

Analysis of Risk Factors Contributing to Delayed Union in Long Bone Fractures

Kukadiya Hiteshbhai Labhubhai¹, Pappu Kumar², Solanki Animesh Mahendrabhai³

¹Associate Professor, Department of Orthopaedics, Gouri Devi Institute of Medical Sciences & Hospital, Durgapur, West Bengal, India

²Assistant Professor, Department of Orthopaedics, Gouri Devi Institute of Medical Sciences & Hospital, Durgapur, West Bengal, India

³Associate Professor, Department of Orthopaedics, Gouri Devi Institute of Medical Sciences & Hospital, Durgapur, West Bengal, India

Received: 10-02-2022 / Revised: 14-03-2022 / Accepted: 23-04-2022

Corresponding Author: Dr. Pappu Kumar

Conflict of interest: Nil

Abstract:

Background: Delayed union is an important complication that occurs in patients with long bone fractures and leads to increased morbidity, longer duration of bone healing, and higher costs. There are multiple risk factors affecting healing of a fracture, some modifiable and others non-modifiable.

Aim: Identification of the risk factors leading to delayed union in patients having long bone fractures and impact on the healing process of the bones.

Methodology: A prospective study was conducted on 120 patients who have long bone fractures in the Department of Orthopaedics, Gouri Devi Institute of Medical Sciences & Hospital, Durgapur, West Bengal, India over a period of one year. Analysis of the results has been done statistically by using SPSS version 25.0 software.

Results: Among the total of 120 patients, delayed union was seen in 26.7% cases. Factors such as smoking, diabetes, open fracture, post-operative infection, and delayed surgery had a significant association with delayed union ($p < 0.05$). Infection and smoking resulted in longer bone healing times.

Conclusion: Early identification and treatment of the risk factors help prevent bone healing delay.

Keywords: Fracture healing, postoperative infection, smoking habits, delayed union, open bone fractures, long bone injuries.

This is an Open Access article that uses a funding model which does not charge readers or their institutions for access and distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/4.0>) and the Budapest Open Access Initiative (<http://www.budapestopenaccessinitiative.org/read>), which permit unrestricted use, distribution, and reproduction in any medium, provided original work is properly credited.

Introduction

Long bone fractures form one of the commonest orthopedic problems, which are usually characterized by a morbidity rate, disability, and huge financial burden [1]. Although there have been advances in orthopedics and the management of fractures, delayed union remains an issue that brings about functional disability and negative impacts on patients' health conditions [2]. According to studies, delayed union can be described as the slow process of healing fractures, which takes more than the usual time frame and might end up in non-union if no proper treatment measures are put in place [3]. A number of biological, mechanical, and patient-based factors play significant roles in the healing process of fractures, such as smoking, diabetes, infections, open fractures, poor vascularization, and late management of injuries [4]. Early detection of risks factors is essential for avoiding any complication during the healing process [5]. This study aims at

investigating the risk factors responsible for delayed union among long bone fractures.

Background of the Study: Bone healing is a highly intricate process involving many systemic and local factors, and bone healing is imperative for regaining proper limb function and decreasing disabilities caused by them [6]. Even with the development of contemporary methods of treating bone traumas with orthopedics, delayed union of long bones remains a major problem because of the time it takes to heal, high costs of treatment, multiple surgeries, and the poor quality of life of those who suffer from this disorder [7]. The number of different factors among the patients and injuries including smoking, diabetes mellitus, open fractures, infections, insufficient vascular supply, and delay in treatment, which lead to problems with healing bones, have been identified [8]. In order to be able to prevent such complications, it is important to evaluate their effect on the healing process.

Evaluation of Risk Factors Causing Delayed Union of Long Bone Fracture: A delay in the process of healing of a long bone fracture can occur due to the influence of various factors, including patient-specific, fracture-related, and therapy-specific factors. These factors adversely influence the biological processes occurring in the fracture healing process [10]. The evaluation of risk factors helps to detect patients who are prone to a delay in the healing process and possible development of complications [11]. Such risk factors as smoking, diabetes, open fracture, surgical site infection, avascularity of bone tissue, and delayed surgery were established by previous studies [12]. Specifically, smoking contributes to a decrease in bone perfusion and bone oxygenation, while diabetes contributes to infection susceptibility [13]. In addition, open fractures and infections after operations are associated with reduced tissue integrity and delayed bone tissue calcification. Thus, the timely identification of these risk factors will allow clinicians to take appropriate measures for early prevention and treatment of the problem [14].

