyseal Forearm Refracture

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INTRODUCTION: Diaphyseal forearm fractures, including those of the radius, ulna, and both bones, are common injuries. Early literature reported the results of reconstruction with 4.5 mm and 3.5 mm plate and screw constructs. These studies showed that both methods provide adequate fracture fixation, but the incidence of peri-prosthetic fracture and re-fracture was much higher with the use of 4.5 mm implants. As a result, small fragment 3.5 mm fixation has been the standard of care for more than 30 years. Despite this, re-fracture and peri-implant fracture rates with 3.5 mm implants remain relatively high following plate removal with published rates around 15%. Reported plate removal rates are significant leaving these patients at risk. Smaller screws were not available for clinical use at the time of earlier studies, but today smaller implants are widely available. These smaller screws, such as 2.7 mm screws, may provide the opportunity to decrease the risk of re-fracture. However, there are no published studies examining the use of screws smaller than 3.5 mm for fixation of diaphyseal forearm fractures. The purpose of this study is to examine the effect of screw hole size on the risk of re-fracture. We believe that the use of 2.7 mm screws will significantly decrease the risks of re-fracture, just as was observed in the comparison of 4.5 and 3.5 mm constructs.

METHODS:, Two screw hole models were created to compare 2.7 mm threaded holes and 3.5 mm threaded holes. The first involved standard four-point bend test of acrylic tubing with one screw hole of either size to measure peak force required for fracture. The second model consisted of lengths of tube with two holes, one of each size, in each length. Ten samples were divided into two groups; one four-point bend group and one torsion group.

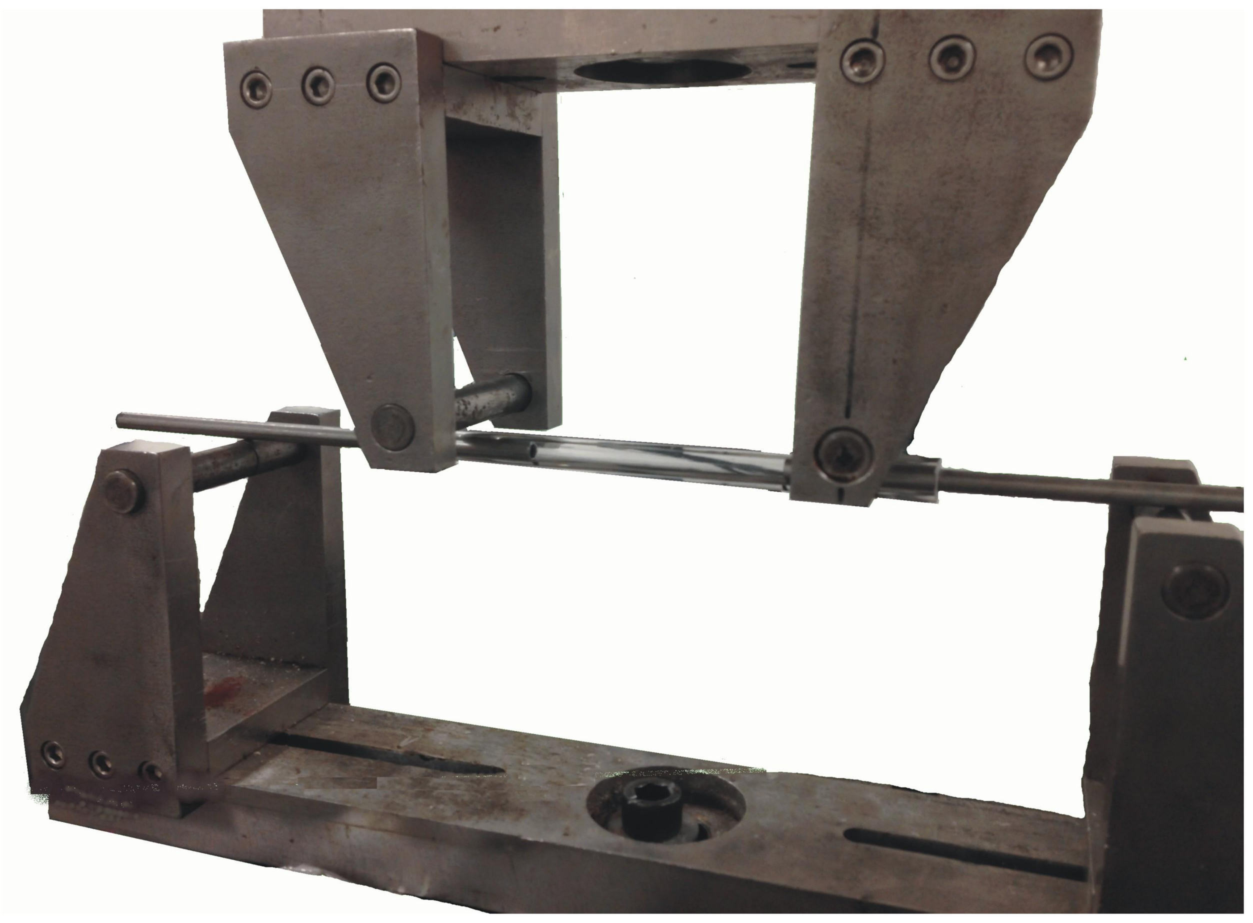

Figure 1 – The four point bend test of the acrylic tubes with 3.5 mm screw hole and one 2.7 mm screw hole in the uniform bending moment region of the test.

