Fixation in the Anterior Mandibular Fracture by Using Titanium Mini-Plates and Stainless Steel Mini-Plates: An Outcome Assessment Study

Yogesh Sharma, Prabhat Kumar Soni
Department of Oral & Maxillogacial Surgery, People's Dental Academy, Bhanpur, Bhopal - 462037

Original Research Article

ABSTRACT

This study was conducted to compare the nature and biocompatibility titanium and stainless steel material, and to determine the effectiveness of titanium over the stainless steel mini plates in the management of anteriormandibular fracture.A total of 30 patients were included in the study with symphysis / para-symphysis fracture and were randomly allotted into two groups: Group A included anterior oblique/straight mandibular fracture patients treated using stainless steel mini-plates and screws. Group B, anterior oblique/straight mandibular fracture patient, were treated using titanium mini-plates and screws. The procedure was performed under general anesthesia. The fracture was exposed using a standard incision.The average adaptation time taken for stainless steel mini-plates was 8.42 minutes and 6.04 minutes for titanium mini-plates. Wound dehiscence in case of stainless steel mini-plate was observed in 4 patients from Group A (26.7%) while in the group B it was 0%.Titanium plates were more biocompatible when compared to stainless steel plates as evidenced by the incidence of wound dehiscence. In all cases the plates were found to be rigid, stable and satisfactory for use in the anterior mandibular region.

KEY WORDS: internal fixation, mandible fracture, stainless steel, titanium

INTRODUCTION:

Mandible fracture is one of the most common type of fracture followed by nasal bone fracture requiring surgical intervention in the craniofacial skeleton. It comprises of 55.9% among all the facial fractures. The unique shape of the mandible resembling a hunting bow, results in an increased strength at the symphysis, whereas the condyles located at the distal ends are structurally weak. The frequency of different types of mandibular fractures reflects this with condylar fracture (26%-37%), followed by body (18%-29%), angle (20%-25%), symphysis or parasymphysis (14%-19%), ramus (2%-4%), and coronoid (1%-3%) fractures[1]. The important factor in the management of any fracture is reduction and stabilization of the fracture segment by the simple method to achieve optimal results. The most common external causative factors are fall, assault, violence, industrial hazard, RTA, sports and ballistic injury. Internal causative factors include osteomyelitis, benign or malignant tumor and muscular spasm during electrical shock treatment[2].

The biomechanical aspect of mandible represents Class III lever joined in the midline with the fulcrum at the summit of each condyle, muscle force applied distal to the fulcrum and occlusal force applied distal to the muscle force. Understanding of the muscle attachments and forces imposed on the mandible aids in assisting the surgeons when planning treatment. Champy and colleaguesused this biomechanical approach when describing the ideal lines of osteosynthesis. In the body of the mandible, the masticatory forces create strains of tension along the alveolar bone superior to the mandibular canal and compression strains along the inferior border of the mandible. With a fracture in the mandibular body, the zone of compression is favorable in maintaining bony contact. However the zone of tension strives to pull the bone apart. This force must be neutralized when applying fixation. In the anterior mandible the moments of torsion are highest in the symphysis region. According to Champy and colleagues, one

Corresponding Author:
Dr Yogesh Sharma
Reader,
Department of Oral & Maxillofacial Surgery, People's Dental Academy,
Bhanpur, Bhopal - 462037
Phone No.: 9826048261
E-mail: sharma.dryogesh@gmail.com

mini-plate proximal to the first premolar below the apices of the teeth and above the inferior alveolar nerve is sufficient to treat a body fracture. In symphysis the placement of two mini-plates separated by 4 to 5 mm is necessary to neutralize the moments of torsion[3].