Research Objectives

The objectives of the study are:

- To evaluate the demographic and clinical profile of patients with long bone fractures.
- To determine the incidence of delayed union among patients with long bone fractures during the one-year study period.
- To assess the association between risk factors such as smoking, diabetes mellitus, open fractures, postoperative infection, and delayed surgical intervention with delayed union in long bone fractures.
- To compare the mean duration of fracture healing among patients with different clinical and risk factor profiles.

Methodology: The purpose of the research was to identify the risk factors related to the delayed healing of long bones after suffering fractures. The approach adopted guaranteed the proper and consistent collection of data, selection of participants, and analysis of results.

Study Design: The study design adopted was a prospective observational study conducted within the hospital setting.

Study Area: The study was conducted within the Department of Orthopaedics, Gouri Devi Institute of Medical Sciences & Hospital, Durgapur, West Bengal, India.

Study Duration: The duration of the study was one year.

Study Participants: The study included patients diagnosed with long bone fractures who were

admitted to the orthopedic department and underwent conservative or surgical management during the study period.

Inclusion Criteria

- Patients aged 18 years old and above.
- Patients with long bone fractures, including fractures of the femur, tibia, humerus, radius, and ulna.
- Definitively treated and undergone follow-up assessment cases.
- Willingness to give consent to participate in the study.

Exclusion Criteria:

- Cases involving pathological fractures.
- Cases with congenital bone disorders or metabolic bone disorders.
- Cases with polytraumas that pose a life-threatening risk to the patient.
- Lost to follow-up cases.
- Incomplete record cases.

Sample Size: A total of 120 patients with long bone fractures were included in the study based on the availability of eligible cases during the study period and fulfilment of inclusion criteria.

Procedure: Demographic and clinical data of the subjects were documented with the help of pre-designed case record forms. Data about age, sex, cigarette smoking habit, intake of alcohol, body mass index, comorbid disorders like diabetes mellitus, hypertension, type of fracture, mechanism of fracture, presence of open fractures, method of treatment, infection, and duration of immobilization was noted.

Clinical and radiographic evaluation of the participants was done in follow-up visits in order to analyze the condition of bone healing. Those cases having delayed bone healing were diagnosed according to their clinical and radiological parameters. Evaluation of pain, tenderness at the site of fracture, functional movement, and presence of callus formation on x-ray was done.

The risk factors that cause delayed healing of bones were investigated.

Statistical Analysis: Data were entered using Microsoft Excel while analysis was done using Statistical Package for the Social Sciences (SPSS) software, Version 25.0. Data representation included use of descriptive statistical tools like mean, standard deviation, frequency, and percentages. The relationship between risk factors and delayed bone union was assessed using Chi-square and independent t-test at $P < 0.05$ level of significance.

Results

A total of 120 patients suffering from fractures of long bones were involved in the study, and the possible determinants of delayed union were

studied among these patients. A statistical analysis was done based on these patients' data.

Table 1: Patient Distribution Based on Demographic Features (N=120)

Variable	Frequency (n)	Percentage (%)
Age Group (Years)		
18-30	34	28.3%
31-45	42	35.0%
46-60	29	24.2%
>60	15	12.5%
Gender		
Male	82	68.3%
Female	38	31.7%
Smoking Status		
Smokers	47	39.2%
Non-Smokers	73	60.8%
Alcohol Consumption		
Present	39	32.5%
Absent	81	67.5%

