Biomechanical Comparison of Unicortical versus Bicortical Proximal Locking Screw in an Osteoporotic Distal Radius Volar Plating Model

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INTRODUCTION:

Distal radius fractures are common in older patients and are often associated with osteoporosis. Peri-implant fractures after distal radius volar plating were previously reported as a rare occurrence. However, with increasing preference for surgical treatment, the aging US population, and the low incidence of plate removal, the occurrence of distal radius peri-implant fractures is likely to increase. Peri-implant fractures most frequently occur at stress risers that, in the case of distal radius fixation, are usually at the proximal plate-bone interface and often traverse the proximal screw hole. The use of a unicortical screw in the proximal hole can theoretically decrease stress riser formation by eliminating the hole in the far bone cortex. The use of unicortical screws has been attempted previously, with multiple biomechanical studies showing decreased bending and torsional strength with a unicortical proximal screw. However, none of these studies used distal radius or osteoporotic models, and none used a locking proximal screw. We sought to investigate if there is a biomechanical advantage to using unicortical locking screws in the proximal hole of a volar distal radius plate in an osteoporotic model.

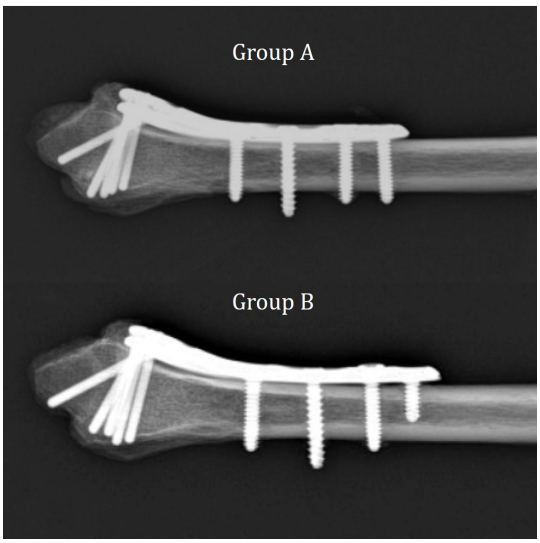
METHODS:

Twelve paired cadaveric radii were used. Bone density was analyzed using radiographs and measurement of bicortical thickness by previously described methods. Eleven of 12 pairs were confirmed as osteoporotic. Titanium 4-hole volar distal radius locking plates were used, which have three locking holes and one oblong non-locking hole. The plates were fixed to the radii and split into two paired groups: Group A used all bicortical shaft screws, with three locking and one non-locking screw; Group B used three bicortical and one proximal unicortical shaft screw, with three locking screws and one non-locking screw. Radiographs of representative constructs can be seen in Figure 1. Each construct was potted and tested for 4-point bending stiffness, torsional stiffness, and load to failure. Failure testing was performed in apex dorsal 4-point bending. During failure testing, the displacement of the shaft was measured using the material testing machine, beginning at 1 N of applied force and ending when failure occurred. Specimens were inspected after failure and the fracture pattern recorded.

RESULTS: Group B had a statistically significant increased displacement during load-to-failure testing when compared to Group A. There was no difference in load-to-failure between the two groups. Stiffness in apex volar bending, apex dorsal bending, internal rotation torsion, and external rotation torsion were similar between the two groups. All fractures occurred through the most proximal bicortical hole, which was the most proximal screw in Group A and the second most proximal screw in Group B.

DISCUSSION AND CONCLUSION:

Peri-implant fractures after distal radius volar plate fixation in patients with osteoporosis, though uncommon, are devastating injuries. Multiple strategies can be used to avoid peri-implant fractures, including timely osteoporosis management, strategic use of implants to match the elastic modulus of bone, and avoiding stress risers. A surgeon may use a proximal unicortical screw in their construct to avoid creating a proximal stress riser near the plate-bone interface. Our biomechanical study shows that this construct is not statistically different in stiffness or load-to-failure in apex dorsal bending but does allow greater displacement prior to failure. Such a construct may help avoid future peri-implant fractures in this vulnerable patient population.


Group A
Group B