

The Healing Time of Closed Femoral Shaft Fractures in Smokers and Non-Smokers Following Open Reduction and Internal Fixation with Plate and Intramedullary Nail

Abstract

Introduction: Non-union or delayed union after long bone fracture surgery is very common. This study aimed at evaluating the healing time of closed femoral shaft fractures in smokers and non-smokers following open reduction and internal fixation with plate and intramedullary nailing.

Methods: In a cohort study, patients were divided into two groups of smokers and non-smokers with closed transverse fracture of the femoral shaft bone. The patients who smoked 6 or more cigarettes per day were considered as smoker. Treatment method was based on the patient's preference and not based on being smoker or not. Patients were followed up for one year for clinical and radiological examinations on the status of the union. The collected data were analyzed using SPSS software version 19.

Results: In our study, 220 patients were studied (110 smokers and 110 non-smokers). Most of the patients with closed femoral shaft fractures were men (79.7%). Their mean age was 32.78 ± 16.93 years. There was a statistically significant relationship between the bone healing in treatment with plate and intramedullary nailing in smokers ($P = 0.004$). All non-smokers had union (100%), 74.1% in the group treated with plate had union and 78.8% in the group treated with intramedullary nailing had union, respectively ($P = 0.234$) 180 days after surgery. There was also a statistically significant association between delayed union in plate treatment and intramedullary nailing in patients who smoked ($P = 0.04$).

Conclusion: The treatment and daily function of smokers is usually worse than non-smokers and needs longer follow-up. It seems that the intramedullary nailing in smokers with closed femoral shaft fracture leads to more delayed union.

Keywords: Smoking, Fracture Healing, Femoral Fractures, Fracture fixation internal, Open Fracture Reduction

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Introduction

Femoral shaft fractures are common in severe traumas⁽¹⁾ and often occur in patients with blunt multisystem trauma. They occur in 10-20 cases per 100000 population⁽²⁾. These fractures are usually observed after severe trauma in young people and after mild trauma in the elderly⁽³⁾. The most common cause of fractures is high-energy collisions in car accidents and falls⁽⁴⁾. The treatment and return to work in these patients need time, costs and human resources⁽⁵⁾. The healing of femur is complex, susceptible to biological, mechanical and systemic factors⁽⁶⁾. Instruments such as plates, locking plates, and femoral nailing are used to stabilize the bone^(5, 7). Using plate is fairly common in the treatment of this type of fracture particularly for cases where the bone is thin and deformed^(8, 9). Femoral nailing is the standard method for treating femoral shaft fractures in adults, which is associated with less complications and high rates of union⁽¹⁰⁾. Non-union or delayed union is one of the known problems after orthopedic surgery which sometimes leads to multiple complications and the inefficiency of the limb⁽¹¹⁾. There are several effective variables on bone healing including injury, tissue, patient, and treatment. Age, nutrition, hormonal system, and nicotine are the most important variables related to patients. Malnutrition, smoking, and alcohol consumption have been shown to interfere with the bone healing process⁽¹²⁾. Studies have reported that smoking is a fundamental factor which can be changed. It can delay or prevent bone healing after surgery⁽¹³⁻¹⁵⁾.

Smoking reduces bone mineral density due to decreased calcium absorption with secondary hyperparathyroidism and increased bone resorption and toxins as well. It can also increase the risk of fractures and consequently impose a heavy burden on the health care system^(16, 17). Cigarette smoking alters the migration and survival of fibroblasts that are essential for callus formation⁽¹⁸⁾. Some of the compounds in cigarettes are also cartilaginous inhibitors⁽¹⁹⁾. Cigarettes contain 4,000 chemicals, of which 109 are known chemicals, including nicotine, benzene, tar, etc., which damage our musculoskeletal system, causing peripheral vasoconstriction, tissue ischemia, hypoxia, and decreased osteoblastic activity⁽¹⁷⁾. Due to the significant and negative role of smoking and the high occurrence of traumas and limb fractures, especially femoral bone fractures in Guilan, north of Iran and the increased smoking habit, we decided to study the time of healing of closed femoral shaft fractures in smokers and non-smokers referring who had undergone open reduction and internal fixation with plate or intramedullary nail.

