

Risk Factor of Proximal Lag Screw Cut-Out After Cephalomedullary Nail Fixation in Trochanteric Femoral Fractures: A Retrospective Analytic Study

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ABSTRACT

Objective: A cephalomedullary nail is the treatment of choice for trochanteric fractures; however, a lag screw cut-out is one of the most devastating complications. The lag screw cut-out rate was reported to be around 2.5%–8.3%. This study aimed to evaluate the prevalence of lag screw cut-outs and identify the associated risk factors.

Materials and Methods: A retrospective review of 267 trochanteric fracture patients treated with cephalomedullary nail fixation from January 2007 to December 2017 was conducted. The demographic variables were documented, comprising age, gender, fracture pattern, and AO/OTA classification. Immediate postoperative radiographs were assessed for quality of reduction and implant position. Lag screw cut-outs or radiographic union were determined using the final follow-up radiograph. Prognostic factors associated with lag screw cut-out were determined using univariate and multivariate logistic regression analyses.

Results: Of the 175 patients, 154 were successfully treated, and 21 had a lag screw cut-out. There were no significant differences in mean ages or genders of the union and cut-out groups. No lag screw cut-outs were observed in patients with AO/OTA 31-A1. Patients with AO/OTA 31-B2.1 had a higher rate of screw cut-out (OR 10.5, [3.22, 34.25] $p < .001$). The disintegration of basicervical fragments was significantly associated with lag screw cut-out (OR 5.51, [2.01, 15.12] $p = .001$). The highest cut-out rate was found in the superoanterior and superoposterior positions of the lag screw. However, the screw position did not reach the significance level in a multivariate analysis ($p = .094$).

Conclusion: The prevalence of lag screw cut-out after cephalomedullary nail fixation for trochanteric fractures was 12%. A simple, two-part, basicervical trochanteric fracture had a significantly higher risk of lag screw cut-out.

Keywords: Trochanteric fracture; pertrochanteric fracture; hip fracture; cut-out; cephalomedullary nail (Siriraj Med J 2022; 74: 627-633)

INTRODUCTION

Hip fracture is one of the common osteoporotic fractures in the geriatric population. Surgical treatment can reduce mortality and improve patients' quality of life.¹⁻⁵ A cephalomedullary nail is the treatment of choice for trochanteric fractures, offering superior biomechanical

stability to a sliding hip screw.^{2,6} However, a lag screw cut-out is one of the most devastating complications, causing difficulties for reoperations or hip replacements.^{7,8}

The risk factors associated with lag screw cut-outs have been reported in recent studies. As well as patient factors-age, bone mineral density (BMD) and fracture

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configuration-the fixation technique strongly influences the outcomes.^{7,9-11} The tip-apex distance (TAD) is the most commonly used parameter to determine the prognosis of a lag screw cut-out.¹²

Even though implant development has tended to match the configuration of a proximal femur, the reported lag screw cut-out rate is still around 2.5% - 8.3%, according to the previous study.² This study aimed to evaluate the prevalence of lag screw cut-outs and identify the associated risk factors.

MATERIALS AND METHODS

A retrospective review was conducted of all patients admitted with a trochanteric fracture between January 2007 and December 2017. Only those patients treated with a short cephalomedullary nail (Natural Nail system cephalomedullary nails, Zimmer) with no additional fixation were enrolled. The exclusion criteria were: (1) a patient was treated with other implants; (2) a patient had a pathologic fracture; (3) the pre-or postoperative radiograph was not present in a patient's medical records; (4) a patient was lost to follow-up before the fracture union or screw cut-out; and (5) a patient had a peri-implant fracture.

The demographic data recorded were age, gender, and fracture classification. Based on the AO/OTA classification system¹³, the patients were grouped into 31-A1, 31-A2, 31-A3, and 31-B2.1. The preoperative radiographs were reviewed by two investigators (MC and PN), who recorded the following data: (1) lateral buttress fragment-anatomically defined as the lateral femoral cortex distal to the vastus ridge in the trochanteric region¹⁰; (2) posteromedial fragment-represented by the calcar femorale. The integrity of the lesser trochanter was used as evidence of the presence or absence of the calcar femorale¹⁴; and (3) basicervical fragment-the fracture line separating the proximal fragment at the intertrochanteric line, corresponding with AO/OTA classification 31-B2.1 (Fig 1). Data from both investigators were compared for inter-observer reliability. Disagreements regarding the result of the measurements were resolved by a third-person review.

