

Determinants of fracture patients in nonunion or delayed union



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Received: 2023-03-24

Accepted: 2023-05-15

Published: 2023-06-03

ABSTRACT

Background: Fractures are a common cause in the present, where the main cause is trauma/injury. The ideal current fracture treatment is orthopedic surgery in the hospital, sometimes with bones that are not completely fused (non-union) or delayed union. This study aimed to determine the risk factor associated with the incidence of the non-union and delayed union in patients operated at Siloam General Hospital, Kupang, Indonesia.

Method: An observational retrospective study with a case-control design was conducted from January 2020 to June 2021 in Siloam Kupang Hospital, East Nusa Tenggara. The case involved patients experiencing non-union or delayed union complications, while the control involved fractured patients without both complications. Data were extracted from Electronic Medical Records (EMR) and then were analyzed by χ^2 Cramer's V. The $p < 0.05$ was significant.

Result: The study results found a relationship between smoking ($p=0.000$), open fracture ($p=0.001$), infections ($p=0.000$), time intervals between events and surgeries ($p=0.000$), high energy injury mechanisms ($p=0.021$), and crush injury ($p=0.000$) with non-union or delayed union events in fracture patients at Siloam Hospital Kupang.

Conclusion: The non-union and delayed union complications in fractured patients were related to smoking habits, open fracture, local infections, time intervals between events and surgeries, high energy injury mechanism, and crush injury.

Keywords: non-union, delayed union, risk factors.

Cite This Article: Rante, S.D.T., Koamesah, S.M.J., Pakan, P., Folamauk, C.L.H. 2023. Determinants of fracture patients in nonunion or delayed union. *Bali Medical Journal* 12(2): 1769-1773. DOI: 10.15562/bmj.v12i2.4427

INTRODUCTION

Fractures are common nowadays, where trauma/injury is the main cause of fractures. An orthopedic is an ideal doctor for the current fracture treatment in the hospital. Depending on the case, fracture treatment can be done by surgery or without surgery.^{1,2} However, in treating patients who have been operated on, sometimes there are cases with bones that are not completely fused (non-union) or delayed unions.³ Nonunion is a condition in which bones cannot fuse within nine months, or there is no change in bone growth in three consecutive X-rays. While delayed union is a condition in which bones are connected but take longer than they should be.⁴ This case of non-union or delayed union can affect the quality of the patient based on economy or social function. Therefore, looking for the factors that cause the above conditions is necessary.

In another study involving 111 studies and 41,429 patients examined

the relationship between factors that influence the incidence of non-union fractures in the tibia bone, 15 significant factors were obtained, such as age >60 years, male sex, smoking, body mass index (BMI) >40 , diabetes, use of non-steroidal-steroidal anti-inflammatory drugs (NSAIDs), use of opioid class drugs, fractures of the middle and lower tibia bones, high-energy injury mechanisms, open fractures, Gustilo-Anderson grade IIIB or IIIC, type C fractures according to the AO classification, open reduction, fixation models (mechanical instability/fixation failure), and infections. Also, the prevalence of non-union cases in tibia fracture patients was 0.068. The treatment of tibia fractures in a closed and minimally invasive percutaneous plate osteosynthesis (MIPPO) has a low incidence of non-union.⁵⁻⁹

In addition to the risk factor above, there is one condition experienced in East Nusa Tenggara Province (NTT), where many patients arrive late to the hospital due to local cultural influence,

where traditional medicine is the first choice of many patients. Unfortunately, some patients who undergo traditional medicine first get unsuccessful treatment or cause disability; after that, the patient will go to the hospital asking for treatment. Patients sometimes come with infectious conditions, which indirectly inhibit bone growth. In this case, the time of the injury event, until the patient gets treatment at the hospital, is also one of the important factors for non-union or delayed union events.¹⁰ This study determined the risk factor associated with the incidence of the non-union and delayed union in patients operated on at Siloam Kupang General Hospital.

METHOD

Research Design

This study was an observational retrospective study using a case-control research design. The case was the patient experiencing non-union or delayed union complications (Figure 1), while the control

was the fractured patients without both complications (Figure 2). This research was conducted at Siloam Kupang Hospital, East Nusa Tenggara, Indonesia, from June to September 2021.

The population in this study was all fracture patients who underwent surgery from January 2020 to June 2021 and were registered in the Electronic Medical Record (EMR) of Siloam Kupang Hospital. The inclusion criteria applied in this study were patients with a non-union fracture or delayed union fracture as a case group and patient fracture that experienced union as a control group. We excluded patients with a pathological fracture or malignancy and if the medical record data were incomplete.

The collected data would be processed, analyzed and interpreted to test hypotheses. For this study, researchers used a p-value was <0.05 showing a significant relationship between dependent and independent variables. Bivariate analysis used the correlation test χ^2 Cramer's V.

