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# Shortening of the Femoral Neck Following Peritrochanteric Fracture

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## Summary

Proximal femoral neck and peritrochanteric fractures are a devastating musculoskeletal injury resulting in markedly increased patient morbidity and mortality. As the annual incidence of fracture continues to increase, there is a recognized need to improve clinical outcomes following fixation, especially in peritrochanteric fractures. While many factors are associated with adverse patient outcomes, the collapse and shortening of the femoral neck that can occur during osteosynthesis of neck fractures or in surgically treated unstable peritrochanteric fractures may represent a preventable complication. Femoral neck shortening is known to decrease the moment arm of the hip abductors reducing patient function. Contemporary internal fixation devices for neck fractures allow head-neck fragments in peritrochanteric fractures to slide along/together with the implant, increasing the risk of an unlimited compression and collapse. However, the newly developed INTERTAN® intertrochanteric antegrade nail improves rotational fracture stability and allows for intraoperative interfragmentary compression, thereby reducing the erosion of the fracture surfaces between the lateral end of the neck fragment and the trochanteric region that might result in uncontrolled collapse with the risk of shortening.

## Introduction

Despite contemporary advances in orthopaedic technology, hip fracture remains one of the most devastating musculoskeletal injuries. [1] Increased mortality is a well-established risk following fracture, with approximately 20-24% of patients dying within the first year of injury. [2-4] Further, 50% of surviving patients have to live with a reduced ability to walk following fracture union, which critically affects functional recovery and quality of life. [1, 5]

Rates of fracture related mortality and morbidity are expected to increase markedly as life-expectancy of the population grows. [6, 7] An estimated 280,000 fractures occur annually in North America. [8-10] That value is expected to increase to over 500,000 during the next 30-50 years, with the global incidence of hip fracture exceeding 4.5 to 6.3 million annual cases. [8-13] This sharp increase in hip fracture will likely contribute to a cumulative health-economic cost burden of $240-$474 billion. [9, 14] Accordingly, there is a recognized and growing need to improve clinical outcomes following fracture fixation, especially with peritrochanteric fractures. [13]

Advanced age, cognitive dysfunction, and social inactivity have all been associated with adverse patient outcomes. [1, 15]

However, the primary contributing factor to patient morbidity after hip fracture is the relatively high frequency of revisions and complications. [16, 17] In particular, uncontrolled collapse and subsequent shortening of the femoral neck, which can result in impaired function, decreased strength, and leg length discrepancy, are complications that may be prevented with improved internal fixation device technology. [8]

## Patient function after fracture

Functional outcomes following hip fracture have been previously reported in the orthopaedic literature. Barnes and Dunovan [18] assessed independent ambulation in 65 femoral neck fracture patients. The investigators measured 10 outcome variables, correlating each to patient walking ability. Study results demonstrated that patient age, leg contracture, surgical technique, number of physical therapy visits, and number of days from hospital discharge can all affect ambulation. However, an important finding is that strength of the affected hip abductor muscles was positively correlated with walking ability. The investigators suggest that loss of strength could be the result of muscular atrophy following prolonged patient inactivity. However, additional evidence suggests that the actual cause could be shortening of the femoral neck following fracture union.

Zlowodski et al [16] measured function in 56 patients with united femoral neck fractures treated with multiple cannulated screws. A radiographic comparison of the fractured and contralateral hips was performed to assess incidence of neck shortening. Patient function was measured utilizing the Short Form-36 (SF-36) functional outcome questionnaire. The authors reported a shortening rate of 31% and 27% for undisplaced and displaced fractures, respectively. The average decrease in femoral neck length was 8 ± 5 mm, resulting in a concurrent abductor moment arm decrease of 10 ± 4 mm. Radiographs illustrating a shortened femoral neck can be found in **Figure 1**. Patients with shortening demonstrated statistically reduced Physical Function and Role Physical SF-36 subscores. During a follow-up investigation, Zlowodski et al [8] assessed patient function according to the degree of neck shortening. Average shortening was < 5 mm (mild) in 34%, 5 mm to 10 mm (moderate) in 36%, and > 10 mm (severe) in 30% of respective cases. The average decrease in abductor moment arm was 7 mm (range: 0 to 23 mm). Results of this investigation showed that SF-36 Physical Function and EuroQol questionnaire (EQ5D) scores were significantly greater for the mild versus moderate group. Further, patients with moderate shortening had significantly greater function scores when compared to those with severe shortening. This data suggests that decreased patient function is negatively correlated with reduced femoral neck length.