Osteosynthesis in the maxillofacial skeleton has revolutionized the operative management of trauma and reconstructive surgery. Non-compression mono-cortical/ bi-cortical mini-plate fixation of the mandibular fracture is an accepted and reliable method for providing functional rigidity. The technical advantages of mini-plates are that they are small and easily adapted, are applied mono-cortically or bi-cortically, approach is intra-oral and they provide functional stability since the system is biomechanically balanced. Several trials were conducted on various metals for rigid fixation since 1920. Although various metals like gold, silver, copper, lead and aluminum and its alloys were used and tested, stainless steel emerged through the era as the new corrosion resistant material. At about the same time or later, other metals or alloys like titanium were introduced with claims of several advantages over the classic stainless steel. Titanium was the first known material with a property of corrosion resistance. It has an excellent ductility, tensile strength and is completely non-toxic/ biocompatible[4]. Stainless steel is also one of the commonly used material in internal fixation because of its higher mechanical strength, ease of availability and cost effectiveness. Disadvantages of stainless steel include surface corrosion phenomena and a high rate of local and systemically released corrosion products[5]. Numerous studies have examined the morbidity rates of mandibular fracture fixation with mini-plate osteosynthesis. This study was performed to compare titanium and stainless steel for osteosynthesis in anterior mandibular fracture[6].

MATERIALS AND METHODS:

A randomized prospective clinical study was performed with a sample size of 30 patients. Data was obtained from the Casualty of People's Hospital/ Out Patient Clinic of the Department of Oral and Maxillofacial Surgery, Peoples Dental Academy, Bhopal. Patients reported were referred for the management of maxillofacial trauma. Patients were screened and evaluated through a comprehensive case history and physical examination to identify fracture of mandible in symphysis and parasymphysis region. Relevant radiograph/CT scans were taken to identify and rule out coexisting skeletal injuries. Patients included in the study were having oblique fracture as well as straight fractures of mandible, fractures of the symphysis/parasymphysis associated with condylar fracture, symphysis and parasymphysis fracture with or without fractures of any other facial bone, patients from 15-50 years of age range. The exclusion criteria was pediatric patient up to age 15, non-united/mal-united fractures, isolated condylar fractures and medically compromised/pathologic fracture. All the patients were treated by open reduction and direct internal fixation using stainless steel or titanium mini-plates.

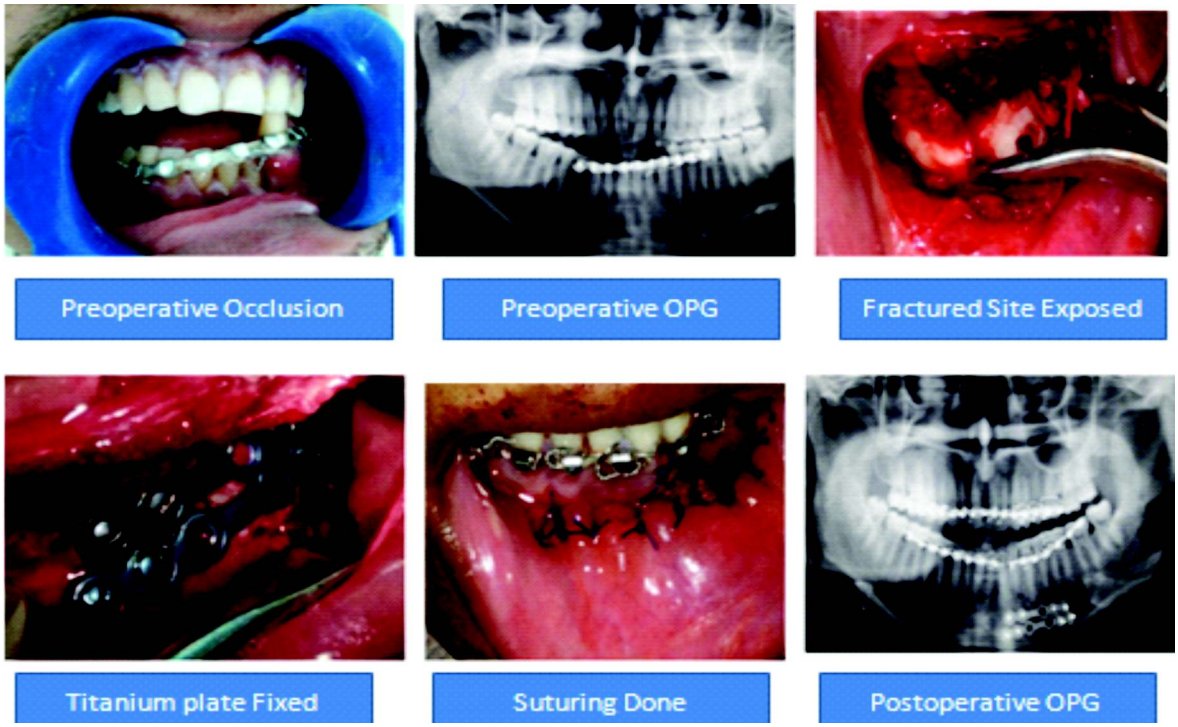
Patients with symphysis / para-symphysis fracture were randomly allotted into two groups. Group A patients were treated using stainless steel mini-plates and screws. group1 stainless steel plateand hospital or to the ible fracture, the studum plate fracture promt to study about the compariso Group B patients were treated using titanium mini-plates and screws. A detailed history was recorded including the time and date of injury, time of reporting to the department, mechanism of injury along with other relevant findings were also recorded along with systemic examination to rule out associated injuries if present. Routine blood investigation were performed and data was documented. The radiographic evaluation consisted of OPG, mandibular occlusal radiograph/PA view.

