Varus Malunion as an Outcome of Pertrochanteric Fracture Fixation

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Abstract

Background: Despite the high incidence of pertrochanteric fractures in African countries, there are insufficient data on radiographic outcomes of fixation. Previous studies focused on cut-out as an outcome measure. Varus malunion may be a significant outcome measure as it results in biomechanical alterations at the hip. **Objective:** This study aimed to identify varus malunion as an outcome of pertrochanteric fracture fixation in our population. **Study design:** This was a cross-sectional, prospective, observational study. **Patients and methods:** Fifty-nine patients were operated on at three facilities over a 1-year period. Post-operative neck–shaft angle (NSA) and tip–apex distance (TAD) were measured. After 12 weeks, radiographs were assessed for varus malunion and cut-out. **Results:** The mean post-operative NSA was 3° of varus and the mean TAD was 36 mm. After 12 weeks, there was an average varus collapse of 6°. Predictors of varus collapse were increased TAD ($p = 0.002$) and decreased post-operative NSA ($p < 0.001$). The cut-out rate was 4.9%. **Conclusion:** Pertrochanteric fractures show varus collapse after fixation. Reduction in valgus may allow the fracture to collapse into a near-anatomical position, avoiding malunion. The position of the implant within the femoral head plays an active role in preventing varus malunion.

Keywords: Pertrochanteric, Intertrochanteric, Hip fractures, Cut-out, Varus

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Introduction

Pertrochanteric fractures are fractures that occur within the intertrochanteric region of the proximal femur. They comprise 34% of all hip fractures and are the most frequently operated fracture type globally (1).

Epidemiological studies on both intracapsular (femoral neck) fractures and extracapsular (pertrochanteric) fractures show that the incidence of hip fractures shows geographic variation, ranging from 150 to 853 per 100,000 in Asia, Europe, and North America. The incidence of hip fractures in African countries is much lower, with values across the continent ranging from 2 to 85.9 per 100,000. The incidence rate of hip fractures in Kenya, however, is much higher than that reported in other African countries, at 245 per 100,000 (2). This figure is comparable to those in countries where hip fracture research is concentrated, signifying the burden posed by hip fractures on our healthcare system. In addition, hip fractures pose a high economic burden.

Healthcare costs are estimated at more than $10 billion in the United States alone, accounting for 72% of costs associated with all fractures (3). This high cost of care is likely to have more of an impact on low- and middle-income countries. Despite their high incidence and economic burden, there are insufficient clinical data on hip fractures in our country.

The choice of treatment for pertrochanteric fractures, barring significant contraindications, is internal fixation. Numerous implant types have been designed for the fixation of pertrochanteric fractures, with the most frequently used being the dynamic hip screw (DHS), the proximal femoral nail (PFN), and the proximal femoral nail antirotation (PFNA). While internal fixation gives better results than non-operative treatment, it is subject to poor surgical outcomes requiring surgical revision (4).

Up to 49% of pertrochanteric fractures require revision surgery. Fixation failure rates range from 16% to 23% and the most common cause is cut-out from the femoral head (5). Numerous studies have assessed cut-out and its predictors. The major factors associated with implant cut-out are the quality of fracture reduction and the position of the implant within the femoral head. Fractures reduced in a varus position relative to the contralateral unaffected side have higher rates of cut-out than those reduced in a valgus position (6). The position of the implant within the femoral head is most commonly defined by the tip–apex distance (TAD) and studies have shown that a TAD of >25 mm is a strong predictor of cut-out (7).

These two factors affect the quality of the final fixation construct and their role in cut-out is well established. However, cut-out may not be a sufficient outcome measure. Unlike other fractures, where emphasis is placed on avoidance of malunion, shortening with varus collapse has been considered inevitable in internal fixation of pertrochanteric fractures. As such, assessment of outcomes of pertrochanteric fractures has focused on the predictors of cut-out with less attention paid to varus malunion and its predictors (8).

