



# Clinical outcomes of dynamic hip screw fixation of intertrochanteric fractures: comparison with additional anti-rotation screw use

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## Abstract

**Background** Hip screw cutout is among the most common causes of intertrochanteric fracture fixation failure using dynamic hip screws (DHS). This study aimed to evaluate the effect of using an additional anti-rotation screw on hip screw migration or cutout in intertrochanteric fracture fixation.

**Materials and methods** We screened 488 patients with unilateral fragile intertrochanteric fractures treated with DHS between January 2001 and March 2016. The inclusion criteria were as follows: (1) age  $\geq 50$  years; (2) low-energy injury; (3) follow-up of at least 6 months; and (4) short barrel plate used in the operation. The exclusion criteria were as follows: (1) combination with other fracture; or (2) pathological fracture. Subsequently, 166 patients were enrolled; of them, 128 underwent surgery using DHS with an additional screw (Group 1) and 38 patients underwent surgery without an additional screw (Group 2). We compared the postoperative results and clinical outcomes while focusing on screw migration and cutout. Furthermore, we investigated the risk factors for lag screw migration.

**Results** Bone union was achieved in 160 patients (96.4%) without secondary intervention. Two patients (1.6%) in Group 1 and 1 (2.6%) in Group 2 developed screw cutout, while 18 (14.1%) in Group 1 and 12 (31.6%) in Group 2 developed screw migration. Thus, Group 2 demonstrated a higher screw migration rate. Multiple logistic regression analysis revealed that the additional anti-rotation screw was the most important factor in preventing screw migration ( $P=0.019$ ).

**Conclusion** The additional anti-rotation screw reduced the lag screw migration rate following DHS surgery for intertrochanteric fractures.

**Level of evidence** Level IV, retrospective series.

**Keywords** Intertrochanteric fracture · Anti-rotation screw · Dynamic hip screw · Cutout · Mechanical failure

## Introduction

Several implants have been invented to fix femoral intertrochanteric fractures; among them, the dynamic hip screw (DHS) fixation system is one of the most widely used [1, 2]. Although DHS fixation is an improved system, it can lead to postoperative failure. The most common mechanical complication of DHS surgery is lag screw migration and subsequent hip screw cutout [3–8].

A technique using an additional anti-rotation screw for fixation was introduced to strengthen proximal fixation in

DHS. Several studies have reported its efficacy, especially in the treatment of femoral neck fracture [9, 10]. However, its efficacy in the fixation of femoral intertrochanteric fractures using the DHS system has not yet been investigated. Additionally, the relationship between the use of an additional screw and hip screw failure rates has not been studied. We hypothesized that the use of an additional anti-rotation screw could reduce lag screw migration or cutout or prevent fixation failure. Thus, this study aimed to evaluate the effect of adding an additional anti-rotation screw on lag screw migration and cutout in intertrochanteric fractures treated by DHS fixation.

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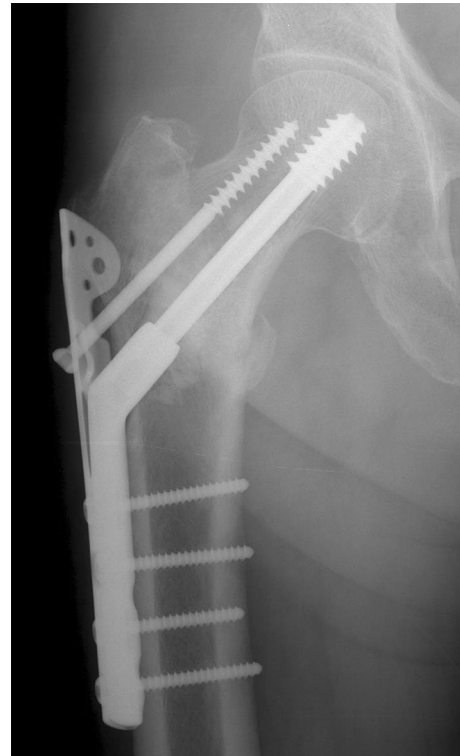
## Materials and methods

### Patient selection

This retrospective cohort study was approved by our facility's institutional review board. Four hundred and eighty-eight patients with intertrochanteric fracture of the femur treated with DHS surgery at our institution between January 2001 and March 2016 were screened. The inclusion criteria were as follows: (1) age  $\geq 50$  years; (2) low-energy or worse fracture; (3) follow-up duration of at least 6 months; and (4) short barrel plate used in treatment. The exclusion criteria were as follows: (1) combination with other fractures; or (2) pathological fractures. Accordingly, 166 patients were enrolled in this study (Fig. 1).

