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"COMPARISON OF LOCKING MINIPLATES WITH CONVENTIONAL MINIPLATES IN MANDIBULAR SYMPHYSIS AND PARASYMPHYSIS FRACTURES - A CLINICAL STUDY"

Maxillofacial Surgery

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ABSTRACT

Aim And Objectives: The aim of the study is to evaluate the efficiency of locking miniplates and conventional miniplates in the management of mandibular symphysis and para symphysis fractures. The objectives are to assess the Biteforce, Post-operative occlusion, Post operative complications, as Infection, mal union, non-union and Incidence of hard ware failure. **Materials And Methods:** This clinical study consisted of a sample size of 12 patients who reported to the department of OMFS, Government Dental College and Hospital, Kadapa, Andhra Pradesh with fracture of mandible in symphysis and Para-symphysis region. Patients were randomly divided into 2 equal groups of 6 patients each. Group A patients underwent open reduction and internal fixation with locking miniplates and group B patients underwent ORIF with conventional miniplates. **Results:** In this study we found that the increase in bite force was more in group treated with locking miniplates compared to conventional miniplates, and it was statistically significant. There was no statistical significance regarding the parameters like post-operative occlusion, post-operative complications, infection malunion non-union and incidence of hard ware failure. **Conclusion:** The present study concluded that locking plate system is an extremely useful supplement to plate osteosynthesis as it increases the masticatory efficiency. Clinically locking plates were found to be better than conventional miniplates in terms of functional improvement. As the present study was done with a limited sample of 12 patients, further clinical trials with larger sample size are suggested for more affirmative and conclusive results.

KEYWORDS

Locking mini plate, Conventional mini plate, Bite force, Mandible, Fracture.

INTRODUCTION

The head, because it is the most exposed part of the body, is involved in the greatest percentage of injuries of the entire body.[1] For the past decades, there has been a significant increase in head-maxillo-facial trauma. [2] Mandible, in spite of being the largest and strongest facial bone, by asset of its position on the face and its prominence, is frequently fractured when maxillofacial trauma is sustained. Given that the mandible is the only facial bone that has mobility and the remaining portion is part of the fixed facial axis, the fracture is never left unnoticed because it is very painful, pain that worsens with mastication and phonation movements, and even respiratory movements. The mandible fracture site is variable, depending on the many different causes of fracture.[2] Symphysis and para symphysis fractures of the mandible have been reported to occur with a frequency of 9% to 57%.[3]

The stability of conventional bone plating systems, is achieved when the head of the screw compresses the fixation plate to the bone.[4]Various types of miniplating systems have been developed to provide stable fixation for mandibular fractures[5]. Miniplate osteosynthesis, first introduced by Michelet in 1973, and further developed by Champy et al in 1975, is the current standard for the treatment of mandibular fractures. Champy et al determined the ideal lines of osteosynthesis on which plates must be applied to resist the torsional forces. This technique uses non- compression monocortical miniplates placed through transoral incision in the region of optimal stress to neutralise the tension.[5-8]A disadvantage of conventional miniplate systems has been that the plate must be perfectly adapted to the underlying bone to prevent alterations in the alignment of the segments and changes in the occlusal relationship.[1]

To overcome the problem of fracture displacement and at same time retain the advantages of Champy's conventional miniplates, locking screw and plates system was introduced in the maxillofacial region by Ralf et al in 2003.[9] The theoretical advantages proposed have included *1*) less screw loosening *2*) greater stability across the fracture site *3*) less precision required in plate adaptation because of the internal/external fixator and *4*) less alteration in the osseous or occlusal relationship with screw tightening[1]. Ellis and Graham reported encouraging results with 2.0mm locking plate and screw system applied to a consecutive series of patients.[5]

Because the several reports show a number of clinical studies to challenge the conventional miniplate simultaneously, these individual studies have proven that locking miniplates are a prospective alternative for fixation of mandibular fractures. The present study compares the treatment outcome of mandibular symphysis or parasymphysis fractures through titanium locking miniplates and conventional miniplates.

AIM:

The aim of the study is to compare the efficacy of locking mini plates with conventional miniplates in the treatment of mandibular symphysis and parasymphysis fractures.

