Intramedullary Nailing of Subtrochanteric Fractures Does Malreduction Matter?

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Abstract

Introduction: Subtrochanteric femur fractures remain challenging injuries to treat. Historically, varus malreduction has been linked to the development of nonunion; however, there is a paucity of literature evaluating the impact of sagittal plane malreduction. The purpose of this study was to evaluate the influence of coronal and sagittal plane malreductions on time to union of subtrochanteric femur fractures treated with an intramedullary device.

Methods: A retrospective study was performed of all subtrochanteric fractures (AO/OTA type 32) treated at a single institution. Inclusion criteria consisted of: 1. 18 or more years of age, and 2. fracture stabilization using an intramedullary device. All patients included were followed to union or revision surgery. Radiographic evidence of healing was defined as bridging callus on three of four cortices on AP and lateral views. Delayed union was defined as lack of radiographic healing by 4 months postoperatively and nonunion as lack of healing by 6 months. The definition of malreduction was coronal or sagittal plane deformity greater than 10° at the fracture site.

Results: Thirty-five patients met inclusion criteria; 20 men and 15 women with an average age of 55 years (range 19 to 100 years). Mean clinical follow up was 7 months (range 3 to 18 months). Thirty-four of 35 fractures (97%) healed without need for additional surgery. Twenty-one of the 35 fractures (60%) healed within 4 months of surgery. Thirteen fractures (37%) had delayed union, and 1 (2.9%) developed nonunion requiring reoperation.

Seven of 35 fractures (20.0%) had a malreduction of greater than 10°, defined as varus (2 fractures), flexion (4 fractures), or both (1 fracture). Of the seven fractures with a malreduction, all (100%) developed a delayed (6) or nonunion (1). Of the 28 fractures without malreduction, 21 (75%) healed within 4 months, 7 (25%) had a delayed union, and none had a nonunion. The presence of a malreduction greater than 10° in any plane resulted in a significantly higher rate of delayed or nonunion (p = 0.0005).

Conclusion: For patients with subtrochanteric fractures treated with an intramedullary device, malreduction in any plane of greater than 10° resulted in a significantly increased rate of delayed or nonunion or both.

The treatment of subtrochanteric femur fractures has changed substantially over the past two decades. With the widespread use of intramedullary (IM) nails and indirect reduction, secondary fracture healing is the primary goal; however, nonunion remains a well described complication in the treatment of these difficult fractures. Historically, varus malreduction on the anterior-posterior view of the proximal femur has been linked to the development of nonunion. We believe this has led to neglect of sagittal plane deformity seen on the lateral view with IM nail stabilization. It has been our experience that malreduction in either the coronal or sagittal plane leads to prolonged time to union for these fractures. This study was performed to evaluate the influence of both coronal and sagittal plane malreduction on nonunion of subtrochanteric femur fractures that have been treated with an intramedullary device.

Methods

A retrospective review was performed on patients who sustained a subtrochanteric femur fracture (AO/OTA type 32) and were stabilized using a statically locked intramedullary nail between January 1, 2008, and August 1, 2011, at a level 1 trauma center. The study was Institutional Review Board-approved.
Inclusion criteria consisted of: 1. age 18 years or older, 2. presence of a nonpathologic subtrochanteric femur fracture (from level of lesser trochanter to 5 cm distal), and 3. fracture stabilization using a statically locked intramedullary device. Patients were excluded if they had less than 3 months of follow-up. All included patients were followed to clinical and radiographic union or revision surgery.

Surgeries were performed using manufacturer’s suggested technique for nail placement. A fracture table was utilized in all cases with the patient in the supine position. Supplemental use of cerclage wiring was recorded as well as nail type (hip nail, reconstruction, or standard locked nail). All nails placed were from the trochanteric starting point. Patients were allowed to bear weight as tolerated following the procedure.

Patients were found through a review of the institution’s trauma database. Charts for all patients treated with an IM nail for intertrochanteric, subtrochanteric, or peritrochanteric fractures during the study period were evaluated for inclusion and exclusion criteria. Demographic information, mechanism of injury, medical comorbidities, the presence or absence of open fracture, and orthopaedic implant were recorded from the medical record. Preoperative and all postoperative x-rays were reviewed to determine fracture type and final reduction. Alignment of the immediate postoperative plain x-rays were evaluated and measured digitally on the PACS system (Fig. 1). Angulation was measured and recorded at the fracture site on both anteroposterior and lateral views. Angulation of 10° or greater in the coronal or sagittal plane was defined as malreduction.

