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Comparison of Healing Time in Closed Fractures of the Tibial Diaphysis and Tibial-Fibula after ORIF *Plate and Screw* at Waled Regional Public Hospital, Indonesia

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ABSTRACT

Background: Fractures are projected to become the fourth leading cause of death by 2030. A fracture is a discontinuity in the bone that is often accompanied by damage to the surrounding tissues. The healing process of fractures is influenced by various factors, the greater the damage to the bone and surrounding tissues, the longer the healing time. In cases of tibia and fibula fractures, the most commonly used surgical procedure in Indonesia is Open Reduction and Internal Fixation (ORIF) using Plates and Screw.

Aims: To compare of healing time in closed fractures of the tibial diaphysis and tibial-fibula after ORIF *Plate and Screw* at Waled regional public hospital.

Methods: This research uses a cross sectional design. A total of 77 samples were obtained using total sampling. Statistical tests use Mann Whitney.

Results: There were 37 patients with closed fractures of the tibia diaphysis and 40 patients with closed fractures of the tibia-fibula diaphysis. The healing time for closed tibial diaphyseal fractures was ≤ 24 weeks in 12 patients (32.4%), while > 24 weeks was 25 patients (67.6%). In patients with closed fractures of the tibia-fibula diaphysis within ≤ 24 weeks and > 24 weeks, the number was the same, namely 20 patients (50.0%). In the Mann-Whitney test, a significance value of 0.032 ($p<0.05$) was obtained, indicating a significant difference in the healing time between closed fractures of the tibial diaphysis and tibia-fibula after ORIF *Plate and Screw* at Waled Regional Hospital, with an average healing of 44.69 weeks for closed fractures of the tibial diaphysis, whereas for fractures closed tibia-fibula diaphysis 33.74 weeks.

Conclusion: The average healing time for closed tibial diaphyseal fractures is longer than for tibia-fibula.

Keywords: *Healing Time; Closed Fractures; Tibia Diaphysis; Tibia-Fibula; Open Reduction Internal Fixation (ORIF).*

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1. Introduction

Injuries currently represent a major global health burden, with projections indicating that they will become the fourth leading cause of death by 2030. Among the most prevalent types of injuries are bone fractures. A fracture is defined as a discontinuity in the bone, which may be partial or complete, occurring at one or multiple sites, and often accompanied by damage to the surrounding tissues (Ewari et al. 2021).

In 2020, the World Health Organization (WHO) reported a rising incidence of fractures, with 13 million cases and a prevalence rate of 2.7% (Cornelia et al. 2022). Data from the 2018 Basic Health Research (Riset Kesehatan Dasar) indicates that among the many fracture cases in Indonesia, lower extremity fractures due to accidents are the most common, accounting for 67.09% of cases. Specifically, 3,775 individuals experienced tibia fractures, while 14,027 suffered from tibia-fibula fractures (Jhonet et al. 2022). In West Java, the incidence of lower extremity fractures reached 68.82%. In Cirebon Regency, the prevalence of injuries caused by traffic accidents is 1.54%, with lower extremity injuries accounting for 72.86% of those cases (Riskesdas. 2018). One of the hospitals in Cirebon Regency, Waled General Hospital (RSUD Waled), reported approximately 110 injury cases between 2021 and 2022 (Wibisono et al. 2023).

Injuries resulting in fractures can cause a disruption in bone continuity, commonly affecting the tibia and fibula. The tibia plays a crucial role in supporting body weight, while the fibula serves as an attachment site for surrounding muscles (Ewari et al. 2021). Tibia and fibula fractures are associated with significant morbidity and often require prolonged treatment. Individuals with lower limb injuries may experience difficulty standing or walking for extended periods, squatting, lifting heavy objects, or performing weight-bearing tasks. Therefore, appropriate treatment is essential, with particular attention to the repositioning of the tibia in cases of tibia-fibula fractures. When both the tibia and fibula are fractured, the primary focus should be on realigning the tibia. This is because isolated tibial fractures are often subject to delayed union, which may result from an intact fibula preventing compression along the tibial axis. In such cases, a fibular osteotomy may be necessary to enable proper alignment of the tibial fracture ends. Internal fixation is typically recommended in these situations (Sjamsuhidajat et al. 2017). The standard method of fixation commonly used for tibial fractures, and the preferred surgical intervention is locked intramedullary nailing. However, this technique primarily maintains bone alignment. Alternatively, the plate and screw method may be more effective, as it not only preserves alignment but also provides compression to the fractured segments (Saied et al. 2016).

