



Cannulated screw fixation for femoral neck fractures using a fully threaded versus a partially threaded screw as an inferior screw

© J ORTHOP TRAUMA SURG REL RES

17(7) 2022

Review

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Received: 11.07.2022;

Manuscript No. jotsrr-22-79188;

Editor assigned:

12.07.2022, PreQC No. jotsrr-22-79188 (PQ);

Reviewed: 26.07.2022, QC No. jotsrr-22-79188 (Q);

Revised: 3.08.2022,

Manuscript No. jotsrr-22-79188 (R);

Published: 9.08.2022,

DOI. 10.37532/1897-2276.2022.17(7).72

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Abstract

Objectives: To evaluate the outcomes of a fully threaded versus partially threaded medial calcar screw-in Femoral Neck Fractures (FNF) and its effect on Femoral Neck Shortening (FNS) A retrospective cohort study.

Setting: One academic medical center. Saint Louis University Hospital. (Level 1 Trauma Center)

Patients/Participants: Seventy-eight skeletally mature patients with intracapsular FNF (18 Garden 1, 42 Garden 2, 8 Garden 3, and 10 Garden 4) received treatment between July 2012 and November 2018 at a single Level 1 Trauma hospital with percutaneous pinning with a cannulated screw system to ensure successful union.

Intervention: In situ percutaneous pinning with 3 cannulated screws in an inverted triangle orientation with a partially or fully threaded medial calcar screw.

Main Outcome Measurements: Femoral neck fracture varus collapse and femoral offset shortening in both the horizontal (X), vertical vectors (Y), and combined vector (Z).

Secondary Outcome Measurements: Basic demographic information including age, sex, and ethnicity; index operative procedure; comorbidities including diabetes, hypertension, vascular disease, body mass index, smoking, posterior comminution, and nonunion.

Results: Patient demographics, significant complications, and nonunion rates were similar in the two groups ($p > 0.05$). Femoral neck shortening along the X-axis ($p = 0.387$), y-axis ($p = 0.782$), and z-axis ($p = 0.651$) when comparing fully threaded screws vs. partially threaded screws.

Conclusions: This study demonstrates that using a fully threaded medial calcar screw is associated with non-inferior radiographic results in femoral neck fractures.

Keywords: femoral neck fracture, partially threaded screws, fully threaded screws

INTRODUCTION

Femoral neck fractures continue to be a challenging problem for orthopaedic surgeons. Over the next 20 years, with a growing aging population, the incidence of these fractures is projected to increase exponentially [1]. In practice, nondisplaced fractures and displaced fractures in young patients are treated with internal fixation with cancellous, parallel placed, partially threaded screws fixation in an inverted triangle configuration confirmed with fluoroscopy [2]. The reasoning behind the use of partially threaded screws is two-fold: to enable healing by controlled fracture impaction along with the implant and to avoid nonunion due to a persistent fracture gapping.

The FAITH study, which compared parallel cannulated screws for internal fixation with a sliding hip screw device, demonstrated no difference in rates of reoperation, complications, or health-related quality of life measures between these two implants. However, the use of sliding implants has been associated with excessive fracture collapse, causing a shortened femoral neck. The arthroplasty literature suggests that a shortened femoral neck can cause abductor muscle weakness as a result of decreased abductor lever arm length and changes in gait. In addition, recent studies demonstrated that femoral neck collapse after cannulated screw fixation is associated with lower functional outcomes. Finally, the FAITH study showed a mean femoral neck collapse of 6 mm in 216 nondisplaced fractures. These findings expose the importance of exploring different methods to reduce femoral neck shortening [3].

We believe that providing a length stable implant in the inferior calcar region of the femoral neck with a fully threaded screw will minimize femoral neck shortening and varus angulation. This study aims to evaluate the outcomes of a fully threaded versus partially threaded inferior calcar screw in femoral neck fractures and its effect on Femoral Neck Shortening (FNS). We hypothesized that the magnitude of femoral neck fracture collapse and offset shortening would be significantly lower for patients treated with a fully threaded medial calcar screw and no difference in complication rates.

LITERATURE REVIEW

PATIENTS AND METHODS

Patient selection criteria following approval by the institutional review board (protocol H-30219), a level 1 academic medical center database was queried by Current Procedure Terminology (CPT code 27235) for a case series of patients who received internal fixation for a femoral neck fracture between July 2012 and November 2018. Inclusion criteria were orthopedic trauma patients between 18 years-90 years old treated for a femoral neck fracture with operative internal fixation to a successful union. Exclusion criteria were prior hip surgeries, a significant trauma defined as having an Injury Severity Score (ISS) of greater than 15, >2 fractures, presence of visceral injury, presence of brain bleed; operative intervention by any alternative method, follow-up < 2 months, stress fractures, pathologic fractures, gunshot fractures, and insufficient chart information. Demographic data for patients that met inclusion criteria were: age at injury, sex, BMI, cardiac comorbidities, smoking status, presence of posterior comminution, ASA classification, AO/OTA classification, Pawel classification, Garden classification, and Nonunion rates. For analysis, patients were grouped as having a fully threaded medial calcar screw or a partially threaded medial calcar screw [4,5].

