

Original Article

Bas J Surg, 2024; 30(2) : 57-66



THE IMPACT OF SMOKING, AGE, AND BMI ON BONE HEALING IN PATIENTS UNDERWENT MINIMALLY INVASIVE PLATE OSTEOSYNTHESIS FIXATION FOR LONG BONES FRACTURESAUTHORS

Document Type : Original Article

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https://doi.org/10.33762/bsurg.2024.155582.1098

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Receive Date: 04 December 2024 Revise Date: 22 December 2024 Accept Date: 25 December 2024 Publish Date: 30 December 2024

Abstract

Background: Fractures of the long bones in the lower limbs, such as the femur and tibia, are common injuries that typically result from high-energy trauma. These injuries often require surgical intervention, with techniques like Minimally Invasive Plate Osteosynthesis (MIPO) being favored due to their ability to minimize soft tissue damage while providing stable fixation. However, the success of fracture healing is influenced by various risk factors, including smoking, age, and body mass index (BMI), which can significantly affect the biological and mechanical processes essential for bone repair.

Aime: This study aims to assess the impact of various risk factors, including smoking, age, and body mass index (BMI), on the bone healing process in patients who underwent Minimally Invasive Plate Osteosynthesis fixation for extra-articular long bone fractures in the lower limbs.

Patients and Methods: A cross-sectional analysis was conducted at Basrah Teaching Hospital from June 2010 to June 2012, involving 76 patients aged 20-60 years. Patients with extra-articular comminuted fractures were treated using the Minimally Invasive Plate Osteosynthesis technique. Data on patient demographics, fracture characteristics, surgical details, and postoperative outcomes were collected and analyzed. Statistical significance was determined using appropriate tests, with a p-value of <0.05.

Results: The study found that smoking significantly delayed bone healing, with smokers showing slower healing times compared to non-smokers (p=0.0008). Younger patients (<30 years) demonstrated faster healing compared to older patients (p=0.041). Although BMI did not show a statistically significant impact on healing (p=0.716), trends indicated that underweight and normal-weight patients healed faster.

Conclusion: Smoking and age are significant factors influencing bone healing in patients undergoing Minimally invasive plate osteosynthesis fixation for lower limb fractures. While BMI did not significantly affect healing outcomes, the findings suggest that lifestyle factors play a crucial role in recovery after fracture fixation.

Keywords: Minimally invasive plate osteosynthesis fixation, bone healing, smoking, age, body mass index, lower limb fractures

Impact of Smoking, Age, and BMI on Bone Healing Introduction

ractures of the long bones in the lower limbs, such as the femur and tibia, are prevalent injuries that often result from high-energy trauma, leading to significant morbidity if not properly managed. These fractures typically require surgical intervention, and the methods used have evolved to focus on minimizing soft tissue damage and preserving the biological processes essential for healing.¹

Fracture healing involves a complex sequence of biological events, generally categorized into primary (direct) and secondary (indirect) healing. Primary healing occurs with direct bone formation when fracture ends are closely aligned, while secondary healing, which is more common, involves the formation of a callus and proceeds through inflammation, cartilage formation, and remodeling stages.² Indirect healing, or secondary healing, is the predominant process for most fractures and involves callus formation that gradually transforms into bone through endochondral ossification. This method is favored in fractures treated with relative stability, as it promotes robust bone regeneration and reduces the risk of non-union.³

The periosteum and fracture hematoma are critical for successful bone healing. The

periosteum provides osteogenic cells necessary for callus formation, while the hematoma acts as a reservoir for growth factors that initiate the healing process. Preservation of these elements during surgical intervention is crucial for effective healing.^{4,5}

Internal fixation methods, including plates, screws, and intramedullary nails, are essentials to the treatment of lower limb fractures. Minimally invasive plate osteosynthesis fixation (MIPO), in particular, has emerged as a promising fracture technique where traditional methods are challenging. This approach provides stable fixation while minimizing soft tissue damage, enhancing the healing environment.^{6,7}

Both biological and mechanical factors influence bone healing after fixation.