Fractures treated with open reduction and internal fixation (ORIF) using plates and screws heal directly without the formation of callus. The radiological healing process of a fracture begins immediately after the injury and continues until the fracture line disappears. The healing of fractures is influenced by various factors, including the load on the fractured bone and the condition of the surrounding soft tissues. The greater the damage to the bone and soft tissues, the longer the fracture healing process will take (Donsu et al. 2021).

This study is important for providing information on the incidence rates of fractures, particularly tibia and fibula fractures, as these bones play a crucial role in the musculoskeletal system. If this situation continues, it could undermine efforts to prevent fractures. Additionally, individuals who experience fractures can estimate their healing duration and better understand the factors that may either accelerate or delay the healing process.

Therefore, there is a need for research aimed at analyzing the comparison of healing times in closed fractures of the tibial diaphysis and tibia-fibula fractures following ORIF with plate and screw fixation at Waled Regional Public Hospital.

This study aims to compare the healing times of closed tibial diaphysis fractures and tibia-fibula fractures following ORIF with plate and screw fixation at Waled Hospital. The hypothesis is that there is a difference in healing time between these two types of fractures after ORIF with plate and screw fixation at Waled Hospital.

2. Methods

Research procedures

This study utilized an analytical observational method with a cross-sectional approach to compare the healing times of closed diaphyseal tibia and tibia-fibula fractures following ORIF with plate and screw fixation at RSUD Waled. The study was conducted at RSUD Waled in Cirebon Regency from June to July 2024. The respondents were patients with closed diaphyseal tibia and tibia-fibula fractures who underwent ORIF with plate and screw fixation at RSUD Waled between 2020 and 2023 and received follow-up care. The sample included patients aged 10 to 59 years whose fractures were caused by trauma. Patients excluded from the study were those with closed diaphyseal tibia and tibia-fibula fractures who underwent ORIF with plate and screw fixation at RSUD Waled during the same period but developed complications such as non-union or mal-union. Sampling was performed using a total sampling technique, meaning that the sample size was equal to the population size for each independent variable. This study did not classify or examine the types or configurations of fractures. Instead, it included all patients with closed fractures of the tibial diaphysis and tibia-fibula fractures who underwent ORIF with plate and screw fixation.

Measurements

This study utilized secondary data derived from medical records, including age, gender, date of initial injury, and the date of recovery indicating the disappearance of the fracture line. Healing time is defined as the period between injury and full weight-bearing accompanied by radiological signs of progressive consolidation. Radiological healing is assessed when the fracture line completely disappears, while clinically it is defined as the ability to bear full weight. In this study, the initial assessment was based on the date of diagnosis of a closed tibial diaphyseal or tibia-fibula fracture, followed by the ORIF plate and screw procedure. The final assessment was based on radiological results indicating that "no discontinuity is seen," meaning the fracture line has disappeared. The radiological healing process begins immediately after the fracture occurs and continues until the fracture line disappears. Tibial fractures with an intact fibula have been shown to require a longer time for bone union compared to fractures involving both leg bones, namely the tibia and fibula. This is because an intact fibula can disrupt union at the tibial fracture site due to differences in tibio-fibular length, which can alter strain patterns in the tibia and fibula during internal fixation, thereby prolonging tibial fracture healing. In this study, several confounding factors, such as fracture configuration, mobilization time, vascularization, active and passive movement, history of comorbidities, use of NSAIDs, nutrition, and smoking, were not measured, which could potentially introduce bias to the research.

Statistical techniques

Respondent data extracted from medical records were collected with confidentiality ensured and then analyzed statistically using univariate and bivariate analyses in SPSS. The study initially conducted a normality test using the Shapiro-Wilk test, which is appropriate for small sample sizes. If the data followed a normal distribution, an Independent T-test was performed, if the data were not normally distributed, the Mann-Whitney test was applied. Data collection for this study was conducted after obtaining ethical approval from the Health Research Ethics Committee (KEPK) at RSUD Waled.

Ethical Clearance

This study received ethical approval from the Health Research Ethics Committee (KEPK) at RSUD Waled on May 21, 2024, under approval number 000.9.2/065/KEPK/V/2024.