SURGICAL TECHNIQUE

A standard fracture table with in-line traction was used on all patients. Acceptable reduction was achieved with the closed reduction technique in all fractures according to Lowell criteria. None of the fractures underwent an open reduction. Fixation was achieved under fluoroscopic guidance. Three guide wires were placed in an inverted triangle orientation with position confirmation on anteroposterior and lateral fluoroscopic views. The inferior implant was placed adjacent to the calcar to facilitate buttress fixation of the inferior-medial cortex. A 6.5 mm to 7.3-mm cannulated partially threaded screw implant was used inferiorly, depending on the patient's size. Two superior screws were placed in separate quadrants, anteriorly and posteriorly, with care taken to ensure placement adjacent to the posterior cortex. All

screws were measured and appropriately sized. The decision to place a fully threaded medial calcar screw was made at the surgeon's discretion. Five trauma fellowship-trained orthopedic surgeons performed the surgeries. All patients were made weight-bearing as tolerated after surgery [6,7].

RADIOGRAPHIC CLASSIFICATION

Standard AP pelvis, AP hip, and lateral hip radiographs obtained at the time of injury were reviewed by an orthopedic trauma surgeon and classified according to the Garden system. The absence of displacement was discerned by examining the trabecular lines in the femoral head, neck, and acetabulum. Nondisplaced and valgus impacted fractures were classified as type 1. Complete but nondisplaced fractures were considered type 2 fractures. Complete and less than 100% displaced were considered type 3, while complete and 100% displaced were considered Garden [8-11].

QUANTITATIVE ASSESSMENT OF FEMORAL NECK FRACTURE COLLAPSE

Patients underwent the same radiographic protocol at 2 weeks, 6 weeks, 2 months, and if necessary, at final follow-up using a standard protocol with the patella facing up. We examined the following radiographic data: Initial fracture displacement (mm), femoral neck shortening (mm), shortening along the X-axis (mm), shortening along the Y-axis (mm), along the Z plane (mm), and femoral neck varus collapse (degrees). Image calibration was performed using the screw diameter (6.5 or 7.3 mm) in ImageJ. Measurement of femoral neck shortening was performed as described by Zlowodski and Weil. Images from the Picture Archiving and Communication System (PACS) (Centricity; GE Healthcare System, Inc, New York, NY) were imported to the ImageJ processing system (LOCI, University of Wisconsin). At the latest follow-up, a true AP pelvis radiograph of both hips and lateral of the injured hip were obtained. The latest post-operative follow-up image of the treated (injured) side was then cropped using a lasso tool and superimposed on the healthy (non-injured) side. The images were matched using the tip of the greater trochanter. Lines were drawn at both femoral heads'

superior and medial edges after superposition. The horizontal difference between the healthy and the treated side represented the abductor lever arm, termed x . The vertical difference between the top of femoral heads of both the healthy and treated sides represented the vertical shortening termed y . If screw pullout occurred, the distance between the tip of the screw and the lateral femoral cortex was also collected [12-14].

STATISTICAL ANALYSIS

Nonparametric equivalent to the student's t-test (Mann Whitney U) was performed to analyze continuous data, while Chi-square tests were used to compare categorical data. Results were analyzed using IBM SPSS 27 (Armonk, New York 10504-1722) [15-18].

RESULTS

The study included 161 patients with an intracapsular fracture who underwent closed reduction percutaneous pinning. Of these, 78 patients (61 PTS, 17 FTS) remained after exclusion. Most patients included in the study were older, with 65 patients being over the age of 50 and only 13 patients being younger than 50 years old.

The mean age of these 78 patients was 66.5 years (range 18-97), and 35 (44.9%) were female. Of the fractures, 56 (71.8%) were nondisplaced, and 22 (28.2%) were displaced. No statistically significant difference was seen between sex ($p=0.729$) or age at the time of surgery ($p=0.957$) in the PTS and FTS groups. All patients were assessed at two weeks, six weeks, and two months from surgery. The mean time from fracture to the final follow-up x-ray was 239 ± 57.0 days.