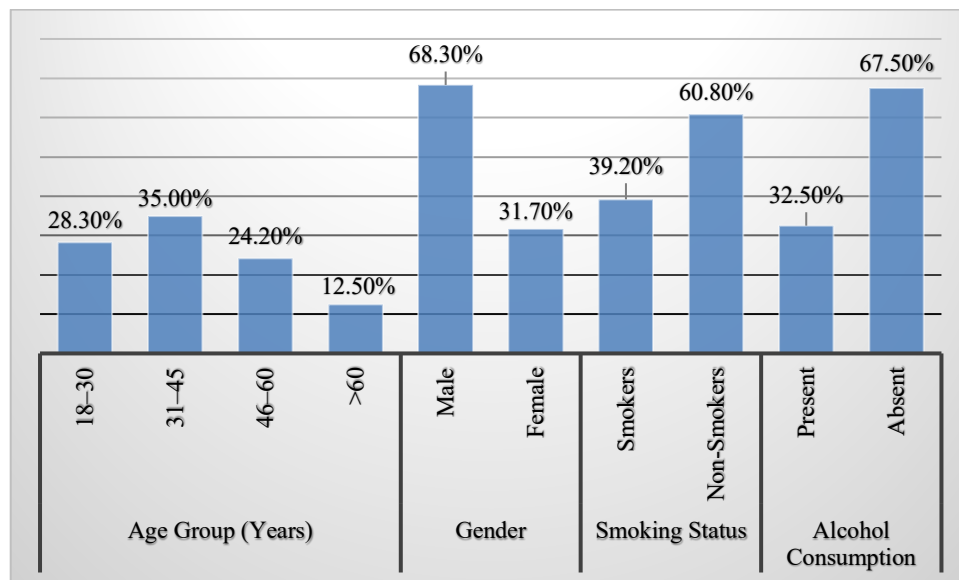


Figure 1: Graphical Presentation of Patient Distribution Based on Demographic Features (N=120)

As per Table 1, the highest percentage of patients was found to be within the age range of 31-45 (35.0%), followed by that of patients in the age range of 18-30 years (28.3%). 68.3% of patients

who participated in the study were males, while females made up 31.7% of the patients. A record of smoking was made for 39.2% of the patients, while alcohol consumption accounted for 32.5%.

Table 2: Clinical Characteristics of Fractures of Long Bones in Study Participants

Clinical Variable	Frequency (n)	Percentage (%)
Type of Bone Involved		
Tibia	41	34.2%
Femur	33	27.5%
Humerus	21	17.5%
Radius/Ulna	25	20.8%
Nature of Fracture		
Closed Fracture	86	71.7%
Open Fracture	34	28.3%
Mode of Treatment		
Conservative	36	30.0%

Surgical	84	70.0%
Postoperative Infection		
Present	26	21.7%
Absent	94	78.3%

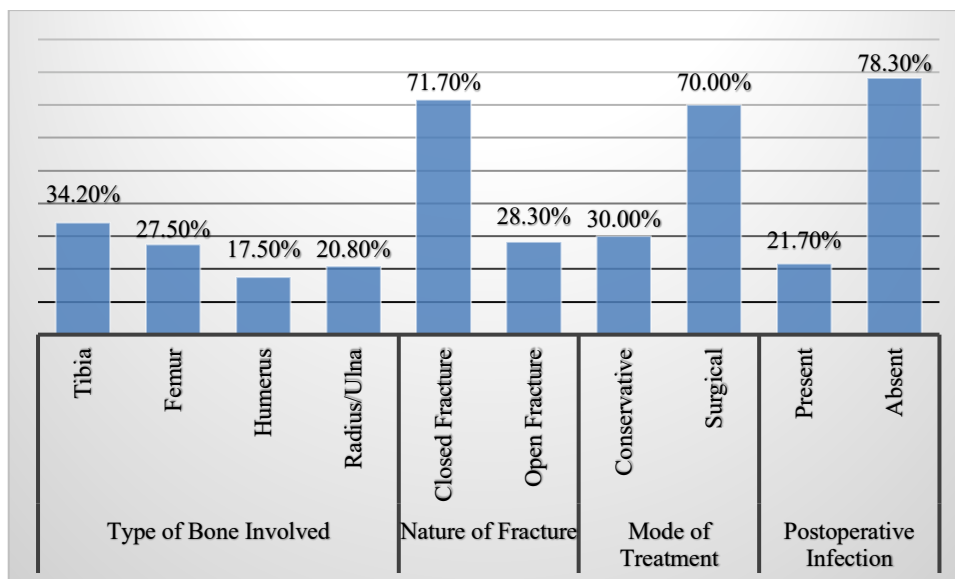


Figure 2: Graphical Presentation of Clinical Characteristics of Fractures of Long Bones in Study Participants

As it can be seen from Table 2, tibial fractures occurred in 34.2% cases, which was the most common type of long bones' fractures, whereas femur fractures were noted in 27.5% cases. Among the cases, 71.7% were found to be closed fractures,

whereas 28.3% cases were categorized as open fractures. 70% of the patients underwent surgical intervention, suggesting that surgery was preferred more commonly.