The following parameters were measured in the immediate postoperative radiographs: (1) TAD in the anteroposterior (AP) and lateral view; (2) the medial gap after reduction; (3) the postoperative neck-shaft angle; (4) the position of the lag screw in the AP view-defined as inferior, centered and superior; (5) the position of the lag screw in the lateral view-defined as posterior, centered and anterior; (6) the number of distal locking screws; and (7) the mode of distal locking. The TAD

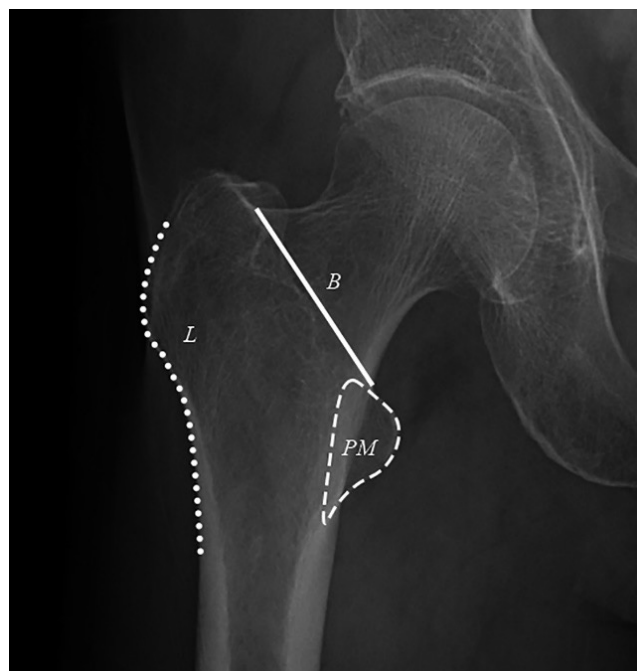


Fig 1. Integrity of specific fragment: Lateral buttress fragment (L), Posteromedial fragment (PM), Basicervical fragment (B)

measurement was obtained using the Baumgaertner method.¹ In this, an imaginary line was drawn parallel to the femur neck, dividing it into superior and inferior portions. The position of the lag screw was recorded using this line as a reference. If the line bisected the screw, the position was recorded as centered.¹ The lateral radiograph used the same method but labeled the positions as posterior, centered, and anterior.

The radiograph with a minimum of 3 months follow-up was measured again when the patient met the endpoint of fixation-union or cut-out. The fracture was labeled as “union” if the bone bridge was present in both the AP and lateral views. If the last follow-up film did not have a lateral view, the presence of both the medial and lateral bone bridges in the AP view was labeled as a union.^{4,5,7,15} A *lag screw cut-out* was defined as a protrusion of the screw past the subchondral bone on either the AP or lateral projection (Fig 2).^{8,16} Medial migration of the screw past the subchondral bone-recently called “axial migration”-was also labeled as a cut-out.⁸

Statistical analysis

The sample size calculation was based on a report on lag screw cut-outs, which indicated that they represented about 10% of the overall population.⁷ A minimum of 139 patients was needed to demonstrate a 10% lag screw cut-out prevalence with a 95% confidence interval and 5% allowable error. Statistical analyses were performed

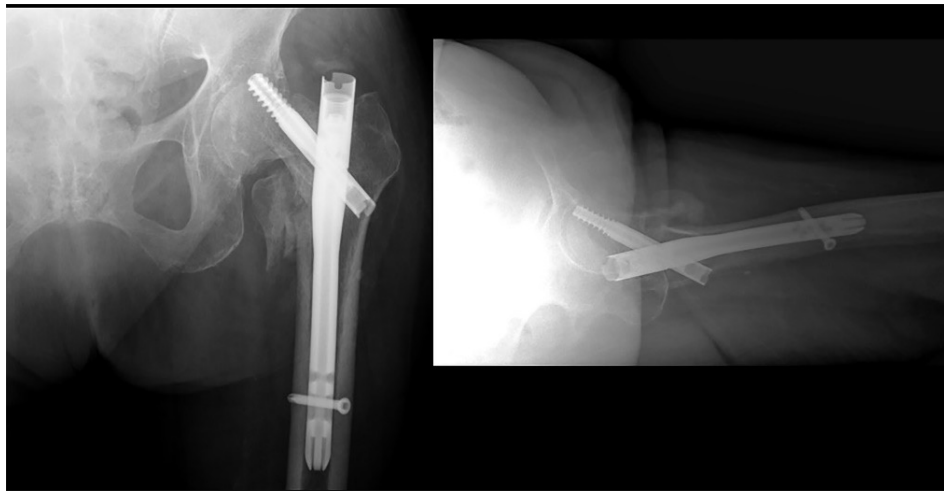


Fig 2. *Left* The radiograph of the affected hip in AP view shows proximal screw cut-out. The proximal screw cut through superolateral aspect of the femoral neck. *Right* The radiograph of the affected hip in the Lateral cross-table view shows proximal screw protrusion past the anterior aspect of the subchondral bone of the femoral head.

