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Risk factors for malocclusion in patients with mandibular fractures within 3 months post open reduction and internal fixation surgery at Prof. Dr. IGNG Ngorah General Hospital Denpasar

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Abstract---Open reduction and internal fixation is the gold standard for managing mandibular fractures with the primary goal of restoring premorbid occlusion status. Malocclusion is one of the most common and functionally significant postoperative complications of mandibular fracture. This study aims to determine the factors that influence the occurrence of malocclusion in patients with mandibular fractures three months after open reduction and internal fixation surgery at Prof. Dr. I GNG Ngoerah Hospital Denpasar. This study was an analytic observational study with a retrospective cohort design. The result is the age of 40 years, mandibular fracture sites in more than one region, a complex type of mandibular fracture, involvement of other facial bones fracture, waiting time for surgery > 7 days, and internal fixation with wire are risk factors for malocclusion within three months postoperatively. Gender was not statistically associated with the incidence of malocclusion post-operation (p-value 0.705). The combination of internal fixation with maxillo-mandibular fixation (MMF) was a preventive factor for postoperative malocclusion (RR 0.4 (CI: 0.23-0.99)). The results of the multivariate analysis showed that the number of fracture locations in more than one region had the highest effect on the occurrence of postoperative malocclusion by 131.7 times.

Keywords---malocclusion, mandibular fracture, MMF.

Introduction

Malocclusion is a severe problem that significantly interferes with chewing function. A malocclusion is a form of maxillary and mandibular relationship that deviates from the standard form due to a mismatch between the dental and jaw arch, which can be measured up to six months postoperatively (Apriza and Hasan, 2020). Mandibular fractures most commonly occur in the region between the distal canine and the anterior attachment of the masseter muscle. Mandibular fractures can be classified according to anatomic location, the direction of the fracture line, and the position of teeth relative to the fracture (Jain and Rathee, 2020).

The location of mandibular fracture is one of the prognostic factors for malocclusion after open reduction surgery and internal fixation of mandibular fracture. The study showed that the location of mandibular fracture correlated with postoperative malocclusion of open reduction and internal fixation of the mandible. The incidence of malocclusion after surgery open reduction and internal fixation of the mandible mainly occurs at the angle and subcondyle of the mandible (Bicsák *et al.*, 2020). Until now, there has been no research on the

factors that influence the occurrence of malocclusion in patients with mandibular fractures within three months after open reduction and internal fixation surgery at Prof. RSUP. Dr. IGNG Ngoerah Denpasar, so this research needs to be done.

Method

This study uses an analytical observational study design with a retrospective cohort design. This study started by observing risk factors and preventive factors related to malocclusion in patients with mandibular fractures within three months after open reduction and internal fixation surgery at Prof. RSUP. Dr. IGNG Ngoerah Denpasar, at the time the patient was hospitalized. Observation of independent and dependent variables and follow-up up to 3 months postoperatively based on records in the patient's medical record. Research ethics permit from Udayana University with number 425/UN14.2.2VII.14/LT/2022. Inclusion criteria: All patients with facial bone fractures involving the mandible recorded in medical records, aged above or equal to 18 years, who underwent open reduction and internal fixation surgery at Prof. RSUP. Dr. IGNG Ngoerah Denpasar, from January 2020 to December 2021, came for control within three months after surgery with an occlusion assessment recorded in the medical record. Exclusion criteria: (1) Incomplete medical record, (2) Patient does not come for control, (3) Comorbidities (DM, HT, Heart, Kidney, Liver, Immunocompromise, Autoimmune, Malignancy), (4) Congenital disorders involving facial bones (5) edentulous patient, The data analysis in this study consisted of descriptive statistical, bivariable, and multivariable with a significance value of $p < 0.05$.

Results and Discussion

This study involved 60 patients with a history of mandibular fractures who underwent surgery at Prof. RSUP. Dr. IGNG Ngoerah Denpasar period January 2020-December 2021. In this study, the characteristics data in Table 1.