RESULTS

Most respondents were in the age of 20 to 50 years group (59.1%), while the least was in the ages of 1 to 20 years group (15.4%). Around 90.3% of respondents did not have a smoking habit. However, 96.8% of respondents were undiagnosed with diabetes mellitus before surgery. About 17.0% of patients had fractures related to the external environment. Most patients (94.3%) did not have a history of local infection in the fracture area; however, 14 people (5.7%) had a local infection in the fracture area. We found that the majority of the fracture caused by traffic accidents or falls from a height (75.7%). Seven people had a history of injury with grade III open fracture tissue conditions (2.8%). In addition, patients with a duration >7 days between the event and the performed operation time were 41 people (16.6%) (Table 1).

Non-union or delayed union events

The results showed several prescriptions for those who experienced union after surgery. We found that most patients (83.8%) had successful fracture unions (Figure 1), while 16.2% presented non-



Figure 1. The results of the examination with X-rays in patients who have unionized.



Figure 2. Image of the examination results with X-ray photos in patients who experience non-union / delayed union.

union or delayed unions after the surgery (Figure 2).

Bivariate Analysis

The calculation results showed that there were 26 patients between the ages of 20 and 50 years; 14 patients with a smoking habit; 3 diabetic patients; 14 patients with open fractures; 14 patients with local infections in the fracture area; 15 patients operated on more than seven days after the incident; 36 patients whose injuries were caused by a traffic accident or a fall from a height; 7 patients had grade III open fracture (Table 2).

The hypothesis test results using the χ^2 Cramer's V test stated a relationship between smoking habits, diabetes, open fractures, infections, time intervals of events and operations, the mechanism of energy injury, and severe tissue injury

with non-union events or delayed union ($p < 0.05$).

DISCUSSION

The relation of age and non-union or delayed union events

Some studies have reported that age positively correlates with non-union risk,^{11,12} while other reports suggest no significant correlation.^{13,14} It should be noted that most study subjects had an average age of 20-50 years, and the results may not apply to younger or older patients. This result may also explain why age-related factors such as diabetes have not been identified as statistically significant risk factors in this study. However, diabetes was a possible non-union cause of bones in previous studies.¹⁴⁻¹⁸ Without controlling potential disruptive factors, it cannot be explained whether age is a

Table 1. The patient characteristics based on risk factors identification

Risk factors	Number	Percent (%)
Age Category (years)		
1-20	38	15.4
20-50	146	59.1
>=50	63	25.5
Smoking habits		
No	223	90.3
Yes	24	9.7
History of Diabetes Mellitus		
No	239	96.8
Yes	8	3.2
Fractures related to the external environment		
No	205	83.0
Yes	42	17.0
Local infection of the operated fracture area		
No	233	94.3
Yes	14	5.7
The mechanism of injury caused by a traffic accident or a fall from a height		
No	60	24.3
Yes	187	75.7
Grade III Open Fracture Tissue Condition		
No	240	97.2
Yes	7	2.8
The time between the event and the performed operation time		
0-1 day	206	83.4
>7 day	41	16.6

Table 2. The relationship between risk factors and non-union or delayed union events

Risk factors	Nonunion or delayed union	Correlation Test	
		χ^2 Cramer's V	P-value
Patient Age 25-50 years	26	0.096	0.319
Patient smoking habits	14	0.375	0.000
History of Diabetes mellitus	3	0.106	0.096
Open fracture	14	0.211	0.001
Local infection of the fracture operated area	14	0.558	0.000
Time Interval of Events and Operations	15	0.247	0.000
High energy injury mechanism	36	0.146	0.021
Crush injury	7	0.389	0.000

risk factor for non-union events. For this reason, it is necessary to control the effects of age.

The relation between smoking and non-union or delayed union events

Smoking is one of the important risk factors for non-union or delayed union events. This study showed that smoking is one of the risk factors for non-union

and delayed unions to the study subjects. Smoking affects impaired wound healing and the immune system.^{19,20} Smoking can increase the duration of the wound healing process, especially in case of infection, because smoking can increase the risk of complications. In addition, evidence has shown that smoking also accelerates the aging process in the cardiovascular, lung, and musculoskeletal systems. So

indirectly, the premature aging process due to smoking can impact the wound healing process longer, increasing the risk of non-union and delayed union.²¹ However, Mehmood's study of 153 subjects at AVBRH Hospital India explained that smoking and infection could be controlled to reduce the prevalence of delayed unions.