Results: In the single hole portion of the experiment, all samples fractured through the screw hole. The 2.7mm screw hole group had a significantly higher peak fracture force compared with the 3.5mm group (225.5 vs 166.7, $p<.05$). The second portion of the experiment, in which each length of tube had two screw holes, fractures occured at the 3.5mm screw hole in all ten samples for both bending (5 samples, $p=.0015$) and torsion (5 samples, $p=.0015$). All bending samples resulted in transverse or slightly oblique fracture patterns and torsion caused all spiral fractures.

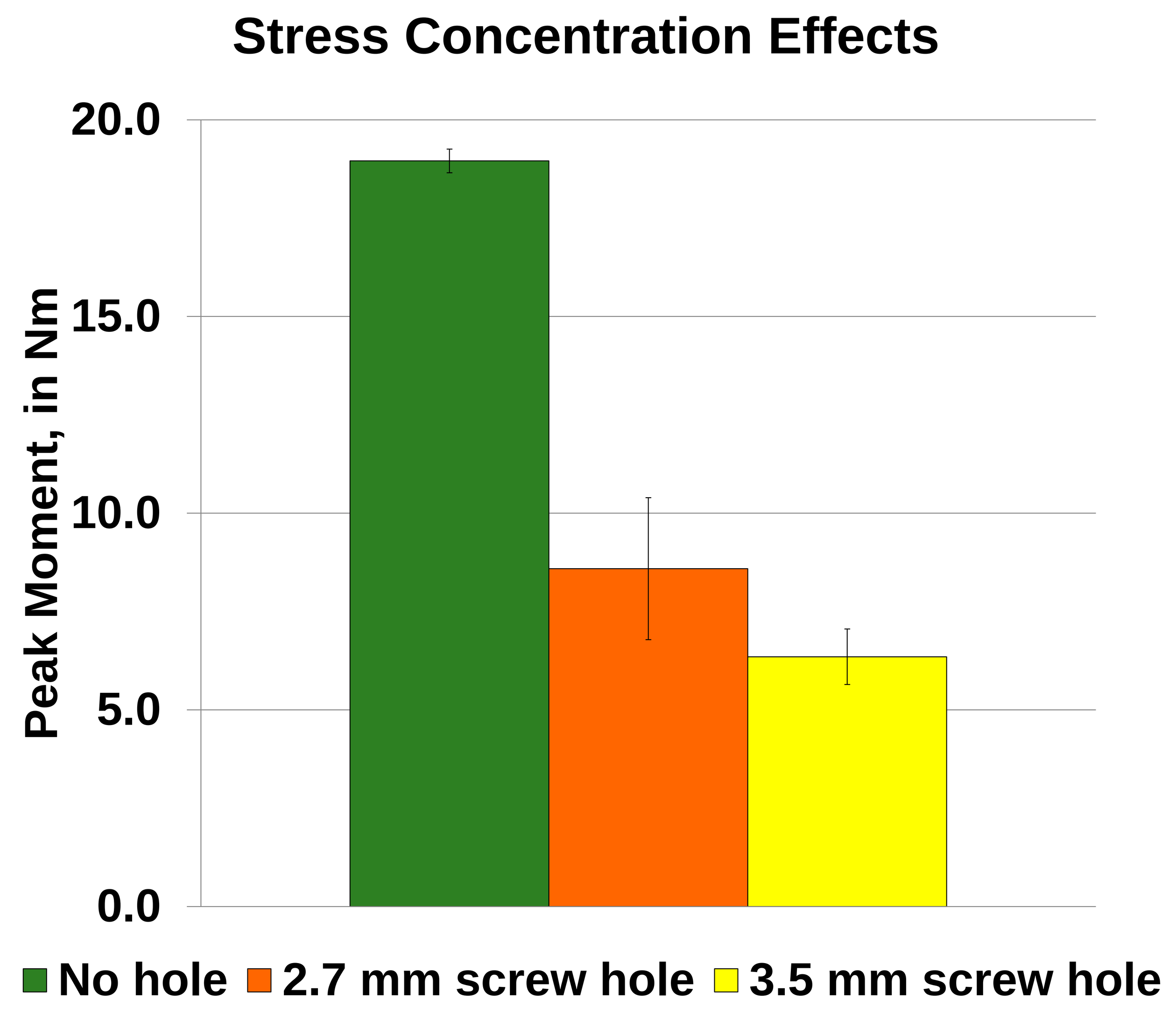

Figure 2 – The 3.5 mm screw holes weakened the bone model significantly more than the 2.7 mm screw holes in bending.

