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Original Research Article

The Patterns and Trends in the Surgical Fixation Modalities of Intertrochanteric Femoral Fractures

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Abstract: ***Objectives:*** To study the Intertrochanteric fractures patterns, distributions, and fixations modalities. In addition to assessing orthopedic surgeons' tendencies toward implant choices according to the fracture morphology. ***Methods:*** This descriptive study reviewed the clinical and radiological records of 574 admitted with intertrochanteric femoral fractures in two hospitals of Jordanian Royal Medical Services from January - 2017 to December – 2020. Utilizing Picture Archiving and Communication System (PACS), patients' radiographs were evaluated regarding the fracture patterns, surgical fixation technique, and indications. ***Results:*** Females accounted for 59.1% of patients. The mean age was equal to 76.40 ± 11.65 years, with an age range of 82 years (20 – 102 years). Comorbidities were found in 65.3% of patients. The majority of the fractures (54.5%) were of a simple fracture pattern, and the Dynamic Hip Screw (DHS) was the most commonly used surgical implant (51.9%). Preoperative mortality accounted for 2.3%. ***Conclusions:*** Understanding intertrochanteric femoral fracture patterns and proper implant choice improves outcomes and avoids complications. We found that DHS use was the first choice in stable fracture patterns. However, there is an increasing tendency to use PFN over other modalities in both stable and unstable intertrochanteric fractures. The use of other modalities to treat unstable fracture may be explained by the occasional non-availability of the superior PFN.

Keywords: Dynamic Condylar Screw, Dynamic Hip Screw, Intertrochanteric Femoral Fracture, Proximal Femoral Nail, Thin Lateral Cortex, Reverse Oblique.

INTRODUCTION

The intertrochanteric femoral region is formed from dense trabecular bone and refers to the anatomical area between greater and lesser trochanters [1, 2]. However, fractures in this area are most commonly seen in the elderly population, with a higher frequency among females secondary to higher osteoporosis risk [3-5]. Fractures in this area are considered extracapsular. [6]. Early surgical fixation to restore mobility is essential to reduce fracture-associated morbidity and mortality [7, 8].

Several classification systems for intertrochanteric fractures have been suggested, but none of them are widely adopted. The widely accepted one is the Jensen modification of Evans classification [Figure 1]. According to this classification, types 1 and 2 are considered stable fractures and exhibit post-reduction stability. Types 3, 4 and 5, are unstable fractures secondary to fracture comminution, and they demonstrate inferior reduction and post-reduction instability [9-11]. A reverse oblique fracture is a variant where the fracture line extends from the medial peri-trochanteric cortex to the inferolateral cortex; this causes shearing force with axial loading and predisposes for fracture displacement and fixation failure [12, 13].

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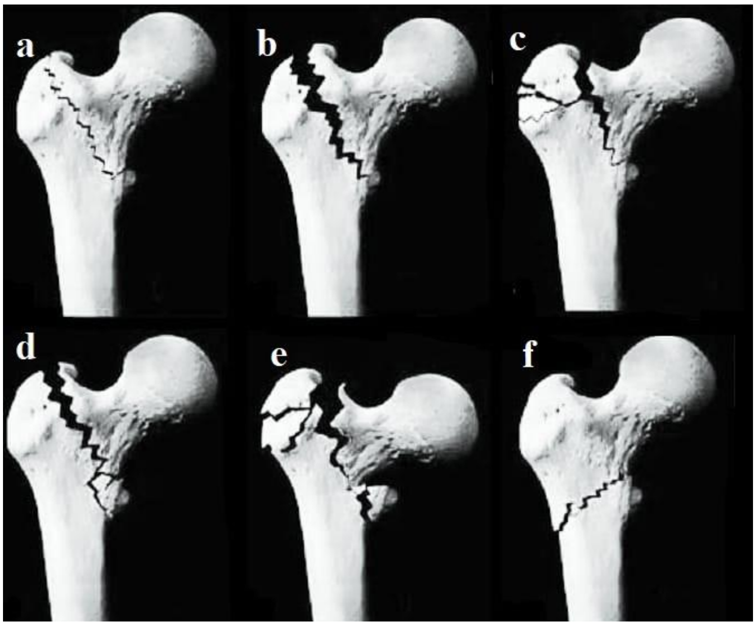