**Figure 1: Radiographic images of shortened femoral necks following fracture**

The reported incidence of decreased patient function following fracture appears to be caused primarily by a biomechanical inefficiency of the hip abductors. The gluteus medius and gluteus minimus, which insert at the greater trochanter of the proximal femur, serve to counteract vertical weight-bearing forces and stabilize the pelvis during gait. [16] Shortening the femoral neck decreases the moment arm of the abductors, increasing requisite muscular force and joint reaction forces during functional activities. [13-16] In contrast with the orthopaedic trauma literature, dealing with the results after osteosynthesis of neck as well as periotrochanteric fractures, this phenomenon is well documented during total hip arthroplasty where utilization of high neck offsets has been shown to decrease implant wear and abduction force required during normal gait. [19-22] However, the perceived clinical importance of femoral neck shortening appears to be increasing amongst orthopaedic trauma surgeons. In a recent survey, 89% and 69% of responding surgeons confirmed that shortening does reduce hip abductor and patient function, respectively. [13] Moreover, the authors note recognized limitations with contemporary internal fracture fixation devices. Specifically, clinical outcomes are limited by relatively high procedure revision rates of approximately 35%, and the inability of existing screw and compaction mechanisms to stop shortening. [13, 17, 23]

### Prevention of femoral neck shortening

The most common internal fixation devices for femoral neck fracture feature parallel screws or sliding hip screws coupled. [8, 24, 25] Both mechanisms allow for dynamic compression of the fracture along the gliding mechanism during weight-bearing, supporting union and largely equivocal clinical outcomes. [13, 25, 26] However, both designs also allow unnecessary, sometimes excessive sliding of neck fracture fragments together with the lag/compression screw within the bevel and along the implant. [16] This feature can result in unlimited compression and collapse of the fracture, thus increasing the risk of malunion and shortening. [16, 27-29] In addition, this collapse can increase the risk of prominent and painful lateral screw protrusion. [27] Therefore, these devices may not be capable of eliminating complications associated with collapse and shortening of the femoral head/neck fragment in peritrochanteric fractures. [27, 30]

A promising alternative to sliding screw designs are intramedullary nails developed specifically to treat peritrochanteric fractures. Ruecker et al [27] report the clinical outcomes of 100 patients with peri- as well as subtrochanteric fractures implanted with a recently developed intertrochanteric antegrade nail (INTERTAN®, Smith & Nephew, Inc., Memphis, TN, USA; **Figure 2**). This device features a unique integrated, interlocking screw mechanism that has a "rack and pinion" design (**Figure 3**). Following insertion of the lag screw into the head/neck fragment through the nail, a smaller compression screw is inserted, engaging the lag screw and enabling an active linear compression of the head/neck fracture with the lateral fragments interoperatively. Compression remains under the control of the surgeon. The advantage of this design is that necessary compression can be applied to the fracture intraoperatively, controlled and with the required amount of force. This helps to avoid disruptive rotational forces on weight bearing, during post operative ambulation, thus preventing erosion of the fracture surfaces, uncontrolled collapse, and shortening of the femoral neck. [27] In addition, this integrated mechanism of lag and compression screw prevents the Z-effect described by Werner-Tutschku, et al. [31] In devices with two separate, unlocked screws, disproportionate load bearing can increase the risk of back out of the inferior lag screw, migration of the superior antirotation or compression screw into the acetabulum, and varus collapse. [27, 31] During the current study, there was no incidence of neck malunion, nonunion, uncontrolled collapse, or Z-effect at a minimum follow-up of 1 year. No shortening was observed in 73% of cases, while 27% exhibited mild shortening of < 5mm. Further, there was no significant difference in pre- and post-fracture Barthel Index scores, a measure of function during activities of daily living. Overall, 90% of patients recovered their pre-fracture functional status.

### Conclusion

Contemporary internal fixation devices have proven effective in achieving union following peritrochanteric fractures. However,

**Figure 2: INTERTAN Intertrochanteric Antergrade Nail (Smith & Nephew, Inc., Memphis, TN, USA)**

**Figure 3: INTERTAN interlocking screw construct. Compression pulls the fracture laterally while medializing the nail, unloading the lateral wall.**

parallel and sliding hip screw designs have not reduced the complication risk associated with femoral head/neck fragment sliding, leading to collapse and ultimate shortening. There is evidence that a newly developed intertrochanteric antegrade nail may support better function by improving rotational stability, based on the achievable, controlled, intraoperative interfragmentary compression between the head/neck fragment and the lateral trochanteric area, thus reducing the incidence of collapse and shortening. Furthermore, there is, except for transverse and short oblique shaft fractures in the femur and tibia after dynamic nailing, no other orthopaedic trauma entity in which the surgeon relies on secondary compaction to create interfragmentary compression, allowing final setting of the fracture anatomy by uncontrolled forces. One wonders why we continue to do so, if a superior nail technology is available. Therefore, further clinical research is warranted to establish the effect of this device on overall patient morbidity.

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