Table 1 Characteristics of Respondents

Characteristics	Sample (n=60)
Respondent's age (n, %)	
40 years	18 (30%)
< 40 years old	42 (70%)
Gender (n, %)	
Man	39 (65%)
Woman	21 (35%)
Number of Fracture locations (n, %)	
one region	32 (53.3%)
more than one region	28 (46.7%)
Fracture type (n, %)	
Complex	20 (33.3%)
Simple	40 (66.7%)
Other facial bone fracture involvement (n, %)	
Other facial bone fractures involved	26 (43.3%)
Other facial bone fractures are not involved	34 (56.7%)

Operation waiting time (n, %)	
7 days	44 (73.3%)
> 7 days	16 (26.7%)
Combination of internal fixation (n, %)	
MMF installed	49 (81.7%)
Not installed MMF	11 (18.3%)
Internal fixation type (n, %)	
Internal fixation with wire	13 (21.7%)
Internal fixation with miniplate	47 (78.3%)

The bivariate analysis aims to determine the relationship between age, gender, fracture location, fracture type, involvement of other facial bone fractures, length of the operation time, a combination of internal fixation, and type of internal fixation on the incidence of malocclusion presented in Table 5.2.

Table 2 Result Bivariate Analysis

Variable	Malocclusion incident		RR	95% CI	p
	Malocclusion	No malocclusion			
Respondent's age (n, %)					
40 years	11(18.3%)	7 (11.7%)	3.2	1.55-6.61	0.001
< 40 years old	8 (13.3%)	34(56.7%)			
Gender (n, %)					
Man	13(21.7%)	26 (43.3%)	1.1	0.52-2.62	0.705
Woman	6 (10%)	15 (25%)			
Number of fracture sites (n, %)					
More than one region	18 (30%)	10 (16.7%)	20.	2.93-	0.000
one region	1 (1.7%)	31 (51.7%)	5	144.41	
Fracture type (n, %)					
Complex	18 (30%)	2(3.3%)	36	5,16-	0.000
Simple	1 (1.7%)	39 (65%)		250.79	
Involvement of other facial bone fractures (n, %)					
Yes	14(23.3%)	12 (20%)	3.6	1.51-8.86	0.001
Not	5 (8.3%)	29 (48.3%)			
Operation waiting time (n, %)					
> 7 days	13(21.7%)	3 (5%)	5.9	2.73-	0.000
7 days	6 (10%)	38 (63.3%)		12.99	
Combination of internal fixation with MMF insertion(n,%)					
MMF installed	13(21.7%)	36 (60%)	0.4	0.23-0.99	0.071
Not installed MMF	6 (10%)	5 (8.3%)			
Internal fixation type (n, %)					
Wire	10(16.7%)	3(5%)	4	2.07-7.76	0.000
Miniplateand screw	19(15%)	38(63.3%)			

The multivariate analysis was aimed to determine the dominant factor of the independent variables that caused the incidence of malocclusion in patients with mandibular fractures within three months after open reduction and internal fixation surgery results were concluded in table 3

Table 3 Results of Multivariate Analysis

Variable	B	Exp (B)	95% CI	<i>p</i>
Age 40 years old	3,135	22.9	1.63-323.93	0.020
Fracture location > 1 region	4,881	131.7	6,16-2813.71	0.002
There is the involvement of other facial bone fractures	4.184	65.6	2.93-1467.76	0.008
Internal wire fixation type	2,591	13.3	0.64-276323	0.094

Research results by category age got an average of 29.2 years (SD: 13,2). The results of this study are similar to research by (Manalu *et al.*, 2018), who found that the mean age of subjects in the study with mandibular fractures was 26.14 years. A study (Subyakto *et al.*, 2021) stated that the highest incidence of mandibular fracture was in patients aged 20-60, with as many as 215 cases (62.14%). Research result (Jung *et al.*, 2014) also stated that the highest incidence of mandibular fracture was found in patients aged 20-29. The study's results (Natu *et al.*, 2012) stated that the highest incidence of mandibular fracture was in the age group of 21-30 years (37.8%). Trauma is considered a problem in this age group, possibly due to activity-related injuries and careless driving on the road. Fights that result in mandibular fractures or extreme sports are also more prone to occur in this age group (Natu *et al.*, 2012; Sultana and Haider, 2018).

These results are by research by (Kim, Choi and Kim, 2018), which stated that post-ORIF malocclusion was more common in the age group above 40 years, as much as 55.6%. With age, the amount of bone deposited in each remodeling cycle decreases, possibly due to a reduction in the number of osteoblast precursor cells, a reduction in the number of stem cells from which these precursors originate, and a reduction in osteoblast lifespan. This causes postoperative malunion and non-union to occur more quickly in older fracture patients, leading to malocclusion (Szulc & Seeman, 2009).