### Surgical technique

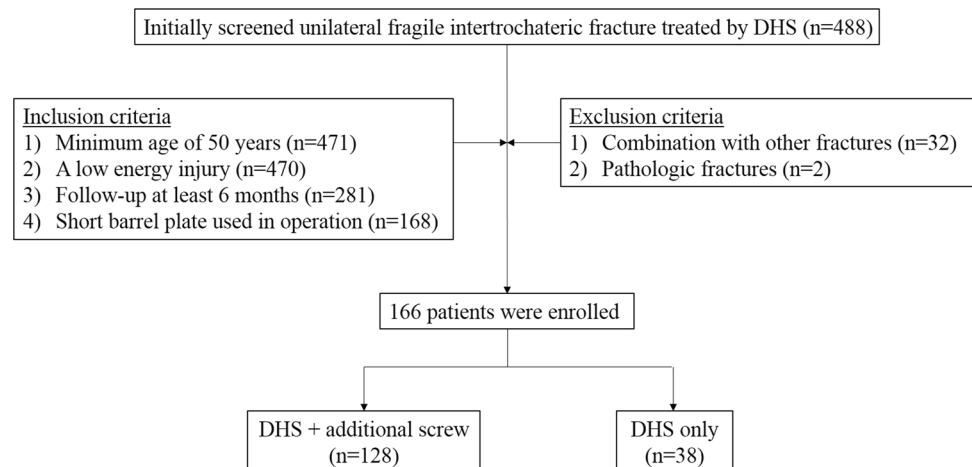
All procedures using the DHS system were performed by a single experienced surgeon on a fracture table. Using the direct lateral approach, the tensor fascia lata was incised and the vastus lateralis muscle was retracted, followed by an L-shaped incision into the vastus lateralis muscle. Anatomical reduction was achieved; in cases in which it was impossible, valgus reduction was achieved. The reduction was confirmed under fluoroscopic guidance on anteroposterior and axial images, and a guide pin was inserted, followed by a lag screw. When rotation of the proximal fragment was observed at the end of the lag screw insertion, an additional anti-rotation screw was inserted. The additional screw, a 6.5-mm partial-threaded cannulated screw, was inserted in the last step of the DHS procedures. The additional screw was started just above the entry of the lag screw and positioned parallel to its trajectory under C-arm assistance (Fig. 2). In all cases of unstable fracture (AO Foundation/Orthopaedic Trauma Association [AO/



**Fig. 2** Radiograph of dynamic hip screw (DHS) fixation with an additional anti-rotation screw

OTA] type 31.A2.2, 2.3) and some cases of AO/OTA type 31.A1.2, A1.3, and A2.1 with a thin lateral wall of the greater trochanter, a trochanter stabilizing plate (TSP) was used. Wiring was performed for the tip of the greater trochanter (GT) fragment when the GT fragment was superiorly displaced. Short barrel plates were used in all cases because we preferred a short barrel plate in unstable fractures and a long barrel plate in cases for which a locking plate variant was not available.

**Fig. 1** Visual chart of cohort profile



## Postoperative rehabilitation

All patients followed a standardized postoperative rehabilitation program, and early assisted ambulation was encouraged. Each underwent continuous passive motion and wheelchair ambulation on postoperative day 1 and standing exercises with a tilting table from day 2 onward. From day 3, complete weight bearing with a walker was supervised by a rehabilitation physician and a therapist. In our protocol, complete weight bearing was defined as the degree tolerated by the patient, which was usually 50–100% of the body weight, on the affected leg. Complete weight bearing with a contralateral side crutch was permitted from postoperative week 6, while complete unassisted weight bearing was allowed from postoperative week 12. The mean follow-up period was 25.5 months (range 6.0–159.4 months) after the initial DHS surgery.

