

“Standard 3D Titanium Miniplate Versus Locking 3D Titanium Miniplates in Mandibular Fractures:” A Comparative Study

Mukesh Reddy Gujjula¹, K. Surekha², Gudipalli Sudhakar², Dhiraj Kadiyala³, Anil Budumuru⁴, Golla Gowtham^{5*}

¹Modern Dental Care, Tadepalli, Andhra Pradesh, India.

²Department of Oral and Maxillofacial Surgery, Government Dental College and Hospital, Vijayawada, Andhra Pradesh, India.

³Department of Prosthodontics, St. Joseph Dental College, Eluru, Andhra Pradesh, India.

⁴Vishnu Dental College, Bhimavaram, Andhra Pradesh, India.

⁵Department of Oral and Maxillofacial Surgery, St. Joseph Dental College, Duggirala, Eluru, Andhra Pradesh, India.

Abstract

Background: The purpose/aim of the study conducted was to compare the efficiency of two principles of the plating system, 3D non-locking miniplates versus 3D locking miniplates. **Materials and Methods:** A total of 20 adult patients were selected according to the inclusion criteria and divided into two groups of locking plates/screws and non-locking plates/screws of ten each. All patients were treated with 2.0 mm 3D locking and non-locking miniplates and screw system. Comparison of ease of use, functional stability, bite force, post-operative mouth opening, and complications were tabulated. **Results:** A total of 26 fractures in 20 patients were treated. Each group contained ten patients. Fracture reduction was good in all the cases. At the follow-up of 3 months, all fractures had healed, only one patient had an occlusal discrepancy. **Conclusion:** There was no difference in the stability in both the groups. Intraoperatively, locking group consumed more time in fixation as it demands precision in making a hole exactly in the center of plate necessitating the use of drill guide. Clinical and radiographic healing was good in both the groups.

Keywords: 3D Locking miniplates, 3D Non-locking miniplates, Mandibular fractures.

INTRODUCTION

The primary goal in treating the fracture is to predictably restore the pre-injury anatomical form and associated esthetics and function. The goal must be achieved using methods that cause the least disability, the least risk, and the shortest recovery time for the patient. Techniques for treating mandibular fractures have evolved significantly over the past decade. These techniques ranged from “closed” treatment with maxillomandibular fixation (MMF), to open reduction with wire osteosynthesis, to open reduction with either rigid internal fixation or adaptive miniplate fixation. Research continues to focus on the size, shape, number, and biomechanics of plate/screw systems to improve surgical outcomes. The concept of 3D titanium plates was developed and first described by Farmand and Dupoirieux in 1992.^[1,2]

Locking plate/screw systems have certain advantages over traditional plates and screws. Proposed theoretical advantages include: (1) less screw loosening; (2) greater stability along the fracture site; (3) less precision required in plate adjustment; (4) less change in bony or occlusal relationship when tightening the screw; and (5) for stability reasons, no frictional connection

is required between the plate and bone, resulting in less pressure transfer to the underlying bone. The geometry of three-dimensional plates conceptually allows for an increased number of screws and stability in three dimensions.

The purpose of the present study is to compare two treatment methods – locking three-dimensional plates and non-locking three-dimensional plates in various mandibular fractures reported to the Department of Oral and Maxillofacial Surgery, Government Dental College and Hospital, Vijayawada.

MATERIALS AND METHODS

Patients who were clinically and radiographically diagnosed to have mandibular fractures in the out-patient section of the

Address for correspondence: Dr. Golla Gowtham,
Department of Oral and Maxillofacial Surgery, St. Joseph Dental College,
Duggirala, Eluru, Andhra Pradesh, India.
Email: gowthamomfs@gmail.com

Received: Aug. 19, 2024; **Accepted:** Sep. 29, 2024; **Published:** Oct. 05, 2024

This is an open access journal, and articles are distributed under the terms of the Creative Commons Attribution-NonCommercial-ShareAlike 4.0 License, which allows others to remix, tweak, and build upon the work non-commercially, as long as appropriate credit is given and the new creations are licensed under the identical terms.

How to cite this article: Gujjula MR, Surekha K, Sudhakar G, Kadiyala D, Budumuru A, Gowtham G. “Standard 3D Titanium Miniplate Versus Locking 3D Titanium Miniplates in Mandibular Fractures:” A Comparative Study. J Res Adv Dent 2025;16(1):1-6.

