

Management Strategies of Isolated Mandibular Fractures Using 3D and 2D Miniplating System with Clinical and Radiographic Evaluation - A Comparative Study

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Abstract

Aim and Objective: This study is Clinical and radiographic evaluation of 3D miniplate and 2D miniplate fixation in the management of isolated mandibular fractures - A comparative study. 1. Advantages. 2. Treatment outcome. 3. Stability. 4. Comparison of drawbacks of two different plating system in the management of isolated mandibular fractures.

Materials and Method: The present study was to evaluate the comparison of 2mm 3D titanium miniplates with 2 mm 2D titanium miniplates in isolated mandibular fractures. This study was conducted for the period of September 2018 to September 2020 at the Department of Maxillofacial surgery, College of Dental Sciences, Davanagere. Patient who fulfilled the inclusion criteria were treated by open - reduction and internal fixation using 2 mm 3D titanium miniplates and 2 mm 2D titanium miniplates with 2 mm X 8 mm or 2 mm X 6 mm length monocortical screws. Post-operatively patients were assessed for Presence or absence of infection, swelling or local inflammation, mal union/Fibrous union, Implant failure, postoperative mobility at fracture site. Post-operatively fracture healing assessed using digital orthopantomograph and was compared between 2 mm titanium 2D miniplate and 2 mm 3D miniplate.

Results: In our study radiological assessment was done by measuring maximum distance between two fracture segments were obtained using annova test, in respective pre-operative and post-operative radiographic views. The maximum distance between two fractures segments in isolated mandibular fractures were assessed in orthopantomograph using vernier calliper. An outstanding Difference was noted between two plating systems used in treatment protocol. 2 mm 3Dimensional miniplate has higher significance when compared to the 2 mm conventional miniplate system. Also, clinical assessment was done with post-operative mobility, infection, Malunion/Non-union and hardware loosening showed 3D plates have better outcome than 2D Miniplates.

Keywords: 2Dimensional Miniplate (2D Miniplate); 3Dimensional Miniplate (3D Miniplate); Maxillomandibular Fixation (MMF); Orthopantomogram (OPG); Road Traffic Accident (RTA); Open Reduction and Internal Fixation (ORIF)

Introduction

The face is being the evident structure of human body, mandible being prominent and well contoured to make a prominent part of face much more prone for the injury from war injuries, fall, sports injuries to major road traffic accidents commonly injured bone in the face. With the advent of history of World War I and II there has been significant transpose in management protocol in dealing with the mandibular fractures. Due to its anatomical position, its attachments, its prominence on the face proper rigid fixation in management of mandibular fractures makes it unique with

different plating systems used. Various methods of management of mandibular fractures are available following the decade and have made remarkable progress in the managing strategies though the most commonly accepted one is open reduction and internal fixation with the stainless steel or titanium hardware. Which prevents the long hospital stays for patient and instant functioning; faster healing process thus put an end to need for Maxillomandibular fixation (MMF) [8-10]. In recent times the 3D miniplating system are more preferred compared to 2D miniplate system as the geometrical concept of 3D plating system is that provides 3-dimensional

stability for the fixation maintaining the resistances acting while preserving low profile and malleability [11]. Many studies have concluded that saying in the management of isolated or non-comminuted fracture of mandible 3D miniplate system is better than the 2D miniplate system; 3D miniplates are designed with vertical struts forming a quadrilateral geometry facilitating the stabilization of both superior and inferior border with one plate as they carry reduction in palpability (low profile) strong yet malleable providing that no requirement of additional hardware for stabilization of reduced fracture segments [11-13].

Materials and Methods

The study was done on 30 patients reporting to department of Maxillo-facial surgery, College of Dental Sciences and Hospital, Davangere. Who were diagnosed with isolated mandibular fracture based on history, clinical examination and confirmed with orthopantomography. Informed consents were obtained prior to the conduct of study from all the patients:

- 1. Inclusion criteria:** Dentulous patients, patients with mandibular symphysis, parasymphysis, body and angle fractures, patients who come under ASA I and ASA II category, all the subjects who had given written informed consent were included in the study.
- 2. Exclusion criteria:** Edentulous patients, Paediatric mandibular fractures, Patients with comminuted fracture, Patients with pathology of mandible, Patients with mixed dentition, Condylar fractures, Patient lacking cooperation or from whom the inform-consent cannot be obtained.
- 3. Study design:** A prospective and Comparative study done with sample size of 30.
- 4. Methods of collection of data:**
 - Ethical clearance was approved by The Institutional review board of college of dental sciences, Davanagere.
 - A prospective study was done on 30 patients presenting with mandibular fractures.
 - The patient's clinical examinations were complemented with pertinent Orthopantomography to arrive at a final diagnosis.