Methods

In a cohort study, 218 patients with femoral bone fractures who had referred to the Orthopedic Clinic of Poursina Hospital, Rasht were placed in two groups of smokers and non-smokers after obtaining informed consent. Patients who were in the age range of skeletal maturity up to 40 years were selected. The patients with a history of contraceptive and hormonal drugs consumption, open fractures, history of metabolic and rheumatologic bone diseases, diabetes, use of drugs that affect bone and its metabolism such as NSAIDs, drug addiction, intra-articular fractures, segmental fractures of benign and malignant tumors, pathological fractures of bone atrophy following polio, bone necrosis following radiotherapy, congenital disorder, hyperthyroidism, delayed treatment more than 3 weeks, burn at the fracture site, kidney disease and Cushing's disease, multiple traumas and history of drug

abuse were excluded from the study. Test strips and morphine test were used for screening drug addiction. Different criteria have been considered for smoking and the number of cigarettes smoked in different studies. In this study, those with the consumption of 6 or more cigarettes per day were considered smoker, which was in line with the WHO standards⁽²⁰⁾. Patients underwent open reduction and internal fixation with plate or intramedullary nail based on surgeon's preference surgeon's choice and based on location of fracture. They were followed up clinically and radiologically for fracture union for six months. Next, the collected data were entered into SPSS software (version 19). In order to determine the mean time of union based on the measurement times, 95% confidence interval was used. Moreover, in order to compare the mean time of union between the two groups in case of normal distribution of the variable, one-way ANOVA was used. In absence of normal distribution, Kruskal Wallis test was used. Multivariate analysis of variance (MANOVA) was employed to compare the union time between the main study groups and the demographic variable (age and sex).

Results

The highest and lowest percentages of patients with closed femoral shaft fractures were 31-40 years (39.1%) and 18.20 (22.7%), respectively. The mean age of patients was 32.78 ± 16.93 years; 79.7% were male and 20.3% female. There was no significant correlation between age ($P = 0.99$) and gender ($P=0.917$) of patients with smoking. Fracture union after treatment with plate and intramedullary nail significantly correlated with smoking ($P = 0.00$).

In smoker patients treated with plate, 74.1 had union in 180 days after surgery. This figure was 78% in treated patients with intramedullary nail. However, all non-smokers had union in the same period (100%) (Table 1).

Table 1. Distribution of union/non-union of femur fracture according to treatment with plate and intramedullary nail and smoking habits

Union	Non-smokers treated with plate		Smokers treated with plate		Non-smokers treated with intramedullary nail		Smokers treated with intramedullary nail		Total		P-value
	No	%	No	%	No	%	No	%	No	%	
Yes											
No	55	100	43	74.1	55	100	41	78.8	194	88.1	
Total	0	0	15	25.9	0	0	11	21.2	26	11.9	0.004
	55	100	58	100	55	100	52	100	220	100	

Table 2. Frequency distribution of union/non-union of femur in 18 days according to treatment with intramedullary nail considering smoking

Union	Non-smokers		Smokers		Total		P-value
	No	%	No	%	No	%	
Yes							
No	55	100	41	78.8	96	83.7	
Total	0	0	11	21.2	11	16.3	0.006
	55	100	52	100	107	100	

Table 3. Frequency distribution of union/non-union of femur according to treatment with plate considering smoking

Union	Non-smokers		Smokers		Total		P-value
	No	%	No	%	No	%	
Yes	55	100	43	74.1	96	86.7	
No	0	0	15	25.9	13.3	15	0.024
Total	55	100	58	100	100	113	

Table 4. Frequency distribution of delayed union of femur according to treatment with plate and intramedullary nail considering smoking

Union	Non-smokers treated with plate		Smokers treated with plate		Non-smokers treated with intramedullary nail		Smokers treated with intramedullary nail		Total		P-value
	No	%	No	%	No	%	No	%	No	%	
Yes	5	9.10	23	39.7	0	0	11	21.2	39	11.9	
No	50	90.90	35	60.3	55	100	41	78.8	181	88.1	0.0001
Total	55	100	58	100	55	100	52	100	220	100	

In patients treated with intramedullary nail, a statistically significant relationship was noticed between the status of union and smoking ($P = 0.006$), such that all non-smokers had union by the end of 180 days

after surgery (100%). In smokers, however, 78.8% had union in the same period (Table 2). In patients treated with plate, there was a statistically significant relationship between bone union in plate treatment related to smoking ($P = 0.024$) and all non-smokers had

union 180 days after surgery (100%). However, only 74.1% of the smokers had union in this duration (Table 3).

Using Chi-square test, it was indicated that with 99% confidence, a statistically significant relationship was observed between the delayed union of femur and treatment using plate and intramedullary nail in relation to smoking ($P = 0.0001$). Non-smokers had union 120 days after surgery (100%), while in the smokers group treated with plate 60.3% and in the group treated with intramedullary nail 78.8% of smokers had union. A statistically significant relationship was present between delayed bone healing in treatment with plate and intramedullary nail in smokers ($P = 0.04$) (Table 4).

Using the Kruskal-Wallis test, it was found that there was no statistically significant difference between the time of union formation (days) in the four groups ($P = 0.059$).