Varus malunion is associated with femoral neck shortening. These changes affect hip biomechanics hindering recovery of mobility. Varus malunion may be a significant outcome measure that is impacted by the quality of fracture reduction and the position of the implant within the femoral head (9). The aim of this study was to identify varus malunion as an outcome of pertrochanteric fracture fixation in our population, highlighting its radiographic predictors.

Objectives

Broad objective

The objective of this study was to identify varus malunion as an outcome of pertrochanteric fracture fixation.

Specific objectives

1. To measure the post-operative neck–shaft angle (NSA) after pertrochanteric fracture fixation.
2. To calculate the TAD after pertrochanteric fracture fixation.
3. To quantify the degree of varus malunion after pertrochanteric fracture fixation.
4. To assess the implant cut-out rate after pertrochanteric fracture fixation.

Study design

This was a cross-sectional, prospective, observational study.

Study setting

The study was carried out on patients admitted at Kenyatta National Hospital, AIC Kijabe Hospital and PCEA Kikuyu Hospital between April 2017 and March 2018.

Study hypothesis

Varus malunion is a significant outcome measure of pertrochanteric fracture fixation

Patients and Methods

This was a multi-center, cross-sectional, prospective, observational study conducted at three hospitals between April 2017 and March 2018. Ethical approval was obtained from the relevant bodies (P711/12/2017; 02718/0002/2018) and informed consent obtained from patients. The study was aimed at all patients with

pertrochanteric fractures who were admitted and operated on within the 1-year period. Patients excluded from the study were those younger than 18 years, those unable/unwilling to consent to the study, patients with pathological fractures, polytrauma patients, patients with bilateral lower limb fractures, and patients with multiple fractures of the ipsilateral femur.

Patient anonymity was maintained during data collection. Patient age, sex, the implant type, and side of the operation were recorded. The patients' pre-operative anteroposterior pelvic radiographs were evaluated and classified according to the Arbeitsgemeinschaft für Osteosynthesefragen/Orthopedic Trauma Association (AO/OTA) classification system. Post-operative radiographs were assessed for angulation at the fracture site and TAD using digital radiography software by one author.

Angulation was described by measuring the NSA on the anteroposterior radiograph using standard goniometry.

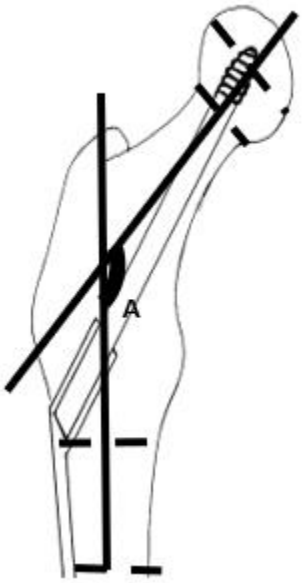

Figure 1. Illustration of a pertrochanteric fracture fixed with a sliding hip screw. Measurement of NSA is shown. For both the femoral neck and shaft, diameters were taken at two different points (dashed lines) and two lines subtended between the midpoints of these diameters (continuous lines). The angle between the two lines is the NSA (A) and was recorded as the deviation from the contralateral unaffected side (NSA difference). NSA, neck–shaft angle. Original illustration.

This is the angle between the central axis of the femoral neck and that of the femoral shaft. To establish the femoral neck axis, a midpoint was found at two different points on the femoral head and neck; the axis was the line subtended between the two points. The same was done to establish the femoral shaft axis, with a line subtended between two midpoints distal to the lesser trochanter (Figure 1) (10). The NSAs of both the affected and contralateral sides were recorded, and the NSA was described as the deviation from the contralateral unaffected side (post-operative NSA difference). The TAD was calculated (Figure 2) as described by Baumgaertner et al. (11).