The parameters observed in this study are working time period in minutes, post -operative pain using 10 point Visual Analogue Scale (VAS score), post-operative infection, occlusion at post-operative 1st week, post-operative mobility of fractured segments, post-operative wound dehiscence, post-operative hardware failure, IMF placement is required or not. All the patients were followed up post-operatively on 1st week and then at 1st, 3rd and 5th month clinically as well as radiographically.

RESULTS:

The study was conducted to compare the clinical outcome of fixation of anterior mandibular fracture with titanium plates versus stainless steel plates.30 patients were included in the study, 15 patient were treated by Titanium mini-plates (Group A) while 15 patient were treated by Stainless steel plates (Group B).Patients were evaluated clinically and radiographically at regular intervals for the various parameters such as working time period in minutes, post-operative pain, post-operative infection,

CASE1: Titanium mini-plate.



CASE 2: Stainless steel Plate.

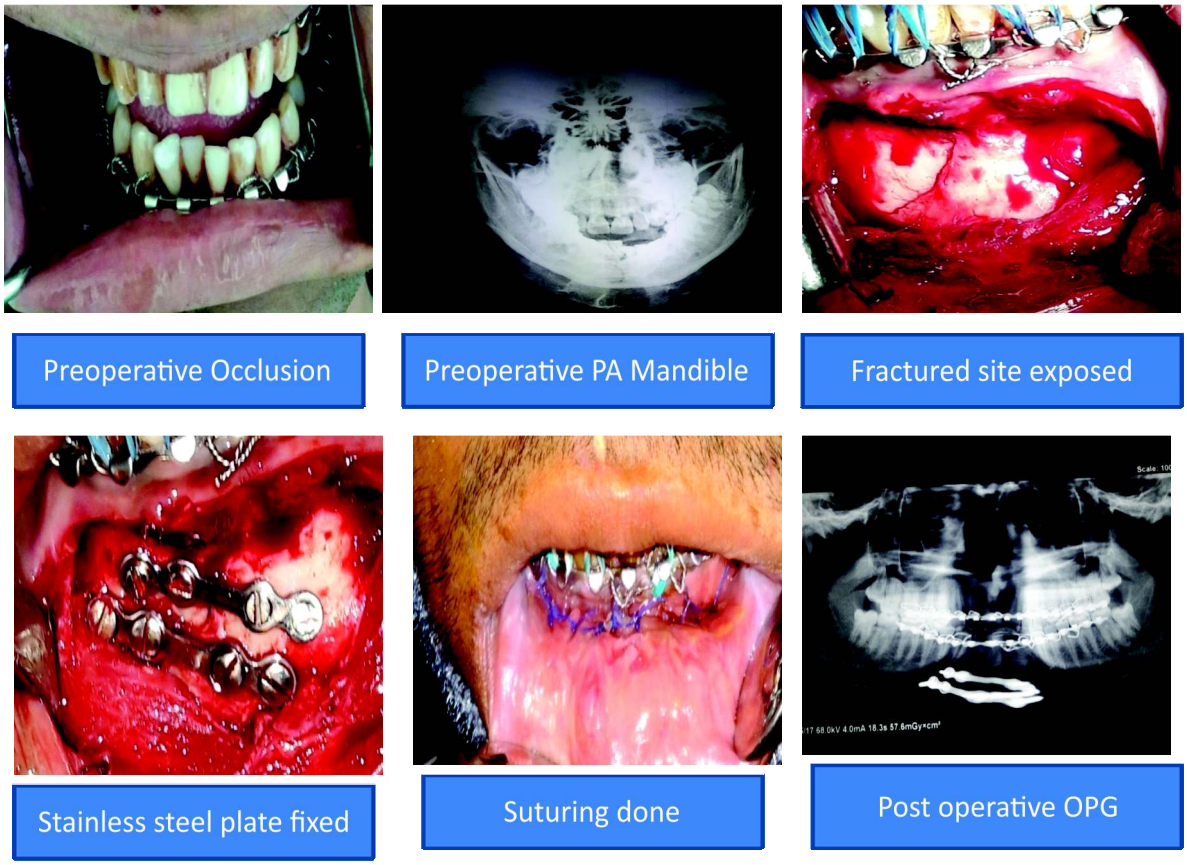


Table 1: Demographic distribution of study subjects (Mandibular anterior fracture cases) according to type of plate and gender.

Groups	Male N (%)	Female N (%)	Total N (%)
Group A: Titanium Mini Plates	12(80.0%)	3(20.0%)	15
Group B: Stainless Steel Mini Plates	11(73.3%)	4(26.7%)	15
Total	23(76.6%)	7(23.3%)	30
Chi Square Value		0.186	
p-value		0.666(NS)	

post-operative occlusion, post-operative mobility of fractured segments, post-operative wound dehiscence,IMF placement is required or not, post-operative hardware failure.

Post-operative pain was recorded based on VAS score post operatively at 1st week, 1st, 3rd and 5th month. Pain was assessed on mild to severe scale. At first week, 12(80.0%) patients from group A and 11(73.3%) patients from group B had moderate pain while 3(20.0%) patients from group A and 4(26.7%) patients from group B cases had mild pain. After 1 month post-operatively, pain was reduced and there was no pain among 8(53.3%) group A and 3(20.0%) group B cases, 11(73.3%) & 7(46.7%) group B and A cases had mild pain. Only 1(6.7%) group B case had moderate pain. After 3rd and 