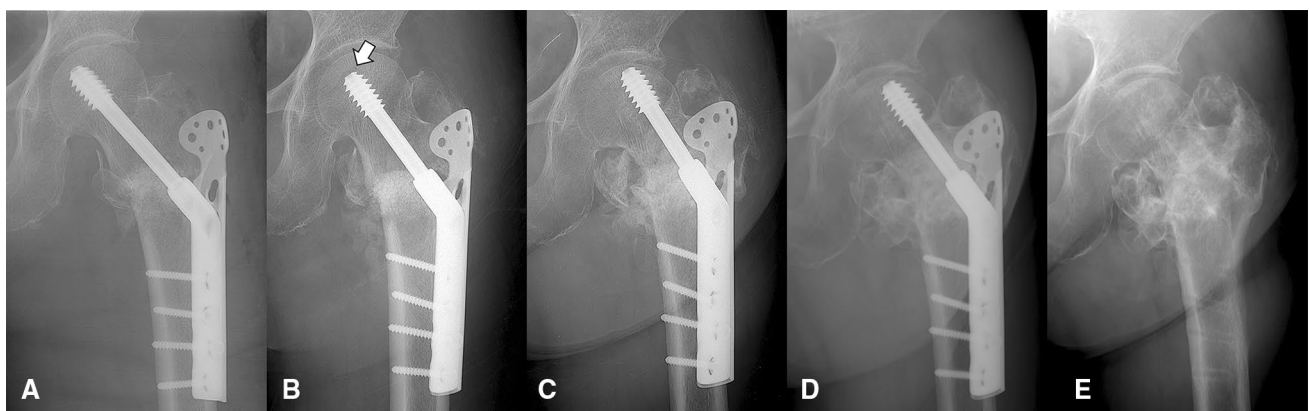
## Data collection

Some of the baseline variables collected from the patients were age, sex, body mass index (BMI), and bone mineral density (BMD) of the contralateral hip and/or spine measured by dual-energy X-ray absorptiometry (Lunar Prodigy Advance System). Fracture type was noted according to AO/OTA classification, and TSP or GT wiring was used to evaluate the surgical technique applied. The outcomes were measured by union rate and complications with a focus on mechanical failure. Lag screw cutout and screw migration rates were determined by serial postoperative hip radiographs. The radiographs were reviewed by a faculty and a fellow orthopedic surgeon simultaneously to measure the distance between the screw tip and the apex of the

femoral head and quantify the screw migration, if any. “Screw migration” was defined as a positional change of more than 3.5 mm of the screw thread or blade between the immediate postoperative radiographs and the radiographs obtained 3 months postoperatively (Fig. 3) [11]. In cases of doubt, screw migration was confirmed by consensus. Tip–apex distance (TAD) [12] was measured to confirm the accurate positioning of the lag screw, while postoperative fracture reduction was confirmed using Kyle’s method [13]. The Cleveland method, which divides the femoral head into nine areas, was used to evaluate the distributions of screw position and identify the correlation between screw position and mechanical failure [14]. The patients were divided into two groups based on the use of an additional anti-rotation screw: Group 1 (with an additional anti-rotational screw) had 128 cases and Group 2 (without an additional screw) had 38 cases. Clinical outcomes and the incidence of lag screw cutout or migration were compared between groups.

## Statistical analysis

Normal distribution was tested using the Kolmogorov–Smirnov and Shapiro–Wilk tests; the independent samples *t* test or Mann–Whitney *U* test was performed for continuous data, while the Chi-square test or Fisher’s exact test was used for categorical data. Multiple logistic regression analysis was used to investigate the correlation between the independent variables and their ability to predict screw migration. The parameters included in the model were selected using univariate analysis ( $P < 0.05$ ), and the statistical analyses were performed using PASW Statistics, version 18.0 (IBM Corp., Armonk, NY, USA). Statistical significance was defined as a *P*-value  $< 0.05$ . For the cases



**Fig. 3** Hip screw migration seen in follow-up radiographs. Radiograph on postoperative day 1 after DHS fixation (a). Radiolucent line is seen around the head of the screw (arrow) at one month after surgery (b). Obvious hip screw migration is seen on the radiograph taken at postoperative 3 months (c). At subsequent follow-up, screw migration had stopped and fracture union was achieved. There was

no significant change in radiographs until postoperative 2 years (d). Finally, we performed implant removal due to discomfort at the proximal lateral thigh. Radiographs were obtained 2 years postoperatively. Hip screw migration had progressed as compared to previous radiographs, but finally fracture union and migration were stopped (e)