Fig-1: Jensen modification of Evans classification for inter-trochanteric fractures. (a) type 1: non-displaced two-part fractures. (b) type 2: displaced two-part fractures. (c) type 3: three-part fractures with posterolateral cortex comminution. (d) type 4: three-part fractures with posteromedial cortex comminution. (e) type 5: consists of four or more parts with both medial and lateral cortical comminution. (f) a reverse oblique fracture, which is a variant where the fracture line extends from the medial peri-trochanteric cortex to the inferolateral cortex.

Different fracture patterns mandate different implants choice. However, there is a controversy regarding which option is superior. An inter-trochanteric fracture can be fixed with one of the following options: [Figure 2]. Dynamic Hip Screw (DHS), Proximal Femoral Nail (PFN), Dynamic Condylar Screw (DCS), and Proximal Femoral Locking Compression Plate (LCP) [14-17] Arthroplasty might be one of the treatment options in complicated and pathological inter-trochanteric fractures [18]. Although the present controversy in which implant is the best choice in treating these fracture, there is a universal agreement about not using the DHS to treat reverse oblique fractures [19].

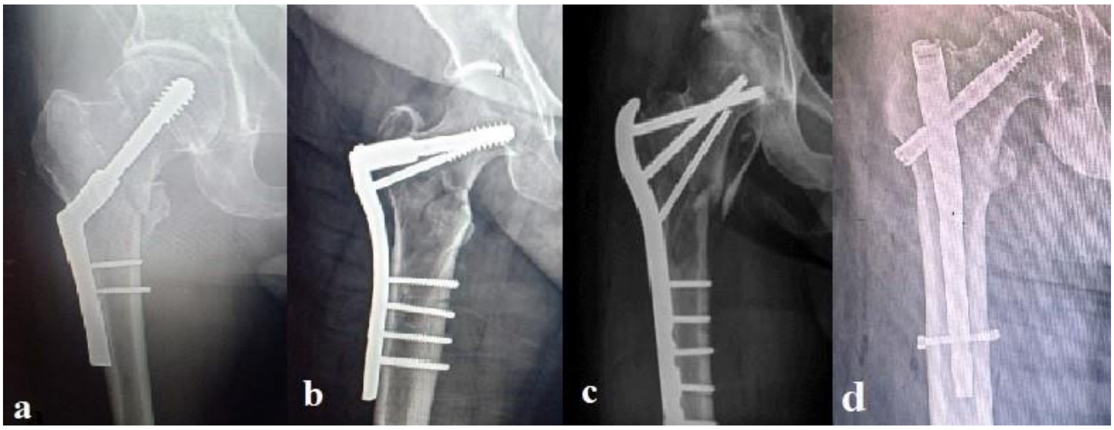

Fig-2: Different implants used in inter-trochanteric fracture fixation. (a) Dynamic Hip Screw (DHS). (b) Dynamic Condylar Screw (DCS). (c) Proximal Femoral Locking Compression Plate (LCP). (d) Proximal Femoral Nail (PFN).

Recently, there is an increasing awareness of the lateral wall cortex importance in post-reduction stability [Figure 3]. 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 represents the lateral wall thickness. A distance of 20.5 mm is considered a thin lateral cortex. Being familiar with these fracture patterns aids in the surgical decision and implant choice, consequently improving the outcome [20, 21]. However, DHS use in thin lateral wall fracture patterns may be complicated by a lateral wall fracture intra-operatively during reaming. Therefore, there is a decrease in DHS use in this category regardless that it is still a valuable option.