using IBM SPSS Statistics for Windows, version 20 (IBM Corp., Armonk, N.Y., USA). The chi-square and independent t-test were used for univariate analyses of the categorical and continuous parameters, respectively, with the significance level (p) $< .05$. A multivariate analysis was performed for all parameters with $p < .2$.

The inter-observer reliability was calculated for the parameters identified as significant in the univariate analysis. A two-way random-effects model with a 95% confidence interval was used to determine the measurements' intra-class correlation coefficient (ICC). The ICC interpretation scale used was poor to fair (< 0.4), moderate (0.41 to 0.60), excellent (0.61 to 0.80) and almost perfect (0.81 to 1). For categorical data, the κ coefficients were calculated using the same interpretation scale as for the ICC.

RESULTS

Between January 2007 and December 2017, 267 patients diagnosed with a trochanteric fracture treated at Siriraj Hospital, Bangkok, Thailand, with cephalomedullary nails were enrolled. Of those, 92 were excluded: the preoperative radiograph was missing for 7 patients; 6 had a pathologic fracture; the endpoint was unable to be determined for 10 patients due to incomplete radiographs, and 69 were lost to follow-up after discharge from the hospital. The total number of patients included in this study was 175; 154 were successfully treated with a radiographic union of the trochanteric fracture, while 21 (12%) had a lag screw cut-out.

The demographic data are summarized in Table 1. There were no significant differences in the mean ages or the gender proportions of the union and cut-out groups. However, the fracture classifications of the groups were

significantly different, with all patients with AO/OTA 31-A1 having been successfully treated without a lag screw cut-out, whereas one-third of the patients with AO/OTA 31-B2.1 experienced a lag screw cut-out. The T-scores of BMD were only available for 40 patients due to the surgeons' judgment to forego a further investigation. Concerned that a large amount of missing data would reduce the study's statistical power, the authors excluded this factor from the multivariate analysis, notwithstanding that it reached a statistically significant level ($p = .048$).

All recorded parameters were evaluated in univariate analysis for an association with lag screw cut-out; the results are in Table 2. The integrities of the basicervical fragment fractures of the union and cut-out groups were statistically significantly different ($p = < .001$). However, the lateral buttress and posteromedial fragment fractures of the two groups showed no significant difference ($p = 1.0$ and $.064$, respectively).

The postoperative lag screw positions were evaluated in the AP and lateral projections. The screw placement was divided into nine zones (Fig 3). The screws were most frequently placed in the inferoposterior zone. The lowest rate of cut-outs occurred in the center-inferior zone, while the highest cut-out rate was found in the peripheral area, in the superoanterior and superoposterior positions. However, after comparing the cut-out rate of each zone, no statistical significance was found ($p = .053$).

An inter-observer reliability test was performed on the factors with $p < .2$ before a multivariate analysis was carried out; all factors demonstrated good inter-observer reliability (Table 3). The results of the multivariate regression analysis are in Table 4. The integrity of the basicervical

TABLE 1. Summary of demographic data.

Factor	All (n=175)	Union (n=154)	Cut-out (n=21)	P-value
Age	80.45 ± 10.17	80.21 ± 10.01	82.24 ± 11.35	.39
Gender				.62
Male	31.4% (55)	32.5% (50)	23.8% (5)	
Female	68.6% (120)	67.5% (104)	76.2% (16)	
Fracture classification				<.0001
31-A1	8.6% (15)	9.7% (15)	0%	
31-A2	75.4% (132)	77.3% (119)	61.9% (13)	
31-A3	8% (14)	8.4% (13)	4.8% (1)	
31-B2.1	8% (14)	4.5% (7)	33.3% (7)	
Total T-score of hip BMD*	-2.6 ± 1.0	-2.4 ± 1	-3.3 ± 0.7	.048

*Data were available for only 40 out of the total of 175 patients.

TABLE 2. Summary of associated factors evaluated in univariate analysis.