These 30 patients were randomly divided in to two groups of for managing mandibular fractures:

- 1. Group - A (2-Dimensional miniplate):** Patients underwent open reduction and internal fixation of isolated mandibular symphyseal/parasymphysis, body and angle fractures using 2-D miniplates.
- 2. Group - B (3-Dimensional miniplate):** Patients underwent open reduction and internal fixation of isolated mandibular symphyseal/parasymphysis, body and angle fractures using 3-D miniplates.

Equipment's used for plating: Basic instrument set for maxillo-facial surgery, Instrument used for inter-maxillary fixation.

Normed 2-dimensional and 3-dimensional titanium miniplate 2.0 mm system

Plate design: 4 Different designs of 3-Dimensional miniplates were included:

- 2 X 2 holed - Rectangular Plate, 3 X 2 holed - Double rectangle/Continuous rectangle, 4 X 4 holed - Double rectangle/Continuous rectangle, All the plates had 2 mm diameter holes. Profile height: 1.0 mm (Standard plates).

Screws: Non-compression, self-tapping, monocortical screws with round head, Diameter: 2 mm, Length: 6 mm and 8 mm, Emergency screws: 2.3 mm, Drill bit Diameter: 1.6 mm.

Accessories: Screw drivers, Bone plate holding forceps, Bone plate bending pliers, Plate cutting pliers.

Operative technique: Under all aseptic precautions Patients underwent surgery either under Local anesthesia or General anaesthesia with nasal intubation. (North pole endotracheal tube). Incision design: For inter-mental foraminal fractures - the fracture sites were exposed through an intraoral, sub-labial approach or extra-oral approach, submental approach as required depending upon the case. For angle fractures: Fractured sites were exposed with more cosmetic approach via intraoral approach and Trans buccal approach was used in patients with angle fracture. Fracture sites were exposed and visualized, mental neurovascular bundle was isolated and preserved. Reduction of the segments was done

after curettage of granulation tissue and thorough irrigation with betadine and saline. suitable 3-D miniplate or 2-D miniplate were selected contoured and adapted to bone using plate bending pliers to confirm the proper adaptation of plates to the bone surface following an intra operative temporary maxillomandibular fixation.

Plate adaptation: For inter-mental foraminal fractures-A unique design of 3D titanium miniplate were selected and adapted to the reduced fracture segments so that the vertical struts of 3D miniplates were parallel to it and horizontal plate were parallel to fracture segments. In Cases of symphysis and parasymphysis upper parallel struts were placed in sub apical position. In the mental foramen region placed in such a way that they are above the inferior alveolar nerve and below the inferior alveolar nerve with inferior struts. In the fixation of the fracture near and involving the mental foramen a unique design of plates with open end 6-hole 3D plates were used to facilitate not injuring the mental nerve coming out of the mental foramen. For angle fractures-At the angle region the plate was adapted and fixed along the lateral surface of the angle of mandible along neutral zone of forces. After the adaptation of the plates to the contours of the bone stabilized with plate holding forceps, drilling of the holes in the plate performed keeping the drill bit perpendicular to the plate and surface of the bone to keep drill holes were monoaxial. Care was taken to prevent thermal injury to bone while drilling using copious amount of saline irrigation and running the drill bit in slow speed. The superior holes were drilled in between the roots of tooth to prevent injury to the viable tooth which are functional or not injured or infected. Selection of the screws was done with suitable length for the fixation, while fixation the upper strut holes were fixed first following the lower struts using screw-holding screwdriver with all the basic principles of internal fixations were followed as per the guidelines setup by The Champy, *et al.* in their adaptation by Michelet's method. Using as minimum hardware possible two screws were placed on each sides of the plate. Temporary MMF was taken off and occlusion was checked after fixation for derangement. The intraoral site was closed in layers with 3-0 Ethicon Vicryl suture and extraoral site was closed with 3-0 Ethicon Vicryl for deep layers closure and 5-0 Prolene was used for superficial skin closure. Sterile and Pressure dressing was done and patient shifted to the wards. Each patient was administered with intravenous antibiotics for three days. Post-operatively and analgesics followed by 2 days oral antibiotics and analgesics. 3rd post-operative day orthopantomograph was taken to assess the reduction. Patients were followed up at intervals of 1 month, 3 months and 6 months post-operatively by a blinded se-

nior and oral surgeon (for a total period of 6 months) during which were assessed.

