Reduction of butterfly fragments in femur fractures: a comparative analysis

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Purpose
This study compares the outcomes, 6 months postoperative, of femoral fracture interventions featuring nondisplaced and displaced butterfly fragments. The progress of healing, presence or absence of cortical defects, pain score after 6 months, and necessity of revision surgery are measured.
Materials and methods
This is a retrospective cohort study reviewing 100 patients with butterfly femur fractures treated with an intramedullary nail at King Fahad Hospital Hofuf. The patients were divided into two groups: one, of 48 patients, with displaced butterfly fragments after surgery and a second group of 52 patients with nondisplaced butterfly fragments, and all butterfly fragment was not fixed by any method, none of the fragment approximated by close or open reduction methods.
Result
In the first group, 38 patients (79.2%) showed delayed union 6 months after surgery, 30 (62.5%) had a cortical defect, 6 (12.5%) required revision surgery, and 42 (87.5%) still reported feeling pain. In the second group, 8 patients (15.4%) showed delayed union, none had cortical defects, 4 (07.7%) required revision surgery, and 10 (19.2%) reported pain 6 months after surgery.
Conclusion
Displaced butterfly fragments should be reduced to near-anatomical alignment to prevent delayed union, cortical defects, and pain.

Keywords:
butterfly fragment, cortical defect, delayed union, femur shaft fracture

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Level of evidence: Level 3.

Introduction

Femur shaft fractures are one of the most common long bone fractures. There are 1.1–2.9 million diaphyseal femur fractures each year, many caused by motor vehicle accidents (MVA) in the young population, and they are associated with multiple injuries to the skeletal system and other systems. Achieving and maintaining reduction of diaphyseal femur fractures may be difficult and require perioperative planning; the orthopedic surgeon must consider appropriate patient positioning and ensure access to the necessary tools, including surgical tables, traction devices, and instruments. Maintaining adequate fracture reduction is important to prevent delayed union, nonunion, and malunion, which may affect patient quality of life [1]. Many femoral fractures feature butterfly fragments, which can complicate or prolong the treatment and healing process, especially if not adequately addressed by the surgeon.

Locked intramedullary nailing (IMN) is currently considered the treatment of choice for most femoral shaft fractures [2]. Surgeons performing IMN must consider how best to address butterfly fragments so that postoperative complications do not arise. Butterfly fragments raise the risk of delayed union (fractures not healing within the usual time period). Union of the fracture is still possible without surgical intervention [3], but patients will suffer additional pain and disability during the delayed healing process.

This retrospective study will address whether we should reduce the butterfly fragment or not by close or open methods, its effect on fracture healing, and the patient pain.

Materials and methods

This is a retrospective cohort study reviewing 100 patients with butterfly femur fractures treated with IMN, and all butterfly fragment was not fixed by any method, none of the fragment approximated by close or open reduction methods; this done in King

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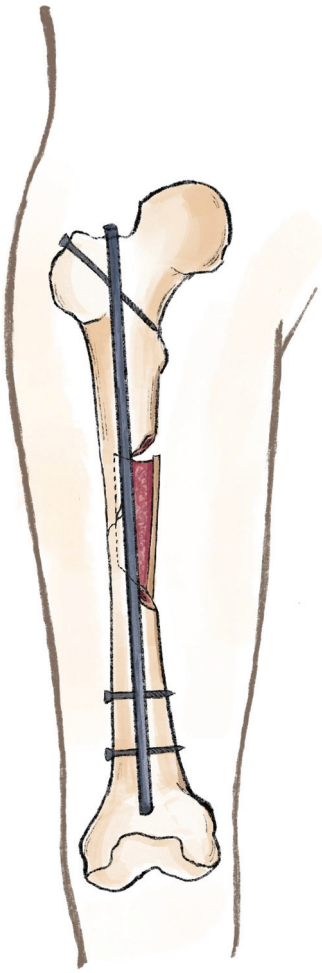
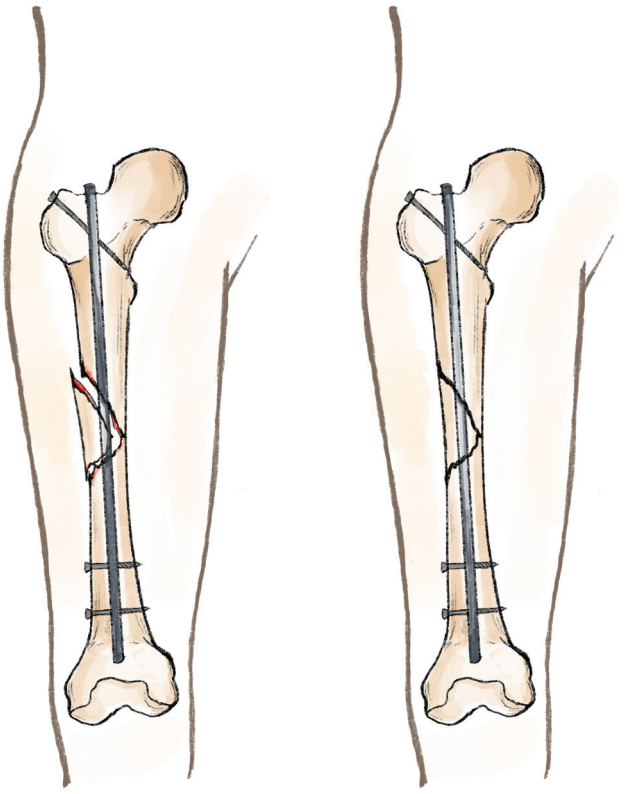
Figure 1



