EFFECT OF TUNNELS USED FOR SLIL RECONSTRUCTION AND OSTEOPOROSIS ON LUNATE MECHANICAL INTEGRITY

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DISCLOSURES: Albanese (N), Miller (N), Benoit (N), Mayers (N), Werner (4-Moximed)

INTRODUCTION: Recently, six cases of carpal collapse or bone necrosis after bone tunneling for ligamentous reconstruction were reported, three in the scaphoid and three in the lunate[1]. All cases were secondary to ligament reconstruction using wrist tendons for chronic scapholunate dissociations, with none having preoperative structural scaphoid or lunate deformities. Consequently, this study was initiated to assess if the presence of a bone tunnel, such as in the anatomic front and back scapholunate interosseous ligament (ANAFAB SLIL) reconstruction, would reduce the force to initiate compressive bone failure. Additionally, previous studies have demonstrated that the force required to pull out headless screws in osteoporotic/osteopenic carpal bones is less than in normal bones[2]. A secondary purpose was to determine whether the force required to cause carpal collapse in intact carpal bones might be lower in osteoporotic/osteopenic bones than in normal bones.

METHODS: Dual Energy X-ray Absorptiometry (DXA) measured ultra-distal radius bone mineral density (UDBMD, g/cm2) in 13 pairs of fresh-frozen cadaver arms (ave age 76.6 years; range 42 to 102) and was used to classify specimen groups as “normal” UDBMD or “low” UDBMD (osteopenic or osteoporotic) based on established criteria (Hologic DXA T-score standards). A 3.2 mm bone tunnel extending from dorsal to palmar, just ulnar to the scapholunate interosseous ligament, similar to that used with the ANAFAB procedure, was then drilled into one of each paired lunates. Of the 13 lunates with a tunnel, 5 were found to have an improperly located tunnel. Thus, the paired comparison evaluating the effect of a tunnel was based on 8 pairs of lunates. Lunates were extracted from each wrist, and micro-computed tomography (µCT) scans assessed the trabecular bone volume fraction (Tb.BV/TV). The proximal lunates were potted in 5 mm of bone cement with the lunate oriented in a neutral wrist position. The construct was clamped in an MTS fixture with a 3/8-inch threaded rod directly above the capitate-lunate articulating fossa. Unpolymerized cement was applied to the rod and lowered into the fossa so that the cement, once polymerized, matched the lunate’s articulating surface (FIG. 1). Under displacement control at 3 mm/min, a compressive force was applied to the capitate-lunate surface through the threaded rod and cement until 1.5 mm of crosshead displacement was reached. The peak force was recorded for each lunate. A paired t-test was used to assess the significance of differences in peak forces between intact and tunneled lunates in 8 pairs. A linear regression model was used to explore the relationship between bone volume fraction and peak compressive force in the 13 intact lunates. Specimens from osteopenic and osteoporotic individuals were compared to normal donors to determine the effect of trabecular bone volume fraction on peak force.

RESULTS: The presence of a 3.2mm bone tunnel in paired lunates significantly ($p = 0.02$) reduced the peak force from 1,119 N (std dev 874 N) in intact lunates to 866 N (std dev 766 N) in lunates with tunnels. FIG. 2 shows the reduction of compressive peak force in the mechanical test for a paired intact lunate and the contralateral lunate with a tunnel. A strong relationship (FIG. 3) between peak force and trabecular bone volume fraction was observed in the intact lunates ($R^2 = 0.67$, $p = 0.0006$). Donors with osteopenia or osteoporosis exhibited a lower peak compressive force in the lunate than normal donors, with values of 743 N (std dev 240 N) and 1,784 N (std dev 665 N), respectively ($p = 0.003$).

DISCUSSION: Bone tunneling has been described for various reconstructive procedures in the hand and wrist. Recently, there have been reports of bone tunnel collapse.[1] Our study supports the hypothesis that bone tunnel placement does weaken the bone and puts it at risk for collapse. The data showed that lunates with 3.2 mm ANAFAB-style bone tunnels experienced a significant 23% average decrease in peak compressive load compared to intact lunates. There was a 2.5x reduction in peak force in intact lunates from osteopenic and osteoporotic donors compared to normal donors, suggesting these donors may be at risk for carpal collapse. Additionally, bone density, measured by trabecular bone volume fraction, was positively correlated with peak compressive load, which is consistent with the findings from the capitate screw pullout test[2].

CLINICAL SIGNIFICANCE: This study supports the need to inform patients about the risks of carpal fracture, avascular necrosis, and related complications when considering intrinsic ligament reconstruction using carpal bone tunnels. Patients should be made aware of an increased risk of carpal collapse in osteoporotic/osteopenic bone. Physicians might consider preoperative evaluation of carpal bone health, including bone density and metabolic labs, before performing bone tunnel reconstruction techniques.

FIG 1

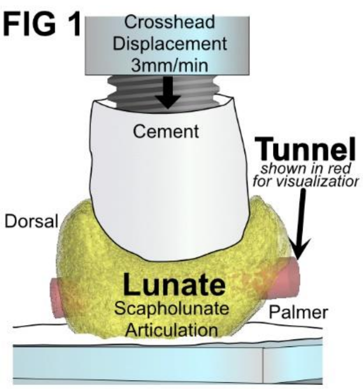


FIG 2

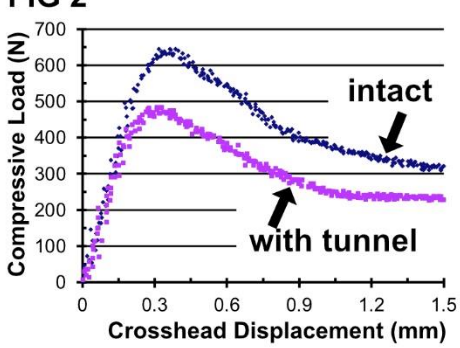
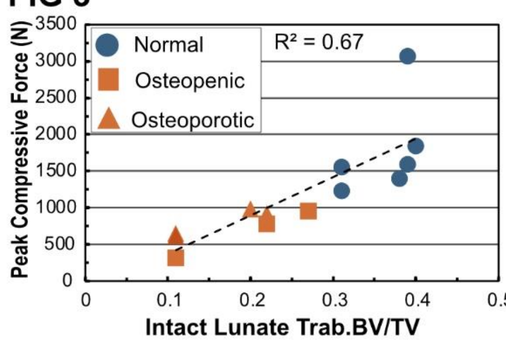


FIG 3



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