Objectives Of The Study:

The objectives of the study are to compare efficacy of locking miniplates and conventional miniplates by assessing certain parameters like

- Bite force
- Postoperative occlusion
- Post operative complications like infection, malunion and non-union.
- Incidence of hard ware failure like screw loosening, plate fracture.

MATERIALS AND METHODS

The clinical study included a sample size of 12 cases of both genders with age group 18-50 years, who were clinically and radiographically diagnosed with mandibular symphysis or parasymphysis fracture, in department of oral and maxillofacial surgery, Government Dental College and Hospital, KADAPA, over a period between November 2019 and October 2021. Each patient was given a brief description of the study and signature obtained on informed consent sheet. Along with patient 's demographics (age, sex) and diagnosis, procedure requiring the type of miniplates for osteosynthesis, intra operative and post operative complications were also recorded.

The inclusion criteria of our study included patients with non communited mandibular symphysis or parasymphysis fractures planned for open reduction and miniplate fixation, age group between 18-50 years of age with no systemic disease (ASA I) and surgical site free of active infection. The exclusion criteria for our study include patients who are medically compromised patients (ASA III &ASA IV), with pathological or communited fractures of the mandible, paediatric mandibular fractures and fractures of the edentulous mandible or with trauma history past more than 4 weeks. In this study patients were randomly divided into two groups GROUP A Patients underwent osteosynthesis with locking mini plates (fig 1), while GROUP B underwent osteosynthesis with conventional mini plates.

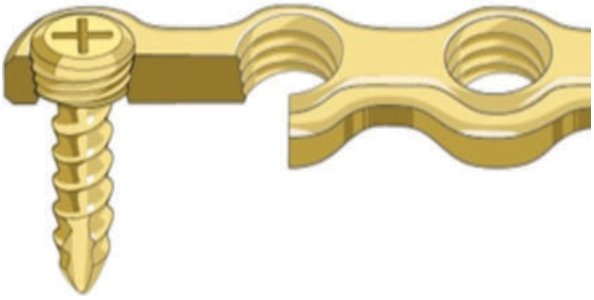

Fig 1: Locking plate and screw

Surgical Technique:

In both the groups surgery was carried either under local anaesthesia or general anaesthesia under aseptic conditions. To get pre-injury occlusion, fixation was done by Erich's arch bar. Approach to the fracture was gained via the intraoral vestibular approach. Proper reduction of fracture fragments was done. Maxillomandibular fixation were maintained intraoperatively using a 26-gauge wire. Once proper occlusion has been achieved, fractures were fixed with either a locking miniplate or a conventional miniplate along Champy's line of ideal osteosynthesis. In symphysis, Para symphysis fractures, fixation was done with two miniplates, with one plate in the subapical position and other plate was placed few millimeters superior to the inferior border of the mandible. (Fig 2&3).

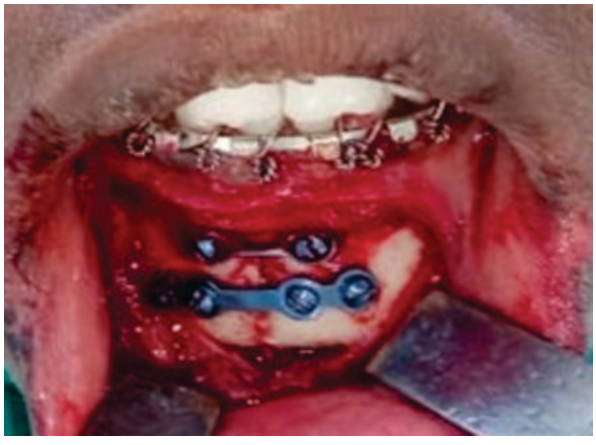

Fig2: Fixation done with locking plate

Fig 3: Fixation done with conventional plate

After achieving proper haemostasis, the incision site was closed layer wise using 3-0 vicryl. All patients received intravenous antibiotics for five days duration. Postoperatively, after 24 hours, the status of the occlusion was checked. Patients were instructed to continue a soft diet for 4 weeks.

