Butterfly Fragment in the Femoral Shaft Fractures Treated by Intramedullary Nail: Do We Need to Reduce It or Not?

Tayyar Kürşat Dabak (kdabak@akdeniz.edu.tr)
Akdeniz Universitesi https://orcid.org/0000-0002-5506-8972
Osman Cİvan
Akdeniz Universitesi
Hakan Özdemİr
Akdeniz Universitesi

Research article

Keywords: Fractures, Femoral Shaft Fractures, Femur Fractures, Union, Union Score.

Posted Date: August 5th, 2020

DOI: https://doi.org/10.21203/rs.3.rs-51108/v1

Abstract

Background: Limited data is available regarding the effect of gap size, fragment size and position of fragment on union in fragmented femur shaft fracture. The aim of the study is to analyze the effect of these parameters on union and determine cut-off values that necessitate reduction of fragment.

Methods: Total of 59 patients with fragmented femur shaft fracture were reviewed and the effect of fragment size, gap size and fragment position on union were evaluated on 3^{rd}, 6^{th} and 12^{th} month graphies from medical record of patients. Union rate was determined due to Radiographic Union Score of Femur. Patients were divided into small gap (□ 10 mm) or large gap (□10 mm), reverse fragment or non-reverse fragment and small fragment (□50 mm) or large fragment (□50mm) groups. Kruskal–Wallis Variance Analysis and Mann Whitney U test was used for comparisons among groups. The post-hoc Mann Whitney U-Test with Bonferroni Correction was used when the Kruskal Wallis Variance Analysis determined a significant difference.

Results: In comparison of union scores of groups in regarding gap size and fragment size, there was not significant difference between groups at 3rd, 6th and 12th months. Union scores in the 3^{rd} month (p=0,011) and 6^{th} month (p=0,039) were lower in the reverse group than non-reverse group. But there was not statistically significant difference between two groups at 12^{th} month (p=0.819). There was no significant difference in union rates in respect to intramedullary nail types. There was an indirect correlation between age and mean union score at 12^{th} month.

Conclusions: we could not determine any cutoff value regarding gap width and fragment size in the treatment of the femoral shaft fractures by IMN. Although there was a tendency to decrease in union scores due to the increase in the gap size, any significant difference was not determined. Only the reverse position of fragment had an adverse effect on the union until 6^{th} months but the union score of reverse group reached the result of the non-reverse group by 12^{th} months.

Background

The incidence of femoral shaft fractures has been reported as 1- 1.3 fractures per 10,000 people per year. While it usually occurs due to high-energy injuries in the young population, it may occur due to low-energy injuries in elderly [1]. The most common causes of femoral shaft fracture were pedestrian accidents (37%), falls (24%) and motorcycle accidents (15%) [2]. Accepted treatment modality for the femoral shaft fracture is the intramedullary nailing performed with minimal soft tissue disruption however, some unclear points still exist [3]. The management of the butterfly fragment is one of these challenging problems while treating femur shaft fractures by intramedullary nailing. In a morphologic study, Salminen reported the incidence of femur shaft fracture types classified according to AO/OTA (Arbeitsgemeinschaft für Osteosynthesefragen/Orthopaedic Trauma Association) classification system as follows: 48% Type A, 39% Type B, and 13% Type C. He also reported that AO 32 B2 subgroup with a wedge was the second most common femur shaft fracture subtype [5,6]. It means that this is a quite often fracture pattern. In the literature, but, there is little evidence to use in the management of the butterfly fragment. Winquist proposed that it was reasonable to perform an open reduction and cerclage wiring of these fractures to gain anatomic restoration in young person [7]. Lin reported that greater than 1 cm displacement of fragment after nailing had adversely affected the bone healing and also proposed that an unreduced reversed fragment indicated poor prognosis [8]. Lee reported that the degree of fragment displacement had a greater effect on bone union than did the fragment size [9]. He suggested that any attempt such as reinforcement with percutaneous wiring might be required during the initial surgery. Some other authors also reported that the presence of a post-surgical fracture gap was also an important factor that might deteriorate the fracture healing [10,11,12]. On the other hand, open reduction is a risk factor for delayed union, non-union or infection.

In this study, we aimed to determine the relationship between gap size, fragment size, position of the fragment with the union in the AO/OTA 32B and AO/OTA 32C type femur shaft fractures and compared the results with the literature.

Methods

Total of 59 patients with AO/OTA type 32-B and 32-C type femoral shaft fractures treated by intramedullary nailing from 2014 to 2017 were included in the study. Exclusion criteria were: Periprosthetic fracture, reoperation by intramedullary nail for nonunion after plate fixation, pathological fracture, subtrochanteric fracture, fracture extending to the knee joint and the fracture with follow-up period less than 12 months.