The results showed that mandibular fractures were more common in men (65%) than women. Epidemiologically, mandibular fractures are more common in men than women. The most common causes of mandibular fractures are road traffic accidents, accidental falls, and direct physical attacks on the facial bones, especially the mandible (Jha, Sinha and Swati, 2018). Suryantari *et al.* found that mandibular fractures that occurred in men (84.4%) were higher than in women (15.6%). (Suryantari, Hamid and Sanjaya, 2019). The study's results at the Arifin Achmad Hospital in Riau Province also stated that 80.10% of mandibular fracture patients were male from January 2011 to December 2013 (Mutia, 2015). Research at H. Adam Malik Hospital Medan stated that 90.6% of mandibular fracture patients from August 2016 to March 2017 were male (Manalu *et al.*, 2018). Not only in Indonesia, but research conducted in India also stated that men, namely 78.6% dominated the incidence of mandibular fractures (Chaurasia and Katheriya, 2018)

The high incidence of mandibular fractures in men is believed to be due to the nature of men who are more aggressive than women, so fractures occur more often, such as fractures due to assault, aggressive driving, or extreme sports. Women also tend to be more careful and do housework more often than driving, extreme sports, or assaults that are at risk of causing fractures (Yada, Pratap and Dandriyal, 2015)

Gender in this study was not significantly associated with the incidence of postoperative malocclusion. Similar results were obtained by Dodson et al., who stated that gender was not associated with the incidence of postoperative malocclusion (Dodson, 2000). Mehta et al. obtained different results, who stated that the female sex experienced slower bone healing in Wistar rats. Radiographic analysis revealed bridging, and callus formation occurred earlier in the male group than in the female group, whereas micro-CT analysis showed a larger callus size in male animals. Slow bone healing is more at risk of non-union-causing malocclusion. However, this study was conducted on Wistar rats, so it is not fully representative of the conditions that occur in humans as in this study (Mehta and Duda, 2011)

This study showed that more mandibular fracture patients had fracture locations in one region (53.3%) than in one region (46.7%). This result is similar to the study by Mutua et al. (2015). They stated that more mandibular fracture patients had only one fracture site (68.6%) than more than one, with the most common regions experiencing fractures being the symphysis and parasymphysis. This result Kim et al. (2018), who stated that 66.67% of patients with post-ORIF malocclusion had fractures in more than two regions of the mandible. The study by Dodson et al. (2000) also stated that the number of fracture sites affected the incidence of postoperative malocclusion, along with the patient's dental condition and fracture displacement. The study by Mathog et al. showed that fractures in more than one region of the mandible doubled the incidence of malocclusion (39% vs. 17.6%) (Mathog *et al.*, 2000).

Fractures in more than one location will make management more difficult because they are in two different places. More difficult management can lead to an increased risk of errors in reduction or stabilization, further increasing the risk of malunion and non-union, leading to malocclusion. In the study by Mathog et al., the leading cause of malocclusion in patients with more than one fracture region was instability (Mathog *et al.*, 2000). Fractures of one or both mandibular condyles and fractures of the mandible in other regions are the most influential factors in causing malocclusion due to changes in mandibular width due to reduction or stabilization errors (Dodson, 2000). In a case series, we presented a patient with a mandibular fracture of the mandibular body and both mandibular condyles. Only the mandibular body was reduced at surgery, while both condyles were not treated. This causes malocclusion and temporomandibular disorders after surgery (Kim, Choi and Kim, 2018).

The type of fracture in this study was divided into 2, namely simple and complex. Simple/straightforward fracture means that it involves a single disruption between two bone segments, while complex or comminuted fracture means a fracture that involves several fracture fragments. In complex fractures, there is

more than one fracture fragment, so the anatomical reduction is undoubtedly more complicated than simple ones, with small and many bone fragments making the technical operation more difficult. Anatomical reduction plays an essential role in the bone healing process. In addition, the stabilization of complex fractures requires more fixation points, so there is a greater risk of instability.

The results of this study are similar to the study by Dodson et al., which stated that the severity of the fracture, including the type of fracture, was significantly associated ($p < 0.05$) with the incidence of postoperative complications, including malocclusion in mandibular fracture patients. (Dodson, 2000). Another study by Cerqueira et al. stated that in patients with mandibular fractures with complications including malocclusion, 70% were complex fractures, while only 30% had simple fractures. In contrast, in uncomplicated mandibular fracture patients, 70% were simple fractures. This difference is statistically significant with p value = 0.003 (Cerqueira, 2013). The same thing was found in a 2003 study in Dallas, where there was a significant relationship between the number of fragments in complex maxillofacial fractures and surgical complications, including the incidence of malocclusion (Sethuraja and Thirumalaisamy, 2017).