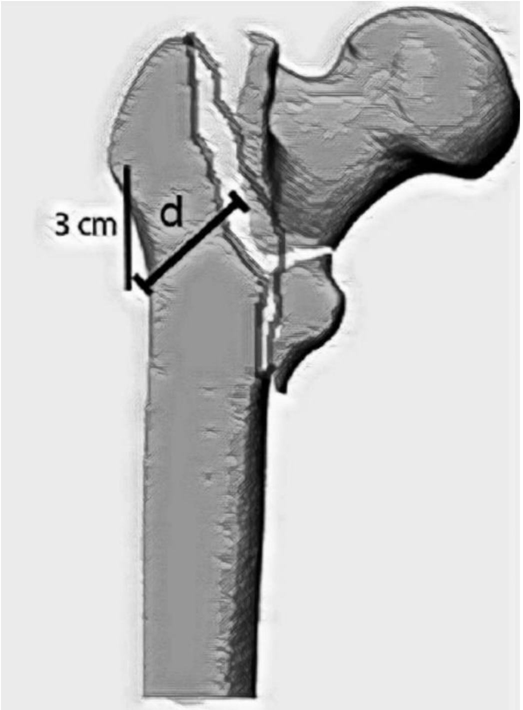

Fig-3: The thickness of the lateral trochanteric wall. A line is drawn from the greater trochanter's innominate tubercle angled at 135° upward to the fracture on anteroposterior radiograph. The distance between the lateral wall and the fracture line (d) represents the lateral wall thickness. A distance less than 20.5 mm is considered a fracture with a thin lateral wall.

This article aimed to study the intertrochanteric fracture patterns, evaluate the fixation modalities, and assess the tendency of orthopedic surgeons at Jordanian Royal Medical Services toward implant choices according to fracture morphology. Consequently, this provides us with a better perception of the distribution of intertrochanteric fractures and a better understanding of the requirements of our institute.

METHODS

This is a descriptive review of the clinical and radiological records of 574 admitted with 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.

A Picture Archiving and Communication System (PACS) was used to study the fractures patterns, surgical fixation technique, and indications. Sociodemographic and clinical data were obtained from patients' records. Five orthopedic surgeons evaluated the intertrochanteric fractures' radiographs and classified them into six categories according to the fracture stability and morphology: Simple; thin lateral wall; comminuted, subtrochanteric extension; calcar involvement, and reverse oblique fracture.

Although intertrochanteric fractures mandate surgical treatment, some patients received conservative treatment due to their high surgery risk, or the patient refused the surgical intervention and did not give consent when counseled about the risk. Mortality before surgery was analyzed with the conservative treatment group.

STATISTICAL DATA ANALYSIS

The mean and standard deviation were used to describe continuously measured variables and the frequency and percentages for the categorically measured variables. The chi-squared test of independence was used to compare the patients' demographics, comorbidity, fracture patterns, and orthopedic implant applied to them across years.

The normality statistical assumption was tested with the Kolmogrove Smirnov statistical test. Levene's test was used to test the statistical equal variances assumption for the continuous variables. The One-way ANOVA test was applied to compare the patients' mean age across years for the statistically significant differences.

The SPSS IBM V 21 program was used for the statistical data analysis, and the alpha significance level was considered at 0.050 level.

RESULTS

Females constituted 59.1% of the patients, and the remaining 40.9% were males. The patients' mean age was equal to 76.40 ± 11.65 years, with an age range of 82 years (20 – 102 years). According to their age groups, patients' distributions were as follows: 8.9% were younger than sixty years, the majority (52.6%) was aged between 61-80 years, and 38.3% were older than 81.

Comorbidities were found in 65.3% of patients, 35.9 % of total patients are known to have diabetes mellitus. Half of the patients (50.7 %) had hypertension, 20.9 % had ischemic heart disease (IHD), while 8.1 % of the total patients had a previous history of cerebrovascular accident (CVA).