Access this article online

Website:
www.jrad.co.in

DOI:
<https://doi.org/10.53064/jrad.2024.16.1.614>

department of oral and maxillofacial surgery were selected according to the following inclusion criteria:

Inclusion criteria

The following criteria were included in the study:

- Patients in the age range of 15–75 years
- Patients with fractures involving the mandibular symphysis, para symphysis or the angle or combinations of these
- Patients who come under ASA I and ASA II category
- All the subjects who had given written informed consent were included in the study.

Exclusion criteria

The following criteria were excluded from the study:

- Patients with pathological or comminuted fractures of the mandible
- Pediatric mandibular fractures
- Fractures of the edentulous mandible
- Patients lacking cooperation or from whom the informed consent cannot be obtained.

Study design

This was a prospective clinical study.

Patients were assessed postoperatively at 1 week, 1 month, and 3 months interval.

Twenty patients were randomly divided into two groups for managing mandibular fractures:

1. Group-A (3-D non-locking plate group) patients underwent osteosynthesis using three-dimensional 2.0 mm titanium miniplates and self-tapping 8 mm × 2 mm screws
2. Group-B (3-D locking plate group) patients underwent osteosynthesis using three-dimensional locking 2.0 mm titanium miniplates and pre-tapped 8 mm × 2 mm screws.

Operative technique

Patients were operated either under general anesthesia (Nasotracheal intubation) or local anesthesia. Strict asepsis was followed. The incision for inter-mental foraminal fractures the fracture sites was exposed through an intraoral, sublabial approach as required depending on the case; for angle fractures, intraoral approach for fracture reduction and transbuccal approach were used for plate fixation (Figures 1 and 2).

The three-dimensional miniplate was then positioned in such a way that the horizontal cross-bars were perpendicular to the fracture line and the vertical ones were parallel to it. In the symphysis and parasymphysis region, the upper cross-bar was placed in a subapical position. Posterior to the mental foramen the plates were placed with the superior cross-bar between the roots and the inferior alveolar nerve and the lower cross-bar below the nerve. To treat fractures near the mental foramen, the lower bar of the plate was bent and placed above the mental nerve. A rectangular plate was preferred in these cases. At the angle region, the plate was adapted and fixed along the lateral surface of the angle of mandible along the neutral zone of forces. Holding the plate perpendicular to the reduced fracture with a plate holding



Figure 1: 3D-locking plate

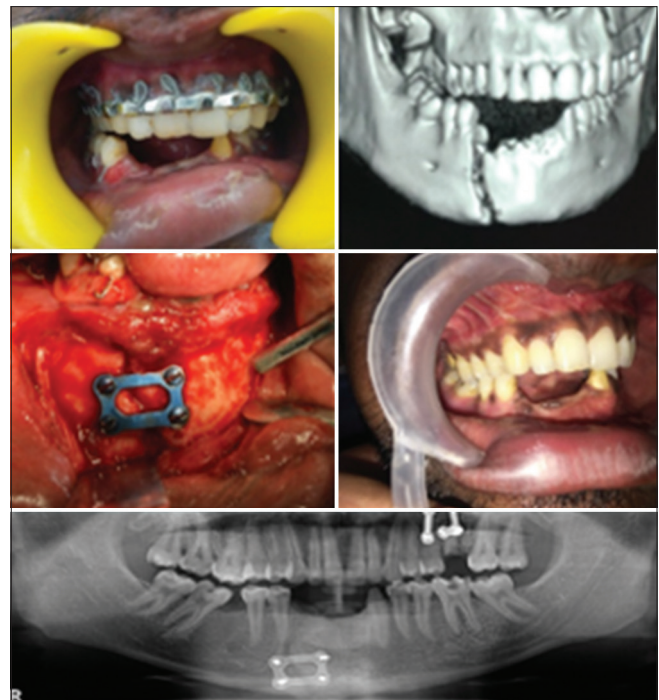


Figure 2: 3D-non-locking plate

forceps, drilling was performed through the hole in the plate strictly perpendicular to the bone surface so that the drill hole was monoaxial.

Statistics

The results of the study were subjected to statistical analysis by applying the following tests:

1. Mean
2. Standard deviation (SD)

3. Standard error of mean
4. Paired Student's *t*-test

RESULTS

A total of 20 patients (19 males and one female) met the inclusion criteria and were included in the study. They were divided equally into two groups of ten patients each. Non-locking plate group consisted of one female and nine males. In locking plate group, all patients were males. The average age in locking group was 28.8 ± 7.79 and the average age in the non-locking group was 28.6 ± 11.35 . The cause of trauma was road traffic accident (RTA) in 18 patient's assault in 1 and fall in 1.