Factor	All (n=175)	Union (n=154)	Cut-out (n=21)	P-value
Lateral buttress fracture	18.3% (32)	18.2% (28)	19% (4)	1.0
Posteromedial fragment fracture	80% (140)	81.8% (126)	66.7% (14)	.142
Basicervical fragment fracture	20% (35)	15.6% (24)	52.4% (11)	<.001
TAD*	19.62±5.53	19.53±5.48	20.3±5.97	.56
Neck-shaft angle	137.25±7	137.15±6.75	137.95±8.79	.62
Medial gap	2.07±2.4	2.04±2.35	2.27±2.71	.68
Distal locking screw				.62
Single screw	93.7% (164)	94.2% (145)	90.5% (19)	
Two screws	6.3% (11)	5.8% (9)	9.5% (2)	
Distal locking mode				.49
Static	54.3% (95)	53.2% (82)	61.9% (13)	
Dynamic	45.7% (80)	46.8% (72)	38.1% (8)	

*Post-operative lateral films were retrieved for 143 patients. The missing data were not included in the analysis.

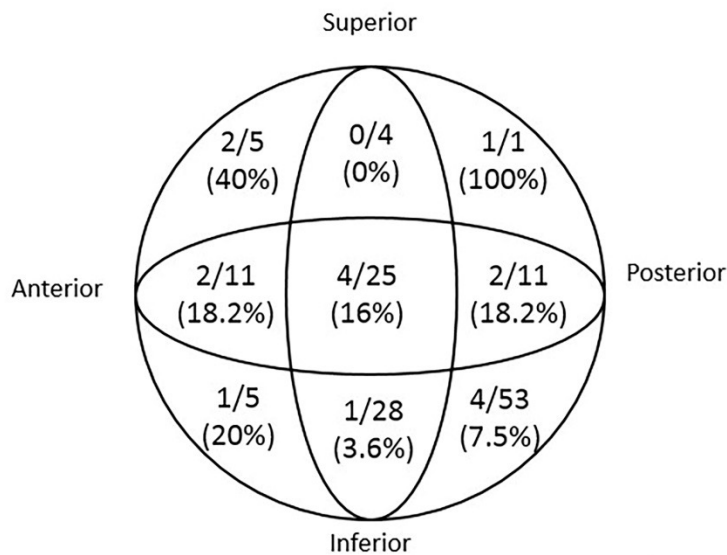


Fig 3. Summary of screw position: The total number of screws in each position was represented by the denominator, and the number of the screw(s) cut-out was represented by the numerator. Post-operative lateral films were retrieved for 143 patients. The missing data were not included in the analysis.

TABLE 3. Summary of inter-observer reliability tests.

Factor	Measure of agreement (κ)
Fracture classification	0.932
Posteromedial fragment fracture	0.888
Basicervical fragment fracture	0.982
Screw position	0.867

TABLE 4. Summary of multivariate analyses by odds ratio.

Factor	P-value	Odds ratio	95% confidence interval for odds ratio
Fracture classification	<.001	10.5	[3.22, 34.25]
Posteromedial fragment fracture	.62		
Basicervical fragment fracture	.001	5.51	[2.01, 15.12]
Screw position	.094		

fragment fractures and the fracture classification reached a significant level. Those patients with AO/OTA 31-B2.1 had a significantly high rate of lag screw cut-out (OR 10.5, [3.22, 34.25] $p < .001$). The disintegration of the basicervical fragments was associated with lag screw cut-out (OR 5.51, [2.01, 15.12] $p = .001$), whereas neither posteromedial fragments nor the lag screw position showed a significant association.

DISCUSSION

The fixation of choice for trochanteric fractures has shown a paradigm shift toward cephalomedullary nails (CMNs) from sliding hip screws (SHSs).⁸ The advantages of CMNs include; more biomechanical stability, less invasive, and safer for early weight-bearing ambulation than SHSs.² Another factor encouraging using CMNs instead of SHSs is the fracture configuration.^{2,4} To date,

the fragments associated with fixation failure in SHS are posteromedial and lateral buttress fragments.¹⁰ With the size of the geriatric population steadily growing, patients with trochanteric fractures increasingly present with osteoporotic bones and comminuted configurations. With such complex fracture configurations, fixation with an SHS has a higher failure rate than with a CMN.

Although the design of CMNs has improved over several generations, the fixation failure rate remains nearly the same. Our study showed a cut-out rate of 12%, which was similar to that reported by another study. Aside from the patient factors, surgical technique plays an important role in predicting the outcomes. The tip-apex distance (TAD) has been proposed to predict a failed SHS or CMN fixation.^{1,4,9} With this concerning factor of TAD, careful placement of lag screw during surgery was attempted in all cases of this series; patients in both groups treated in our institute had a mean TAD value of 20 mm. Thus, our study revealed no significant association between the TAD and lag screw cut-outs. Reduction quality also plays a vital role in achieving bone union. Varus mal-reduction or wide posteromedial gap resulted in unstable fixation and increased the cut-out rate. This study's overall reduction quality was good to excellent, with minimal medial gap and slightly valgus neck-shaft angle. From this result, the authors conclude that the surgical technique was appropriate in both the union and cut-out groups, with an insignificant difference in the reduction quality.