3. Results

The number of respondents was 77, including 37 with closed diaphyseal tibia fractures and 40 with closed diaphyseal tibia-fibula fractures. The respondents were selected using the total sampling method, based on the inclusion and exclusion criteria. The characteristics of the respondents were described in terms of age, gender, and healing time.

Based on Table 1, it can be observed that among patients with closed tibial diaphyseal fractures treated with ORIF using plates and screws, the largest group is in the 19–44-year age range, comprising 23 patients (62.2%). The 45–59-year age range includes 11 patients (29.7%), while the smallest group is in the 10–18-year age range, with 3 patients (8.1%). For patients with closed tibia-fibula diaphyseal fractures treated with ORIF using plates and screws, the majority are also in the 19–44-year age range, with 23 patients (57.5%). The 45–59-year age range includes 13 patients (32.5%), and the 10–18-year age range includes 4 patients (10.0%).

Table 1. Respondent Characteristics

Variables	Closed fractures diaphyseal tibia		Closed fractures diaphyseal tibia-fibula	
	Frequency (n)	Percentage (%)	Frequency (n)	Percentage (%)
Type of Fracture	37	48.1	40	51.9
Age				
10-18 years old	3	8.1	4	10.0
19-44 years old	23	62.2	23	57.5
45-59 years old	11	29.7	13	32.5
Gender				
Male	25	67.6	29	72.5
Female	12	32.4	11	27.5
Healing Time				
≤ 24 Weeks	12	32.4	20	50.0
> 24 Weeks	25	67.6	20	50.0
Total	37	100.0	40	100.0

Regarding gender, among patients with closed tibial diaphyseal fractures treated with ORIF using plates and screws, the majority are male, comprising 25 patients (67.6%), while females account for 12 patients (32.4%). For patients with closed tibia-fibula diaphyseal fractures treated with ORIF using plates and screws, the majority are also male, with 29 patients (72.5%), while females account for 11 patients (27.5%).

Among patients with closed tibial diaphyseal fractures treated with ORIF using plates and screws, 12 patients (32.4%) experienced a healing time of ≤ 24 weeks, while 25 patients (67.6%) had a healing time of more than 24 weeks. In contrast, for patients with closed tibia-fibula diaphyseal fractures treated with ORIF using plates and screws, the number of patients with healing times of ≤ 24 weeks and > 24 weeks was equal, with 20 patients (50.0%) in each category.

Table 2. Normality Test

Type of Fracture	Shapiro-Wilk		
	Statistic	df	Sig.
Closed fractures diaphyseal tibia	.798	37	0.001
Closed fractures diaphyseal tibia-fibula	.903	40	.002

In the table above, the significance p-value for patients with closed tibial diaphyseal fractures is (Sig) = 0.001, while for patients with closed tibia-fibula diaphyseal fractures, it is (Sig) = 0.002. Therefore, it can be concluded that the data are not normally distributed since the significance values (Sig.) are less than 0.05. Consequently, the Mann-Whitney test was used for the comparative analysis, as presented in Table 4 below.

Table 3. Comparison test with Mann Whitney

Type of Fracture	N	Mean Rank	Std Deviation	95% Confidence Interval for Mean		Sig.
				Lower Bound	Upper Bound	
Closed fractures diaphyseal tibia	37	44.69	32.032	29.8877	51.2475	.032
Closed fractures diaphyseal tibia-fibula	40	33.74	16.989	21.2918	32.1582	
Total	77					

Based on Table 3, a significance value (Sig.) of 0.032 (< 0.05) indicates that there is a significant difference in healing times between closed tibial diaphyseal fractures and closed tibia-fibula diaphyseal fractures. The average healing time for closed tibial diaphyseal fractures is 44.69 weeks, whereas it is 33.74 weeks for closed tibia-fibula diaphyseal fractures.

4. Discussion

Fractures can occur due to a single traumatic event, repetitive stress, or abnormal weakness in the bone (pathologic fractures). The tibia is located at the anteromedial border and lies subcutaneously (Setyoko et al. 2021). The distal diaphysis becomes thinner in this area, making it more prone to injury. The tibial diaphysis is the most common site for tibial fractures, and approximately 80% of these injuries are associated with fibula fractures (Madhukar et al. 2017).

The fibula is the slender lateral bone of the lower leg, playing a role in the attachment of surrounding muscles (Snell et al. 2011). The combination of the tibia and fibula resembles a bow, with the fibula acting as the bowstring (Rajan et al. 2022).