A series of pre-operative parameters recorded included, pain, mouth opening, neurosensory deficits, occlusion, sites of fractures, requirement for MMF, teeth in the line of fractures, and inferior alveolar canal continuity (Table 1). A total of 26 fractures were treated in 20 patients. Single fractures occurred in 14 patients and double fractures occurred in six patients.

In locking group, ten patients showed 13 fracture sites, out of which 5 fractures (38.46%) occurred at the left parasymphysis region, 3 fractures (23.08%) at the right Parasymphysis region, 2 fractures (15.38%) at the right angle region, 1 fracture (7.69%) at the left angle of the mandible, 1 fracture (7.69%) at symphysis of mandible, and 1 fracture (7.69%) at the left condyle of the mandible.

In non-locking group, ten patients showed 13 fracture sites, out of which 5 fractures (38.46%) at the right parasymphysis region, 4 fractures (30.77%) occurred at the left parasymphysis region, 1 fracture (7.69%) at the right angle region, 1 fracture (7.69%) at the left condylar region, 1 fracture (7.69%) at the left angle of the mandible, and 1 fracture (7.69%) at symphysis of mandible.

Postoperatively (Table 2a and b), mean pain for locking group at 1 week was 3.4 ± 1.14 , at 1 month 2.1 ± 1.46 , and at 3 months

was 1 ± 0 . For the non-locking group at 1 week it was 3.6 ± 1.24 , at 1 month it was 1.9 ± 1.2 , and at 3 months it was 1 ± 0 . Preoperatively in locking group, eight cases had deranged occlusion. None of the patients developed derangement of occlusion after 3 months follow-up. In the non-locking group, seven cases had deranged occlusion. One patient developed mild derangement of occlusion after 1-month follow-up which required correction by arch bars and elastics. All patients have been inspected by digital palpation for verifying interfragmentary mobility intraoperatively, at the end of 1 week, 1 month, and 3 months in both groups. No patients have shown interfragmentary mobility at the end of 3 months follow-up.

Preoperatively, all the patients in locking group had inadequate mouth opening of $26.1 (<30 \text{ mm})$. Post-operative mean average mouth opening obtained was $44.4 \pm 5.16 \text{ mm}$. at 3 months follow-up. A significant change in mouth opening was obtained postoperatively at all intervals. In non-locking group also preoperatively, all the patients had inadequate mouth opening of $24.3 (<30 \text{ mm})$. Post-operative mean average mouth opening obtained was $42.2 \pm 2.57 \text{ mm}$ after 3 months. Mean bite force in our study preoperatively is $3.05 \pm 0.27 \text{ Kpa}$ and $16.90 \pm 0.406 \text{ Kpa}$ at the end of 3 months follow-up period in the non-locking group. In locking group preoperatively, it is $3.14 \pm 0.303 \text{ Kpa}$ which increased to $17.41 \pm 0.35 \text{ Kpa}$ after 3 months. All the patients were evaluated for complications such as hardware failure and infection at the end of follow-up intervals. Only one patient had an infection which subsided on antibiotic therapy. None of the patients had any dehiscence, screw loosening, and exposure postoperatively.

DISCUSSION

There were 19 male patients (95%) and 1 female patient (5%) in our sample. This male predominance was also reported by Haug *et al.*,^[3] who conducted a 5-year retrospective study of facial fractures. This can be justified by the fact that men are generally more susceptible to situations in which there are a higher risk of trauma. The incidence of mandibular fractures was more common in the age group of 15–35 years (75%), with the average age of the sample being 28.7 years. This distribution was consistent with the results in the literature.^[4–7]

According to estimates by the Association of Automobile Manufacturers of India (AIAMI), the number of cars on the road has increased more than tenfold in the past decade (source: AIAMI website). The increasing number of motor vehicles on the roads has led to an increasing number of accidents, often resulting in mouth, jaw, and facial injuries. For this reason, in our study, most patients suffered trauma due to traffic accidents (RTA), in the locking group, all patients had traffic accidents (100%), and in the non-locking group, eight patients had traffic accidents (80%), followed by assault (10%) and self-fall (10%), which also correlates with the 1968 study by Rowe and Killey and found similarity to Singh and Arunkumar.⁷ RTA (75%), assault (15%) and fall (10%) and Gandhi and Kattimani^[8] study (RTA [75%], assault [15%], and other [20%]). This can