Explain the displaced >1 cm or flipped fragment after intramedullary nailing.

Figure 2



Explain the nondisplaced fragment after intramedullary nailing with anatomical or near anatomical reduction.

Fahad Hospital Hofuf from 2013 to 2018. Patients were divided into two groups based on fragment location on postoperative X-rays: the first group had displaced butterfly fragments >1 cm or flipped away from its anatomical position; if the fragment flipped from lateral to medial or vice versa, we considered the patient part of the displaced group (Fig. 1), and the second group had nondisplaced butterfly fragments <1 cm or near anatomical reduction (Fig. 2).

Including criteria

(1) Midshaft femur fracture with butterfly fragment.
(2) Treated with an intramedullary nail.
(3) Mechanism of injury MVA or fall from height.
(4) Ploytrauma patient.
(5) The patient was followed up with at least 6 months postoperative.

Excluding criteria

(1) Transverse, comminuted, segmental, proximal, or distal femur fracture.
(2) Treatment1with an external fixator or plate and screws.
(3) Low-energy trauma.athological fracture.
(4) Pathological fracture.
(5) Stress fracture.
(6) Infected nonunion.
(7) The patient only followed up after less than 6 months.

Selection of the cases based on these including and excluding criteria was performed independently in an unblinded standardized manner by the author. Using the hospital's electronic files, I extracted patient data including age, sex, multisystem involvement, head injury, other musculoskeletal injury, pain 6 months postoperative and whether the fracture was open or closed (Gustilo-Anderson classification). I used PACS X-Ray system data to locate the place of the fragment postoperative and assessed the healing process and presence or absence of cortical defects at 6 months.

Statistical method

Descriptive statistics have been presented using counts and proportions (%). The relationships between reducing or not reducing the butterfly fragment and

the progress of healing, development of cortical defects, and presence or absence of pain after 6 months were determined using the Fischer exact test. A *P* value cutoff point of 0.05 at 95% confidence interval was used to determine statistical significance. All data analyses were carried out using Statistical Packages for Software Sciences (SPSS) version 21.

Results

As seen in Table 1, this study reviewed the cases of 100 patients and compared the outcomes of those with nondisplaced and displaced butterfly fragments. The age range was 16–52 years (mean 28.5 years) and the majority (58.0%) of patients were in the younger age group (*P*=0.405). Nearly all (92.0%) of the patients were males (*P*=0.999). Of the 100 cases, 26 involved polytrauma, 10 involved a head injury, and 38 cases involved other musculoskeletal injuries. Almost all (98%) of the fractures were due to MVA (*P*=0.999). Right-side injuries made up 48% of the cases and left-side injuries 44%; there were also 8 cases of bilateral injury (*P*=0.481). A high proportion of patients had closed fractures (64%) and the rest were open (*P*=0.149). Among those open fracture cases, 20 patients were classified by Gustilo-Anderson classification; 14 were type 2 and 3 cases were type 1. All patients were treated with an IMN.

After 6 months, of the first (displaced) group of patients, 38 patients (79.2%) exhibited delayed union, 30 patients (62.5%) had a cortical defect, 6 patients (12.5%) received revision surgery, and 42 patients (87.5%) were still experiencing pain.