5th month, no pain was seen among the patients from both the groups. There was statistically no significant difference found in post-operative pain among group A & B patients at follow up. More pain was present in stainless steel mini plate group than titanium mini plate group because stainless steel mini plate requires more working (Adaptation) time.

In the study the comparison of Post-operative Wound Dehiscence among group A and B patients was observed only in group A cases and during first post-operative week. There was no wound dehiscence at 1st, 3rd & 5th month among both the groups. At first week wound dehiscence was seen more in 4(26.7%) group B cases. There was statistically significant difference in post-operative wound dehiscence among group A & B patients.

The requirement of IMF among group A and B patients was followed up. Post-operatively at 1st week there was requirement of IMF among 6(40.0%) patients from group A and 7(46.7%) patients from group B. At 1st month only 1(6.7%) group A required IMF. After that at 3rd & 5th month there was no requirement of IMF among both the groups. There was statistically no significant difference found in requirement of IMF among group A & B patients at follow up.

Discussion:

Described the treatment of mandibular fractures using small, easily bendable, non-compression mini-plates, anchored with minicortical screws. Using a simple cantilever beam model, Champy et al.concluded that the superior mandibular border was subjected to tension and splaying and the inferior border was subjected to compression. Luhr, Spiessl, Schmoker derived inspiration from orthopedic biomechanical studies performed by Schenk who suggested accelerated bone healing through compression.[7]. The transition zone between the areas of tension and compression has been referred to as a "Line of zero force" running along the inferior alveolar nerve. Champy's experiment with miniplates further delineated the "Ideal line of osteosynthesis" within the mandible. Plates placed along these lines were thought to provide optimal fixation and stability. As these plates placed were small and the screws were monocortical, it simplified the surgery and reduced surgical morbidity[8].