The area accepted as the femur shaft in the study is the region extending from trochanter minor distally to the level of eight cm proximal to the adductor tubercle. Fractures were classified according to AO Classification System [6] and Winquist and Hansen (W-H) Classification System [7]. IM Nail type and entry point were recorded as locked antegrade trochanteric, locked antegrade piriformis or locked retrograde nails. Open fracture was classified according to Gustilo-Anderson (G-A) Classification [13]. In all cases, closed reduction techniques were applied.

Fragment displacement was determined by measuring the distance from the farthest point of the fragment perpendicular to the cortex of the femoral shaft on AP and lateral radiographies (Figure 1). The gap distance was grouped as *"large gap"* or *"small gap"*. If the gap distance was � 10 mm it was classified as *small gap.* If the gap distance was �10 mm it was classified as *large gap*. The position of the butterfly fragment described as follows: *reverse* or *non-reverse*, if the butterfly fragment was on the cortex to cortex position on AP or lateral radiographies, ıt was described as *reverse*. If not, it was described as *non-reverse*. Size of butterfly fragments were divided into two groups: *large fragment group* and *small fragment group*. It was called *large fragment* when the size of the butterfly fragment was larger than 50 mm. When the size of the butterfly fragment was smaller than 50 mm it was called *small fragment* (Figure 2, 3).

Anteroposterior and lateral radiographies at 3rd, 6th and 12th months were evaluated for union rate. Evaluation of union rate was made due to Radiographic Union Score of Femur (RUSF) described by Lin [8]. This scoring system is a modification of the tibia union scoring system reported by Whelan [14].

The mean union time, re-operation, implant failure and other complication rates were recorded for each group. Nonunion was defined as "persistent pain at the fracture site combined with the absence of progressive healing on 6th month radiography" [15]. Delayed union is an ununited fracture which continues to progress toward healing or that has not been present for long enough to satisfy an arbitrary time standard for nonunion [16].

Statistical Analysis:

Continuous variables were expressed as mean ± standard deviation (SD), median (minimum–maximum values) and categorical variables as number and percent. Shapiro–Wilk tests were used for testing normality. Kruskal–Wallis Variance Analysis and Mann Whitney U test was used for comparisons among groups. The post-hoc Mann Whitney U-Test with Bonferroni Correction was used when the Kruskal Wallis Variance Analysis determined a significant difference. In addition, the relationships between continuous variables were analyzed by Spearman correlation analysis. All statistical analyses analyzed by SPSS, 24.0 and p-value less than 0.05 was considered statistically significant.

Results

The average age of the patients was 31, 44 years (range 16 to 61 years). Nine of 59 patients were female (15.3%) and 50 of 59 patients were male (84.7%). 34 out of 59 patients had been operated for right femur fractures (57.6%), 21 out of 59 patients (35.6%) had been operated for left femur fractures and 4 patients had been operated for bilateral femoral fractures (6.8%). Patients being operated for bilateral femoral fractures were included only for one side because the other side was inappropriate for our study (fixation by plate or external fixator) (Table 1). Femur shaft fracture was classified according to AO/OTA Classification System and W-H Classification System. 42 of 59 fractures were AO 32-B (71.2%) and 17 of 59 fractures were AO 32-C (28.8%) according to AO/OTA Classification System. 22 of 59 fractures were T4 (37.3%), 17 of 59 were T3 (28.8%), 15 of 59 were T2 (25.4%) and five of 59 were T1 (8.5%) according to W-H Classification System (Table 1).

38 of 59 patients had *non-reverse* type fractures (64.4%) and 21 of 59 patients had *reverse* type fractures (35.6%) (Table 1). The average size of the butterfly fragment was 76.1 mm (range 18 to 250 mm, SD=52,99). 21 of 59 fractures were *small fragment* (35.6%). 38 of 59 fractures were in *large fragment* (64.4%) (Table 2).

According to gap distance; 22 of 59 fractures had *small gap* (37.3%) and 37 had *large gap* (62.7%). Average gap size in large gap group and small gap group were 23.4 mm (range 11 to 62 mm) and 7.05 mm (range 4 to 10 mm) respectively (Table 2).

The distribution of IM nail type was as follows: Antegrade intramedullary nail via trochanteric portal – 33 cases (56%), antegrade intramedullary nail via piriformis fossa portal – 14 cases (23.7%) and retrograde intramedullary nail - 12 cases (20.3%) (Table 1).

Mean union score of 59 patients at 3th month was 7.68 (range 4 to 12), mean union score at 6th month for 58 patients was 10.09 (range 4 to 12) and mean union score at the end of 12th month for 49 patients were 11.84 (range 9 to 12) according to RUSF scale (Table 2).