**Table 1** Patient demographic data and operative details

Variable	Group 1 (n = 128)	Group 2 (n = 38)	P value
Mean age (range), years	76.5 (51–98)	73.3 (51–89)	0.091
Sex, M/F (%)	30 (23.4)/98 (76.6)	14 (36.8)/24 (63.2)	0.100
AO/ASIF classification			
Stable fracture, n, (%)	56 (43.8)	21 (55.3)	0.211
A1.1	14 (10.9)	11 (28.9)	
A1.2	36 (28.1)	9 (23.7)	
A1.3	0 (0)	0 (0)	
A2.1	6 (4.7)	1 (2.6)	
Unstable fracture (%)	72 (56.3)	17 (44.7)	
A2.2	11 (8.6)	9 (23.7)	
A2.3	51 (39.8)	6 (15.8)	
A3	10 (7.8)	2 (5.3)	
BMI, kg/m <sup>2</sup>	21.9 (SD 3.7)	22.7 (SD 3.1)	0.277
BMD of hip, T-score	-2.9 (SD 1.1)	-2.5 (SD 0.8)	0.036
No. of TSP applied (%)	114 (89.1)	20 (52.6)	0.000
No. of GT wiring applied (%)	52 (40.6)	4 (10.5)	0.001
TAD, mm	21.5 (SD 5.5)	21.4 (SD 4.9)	0.800
Second intervention (%)	4 (3.1)	2 (5.3)	0.621

BMI body mass index, BMD bone mineral density, TAD tip–apex distance, calTAD calcar tip–apex distance

**Table 2** Clinical result: comparison of mechanical failure

	Group 1 (n = 128)	Group 2 (n = 38)	P value
Screw cutout (%)	2 (1.6)	1 (2.6)	0.544
Screw migration (%)	18 (14.1)	12 (31.6)	0.014

of screw migration, a power analysis of the outcome measures showed 66.9% power to yield a statistically significant result assuming a two-sided error rate of 5% for the sample size for each group.

## Results

The baseline parameters between the two groups and the operative findings are summarized in Table 1. The differences in BMD of the hip and the proportions of usage of TSP and GT wiring were statistically significant between the two groups ( $P=0.036$ ,  $<0.001$ , and  $0.001$ , respectively). Acceptable reduction, with neutral or valgus reduction, was achieved in all cases.

There were 3 cases of lag screw cutout: 2 (1.6%) in Group 1 and 1 (2.6%) in Group 2; the difference was not statistically significant. There were 18 cases (14.1%) of screw migration in Group 1 versus 12 (31.6%) in Group 2 ( $P=0.014$ ) (Table 2).

To exclude the effect of the TSP, we compared the differences in the cutout and migration rates of the two groups for TSP cases only. The screw migration rate was

**Table 3** Clinical results: comparison of mechanical failure in cases using TSP

	TSP + additional screw (n = 114)	TSP without additional screw (n = 20)	P value
Screw cutout (%)	2 (1.8)	1 (5.0)	0.387
Screw migration (%)	16 (14.0)	7 (35.0)	0.047

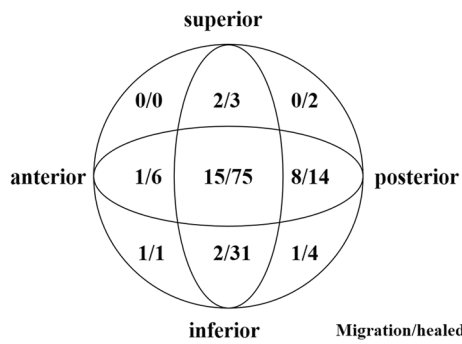
TSP trochanter stabilizing plate

**Table 4** Clinical results: comparison of mechanical failure in the additional screw group (Group 1) according to TSP use

	Group 1 (n = 128)		P value
	TSP (n = 114)	Without TSP (n = 14)	
Screw cutout (%)	2 (1.8)	0 (0)	>0.999
Screw migration (%)	16 (14.0)	2 (14.3)	>0.999

higher in the no additional screw group (Table 3). In the additional screw group (Group 1), the screw cutout and migration rates did not differ regardless of TSP use (Table 4).