Post operative care

All patients were peri-operatively kept on the following drug regimen. IV Ceftriaxone 1 gm BD for 5 days, IV Ornidazole 500 mg BD for 5 days, IV Pantoprazole 40 mg OD for 5 days, IM Diclofenac sodium 75 mg BD for 3 days, IV Ondansetron 4 mg SOS, 0.2% Chlorhexidine gluconate mouthwash for 30 days.

Follow up design

All 30 patients were evaluated for; Stability of fracture segments, post-operative occlusion, The incidence of post-operative complications like wound dehiscence, infection, plate exposure, screw loosening, other complications like malunion or non-union of fracture segments, All the patients were followed up both clinically and radiologically at regular intervals of 1, 3, 6 months post-operatively.

Results and Discussion

Incidence of mandibular fracture, mostly isolated mandibular fracture is more common as they are second ranked around 23.3% was recorded comparing to other facial bone fractures i.e. nasal bone fractures 58.6% [1], coming to the etiology of the fractures most common happening to be road traffic accidents in a developing country like India around 45.3%, other common etiology we came across were falls 42.6%, inter personal violence 8.9%, Sports injuries 2.2% and gunshot wound being the last with less commonly seen apart from war fair injuries is less than 1% [2]. 90% was seen in male patients and more commonly encountered age group is between 20 - 40 years [21]. In our study, incidence of mandible fracture is 80%, where in for age group between 18 - 30 years is 73.3% and where in for age group between 31 - 75 years is 26.6%. Aetiology of mandible fracture is a road traffic accident which accounts 80% and history of fall accounts for 10%, history of assault accounts for 10%. The common site of fracture is Parasymphysis which is 30% and angle 16.6% and body 13%, midsymphysis 3.3% and 36.6% cases were associated with combination of fractures. The aim and objectives of treating a mandibular fracture is to restore the function, establish occlusion and anatomic form, Traditional conservative methods of treating mandibular fractures were by immobilizing the mandible for a healing period by IMF, done by dental wiring, arch bar, cap splints and gunning splints [38]. With advancement of technology and increasing fame open reduction and internal fixation with use of hardware being used as first mo-

dality in the management of mandibular fracture as its function of chewing, speaking is considered to be important. Morbidity with using the latest miniplate system is easier for patient cosmetically also they can get back to function and less hospital stay are the basic advantages of internal fixation [38]. With the invention of 2 mm 3D miniplate system by Mostafa Farm and by achieving the stability of the reduced fractured segment with less hardware incorporation with less thickness and unique geometry of each design of plates provide increased resistance to the torsional movement happening post-operatively. Various designs and shapes are available in 3D miniplate system as described earlier also can be used for various isolated fracture of mandible with screws are being monocortical and engage only one outer cortex which provide 3-dimensional support to the reduced fractured segments until the healing process is complete [27]. In our study 30 patients with isolated mandibular fractures were selected for the study and divided into two group of 15 patients, group A were treated with 2 mm conventional miniplates, and group B were treated with 2 mm 3 Dimensional miniplates and followed up post-operatively for 1st month, 3rd month, 6th month for healing and complications. Advantages of 2 mm 3D miniplates over 2D conventional miniplates are easy application, simultaneous stabilization from both superior and inferior aspects of mandible, less operating time, improved biomechanical stability [35]. Disadvantages of 2 mm 3D miniplate over 2D conventional miniplate are when the fracture line involving the mental foramen, in case of displaced mandibular fractures, in cases of comminuted mandibular fractures, excessive implant material resulting from extra vertical bars incorporated for countering the torque force. In our study, intra-operative and immediate post-operative stability of fracture segments were evaluated manually by digital palpation. Immediate post operatively stability of the miniplate system was checked with application of alternative pressure over the fracture reduced side around 95% of mobility was found in group A who were fixed with 2D miniplate and group B was found to be 80% with 3D miniplate system. In the follow up period of time no mobility was noted in wither of the groups. In our study post-operatively mild derangement was noted in both the groups, 3.3% in 3D miniplate osteo-synthesis and 6.6% in 2 mm conventional 2D miniplate osteo-synthesis shows results with 3D miniplates has significant results. This co-relates with the study conducted by Khalid Ansari, *et al.* to compare complication rates after use of IMF bone screws for anterior and posterior mandible fractures [22]. In our study all the patients required arch bar fixation i.e. both 2 mm conventional miniplate and 2 mm 3D titanium miniplate, which patient discomfort was noted and post-operative oral hygiene maintenance by