Table 3: Occurrence of Delayed Union in Patients

Fracture Healing Outcome	Frequency (n)	Percentage (%)
Delayed Union Present	32	26.7%
Delayed Union Absent	88	73.3%

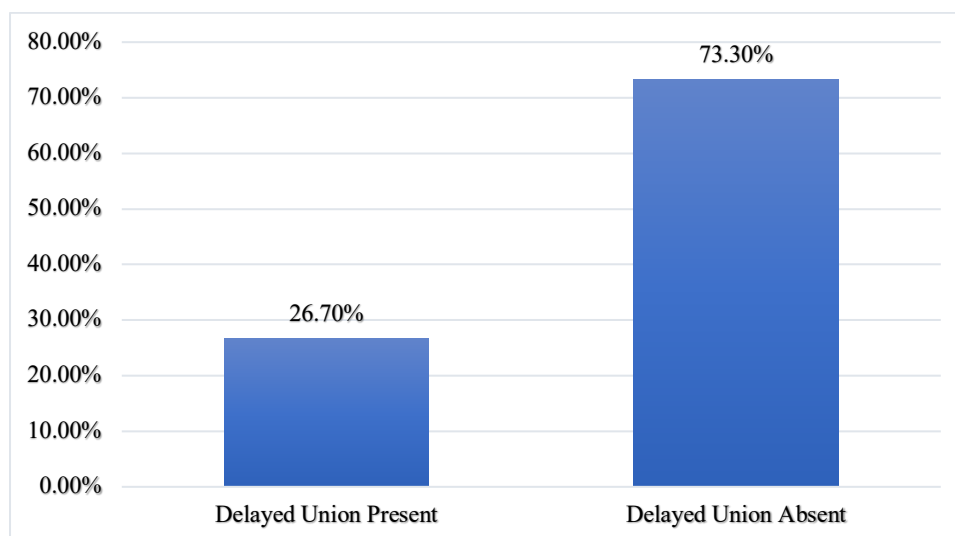


Figure 3: Visual Representation of Incidence of Delayed Union Among Study Participants

As indicated by Table 3, delayed union was reported to be evident in 32 out of 120 subjects, making up 26.7% of all the subjects included in the

study. On the contrary, in 73.3% of cases, fracture healing occurred normally without any development of delayed union. This means that

about one-fourth of patients having suffered from long bone fractures had developed delayed union.

Table 4: Correlation Between the Risks and Delayed Union

Risk Factor	Delayed Union Present n (%)	Delayed Union Absent n (%)	p-value
Smoking	21 (65.6)	26 (29.5)	0.002*
Diabetes Mellitus	15 (46.9)	18 (20.5)	0.008*
Open Fracture	17 (53.1)	17 (19.3)	0.001*
Postoperative Infection	14 (43.8)	12 (13.6)	0.000*
Surgical Delay >7 Days	18 (56.3)	24 (27.3)	0.005*

*Statistically significant ($p < 0.05$)

From Table 4, it was found that a statistical relationship existed between some of the risk factors and delayed union. The smoking factor was found among 65.6% of patients having delayed union, whereas among those patients who did not

have delayed union, only 29.5% were smokers ($p = 0.002$). Open fractures were found in 53.1% of cases of delayed unions, whereas 43.8% patients suffering from delayed union had postoperative infections.