Proximal screw position also has been reported to have an association with lag screw cut-outs. The most common direction of the cut-outs in the anterosuperior portion of the femoral head^{17,18}; although placing the screw in this position might increase the risk of lag screw cut-outs, the results of the multivariate analysis in this study did not reach the significant level.

Most hip fragility fractures tend to be comminuted, classified as AO/OTA 31-A2. About half of the patients with a lag screw cut-out fall into this classification. Theoretically, a complex fracture configuration tends to give poor results after fixation.^{4,7,8} Interestingly, when the proportions of unions to cut-outs are compared, simple basicervical trochanteric fractures-classified as 31-B2.1-have a 50% cut-out rate, while comminuted fractures have only a 9.8% cut-out rate. In our study, simple trochanteric fractures-AO/OTA 31-A1-showed promising results with cephalomedullary nails, with zero cut-outs. After analyzing specific fragment integrity, the authors found an association between basicervical fragment fractures and five times the odds of a lag screw

cut-out. Based on this result, the authors believe that a specific fragment has more influence on the results than the comminution of fracture.

Bone mineral density has been reported as a factor associated with lag screw cut-outs.² Osteoporosis decreases the density of the cancellous bone in the femoral head and decreases the pull-out strength after fixation, which results in fixation failure. The current study showed a significant association with BMD; nevertheless, due to the large amount of missing data that would have resulted in an underpowered analysis, the authors cannot draw any conclusions about the effects of BMD on lag screw cut-outs.

The dilemma in choosing a fixation implant probably stems from the intraoperative additional fragment fracture. Because lateral buttress disintegration can cause a fixation failure if SHS is chosen, an intraoperative lateral wall fracture in the osteoporotic bone can be a significant drawback, influencing surgeons to choose CMN fixation.

The most suitable treatment for basicervical fractures is a contentious issue. Because the fracture line stays between the femoral neck and the intertrochanteric region, the treatment can be either for a femoral neck or a trochanteric fracture. A previous study described this area as an "extracapsular area," which should be considered for treatment as a trochanteric fracture.¹⁹ Still, as the configuration is comprised mainly of the femoral neck, the motion of the basicervical fragment after fixation behaves as a femoral neck fracture with high rotational instability. Massoud¹⁹ reported an excellent result with no cut-out of the lag screw using SHS combined with a derotation screw as the fixation of choice for this type of fracture as it provides an interfragmentary compression effect along with rotational stability via the additional screw. The results of the present study support this concept since the CMN did not provide a lag effect, and there was no room for an additional screw to improve the rotational stability, resulting in a higher rate of lag screw cut-out after fixation for simple basicervical fractures. The rate of screw cut-out for basicervical fractures was also higher than those for other types of trochanteric fractures in a large case series of trochanteric fracture fixations using a gamma nail, reported by Bojan et al.⁷ Recently, Yoo et al. and Yoon et al. have also reported that the basicervical fracture is the most important risk factor for the cut-out problem of cephalomedullary nail fixation in treating the trochanteric fracture in their case series.^{20,21} Our findings also support the awareness of using cephalomedullary nails in basicervical fractures. We believe such a gray-zone fracture should be considered

differently from the typical neck or trochanteric fracture. Further investigation for an appropriate fixation device or design should be considered.

The limitations of this study are its retrospective design, the sizeable proportion of excluded patients, and the small number of patients with lag screw cut-outs. The overall trochanteric fracture patient admitted to Siriraj Hospital was about 100 cases per year. Due to the strict criteria, only the patient who received surgical treatment with short CMN were included, resulting in only about 26 cases per year. Those patients who were lost to follow-up possibly moved to another province or may have been inconvenient to visit the hospital.

CONCLUSION

The prevalence of lag screw cut-outs after cephalomedullary nail fixation for trochanteric fractures was 12%-a simple, two-part, basicervical trochanteric fracture has a significantly higher risk of a lag screw cut-out. Using a CMN fixation for basicervical fractures should be avoided.

Disclosure

No benefits in any form related directly or indirectly to the subject of this article have been received or will be received from a commercial party

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