Clinical Parameters:

Patients were recalled on regular intervals at 1 week, 3 weeks, 6 weeks and 3 months. Both the groups were assessed for certain clinical parameters. Bite force was measured using a bite force recorder. (Fig 4).

Figure 4: Bite force recorder

Biting fork was placed between upper and lower teeth at incisor region, right first molar, left first molar and patient was asked to bite on it. The force exerted by the teeth will be displayed on the screen. This measurement was taken preoperatively, and on 1 week, 3 weeks,6 weeks and 3 months post operatively. The measured bite force was compared between the two groups.

The parameter occlusion was checked clinically on post-operatively, 1 week, 3 weeks, 6 weeks & 3 months, in maximal intercuspal position to ensure proper occlusion relation including molar relation and midline centralization and graded.

- No occlusal derangement.
- MILD - Slight derangement of occlusion and no need for intervention.
- MODERATE - The occlusion is deranged and the function is affected and needed correction by non-surgical means (elastics or coronoplasty).
- SEVERE - Gross occlusal derangement with functional disability that needed reoperation.

Patients were examined clinically for any signs of infection, at 1 week, 3 weeks, 6 weeks and 3months post operatively. Case was considered infected if patient has pus discharge. Patients were evaluated for any complications like non–union, mal-union and hard ware failures such as loosening of screws, plate fracture by clinical and radiographic examination on 1 week, 3 weeks, 6 weeks and 3 months postoperatively.

RESULTS

The mean age of group A patients was 36.00 ± 6.1years with a range (30-45 years); whereas in group B patients it was 30.33 ±7.71 with a range of (19-42 years). Out of 12 patients, 9 patients were male and 3 patients were female. In a group A 3 patients (50%) were male and 3 patients (50%) were female, and in group B all 6 patients (100%) were male.

Out of 12 patients, in group A, 3 patients had symphysis fracture, 2 patients had left para symphysis fracture, 1 patient had right para symphysis fracture and in group B, 1 patient had symphysis fracture, 3 patients had left para symphysis fracture, 2 patients had right para symphysis fracture

Bite force

The incisor bite force in group A which was measured preoperatively as 2.18 ± 0.73 kgs increased markedly to 18.57 ± 0.59 kgs at 3 months post operatively and in group B, it was measured preoperatively as 2.52 ± 0.27 kgs and raised to 16.8 ± 0.94 kgs at 3months post operatively. The incisor bite force was compared between group A and group B at different time intervals by using Mann-whitney U test and p value obtained was 0.016($p<0.05$). (graph 1)

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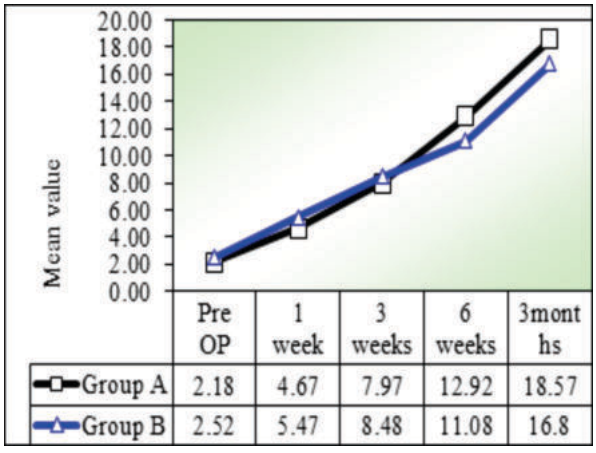
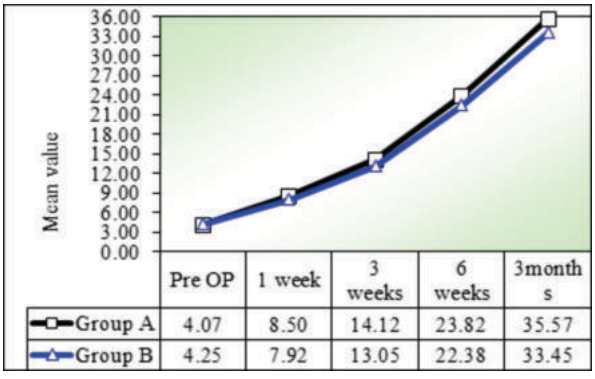


	Pre OP	1 week	3 weeks	6 weeks	3months
Group A	2.18	4.67	7.97	12.92	18.57
Group B	2.52	5.47	8.48	11.08	16.8

Graph 1 : Comparison of group A and group B with incisor bite force at different time intervals.