There were two implant failures, three non-union and all had been treated by exchange nailing. There were five delayed union. One delayed union case was treated by plating+ grafting (Figure 4), one delayed union was treated by repositioning and cerclage wiring of the fragment and three delayed unions was treated by dynamization between six to 12 months. Ten of the 59 patients had re-operation. Four out of ten patients were in non-reverse group and six were in reverse group. But there was not statistically significant difference between two groups in terms of reoperation (p=0.144).

We determined implant failure in two patients. Both were in the reverse group. There isn't statistically significance between reverse and non-reverse groups related to implant failure (p=0,144). However, we thought that this was due to the low number of implant failure.

The union scores at the 3rd month (p=0,011) and 6th month (p=0,039) were lower in reverse group than the non-reverse group and it was statistically significant. However, when the union scores of two groups at the 12th month were compared, there was no statistically significant difference (p=0.819) (Table 3).

In comparison of union rates in related to gap size and fragment size, there wasn't any statistically significant difference between groups at 3rd, 6th and 12th months (Table 4,5). Although two patients could not get the perfect healing RUSF score at 12th month follow-up period. They don't have pain during weight-bearing. We didn't plan any intervention. When the union rates were compared in related to fracture type classified according to AO Classification and W-H Classification, we didn't' find any statistically significant difference between groups at 3rd, 6th and 12th months (Table 6,7).

Mean RUSF score of 31 isolated femur fractures (8 ± 1.15) was higher than that of 24 cases with additional extremity trauma (6.96 ± 1.81). It was statistically significant (p=0.048). In comparison of union rates in related to IMN type, there was no statistically significance difference. Evaluation of continuous variables by Spearman Correlation Analysis has shown that there was a direct correlation between the fragment size and age. In addition, there was an indirect correlation between age and mean RUSF score at 12th month (Table 8).

Discussion

Although high success rates have been reported for the treatment of femoral shaft fractures by closed reduction and intramedullary nailing, nonunion is still a problem [17,18]. Patient with femoral nonunion is faced with significant functional and economic problems, including persistent disability, gait abnormality, and prolonged physical and psychological disability [19,20]. The presence of a gap at the fracture site has been reported as one of the 4 main factors resulting in delayed union or nonunion [19-21]. In AO/OTA 32 B or 32C type fracture a residual gap is usually persistent after closed reduction which may result in nonunion. However, there is limited data in the literature about the effects of the gap size and the butterfly fragment size on the fracture healing. Lin reported that a gap size greater than 10 mm had an adverse effect on fracture healing [8]. He proposed that excessive motion resulting from larger gap might lead to poor callus formation and also presence of a reversed fragment resulted in unfavorable outcome that need to reoperations. On the contrary, there was not any significant difference between small and large gap groups in present study, even in the early healing period. We thought that this might have resulted from the difference in fracture subtypes. While W-H type 3 and type 4 fractures account for 31.25% of total cases in Lin's study, it was 66.1% in our study. High rates of more fragmented fractures and fractures with longer fracture line might have resulted in this difference. In the article explaining the basics of fracture healing, Perren has reported that "the repair cell does not see the amount of fragment movement nor the width of the gap but senses its own deformation, called strain" [22]. This means that even the gap size is wider, depending on the amount of movement, strain may be less than the limit of strain tolerance and vice versa. So more fragmentation and longer fracture line might reduce the strain and keep it within strain tolerance as in bridging plate technique.

When the effect of the IM nail type on the union have been evaluated there was no significant difference. There was a direct correlation between the fragment size and the age and an indirect correlation between age and mean RUSF score in 12th month.

Evaluation of the effect of the fragment position on healing has shown that the union scores at 3rd month (p=0,011) and 6th month (p=0,039) were significantly lower in the reverse group than the non-reverse group but there was no statistically significant difference at 12th month (p=0.819). Lin also didn't find any correlation between the mean union scores of reverse and non-reverse fragment groups at 3rd, 6th and 12th months [8]. But he still suggested the percutaneous and minimally invasive reduction techniques because of increased risk of reoperation. In terms of clinical practice, ıt may be considered that in the presence of a reverse fragment, delayed weight-bearing (after 6th month) will be more reliable to prevent implant failure according to our results. There were two implant failures in our study and both were in reverse group. Although It was not statistically significant (p=0.123), we thought that it was an underestimation due to the small size of the group.

In our study, we didn't find any effect of fragment size on the median RUSF score on the 12th month. It was 12 and 12 respectively for the large fragment group and small fragment group (p = 0.588). In their study, Lee et al. [9] reported that fractures with fragments 8 cm or longer might have more negative outcomes when intramedullary nailing was performed. However, they also underlined that as fragments increased in size, the degree of displacement also tended to increase, whereas the union rate did not decrease as much and so the degree of fragment displacement has a greater effect on bone union than does fragment size. When they compared the union rates according to the fragment size and degree of fragment displacement by logistic regression analysis, no significant effect of fragment size on union has been observed. Vicenti et al. [23] reported a prognostic algorithm about how to manage the third fragment of the femoral shaft fractures treated by intramedullary nail and determined 40 mm fragment size as the cut-off value and the leading parameter that influences the fracture healing in first six months or more. They also reported that the amount of third fragment displacement may result in delayed union.