Fractures frequently occur due to traffic accidents. According to Riskesdas 2018, the prevalence of lower extremity fractures is the highest. One type of these fractures is crural fractures, or tibia-fibula fractures. The study revealed that the most common type of fracture was closed tibia-fibula diaphyseal fractures, with 40 patients (51.9%). These findings align with a previous study by Gede et al. which reported that the most common type of fracture was tibia-fibula fractures, accounting for 21 cases (70%), followed by tibial fractures with 8 cases (27%), and fibular fractures with 1 case (3%).

Based on age, the group experiencing closed tibial diaphyseal and tibia-fibula fractures treated with ORIF using plates and screws in this study includes patients in the 19–44 year age range, with 23 patients (62.2%) for tibial fractures and 23 patients (57.5%) for tibia-fibula fractures. This is consistent with the study conducted by Ridwan et al. which found that for the age variable, the majority of cases were in the >18 year age group, with 35 cases (68.6%), while the <18 year age group had 16 cases (31.4%). However, this differs from previous studies that categorized age simply as <18 years and >18 years, whereas in this study, categorization was based on age groups defined by the WHO. Fractures are often found in younger or productive age groups due to their high-intensity activities. This increased level of activity contributes to a higher risk of accidents (Ridwan et al. 2019).

Additionally, the majority of tibia and tibia-fibula fractures occur in male patients, as men are generally more involved in high-risk occupations such as athletics or engage in risky behaviors like speeding, driving without following regulations, or driving under the influence of alcohol (Ewari et al. 2021). This is consistent with the study's findings, where the majority of closed tibial and tibia-fibula diaphyseal fractures treated with ORIF using plates and screws were in males, with 25 patients (67.6%) for tibial fractures and 29 patients (72.5%) for tibia-fibula fractures. These results align with another study conducted by Ewari et al., which showed that the majority of the sample were male, with 17 men (56%) and 13 women (44%). Men are 2.9 times more likely to experience fractures compared to women between the ages of 15 and 49. Conversely, women approaching age 60 have a 2.3 times higher risk of fractures compared to men (Ewari et al. 2021). Female patients experiencing fractures are often related to the onset of menopause as they age, with increasing age being a risk factor for developing osteoporosis (Ridwan et al. 2019).

In cases of lower extremity diaphyseal fractures, most medical literature recommends the use of nails rather than plates. This recommendation is based on the higher union rates achieved with nails. However, in Indonesia, most fracture fixations use plates because they are cheaper and more readily available than nails, despite the risk of nonunion being 9%–19%. Fracture management varies widely and includes methods such as Open Reduction and Internal Fixation (ORIF), a surgical procedure involving internal fixation of the fracture. The most commonly used method is Plate and Screws (Susanti et al. 2023). Tibial fractures often experience complications such as delayed union, nonunion, and malunion. These complications occur due to the intact fibula, which can impede the union of the tibial fracture line. The discrepancy in tibio-fibular length can alter the strain patterns on the tibia and fibula during internal fixation, leading to residual symptoms and joint disturbances (Madhukar et al. 2017).

Estimating the healing time of a fracture immediately after treatment is difficult. It often relies on the individual surgeon's experience and is further complicated by the absence of an accepted gold standard for determining fracture healing. Several clinical studies consider healing based on both (i) radiographic criteria: the presence of bone callus in at least three cortices on radiographs taken from two projections, and (ii) clinical criteria: absence of tenderness at the fracture site, absence of pain upon applying pressure to the fracture site, and during full weight-bearing (Massari et al. 2018). However, in this research, healing is defined as the duration from injury to the point when the patient can fully bear weight, accompanied by signs of progressive radiological consolidation. Radiological healing is determined when the fracture line has completely disappeared, while clinical healing is indicated by the ability to bear full weight (Houben et al. 2018). Tibial fractures with an intact fibula have been shown to take longer to achieve bone union compared to fractures involving both the tibia and fibula (Madhukar et al. 2017).