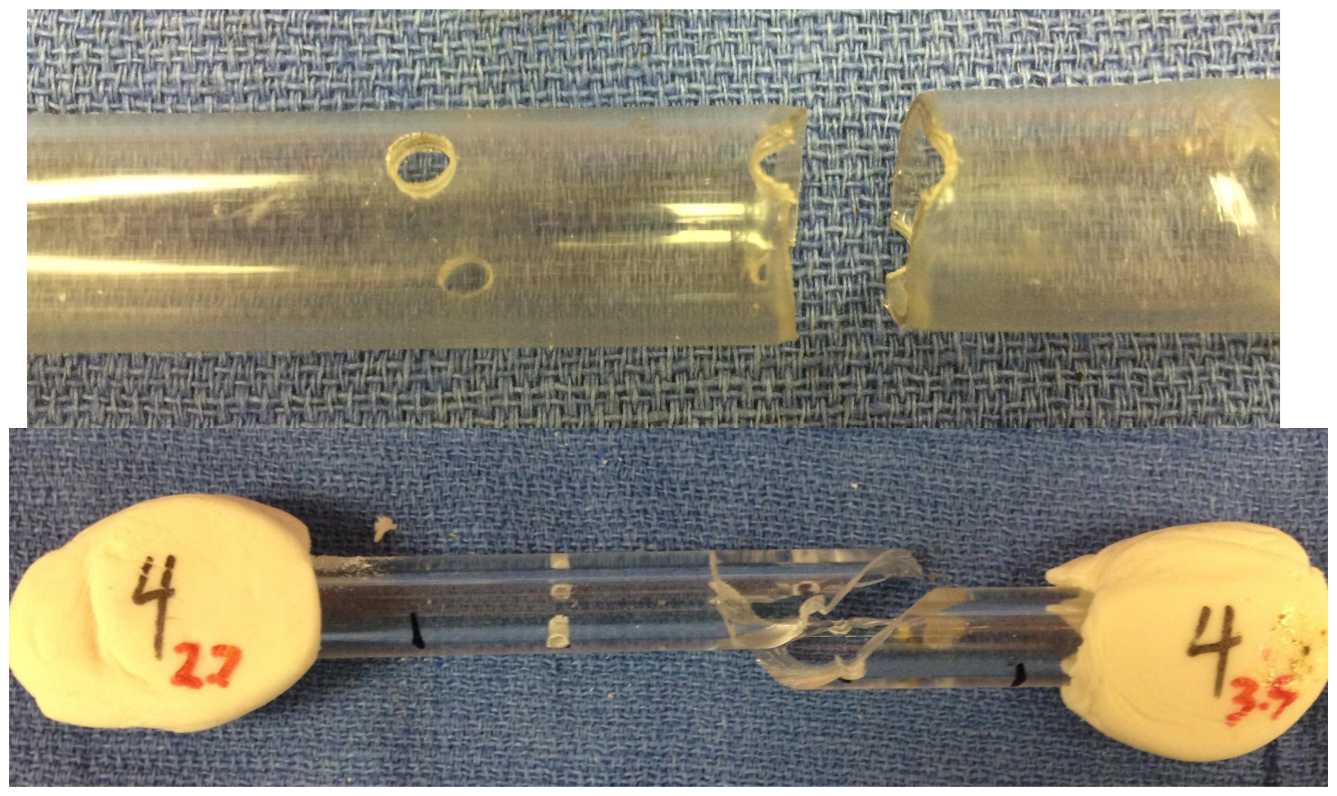

Figure 3 –The failure mode for bending was a transverse fracture through the 3.5 mm screw hole, top, and for torsion it was a spiral fracture through the 3.5 mm screw hole, bottom.

Discussion: Despite the high union rates achieved with 3.5 implants in the treatment of diaphyseal forearm fractures, re-fracture and peri-implant fracture remain significant concerns. In this study, we have provided strong evidence, in a biomechanical model, that fracture risk in the diaphyseal forearm is strongly correlated to screw hole diameter when comparing 3.5 and 2.7 mm screws. This supports the hypothesis that the current widely accepted use of 3.5 mm screws likely poses a greater risk of re-fracture than would the use of constructs with 2.7 mm screws. However, the effect of using 2.7 mm screws on construct stability and fracture healing rates is not known. Therefore, this study provides a strong rationale for further investigation of the use of 2.7 mm screws in forearm fracture fixation in order to determine if equivalent stability and fracture healing can be achieved as is seen with 3.5 mm implants. If equivalent fracture stability can be achieved with 2.7 mm implants, then the decreased risk of re-fracture should make these the preferred implants.

SIGNIFICANCE: The stress concentration effect of the screw holes is significantly reduced with 2.7 mm vs. 3.5 mm screw holes.

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