In the second (nondisplaced) group, 8 patients (15.4%) exhibited delayed union, no patients had a cortical defect, 4 patients (07.7%) had revision surgery, and 10 patients (19.2%) still had pain 6 months after surgery.

Table 1 Baseline characteristics of patients according to fragment placement

Study data	Overall N (%) (*n*=100)	Fragment placement		*P* value
		Displaced *N* (%) (*n*=48)	Nondisplaced *N* (%) (*n*=52)	
Age group (years)				
16–29	58 (58.0%)	26 (54.2%)	32 (61.5%)	0.405
≥30	42 (42.0%)	22 (45.8%)	20 (38.5%)	
Sex				
Male	92 (92.0%)	44 (91.7%)	48 (92.3%)	0.999
Female	8 (8.0%)	4 (8.3%)	4 (7.7%)	
Polytrauma				
Yes	26 (26.0%)	16 (33.3%)	10 (19.2%)	0.208
No	74 (74.0%)	32 (66.7%)	42 (80.8%)	
Head injury				
Yes	10 (10.0%)	8 (16.7%)	2 (3.8%)	0.150
No	90 (90.0%)	40 (83.3%)	50 (96.2%)	
Other musculoskeletal injuries				
Yes	38 (38.0%)	16 (33.3%)	22 (42.3%)	0.359
No	62 (62.0%)	32 (66.7%)	30 (57.7%)	
Mechanism				
MVA	98 (98.0%)	48 (100%)	50 (96.2%)	0.999
Fall	2 (2.0%)	0	2 (3.8%)	
Side of injury				
Right	48 (48.0%)	20 (41.7%)	28 (53.8%)	0.481
Left	44 (44.0%)	22 (45.8%)	22 (42.3%)	
Bilateral	8 (8.0%)	6 (12.5%)	2 (3.8%)	
Type of fracture				
Closed	64 (64.0%)	36 (75.0%)	28 (53.8%)	0.149
Open	36 (36.0%)	12 (25.0%)	24 (46.2%)	
Gustilob				
Type 1	6 (30.0%)	2 (20.0%)	4 (20.0%)	0.999
Type 2	14 (70.0%)	6 (60.0%)	8 (80.0%)	
Mode of fixation				
IMN	100 (100%)	48 (100%)	52 (100%)	1

IMN, intramedullary nailing; MVA, motor vehicle accident. [a]*P* values have been calculated using the Fischer exact test. [b]Cases where these data were missing were excluded from the analysis. Significant at $P \leq 0.05$ level.

Measuring the relationship between the patient groupings and postoperative healing, cortical defects, revision of surgery, bone grafts, and pain level after 6 months, we found significant relationships between fragment placement and postoperative healing ($P<0.001$), cortical defects ($P<0.001$), and pain level ($P<0.001$) (Table 2).

Discussion

Characterization of delayed union is dependent on healing time; fractures that exceed adequate healing time are considered to be experiencing delayed union. (Another definition includes patients with no change in the progression of healing radiologically but with clinical symptoms like pain or inability to bear weight 4 months after the fracture.) The union of the fracture is still possible without surgical intervention [3], but patients suffer from additional pain and disability. In some cases (12.5% in this study), delayed union may require further surgical intervention. The incidence of further surgery in diaphyseal femur fractures suggests that delayed union may be more common than suggested by some reports. Risk factors related to femoral fractures that would be expected to be associated with an increased incidence of delayed union include open fracture, infection, impaired vascularity, questionable mechanical stability, distraction at the fracture site, bone loss, and soft tissue interposition [4].

Specific patient variables and comorbidities are also risk factors for delayed union and nonunion. Delayed union and nonunion incidence are higher in men. Morbidities, such as high body mass index, smoking, diabetes mellitus type I and II, osteoarthritis and rheumatism, osteoporosis, vitamin D deficiency, and renal insufficiency, are also correlated with nonunion. In addition, delayed unions and nonunions are found more frequently in patients taking anticoagulants, benzodiazepines, insulin, antibiotics, diuretics, (Non-steroidal anti-inflammatory drugs) NSAIDs, and opioids [5].

The results of this study suggest that displaced butterfly fragments should also be considered a risk factor for delayed union. Analysis of the data found a significant relationship between butterfly fracture position and delayed union. In the first group of patients (displaced butterfly fractures), 38 patients (79.2%) developed delayed union compared with 8 patients (15.4%) in the second group (nondisplaced butterfly fractures) ($P<0.001$) (Table 2).