Discussion

Femoral shaft fractures are one of the common injuries treated by orthopedic surgeons. These fractures are often associated with polytrauma and can be life-threatening. They are often caused by high-energy mechanisms such as the collision of motor vehicles (MVCs), leading to limb shortening and deformity if not treated properly⁽³⁾. Several non-surgical factors are effective in preventing the femoral shaft bone from union, relating directly to the patient, including smoking⁽¹¹⁾. Smoking is one of the harmful causes in bone healing⁽²¹⁾. Today, more than 1 billion people in the world are smokers, and in Iran, 14% of the population smoke⁽²²⁾. In this study, most of the patients with femoral shaft fracture were men, the majority of whom were under 40 years old. In the study by Shukla et al, the mean age of patients was 43.72 ± 16.0 years⁽²³⁾. In Kuan et al.'s study, men constituted the majority of patients and their mean age was 53.2 ± 11.6 years⁽⁴⁾. In our study at the end of 6 months, a significant relationship between bone union and different groups considering smoking

cigarettes was proved. There was a statistically significant difference between the control group and patients in the smoking group in terms of the condition of the union. In the study by Tay et al., which examined 356 fractures, 41% of the patients in the smoking group had union whereas in 53% of the patients, no union or delayed union was reported⁽²⁴⁾. In a study by Martin et al. it was revealed that smoking increased the rate of non-union and in smoking patients or patients with a previous history of smoking, the risk of non-union was twice more than that of the non-smoking patients. Even in active smokers, the risk of non-union increased three to four times compared with those who did not smoke at the time⁽²⁵⁾. In a study by Shukla et al., the radiological findings demonstrated that the time of union was 16 weeks in smokers (ranging from 12 to 24 weeks) and 12 weeks in non-smokers (ranging from 12 to 20 weeks), and the incidence of infection was higher in smokers compared with non-smokers⁽²³⁾. In 2013, Schenker et al. in a meta-analysis study of 18 articles concluded that the probability of non-union in the smoking group was 2.3 times higher than that of the non-smoking group⁽²⁶⁾. Ischemia is one of the causes of non-union⁽²⁷⁾. Norepinephrine is released from adrenergic axon terminals in smokers' tissues, and oxygen perfusion in damaged subcutaneous tissue decreases rapidly and remains low for 30 to 50 minutes. Following the inhibition of smoking in the vascular endothelial growth factor (VEGF), induced tube formation occurs, which negatively affects the endothelial function and vascular growth and ultimately leads to delayed union or non-healing of the fracture⁽²³⁾. Smoking can cause osteoporosis, increases the risk of injury and post-operative complications, and reduces the healing process of the fracture⁽²⁸⁾. One possible reason for this is that smoking can reduce bone mass by altering the proliferation of bone cells, especially osteoblasts and osteoclasts. Calcium is a key factor in maintaining bone health, and smoking may affect and impair calcium absorption and bone metabolism^(29, 30). Several studies have shown that smoking reduces bone mass^(31, 32).

In a retrospective study on patients with open tibial fracture, it was shown that in smokers, the bone healing took longer⁽³³⁾. Furthermore, comparison of the two variables in terms of the treatment method showed that the operation method using plate or intramedullary nail did not affect the non-union in patients and the smoking in either of these methods. Also, there was no statistically significant difference between the treatment method and delayed union or non-union. Yet, in patients who smoked and were treated with plate, the rate of delayed union was significantly higher than that of smokers treated with intramedullary nail. The intramedullary nailing is an effective method for the treatment of femoral fractures with a high rate of bone fusion and fewer complications⁽³⁴⁾. The advantages of this method are the initial mobility of the hip joint and less damage to soft tissue⁽³⁵⁾. In the study by Gianluca et al., it was shown that the healing time after intramedullary nailing surgery was shorter and can be mentioned as a golden method for definitive treatment of femoral shaft fractures⁽³⁶⁾. In the study by Mehdi Nassab et al., the mean time of bone union was 21.6 weeks in the plate group and 19.8 weeks in the nail group, and this difference was statistically significant⁽³⁷⁾.

Conclusion

The results of our study exhibited a statistically significant difference between patients in the non-smoking and smoking groups in terms of union condition and clinical performance at the end of 6 months, suggesting that the treatment and performance in smokers are worse and requires more investigations and follow-up courses. Treatments such as bone grafts and alternatives methods are essential in case of non-union in smokers. Therefore, preventive programs in high-risk groups can play an important role in the initial diagnosis, treatment and reduction of fracture complications. Our finding further shows that the intramedullary nailing can cause fewer delayed union in smokers, which makes it a

relatively more effective therapeutic method in smokers.

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