Conclusions

We could not determine any cutoff value regarding gap width, fragment size or position of fragment in the treatment of the femoral shaft fractures by IMN. Our results do not match the literature information in all aspects. The only suggestion of this study is that delayed weight bearing after 6 months will be beneficial to prevent implant failure in the reverse fragment fractures. We think that larger series are needed to determine precisely the effect of the gap width, fragment size on the union.

Abbreviations

AO/OTA: Arbeitsgemeinschaft für Osteosynthesefragen/Orthopaedic Trauma Association

W-H: Winquist and Hansen

RUSF: Radiographic Union Score of Femur

Declarations

Ethics approval and consent to participate

The study has been approved by Akdeniz University School of Medicine, Clinical Research Ethics Committee (No: 683)

Consent for publication

Not applicable

Availability of data and materials

The data are available from Department Information Technologies, Akdeniz University School of Medicine Hospital

Competing interests

The authors declare no conflict of interest.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors

Authors' contributions

In this study, T. Kürşat Dabak is responsible for study design and major writing of the article. Osman Civan contributed to data collection and radiographic assessment and statistical analysis. Hakan Özdemir contributed to manuscript review. All authors read and approved the final manuscript

Acknowledgements

Not applicable.

References

1. Singer BR, et al. Epidemiology of fractures in 15,000 adults: the influuence of age and gender. J Bone Joint Surg Br. 1998;80:243–248.
2. Taylor MT, Banerjee B, Alpar EK. Injuries associated with a fractured shaft of the femur. Injury. 1994;25:185–187.
3. Ficco RP, Nowotarski PJ. Femoral shaft fractures. In: Papadakos PJ, Gestring ML, editors. Encyclopedia of Trauma Care. Springer, Berlin, Heidelberg; pp. 607-614.
4. Norris BL, Dobrasevic NM. Femoral Shaft Fractures. In: Stannard JP, Schmidt AH, editors. Surgical treatment of orthopedic trauma: a comprehensive text and video guide: Thieme 2016. pp. 796-826.
5. Salminen ST, et al. Population based epidemiologic and morphologic study of femoral shaft fractures. Clin Orthop Relat Res. 2000;372:241–249.
6. Fracture and dislocation compendium. Orthopaedic Trauma Association Committee for Coding and Classification. J Orthop Trauma 1996; 10(Suppl 1):v–ix, 1–154.
7. Winquist RA, Hansen Jr ST. Comminuted fractures of the femoral shaft treated by intramedullary nailing. Orthop Clin North Am. 1980;11:633–648.
8. Lin SJ, et al. Effect of fragmentary displacement and morphology in the treatment of comminuted femoral shaft fractures with an intramedullary nail. 2014; *45*(4), 752-756
9. Lee JR, Kim H-J, Lee K-B. 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.
10. Santolini E, West R, Giannoudis PV. Risk factors for long bone fracture non-union: a stratification approach based on the level of the existing scientific evidence. Injury. 2015;46, 8-19.
11. Bishop JA, et al. Assessment of compromised fracture healing. J Am Acad Orthop Surg. 2012; 20(5), 273-282.

12. Ito K, Perren SM. Biology and biomechanics in bone healing. In: Ruedi TP, Buckley RE, Moran CG, editors. AO Principles of Fracture Management, ed 2. New York, NY, Thieme, 2007, vol 1, pp 9-31.
13. Gustilo RB, Anderson JT. Prevention of infection in the treatment of one thousand and twenty-five open fractures of long bones: retrospective and prospective analyses. J Bone Joint Surg Am. 1976;58: 453–458.
14. Whelan DB, et al. Development of the radiographic union score for tibial fractures for the assessment of tibial fracture healing after intramedullary fixation. J Trauma. 2010;68:629–32.
15. Bellabarba C, Ricci WM, Bolhofner BR. Results of indirect reduction and plating of femoral shaft nonunions after intramedullary nailing. J Orthop Trauma. 2001; 15(4), 254-263.
16. Phieffer LS, Goulet JA. Delayed unions of the tibia. J Bone Joint Surg. 2006; 88(1), 205-216.
17. Wolinsky PR, et al. Reamed intramedullary nailing of the femur: 551 cases. J Trauma Acute Care Surg.1999;46(3), 392-399.
18. Metsemakers WJ, et al. Risk factors for nonunion after intramedullary nailing of femoral shaft fractures: remaining controversies. Injury. 2015;46(8), 1601-1607.
19. Lynch JR, Taitsman LA, Barei DP, Nork SE (2008) Femoral nonunion: risk factors and treatment options. J Am Acad Orthop Surg *16*;(2), 88-97.
20. Hak DJ, et al. Delayed union and nonunions: epidemiology, clinical issues, and financial aspects. Injury, 2014; 45, 3-7.
21. Pihlajamäki HK, Salminen ST, Böstman OM. The treatment of nonunions following intramedullary nailing of femoral shaft fractures. J Orthop Trauma. 2002;*16*(6), 394-402.
22. Perren SM, Fernandez A, Regazzoni P. Understanding fracture healing biomechanics based on the “strain” concept and its clinical applications. Acta Chir Orthop Traumatol Cech. 2015;4(82), 253-260.
23. Vicenti G, Carrozzo M, Caiaffa V et al. 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*(1), 193-200.