Table 1: Pre-operative record of Group A and Group B

S. No	Parameters	Locking	Non-locking
1	Age	28.8	28.6
2	Gender	Male-10 Female-0	MALE-9 FEMALE-1
3	Nature of injury	RTA-10	RTA-8 Assault-1 Fall-1
4	Pain	6.4 ± 2	5.9 ± 2
5	Mouth opening	26.1 ± 4.33	24.3 ± 3.16
6	Occlusion	Deranged=8 Normal=2	Deranged=7 Normal=3
7	Bite force (Kpa)	3.14 ± 0.303	3.05 ± 0.276
8	No of fractures	13	13
9	Site of fractures	Angle=3 Symphysis=1 Parasymphysis=8 Condyle=1	Angle=2 Symphysis=1 Parasymphysis=9 Condyle=1

RTA: Road traffic accident

Table 2: Statistical Analysis of Group A and Group B

(a) Record of locking group		Post-operative		
Parameters	Pre-operative	1 Week	1 Month	3 Months
Pain	6.4±2	3.4±1.14	2.1±1.46	1±0
Mouth opening	26.1±4.33	30.50±3.50	41.90±6.47	44.40±5.16
Occlusion	Deranged=8 Normal=2	Satisfactory	Satisfactory	Satisfactory
Bite force (Kpa)	3.14±0.303	6.03±0.320	14.43±0.291	17.41±0.351
Neurosensory deficit	Yes-1	Yes-1	No	No
(b) Record of non-locking group		Post-operative		
Parameters	Pre-operative	1 Week	1 Month	3 Months
Pain	5.9±2	3.6±1.24	1.9±1.2	1±0
Mouth opening	24.3±3.16	30.10±2.42	38.70±2.35	42.20±2.57
Occlusion	Deranged=8 Normal=2	Satisfactory	Deranged=1 Satisfactory=9	Satisfactory
Bite force (Kpa)	3.05±0.276	5.58±0.388	14.03±0.340	16.90±0.406
Neurosensory deficit	Yes-2	Yes-2	No	No

be attributed to the overpopulated cities, poor road conditions, rash driving, and lack of traffic discipline among the masses in our country. The etiology was very different compared to studies conducted in developed countries. Guimond *et al.*^[9] The study showed different causes of trauma, with assault (81.1%), fall (10.8%), and RTA (8.1%) dominating.

Out of the 20 patients who were evaluated, 6 patients (30%) had multiple mandibular fractures; the concomitant fracture site involved being the condylar fracture in two patients and four angle fractures. Among the 20 patients studied, 15 patients had a complete set of dentition and five patients were partially edentulous. Twenty patients showed 26 fracture sites, out of which 9 fractures (34.6%) occurred at the left parasymphysis region, 8 fractures (30.7%) at the right parasymphysis region, 2 fracture (7.6%) at the left condylar region, 3 fractures (11.5%) at the right angle region, 2 fracture (7.6%) at the left angle of the mandible, and 2 fracture (7.6%) at symphysis of mandible. Lucca *et al.*^[10] in their study, found the following order of fracture in mandible: condyle, sub condyle, angle, body, and parasymphysis fractures. Kumar *et al.*^[11] in their study, found more of angle fractures followed by parasymphysis, body, and ramus fractures. These are comparable with the data studied by Prabhakar *et al.*^[12] who encountered 43.75% fractures at parasymphyseal region followed by 25% angle fractures.

In our study, patients were assessed for the establishment of maximal mouth opening pre- and postoperatively. Preoperatively, mean mouth opening is 26.10 mm with a SD of 4.33 which had significantly increased to 44.40 mm with SD 5.16 at the end of 3 months follow-up period in locking group. Similarly, in non-locking group preoperatively, mean mouth opening is 24.30 mm with a SD of 3.16 which had significantly increased to 42.20 mm with SD 2.57 at the end of 3 months follow-up period. There was a progressive increase in the values according to the time of observation which is statistically significant in each group. However, when compared to groups, it is not significant.