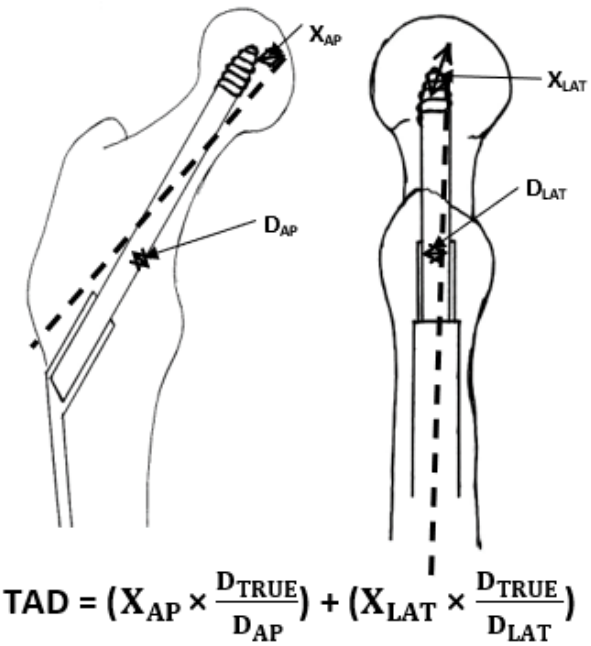

Figure 2. Illustration of a pertrochanteric fracture fixed with a sliding hip screw. Measurement of the tip–apex distance (TAD) is shown. X is the distance between the tip of the screw and the centre of the femoral head. D is the diameter of the screw. X and D are measured on both AP and Lateral views. Original illustration.

Follow-up radiographic assessment was done after a minimum period of 12 weeks. Twelve weeks was chosen as this has been shown to be the period within which both full union and cut-out occur (12). The NSA of the affected limb was measured as previously described and compared to the contralateral unaffected

side (follow-up NSA difference) to assess for varus malunion. Radiographs were also assessed for implant cut-out from the femoral head.

Data were collected using structured data entry sheets and entered into a password-protected database. Bivariate analysis was carried out to relate outcomes to patient biodata and radiographic parameters. Comparison between means was done using Student's t-test/analysis of variance, while chi-squared test was used to compare propositions. Multivariate analysis was done to determine independent factors associated with outcomes while adjusting for confounders and effect modifiers. This was achieved using binary stepwise backward logistic regression. All analysis was carried out using IBM Statistics Software Version 24 (IBM Corp, Armonk, NY, USA) and presented using tables and prose.

Results

A total of 59 patients were operated on within the 1-year study period. Patient age ranged from 18 to 103 years, with a mean age of 65 years (standard deviation [SD]=22).

Table 1. Distribution of patients by age groups

Age group	n	%
18–24 years	1	1.7
25–35 years	7	11.9
36–49 years	10	16.9
50–69 years	12	20.3
≥70 years	29	49.2
Total	59	100

Close to half (49.2%) of the patients were aged ≥70 years (Table 1). Thirty-six patients (61%) were male, while 23 patients (39%) were female. Patient age also showed a bimodal distribution, with peaks between ages 30–40 years and 70–90 years.

Twenty-five operations were carried out on the left femur, while 34 were carried out on the right.

Table 2. Distribution of implant type used by side of operation

		Implant side					
		Left		Right		Total	
		n	%	n	%	n	%
Implant type	DHS	13	22.03	14	23.73	27	45.76
	PFN	0	0	2	3.39	2	3.39
	PFNA	12	20.34	18	30.51	30	50.85
	Total	25	42.37	34	57.63	59	100

DHS, dynamic hip screw; PFN, proximal femoral nail; PFNA, proximal femoral nail antirotation.

Table 3. Distribution of radiographic parameters

Radiographic parameter	Mean	Standard deviation	Median	Minimum	Maximum
Post-op **NSA** ipsilateral **(°)**	127	12	127	91	155
NSA contralateral **(°)**	130	8	129	118	150
Post-op **NSA** difference **(°)**	−3	11	−4	−33	18
Tip–apex distance (mm)	36	19	30	12	86
F/U NSA ipsilateral **(°)**	121	14	124	89	150
NSA contralateral **(°)**	130	8	129	118	150
F/U NSA difference **(°)**	−9	12	−6	−39	16

F/U, follow-up; NSA, neck–shaft angle.