The relation between diabetes and non-union or delayed union events

Diabetes is a metabolic disease associated with non-union and delayed union events. Diabetes can increase the risk of non-union and delayed union events by increasing the risk of complications in the bone healing process. However, this study found that diabetes was not associated with non-union and delayed union events. Because without controls for potential confounding factors, it cannot be explained that diabetes, an age-related metabolic disease, is a risk factor for non-union and delayed union events. For this reason, it is necessary to control the effects of age. Some studies have reported that diabetes positively correlates with non-union and delayed union risks.^{6,22} In contrast, other reports show that there was no significant correlation.⁸ It should be noted that the majority of the subjects of this study had an average age of 20-50 years, and the results may not apply to younger or older patients. This condition may also explain why age-related factors such as diabetes have not been identified as statistically significant risk factors in this study.

The relation between open fractures and non-union or delayed union events

Cases of non-union significantly occur in open fractures, where patients with open fractures have a greater risk of non-union problems. Compared to a closed fracture, an open fracture is more likely to be traumatized, destroy blood supply tissue, be infected, and reduce blood supply which ultimately greatly affects bone healing. Therefore, an open fracture is so risky to disrupt bone healing.⁸ Also, using non-steroidal-steroidal anti-inflammatories that generally occur in open fracture patients can disrupt bone healing. This condition is caused by cyclooxygenase-2 in non-steroidal-

steroidal anti-inflammatories can inhibit bone healing.²³ Use of non-steroidal-steroidal anti-inflammatories may increase the risk of non-union twice.⁸

The relation between infection and non-union or delayed union events

There are different opinions related to infections and non-unions. Most experts argue that infection does not increase the risk of non-union.^{24,25} However, a cohort study of 736 subjects found that infection was significantly associated with non-union.⁵ A cohort study of 669 subjects also found that infection became an independent risk factor. Infection can increase the risk of non-union by 6.77 times. This may occur due to increased necrosis of the fracture end and vascular embolism, resulting in the poor local blood supply of the bone, which causes the bone formation to be disturbed, and healing is also disturbed, ultimately resulting in non-union.^{8,26}

The relation between time between events and operations and non-union or delayed union events

Amir Matityahu et al. observed a significant inverse correlation between resources in available hospitals and the time interval from hospital admission to surgery.²⁷ This increases the duration of time for fracture healing, and one of them is the cause of the delayed union of bones (delayed union). A case-control study at AVBRH Hospital India found that the duration between events and surgeries was related to non-union and delayed union.²⁸

The relation between high-impact injury and non-union or delayed union events

High-impact injuries usually result in open fractures, increasing the risk of infection complications. Because the skin is injured, it can create a vacuum effect that attracts all the dirt around it to the wound. Foreign material and impurities can often be deposited into the intramuscular cortex and bones. This can increase the risk of infection, so high-impact injury takes a long time for bone recovery, especially when the infection is not handled properly.^{29,30}

High-impact injuries are associated with surgery with biomechanical principles that may be inadequate or inconsistent with the fracture indications of the diagnosis. An inadequate implant can lead to non-union after nine months of patient follow-up. It was observed that the percentage of non-union occurrences with external fixators as a definitive treatment has a high degree of presentation compared to osteosynthesis with plates and, finally, intramedullary nails, which is the treatment of choice for this type of fracture.²⁹

The relation between severe tissue injury (crush injury) and non-union or delayed union events

Severe tissue injury usually occurs due to accidents experienced by patients. The opener has a higher non-union fracture rate than closed reduction. Although open reduction can bring good fracture repair in surgery, a closed reduction can better protect the blood supply and soft tissues.⁹ Severe tissue injury usually results in an open fracture, which can increase the risk of infection because this fracture is directly related to the environment. When the skin is injured, it can create a vacuum effect that attracts all the dirt around it to enter the wound. Foreign material and impurities can often be deposited into the intramuscular cortex and bones. This can increase the risk of infection, so high-impact injury takes a long time to recover.^{29,30}

Patzakis and Wilkins claim that the most important factor in reducing infections is the early administration of antibiotics.³¹ Contrary to Gustillo and Anderson, who claims that debridement is the most important factor for achieving good results for an open fracture.³⁰ So, it can be concluded that the most appropriate approach may be between these two ideas, namely that antibiotics should be given as early as possible. Lavage and good debridement should be carried out.³²

This study has a limitation; therefore, we suggest measuring the risk ratio of non-union or delayed union-related variables and reanalyzing the variables relating to non-union or delayed union.

CONCLUSION

The non-union and delayed union complications in fractured patients were related to smoking habits, open fractures, local infections, time intervals between events and surgeries, high-energy injury mechanisms, and crush injury.

DISCLOSURE

Author Contribution

All authors fully contributed to the research.

Ethical Consideration

The ethical commission of Siloam Kupang Hospital, East Nusa Tenggara has approved this study.

Funding

None.

Conflict of Interest

All authors stated no conflict of interest regarding the research and publication.

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