The results of our study are similar to that of study conducted by Junior *et al.* (2016)^[13] and Singh and Arunkumar (2016).⁷

The incidence of deranged occlusion reported by Champy *et al.*,^[14] in their 183 cases, was 0.5%. In our study, none of the patients in both groups had any deranged occlusion on 1-week post-operative. Out of ten patients treated using the non-locking 3D plate in mandibular fractures, 1 patient (10%) had slightly deranged occlusion after 1-month post-operative period compared to none in locking group. However, these differences were not statistically significant. Light elastics were used to guide unstable occlusion for 5–7 days.^[5] Subsequent follow-ups showed comparable results in both locking and non-locking plate groups and overall stable occlusion after a 3-month post-operative period. This is in accordance with the results reported in the literature.^[5,15,16]

In a study conducted by Sanjay rastogi *et al.*(2016) that compared the bite force of conventional plating system and locking plating system. Pre-operative occlusion was deranged in all the cases of locking group, but post-operatively functional occlusion was achieved in all the patients. Pre-operative occlusion was deranged in all the cases of locking group, but postoperatively, functional occlusion was achieved in all the patients. Richard *et al.*,^[18] in their comparative study on the mechanical behavior of locking versus non-locking plate and screw system, found that the non-locking system had significant yield load, displacement, and stiffness when compared with locking system. They also concluded that the degree of adaptation affected the mechanical behavior in the non-locking system. Therefore, supporting our study of the reason for better masticatory comfort in locking group compared with non-locking. Gutwald *et al.*^[19] and Pektas *et al.*,^[20] in a cadaveric study comparing the mini-locking system with conventional miniplates, subjected to mechanical loading simulating muscle forces showed the lowest gaps and torsion, best stability at the caudal border in case of mini locking plates. Authors stated that the locking principle prevents stripping,

movement, and loosening of screws. Fixation technique simplifies plate bending and decreases torsion or opening at the fracture site.

Agarwal *et al.*,^[6] in their study, found a statistically significant positive correlation between the bite force compared preoperatively and on progressive follow-up visits. When compared the pre-operative bite force with the bite force on 1st week, *P*-value is found to be <0.01 which is not significant, but highly significant *P* < 0.001 is observed on comparing the pre-operative bite force with the bite force on 3, 6, and 12 weeks.

In our study, the mean pre-operative bite force in locking group is 3.14 Kpa with a SD of 0.303 Kpa and the mean 3 months post-operative bite force generated is 17.41 Kpa with a SD of 0.351 Kpa and this increase in bite force is statistically significant. Results of our study are in accordance with the above-mentioned studies with the similar *P* < 0.01 between pre-operative and 1 week, and *P* < 0.001 between pre-operative and 1 week, 1 month, and 3 months. In non-locking group, it was 3.05 Kpa with a SD of 0.276 Kpa and significantly increased to 16.90 Kpa with a SD of 0.406 Kpa at the end of 3 months. When compared in between two groups, *P*-values are statistically significant, that is, <0.05 showing that locking plates provide early masticatory efficiency. The neurosensory deficit was assessed with two-point discrimination test and also subjective symptoms.

Either of the one if positive was accepted as present or absent (if both negative).^[7,9,10] Out of ten patients treated using the non-locking 3D plate in mandibular fractures, 2 patients (20%) had paresthesia over ipsilateral lower lip and chin region showing inferior alveolar nerve injury compared to one in locking 3D plate group. However, these differences were not statistically significant. Subsequent follow-ups showed a decrease in the number of patients with paresthesia over operated side chin region and comparable results in both plating groups. These results are in agreement with those reported in published literature.^[7,9,10]

The post-operative evaluation showed that there was no case of fibrous union, malunion, or non-union detected clinically. Post-operative radiographs showed adequate fixation of fracture segments. At the end of 3 months, the anatomic reduction of the treated fracture was evident at the two fractured ends. The blending of margins and trabecular bone formation was indistinguishable at the end of 3rd month, showing new bone formation radiographically. Blending of margins showed a gradual increase from 1 month to 3 months.

In our study, the treatment outcome with the 3D locking plate and 3D non-locking plate system in the management of mandible fractures was comparable. Overall, complications were lesser in locking 3D plate group but results were not statistically significant. Radiographic assessment of reduction showed better results in locking 3D plate group. However, due to the smaller study sample, a more extensive clinical study is recommended for better understanding the full spectrum of its application in maxillofacial surgery.

Our recommendations for 3-D plating system are as followed-

1. Need of standardization of 3-D plates sizes and material used
2. Modifications in 3-D plate design for oblique fractures and fractures around the mental neurovascular bundle
3. Need of standardized kit of plates and contra-angled drills and screwdrivers, for intra-oral angle fracture plating.

In the present study, a sincere attempt has been made to clinically compare and evaluate the efficacy of 2.0 mm 3D titanium locking plate/screw system and 2.0 mm 3D titanium non- locking plate/screw system in the management of mandibular fractures and the results of this study are in accordance with the study conducted by different authors.