A DHS was used in 27 patients, a PFN in 2 patients, and a PFNA in 30 patients (Table 2). The post-operative NSA when compared to the contralateral side ranged from 33° of varus to 18° of valgus, with a mean NSA of 3° of varus (SD=11). The TAD ranged from 12 to 86 mm, with a mean TAD of 36 mm (SD=19) (Table 3). On parametric inferential analysis, the post-operative NSA

showed statistically significant correlations with TAD ($p = 0.001$).

Twelve patients (20.3%) were lost to follow-up post-operatively and six deaths were observed during the study period, resulting in a mortality rate of 10.2%. Two patients died from medical conditions unrelated to the operation, three developed a pulmonary embolism in the immediate post-operative phase (<48 h), and one died from complications of post-operative sepsis. Forty-one patients were therefore available for follow-up assessment.

On follow-up, there was an average varus collapse of 6° (Table 3). Predictors of the degree of varus collapse were increased TAD ($p = 0.002$) and decreased post-operative NSA ($p < 0.001$). There were no correlations with age, gender, fracture pattern, or choice of implant. Cut-out was observed in two patients (4.9%).

Discussion

Previous studies on outcomes of pertrochanteric fracture fixation have focused on cut-out as an outcome measure. The main predictors of cut-out are the quality of reduction and the position of the implant within the femoral head (13, 14). These factors affect the stability of the fixation construct and the subsequent tendency of the implant to migrate within the femoral head as the fracture collapses into varus. As such, varus collapse at the fracture site has been considered inevitable, and to the best of our knowledge, there are insufficient data in our population on the factors that affect the degree of collapse and the final NSA at the fracture site after fixation (15, 16).

In our study, the NSA decreased by 6° from a mean of 127° to 121°. In a randomized controlled trial comparing pertrochanteric fractures treated with the DHS and PFN, Pajarinen et al. (17) found a significant decrease in the NSA within the first 6 weeks after operation. In the same study, the degree of varus collapse did not correlate significantly with the post-operative NSA or TAD. These findings suggest that pertrochanteric fractures tend to collapse into varus during the follow-up period and that the degree of collapse is not affected by the initial quality of the fixation construct. However, in our study, the post-operative NSA correlated significantly with the follow-up NSA. This finding is similar to those made in other studies (18, 19). Therefore, an initial reduction in varus is likely to result in significant varus malunion. As such, the fracture reduction should target a position of slight valgus in order to allow the fracture to collapse into a near-anatomical NSA and avoid varus malunion.

The TAD is an objective method of quantifying the position of the implant within the femoral head. The ideal TAD is <25 mm; this is the position where minimal migration occurs as the implant is subjected to forces associated with activities of daily living (20, 21). In our study, the average TAD was 36 mm. This increased TAD was a predictor of varus malunion on follow-up. This finding suggests that the position of the implant plays an active role in preventing varus malunion and that the implant does not passively migrate through the femoral head during an inevitable fracture collapse. It is also possible that the TAD achieved during surgery is dependent on the ability to reduce the fracture to an optimal NSA. Thus, poor fracture reduction may result in poor placement of the implant and compromise overall fracture stability.

The main limitation of this study was potential bias with regard to the choice of implant and the fracture pattern. While no correlation was found between varus malunion and either of the two parameters, this may be due to surgeons choosing certain implants for particular fracture patterns. Future trials that control for the surgeon, fracture pattern, and implant may offer more accurate information on the effect of these parameters on varus malunion. Another limitation of this study was the potential effect of variations in limb position on the measurements taken. In as much as this was compensated for by presenting measurements in ratios, future studies may need to assess the inter-observer reliability of these post-operative parameters.

Conclusion

Pertrochanteric fractures show a decrease in NSA after fixation with a risk of varus malunion. Reduction in slight valgus may allow the fracture to collapse into a near-anatomical position, avoiding malunion. The position of the implant within the femoral head plays an

active role in preventing fracture collapse and surgeons may reduce the risk of varus malunion by minimizing the TAD intra-operatively.

Author contributions

WN led in conceptualization, data curation, formal analysis, investigation, methodology, project administration, resources, writing, review & editing of the original draft. VMM and JKK equally contributed to supervision and in reviewing & editing of the original draft.

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