patient was not adequately done, can be a reason for the wound gaping or secondary infection. Zix, *et al.* in his study reported 0% infection rate whereas Guimond, *et al.* reported 5.4% infection rate and with use of 2 mm 3D titanium miniplates and Feledy, *et al.* reported 9% of infection rates in their study. Also been noted that incidence of chances of wound dehiscence and plate exposure with 2 mm titanium 3D miniplate system were less compared to conventional one [19]. Similarly Sebastian, *et al.* reported wound dehiscence and infection in 7.5% of the patients among 87% of them had a positive history of either alcohol or tobacco use or both [27]. In our study post-operatively 33.3% patients with 2 mm conventional 2D miniplate had infection whereas 20% patients with 2 mm 3D miniplate had infection and 13.3% plate exposure, 6.6% screw loosening in 2 mm conventional 2D miniplate whereas none of the patients from 2 mm 3D miniplate group had plate exposure, screw loosening, showed the higher significance of reduced rates of hardware failure in 3D miniplates. Mohamed El-Essawy, M.D., *et al.* in his study in the 6th week post-operative follow-up period, panoramic radiograph was taken and was compared to the immediate post-operative panoramic radiograph, both images were assessed for evidence of bone healing by considering the shrinkage of fracture line as the evidence of bone healing and presence of callus formation was used to distinguish between the primary and secondary bone formation [42]. In our study, panoramic radiographs were taken pre-operatively, 1st month, 3rd month and 6th month follow-up period post-operatively both pre-operatively and post-operatively panoramic radiographs were assessed for bone healing by reduction in distance between two fracture lines was measured with vernier calliper device measurements were obtained and tabulated. Statistical data shows higher statistical significance value for the system of osteo-synthesis though when we compare numerically 3D miniplates shows higher significant value 3.45+/- 2.61 when compared to 2 mm conventional 2D miniplates 5.18 +/- 2.7.

Conclusion

Study we conducted concludes that inspite drawbacks of 2 mm 3D miniplate system i.e. the possible limitations of 3Dimensional miniplates derived are: Difficult to use in cases of comminuted fractures, Difficulty in its placement and adaptation where fractures involving the mental foramina. Though the 3D miniplates are strong with low profile yet malleable facilitate more stability at both superior and inferior borders of reduced fracture site gives 3D stability when comparing to the conventional 2 mm 2D miniplate system. However, results from the study show 3D miniplate system avail

oneself of better fixation of un displaced, non-communitated and simple fractures has lower morbidity and infection rates.

Conflict of Interest

None.