Titanium has been the material of choice for facial osteosynthesis. The biotechnical advances and the inherent advantages of this material in the recent past has seen it become the traditional choice for cranio-maxillofacial reconstruction, dental implantology, traumatology, cosmetic osseous surgeries etc.[4] The composition of Titanium alloy is Aluminium 6.04%, Vanadium 4.5%, Iron .17%, Carbon .08%, Oxygen .13%, Nitrogen.03%, Hydrogen .01%, Titanium (Balance), and Stainless steel is Chromium 17.9%, Nickel 13.4%, Molybdenum 1.6%, Manganese 2.4%, Silicon .5%, Carbon .02%, Phosphorus .02%, Sulphur .007%, Iron(Balance).[9] Titanium is considered a highly biocompatible and corrosion resistant material with excellent osseointegration and its pliability is an added advantage for better adaptability.Stainless steel is the

Table 2: Comparison of working time (Adaptation Time) among group A & B patients.

Groups	Working time (Adaptation Time in Min.)		
	MEAN	SD	Mean Difference
Group A: Titanium Mini Plates	6.0487	0.508	2.37 min
Group B: Stainless Steel Mini Plates	8.4253	0.767	
Student 't' Test Value	10.004		
p-value	0.001(HS)		

Table 3: Comparison of Post operative occlusion among group A & B patients at follow up.

Follow Up	Post operative occlusion Disturb.	Group A: Titanium Mini Plates	Group B: Stainless Steel Mini Plates	Chi Square Value	p-Value
1st Week	NO	10(66.7%)	8(53.3%)	0.556	0.456(NS)
	YES	5(33.3%)	7(46.7%)		
1st Month	NO	14(93.3%)	15(100.0%)	1.034	0.309(NS)
	YES	1(6.7%)	0(0.0%)		
3rd Month	NO	15(100%)	15(100%)	NA	NA
	YES	0(0.0%)	0(0.0%)		
5th Month	NO	15(100%)	15(100%)	NA	NA
	YES	0(0.0%)	0(0.0%)		

Table 4: Comparison of Post operative pain among group A & B patients at follow up.

Follow Up	Post operative pain	Group A: Titanium Mini Plates	Group B: Stainless Steel Mini Plates	Chi Square Value	p-value
1st Week	Mild	3(20.0%)	4(26.7%)	0.186	0.666(NS)
	Moderate	12(80.0%)	11(73.3%)		
1st Month	No Pain	8(53.3%)	3(20.0%)		
	Mild	7(46.7%)	11(73.3%)	4.162	0.125(NS)
	Moderate	0(0.0%)	1(6.7%)		
3rd Month	No Pain	15(100%)	15(100%)	NA	NA
	-	-	-		
5th Month	No Pain	15(100%)	15(100%)	NA	NA
	-	-	-		

most frequently used material for internal fixation because of its mechanical strength, easy availability & cost effective[6].

Deepak Sand Manjula S[4]study on comparing the working time with titanium and stainless steel mini-plates were 3.64 minutes and 6.82 minutes respectively. They reported a reduction in operating time in group receiving titanium plate as it is more malleable and biocompatible when compared to stainless steel plates. This was substantiated in another similar study by Kumar et al[10]on stainless steel plate where working time was approximately 8 to 10 minutes.

As these plates are self-adaptable and non-compressive they do not fix fragments rigidly. Hence self-correction due to action of Oro-facial musculature can take place. The operator plays an important role and the incidence of failure is seen to decrease as the surgeon's experience increases.

Deepak Sand Manjula S[4]in their study observed that wound dehiscence was noted in one out of five patients (20%) when stainless steel plates was used while in the group treated with titanium plate it was 0% because stainless steel has surface corrosion

Table 5: Comparison of Post operative Wound Dehiscence among group A & B patients at follow up.

Follow Up	Post operative Wound Dehiscence	Group A: Titanium Mini Plates	Group B: Stainless Steel Mini Plates	Chi Square Value	p-Value
1st Week	Absent	15(100.0%)	11(73.3%)	4.615	0.032(S)
	Present	0(0.0%)	4(26.7%)		
1st Month	Absent	15(100%)	15(100%)	NA	NA
	Present	0(0.0%)	0(0.0%)		
3rd Month	Absent	15(100%)	15(100%)	NA	NA
	Present	0(0.0%)	0(0.0%)		
5th Month	Absent	15(100%)	15(100%)	NA	NA
	Present	0(0.0%)	0(0.0%)		

Table 6: Comparison of requirement of IMF among group A & B patients at follow up.

Follow Up	Requirement of IMF	Group A: Titanium Mini Plates	Group B: Stainless Steel Mini Plates	Chi Square Value	p-value
1st Week	NO	9(60.0%)	8(53.3%)	0.136	0.713(NS)
	YES	6(40.0%)	7(46.7%)		
1st Month	NO	14(93.3%)	15(100.0%)	1.034	0.309(NS)
	YES	1(6.7%)	0(0.0%)		
3rd Month	NO	15(100%)	15(100%)	NA	NA
	YES	0(0.0%)	0(0.0%)		
5th Month	NO	15(100%)	15(100%)	NA	NA
	YES	0(0.0%)	0(0.0%)		

Table 7: Comparison of Post-operative Infection among group A & B patients at follow up.

Groups	Post-operative Infection, Mobility and Hard Ware Failure			
	1st Week	1st Month	3rd Month	5th Month
	No Infection	No Infection	No Infection	No Infection
Group A: Titanium Mini Plates	15(100%)	15(100%)	15(100%)	15(100%)
Group B: Stainless Steel Mini Plates	15(100%)	15(100%)	15(100%)	15(100%)

phenomena and the high rate of local systemically released corrosion products. They also observed that there was absence of local infection in patients where titanium mini-plates were used where as one of the five patients had infection in the stainless steel group in the 2nd and 3rd post-operative week.

Lizka et al[11] performed a study on the infection rate calculated after rigid internal fixation which was caused due to irregular fracture line, segmental mobility, tooth present in fracture line. Similar a study was conducted by Voggenreiter et al[12] who found that the infection rate was high in stainless steel as compared to titanium plate because nickel is a major component of stainless steel with hypersensitivity reaction increased than titanium plate.

Sheony et al. (2011)[13] conducted a questionnaire survey comprising of 25 Oral and Maxillofacial Surgeon and 25 Plastic Surgeons to ascertain if the practice of the routine use of

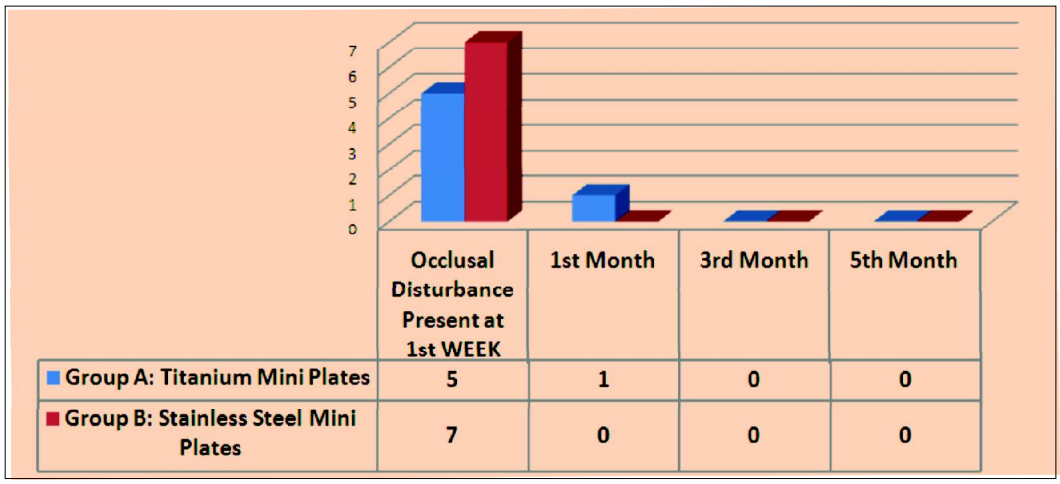


Figure 1: Comparison of post operative occlusion among group A & B patients at follow up.