Both body sides are affected equally. According to the fracture pattern, the majority of the fractures (54.5%) were of a simple fracture pattern; comminuted inter-trochanteric fractures accounted for 13.2%, thin lateral cortex category represented 13.1% of all fractures, 9.4% were of calcar involvement pattern, subtrochanteric extension and reverse oblique fractures represented 6.4% and 3.3% of all fracture pattern, respectively.

According to the treatment modalities, DHS was the most used surgical implant and accounted for 51.9%, followed by PFN with a percentage of 27.2%. DCS was used in 14.3% of the fractures. Proximal Femoral LCP and the Hemiarthroplasty were the options at 1.4% and 0.5%, respectively.

Twenty-seven patients (4.7%) did not receive surgical treatment; 14 patients (2.4%) due to the high risk of surgery and the remaining 13 patients (2.3%) passed away during admission before surgery. The annual distribution of inter-trochanteric fracture was as follows, 21.8% of admissions were in 2017, 14.6% were in 2018, while in 2019, the percentage was 25.6%, 2020 accounted for most admissions (38%).

The analysis showed no difference between inter-trochanteric fracture patterns regarding gender and age (table 1). The fracture was most commonly seen in the age group between 60 – 80 years old. Despite that, there is an annual alteration of the affected body side in the frequency across the four years; there were more left side fractures in 2020, p = 0.009. Twenty-six patients (4.5%) had previous surgery for the contralateral hip. The year 2020 was associated with higher comorbidities than the previous years, p<0.001, particularly diabetes, hypertension, and IHD.

Table-1: Comparison of the intertrochanteric proximal femoral fracture across the study years.

	Total	2017	2018	2019	2020	test statistic $\chi 2$	p-value
Gender							
Female	339 (59.1)	81 (64.8)	45 (53.6)	83 (56.5)	130 (59.6)	$\chi 2(6)=4.55$	0.602
Male	235 (40.9)	44 (35.2)	39 (46.4)	54 (43.5)	88 (40.4)		
Total	574 (100)	125 (21.8)	84 (14.6)	147 (25.6)	218 (38)		
Age (years), mean (SD)	76.40 (11.65)	78.26 (10.84)	75.89 (10.75)	76.44 (11.23)	75.50 (12.61)	f(3,570) = 1.55	0.199
Age group							
≤ 60 years	51 (8.9)	11 (8.8)	5 (6)	13 (8.8)	22 (10.1)	$\chi 2(6)=4.55$	0.602
61-80 years	302 (52.6)	60 (48)	42 (50)	79 (53.7)	121 (55.5)		
≥ 81 years	221 (38.5)	54 (43.2)	37 (44)	55 (37.4)	75 (34.4)		
Affected side							
Left	292 (50.9)	51 (40.8)	50 (59.5)	68 (46.3)	123 (56.4)	$\chi 2(3)=11.53$	0.009
Right	282 (49.1)	74 (59.2)	34 (40.5)	79 (53.7)	95 (43.6)		
Comorbidity							
No	199 (34.7)	55 (44)	41 (48.8)	46 (31.3)	57 (26.1)	$\chi 2(3)=19.80$	<0.001
Yes	375 (65.3)	70 (56)	43 (51.2)	101 (68.7)	161 (73.9)		
Comorbidity type							
Diabetes Mellitus	206 (35.9)	42 (33.6)	17 (20.2)	56 (38.1)	91 (41.7)	$\chi 2(3)=12.79$	0.005
Hypertension	291 (50.7)	56 (44.8)	31 (36.9)	74 (50.3)	130 (59.6)	$\chi 2(3)=15.10$	0.002
Ischemic Heart Disease	120 (20.9)	17 (13.6)	12 (14.3)	28 (19)	63 (28.9)	$\chi 2(3)=14.98$	0.002
Cerebrovascular Accident	47 (8.1)	8 (6.4)	4 (4.8)	12 (8.2)	23 (10.6)	$\chi 2(3)=3.50$	0.326

* Numbers between brackets represent percentages.