Table 5: Mean Duration of Fracture Healing According to Selected Variables

Variable	Mean Healing Duration (Weeks)	Standard Deviation	p-value
Smokers	21.4	4.2	0.003*
Non-Smokers	16.8	3.7	
Open Fractures	23.1	4.8	0.001*
Closed Fractures	17.2	3.5	
Infection Present	24.5	5.1	0.000*
Infection Absent	16.5	3.2	

*Statistically significant ($p < 0.05$)

The results of Table 5 show that the meantime taken by smoking patients to heal their fractures was 21.4 ± 4.2 weeks compared to 16.8 ± 3.7 weeks for non-smoking individuals. Open fracture patients required 23.1 ± 4.8 weeks to heal their fractures, whereas closed fracture patients took an average of 17.2 ± 3.5 weeks to heal their fractures. The maximum mean healing period was reported by patients suffering from infection after surgery (24.5 ± 5.1 weeks). This result is highly significant.

Discussion

In the current research, delayed union occurred in 26.7% of all cases of long bone fractures and their treatment. It means that nearly one fourth of all fracture cases have a problem of delayed healing process. Such results coincide with those obtained by CL Ekegren (2018) [15], when he underlined that there is a high prevalence of this condition as well as a considerable number of related complications that can influence patient's health and life. Additionally, as shown by M Mehmood (2017) [16], delayed healing process takes place in case of soft tissue injuries associated with long bone fractures as well as in case of tibial fractures, namely, 34.2% of all cases were found to be tibial fractures. This result is not surprising since previously there was an assumption that tibial fractures are the most common ones.

The current research identified several risk factors for delayed union among which the following should be mentioned: smoking, diabetes mellitus,

open fractures, presence of postoperative infection and delayed surgery. Smoking was identified in 65.6% of cases with delayed union, whereas open fractures were found in 53.1% of these patients. These results coincide with those obtained by J Westgeest (2016) [17], where it was stated that presence of infection and open fractures increases the risks of delayed healing process and non-union of long bone fractures. Additionally, as mentioned by RG Pearson (2016) [18], smoking increases the probability of delayed healing processes and non-union because smoking impairs vascular system. Finally, the findings of the current research were in line with the results of the work by D Indu (2014) [19], where it was shown that the most common risk factors for delayed union included diabetes mellitus, infections, and smoking.

It should be noted that the mean duration of the fracture healing process was significantly prolonged in case of smoking, open fractures, and postoperative infection. Among these three groups, postoperative infections have been identified as the cause of the highest mean time needed for fracture consolidation. It equals to 24.5 ± 5.1 weeks. Smokers were characterized by slower healing than non-smokers. These results coincided with the findings of DJ Hak (2014) [20], who emphasized that such conditions as presence of infection, soft tissue injuries and some systemic diseases influence fracture healing process and lead to longer treatment period. Thus, the results obtained during this study can be considered as the extension

of available knowledge about delayed union of long bone fractures.

Conclusion

Results of the current study have shown that delayed union still poses a considerable problem in long bone fractures as it was noted in 26.7% of cases. Smoking, diabetes mellitus, open fractures, post-operative infection, and late surgery are some of the identified factors strongly associated with poor healing. Tibial fractures occurred to be the most prevalent types of fractures seen in this sample of patients, while patients having infections and smoking history had longer healing periods than the rest of them. It can be suggested that early identification of risk factors, appropriate surgical treatment, prevention of infection, and addressing the modifiable risk factors can positively influence healing in long bone fractures.