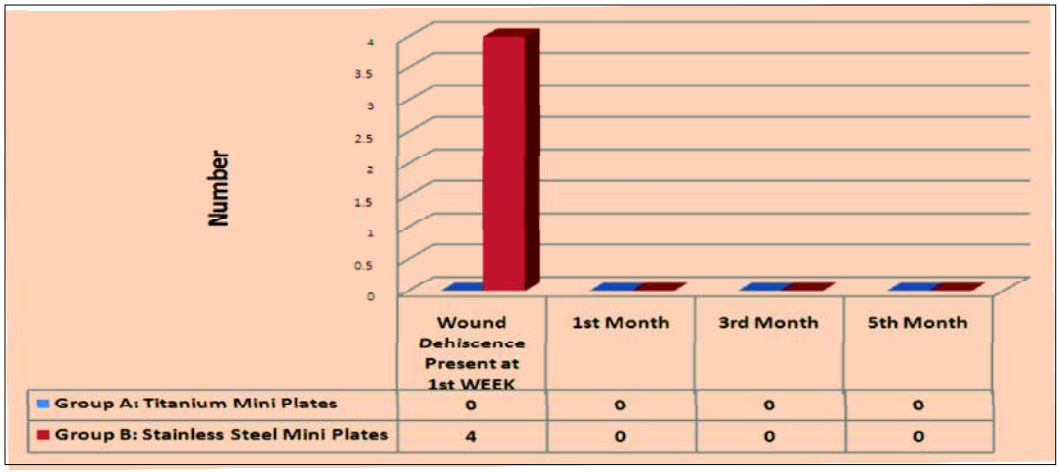


Figure 2: Comparison of post operative wound dehiscence among group A & B patients at follow up.

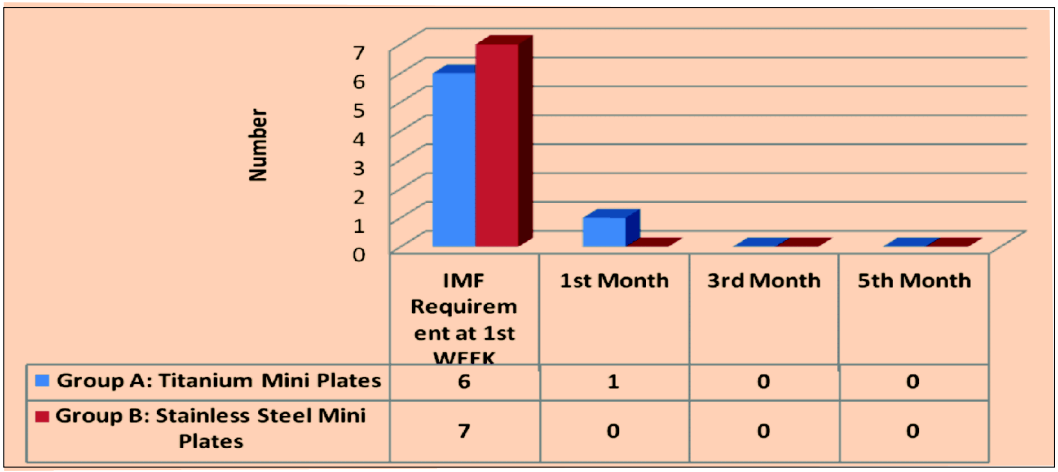


Figure 3: Comparison of requirement of IMF among group A & B patients at follow up.

postoperative IMF in mandibular trauma was based on evidence available in the literature. He concluded that although majority of the surgeons use open reduction and internal fixation, 25% of the surgeons still prefer using only IMF as the sole modality of treatment for mandibular fracture. According to the survey, the majority of surgeons use IMF routinely in the postoperative setting even after using ORIF. Occlusion seems to be the critical factor among 72% of surgeons in deciding on the use of IMF as an adjunct after ORIF. 78% presence of surgeon varies in their period of IMF based on the site of fracture. Saman et al.(2014)[14] conducted a study and found that maintaining patient with IMF after ORIF of symphseal, parasymphyseal or angle fractures does not confer an advantage and immediate release of IMF may lead to improved patient comfort.

CONCLUSION:

It is inferred that titanium plates being more malleable were easily adaptedto the varying contours of the facial skeleton which clinically translated into reduced time required for plating and were more biocompatible when compared to stainless steel plates as evidenced by the rate of infection.In all cases the plates were found to be rigid, stable and satisfactory for use in the facial skeleton.In this study of short duration, titanium plates were found to be very ideal for use where the requirement for contour is maximum. It is an alternative mini-plating system when used judiciously in clinically controlled cases and serves as an excellent biomaterial for use in the facial skeleton.

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Cite this article as: Sharma Y, Soni PK: Fixation in the anterior mandibular fracture by using titanium mini-plates and stainless Steel mini-plates: An outcome assessment study. PJSR ;2018:11(2):37-44.
Source of Support : Nil, Conflict of Interest: None declared.