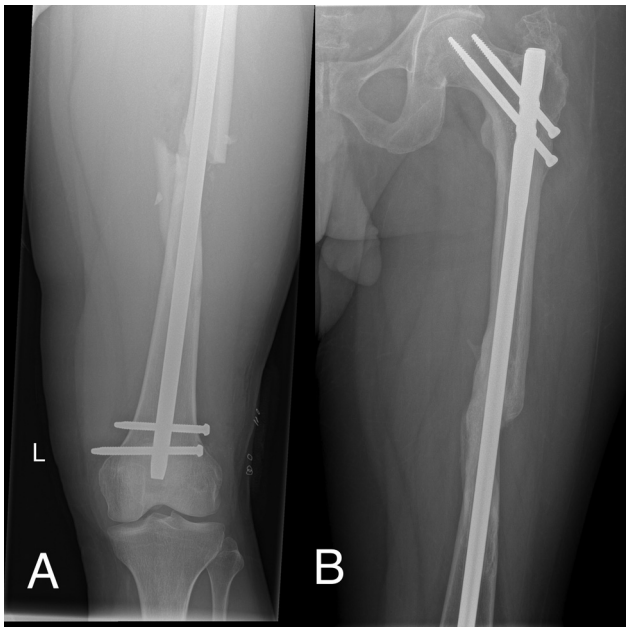
Pain evaluation of the cases employed a numerical rating scale [6]. The outcome measures used by many previous studies focus on objective clinical parameters and neglect patient satisfaction and patient perceptions of the outcome, including pain [7]. This study found a significant relationship between the groupings based on butterfly fragment position and pain 6 months after surgery. In the first group, 42 patients (87.5%) reported pain 6 months after surgery, compared with 10 patients (19.2%) in the second group ($P<0.001$). In addition, 30 patients (62.5%) in the first group had cortical defects 6 months after surgery (Fig. 3), whereas no patients from the second group developed cortical defects

Table 2 Relationship between fragment placement and patient characteristics after 6 months

Factor	Overall N (%) (n=100)	Fragment		P value
		Displaced N (%) (n=48)	Nondisplaced N (%) (n=52)	
Healing after 6 months				
Healed	54 (54.0%)	10 (20.8%)	44 (84.6%)	<**0.001****
Delayed union	46 (46.0%)	38 (79.2%)	8 (15.4%)	
Cortical defect after 6 months				
Yes	30 (30.0%)	30 (62.5%)	0	<**0.001****
No	70 (70.0%)	18 (37.5%)	52 (100%)	
Revision of surgery				
Yes	10 (10.0%)	6 (12.5%)	4 (7.7%)	0.461
No	90 (90.0%)	42 (87.5%)	48 (92.3%)	
Bone graft				
Yes	2 (2.0%)	0	2 (3.8%)	0.999
No	98 (98.0%)	48 (100%)	50 (96.2%)	
Pain level after 6 months				
With pain	52 (52.0%)	42 (87.5%)	10 (19.2%)	<**0.001****
No pain	48 (48.0%)	6 (12.5%)	42 (80.8%)	

[a]P values have been calculated using the Fischer exact test. **Significant at $P\leq0.05$ level.

Figure 3



A 32-year-old male after closed intramedullary nailing with a flipped fragment (A). After 6 months, his fracture healed with lateral cortical defect (B).

Figure 4

A 25-year-old male after closed intramedullary nailing with near anatomical reduction for the fragment (A). After 6 months, his fracture healed without any cortical defect (B).

(Fig. 4) ($P<0.001$) (Table 2). A cortical defect means one or more of the four cortices are missing at the site of the displaced butterfly fragment. All patient in the first group reported midthigh pain, whereas patients in the second group reported hip and thigh pain, suggesting that the cause of pain in first group is delayed union [8].

Vincenti *et al.* [9] retroactively studied X-rays postoperatively for 52 patient, measuring four radiological parameters the size, angle, and displacement of the fragment, and fracture gap, and he conclude that the third fragment if the fragment size more than 40 mm, fragment displacement more than 12 mm will cause delayed union.

Lee *et al.* [10] retroactively studied femoral shaft third fragment in 64 patients, the size and displacement of the fragment affect the healing of the fracture, and he conclude that more than 8 cm in fragment size and 20 mm proximal displacement or 10 mm distal displacement will affect the fracture healing.