The overall screw migration rate was highest in the center–center screw position (50%), followed by center–posterior position (26.7%), but the differences between them were not statistically significant (Fig. 4). The intergroup differences in the screw migration/cutout position are shown in Fig. 5.



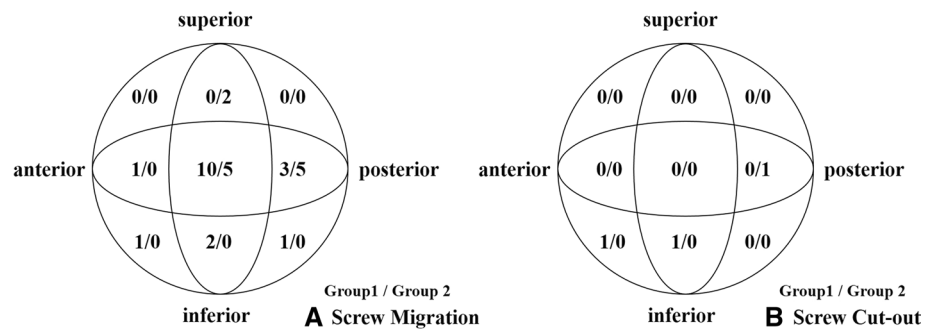
**Fig. 4** Distribution of lag screw position according to Cleveland zone in all patients

Secondary intervention was performed in 6 cases: 3 cases of conversion to arthroplasty due to hip screw

cutout, 1 of implant removal, 1 of DHS revision due to periprosthetic fracture, and 1 of conversion to arthroplasty due to osteonecrosis of the femoral head (ONFH). Four of these cases were in Group 1 (3.1%): 2 cases of hip screw cutout, 1 of ONFH, and 1 of periprosthetic fracture. The other 2 cases were in Group 2 (5.3%): 1 case of hip screw cutout and 1 of implant removal.

Univariate analysis of the cases with and without screw migration revealed that the additional anti-rotational screw had a significant correlation with lag screw migration with mean TAD of 22.0 mm and 22.4 mm, respectively. Furthermore, in the two groups, the position of the lag screw was in the center and inferior portions of the femoral head in 93.3% and 96.3% of cases, respectively (Table 5). Multiple logistic regression analysis revealed that the lack of usage of an additional anti-rotational screw was the unique factor that elevated the risk of screw migration ( $P=0.016$ ; odds ratio 2.821; 95% confidence interval 1.210–6.575).

**Fig. 5** Comparison of lag screw positions between two groups. Distribution in screw migration is shown (a), and screw cutout is shown (b)



**Table 5** Univariate analysis to evaluate the risk factor for lag screw migration

Variable	Screw migration (n=30)	Non-migration (n=136)	P value
Mean age (range), years	73.4 (51–89)	76.3 (51–98)	0.135
Sex, M/F (%)	6 (20.0)/24 (80.0)	38 (27.9)/98 (72.1)	0.372
Unstable fractures (%)	18 (60.0)	71 (52.2)	0.438
No. of additional screws inserted (%)	18 (60.0)	110 (80.9)	0.014
No. of TSP applied (%)	23 (76.7)	111 (81.6)	0.534
No. of GT wiring applied (%)	8 (26.7)	48 (35.3)	0.366
TAD, mm	22.0 (SD 4.6)	21.4 (SD 5.5)	0.371
Screw distribution (%)			0.057
Superior–anterior	0 (0)	0 (0)	
Superior–center	2 (6.7)	3 (2.2)	
Superior–posterior	0 (0)	2 (1.5)	
Center–anterior	1 (3.3)	6 (4.4)	
Center–center	15 (50.0)	75 (55.1)	
Center–posterior	8 (26.7)	14 (10.3)	
Inferior–anterior	1 (3.3)	1 (0.7)	
Inferior–center	2 (6.7)	31 (22.8)	
Inferior–posterior	1 (3.3)	4 (2.9)	