CONCLUSION

In conclusion, the study shows that both standard and locking 3D titanium miniplates are effective for managing mandibular fractures, with locking plates offering advantages in stability and bite force. However, further research with larger, more diverse populations is needed to confirm these findings and explore their applicability in specific patient groups, such as the elderly or those with bone pathologies. Long-term research is necessary to improve knowledge of the results related to these fixation techniques.

REFERENCES

1. Farmand M, Dupoirieux L. The value of 3-dimensional plates in maxillofacial surgery. *Rev Stomatol Chir Maxillofac* 1992;93:353-7.
2. Farmand M. Three-dimensional plate fixation of fractures and osteotomies. *Facial Plast Surg Clin North Am* 1995;3:39-56.
3. Haug RH, Prather J, Indresano AT. An epidemiologic survey of facial fractures and concomitant injuries. *J Oral Maxillofac Surg* 1990;48:926-32.
4. Macdonald D, Nicolaou S, O'Keeffe M. Fractures of the face and jaws. In: *Oral and Maxillofacial Radiology: A Diagnostic Approach*. United States: John Wiley and Sons; 2019.
5. Sehgal S, Ramanujam L, Prasad K, Krishnappa R. Three-dimensional v/s standard titanium miniplate fixation in the management of mandibular fractures--a randomized clinical study. *J Craniomaxillofac Surg* 2014;42:1292-9.
6. Agarwal M, Mohammad S, Singh RK, Singh V. 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 Surg* 2011;69:1995-2000.
7. Singh A, Arunkumar KV. Standard 3D titanium miniplate versus locking 3D miniplate in fracture of mandible: A prospective comparative study. *J Maxillofac Oral Surg* 2016;15:164-72.
8. Gandhi L, Kattimani VS. Three dimensional bone plating system in the management of mandibular fractures-a clinical study. *Ann Essences Dent* 2012;4:42-52.
9. Guimond C, Johnson JV, Marchena JM. Fixation of mandibular angle fractures with a 2.0-mm 3-dimensional curved angle strut plate. *J Oral Maxillofac Surg* 2005;63:209-14.
10. Lucca M, Shastri K, McKenzie W, Kraus J, Finkelman M, Wein R. Comparison of treatment outcomes associated with early versus late treatment of mandible fractures: A retrospective chart review and analysis. *J Oral Maxillofac Surg* 2010;68:2484-8.
11. Kumar N, Malhan S, Mahajan S, Asi KS. Titanium miniplate osteosynthesis of mandibular fractures. *IJDS* 2012;1:21-4.
12. Prabhakar C, Shetty JN, Hemavathy OR, Guruprasad Y. Efficacy of 2-mm

- locking miniplates in the management of mandibular fractures without maxillomandibular fixation. *Natl J Maxillofac Surg* 2011;2:28-32.
13. Junior RC, Saavedra MS, Linard-Martins LR, Luz JG. Use of the locking 2.0-mm fixation system for treating mandibular fractures with the potential for complications. *J Oral Maxillofac Surg Med Pathol* 2016;28:13-8.
14. Champy M, Lodde JP, Jaeger JH, Wilk A, Gerber JC. Mandibular osteosynthesis according to the Michelet technic. II. Presentation of new material. Results. *Rev Stomatol Chir Maxillofac* 1976;77:577-82.
15. Kumar BP, Kumar J, Mohan AP, Venkatesh V, Kumar HR. A comparative study of three-dimensional stainless-steel plate versus stainless steel miniplate in the management of mandibular parasymphysis fracture. *J Bio Innov* 2012;1:19-32.
16. Mittal G, Dubbodu RR, Cariappa KM. Three dimensional titanium mini plates in oral and maxillofacial surgery: A prospective clinical trial. *J Maxillofac Oral Surg* 2012;11:152-9.
17. Rastogi S, Reddy MP, Swarup AG, Swarup D, Choudhury R. Assessment of bite force in patients treated with 2.0-mm traditional miniplates versus 2.0-mm locking plates for mandibular fracture. *Craniofac Trauma Reconstr* 2016;9:62-8.
18. Richard HH, Street CC, Goltz M. Does plate adaptation affect stability? A biomechanical comparison of locking and nonlocking plates. *J Oral Maxillofac Surg* 2002;60:1319-26.
19. Gutwald R, Alpert B, Schmelzeisen R. Principle and stability of locking plates. *Keio J Med* 2003;52:21-4.
20. Pektas ZO, Bayram B, Balcik C, Develi T. Effects of different mandibular fracture patterns on the stability of miniplate screw fixation in angle mandibular fractures. *IJOMS* 2011;41:339-43.