Tables

Table 1: Demographic Data of the Patients

Parameters		Number (n)	Percentage (%)
Gender	Male	50	84.7
	Female	9	15.3
ExtraTrauma	No	31	52.5
	Other extremity	24	40.7
	Head	4	6.8
Gustilo-Anderson Type	Closed	44	74.6
	Type 1	4	6.8
	Type 2	4	6.8
	Type 3	7	11.9
AO Classification	AO-32B	42	71.2
	AO-32C	17	28.8
W-H Classification	Type 1	5	8.5
	Type 2	15	25.4
	Type 3	17	28.8
	Type 4	22	37.3
Side	Bilaterally	4	6.8
	Right	34	57.6
	Left	21	35.6
Position	Non-reverse	38	64.4
	Reverse	21	35.6
Gap	Large	37	62.7
	Small	22	37.3
Fragment Size	Large	38	64.4
	Small	21	35.6
Re-operation	No	49	83.1
	Yes	10	16.9
Dynamization	No	56	94.9

	Yes	3	5.1
Implant Failure	No	57	96.6
	Yes	2	3.4
Nailing Type	Piriformis	14	23.7
	Trochanteric	33	55.9
	Retrograd	12	20.3
Time that fracture gets maximum healing score (12)?	0-3 month	2	4.7
	3-6 month	21	48.8
	6-12 month	20	46.5

Table 2: Numerical data of the RUSF Score, Gap, and Fragment Size

Parameters	**A.M ± S.D**	**Median and Range**
3rd month RUSF Score (n=59)	7.68 ± 1.72	8 (4 - 12)
6th month RUSF Score (n=58)	10.09 ± 2.02	10 (4 - 12)
12th month RUSF Score (n=49)	11.84 ± 0.51	12 (9 - 12)
Gap (n=59)	17.31 ± 11.6 mm	14 (4 - 62) mm
Large (n=37)	23.4 ± 10.6 mm	20 (11 - 62) mm
Small (n=22)	7.05 ± 1.9 mm	7.5 (4 - 10) mm
Fragment (n=59)	76.1 ± 52.99 mm	63 (18 - 250) mm
Large (n=38)	101.71 ± 49.68 mm	85 (51 - 250) mm
Small (n=21)	29.76 ± 8.75 mm	30 (18 - 46) mm

Table 3: Comparison between RUSF and Fragment Position

	Position	A.M ± S.D.	Median (min - max)	P value
3rd month RUSF	non-reverse (n=38)	8.05 ± 1.79	8 (4 - 12)	0.011 β *
	reverse (n=21)	7 ± 1.38	7 (4 - 10)	
6th month RUSF	non-reverse (n=38)	10.5 ± 1.78	11 (6 - 12)	0.039 β *
	reverse (n=20)	9.3 ± 2.25	9 (4 - 12)	
12th month RUSF	non-reverse (n=34)	11.88 ± 0.33	12 (11 - 12)	0.819 β
	reverse (n=15)	11.73 ± 0.8	12 (9 - 12)	
*p<0.05 is statistically significant; β: Mann Whitney U Test				

Table 4: Comparison between RUSF and Gap Size

	Gap	A.M ± S.D.	Median (min - max)	P value
3rd month RUSF	large gap (n=37)	7.7 ± 1.76	8 (4 - 12)	0.661 β
	small gap (n=22)	7.64 ± 1.68	8 (4 - 10)	
6th month RUSF	large gap (n=36)	10.06 ± 2.19	11 (4 - 12)	0.934 β
	small gap (n=22)	10.14 ± 1.75	10 (6 - 12)	
12th month RUSF	large gap (n=30)	11.83 ± 0.59	12 (9 - 12)	0.588 β
	small gap (n=19)	11.84 ± 0.37	12 (11 - 12)	
p<0.05 is statistically significant; β: Mann Whitney U Test				