## Discussion

Many previous studies reported an estimated lag screw cutout rate in DHS surgery of 8–17% [5, 12, 15]. A number of studies reported on the catastrophic complications other than lag screw cutout, such as extreme cases of intra-abdominal screw migration, following hip screw migration in DHS surgery [16–18]. Therefore, in an effort to address these complications, several studies investigated the risk factors for DHS mechanical failure. TAD and screw position were important predictors of lag screw cutout. Debate persists about the optimal TAD or ideal lag screw position, but the general consensus is that a small TAD, preferably less than 25 mm, and lag screw position in the central or inferior parts of the femoral head can reduce the risk of lag screw cutout [2, 4, 12, 19–21]. The results of such guidelines were evident when Hsueh et al. [4] reported a cutout rate of 6.8%, which is slightly lower than those of previous studies. Nevertheless, screw migration leading to lag screw cutout remains the most common cause of DHS mechanical failure.

Using an additional anti-rotation screw is technically simple and provides greater biomechanical resistance [9, 22]. However, clinical evidence of the efficacy of using an additional screw in DHS surgery is limited. Makki et al. [23] reported the uselessness of an additional screw in the treatment of femoral neck fractures using DHS fixation because it required longer surgical time and more radiation exposure without resulting in a significant difference in clinical results. On the contrary, our results showed that the usage of an additional anti-rotational screw reduced the lag screw migration rate, and a lack of an additional screw in the treatment of femoral intertrochanteric fracture using DHS fixation was a risk factor for lag screw migration. In this study, the cutout rate was only 1.6% and the screw migration rate was 14.1% in the group with an additional anti-rotation screw. Compared with a previously reported screw cutout rate of 6.8%, the previous lowest rate [4], our rate of 1.5% is significantly lower. In our opinion, this simple technique could increase the rotational stability of the fracture fragments because of the screw's "anti-rotation" effect on the DHS device.

TSP reportedly prevents femoral medialization, improves functional outcomes of patients with various unstable intertrochanteric fractures [24], and prevents postoperative lateral wall fracture in patients with a thin lateral wall [25]. In this study, the effect of TSP on screw migration (Table 4) was excluded, and the screw migration rate was higher in only the TSP cases among the no additional screw group.

We found that the major risk factor for hip screw migration was the lack of an additional screw and that the use

of an additional anti-rotation screw was the most powerful negative risk factor when appropriate TAD and lag screw positioning were applied. In the current study, we found no intergroup difference in TAD and screw positions between each group. Therefore, we believe that an additional anti-rotation screw can reduce the rates of mechanical failure with appropriate reduction and screw position.

As for another major treatment option for the intertrochanteric fracture of the femur, there are the cephalomedullary nails. Nowadays, even there are many surgeons who prefer cephalomedullary nail compared to DHS, there is consensus that the functional outcome between both devices has no difference [26]. In this condition, our additional anti-rotation screw insertion technique could be helpful to the surgeons who prefer DHS technique.

This retrospective study has several limitations. First, the number of cases of hip screw cutout was small; therefore, we used hip screw migration rather than screw cutout as an indicator of proximal fixation strength. Second, the number of patients who underwent surgery with an additional anti-rotation screw was obviously larger than that without it. Most of the patients were old and had poor bone quality; thus, in many cases, we observed rotation of the proximal fragment at the end of the lag screw insertion and inserted an additional anti-rotation screw. Third, we could not evaluate the BMD and BMI of all patients: The BMD of 6 patients could not be evaluated due to their elderly age, while the BMI of 5 patients could not be found in the medical records. Hence, these data were missing from the multivariate analysis. A prospective randomized control study would be the ideal way to validate the role of an additional anti-rotational screw.

Despite these limitations, this study demonstrated the utility of an additional screw in preventing screw migration in DHS fixation. Therefore, we believe that the use of an anti-rotational screw is an easy and useful option for strengthening the proximal fixation in intertrochanteric hip fractures.

## Conclusion

The use of an additional anti-rotation screw reduced the lag screw migration rate and demonstrated a negative correlation with lag screw migration following DHS in intertrochanteric fractures. Therefore, an additional anti-rotational screw can help reduce hip screw failure rates following DHS fixation of intertrochanteric fractures.

## Compliance with ethical standards

**Conflict of interest** The author(s) declare that they have no competing interests

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