INTRODUCTION:

The orthopedic literature reports an incidence of simultaneous femoral neck shaft fractures in 2.5 to 6% of all femoral shaft fractures [1]. In the majority of cases, the femoral neck fracture is vertically oriented and minimally displaced, often making it difficult to appreciate in the trauma x-rays [2]. This injury generally occurs in young adults and is mostly due to high-energy trauma mechanisms [3]. Two major complications are associated with the femoral neck fracture – osteonecrosis of the femoral head and nonunion of the neck fracture [4].

All series in the literature agree that stable anatomic fixation of both the neck and shaft fractures leads to the most satisfactory outcomes. Treatment choices are abundant; there have been over sixty recommended methods of fixing this type of fracture combination. [5]. The four most common methods of fixation of this fracture combination are: retrograde nails with cannulated screws, antegrade nails and cannulated screws, cephalomedullary reconstruction nails, and AO plating with cannulated screws.

Our objective in this study was to measure and compare the axial and torsional stiffness of the four methods of fixation commonly utilized to stabilize ipsilateral femoral shaft and neck fractures in a simulated femur fracture model.

MATERIALS AND METHODS:

Twenty-four synthetic femora (Pacific Research, Vashon WA, USA) were obtained and baseline axial stiffness data was obtained by loading each five times to 1500 N at 10 N/sec in an MTS 858 Bionix servohydraulic materials testing frame. Each femur was then randomly assigned to one of four test groups:

- **Antegrade Group:** 11.5 mm titanium alloy antegrade nail with proximal and distal locking screws plus 2 parallel 6.5 mm x 100 mm cannulated titanium screws around the nail for the femoral neck.
- **Retrograde Group:** 11.5 mm titanium alloy retrograde nail with proximal and distal locking screws plus 3 parallel 6.5 mm x 100 mm cannulated titanium screws for the femoral neck.
- **Reconstruction Group:** 11.5 mm titanium alloy reconstruction nail inserted in an antegrade fashion with 2 distal locking screws and two proximal locking bolts placed into the femoral head for simultaneous locking of the nail and fixation of the neck fracture.
- **Plate Group:** A 4.5 mm wide DC plate with 8 cortices of proximal and distal fixation plus 3 parallel 6.5 mm x 100 mm cannulated titanium screws for the femoral neck.

All nails were closed section with a length of 44 cm for antegrade and 40 cm for retrograde insertion. The reaming of the canals was to 13.5 mm. After instrumentation, a simulated fracture of the neck and shaft were created by cutting a circumferential osteotomy with a coping saw 1 mm thick at the base of the femoral neck and removing a 3 cm defect from the femoral midshaft to simulate an unstable, comminuted fracture pattern.

The instrumented femurs were then attached to a custom jig that secured the proximal and distal ends with the femoral head and center of the femoral condyles collinear with the MTS actuators. Each femur was the elastically loaded in axial compression/bending to 800 N for five cycles at 10 N/sec with load and displacement continuously recorded. Torsional stiffness was measured by applying a 1 deg. rotatory displacement with continuous recording of angle and torque measurements.

RESULTS

Comparison of the baseline data showed that the four randomly assigned groups of synthetic femora were statistically equivalent.

<table>
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<tr>
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<th>Axial Stiffness (N/mm)</th>
<th>Torsional Stiffness (N-m/deg)</th>
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<tbody>
<tr>
<td><strong>Antegrade</strong></td>
<td>210 ± 26</td>
<td>1.18 ± 0.20</td>
</tr>
<tr>
<td><strong>Retrograde</strong></td>
<td>251 ± 26</td>
<td>1.83 ± 0.39</td>
</tr>
<tr>
<td><strong>Reconstruction</strong></td>
<td>442 ± 34</td>
<td>1.54 ± 0.19</td>
</tr>
<tr>
<td><strong>Plate</strong></td>
<td>192 ± 45</td>
<td>2.06 ± 0.54</td>
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Single factor ANOVA and subsequent post-hoc evaluation showed that the reconstruction group were significantly stiffer (p<0.05) under axial loading and that the antegrade group was significantly less stiff in torsion (p<0.02). There were no other statistically significant differences in axial loading (compression/bending) or torsional loading. The plate construct had the highest torsional stiffness as would be expected since the mass of the plate is off the rotatory axis. The relatively low torsional stiffness of the antegrade construct may reflect the fact that only two cannulated screws could be inserting around the nail into the femoral neck whereas three screws were used in the retrograde and plate fixation schemes.

DISCUSSION

Ipsilateral femoral neck and shaft fractures was first discussed by Delaney and Street in 1953 [6]. The most common mechanisms for this fracture are motor vehicle accidents, motorcycle accidents and falls from significant heights [1]. The femoral neck fracture is often missed initially; studies have shown that almost 19% of neck fractures were missed in a review of the trauma x-rays.

This study demonstrated that the reconstruction nail was stiffer in compression/bending than the other constructs and the plate was stiffer under torsional loads. The advantage of the reconstruction nail is that the proximal locking screw is placed through the nail and into the femoral neck. However, the neck fracture must be identified preoperatively to make use of this device.

If the neck fracture is identified during or after fixation of the shaft fracture, the addition of cannulated screws into the femoral neck results in a stable construct.

REFERENCES


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