Biological factors include patient-related conditions such as smoking, diabetes, advanced age, and the presence of infection. Smoking impairs blood flow and osteoblast function, leading to delayed healing or nonunion. Diabetes compromises circulation and increases the risk of infection, which can further impede healing. Age-related factors, such as decreased cellular activity and bone density, also negatively impact the healing

Impact of Smoking, Age, and BMI on Bone Healing

process. These biological factors require careful management to optimize healing outcomes.⁸

Mechanical factors related to fixation include the stability and type of fixation used. The mechanical environment at the fracture site, including factors like fixation stability, interfragmentary movement, and the strain on the fracture, plays a critical role in the healing process. Stable fixation with minimal movement at the fracture site promotes primary healing, while some degree of controlled movement can enhance callus formation and secondary healing. The choice of fixation technique, such as intramedullary nailing versus Minimally invasive plate osteosynthesis fixation, can significantly impact the mechanical conditions and thus the healing outcomes.^{3,9}

This study aims to assess the risk factors that affect bone healing among patients who underwent a MIPO fixation as a treatment modality for extra-articular long bone fractures in the lower limbs.

Patients and Methods:

This study is a cross-sectional analysis conducted at Basrah Teaching Hospital over a period from June 2010 to June 2012. The study population included 76 patients, aged between 20 and 60 years, who presented with comminuted extra-articular long bone fractures of the lower limbs.

The Inclusion criteria for the study were patients with extra-articular comminuted fractures, diaphyseal or metaphyseal fractures, fractures less than 3 weeks old at the time of surgery, closed fractures, and compound fractures classified as less than type 2 according to the Gustilo-Anderson classification. Patients were excluded if they intra-articular fractures, had diabetes, associated neurovascular injuries, hypertension, and other neurological or endocrine diseases.

Preoperatively, a comprehensive evaluation of each patient was conducted, including a detailed assessment of the affected limb for any associated neurovascular injury.

During the surgery, all patients were positioned supine and received prophylactic antibiotics, specifically ceftriaxone 1 gram and gentamicin 80 mg intravenously at the time of anesthesia induction. General anesthesia was used, and a tourniquet was applied to the limb. Three types of plates were utilized for fixation: Dynamic Compression Plates (DCP), Limited Contact Dynamic Compression Plates (LC-DCP), and anatomical locked plates. All fractures were fixed using the MIPO technique. The choice of plate length was dependent on the fracture

Impact of Smoking, Age, and BMI on Bone Healing length, with a minimum of four screws placed on each side of the fracture in intact bone.

Postoperatively, patients were maintained on antibiotics for five days, continuing with ceftriaxone 1 gram and gentamicin 80 mg. On the first postoperative day, active isometric exercises were initiated to promote early mobilization and recovery.

Data were collected on patient demographics, fracture characteristics, surgical details, and postoperative outcomes. The primary outcomes assessed included the rate of fracture healing, functional recovery, and any

Results

The majority of the sample consists of younger individuals aged 20-40 years (78.9%), with males being predominant (81.6%). The body mass index data shows that most participants are obese (60.5%), which could have implications for their health outcomes. The most common

complications such as infection or non-union. Radiographic evaluations were performed at regular intervals to monitor healing progress, and functional outcomes were assessed using standardized scales.