Lin *et al.* [11] retroactively examined 48 patient with femoral shaft fracture with butterfly fragment; he divided the patients in two groups, a group with more than 10 mm displacement and group less than 10 mm displacement, and concluded poor prognosis for bone healing with the group with more than 10 mm displacement.

Ten patients' surgeries were revised with exchange nailing (10.0%) and one received a bone graft due to large cortical defects in two cortices. Exchange nailing relies on the improvement of biomechanical stability to increase the nail size at least 1-mm thicker in its diameter and on an internal bone grafting by the reaming technique with subsequent transport of mesenchymal stem cells into the nonunion site [12,13]. Creating the correct amount of stability by using plates or intramedullary nails. However, surgeons often overlook the loading of a defect. As mechanical loading has a significant impact on bone healing, it is a very important part of patient management. Providing sufficient stability is crucial to allow weight bearing as early as possible after treatment of diaphyseal femur defects. Treatment of posttraumatic bone defects is a difficult and challenging procedure for any orthopedic surgeon and requires a variety of approaches. The local environment of the defect should determine the treatment [14,15].

Conclusion

Displaced butterfly fragments should whenever possible be reduced to near-anatomical position to prevent delayed union, cortical defects, and pain. The findings of this study show the importance of reducing butterfly fragments by closed or open reduction with or without using fixation methods to fix the butterfly fragment. Additional research is

needed to measure the difference between reducing butterfly fragments with and without fixation by any method.

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Conflicts of interest

There are no conflicts of interest.

References

1 Wolinsky PR, Lucas JF. Reduction techniques for diaphyseal femur fractures. J Am Acad Orthop Surg 2017; 25:e251–e260.

2 Azar FM, Canale ST, Beaty JH. Campbell's operative orthopedics e-book. Philadelphia, PA 19103-2899 USA: Elsevier Health Sciences; 2016.

3 Rupp M, Biehl C, Budak M, Thormann U, Heiss C, Alt V. Diaphyseal long bone nonunions—types, etiology, economics, and treatment recommendations. Int Orthop 2018; 42:247–258.

4 Heckman JD, McQueen MM, Ricci WM, Tornetta P, McKee MD. Rockwood and Green's fractures in adults. Philadelphia, PA 19103 USA: Wolters Kluwer Health; 2015.

5 Zura R, Xiong Z, Einhorn T, Watson JT, Ostrum RF, Prayson MJ, Steen RG. Epidemiology of fracture nonunion in 18 human bones. JAMA Surg 2016; 151:e162775–e162775.

6 Haefeli M, Elfering A. Pain assessment. Eur Spine J 2006; 15:S17–S24.

7 Harris I, Hatfield A, Donald G, Walton J. Outcome after intramedullary nailing of femoral shaft fractures. ANZ J Surg 2003; 73:387–389.

8 Dodenhoff RM, Dainton JN, Hutchins PM. Proximal thigh pain after femoral nailing: causes and treatment. J Bone Joint Surg Br 1997; 79:738–741.

9 Vicenti G, Carrozzo M, Caiaffa V, Abate A, Solarino G, Bizzoca D, Moretti B. The impact of the third fragment features on the healing of femoral shaft fractures managed with intramedullary nailing: a radiological study. Int Orthop 2019; 43:193–200.

10 Lee JR, Kim HJ, Lee KB. Effects of third fragment size and displacement on non-union of femoral shaft fractures after locking for intramedullary nailing. Orthop Traumatol Surg Res 2016; 102:175–181.

11 Lin SJ, Chen CL, Peng KT, Hsu WH. Effect of fragmentary displacement and morphology in the treatment of comminuted femoral shaft fractures with an intramedullary nail. Injury 2014; 45:752–756.

12 Brinker MR, O'Connor DP. Exchange nailing of ununited fractures. J Bone Joint Surg Am 2007; 89:177–188.

13 Ru JY, Niu YF, Cong Y, Kang WB, Cang HB, Zhao JN. Exchanging reamed nailing versus augmentative compression plating with autogenous bone grafting for aseptic femoral shaft nonunion: a retrospective cohort study. Acta Orthop Traumatol Turc 2015; 49:668–675.

14 Blokhuis TJ. Management of traumatic bone defects: metaphyseal versus diaphyseal defects. Injury 2017; 48:S91–S93.

15 Layon D, Morrell AT, Lee C. The flipped third fragment in femoral shaft fractures: a reason for open reduction?. Injury 2021; 52:589–593.