Table 5: Comparison between RUSF and Fragment Size

	Fragment	A.M ± S.D.	Median (min - max)	P value
3rd month RUSF	large (n=38)	7.47 ± 1.57	8 (4 - 10)	0.393 β
	small (n=21)	8.05 ± 1.94	8 (4 - 12)	
6th month RUSF	large (n=38)	10 ± 2.16	10.5 (4 - 12)	0.76 β
	small (n=20)	10.25 ± 1.77	10 (6 - 12)	
12th month RUSF	large (n=31)	11.81 ± 0.6	12 (9 - 12)	0.827 β
	small (n=18)	11.89 ± 0.32	12 (11 - 12)	
p<0.05 is statistically significant; β: Mann Whitney U Test				

Table 6: Comparison between RUSF and AO Classification

	AO Classification	A.M ± S.D.	Median (min - max)	P value
3rd month RUSF	AO 32 B (n=42)	7.79 ± 1.79	8 (4 - 12)	0.425 β
	AO 32 C (n=17)	7.41 ± 1.54	8 (4 - 10)	
6th month RUSF	AO 32 B (n=41)	10.1 ± 1.91	10 (6 - 12)	0.922 β
	AO 32 C (n=17)	10.06 ± 2.33	11 (4 - 12)	
12th month RUSF	AO 32 B (n=36)	11.81 ± 0.58	12 (9 - 12)	0.55 β
	AO 32 C (n=13)	11.92 ± 0.28	12 (11 - 12)	
p<0.05 is statistically significant; β: Mann Whitney U Test				

Table 7: Comparison between RUSF and W-H Classification

	W-H Classification	A.M ± S.D.	Median (min - max)	P value
3rd month RUSF	Type 1 (n=5)	6.8 ± 1.79	8 (4 - 8)	0.292 γ
	Type 2 (n=15)	8.4 ± 1.5	8 (6 - 12)	
	Type 3 (n=17)	7.71 ± 1.99	8 (4 - 12)	
	Type 4 (n=22)	7.36 ± 1.53	8 (4 - 10)	
6th month RUSF	Type 1 (n=4)	8.5 ± 1.91	9 (6 - 10)	0.053 γ
	Type 2 (n=15)	11.13 ± 1.13	12 (9 - 12)	
	Type 3 (n=17)	9.65 ± 2.09	10 (6 - 12)	
	Type 4 (n=22)	10 ± 2.23	11 (4 - 12)	
12th month RUSF	Type 1 (n=2)	12 ± 0	12 (12-12)	0.588 γ
	Type 2 (n=15)	11.93 ± 0.26	12 (11 - 12)	
	Type 3 (n=14)	11.64 ± 0.84	12 (9 - 12)	
	Type 4 (n=18)	11.89 ± 0.32	12 (11 - 12)	
p<0.05 is statistically significant; γ: Kruskal Wallis Variance Analysis				

Tablo 8: Analysis of continuous variables

		3rd month RUSF (n=59)	6th month RUSF (n=58)	12th month RUSF (n=49)	Age(n=59)	Gap Size (mm) (n=59)	Fragment Size (mm) (n=59)
W-H Classification	r	-.120	-.061	-.066	.183	.248	,753**
	p	.367	.651	.654	.165	.059	.000
3rd month RUSF	r	1.000	,850**	,326	-.146	-.232	-.023
	p		.000	.022	.269	.076	.865
6th month RUSF	r		1.000	,425**	-.169	-.135	.018
	p			.002	.204	.313	.892
12th month RUSF	r			1.000	-,364	.058	-.024
	p				.010	.694	.872
Age	r				1.000	.122	,267
	p					.357	.041
Gap size (mm)	r					1.000	.225
	p						.087
p<0.05 is statistically significant; Spearman Correlation Analysis, ** strong relationship							

Figures

Figure 1

Measurement of the gap size. The dotted line shows the fragment size.

