



Importance of Restoration of Proximal Femur Geometry in the Management of Intertrochanteric Fractures using Dynamic Hip Screw in Egyptian population

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Abstract

Introduction: The characteristic morphology of the proximal extremity of the femur and the muscle balance of the hip are factors that make weight bearing possible among patients. Recent studies have been conducted with the intention of showing the relationship between fracture of the proximal extremity of the femur and the anatomical configuration of the hip. Recently, a number of researchers presented the geometry of trochanteric region and proximal femur to improve the design of new implants, with respect to their anatomical landmarks, structure and distribution of their bony tissue.

Patients and Methods: Dynamic hip screw was used in the treatment of 35 intertrochanteric fractures in 35 patients, including 23 males and 12 females, whose age ranged from 34 to 70 years with a mean of 55 years. All patients were clinically assessed according to the Harris hip scoring system.

Results: were excellent in 25.71%, good in 40%, fair in 20% and poor in 14.29%. Poor results occurred in 5 cases. The changes of proximal femur morphology after fixation by measuring the proximal femur parameters by radiographs of both hips. The measurements were 62.86% not a significant change, 28.57% mild changes and 8.57% significant change.

Conclusion: The neck-shaft angle is the most important parameter in the morphology of the proximal part of the femur and fixation of intertrochanteric fracture by DHS must preserve the normal angle after fixation to avoid valgus and varus malunion.

Abbreviations: DHS: Dynamic Hip Screw; TAD: Tip-Apex Distance; AP: Antero Posterior; FNW: Femoral Neck Width; FNL: Femoral Neck Length; FAL: Femoral Axis Length; NSA: Neck-Shaft Angle; GTPSD: Greater Trochanter-Pubic Symphysis Distance; EQ: Euro Qol; TAD: Tip-Apex Distance; HHS: Harris Hip Score; QOL: Quality of Life; HHS: Harris hip scoring system; FNL: Femoral Neck Length

Introduction

An increase in the elderly population has resulted in raising the incidence of hip fractures in many parts of the world. Increased longevity, together with osteoporosis and senile muscular insufficiency, may explain the increasing number of patients with hip fractures [1]. More recent evidence suggests that variations in Proximal Femoral Geometry also play an important role in the hip fracture etiology [2]. The characteristic morphology of the proximal extremity of the femur and the muscle balance of the hip are factors that make weight bearing possible among patients. Recent studies have been conducted with the intention of showing the relationship between fracture of the proximal extremity of the femur and the anatomical configuration of the hip [3,4].

Surgical stabilization of the intertrochanteric fractures and early mobilization of the patients are the optimal treatment

to prevent the complications of prolonged immobilization, except in patients with medical problems in whom surgery is contraindicated [5], the study of proximal femoral morphology facilitates the procedure of preoperative planning and reduces the risk of injury of trochanteric surrounding structures [6].

The Dynamic hip screw (DHS) had been the standard and the best documented implant in treating intertrochanteric fractures and in several randomized trials it has been associated with lower complications and respiration rates. In addition, it is a less expensive implant [7]. Recently, a number of researchers presented the geometry of trochanteric region and proximal femur to improve the design of new implants, with respect to their anatomical landmarks, structure and distribution of their bony tissue [8,9]. In this study, we tried to evaluate the effect of restoration of proximal femoral geometry on outcome of patients with intertrochanteric fractures treated with dynamic hip screw.

Patients and Methods

This study included 35 intertrochanteric fractures treated by Dynamic Hip Screw (DHS) and followed up for a minimum 2 years. There were 40 patients in this study, 2 patients died with non related causes and 3 patients lost during follow-up. The inclusion criteria: All adult patients with intertrochanteric fractures undergoing surgery. Only recently, isolated and stable intertrochanteric fractures are included in the study. The exclusion criteria: Unstable and comminuted fractures, Pathological and neglected fractures, bilateral hip fractures and associated pelvic fractures, skeletally immature patients.

A written informed consent was obtained from all patients. All data of patients were confidential with secret codes and private file for each patient. All given data were used for the current medical research only. The study was carried out in accordance with The Declaration of Helsinki [10] and the principles of good clinical practice. Fractures were classified radiologically according to AO classification and all were (31-A1) Pertrochanteric simple [11].

Radiological Assessment

Fracture Healing and Implant and Bone Interactions: Serial x-rays were taken pre & post-operative and in every check (4 weeks) to determine union (delayed union, non-union or malunion), implant position in the femoral head (tip-apex distance [TAD]) [12] to predict implant failure and fixation failure (lag screw cut-out, penetration or loosening) and position of lag screw in the femoral neck (superior, central or inferior) according to Goffin et al. [13] Study.

Evaluation of Changes of proximal Femur morphology: The pelvic radiographs were taken in the anteroposterior (AP). The patient was positioned in horizontal supine position with the patella facing straight ahead and the lower limbs internally rotated 20°. The morphometric evaluation was done by radiograph of the normal hips and the fractured hips (AP both hips), the proximal part of the contra lateral femur was used as a control for the measurements. The measurements were taken and changes were recorded.

The analyzed measurements were:

- i. Femoral neck width (FNW).
- ii. Femoral neck length (FNL).
- iii. Femoral axis length (FAL).
- iv. Neck-shaft angle (NSA).
- v. Greater trochanter-pubic symphysis distance (GTPSD).

The choice of these measurement indexes based on Pires et al. [4] Study and Ravichandran et al. [10] study of morphometric analysis of the proximal region of the femur, changes of both

sides were compared by students' t-test [14] to (non significant, mild or significant).

Patients' Quality of Life

EuroQol (EQ-5D) used to evaluate patients' quality of life and activity before trauma and after surgery, according to Hajbagheri et al. [15] Study.

Clinical Assessment

The Harris hip score (HHS) [16] used to assess hip function more specifically.

i. Relation between Proximal femur changes and clinical evaluation: Evaluation of radiological changes of the proximal femur and its clinical effect after fixation of intertrochanteric fractures by DHS had been done according to Ravichandran et al. [17] Study.

Statistical Analysis

Statistics were performed by SPSS Statistics v20.0.0 Multicomputer software.

The p-value is a number between 0 and 1 and interpreted in the following way:

A small p-value (typically ≤ 0.05) indicates strong evidence against the null hypothesis, so you reject the null hypothesis. A large p-value (> 0.05) indicates weak evidence against the null hypothesis, so you fail to reject the null hypothesis. P-values very close to the cutoff (0.05) are considered to be marginal (could go either way). The results were graded as follows:

- a. Extremely significant = 0.0001 - 0.001
- b. Very significant = 0.001 - 0.01
- c. Significant = 0.01 - 0.05
- d. Not significant ≥ 0.05

Results

This study included 35 intertrochanteric fractures in 35 patients. They were evaluated both radiologically and clinically. Radiological evaluation included assessment of union (delayed, nonunion or malunion), failure of fixation and implant failure, position of lag screw in femoral head by (Tip-apex distance [TAD]) and in the femoral neck (central, superior or inferior) and evaluation of changes of proximal femur morphology (non significant, mild or significant). The clinical results were assessed according to the Harris hip score (HHS). There were 23 male and 12 female with an average age of 55 years (range 34-70). The mechanism of injury was a simple fall in 25 (70%) cases; fall on stairs in 7 (20%) cases and RTA in 3 (10%) cases. The fracture was in the right side in 19 cases and on the left side in 16 cases. The follow up period ranged from 25 to 33 months, with an average of 28 months (Table 1).

Table 1: Patients Data Sheet.

No	Age	Sex	Occupation	Previous Disease	Mechanism of Injury	AO grade	Changes of prox. Femur
1	67	Male	Farmer	None	Fall from height	Rt-A1.1	Mild
2	41	Female	Engineer	None	R.T.A	Lf-A1.1	Not significant
3	70	Female	Housewife	D.M-			
Hypertension	Fall on stairs	Lf-A1.1	Significant				
4	58	Male	Teacher	None	Fall from height	Rt-A1.1	Not significant
5	43	Male	Worker	None	Fall from height	Lf-A1.1	Not significant
6	60	Male	Farmer	Hypertension	Fall from height	Lf-A1.1	Not significant
7	66	Male	Plumber	Cardiac-			
Hypertension	Fall from height	Rt-A1.1	Mild				
8	34	Male	Coach	None	R.T.A	Lf-A1.1	Mild
9	43	Male	Worker	None	Fall from height	Rt-A1.1	Not significant
10	65	Female	Housewife	Hypertension	Fall from height	Rt-A1.1	Not significant
11	66	Female	Accountant	None	Fall from height	Lf-A1.1	Not significant
12	70	Female	Housewife	Diabetic-			
Hypertension	Fall on stairs	Lf-A1.1	Mild				
13	58	Male	Hairdresser	Hypertension	R.T.A	Rt-A1.1	Not significant
14	54	Male	Teacher	None	Fall from height	Rt-A1.1	Not significant
15	43	Male	Worker	None	Fall from height	Lf-A1.1	Not significant
16	70	Male	Farmer	Cardiac	Fall from height	Rt-A1.1	Mild
17	45	Female	Tailor	None	R.T.A	Lf-A1.1	Not significant
18	50	Male	Electrician	None	Fall from height	Rt-A1.1	Not significant
19	70	Female	Housewife	D.M	Fall from height	Rt-A1.1	Mild
20	43	Male	Businessman	None	Fall on stairs	Rt-A1.1	Not significant
21	39	Male	Journalist	None	Fall from height	Lf-A1.1	Not significant
22	61	Female	Housewife	Hypertension	Fall from height	Rt-A1.1	Not significant
23	70	Male	Farmer	D.M	Fall from height	Lf-A1.1	Mild
24	45	Male	Worker	None	Fall from height	Lf-A1.1	Not significant
25	56	Female	Teatcher	Cardiac	Fall from height	Lf-A1.1	Mild
26	53	Female	Accountant	Hypertension	R.T.A	Rt-A1.1	Not significant
27	65	Male	Farmer	Cardiac-			
Hypertension	Fall from height	Lf-A1.1	Significant				
28	58	Male	Carpenter	None	Fall from height	Rt-A1.1	Not significant
29	69	Male	Farmer	D.M-			
Hypertension	Fall from height	Rt-A1.1	Mild				
30	50	Female	Housewife	None	R.T.A	Lf-A1.1	Not significant
31	70	Male	Farmer	D.M-			
Hypertension	Fall from height	Rt-A1.1	Significant				
32	55	Male	Teacher	Hypertension	Fall from height	Rt-A1.1	Not significant
33	66	Male	Electrician	D.M-			
Hypertension	Fall from height	Rt-A1.1	Mild				
34	47	Female	Teacher	None	R.T.A	Rt-A1.1	Not significant
35	36	Male	Engineer	None	Fall from height	Lf-A1.1	Not significant

Patients' Quality of Life

In this study, according to Hajbaghery et al. [15] (EQ-5D) used to evaluate quality of life (QOL) and activity of patients before trauma and after surgery, there were 16 active patients with average score 81, 19 inactive patients with average score 34 and 90% of the patients returned to their previous activities after surgery, p-value 0.085 was not Significant.

Radiological Evaluation

Fracture Healing and Implant and Bone Interactions

Based on Goffin et al. [13] Study, implant position in the femoral head, according to (tip-apex distance [TAD]) was average of 27 cases (from 19 mm to 24 mm) and was acceptable in 7 cases (25 mm - 30 mm) and in one case (case no. 3) who had lagged screw backing out was 36 mm. Lag screw position in femoral neck was central in 25 cases and had good union, inferior in 7 cases 2 of them (case no. 8 and case no. 31) had valgus angulation and was superior in 3 cases. One case of them (case no. 27) had varus angulation. Union at 6 months occurred in 28 cases. All cases had united in the final follow up. The average time to radiological union was 6 months.

Male patients had union shorter in duration than female patients by 30%. The P - value 0.085 was not significant and young group patients had a union in shorter period than old groups by 33%. The P - value 0.043 was significant and patients free from medical disorders had union shorter in timing than patients with other medical disorders by 24%. The P - value 0.031 was significant and active patients had union time shorter than inactive by 22%. The P - value 0.025 was significant.

Union Complications

Delayed union (after 3 months there were no signs of radiological union) occurred in one case, despite absence of pain and the presence of normal function. This was detected by the persistence of the fracture line and absence of bone bridging on the lateral view where the proximal fragment was seen to be totally anterior to the shaft. Nonunion occurred in one case

(cases, no. 3) deep infection resulted in lag screw loosening with backing out which precludes progress to union; p-value 0.025 was significant (Table 2).

Table 2: Statistical distribution of union condition.

Condition	N	%
United	31	88.57
Delayed union	1	2.86
Malunion	2	5.71
Non-union	1	2.86
Total	35	100
p. value	0.025	

Varus malunion 8° occurred in one case due to reduction in neck shaft-angle less than contra lateral side. In case no. (27), the proximal fragment fell into varus due to superior, lag screw in the neck early full weight bearing. Valgus malunion occurred in 2 cases. In case no. (31), 15° and case no. (8), 10°. The proximal fragment was fell into valgus due to excessive neck-shaft angle compared with the contra lateral side and inferior lag screw in the neck. Fixation failure occurred in one case. In case no. (3), the patient was suffering from osteoporosis and the proximal part collapsed and lag screw loosening occurred due to infection and eventually backed out, this may be due to TAD was more than average and was 36 mm.

Evaluation of Changes of Proximal Femur Morphology

The fractured hip after fixation by DHS was compared with the contra lateral hip. The femoral neck width, femoral neck length, femoral axis length, neck shaft angle and great trochanter-pubic symphysis distance were measured on anteroposterior radiographs of both hips and by measurement tools, made preoperatively and at the time of the most recent follow-up. The proximal part of the contra lateral femur was used as a control for the measurements. According to t-test, the final changes were minimal and statistical analysis showed no significant differences between both sides for (FNW, NSA, and GTPSD). However, mild differences were found for FNL & FAL (Table 3).

Table 3: Statistical analysis of mean between proximal femurs on both sides (according to our measurement tools).

Parameters	N	DHS hips (Range)	Contra lateral hips (Range)	Changes	(Mean+SD)	p. value
FNW	35	29.3 mm	29.7 mm	-0.4	29+1	0.0885
FNL	35	13.4 mm	13.5 mm	-0.1	13+0.5	0.0088
FAL	35	70.2 mm	72.8 mm	-2.6	71+1	0.2858
NSA	35	136.5°	125.5°	11	131+5	0.9136
GTPSD	35	109.5 mm	113.1 mm	-3.6	111+2	0.3134

In this study, according to students't-test changes between fractured hip and contra lateral side were compared and it was found that age and gender play a very important role in changes of proximal femur morphology. Twenty two cases had a no significant change and were near normal, t-test 0.082. Ten cases

had minimal changes, but also within normal, t-test 0.049. Three cases had a significant change, t-test 0.009 (Table 4). P-value 0.039 significant. Young and male patients were less changed than old and women (Tables 5 & 6).

Table 4 : Statistical distribution of changes of proximal femur morphology.

Changes	N	%
Not significant	22	62.86
Mild	10	28.57
Significant	3	8.57
Total	35	100
p. value	0.039	

Table 5: Distribution of changes of proximal femur according to age.

Age Group	No. of patients	FNW	FNL	FAL	NSA	GTPSD	t-test
30-40	3	30	13.5	71.1	135.2	109.2	0.012
41-50	10	28.6	13.4	70.5	134.8	109.6	0.007
51-60	9	27.9	13.2	71.4	133.5	111.2	0,018
61-70	13	29.1	12.6	70.2	131.9	110.5	0.011
P value		0.062	0.062	0.062	0.062	0.062	0.062

Table 6: Distribution of changes of proximal femur according to gender.

Gender	N	Parameters (mean) DHS hips					t-test
		FNW	FNL	FAL	NSA	GTPSD	
Male	23	29.5	13.4	71.5	135.4	110.2	0.019
Female	12	28.7	13.3	70.5	132.8	109.6	0.101

Clinical Evaluation

According to the Harris hip scoring system (HHS), we had (9) excellent patients, (14) good patients, (7) for patients and (5) poor patients (Table 7).

Table 7: Statistical distribution of (HHS) results.

HHS	N	%
Excellent	9	25.71
Good	14	40
Fair	7	20
Poor	5	14.29
Total	35	100
p. value	0.037	

Complications

The complications were divided into intra and postoperative and according to our results there was one case with intraoperative complication case no (13) and 4 cases with postoperative complication cases no. (2) - (3) - (27) - (31) (Table 8).

Table 8: Summary of intra & postoperative complications.

Case number	Intraoperative	Postoperative
(2)	_____	1. Superficial infection 2. Delayed union
(3)	_____	1. Deep infection 2. Collapses 3. Lag screw loosening 4. Lag screw back out 5. Non union
(13)	1. Broken drill bit	
(27)	_____	1. Varus of proximal fragment 2. Delayed union 3. Shortening 1 cm
(31)	_____	1. Valgus malunion 2. Shortening 2cm

Discussion

The predicted increase in the aging population and the associated increase in the fractures of the proximal femur have induced a search for improved treatment methods. Many treatment modalities have been used, including non operative methods, intramedullary nails, fixed angle plates, and the dynamic fixation devices. The dynamic device is the implant of choice for stable intertrochanteric fractures [12]. Several aspects of the geometry of the femoral neck have been found to influence the risk of hip fractures. Studies have correlated greater length of the femoral neck and lower values for the neck-shaft angle with greater incidence of hip fractures [18-20]. The purpose of the research is to analyze the consequences of bad reduction on bony union and function and compare the DHS device measurements with Egyptian femora.

The position of the lag screw was more important determining factor. Cases fixed with acceptable alignment, but without bone contact, have shown no cut out or migration and united when an anterior or posterior position was avoided. Birdle et al. reported a lower incidence of screw cut out and/or migration compared to previous series, reflecting the good lag screw position which they obtained. They found that the incidence of central positioning of the lag screw in the femoral neck was higher for the DHS [15].

The incidence of varus deformity was significantly less in patients treated with the DHS [21]. In a study of George et al. [22] treatment of unstable intertrochanteric fractures with a sliding hip screw led to a 56% failure rate (9 of 16 cases). The most common mode of failure was the mobilization of the distal fragment and loss of proximal fixation with nonunion or cutout of the lag screw superiorly. Alvarez et al. [23] had six out of their total of 43 patients (13.9%) ending with varus malunion. In our work, the neck shaft angle ranged from 107° to 130° with an average of 126.4°. We had only one case of the mild varus collapses of the proximal fragment (mild varus 4° in case no.27) and one case of valgus malunion (13° of valgus in case no.31).

The neck of the femur in humans is a very important structural and functional specialization for man's erect posture. Most of the textbooks of Anatomy quote the average neck-shaft angle in adults as 125 degrees (range 110 deg. To 144 deg.) and in fetuses as 140 degrees [24-30]. The average neck-shaft angle in our study (n= 35) is found to be 131.5 degrees (range 122 - 143). The mean neck length of our study is 13.5 mm. Kate found the Formosans to have lowest average neck shaft-angle (125.6 deg.) and Andamanians the highest angle (134 deg.). We considered the Egyptians population in our study had average angles (131.5 deg.) almost same as previous studies. It is clear that the proximal femoral geometry varies among different ethnic groups. Therefore the usage of implants designed exclusively for Western bones will not be suitable for other ethnic groups [31].

Unlike other studies, we measured the neck-shaft angle based on the axis of the proximal femur. This will replicate the actual neck-shaft angle when performing hip arthroplasty as the stem of the femoral component was designed to restore the anatomy of only the proximal femoral region. Trying to place the implant based on the long axis of the femoral shaft may jeopardize bone stock by unnecessarily removing the medial cortex of the femoral diaphysis. There was a change toward varus angulation of the neck-shaft angle (an inward deviation of the distal femoral segment) if the measurement was performed using the long axis of the femoral shaft instead of using the axis of the proximal femur.

No statistically significant difference was detected in the great trochanter-pubic symphysis distance in relation to the occurrence of fracture. In our study, we found no significant changes of the greater trochanter-pubic symphysis distance. Statistically significant difference was detected in the median of the femoral neck length (FNL) in keeping with the fracture. For the non-fractured femurs, the median of this variable was equal to 36 millimeters and for the fractured femurs it was equal to 33 millimeters. At this point, the normality of the femoral neck length was verified according to sex, and was not normal for the male sex. Sex was a "confusing factor", as it influenced the size of the femoral neck length with statistically significant difference in relation to the fracture, when not considered in the analysis [31]. In performing the comparison of this variable according to the occurrence of fracture separately for each sex, this difference did not appear significant. It has to be noted that the difference between the femoral neck length in this work and previous works was mainly because of different point of measurement in this research where it was just proximal to the fractured area.

Conclusion

In conclusion, improved knowledge of the morphology of the proximal femora will assist the surgeon in restoring the geometry of the proximal femur during hip arthroplasty.

Conflict of Interest

No conflict of Interest. Informed consent was taken from all patients.

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