The involvement of other facial fractures was significantly associated with the incidence of malocclusion in this study. Involvement of other facial bone fractures is a risk factor that increases the occurrence of malocclusion in patients with mandibular fractures within three months after open reduction and internal fixation surgery with an RR value of 3.6. In the case of multiple facial fractures, simple open reduction sometimes results in various aesthetic disturbances from the facial deformity. Malocclusion is a severe complication of open reduction surgery for facial fractures. This is often due to inadequate consideration of the occlusal relationship and intermaxillary fixation during surgery (Lim *et al.*, 2017). In addition, similar to fractures in more than one region of the mandible, other facial fractures cause more reduction and fixation points, thus increasing the risk of error in reduction and fixation instability compared to fractures that are only in the mandible. Incorrect reduction and instability can lead to malunion and/or non-union leading to malocclusion (Dodson, 2000).

A study by Arai et al. stated that patients with various fractures of other facial bones, namely midline sagittal fractures, right maxillary sinus, orbital wall, mandibular body, and condyle process, experienced malocclusion after ORIF. (Arai *et al.*, 2022). The study of Kim et al. presented a patient with a facial pan fracture involving the upper, lower and middle thirds of the face simultaneously. The patient had bilateral orbital, maxillary, mandibular, nasal, and multiple dental and alveolar fractures. The patient's systemic condition was so poor that immediate surgery was performed without adequate dental treatment. This increases the risk of infection and tooth contamination that interferes with the bone union process. This could cause malocclusion in these patients (Kim, Choi and Kim, 2018).

The study's results obtained land waiting time for surgery were significantly related to the incidence of malocclusion with a p -value < 0.05 . This means waiting time for surgery of more than seven days is a risk factor for increasing the occurrence of malocclusion in patients with mandibular fractures within three

months after open reduction and internal fixation surgery with an RR value of 5.9. The operation time in question is the time from the incident until the patient received surgery. The results of this study are the study by Mathog *et al.*, which stated that delay in waiting time for surgery contributes to the incidence of post-ORIF non-union in mandibular fractures, which can cause malocclusion. The non-union mandibular fracture patients in Mathog *et al.*'s study were mainly treated after more than 24 hours, with eight patients experiencing a delay of 5 days, two patients for two weeks, one patient each for eight days, three weeks, one month, six weeks, there are even patients who are delayed up to 6 months(Mathog *et al.*, 2000). Various literature has not clearly described the ideal time for maxillofacial surgery. Champy *et al.* and Anderson *et al.* recommend ORIF management within 12 hours, while Cawood *et al.* recommend ORIF management within 24 hours. Some investigators argue that fractures reduced in less than seven days have good results (Kellman, 2006).

Up to 14 days after the incident, the initial healing process has occurred, which makes mobilization and anatomical reduction difficult because the soft tissue has experienced adhesions between the fracture fragments—carrying out treatment more than this time will complicate the procedure because fibrosis has occurred and early healing has been established. Actions carried out more than 14 days from the incident will complicate the operation because they have to deal with fibrosis and the previous ossification process. This certainly affects achieving anatomic reduction so that it risks increasing healing complications and can lead to poor occlusion. The incidence of fracture and the time between trauma and initial treatment should be considered contributing factors to complications requiring re-treatment of mandibular fractures(Cerqueira, 2013).

Different results were obtained by Barker *et al.*, who stated that the reduction surgery performed after 14 days did not give a significant difference in results (Barker *et al.*, 2011). Likewise, a retrospective study from Rothweiler in Germany in 2017 on 168 patients for ten years showed no significant difference in complications in reduction surgery performed before and after three days (Rothweiler *et al.*, 2017). In 2002 Ruller *et al.* also got similar results to the Rothweiler study. The results showed that the combination of internal fixation with MMF was not associated with the incidence of malocclusion. Even so, the value of $RR < 1$ means kThe combination of internal fixation with MMF is a preventive factor for malocclusion in patients with mandibular fractures within three months postoperatively with open reduction and internal fixation.

