Assessment of Extraction Torque for Dual Acid Etched Lag Screw Inserted in Sheep Femoral Heads

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Introduction: Today bone fractures are routinely treated with internal and external fixation methods. Fixation is dependent upon the preservation of the bone screw interface. Intertrochanteric hip fractures are among the most common bone injuries treated with internal fixation. Loss of fixation, however has been shown to be prevalent in the treatment of these proximal femoral fractures in elderly patients. Intertrochanteric fractures internally fixed with lag screws has a failed fixation rate of 5 – 23% (1-4). Moroni et al. (3) performed a prospective study comparing standard stainless steel lag screws with hydroxyapatite (HA)-coated lag screws to treat intertrochanteric fractures in elderly patients with osteoporotic bone. Patients treated with HA-coated screws demonstrated no failures compared to a failure rate of 6% with standard screws. Rather than coating screw threads with bone-like substances other researchers have looked at modifying surface morphologies to biologically enhance fixation. Bone cells have shown a higher rate of attachment to Titanium (Ti) with a roughened surface compared to standard machined metal surfaces (5,6). Similarly, the synthesis of extracellular matrix and attendant bone formation can be enhanced on roughened or porous coated Ti (6,7). The dual acid-etching (DAE) process employed in commercial Osseotite implants creates a roughened Ti surface, with out the negative effects associated with grit blasting or plasma spraying (8,9). Dual Acid Etching creates a surface environment (1-3 μm peak – peak, 5-10 μm peak – valley) that is favorable for bone fixation. Several studies utilizing animal models have demonstrated improved osteointegration with DAE treated bone screws.

The purpose of the this study was to evaluate whether applying the DAE surface treatment to hip lag screws would improve fixation at the bone screw interface.

Materials and Methods: The surgical and postoperative care protocols used in this study were fully approved by the Institutional Animal Care and Use Committee. Skeletally mature male Wether sheep used in this study. Six animals had a standard Ti and a DAE Ti telescoping lag screw (Biomet p/n 29212) implanted bilaterally in the femoral heads. The screws were placed percutaneously in the femoral head and insertion torque was measured. At six months animals were euthanized for screw removal and extraction torque was measured. An unpaired Student’s t test was used to evaluate the differences in extraction torque and insertion/extraction torque ratio between each implant surface.

Results: Extraction Torque: One animal did not survive the six-month post implantation period and was euthanized 2 months PO (rear limb lameness). Standard Ti lag screws: All screws were removed by hand without implant failure. The mean extraction torque was 21.95 +/- 0.37 dNm. The mean ratio of extraction/insertion torque was 0.37 +/- 0.23 Ti DAE Ti lag screws: All screws were removed by hand without implant failure. The mean extraction torque was 83.54 +/- 24.5 dNm. The mean ratio of extraction/insertion torque was 2.24 +/- 0.60.

The DAE surface demonstrated a significantly (p < 0.05) higher extraction torque and extraction/insertion torque than that of the standard surface.

Histology & Histomorphometry: All sections were evaluated for qualitative histology using standard undecalcified sections evaluated with a Zeiss light microscope at 200x magnification. Standard Ti Lag Screws: Normal connective tissues were seen in all histologic sections. Minimal or no bone was evident within the individual screw threads. Some fibrocartilage and fibrous tissue was observed in the outer 1/3 of the thread area.

DAE Ti Lag Screws: Normal connective tissue was observed in all histologic sections. Bone, vessels, marrow, lipids, and fibrocartilage were evident in all DAE Ti screw threads. Bone was in direct apposition to the screw surface within the threads.

Digitized images of the histologic sections were used to measure the bone area within each screw thread of the implant. Olympus MicroSuite Pathology Edition software was used to calculate the area by outlining the thread surface from one outer thread point to the adjacent point. The area of each measured zone was approximately 3.55 mm². Four screw threads (8 zones) were used to calculate the percent of bone within the threads.

Standard Ti Lag Screws: Only three (3) screw threads of eight (8) had bone within the measured area. In all eight measured zones the total area of bone was 1.597 mm² (5.6 % total area). The remaining area was void or filled with fibrous tissue and or fibrocartilage.

DAE Ti Lag Screws: All eight zones measured within the screw threads had bone. The total amount of bone within the 8 measured zones was 21.481 mm² (76 %). The remaining area was filled with vessels, marrow, lipids, and fibrocartilage.

Discussion: Measuring extraction torques has been established as an acceptable method to assess the fixation of various screw type bone fasteners (10). By implanting standard and DAE screws into the right and left femoral heads of the same animal we were able to make a direct comparison of our experimental screw (DAE) to an internal control. The DAE screws tested in this sheep model had a statistically greater extraction torque and extraction/insertion torque ratio than the standard machined screws at 6 months post implantation. This is likely due to the microtopographical surface alteration created by the DAE process promoting the observed increased osteointegration and thereby increased strength at the bone screw interface. Several animal studies have been performed in order to demonstrate enhanced bone fixation of DAE screws, but to our knowledge this was the first study looking at enhanced fixation of a DAE lag screw in the femoral head. Results from this study demonstrate that DAE screws extracted from the femoral heads of sheep at 6 months required more than 3 times the extraction torque for standard screws. Though fixation of the screw heads actually improved over that at the time of implantation all screws were removed without implant failure or damage to the bone.


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