The study results show a difference in healing time between closed diaphyseal tibia fractures and closed diaphyseal tibia-fibula fractures after ORIF with plates and screws. The average healing time for closed diaphyseal tibia-fibula fractures was 33.74 weeks, while the average healing time for closed diaphyseal tibia fractures was 44.69 weeks. These results are consistent with the study by Rajan et al. Although previous studies conducted radiological assessments by examining the bone cortex, this study assessed healing by observing the disappearance of fracture lines in the radiological images. Rajan et al. found a difference in radiological union times, with an average union time of 19.09 weeks for the tibia-fibula fracture group (FF), and 22.23 weeks for the tibia with an intact fibula group (IF). However, these findings do not align with the study by Rustam et al. which showed no significant difference in callus formation between isolated tibia fractures and tibia-fibula fractures; in that study, healing time was assessed using the RUST score. According to another study by Jun et al. the average fracture healing time was significantly longer than the durations reported in the literature. This discrepancy is attributed to the numerous factors that influence fracture healing.

Pediatric fracture patients have distinct characteristics compared to adults; their healing process can be shorter, and remodeling is often more effective. This is due to differences in the anatomy, biomechanics, and physiology of children's bones compared to those of adults. Fractures in geriatric patients tend to have longer healing times due to the presence of comorbid conditions. Conditions such as diabetes and hypertension can lead to decreased bone mineral density, resulting in prolonged fracture healing (Samsir et al. 2023).

Fracture configuration can also impact healing time. For instance, comminuted fractures often cause delayed union. This is because gaps in the fracture need to be bridged by callus formation, and soft tissue trapped between the bone ends can impede union. Transverse fractures generally heal more slowly than spiral fractures due to their smaller contact surface area. These types of fractures usually result from high-energy injuries (Lianturi et al. 2021). Additionally, the initial displacement of a fracture affects healing time. Non-displaced fractures, where the periosteum remains intact, heal twice as fast as displaced fractures. The presence of infection or local malignancy can prolong the local inflammatory process, which may inhibit fracture healing (Maynard et al. 2019).

Early mobilization has become essential, as it is now a standard practice in Enhanced Recovery After Surgery (ERAS) protocols. Early mobilization improves blood circulation and helps the body return to normal function more rapidly. Patients with lower extremity fractures often experience pain, which may result in

reduced muscle movement and subsequently lead to muscle weakness. Fractures cause physiological changes that affect the patient's functional mobility. This condition contributes to muscle strength problems in fracture patients. As a result, movement is limited, particularly in the fractured joint and the surrounding joints. This restricted movement leads to a reduced range of motion and impaired joint flexibility. During the healing timeline before union occurs, there is a significant risk of non-union. Additionally, vascularization of both fracture fragments is important; if both fragments have good vascularization, healing generally proceeds without complications. However, if one side of the fracture has poor vascularization, it can impede healing and potentially lead to non-union (Samsir et al. 2023).

High-dose vitamin D3 supplementation may slightly enhance early clinical bone healing, according to findings from screening trials and other available evidence (Samsir et al. 2023). The use of NSAIDs also affects fracture healing, as prostaglandins play a role in inducing osteogenesis. Additionally, in smokers, nicotine from cigarettes can inhibit osteoblast activity in bone formation, leading to prolonged fracture union times (Lianturi et al. 2021).

This study has limitations, including the presence of confounding factors such as fracture configuration, timing of mobilization, vascularization, active and passive movement, comorbid conditions, NSAID use, nutrition, and smoking in patients, which were not measured and could introduce bias. Therefore, it is necessary to include these additional factors or variables in future studies to reduce bias and obtain more comprehensive results.

5. Conclusion

In this study, it was found that the healing time for closed tibial diaphyseal fractures was ≤ 24 weeks in 12 patients (32.4%), while 25 patients (67.6%) had a healing time of more than 24 weeks. For patients with closed tibia-fibula diaphyseal fractures, the number of patients with healing times of ≤ 24 weeks and > 24 weeks was equal, with 20 patients (50.0%) in each category. The significance value was 0.032 ($p < 0.05$). Therefore, it can be concluded that there is a significant difference in healing times between closed tibial diaphyseal fractures and closed tibia-fibula diaphyseal fractures after ORIF with plates and screws at RSUD Waled, with the average healing time for closed tibial diaphyseal fractures being longer compared to tibia-fibula fractures.

Future researchers conducting similar studies are encouraged to include additional factors or variables to reduce bias and obtain more comprehensive results. This is important because confounding factors, such as fracture configuration, mobilization time, vascularization, active and passive movement, history of comorbidities, use of NSAIDs, nutrition, and smoking, were not measured in this study, and these factors can influence differences in bone healing time.

Conflict of Interest

There is no conflict of interest for the results

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