Treatment of mandibular fractures with miniplate fixation and in combination with MMF placement is a widely used and universally accepted method for fixation fracture fragments. The complication rate of mandibular fracture treatment using a miniplate with a thickness of 2.0 mm and MMF of up to two weeks has been evaluated through a descriptive study involving 50 patients with a single mandibular fracture. The study found that 96% of cases were successful without complications. Only 2 cases (4%) developed a postoperative infection and healed within 7 to 10 days after administration of antibiotics and local wound care, so it is concluded that single miniplate insertion together with a maxillomandibular fixation for up to two weeks has proven to be an effective treatment modality for mandibular fractures.(Habib *et al.*, 2014).

The ability to treat fractures with open reduction and internal fixation has dramatically revolutionized the mandibular fracture approach. The postoperative role of maxillomandibular fixation (MMF) has decreased, but it can still be used to maintain proper occlusion until internal fixation of the fracture is achieved.(El-Anwar, Sayed El-Ahl and Amer, 2014).

Saman et al. compared 413 symphysis, parasymphysis, and angle mandible results after ORIF with postoperative or without MMF placement. The results of the study show that the number of malocclusion complications in the MMF and non-MMF groups did not differ significantly (1.3 vs. 1.0 (95% CI: -4.0 - 4.7) (P = 0.82), however, the study showed that maintaining MMF after mandibular ORIF surgery was beneficial. In treating patients with non-comminuted fractures of the symphysis, parasymphysis, and angle of the mandible(Saman, Kadakia and Ducic, 2014).

The results of this study are similar to those of a randomized multicenter randomized clinical trial study by Dolce et al., which stated that internal fixation with wires was a risk factor for mandibular changes compared to rigid fixation (miniplate and screw). This study assessed cephalometrics two weeks before surgery and at one week, eight weeks, six months, one year, two years, and five years after surgery. Five years after surgery, the wire group had a change of 2.2 mm (42%), while the miniplate and screw fixation group remained unchanged. This shows that the miniplate and screw are more stable than the wire(Dolce *et al.*, 2002)

This study is similar to that of Renton and Wiesenfeld, which compared 83 mandibular fracture patients with miniplate fixation according to Champy's principle, 40 mandibular fracture patients with miniplate fixation without Champy's principle, and 82 mandibular fracture patients with transosseous wire fixation. The results showed that the transosseous wire fixation group had a significantly higher rate of complications, including malocclusion, than the miniplate group and reduced patient morbidity following Champy's principle.(Renton and Wiesenfeld, 1996). Another study by Nyoman et al. stated that the miniplate gave a better outcome than the wire, with 33 (78.6%) occlusions and only 4 (9.5%) malocclusions.(Nyoman, Ketut and Nyoman, 2018).

Open reduction and internal fixation are the best way to achieve occlusion in maxillofacial fractures. Miniplate and screw technology is the gold standard in modern medicine and is widely used in developed countries. The standard miniplate system aims to stabilize fractured bone fragments. A 1.5 mm diameter screw is sufficient for a partial mandibular fracture, but a 2 mm screw ensures less strain distribution in the hole as it prevents the screw from loosening. Effectively osteosynthesis protects bone from masticatory forces while undergoing the healing process because the mobility of the fracture site can increase the risk of malunion and union, leading to malocclusion.(Ramos, Semedo and Mesnard, 2020).

Countries with a lack of resources preclude miniplate technology in most countries, and osteosynthesis is still widely used. Malocclusion can occur as a result of inadequate fixation of mandibular fractures. Different fixation techniques

can provide different degrees of stability. Rigid fixation with plates and screws is thought to provide superior stability by overcoming the functional forces applied by the musculoskeletal system throughout the fracture. On the other hand, stabilization with fixation techniques other than mini plates and screws, such as intraosseous wire, is inferior, so that will be a risk of poor occlusion (Burlew, 2015).

The fixation only with wire osteosynthesis has a rigidity that is not as good as mini plates and screws in maintaining the movement of bone fragments. However, providing additional stability in maxillo-mandibular fixation can give satisfactory results (Baba, 2016; Nyoman, 2018). Maxillo-mandibular fixation can be accomplished using Erich arch bars, hybrid arch bars, intermaxillary screw fixation, circummandibular and piriform wires, and orthodontic brackets with hooks.(Pickrell, Serebrakian and Maricevich, 2017).

Conclusion

Based on the results and discussion above, it can be concluded that risk factors for malocclusion in mandibular fractures postoperatively are age \geq 40 years, mandibular fracture sites in more than one region, a complex type of mandibular fracture, involvement of other facial bones fracture, waiting time for surgery > seven days, and internal fixation with wire.

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