The main outcome measure was fracture healing. Healing was defined as bridging callus on three of four cortices as determined on the AP and lateral views. Fractures healing between 4 and 6 months were defined as delayed unions, while fractures not healed by 6 months or those with hardware failure were defined as nonunions. Fractures nailed with malreduction were compared to those without. Statistical significance was set at $p < 0.05$.

Results

During the study period, 75 patients were treated with an IM nail for a subtrochanteric femur fracture. Forty patients were lost to follow-up, leaving 35 patients available for analysis. There were 20 males and 15 females with an average age of 55 years (range 19 to 100).

The mechanism of injury was classified as high energy in 22/35 (63%) patients. Eighteen patients (51.4%) sustained injury from some form of motorized vehicle accident (10 MVC, 4 MCC, 2 pedestrian vs. auto, 1 ATV, 1 jet ski). Four patients (11.4%) sustained a fall from an elevated distance. Eleven patients (31.4%) sustained a fall from standing height. Finally, two patients (5.7%) sustained their injury from gunshot wounds.

Three patients had open fractures (8.6%). Two of these were due to gunshot wounds and one from an ATV accident. Tobacco usage at the time of fracture was found in 9/35 patients (26%). Fourteen of 35 patients (40%) sustained polytrauma, and 17/35 patients (49%) had one or more medical comorbidities. The majority of patients were treated within 1 day of injury (range 0 to 3). Two of 35 fractures (6%) had an open reduction and cerclage placement at the fracture site. Hip nails were used in 19/35 cases (54%), reconstruction nails in 15/35 cases (43%), and standard proximal interlocking in one case (3%).

Mean clinical follow up was 7 months (range 3 to 18 months). Thirty-four of 35 fractures (97%) healed without need for additional surgery. Twenty-one of the 35 fractures (60%) healed within 4 months of surgery. Thirteen fractures (37%) had delayed union, and one (2.9%) developed nonunion requiring reoperation (Fig. 2).

Seven of 35 fractures (20.0%) had a malreduction greater than or equal to 10°, defined as varus (2 fractures), flexion (4 fractures), or both (1 fracture). Of the seven fractures with a malreduction, all (100%) developed a delayed (6 fractures) or nonunion (1 fracture) (Table 1). Of the 28 fractures without malreduction, 21 (75%) healed within 4 months, 7 (25%) had a delayed union, and none had a nonunion. The presence of a malreduction greater than or equal to 10° in any plane resulted in a significantly higher rate of delayed or nonunion ($p = 0.0005$) (Fig. 3).

No association was found between delayed union or nonunion and open fracture, presence of polytrauma, or the presence of medical comorbidities. Both of the fractures treated with open reduction and cerclage wiring were reduced without deformity and healed within the specified time period.

Discussion

In this study, we examined a cohort of patients who sustained a subtrochanteric femur fracture treated with an intramedul-
lary device. When postoperative radiographs showed malreduction greater than or equal to 10° in any plane, there was a statistically significant higher rate of delayed or nonunion.

Traditional ORIF of subtrochanteric femur fractures relied on medial cortical contact and the tension band principle of a plate placed along the lateral cortex of the proximal femur. In many instances today, IM nailing is the treatment of choice for subtrochanteric fractures. This relies on secondary bone healing and callus, whereas compression plating relies on primary bone healing. The reliance on secondary bone healing negates the need for a perfectly anatomic reduction of the fracture. Furthermore, as IM nailing techniques have evolved, trochanteric starting point nails have developed widespread use among many orthopaedic surgeons. Varus malreduction on the anterior-posterior view is often discussed as being a risk factor for nonunion of these fractures and can be particularly problematic when trochanteric nails are used with a starting point lateral to the tip of the trochanter. An unacceptable amount of varus deformity with IM nail treatment, to our knowledge, has not been quantified prior to now. Additionally, the focus on varus malreduction that is present in the orthopaedic literature has led in part, we believe, to neglect

![Figure 2](image)

**Figure 2** Varus and flexion (A, B) malreduction, leading to nonunion (C, D) at 5 months. Revision surgery was performed with blade plate fixation and patient went on to heal uneventfully (E, F).
of sagittal plane deformity seen on the lateral view.