No significant difference was found in BMI ($p=0.937$), diabetes mellitus ($p=0.971$), cardiac comorbidities ($p=0.463$), anticoagulation status ($p=0.362$), smoking ($p=0.946$), ASA class ($p=0.925$), initial fracture displacement ($p=0.714$), posterior comminution ($p=0.873$), varus collapse ($p=0.690$) or nonunion rates ($p=0.873$) between the groups. There was no significant difference in the femoral neck shortening between groups: horizontal (x) ($p=0.387$), vertical (y) ($p=0.782$), combined vector (z) ($p=0.621$) ($p=0.651$).

DISCUSSION

This retrospective review examined the differences in

outcomes in individuals with femoral neck fractures who underwent internal fixation with a partially threaded screw, or a fully threaded screw placed as an inferior calcar screw. The incidence of femoral neck fractures is approximately 1.6 million annually. With the predicted doubling of this number, it is essential to optimize the technique and instrumentation used to stabilize the fractures. Previous studies demonstrated that surgical fixation is superior to conservative management in femoral neck fractures. The inverted triangle configuration with parallel screws serves as the standard of care in non-displaced femoral neck fractures, despite many treatment options, including a three-screw non-parallel configuration, dynamic hip screws, and the possibility of hemiarthroplasty. We maintained the triangular parallel configuration regardless of the construct used, as it has been proven biomechanically superior in femoral neck fracture fixation. The placement of a fully threaded screw provides a length-stable implant in the inferior calcar region of the femoral neck. We predicted this benefit to minimize the femoral neck shortening and varus collapse in contrast to partially threaded screws, which provide the advantage of compression across fracture lines. With the variability in treatment options, additional research to evaluate the most effective combination of fully threaded and partially threaded screws, whether it entails using 1, 2, or 3 fully threaded screws, the spread of the screws, and the use of washers. Further studies to include different population demographics accounting for various factors, including the type of fracture, age, arthritis, and osteoporosis. Our study reinforces a decrease in femoral neck shortening in all three vectors after cannulated screw fixation when fully threaded screws were used compared to partially threaded screws at the medial calcar. Although it was not statistically significant, we believe this to be a type 2 error due to insufficient sample. The latter did not come at the cost of fracture healing (nonunion rate) or increased complication rate when using this technique. It is worth noting that fully threaded screw back-out was hardly noticed. Additionally, outside of the compression provided with the partially threaded screws, no further attempts were made in any case to reduce the fractures

further. Using two partially threaded screws at the superior anterior and superior posterior was to ensure fracture compression and prevent fracture gapping. Thus, the medial calcar fully threaded screw's purpose was to reduce and avoid impaction and shortening while preventing excessive valgus alignment. Complications such as osteonecrosis and nonunion were similar among the two study groups ($p>0.05$). Makki et al. compared a 2-hole dynamic hip screw (DHS) vs. a DHS in addition to an anti-rotation fully threaded cranial screw. They concluded the addition of an anti-rotation screw provided no advantages to fracture union, the onset of avascular necrosis, and the rate of revision surgeries. Despite DHS variants being biomechanically superior to multiple screws, the clinical evidence to support the benefits of decreased AVN rates and femoral neck shortening is still to be determined. A recent prospective, a multi-center study looking at fully threaded screws for femoral neck fractures concluded that FTS increases time to union and nonunion rates compared to partially threaded screws. However, the screws used were headless compression screws and not placed in a parallel configuration. Thus, the role of such implants and configuration remains to be elucidated. A retrospective review done by Weil et al. found significantly decreased shortening in all three planes and absent screw pull-out in the fully threaded screw group compared to the partially threaded screw group. In contrast to our study, Weil et al. utilized 2-3 fully threaded screws in their patients, whereas only a single fully threaded calcar screw was used at our institution. A study by Shin et al. examined the use of a fully threaded screw in the posterosuperior position of the inverted triangle and found a significant reduction in the shortening and posterior tilt of the femoral neck post-operatively. To our knowledge, no studies compare the use of a fully threaded inferior calcar versus a posterior superior fully threaded screw and their ability to minimize femoral neck shortening and varus angulation. The study has a few limitations. First, it is a retrospective study. However, all the surgeries were performed by the same surgical team. Second, patient loss to follow-up ($n=73$) is a frequent challenge at any large institution. A type 2 error, due to insufficient cohort could

explain the lack of statistical significance. Finally, we did not consider the order of the placement of the screws by individual surgeons or if replacement of partially threaded medial calcar screw with fully threaded screw impacted outcomes.

CONCLUSION

Using a fully threaded screw as a medial calcar screw is

associated with non-inferior radiographic results in femoral neck fractures using cannulated screws. Further randomized clinical studies and larger cohorts are needed to establish these conclusions.

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