Statistical analysis was performed using descriptive statistics for demographic data, and comparisons between groups were made using appropriate statistical tests, with significance set at a p-value of <0.05. The study was approved by the institutional review board of Basrah Teaching Hospital, and informed consent was obtained from all patients before their inclusion.

mechanism of injury was road traffic accidents (63.2%), with fractures predominantly affecting the femur (68.4%). The time between fracture and fixation was generally within 10 days for most patients (84.2%). These are presented in TableI

Variables		Frequency (N=76)	Percent
Age	20-30	38	50%
	31-40	22	28.9%
	41-50	8	10.55%
	51-60	6	7.9%
	>60	2	2.65%
Gender	Male	62	81.6%
	Female	14	18.4%
Body Mass Index	Underweight	11	14.5%
	Normal	19	25%
	Obese	46	60.5%
Mechanism of Injury	Road Traffic Accident	48	63.2%
	Motorcycle	24	31.5%
	Pedestrian	4	5.3%
The time between injury	1-10 Days	64	84.2%
and fixation	11-17 Days	8	10.5%
	<21 Days	4	5.3%
Bone affected	Tibia	24	31.6%
	Femur	52	68.4%

Table I: Demographical Data Analysis (N=	=76)
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Callus formation, a key indicator of bone healing, occurred predominantly within 7-14 weeks for most patients (76.3%). However, 21.1% of patients showed early callus formation within 4-6 weeks. Length discrepancy after healing was relatively common, with 47.35% of patients experiencing a discrepancy, the majority of which was more than 1 cm. See Table II

Table II: The	Time of Callus	Appearance and	Length Discre	pancy Analy	vsis (N=76)
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Variables		Frequency (N=76)	Percent
Time of callus formation	4-6 Weeks	16	21.1%
	7-10 Weeks	32	42.1%
	11-14 Weeks	26	34.2%
	15-18 Weeks	0	0%
	>18 Weeks	2	2.6%
Length discrepancy	<1 cm	14	18.45%
	>1 cm	22	28.9%
	Normal	40	52.65%

Table III shows that smoking was significantly associated with slower bone healing, as indicated by a p-value of 0.0008. Smokers were more likely to experience healing within 7-10 weeks (58.8%) compared to nonsmokers, who showed a higher tendency towards healing in the 11-14 week range (47.6%). This suggests that smoking may delay the bone healing process.

Variables	Smokers	Non-Smokers	P-value
	(N=34)	(N=42)	
4-6 Weeks	12 (35.3%)	4 (9.5%)	0.0008
7-10 Weeks	20 (58.8%)	12 (28.6%)	?
11-14 Weeks	6 (17.6%)	20 (47.6%)	?
15-18 Weeks	0 (0%)	0 (0%)	?
>18 Weeks	2 (5.9%)	0 (0%)	?

Age was found to have a significant impact on healing times, with a p-value of 0.041. Younger patients (<30 years) tended to heal faster, with 73.7% healing within 4-10 weeks. In contrast, older patients (≥30 years) had a higher likelihood of slower healing, particularly within the 11-14 week range (47.4%).Table IV

Га	ble	IV:	Age	Association	with	Time of	Healing	(N=76)
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Variables	<30 Years (N=38)	≥30 Years (N=38)	P-value
4-6 Weeks	10 (26.3%)	6 (15.8%)	
7-10 Weeks	18 (47.4%)	14 (36.8%)	0.041
11-14 Weeks	8 (21.1%)	18 (47.4%)	
15-18 Weeks	0 (0%)	0 (0%)	
>18 Weeks	2 (5.3%)	0 (0%)	

BMI did not show a statistically significant association with bone healing time (p-value = 0.716). However, the data indicates that underweight and normal-weight patients tend to heal faster, with a significant proportion of obese patients (78.3%) healing within the 7-14 week range. This suggests that while BMI might influence healing, its effect was not strong enough to reach statistical significance in this sample. As shown in Table V

Variables	Underweight	Normal (N=19)	Obese (N=46)	P-value
	(N=11)			
4-6 Weeks	4 (36.35%)	4 (21.1%)	8 (17.4%)	0.716
7-10 Weeks	4 (36.35%)	7 (36.8%)	21 (45.7%)	
11-14 Weeks	3 (27.3%)	8 (42.1%)	15 (32.6%)	
15-18 Weeks	0 (0%)	0 (0%)	0 (0%)	
>18 Weeks	0 (0%)	0 (0%)	2 (4.3%)	