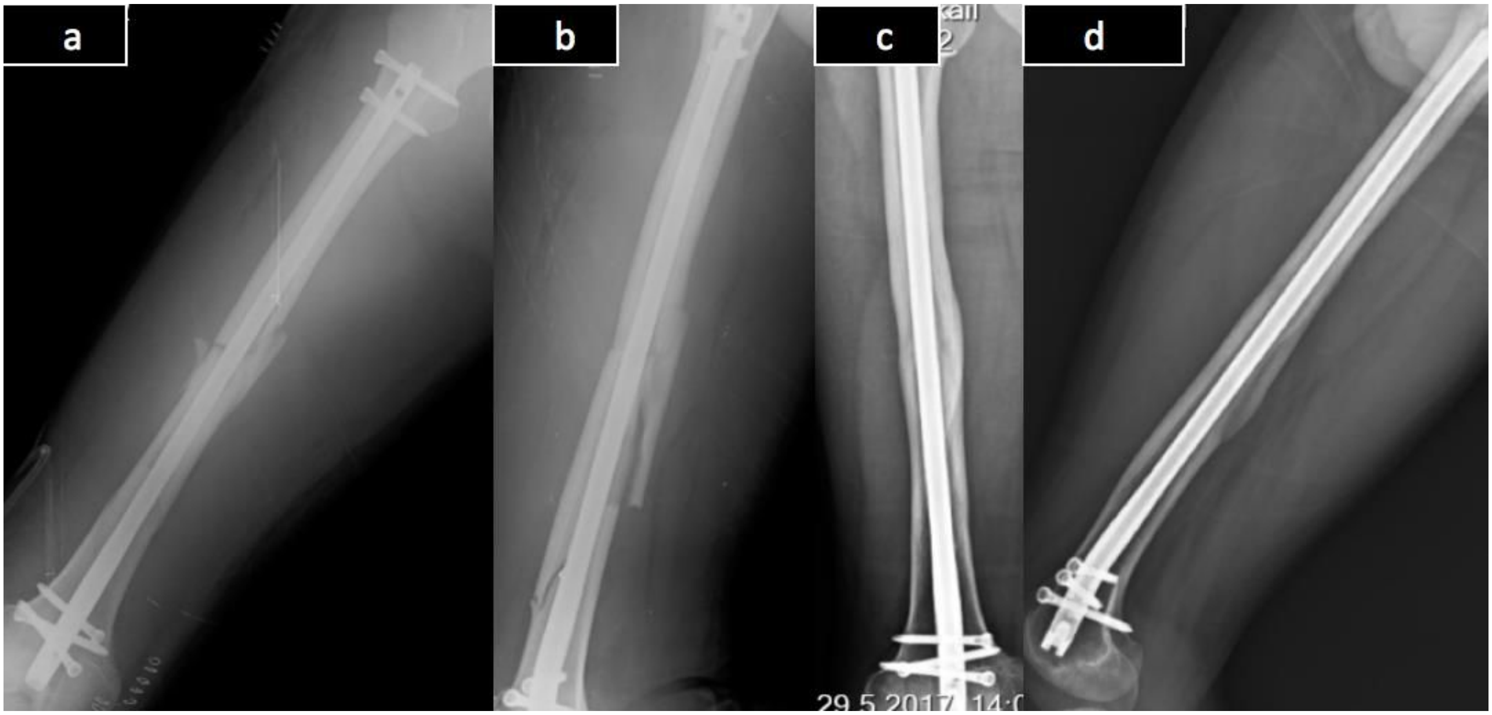

Figure 2

Twenty years old patient. post-operative x-rays; a,b: the butterfly fragment; non-reverse, small gap and large fragment. c and d: shows perfect RFUS healing score at the end of the 12th month.