Table -2 compared alteration over four years regarding patterns of fractures, surgical fixation implants in addition to preoperative mortality, and previous history of contralateral hip fixation. There is an increase in the frequency of PFN use and a decrease in DCS use over the study period.

Table-2: Comparison of the femur intertrochanteric fracture patterns and fixations across the study years.

	Total	**2017**	**2018**	**2019**	**2020**	**test statistic χ2**	**p-value**
Patterns of intertrochanteric fracture							
Calcar involvement	54 (9.4)	4 (3.2)	1 (1.2)	10 (6.8)	39 (17.9)	χ2(15)=53.96	<0.001
Comminution	76 (13.2)	19 (15.2)	14 (16.7)	16 (10.9)	27 (12.4)		
Reverse Oblique	19 (3.3)	4 (3.2)	3 (3.6)	7 (4.8)	5 (2.3)		
Simple	313 (54.5)	84 (67.2)	48 (57.1)	86 (58.5)	95 (43.6)		
Subtrochanteric extension	37 (6.4)	6 (4.8)	3 (3.6)	10 (6.8)	18 (8.3)		
Thin lateral wall	75 (13.1)	8 (5.4)	15 (17.9)	18 (12.2)	34 (15.6)		
Surgical Modality							
Conservative	27 (4.7)	5 (4)	0	6 (4.1)	16 (7.3)	χ2(15)=129.16	<0.001
DCS	82 (14.3)	28 (22.4)	11 (13.1)	27 (18.4)	16 (7.3)		
DHS	298 (51.9)	76 (60.8)	54 (64.3)	86 (58.5)	82 (37.6)		
Hemiarthroplasty	3 (0.5)	0	0	0	3 (1.4)		
PFN	156 (27.2)	8 (6.4)	19 (22.6)	28 (19)	101 (46.3)		
Proximal Femoral LCP	8 (1.4)	8 (6.4)	0	0	0		
Preoperative Morbidity	13 (2.3)	4 (3.2)	0	1 (0.7)	8 (3.7)	χ2(3)=8.22	0.042
Contra-Lateral Fixation	26 (4.5)	7 (5.6)	2 (2.4)	7 (4.8)	10 (4.6)	χ2(3)=1.41	0.704

* DCS: Dynamic Condylar Screw. DHS: Dynamic Hip Screw. PFN: Proximal Femoral Nail. LCP: Locking compression plate.

Table –3 shows the annual fractures patterns and the treatment options distribution, and the tendency toward implant use across the period of four years. PFN replaced DCS in unstable fracture patterns and there is a tendency in PFN use in stable fracture patterns.

Table-3: Fracture pattern and implant choice across years.

	DCS	**DHS**	**PFN**	**LCP**
2017				
Calcar involvement	0	3 (3.9)	0	1 (12.5)
Comminution	8 (28.6)	5 (6.6)	3 (37.5)	3 (37.5)
Reverse Oblique	1 (3.5)	0	2 (25)	1 (12.5)
Simple	12 (42.9)	63 (82.9)	2 (25)	2 (25)
Subtrochanteric extension	5 (17.9)	0	0	1 (12.5)
Thin lateral wall	2 (7.1)	5 (6.6)	1 (12.5)	0
2018				
Calcar involvement	0	0	1 (4)	0
Comminution	4 (36.4)	2 (3.6)	8 (32)	0
Reverse Oblique	1 (9.1)	2 (3.6)	8 (32)	0
Simple	1 (9.1)	46 (82.1)	1 (4)	0
Subtrochanteric extension	0	0	3 (12)	
Thin lateral wall	5 (45.4)	6 (10.7)	4 (16)	0
2019				
Calcar involvement	3 (11.1)	3 (3.5)	2 (7.1)	0
Comminution	12 (44.5)	0	4 (14.3)	0
Reverse Oblique	1 (3.7)	0	6 (21.4)	0
Simple	4 (14.8)	73 (84.9)	5 (17.9)	0
Subtrochanteric extension	3 (11.1)	0	7 (25)	0
Thin lateral wall	4 (14.8)	10 (11.6)	4 (14.3)	0
2020				
Calcar involvement	5 (31.2)	13 (15.9)	20 (19.8)	0
Comminution	1 (6.3)	2 (2.4)	19 (18.8)	0
Reverse Oblique	2 (12.5)	0	3 (3)	0
Simple	3 (18.8)	63 (76.9)	19 (18.8)	0
Subtrochanteric extension	5 (31.2)	2 (2.4)	11 (10.9)	0
Thin lateral wall	0	2 (2.4)	29 (28.7)	0