Right molar bite force

The right molar bite force in group A which was measured preoperatively as 4.07 ± 1.61 kgs increased markedly to 35.57 ± 1.45 kgs at 3 months post operatively and in group B, it was measured preoperatively as 4.25 ± 0.64 kgs and raised to 33.45 ± 1.68 kgs at 3months post operatively. Comparison of Group A and Group B with right molar bite force (in kgs) at different treatment time points by **Mann-Whitney U test** and **p value** obtained was **0.0306**.(graph 2).



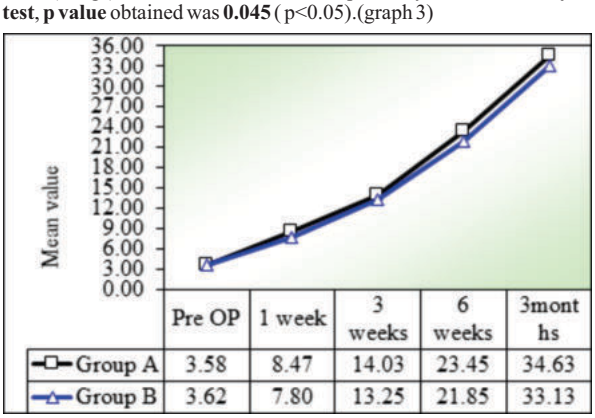
	Pre OP	1 week	3 weeks	6 weeks	3months
Group A	4.07	8.50	14.12	23.82	35.57
Group B	4.25	7.92	13.05	22.38	33.45

Graph 2: Comparison of Group A and Group B with right molar bite force (in kgs) at different treatment time points

Left molar bite force

The left molar bite force in group A which was measured preoperatively as 3.58 ± 1.19 kgs increased markedly to 34.60 ± 0.69 kgs at 3 months post operatively and in group B, it was measured preoperatively as 3.62 ± 0.51 kgs and raised to 33.10 ± 1.45 kgs at 3months post operatively.

Comparison of Group A and Group B was done with left molar bite force (in kgs) at different treatment time points by **Mann-Whitney U test**, **p value** obtained was **0.045** (p<0.05).(graph 3)



	Pre OP	1 week	3 weeks	6 weeks	3months
Group A	3.58	8.47	14.03	23.45	34.63
Group B	3.62	7.80	13.25	21.85	33.13

Graph 3: Comparison of Group A and Group B with left molar bite force (in kgs) at different treatment time points

The left molar bite force in group A which was measured preoperatively as 3.58 ± 1.19 kgs increased markedly to 34.63 ± 0.69 kgs at 3 months post operatively and in group B, it was measured preoperatively as 3.62 ± 0.51 kgs and raised to 33.10 ± 1.45 kgs at 3months post operatively.

There was no occlusal derangement reported in either group. None of the patient in either group had any post operative complications such as infection, non-union or mal-union and incidence of hard ware failure such as loosening of screws or plate fracture.

DISCUSSION

Miniplate osteosynthesis is the standard method for the surgical management of mandibular fractures.[12] The loosening of one or more screws during the convalescent period following miniplate osteosynthesis is a problem especially in mandibular fracture osteosynthesis where loosening of screws requires removal of the fixation appliance.[5] This problem has been overcome by the development of the locking plate/screw system, which offers advantages over other plating systems[13].

Locking 2.0 miniplates utilize double threaded screws, which lock to the bone and the plate, creating a mini-internal fixator. This results in a more rigid construction with less distortion of the fracture or osteotomy, less screw loosening and less interference with bone circulation since the plate is not too tightly pressed against the bone[10].

Since the plate locks to the screw rather than gaining its rigidity by being compressed against the bone, it also avoids the cortical necrosis which is sometimes seen under a plate which is compressed against the bone.[9]The locking screw plate system also reduces compressive forces between the under surface of the plate and lateral bony cortex compared with a conventional mandibular plate. In a locking screw plate system, forces are generated between the threaded portion of the plate and the screw. This limits stress shielding and creates a more stable fixation over time[14].

Due to the fixation method imitating the principles of a fixateur the locking screws form together with the locking plate and the cortical bone a frame construction. Loading forces are transmitted without the need of plate friction directly from bone over the screws to the plate resulting in higher stability.[9] Thus a frame construct was achieved on either side of the fracture fragments. This provided better stability of the fracture fragments and thus better healing environment when compared to the conventional plates while still retaining the same miniature dimensions.[15]

Mandibular fractures represent a high percentage of all facial fractures, and the bite force is a fundamental parameter to measure the actual mandibular function and, subsequently, the masticatory efficiency and quality of life.[16]

Mohit Agarwal et al[1] did prospective study, evaluating the bite force in patients treated with 2-mm locking plates or 2-mm conventional plates for mandibular fractures. **K. Y. Giri** et al[14] compared and evaluated the variation in recorded bite forces in patients with mandibular fractures treated with open reduction and rigid internal fixation using standard 2.0 versus 2.0 mm locking miniplates. **V.Singh**[12] et al. in their prospective study assessed the effectiveness of a 2.0-mm locking plate system in comparison with a 2.0-mm non-locking plate system in mandibular fractures. **Rastogi** [17] et al did a study to analyse the variation in bite forces in mandibular fracture patients stabilised with either 2.0 mm conventional or locking titanium plating system.

In the present study, the increase in incisor bite force was comparatively more in group A compared to group B. This was in accordance with **Mohit Agarwal**[1] (2011), **K.Y. Giri**[12] (2015) and **Rastogi**[17](2015). In group A the incisor bite force has increased markedly after 3 weeks postoperatively as the half of the cases in this group were symphysis fractures with fracture line near to incisors.

In group A, there was remarkable increase in left and right molar bite force in subsequent follow up visits compared with the preoperatively recorded value. In group B also, there was remarkable increase in left molar bite force in their subsequent follow up visits compared with the preoperatively recorded value, like group A. The increase was more in Group A compared to group B. This was in accordance with the studies of **Mohit Agarwal**[1] (2011) and **Rastogi**[17] (2015).[40]

Gerlach and **Schwarz**[18] (2002) specified that the maximum bite force attained at 1 week postoperatively in subjects with mandibular fractures stabilised with miniplate osteosynthesis was 31% when related to a healthy control group. The bite force value at postoperative 6 weeks was increased to 58%. In the present study, the results were in accordance with that of Gerlach and Schwarz.[24] In 1994, **Tate** et al[19] detailed that to resist the maximal force of mastication, adequate internal fixation hardware have to be applied. They supposed that the steadiness of fracture segment should be ensured, while using the masticatory system. In the present study, group A showed comparatively better increase in bite force compared to group B.

Bite force is one indicator of the functional state of the masticatory system that results from the action of jaw elevator muscles modified by the craniomandibular biomechanics.[20] Several factors influence the direct measurements of the bite force. The great variation in bite force values depends on many factors related to the anatomical and physiologic characteristics of the subjects. Apart from these factors, accuracy and precision of the bite force levels are affected by the mechanical characteristics of the bite force recording system. [21]
Bakke et al have reported that bite force decreases with age after 25 years in females and after 45 years in males.[22] Maximum bite force is higher in males than females. The greater muscular potential of the males may be attributed to the anatomic differences. Ferrario et al[23] have recorded larger bite force values in males and explained this result by their larger dental size. Because the larger dental size presents larger periodontal ligament areas, it can give a greater bite force. **Wichelhaus** et al[24] have found no significant differences in bite force between males and females.

The bite force is related to a number of factors, including tactile impulses, pain and pressure reception in the periodontal ligament, the number of residual teeth, and patient age. It has long been known that a neuromuscular protective mechanism occurs throughout the body. For instance, one of the first protective mechanisms called into play when a fracture occurs is "muscle splinting," in which selective components of the neuromuscular system are activated or deactivated to remove the force from the damaged bone.[25]

In the present study, in relative to parameter, **post operative occlusal evaluation** 100% of patients had stable occlusion, both in group A and group B. On comparison of occlusion in group A and group B patients there was no difference noted with all patients having a stable occlusion. This was in accordance with studies of **Mohit Agarwal[1], Pavan kumar[10]** and **K.Y. Giri[15]**.

Restoration of pre injury occlusion is one of the main goals in the treatment of maxillofacial fractures. The consequences of not restoring the pre injury occlusion are disabling, with severe effects, specifically on temporo-mandibular joint. In the study of **Arpit Vashistha,**[26] patients of both the groups had normal occlusion post-operatively. **Nayak** et al.[27] reported occlusal discrepancy in 8% and 28% of their patients treated with locking plate and non-locking plate respectively.

In the present study, none of the patients in either group showed any signs of infection in our present study. In the study of **Pavan Kumar** et al[10] post operative infection was found in one case in each group, treated by conventional miniplate or locking mini plate. In the study of **Mohit Agarwal**[1]et al,1 patient treated with conventional miniplate presented with infection at 6 weeks follow up, while no infection was noted in patients treated with locking miniplate. In the study of **Ellis**[13], on 2.0mm locking plate system in 59 patients with 80 fractures, 6 patients developed postoperative infection. **Bala Sundaram**[11] et al in their study of 2.0mm Locking plate/screw system on 30 patients with 42 mandible fractures, reported only one case of infection.

Mandibular fractures are often contaminated with oral bacteria. Post operative infection, is not the only result of contamination, but can also be due to insufficient fracture stability. Mandibular fractures and alcohol abuse are closely related as regards the cause and incidence of complications. Patients who suffer from chronic alcohol abuse often have poor oral hygiene.[28]

In present study none of the patients in either group had any complication of malunion or non-union. In the study of **Pavan kumar**[10] one month post operatively, mobility of fracture fragments was noted, for one patient in group treated with locking plate system and two patients in group treated with standard Champy's plating system and after 3 months post operatively no mobility of fracture fragments was present in both groups.

In the study of **V**. **Singh**[12] et al the complication percentage in locking group was 6% while it was 13% in non-locking group. In the present study, the complication rate in either group was 0%. **Bolourian** [29] et al reported a complication rate of 5% in their study on 2.0-mm nonlocking miniplate with 2 weeks of Maxillomandibular Fixation in the management of mandibular fractures. **Chandan Prabhakar**[30] et al in their study on twenty mandibular fractures treated with locking plates noted infection at the fracture site in one patient. They reported a post operative complication rate of 6.25%.

In the present study none of the patients in either group showed any incidence of hardware failure. This was in accordance with the studies of **Mohit Agarwal**[1] and **K. Y. Giri**[15], where there was no numerical difference between the two groups pertaining to this parameter.

In the study of **Singh**[12] et al, there was no substantial difference was found in both groups related to incidence of hardware failure. It has been proposed that in the locking bone plate/screw system, screws are unlikely to loosen from the bone plate and there will be decreased incidence of inflammatory complications associated with loosening of hardware.[11] The chances of screw loosening are minimal if they are inserted correctly locking the plates.

Vashistha et al.[26] did not find any variation between the two plating systems used in the parasymphysis region concerning the loosening of screws and plate exposure or fractures. Their results are also in accordance with our study. **Corday** et al [31] stated that abrasion between plate and screw head is the key feeble point of the entire fixation. In the locking plate/screw system, the thread on the screw head locks into the corresponding thread of the plate, converting the plate and screw into a unit, creating a rigid splint with higher mechanical stability. In conventional plates fixation is achieved when screw thread is inserted into bone, creating a friction lock between the plate and the bone which is crucial to achieve stability after reduction. Torsional forces amid the bony segments may result in loss of friction lock and result in reduced primary stability. The loosening of hardware propagates inflammatory reaction and leads to infection. **Seemann** et al.[32] assessed both locking and non-locking type of plating systems in condylar fractures and found that locking plates were more likely to break and non-locking plates showed screw loosening.

CONCLUSION:

The findings of present study have shown that the locking miniplates are comparatively better than conventional miniplates in terms of functional improvement. No variation was found between both groups, with other parameters like infection, mal union, non-union and incidence of hardware failure. The limitations of the present study include a small sample size and a short follow up period. Studies with greater sample size are needed to support the findings of the current study.

REFERENCES:

1. Mohit Agarwal, Shadab Mohammad, Rakesh K. Singh and Vibha Singh Prospective Randomized Clinical Trial Comparing Bite Force in 2-mm Locking Plates Versus 2-mm Standard Plates in Treatment of Mandibular Fractures J Oral Maxillofac Surgery 2011;69:1995-2000.
2. Patrocinio LG, Patrocinio JA, Borba BH, Bonatti S, Pinto LF, Vieira JV, Costa JM. Mandibular fracture: analysis of 293 patients treated in the Hospital of Clinics, Federal University of Uberlandia. Braz J Otorhinolaryngology 2005;71(5):560–564.
3. Matthew J. Madsen, Christopher A. McDaniel, and Richard H. Haug A Biomechanical Evaluation of Plating Techniques Used for Reconstructing Mandibular Symphysis/ Parasymphysis Fractures J Oral Maxillofac Surgery 2008; 66:2012-2019.
4. Richard H. Haug, DDS, Chad C. Street, DMD, MD, and Michele Goltz, Does Plate Adaptation Affect Stability? A Biomechanical Comparison of Locking and Nonlocking Plates J Oral Maxillofac Surgery 2002; 60:1319-1326.
5. Edward Ellis III, DDS, MS, and John Graham, DDS, MD Use of a 2.0-mm Locking Plate/Screw System for Mandibular Fracture Surgery J Oral Maxillofac Surgery 2002; 60:642-645.
6. Champy M, Lodde JP Etude des contraintesdans la mandibulae fracture chezl' homme: measures theoriqueset verification par jaugesextensometriques in situ. Rev Stomatol,1977; 78:545.
7. Champy M, Lodde JP, Grasset D et al Osteosyntheses mandibula ire set compression. Ann Chir Plast, 1977; 22:165.
8. Champy M, Lodde JP, Wilk A et al Problemed und Resultatebeider Verwendung vonde hnungsmestreifen am prapariertenunterkieferundbei Patientenmitunterkieferfrakturen. Dtsch Z Mund Kiefer Gesichts Chir1978; 2:4
9. Ralf Gutwald, Brian Alpert1 and Rainer Schmelzeisen Principle and stability of locking plates. Keio J Med2003; 52 (1): 21–24, March.
10. B. Pavan Kumar, K. A. Jeevan Kumar, V. Venkatesh, Mohan K, Ramesh K, Mallikarjun J. Study of Efficacy and the Comparison Between 2.0 mm Locking Plating System and 2.0 mm Standard Plating System in Mandibular Fractures Maxillofac. Oral Surg. November 2014.
11. Bala Sundaram, Dr. Kavitha Nanjundan, Locking plates and locking screws for

management of mandibular fractures. IOSR Journal of Dental and Medical Sciences Volume 17, Issue 2 Ver. 16 February. (2018), PP 38-42.
12. V. Singh, I. Kumar, A. Bhagol Comparative evaluation of 2.0-mm locking plate system vs 2.0-mm nonlocking plate system for mandibular fracture: a prospective randomized study: Int. J. Oral Maxillofac. Surg. 2011; 40: 372–377.
13. Alan S. Herford and Edward Ellis III, Use of a Locking Reconstruction Bone Plate/Screw System for Mandibular Surgery J Oral Maxillofac Surgery 1998; 56; 1261-1265
14. Thomas A. Chiodo, Vincent B, Malvin and Christopher, Failure Strength of 2.0 Locking Versus 2.0 Conventional Synthes Mandibular Plates: A Laboratory Model J Oral Maxillofac Surg. 2006;64:1475-1479.
15. K. Yada Giri, Puneet, Sanjay Rastogi, Ramakant, Sunil Mall Aishwarya Pratap Singh Niranjana Prasad Indra B Himanshu Pratap Singh. Bite Force Evaluation of Conventional Plating System Versus Locking Plating System for Mandibular Fracture J. Maxillofac. Oral Surgery 2015 March.
16. Jose Cristiano, Andrade Fernandes, Esmeralda Maria da Silveira, Maria de Souza1 Ricardo Lopes Rocha, Gabriel Moreira, Comparison of Bite Force with Locking Plates versus Non-Locking Plates in the Treatment of Mandibular Fractures: A Meta-Analysis Int Arch Otorhinolaryngology 2018;22:181–189.
17. Sanjay Rastogi, Mahendra Reddy, Azeez Gaurav Swarup, D Swarup, Rup Shikha Choudhury, Assessment of Bite Force in Patients Treated with 2.0-mm Traditional Miniplates versus 2.0-mm Locking Plates for Mandibular Fracture Craniomaxillofacial Trauma Reconstruction 2016;9:62–68.
18. Champy K. L. Gerlach, A. Schwarz, Bite forces in patients after treatment of mandibular angle fractures with miniplate osteosynthesis according to: Int. J. Oral Maxillofac. Surg. 2002; 31: 345–348.
19. Tate GS, Ellis E III, Throckmorton G: Bite forces in patients treated for mandibular angle fracture—Implications for fixation—Recommendations. J Oral Maxillofac Surg. 1994; 52:734.
20. Bakke M. Bite force and occlusion semin orthod 2006:12:120-126.
21. Duygu, Arife Dogan, Bulent, Bite Force and Influential Factors on Bite Force Measurements: A Literature Review European Journal of Dentistry April 2010 - Vol.4.
22. Bakke M, Holm B, Jensen BL, Michler L, Moller E. Unilateral, isometric bite force in 8-68year old women and men related to occlusal factors. Scand. J Dent Res 1990;98: 149-158.
23. Ferrario VF, Sforza C, Serrao G, Dell avia C, Tartaglia GM. Single tooth bite forces in healthy young adults. J Oral Rehabilitation. 2004; 31:18-22.
24. Wichelhaus A, Huffmeier S, Sander FG. Dynamic functional force measurements on an anterior bite plane during the night. J Orofacial Orthop 2003; 64:417-425.
25. Ellis E III, Thockmorton GS (2001) Bite forces after open or closed treatment of mandibular condylar process fractures. J Oral Maxillofac Surg 59:389–395.
26. Arpit Vashistha, Manpreet Singh, Manoj Chaudhary, Nimish Agarwal, Gagandeep Kaur. Comparison of 2 mm single locking miniplates versus 2 mm two non-locking miniplates in symphysis and parasymphysis fracture of mandible Journal of oral biology and craniofacial research (2016).
27. Nayak SS, Pushpalatha C, Tammanavar PS, Mohan M. Efficacy of locking plates/screw system in mandibular fracture surgery. J Contemp. Dent Practice 2013;14 (2):222–226.
28. T. Iizuka, C. Lindqvist, Rigid internal fixation of mandibular fractures, an analysis of 270 fractures treated using AO/ASIF method Int J. Oral and maxillofacial surgery 1992;21:65-69.
29. Bolourian R, Lazow S, Berger J. Transoral 2.0-mm miniplate fixation of mandibular fractures plus 2 weeks' maxillomandibular fixation: a prospective study. J Oral Maxillofac Surg. 2002: 60:167–170.
30. Chandan Prabhakar, Jaya prasad N. Shetty, Hemavathy, Y. Guruprasad Efficacy of 2-mm locking miniplates in the management of mandibular fractures without maxillomandibular fixation National Journal of Maxillofacial Surgery Jan-Jun 2011; Vol 2 ; Issue 1
31. Corday J, Borgeaud M, Parron SM. Force transfer between plate and the bone: relative importance of the bending stiffness of screws friction between plate and bone. Injury. 2000; 31:21–28.
32. Seemann R, Fredrich B, Muller S Comparison of locking and nonlocking plates in the treatment of mandibular condyle fractures. Oral Surg. Oral Med Oral Pathology Oral Radiology Endodontics (2009) ;108:328–334