Bibliography

1. Yogesh Mittal., et al. "A Comparative study of 3-Dimensional titanium miniplates for open reduction and internal fixation of mandibular parasymphysis fracture". *Journal of Oral and Maxillofacial Surgery* (2015).
2. Allareddy V., et al. "Epidemiology of facial fracture injuries". *Journal of Oral and Maxillofacial Surgery* 69 (2011): 2613-2618.
3. Vyas A., et al. "A study of mandibular fractures over a 5-year period of time: a retrospective study". *Contemporary Clinical Dentistry* 5.4 (2014): 452e5.
4. Gear AJ., et al. "Treatment modalities for mandibular angle fractures". *Journal of Oral and Maxillofacial Surgery* 63.5 (2005): 655e63.
5. Ellis 3rd E. "Treatment of mandibular angle fractures using the AO reconstruction plate". *Journal of Oral and Maxillofacial Surgery* 51.3 (1993): 250e4.
6. Ellis 3rd E. "A prospective study of 3 treatment methods for isolated fractures of the mandibular angle". *Journal of Oral and Maxillofacial Surgery* 68.11 (2010): 2743e54.
7. Ellis 3rd E and Ghali GE. "Lag screw fixation of mandibular angle fractures". *Journal of Oral and Maxillofacial Surgery* 49.3 (1991): 234e43.
8. Ellis 3rd E Walker LR. "Treatment of mandibular angle fractures using one noncompression miniplate". *Journal of Oral and Maxillofacial Surgery* 54.7 (1996): 864e71.
9. Schmoker R., et al. "Application of functionally stable fixation in maxillofacial surgery according to the ASIF principles". *Journal of Oral and Maxillofacial Surgery* 40.7 (1982): 457e61.
10. Levy FE., et al. "Monocortical miniplate fixation of mandibular angle fractures". *Archives of Otorhinolaryngology-Head and Neck Surgery* 117.2 (1991): 149e54.
11. Schierle HP., et al. "One- or two plate fixation of mandibular angle fractures?" *Journal of Cranio-Maxillofacial Surgery* 25.3 (1997): 162e8.
12. Guimond C., et al. "Fixation of mandibular angle fractures with a 2.0-mm 3-dimensional curved angle strut plate". *Journal of Oral and Maxillofacial Surgery* 63.2 (2005): 209-214.
13. Mohammad Ali R Patel., et al. "Comparison of 2D vs 3D miniplates in the management of anterior mandibular fractures - comparative study". *RGUHS Journal of Medical Sciences* 6.2 (2016): 66-70.
14. Silajiding K., et al. "Three dimensional versus standard miniplate fixation in the management of mandibular fractures: A meta-analysis of randomized controlled trials". *The Kaohsiung Journal of Medical Sciences* 33.9 (2017): 464-472.
15. Frans HM Kroon., et al. "The use of miniplates in mandibular fractures". *Journal of Cranio-Maxillofacial Surgery* 19 (1999): 199-204.
16. Seiji Nakamura., et al. "Complications of miniplate Osteo-synthesis for mandibular fractures". *Journal of Oral and Maxillofacial Surgery* 52 (1994): 223-238.
17. F Ian MD., et al. "Prospective comparison of panoramic tomography and helical compared tomography in the diagnosis and operative management of mandibular fractures". *Journal of Plastic and Reconstructive Surgery* 107.6 (2001).
18. Alper Alkan., et al. "Biomechanical comparison of different plating technique in repair of mandibular angle fractures". *Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology, and Endodontology* 104 (2007): 752-756.
19. Zix Juergen., et al. "Use of straight and curved 3-dimensional titanium miniplates for fracture fixation at the mandibular angle". *Journal of Oral and maxillofacial surgery* 65.9 (2007): 1758-1763.
20. Manoj Kumar Jain., et al. "Management of mandibular interforaminal fractures using 3-Dimensional locking and standard titanium miniplates-A comparative preliminary report of 10 cases". *Journal of Cranio-Maxillo-Facial Surgery* 40 (2012): 475-478.

