INTRODUCTION

Locked plate technology has evolved in an effort to overcome the limitations associated with conventional (non-locked) plating methods, primarily for improving fixation in osteoporotic bone. The relative contribution to construct stability of locked and non-locked screws has been evaluated for plating over relatively long spans of bone. There are clinical situations, however, where only relatively short segments of bone are available for plate-screw fixation. Given the potentially large bending moment concentrated over a short segment in such situations, locked screw fixation has a theoretic advantage over non-locked screws. Short segment fixation, therefore, represents another potential indication for locked plating yet there is no scientific data available evaluating differences in locked versus non-locked fixation over short segments.

The question that we wish to answer is: do short segment locked constructs provide improved stability over non-locked constructs in either non-osteoporotic or osteoporotic bone. The information gathered will provide objective data to enable surgeons to better understand the function and performance of plate constructs when only short segments of bone are available, and thereby improve their care of patients.

As the first step, a two-screw short segment fixation in a simulated osteoporotic bone was investigated. The purpose of this study was to compare the fatigue performance and construct stiffness of locked versus non-locked short segment fixation under a cyclical physiologically relevant combined loading condition in a simulated osteoporotic composite femoral shaft fracture model. Differences in construct stability, screw loosening, and failure mode were evaluated.

METHODS

Ten (10) fourth-generation Sawbones cylinders (Pacific Research Laboratories, Inc. model 3403-9) simulating composite femoral shafts were divided into two groups of five specimens each and assigned to either locked or non-locked distal short segment fixation. All bones were instrumented using PERI-LOC™ 4.5 mm Locked Plates (Smith & Nephew, Inc., Memphis, TN). A distal 18 mm gap simulated a comminuted fracture. Each plate was provisionally secured to the bone so that no gap existed between the plate and bone upon instrumentation. To simulate purchase in osteoporotic bone, all screw-holes were pre-drilled to 0.3 mm less than the diameter of the screw used. The pre-drill size was chosen to match stripping torque and pull-out strength of the model to what observed in osteoporotic cadaveric bones. Screws were then inserted and tightened to 3.96 N-m (35 in-lbs) of torque. Proximal fixation in all specimens was accomplished with four bicortical 4.5 mm cortical locking screws. Distal fixation was with two bicortical 4.5 mm screws, either locked (LD) or non-locked (NLD) (Figure 1). After instrumentation, the simulated osteoporotic composite femoral shaft Sawbones cylinder was potted with Fast Cast® both proximally and distally. Custom-made loading fixtures were used to facilitate the physiological combined loading configuration per ISO 7206-4 (2002(E)). All specimens were subjected to an axial cyclic compressive load of 22.3/223 N (5/50 lbf) at 2 Hz until failure or for 100,000 cycles. Failure was defined as hardware fracture, bone fracture, or a loss of function and performance of plate constructs when only short segments of bone are available, thereby improve their care of patients.

RESULTS

All locked constructs ran out to 100,000 cycles without construct failure. Four of the five non-locked constructs failed at an average of 28,936 ± 3,781 cycles due to distal screw sequential loosening from the most distal end (Figure 1b). One of the non-locked constructs ran out to 100,000 cycles, but post-fatigue examination showed noticeable loosening with no torsional resistance for both its distal screws. Locked constructs showed higher average stiffness than the non-locked constructs at all of the time point of measurements (p << 0.05, Figure 2). Locked construct stiffnesses decreased at a lower average rate (90%) than non-locked constructs. Regarding screw torque, 100% relative reduction was found with the two distal screws for the non-locked group. For the locked group, the average relative screw torque reductions for the second and the most distal screw were shown to be 57% and 61%, respectively.

DISCUSSION

Plate and screw fracture fixation constructs are stressed cyclically during the period of fracture healing while patients undergo rehabilitation. The magnitude of these stresses is especially high for short segment fractures. As opposed to non-locked screws where all screws will individually align to the direction of force and therefore allow for sequential screw toggle and pullout, the locked interface functions to mechanically unite all of the screws to the plate and form a single beam. Thus, the locked plate-screw devices are theoretically advantageous for maintaining short segment fracture stability; however, little data to support this theory exists. The results of this study indicate that when tested in a simulated osteoporotic bone condition, a synthetic bone model with osteoporotic screw purchase, locked short segment fracture fixation constructs are advantageous to maintain stability.

REFERENCES: