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A Review of Fixation Modalities for Thin Lateral Cortex - Intertrochanteric Femoral Fractures

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Abstract*— Introduction:** *Recently, there is an increasing awareness of the importance of the integrity of the lateral wall of the proximal femur, besides the previous agreement on the integrity of the posteromedial portion of the proximal femur, which was considered the most important prognostic indicator of fracture stability. Therefore, this study aimed to compare outcomes of fixation modalities used to treat thin lateral wall intertrochanteric proximal femur fracture.* ***Methods: *In this retrospective study, seventy-five treated thin lateral cortex intertrochanteric fractures were evaluated radiologically at different follow-up intervals to measure the outcome of different treatments. Dynamic Hip screw (DHS), Dynamic Condylar Screw (DCS), and Proximal Femoral Nail (PFN) were compared regarding healing, mortality, and complications.* ***Results:*** *The mean age of patients was 76.75±11.37 years, and 61.3% of them had comorbidities. The three used treatments were similar regarding healing time, need for revision, and mortality rate. The one-year mortality rate was 12%. PFN maintained a superior accepted position on follow-up. Although DHS showed an excellent reduction on initial postoperative X-ray, less than half of fractures sustained accepted reduction on the first follow-up secondary to medialization of the shaft (32%) and varus collapse (24%). Additionally, DHS was most commonly associated with nonunion. Intraoperative lateral wall fracture in DHS treatment occurred in 15.4%. DCS was the inferior treatment and the most commonly associated with varus collapse.* ***Conclusions****: In the fixation of thin lateral wall entity intertrochanteric fracture, PFN revealed superior results regarding reduction and lower complication rate than other modalities. Therefore, PFN should be used, and DHS and DCS should be avoided in this fracture pattern*.

I. INTRODUCTION

Intertrochanteric femoral fracture is a common fracture that necessitates surgical fixation. Being aware of different fracture pattern affect implant use and surgical technique to improve outcome. The integrity of the posteromedial portion of the proximal femur is well known by the orthopedic surgeon and was considered the most important prognostic indicator of fracture stability [1-5]. Recently, there is an increasing awareness of the importance of the integrity of the lateral wall of the proximal femur in choosing the implant to improve the outcome [6-10].

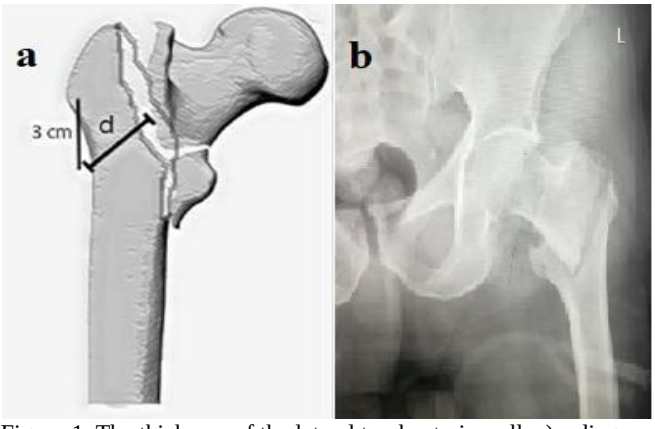

Figure-1. The thickness of the lateral trochanteric wall. a) a diagram demonstrates lateral wall thickness measurement. A line is drawn from the greater trochanter's innominate tubercle angled at 135° upward to the fracture on anteroposterior X-ray. The distance between the lateral wall and the fracture line (d) represents the lateral wall thickness. A distance less than 20.5 mm is considered a fracture with a thin lateral wall. b) X-ray of the left hip with thin lateral cortex intertrochanteric fracture.

The thickness of the lateral femoral wall is measured on the anteroposterior radiograph; a line is drawn from the greater trochanter's innominate tubercle on the lateral aspect of the proximal femur, angled at 135° toward the fracture line. The distance between two lines is referred to as lateral wall thickness. A distance less than 20.5 mm is considered a thin wall [11-12], [Figure-1].

Dynamic Hip Screw (DHS) use in thin lateral wall intertrochanteric fracture might result in iatrogenic lateral wall fracture, which consequently leads to delayed healing, cut through of the metal, varus collapse, and shortening that may need reoperation [13-15], [Figure-2].

In this study, we reviewed seventy-five treated thin lateral wall intertrochanteric fractures to identify the outcomes of different implant choices and compare different implant options regarding the complication and healing time. Accordingly, this will support our surgical technique decision.

II. METHODS

In this retrospective study, we reviewed all patients' clinical and radiological records who were treated for thin lateral cortex - intertrochanteric proximal femur fractures from January- 2017 to December – 2020. The data were extracted from two hospitals of Royal Medical Services, Royal Rehabilitation Center at King Hussein Medical City in Amman, capital of Jordan, and Prince Rashid bin AL Hassan Military Hospital in Irbid city, north of Jordan.

Five hundred and seventy-four intertrochanteric fractures were evaluated using Picture Archiving and Communication System (PACS). Out of them, seventy-five fractures were of a thin lateral cortex pattern. Fractures were evaluated regarding fixation technique and implant choice, followed radiologically at consecutive intervals to compare the outcome of different surgical options regarding healing and complication for each

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implant choice. In addition, we compared different options used in fracture fixation; those include Dynamic Hip screw (DHS), Dynamic Condylar Screw (DCS), and Proximal Femoral Nail (PFN). Sociodemographic and clinical data were obtained from patients' records.

We divided the follow-up period into immediate postoperative, where we depend on the first X-ray after surgery, and the early postoperative period, representing the first three months on follow-up, three-six months, and six months to one year. On the early postoperative radiographs, fracture reduction and fixation technique were determined whether satisfactory or not. We observed the development of complications as cut out; varus collapse; medialization of the shaft, Z-effect [Figure-2]; metal failure; nonunion and mal-union; in addition to per-prosthetic fractures. Healing was determined in months and whether healed in a good position or not. Successful fracture healing was defined radiologically by bridging callus on both anterolateral and lateral views.

This study was approved by the local ethical committee of the Royal Medical Services.

Figure-2: Z-effect deformity is a PFN-specific complication where there is a migration of screws in opposite directions. a) Reverse Z- effect deformity. b) Z- effect deformity. c) Varus collapse of fracture in DHS treatment. d) lateral wall fracture intraoperative complication in a thin lateral cortex treated with DHS.

Statistical Analysis

Descriptive analysis with the mean and standard deviation was applied to continuously measured variables and the frequency and percentages for categorical variables.

The chi-squared test of independence (χ2-test) and Fisher exact test were applied to evaluate the statistical value of associations between categorically measured variables. The One-way ANOVA test was applied to compare the patients' mean age and healing time across treatment modalities for the statistically significant differences. The Kaplan-Meier (KM) method was used to analyze 'time-to-event data.

The Statistical Package for the Social Sciences IBM Version 21 Chicago was used for the statistical data analysis, and the alpha significance level was considered at the 0.050 level.

III. RESULTS

The table 1 demonstrates the sociodemographic characteristic of seventy-five patients with thin lateral cortex intertrochanteric proximal femoral fracture over four years. The majority of patients were females, with a percentage of 69.3 %. The mean age of patients was 76.75±11.37 years. The left femur was predominantly affected in 60 % of patients. Comorbidities including hypertension, diabetes, ischemic heart diseases, and previous cerebrovascular accidents were recorded in 61.3% of the patients.

Table-1: Descriptive analysis of the patients' sociodemographic characteristics. N=75.

	Frequency	Percentage
Sex		
Female	52	69.3
Male	23	30.7
Age (years), mean (SD)	76.75±11.37 (30 -98)	
Affected Extremity		
Right	30	40
Left	45	60
Comorbidity	46	61.3
Comorbidity type		
Hypertension	37	49.3
Diabetes Mellitus	22	39.3
Ischemic Heart Disease	15	20
Cerebrovascular Accident	7	9.3

The table 2 compared the three used treatment options. PFN was used in half of the fractures. There were no differences regarding age, gender, and extremity affected between the three treatment modalities. There was no statistical difference regarding healing time between the three options P=0.242. Moreover, there was no difference regarding one-year mortality rate or the need for revision surgery among different treatment modalities, P=0.626, P=0.841 respectively. DHS is significantly associated with nonunion, P=0.042. The overall mortality rate within the first year was 12%.

The table-3 compared the three used treatment modalities regarding their outcome and complication. Patient radiographs were analyzed at different intervals, immediately postoperative radiograph, within the first three months, between three and six months, and between six and twelve months. The sample size is decreasing during the follow-up secondary to mortality and absence of follow-up. Therefore, the statistical analysis was done for each interval independently.

In the immediate postoperative radiograph, the total sample size was 75 patients. DHS and PFN were associated with superior reduction compared to DCS. Four patients with the DHS fixation technique (15.4%) were complicated by intraoperative lateral wall fracture. Nevertheless, the Fisher exact test demonstrated no statistically significant association between the treatment methods and complication, X2(4)=6.237,p=0.088.

In the follow-up radiographs within the first three months, six patients' X-rays were absent from the follow-up, and analysis was done on 69 patients. Although 96.2% of initial DHS radiographs showed an accepted reduction, only 44% of the fracture maintained an accepted position on follow-up secondary to medialization of the shaft (8 cases, 32%) and varus collapse (6 cases, 24%). Varus collapse was more notable and progressive in DCS treatment (18.2% on initial radiograph and 55.6% on the first follow-up). PFN was the most resistant treatment to varus collapse, but three cases

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demonstrated Z effect, a PFN-specific complication, X2(8)=22.213,p=0.001.

Table-2: Descriptive analysis of different treatment modalities. N=75					
Treatment modality	**DCS**	**DHS**	**PFN**	**test statistic χ2**	**P-value**
Frequency (percentage)	11 (14.7)	26 (34.7)	38 (50.7)		
Mean age (years)	78.54 ± (8.38)	79.42 ± (9.87)	74.39 ± (13.39)	F=(2.58)1.257	0.292[b]
Gender					
Male	4 (36.4)	8 (30.8)	11 (28.9)	0.221	0.895[a]
Female	7 (63.6	18 (69.2)	27 (71.1)		
Side					
Right	5 (45.5)	11 (42.3)	14 (36.8)	0.352	0.839[a]
Left	6 (54.5)	15 (57.7)	24 (63.2)		
Healing Time (months)	3.13 ± (0.35)	3.75 ± (1.07)	3.52 ± (0.83)	F=(2.58)1.454	0.242[b]
Nonunion	1 (9.1)	4 (15.4)	0	6.209	0.042[a]
Revision	1 (9.1)	2 (7.7)	2 (5.3)	0.756	0.841[a]
Mortality Rate*	2 (18.2)	2 (7.7)	5 (13.2)	1.122	0.626[a]

* Mortality rate is the mortality rate within the first year of surgical treatment.
[a] statistical value of associations using the chi-squared test of independence (χ2-test).
[b] statistical value of associations using the One-way ANOVA test.

Table-3: Different treatment modalities outcomes.								
Treatment methods	**Accepted position**	**Cutout**	**Medialization of shaft**	**Varus collapse**	**Z effect**	**DF***	**Fisher Exact test**	**P value****
Immediate postoperative reduction N=75.								
DCS	9 (81.8)	0	0 (0.0)	2 (18.2)	0 (0.0)	4	6.237	0.088
DHS	25 (96.2)	0	1 (3.8)	0 (0.0)	0 (0.0)			
PFN	36 (94.7)	0	0 (0.0)	2 (5.3)	0 (0.0)			
Radiograph within the first three months N= 69.								
DCS	4 (44.4)	0 (0.0)	0 (0.0)	5 (55.6)	0 (0.0)	8	22.213	0.001
DHS	11 (44.0)	0 (0.0)	8 (32.0)	6 (24.0)	0 (0.0)			
PFN	25 (71.4)	2 (5.7)	0 (0.0)	5 (14.3)	3 (8.6)			
Radiograph within three to six months N= 64.								
DCS	3 (37.5)	0 (0.0)	0 (0.0)	5 (62.5)	0 (0.0)	10	25.279	0.001
DHS	10 (41.7)	1 (4.2)	8 (32.0)	5 (20.8)	0 (0.0)			
PFN	24 (70.6)	0 (0.0)	0 (0.0)	5 (14.7)	3 (8.8)			
Radiograph within six to twelve months N=58.								
DCS	3 (33.3)	0 (0.0)	2 (22.2)	3 (33.3)	1(11.1)	8	9.501	0.224
DHS	12 (52.2)	1 (4.3)	5 (21.7)	5 (21.7)	0 (0.0)			
PFN	16 (61.5)	0 (0.0)	1 (3.8)	8 (30.8)	1 (3.8)			

* DF: Degree of Freedom.
** statistical value of associations using the chi-squared test of independence (χ2-test).