21. Manoj Goyal, *et al.* "Mandibular osteosynthesis: A comparative evaluation two different fixation using 2.0 mm titanium miniplates and 3D locking plates". *Journal of Oral and Maxillofacial Surgery* 10.1 (2011): 32-37.
22. Khalid Ansari MD., *et al.* "A comparison of anterior vs posterior isolated mandible fractures treated with inter-maxillary fixation screws". *Journal of Archives of facial plastic surgery* 13.4 (2011).
23. Balakrishnan R., *et al.* "Three-Dimensional titanium miniplates in management of mandibular fractures". *Biomedical and Pharmacology Journal* 7.1 (2014): 241-246.
24. Gaurav Mittal., *et al.* "Three-dimensional titanium mini plates in oral and maxilla-facial surgery: A prospective clinical trial". *Journal of Oral and Maxillofacial Surgery* 11.2 (2012): 152-159.
25. Sadhasivam Gokkulakrishnan., *et al.* "An Analysis of postoperative complications and efficacy of 3-D miniplates in fixation of mandibular fractures". *Dental research Journal* 9.2 (2012): 414-421.
26. Mahmoud E Khalifa., *et al.* "Titanium three dimensional miniplate versus conventional titanium miniplate in fixation of anterior mandibular fractures". *Life Sciences Journal* 9.2 (2012): 1006-1010.
27. Dr. Pavan Kumar B., *et al.* "A comparative study of three-dimensional stainless-steel plate versus stainless steel miniplate in the management of mandibular parasymphysis fracture". *Journal of Bio Innovation* 1.2 (2012): 19-32.
28. Manoj Kumar Jain., *et al.* "Management of mandibular interforaminal fractures using 3-Dimensional locking and standard titanium miniplates-A comparative preliminary report of 10 cases". *Journal of Cranio-Maxillo-Facial Surgery* 40 (2012): 475-478.
29. Virendra Singh., *et al.* "Conventional versus 3-Dimensional miniplate in management of mandibular fractures: A Prospective Randomized study". *Journal of Otolaryngology - Head and Neck Surgery* 147.3 (2012): 450-455.
30. Vineet KRM Lalitha., *et al.* "A comparative evaluation between single non compression titanium miniplate and three dimensional miniplate in treatment of mandibular angle fracture - a randomized prospective study". *Journal of Cranio-Maxillo-Facial Surgery* 41 (2013): 103-109.
31. Uma Shankar Pal., *et al.* "Use of 3-D plate in displaced angle fracture of mandible". *Cranio-maxillofac Trauma Reconstruction* 6 (2013): 25-30.
32. Rajendra Prasad., *et al.* "The role of 3D plating system in mandibular fractures: A prospective study". *Journal of Bio allied Sciences* 5.1 (2013).
33. Bipin S Sadhwani and Sonal Anchlha. "Conventional 2.0 mm miniplates versus 3-D plates in mandibular fractures". *Comparative Study: Annals of Maxillofacial Surgery* 2 (2013): 154-159.
34. Dhananjay H Barde., *et al.* "Efficacy of 3-dimensional plates over champys plates in mandibular anterior fractures". *Journal of International Oral Health* 6.1 (2014): 20-26.
35. Sehgal Saumya., *et al.* "Three-dimensional v/s standard titanium miniplate fixation in the management of mandibular fractures - A randomized clinical study". *Journal of Cranio-Maxillofacial Surgery* 42.7 (2014): 1292-1299.
36. Al-Moraissi EA., *et al.* "Comparison between three-dimensional and standard miniplates in the management of mandibular angle fractures: a prospective, randomized, double-blind, controlled clinical study". *International Journal of Oral and Maxillofacial Surgery* 44.3 (2015): 316-321.
37. Al-Tairi NH., *et al.* "Comparison of three - dimensional plate versus double miniplate osteosynthesis for treatment of unfavourable mandibular angle fractures". *Tanta Dental Journal* 12 (2015): 89-98.
38. Kamal Malhotra., *et al.* "Versatility of titanium 3D plate in comparison with conventional titanium miniplate fixation for the management of mandibular fracture". *Journal of Oral and Maxillofacial Surgery* 11.3 (2012): 284-290.
39. Kubila Silajiding., *et al.* "Three dimensional versus standard miniplate fixation in the management of mandibular fractures: A meta-analysis of randomized controlled trials". *Kaohsiung Journal of Medical Sciences* (2017).

40. Farooque Iqbal Siddiqui., *et al.* "Management of Anterior Mandibular Fractures Using Two Different Fixation Methods". *Archives of CraniOrofacial Sciences* 4.2 (2016): 4-9.
41. Mohammad Ali R Patel., *et al.* "Comparision of 2D vs 3D miniplates in the management of anterior mandibular fractures - a comparative study 6.2 (2016): 66-70.
42. Mohamed El-Essawy MD., *et al.* "Evaluation of the Role of Three-Dimensional Miniplate Technique in Internal Fixation of Mandibular Fractures". *Journal of Plastic and Reconstructive Surgery* 41.2 (2017): 301-309.
43. Yong Liu1., *et al.* "The 3-dimensional miniplate is more effective than the standard miniplate for the management of mandibular fractures: a meta-analysis". *European Journal of Medical Research* 22 (2017): 5.
44. Revati Singh., *et al.* "Comparative Study of 3 Dimensional and Standard Miniplate in Management of Anterior Mandibular Fractures". *International Journal of Contemporary Medical Research* 6.8 (2019): H5-H11.
45. Vivek Singh and Ritesh Giri. "ADEQUACY OF THREE DIMENSIONAL MINIPLATES IN TREATMENT OF MANDIBULAR FRACTURE IN INTERFORAMINAL REGION". *Journal of Chitwan Medical College* 9.28 (2019): 97-102.
46. NK Sahoo and Ritu Mohan. "An ideal intermaxillary fixation device during open reduction of mandibular fractures". *Journal of Oral and Maxillofacial Surgery* 9.2 (2010): 170-172.