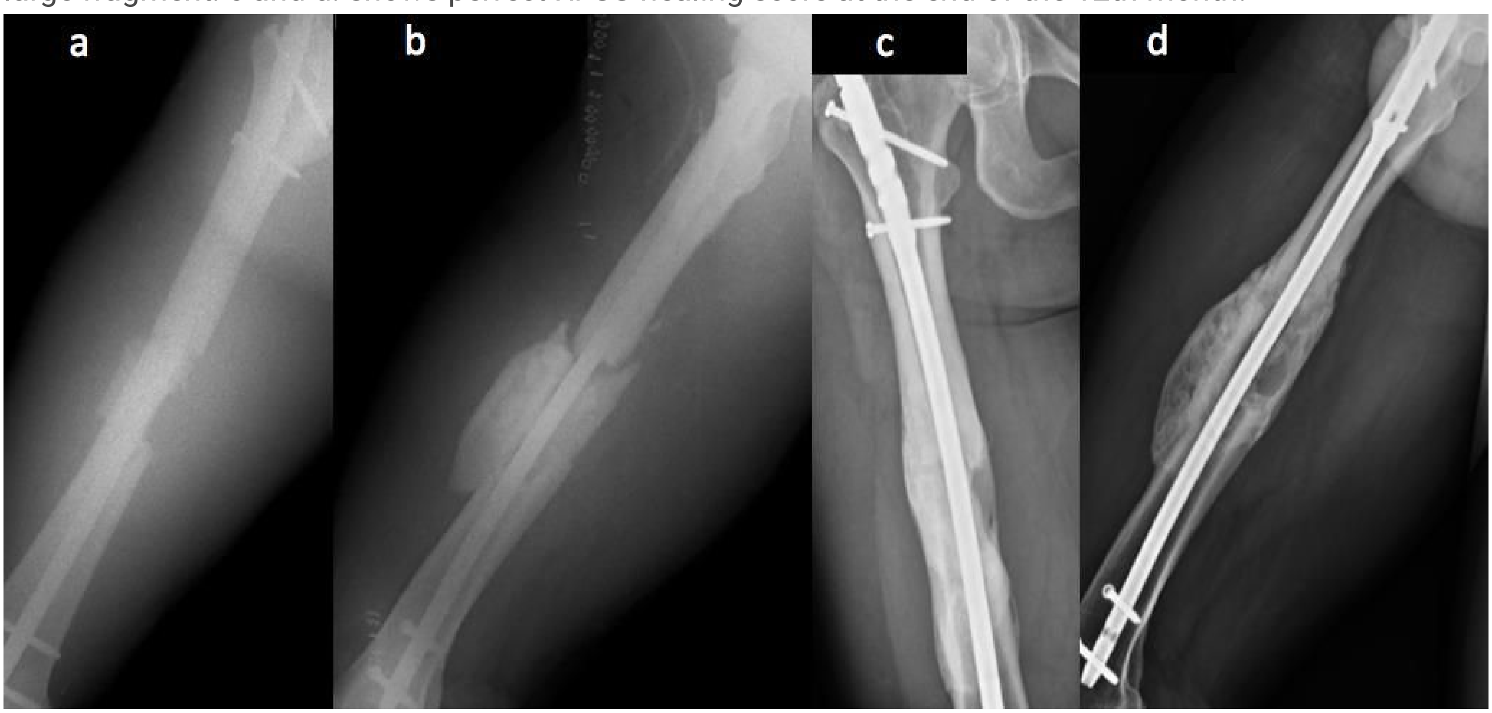

Figure 3

Twenty-three years old patient. post-operative x-rays; a,b: the butterfly fragment; reverse, large gap and large fragment. c and d shows perfect RUSF healing score at the end of 12th month.

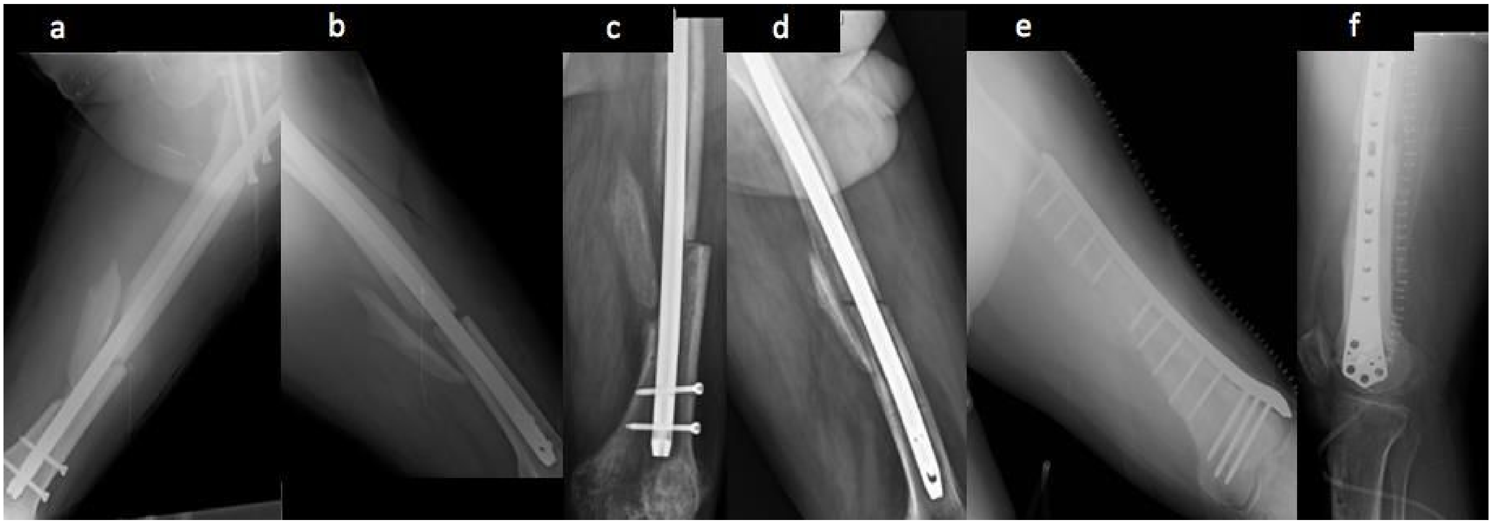

Figure 4

Sixty-two years old patient. a,b: post-operative x-rays; the butterfly fragment is in reverse position, large gap formation and large fragment size. c and d shows 6th month RUSF healing score was 6. Re-operated for delayed union. e,f: open reduction + autografting was done