References

1. Copuroglu, C., Calori, G. M., & Giannoudis, P. V. (2013). Fracture non-union: who is at risk? *Injury*, 44(11), 1379-1382.
2. Bhandari, M., Fong, K., Sprague, S., Williams, D., & Petrisor, B. (2012). Variability in the definition and perceived causes of delayed unions and nonunions: a cross-sectional, multinational survey of orthopaedic surgeons. *JBJS*, 94(15), e109.
3. Schenker, M. L., Yannascoli, S., Baldwin, K. D., Ahn, J., & Mehta, S. (2012). Does Timing to operative debridement affect infectious complications in open long-bone fractures? a systematic review. *JBJS*, 94(12), 1057-1064.
4. Metsemakers, W. J., Handojo, K., Reynders, P., Sermon, A., Vanderschot, P., & Nijs, S. (2015). Individual risk factors for deep infection and compromised fracture healing after intramedullary nailing of tibial shaft fractures: a single centre experience of 480 patients. *Injury*, 46(4), 740-745.
5. Mehrpour, S., Kamrani, R. S., & Abrishami, A. (2015). Evaluating the risk factors of nonunion in long bone fractures of patients referred to Dr Shariati hospital's orthopedic Clinic During 2007-2013. *Journal of Orthopedic and Spine Trauma*.
6. Giannoudis, P. V., Gudipati, S., Harwood, P., & Kanakaris, N. K. (2015). Long bone non-unions treated with the diamond concept: a case series of 64 patients. *Injury*, 46, S48-S54.
7. Calori, G. M., Colombo, M., Mazza, E. L., Mazzola, S., Malagoli, E., Marelli, N., & Corradi, A. (2014). Validation of the Non-Union Scoring System in 300 long bone non-unions. *Injury*, 45, S93-S97.
8. Dimitriou, R., Carr, I. M., West, R. M., Markham, A. F., & Giannoudis, P. V. (2011). Genetic predisposition to fracture non-union: a case control study of a preliminary single nucleotide polymorphisms analysis of the BMP pathway. *BMC musculoskeletal disorders*, 12(1), 44.
9. Mills, L. A., Aitken, S. A., & Simpson, A. H. R. (2017). The risk of non-union per fracture: current myths and revised figures from a population of over 4 million adults. *Acta orthopaedica*, 88(4), 434-439.
10. Ricci, W. M., Streubel, P. N., Morshed, S., Collinge, C. A., Nork, S. E., & Gardner, M. J. (2014). Risk factors for failure of locked plate fixation of distal femur fractures: an analysis of 335 cases. *Journal of orthopaedic trauma*, 28(2), 83-89.
11. Nandra, R., Grover, L., & Porter, K. (2016). Fracture non-union epidemiology and treatment. *Trauma*, 18(1), 3-11.
12. Hernandez, R. K., Do, T. P., Critchlow, C. W., Dent, R. E., & Jick, S. S. (2012). Patient-related risk factors for fracture-healing complications in the United Kingdom General Practice Research Database. *Acta orthopaedica*, 83(6), 653-660.
13. Desai, P., Hasan, S. M., Zambrana, L., Hegde, V., Saleh, A., Cohn, M. R., & Lane, J. M. (2015). Bone mesenchymal stem cells with growth factors successfully treat nonunions and delayed unions. *HSS Journal®*, 11(2), 104-111.
14. Calori, G. M., Mazza, E. L., Mazzola, S., Colombo, A., Giardina, F., Romanò, F., & Colombo, M. (2017). Non-unions. *Clinical cases in mineral and bone Metabolism*, 14(2), 186.
15. Ekegren, C. L., Edwards, E. R., De Steiger, R., & Gabbe, B. J. (2018). Incidence, costs and predictors of non-union, delayed union and mal-union following long bone fracture. *International journal of environmental research and public health*, 15(12), 2845.
16. Mehmood, M., Deshpande, S., Khan, S. M., Singh, P. K., Patil, B., & Rathi, R. (2017). Epidemiology of delayed union of long bones. *J Trauma Treat*, 6(370), 2167-1222.
17. Westgeest, J., Weber, D., Dulai, S. K., Bergman, J. W., Buckley, R., & Beaupre, L. A. (2016). Factors associated with development of nonunion or delayed healing after an open long bone fracture: a prospective cohort study of 736 subjects. *Journal of orthopaedic trauma*, 30(3), 149-155.
18. Pearson, R. G., Clement, R. G. E., Edwards, K. L., & Scammell, B. E. (2016). Do smokers have greater risk of delayed and non-union after fracture, osteotomy and arthrodesis? A systematic review with meta-analysis. *BMJ open*, 6(11), e010303.
19. Indu, D., Asha, K. P., Sujith, H., Narayanan, N., & Hameed, N. (2014). Factors associated

- with delayed union of long bones-a case control study. Kerala Journal of Orthopaedics, 27(1).
20. Hak, D. J., Fitzpatrick, D., Bishop, J. A., Marsh, J. L., Tilp, S., Schnettler, R., ... & Alt, V. (2014). Delayed union and nonunions: epidemiology, clinical issues, and financial aspects. *Injury*, 45, S3-S7.