The anatomy of the subtrochanteric region of the femur creates several issues that affect fracture healing.\textsuperscript{3,4} When compared to the metaphyseal bone of the intertrochanteric region, diminished blood flow to the subtrochanteric region results in slower healing. This combined with the high concentration of stresses and deforming forces in this portion of the bone\textsuperscript{5,6} has made subtrochanteric fractures a challenging problem that has been made evident throughout the orthopaedic literature.\textsuperscript{1-4,7-10} Intramedullary nail treatment has been advocated for these fractures due to the biomechanical advantages of a nail (decreased bending lever arm and torsional force), as well as decreased surgical dissection in most instances.\textsuperscript{11,12} With nail treatment, however, the proximal femoral anatomy in subtrochanteric fractures (wide canal and short proximal segment) can make fixation with intramedullary devices challenging.\textsuperscript{13,14}

The typical deformity in subtrochanteric femur fractures is a proximal fragment that is flexed, abducted, and externally rotated. The distal fragment is adducted and shortened. This results in an overall varus and apex anterior deformity at the fracture site. Several reduction maneuvers

<table>
<thead>
<tr>
<th>Patient</th>
<th>Coronal Plane Angulation</th>
<th>Sagittal Plane Angulation</th>
<th>Time to Union (weeks)</th>
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<td>0°</td>
<td>29</td>
</tr>
<tr>
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<td>10°</td>
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<td>4</td>
<td>11°</td>
<td>15°</td>
<td>Nonunion</td>
</tr>
<tr>
<td>5</td>
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<td>10°</td>
<td>18</td>
</tr>
<tr>
<td>6</td>
<td>11°</td>
<td>7°</td>
<td>25</td>
</tr>
<tr>
<td>7</td>
<td>7°</td>
<td>16°</td>
<td>54</td>
</tr>
</tbody>
</table>

Table 1 Patients with Malreduction in the Coronal or Sagittal Plane

Figure 3 Isolated flexion malreduction (A, B), leading to delayed union at 5 months (C, D).
have been described to correct these deformities. Varus malreduction can be particularly problematic in cases where a trochanteric start nail has been used with a starting point that has been placed lateral to the tip of the trochanter.

Wiss and Brien noted 6 malunions in 95 patients in their series of subtrochanteric femur fractures treated with an IM device. No patient reportedly had sagittal plane deformity. In this series, each case of malunion was due to the fracture being nailed in a malreduced position. Delayed union (defined as lack of healing by 6 months) was not correlated with malreduction, rather with the presence of open fracture in each case of delayed union.

In contrast, the current study demonstrates a highly statistically significant increase in delayed union in fractures with immediate postoperative malreduction (p = 0.0005). In fact, of the seven fractures demonstrating malreduction in any plane, all seven (100%) of those fractures developed delayed union or nonunion. Despite the majority of these fractures eventually going on to heal, we believe that reduction of the deformity to less than 10° in any plane at the time of definitive treatment with an IM device will reduce postoperative healing time as well as reduce postoperative pain and the rehabilitation time.

There are several shortcomings to the current study. Some limitations of our study include the retrospective study design, with inherent surgeon variability and lack of treatment protocols, as well as difficulty in complete data retrieval. For example, 53.3% of patients were excluded from the current study due to lack of radiographic follow up at three months. We have relatively short follow up for many of the patients included in the study, again due in part by the retrospective nature of the study and a lack of any standardization as to when x-rays are obtained in follow up for this injury. This lack of standardization as to time intervals in between when x-rays were taken makes it difficult to determine exactly when healing took place. In this study, the date of the earliest x-rays showing bridging callus on three of four cortices was used as the date of healing. With regard to our radiographic analyses, angles were measured at the fracture site on AP and lateral radiographs. Depending on the rotation of the leg, different measurements could be obtained in this analysis. Despite this shortcoming, the angle would not be less than that measured in this study, and all (100%) of the cases with a measured malreduction greater than 10° in either plane resulted in delayed union. Additionally, no patient subjective clinical outcomes data was available to compare the effects of nonunion on patient functioning and quality of life. Finally, we had a small sample size, although it was large enough to obtain statistical significance in our primary outcome.

In conclusion, we recommend close attention be given to deformity of subtrochanteric femur fractures not only in the coronal plane but also in the sagittal plane. Although this study did not look specifically at rotational deformity, this should be corrected intraoperatively as well. If an acceptable reduction cannot be obtained with percutaneous techniques, we recommend open reduction and nailing for treatment of these difficult fractures in order to avoid the complications of delayed union and nonunion.

### Disclosure Statement

The institution of the authors has received funding for fellowship support from Synthes. Kenneth J. Koval, M.D., receives royalties and consultant fees from Biomet and consultant fees from Stryker. Joshua R. Langford, M.D., receives consultant fees from Stryker. Mark W. Munro, M.D., receives consultant fees from Smith and Nephew. George J. Haidukewych, M.D., receives royalties and consultant fees Biomet and Depuy and consultant fees from Synthes and Smith and Nephew. The authors have no conflicts of interest in addition to those mentioned above.

### References