* Numbers represents numbers of the procedures and numbers between brackets represent the percentage of fracture fixed by one implant in the same year.

DISCUSSION

Intertrochanteric proximal femoral fracture is one of the most common fractures that require hospitalization and surgical fixation. Despite this fracture-mandated surgical fixation, 4.7% of our patients did not receive surgical treatment because of the surgical intervention carried high risk or their preoperative morbidity and mortality did not allow for it (2.3%).

There is a difference in the annual fracture pattern distribution with more calcar involvement during 2020 than in previous years, p<0.00. Similarly, the treatment modalities differed. There was an increment in using PFN instead of DCS across the four years with the unstable fracture pattern, p<0.001. Although the treatment choice difference may be explained by the availability of these treatment options in our institutes, the surgeons preferred to use the less invasive PFN than DCS if both implants were available.

The DHS is used in the simple fracture pattern; the analysis demonstrated no significant difference in its use over the four years. A fracture with reverse oblique pattern, calcar involvement; comminuted or subtrochanteric extension, were considered unstable fractures, and the DHS use is known to be associated with a high failure rate. Consequently, the unstable fracture patterns mandated stabilization by DCS, PFN, or proximal femoral LCP. DHS use in a thin lateral cortex pattern may lead to a lateral wall fracture. In our previous published study about thin lateral cortex in inter-trochanteric fractures, we found that lateral wall fracture occurs in 15.4% with DHS use [22]. In Palm *et al*. study, it occurred in 21%, [23] 20.2% in Hsu *et al*. study, [24] and 19.5% in Pradeep *et al*. study [25]. Therefore, lateral wall fracture is common with DHS use and should be avoided in cases with thin lateral wall cortex. In comparison, the use of PFN avoids this complication. Previous contralateral hip fixation did not affect the implant choice on the other hip.

Although there was a decrease in the orthopedic hospital admissions during 2020 due to the COVID-19 pandemic and the lockdown, hip fractures were highest in our review during 2020. This could be explained by the fact that hip fractures are caused mainly by simple falls at home and daily living activities. Secondary to the restriction of individuals' mobility, this led to unavailability of caregivers, and the elderly individuals depended on themselves more often during the pandemic.

Notably, in our review, the PFN is the preferred treatment for unstable fracture patterns in 2020 compared to previous years, and its use exceeded DCS and LCP use. Similarly, LCP was not used in unstable fracture patterns after 2017 due to the surgeon's preference for the minimal invasive PFN compared to the more invasive LCP. Two reverse oblique fractures were treated by DHS; this may be due to a decision on poor quality radiographs or unavailability of implants.

CONCLUSIONS

In our review, we found that DHS use was the first choice in stable fracture patterns. However, there is an increasing tendency among orthopedic surgeons at RMS to use PFN over other modalities in both stable and unstable intertrochanteric fracture. The use of other modalities to treat unstable fracture may be explained by the occasional non-availability of the superior, less invasive PFN.

RECOMMENDATIONS

Orthopedic surgeons need to understand intertrochanteric fracture patterns and choose a proper implant to improve outcomes and avoid complications.

ETHICAL APPROVAL

This study has been approved by the Royal Medical Services Human Research Ethics Committee Number (3/2021) on 24/2/2021.

Declaration of patient consent

The authors certify that they have obtained all appropriate patients consent forms. In the form, the patients have given their consent for their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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Conflicts of interest

There are no conflicts of interest.

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