BIOMECHANICAL STUDY OF THE COMPARISON OF PROXIMAL SCREW CONFIGURATIONS IN A SUBTROCHANTERIC FRACTURE MODEL

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ABSTRACT INTRODUCTION

Unstable subtrochanteric femur fractures are difficult to repair secondary to the multitude and strength of the forces that act in the area of the hip. The proximal segment is flexed, abducted and externally rotated by the ileopsoas and the gluteus muscles. Also, extensive comminution is often seen, complicating internal fixation. The forces acting on the bone in the area are enormous; an 890 Newton man can generate 8.3 megapascals of compressive stress along the medial aspect of the proximal femur, 2.5 – 7.5 cm distal to the lesser trochanter. Lateral femur forces in this region are tensile in nature and are almost the same magnitude as the compressive forces on the medial femur. Hip reaction forces can reach three times actual body weight simply by muscle contraction.

Many methods of repair have been tried, each with their own subset of complications. Non-operative management (traction) has unacceptable results with displacement, shortening of the femur, and varus malformation. Operative management has included the following: plating, AO angled blade, intramedullary (IM) nail, Enders nail, Zickel nail, hip screw, and most recently the reconstruction nail. Each of these operative methods has complications of varus malformation, shortening, lengthening, mechanical failure, protrusion of the various nails into the joint, non-union, malunion, among others.

The superiority of intramedullary interlocking nails when used for fixation of subtrochanteric fractures has been demonstrated. Second-generation IM nails provide more stability than the first-generation nails in unstable subtrochanteric fractures. With the advent of the reconstruction nail, studies have now shown that the reconstruction nail provides additional stiffness and strength to subtrochanteric fracture repair.

The purpose of this study was to assess two screw configurations that are possible when utilizing the DePuy Reconstruction Nail. This nail is a second-generation trochanteric nail that is placed into the intramedullary canal in an antegrade fashion. The first screw configuration that was tested was the traditional configuration with two cephalomedullary screws into the femoral neck. The comparative configuration was one cephalomedullary screw into the femoral neck, and a second screw placed antegrade into the lesser trochanter. This resulted in a crossed proximal screw configuration.

Our hypothesis was that the crossed screw configuration in the reconstruction nail would be as strong in axial loading as the dual cephalomedullary screw configuration.

MATERIALS AND METHODS

The DePuy Reconstruction Nail is a trochanteric entry nail that allows the testing of two different proximal screw configurations. One option is to place two parallel 6.5 mm screws, angled at 125 degrees into the femoral neck. The other option is to place one screw into the femoral neck and another 6.5 mm screw antegrade into the lesser trochanter, creating a crossed configuration. This nail has the following specifications:

- 13 mm proximal diameter, 11 mm distal diameter
- 2.5 degree anterior bend
- 12 degrees anteverision
- 6 degrees lateral bend
- Two 6.5 mm, 125 degree angled femoral neck screws
- Two distal locking screws.

Synthetic femurs (Pacific Research Labs, Inc., Vashon, WA) were used in order to decrease intra-sample variability found among cadaver femurs. Ten synthetic femurs measuring 455 mm in length with 11 mm canals were instrumented utilizing each screw configuration (twenty total femurs). Two distal locking screws (4.5 mm) were placed in each configuration.

Uninstrumented femurs were potted in Cerrobend alloy to the levels of the condyles distally. The femoral head was then centered with a jig in order to mimic single leg stance. Lateral and mediolateral strain gauges were applied to the femoral shaft 7 cm below the lesser trochanter. Prior to instrumentation, the femurs were tested five times at 10 N/s to a 1500 N axial load. A Materials Testing System (MTS 858, Eden Prairie, MN) with an acetabular cup attached to the vertical load actuator of the MTS to hold the proximal end of the synthetic femur was used for testing.

The femurs were then reamed to 13.5 mm in order to accommodate the 11 mm diameter implant. The DePuy Reconstruction nail was placed, proximal screws placed, and distal locking screws placed.

The unstable fracture was created by removing a 3 cm segment of the proximal femur extending from 1 cm to 4 cm below the lesser trochanter. Five loads at 10 Newtons per second (N/s) to 1500 Newtons (N) were repeated. Each femur was then tested to failure at a rate of 10 N/s. Failure was defined as screw cutout, plastic deformation of the implant or fracture of any part of the construct. If none of the failure criteria were directly observed, a sudden decrease in force, evidenced in the force-displacement diagram, was indicative of fracture of the construct.

RESULTS

Twenty femurs were analyzed: ten with parallel screw configuration and ten with the crossed screw configuration. One femur in the parallel screw configuration was not considered in the final analysis due to malfunction of the MTS during conditioning. The crossed screw configuration failed in axial load at a significantly higher load (p=0.017). The parallel screw configuration failed at an average load of 2301 Newtons (sd 443.6 N). The crossed screw configuration failed at 2848 N (sd 391.3 N).

DISCUSSION

The ability to stabilize an unstable subtrochanteric femur fracture with a reconstruction nail is well recognized. Given that these fractures are only 10% of hip fractures, or are seen in high-energy trauma patients, orthopedic surgeons may not be familiar with the challenge of driving two cephalomedullary screws up the narrow femoral neck. Given that the difficulty in stabilizing these fractures is the requirement for the medial cortex buttress to be rebuilt, the stronger construct in our unstable fracture model would allow for stronger stabilization with less operative time spent attempting to re-align the medial buttress.

The placement of the crossed screw configuration is technically less difficult than placement of two cephalomedullary screws in the narrow femoral neck. The crossed screw configuration appears stronger in axial loading. The crossed screw configuration would potentially make the management of unstable, comminuted fractures involving the subtrochanteric area of the femur technically less challenging.

REFERENCES