Table V: BMI Association with Time of Healing (N=76)

Discussion:

This study examined the effects of smoking, age, and BMI on bone healing times in patients who underwent the MIPO technique for fracture fixation. The results indicate a significant delay in bone healing among smokers, a faster healing rate in younger patients, and a nuanced relationship between BMI and bone healing times. These findings align with and add to the body of research that explores how lifestyle factors impact bone health and recovery, particularly in the context of the MIPO technique, a technique known for its minimal soft tissue disruption and stable fixation.

The significant association between smoking and delayed bone healing observed in this study is strongly supported by the literature. Numerous studies have documented the adverse effects of smoking on bone

metabolism and healing. For instance, Al-Mukhtar (2010) found that elderly smokers experienced significantly slower bone healing compared to non-smokers, with a higher incidence of fractures due to lower bone mineral density (BMD).¹⁰ The use MIPO technique in this study, which is designed to preserve blood supply to the fracture site, could not fully mitigate the negative impact of smoking. This aligns with findings by Ehnert et al. (2019), who demonstrated that smokers had significantly reduced bone formation markers. contributing to delayed fracture healin.¹¹ These results suggest that even with advanced fixation techniques like MIPO, the detrimental effects of smoking on bone healing remain significant.

The study's finding that younger patients (<30 years) heal faster than older patients is consistent with the broader literature. Aging is associated with a decline in bone density and a reduction in the biological processes that contribute to bone regeneration. Emaus et al. (2014) reported that bone loss rates increase significantly with age, particularly in individuals with unhealthy lifestyle factors such as smoking and low BMI.¹²

The relationship between BMI and bone healing in this study was not statistically significant, though the trend suggested that underweight and normal-weight individuals may heal faster. This is consistent with findings from studies like Thorud et al. (2017), who observed that BMI changes were associated with fracture risks, particularly in non-smokers.¹³ The effect of BMI on bone healing, especially in the context of MIPO technique, may be influenced by other factors such as smoking and overall health status. Goodloe et al. (2020) noted that higher BMI could mitigate some of the negative effects of smoking on bone mass in younger women, indicating that the interaction between BMI and bone health is multifaceted.¹⁴ The MIPO technique may provide stable fixation across varying BMIs, but its impact on healing appears consistent across BMI categories in this study.

Conclusion

This study demonstrates that smoking significantly impairs bone healing, even with the use of the MIPO technique, a technique designed preserve the biological to environment for fracture repair. Younger patients show faster healing times, benefiting the most from the MIPO technique due to their enhanced regenerative capabilities. Although BMI did not show a statistically significant effect on healing, trends suggest underweight and normal-weight that individuals may experience quicker recovery.

Acknowledgement: None Conflict of interest : Authors declare no conflict of interest Financial support: No Financial Support For this Work Authors' Contributions: 1.Nabeel Yousif Abdullah ,2. Ahmed Ibrahim Habib Alobaidi , 3.Ahmed Hazim Alaoodh Work concept and design 1,2 Data collection and analysis 1, Responsibility for statistical analysis NA Writing the article 1,2 Critical review, 1, 2 Final approval of the article 1,2, Each author believes that the manuscript represents honest work and certifies that the article is

original, is not under consideration by any other journal, and has not been previously published. Availability of Data and Material: The corresponding author is prompt to supply datasets generated during and/or analyzed during the current study on wise request.

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Cite this article: Abdullah, N., Alobaidi, A., Al Aoodh, A. The Impact of Smoking, Age, and BMI on Bone Healing in Patients Underwent Minimally Invasive Plate Osteosynthesis Fixation for Long Bones Fractures. Basrah Journal of Surgery, 2024; 30(2): 57-66. doi: 10.33762/bsurg.2024.155582.1098