Comparison of Bone Mineral Density in the Distal Radius to Volar Plating Screw Mechanics.

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Disclosures:

Introduction: Fixation of fractures in osteoporotic bone has always been a challenge for orthopaedic surgeons. The most important mechanical problem in osteoporotic bones involves the interface between the screw and the bone where loosening often takes place. Several studies have looked at torque to failure in osteoporotic bone, but stripping also has been seen in normal bone as well and in particular with small pitch threads seen in the distal radius. The amount of screw insertion torque required for construct stability has been estimated to be at least 3 N·m. In some situations such as poor metaphyseal bone or osteoporotic bone, screw stripping can occur before the generation of sufficient torque, leaving the construct unstable. For plate and screw fixation in distal radius fractures, the overall rates were 30.2%, 16.8%, 32.3% and 25.9% for malunion, loss of reduction, loss of radial length and dorsal angulation.

Methods: Fifteen fresh frozen radii were dissected from forearms and bone mineral density (BMD) tests were determined using DXA. A volar plate was then placed on each radius and two 2.4 mm cortical screws, with 1.8mm pilot holes, were driven into the radial shaft. Measurement of torque was recorded for every 180° of rotation as well as maximum torque until stripping of the thread/bone interface occurred. This was repeated for 30 cortical screws. Two variable angle locking screws were then driven into the distal radii. This was repeated for 30 screws and the average insertion torque was recorded before locking. After testing insertion torque, a third cancellous screw was inserted in the middle of the distal portion of the plate to a depth of 60% of the screw length (12 mm), allowing the screw head to be gripped and pulled at a rate of 5 mm/min until failure. A load/displacement curve was generated, from which failure load was determined and compared to BMD.

Results: For the cortical screw insertion into the shaft of the radius, there was an initial spike in insertion torque when entering the near cortex, followed by a decrease as the screw traveled through the intramedullary shaft and then a large spike as the screw penetrated the far cortex. After the screw exited the far cortex, the torque decreased until the screw head came in contact with the plate. The maximum torque was recorded when the screw stripped or the head broke (red values in table). For cancellous screw insertion, the tracking of insertion torque did not yield any obvious peaks until the locking head engaged into
For the first cortical screw and second cortical screw, there were correlation coefficients of 0.79 and 0.90 for the peak torque before stripping respectively when comparing to the BMD, which suggests a high correlation between BMD and insertion torque. For the first screw, the average maximum torque needed to penetrate the far cortex was 0.607 N·m. For the first and second screw, the average minimum torque needed to strip the far cortex was 0.641 N·m and the maximum average torque without breaking the screw was 1.486 N·m. The total cortical thickness in the area of the diaphyseal bone ranged from 3.7 mm to 7.1 mm, which can also be used as a method for quantifying bone quality as the thickness correlates to BMD as one would expect. During testing, several screw heads torqued off the shaft of the screw, ranging from 1.266 N·m to 2.218 N·m, and since those are not representative of the bone/screw interface failure, they were not included in the data analysis, although it is important to know mechanically.

There was a high correlation between BMD and average cancellous insertion torque with correlation coefficients of 0.71 for the first cancellous screw and 0.60 for the second cancellous screw. However, the range of results was quite narrow with the minimum average torque being 0.021 N·m and the maximum insertion torque being 0.067 N·m, which is significantly smaller than the torque necessary to lock the screw into the plate. Also, there was a high correlation between BMD and pullout strength of the cancellous screw inserted 12 mm into the distal radius, with a correlation coefficient of 0.64.
Discussion: Based on the correlation coefficients comparing BMD and screw insertion torque for cortical screws, these values are highly correlated. When looking at the torque needed to lose purchase in osteoporotic bone and comparing it to the maximum amount of torque needed to attain bicortical fixation, a torque limit between 0.6 N·m and 0.75 N·m would allow for the best balance between bicortical fixation and not overloading the screw heads as well as damaging the screw/bone interface. For the cancellous screw insertion torques, the average torque also was highly correlated with BMD, but the torque values were well within the 0.02 N·m error of the measurement system and the small range (0.02-0.06 N·m) of insertion torques related to the plate/screw locking mechanism, thus any stripping of the bone occurred before stripping of the plate/screw locking mechanism.

Significance: The relation of bone mineral density to insertion torque can be used to develop better bone analogue materials as well as instrumentation for volar plating.

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