Similarly, the sample was reduced to 64 radiographs in the follow-up period of three to six months. PFN sustained superior accepted position although varus collapse was developed in five patients (14.7%) and further three patients (8.8%) developed Z effect. Shaft medialization was more notable in DHS and varus collapse in DCS, X2(10)= 25.279,p≤0.001.

Although the findings in the category six to twelve months were similar to the previous interval, this was statistically insignificant, X2(8)=9.501,p=0.224. Thus, the explanation might be due to progressive missing of patients from follow-up.

IV. Discussion

In this study, we aimed to measure the outcome of three used modalities in treating a thin lateral cortex intertrochanteric fracture, DHS, DCS, and PFN. Although we started with a good sample size, we faced a problem of missing patients from follow-up, either due to mortality, follow-up in other institutes, or not attending an appointment. We started the study with seventy-five patients, and at six to twelve months' follow-up interval, the sample was reduced to fifty-eight patients. Therefore, a statistical analysis inconsistency had occurred.

Although there is no difference between the three modalities regarding healing time, mortality rate, nor the need for revision surgery, PFN was the superior treatment in maintaining the position of reduction during follow-up. Additionally, PFN was associated with a lower risk of varus collapse, medialization of shaft and avoid intraoperative lateral wall fracture. Z effect is a unique deformity to PFN treatment. Even though DHS had an excellent initial reduction, more than half of fractures developed lost reduction within the first three months secondary to varus collapse and medialization of the shaft. In addition to the higher nonunion rate associated with DHS in thin lateral cortex intertrochanteric fracture and a considerable risk of lateral wall fracture making DHS treatment inferior option compared to PFN. On the other hand, DCS was associated with a higher

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varus position rate since the start, and this progressed dramatically during the first three months follow up.

Gotfried retrospectively evaluated twenty-four patients with documented postoperative fracture collapse and was the first to report that the presence of the lateral wall on the preoperative radiograph should be a significant factor in determining the internal fixation device used for fracture stabilization [16]. Palm et al., found that a postoperative fracture of the lateral femoral wall after using DHS was the main predictor for reoperation after an intertrochanteric fracture. The fracture in the Palm study occurred in 21% [9]. Similarly, Hsu et al. reported that 20.2% of lateral wall fractures with the DHS fixed thin lateral wall fractures and associated with high reoperation and complication rates. Accordingly, intertrochanteric fractures with a lateral wall thickness < 20.5 mm should not be treated with DHS alone [8]. Pradeep et al., reported 19.5% lateral wall fracture with DHS fixation [12]. In our study, the fracture of lateral wall occurred 15.4% in DHS fixed fracture. Therefore, lateral wall fracture is common with DHS treatment and should be avoided.

Limitation of the study

In this study, we faced many limitations. First: Different surgeons performed the surgeries; accordingly, different decisions for the same fracture pattern may arise, in addition to variation in skills among surgeons, which may affect the outcome. Second: the sample size was relatively small. Third: thin lateral wall measurement needs proper traction internal rotation anteroposterior views; thus, this was not possible for improper available views due to the retrospective design.

V. CONCLUSION

Recently, there is an increasing awareness of the importance of the integrity of the lateral wall of the proximal femur. Improper use of fixation devices in a thin lateral wall intertrochanteric fracture is associated with higher complications and reoperation. Despite that PFN, DCS and DHS demonstrated no difference regarding healing time, mortality, and reoperation rate in our study, PFN revealed superior results regarding reduction and lower complication rates than other modalities. Therefore, PFN should be used, and DHS and DCS should be avoided in treating thin lateral wall entity intertrochanteric fracture.

Conflict of Interest

There are no conflicts of interest

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