The need for a bail-out plan: Screw options for Osteoporotic Bone

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Introduction

Cortical screws have been proven to gain adequate purchase and achieve sufficient insertion torque in healthy bone. However, in osteoporotic bone or poor metaphyseal bone as seen in the foot, screw stripping can occur prior to generation of a sufficient torque for fracture fixation. This is particularly applicable to the geriatric population and diabetic Charcot bone. In this study it was hypothesized that a screw with a larger major/minor diameter ratio, an osteopenia screw, would provide improved bone purchase as compared to conventional screws. Thus, this type of screw could be used as a bail-out measure for screw stripping in osteoporotic bone, or as a primary choice for fixation with plates in cases of midfoot and hindfoot arthrodesis. This study was designed to evaluate the stripping torque and pullout strength of an osteopenia screw, in both bail-out and preemptive manner, as compared to a standard cortical screw.

Methods

Testing groups for this experiment were as follows: cortical screws [(5) 2.7mm cortical bone screws], osteopenia screws in bail-out manner [(4) 4.0mm osteopenia screws inserted into a hole stripped by a 2.7mm screw] and osteopenia screws used in a preemptive manner [(4) 4.0mm osteopenia screws].

For the stripping torque test, screws were inserted through a quarter tubular plate into a block of foam with a 2.0mm predrilled hole. 25.4mm thick low density (10pcf) solid rigid polyurethane foam blocks (n=4) (Pacific Research Laboratories, Vashon, WA) were used to simulate osteoporotic bone. Stripping torque was defined as maximum insertion torque reached by the screw before the screw began to spin freely in the foam. This torque was measured by a Himmelstein 50in-lb torque cell (Hoffman Estates, IL) and recorded by LabView 8.0 (National Instruments Corporation, Austin, TX).

Pullout tests were conducted on screws inserted to a depth of 20mm into the same test media with a 2.0mm predrilled hole. Axial pull-out testing was then conducted on a MTS testing frame (Eden Prairie, MN). A Jacob's chuck was used to apply a tensile load to the screws at a rate of 0.2in/min along its longitudinal axis while a data acquisition system recorded the maximum pull-out force.

For both tests, the screws were inserted by a custom screw testing machine at a rate of 5RPM and an axial load of 2.5lbs, to retain screwdriver engagement.
Results and discussion

The results of the testing agreed with the hypothesis that the bail-out screw (4.0mm osteopenia screw inserted after a stripped 2.7mm screw) would provide superior stripping torque and pullout strength as compared to the 2.7mm cortical screw. The bail-out screw showed a 57% increase in stripping torque \( p<<0.01 \) (Figure 1) and a 76% increase in pullout strength \( p<<0.01 \) (Figure 2) when compared to the 2.7mm cortical screw. Additionally, the bail-out screw only showed minor decrease in both stripping torque (6%, \( p=0.45 \)) (Figure 1) and pullout strength (11%, \( p<<0.01 \)) (Figure 2) when compared to the osteopenia screw tested in preemptive manner.

Conclusions

The osteopenia screw when used as a bail-out screw achieved superior stripping torque and pullout strength when compared to a standard cortical screw. The stripping torque of the osteopenia screw was not significantly influenced when used in the bail-out manner as compared to that in the preemptive manner; however, the pullout strength reduction was minimal. The results of this study indicate that the osteopenia screw of larger major/minor diameter ratio could be an effective bail-out option for screw stripping associated with osteoporotic fracture fixation, or in cases where elective fusions require optimal plate fixation and stability.