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Research Article

Outcome Analysis of Different Plating Positions in Mandibular Angle Fractures: A Prospective Randomized Study

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Abstract

Background/Aim: This is a prospective Randomized study which aims to evaluate the rehabilitation period and functional outcomes associated with three distinct plating positions superior border lateral border and inferior border in cases of favorable mandibular angle fractures. Materials and Methods: Clinical and radiological evaluations were conducted on a sample size of 30 patients with favorable mandibular angle fractures before surgery during the first week at first month and three months post operation. Clinical outcomes, specifically the bite force for the three different plating positions were measured using a bite force device. Functional outcomes were assessed through Maximal Interincisal Opening (MIO), occlusion, neurosensory deficits and radiographic assessment of fracture reduction using pre-operative and post operative radio graphs i.e. OPG. Results: The superior border plating group exhibited a notable enhancement in bite force after surgery when compared to the other two groups with p-value being significant ($p<0.001$). Post operatively the inter-group comparison revealed no significant difference pre-operatively ($p=0.039$) but post-operatively ($p<0.001$) was significant. The inferior border plating group experienced a 30% rate of neurosensory deficits after the operation unlike the other two groups. Occlusal discrepancies were observed in 10% of the inferior border plating group while there was no significant difference in radio graphic reduction among the three plating groups. Conclusion: The study concludes that superior border plating is the most effective plate position for facilitating prompt recovery and minimal complications providing sufficient stability for favorable angle fractures.

Keywords

Bite Force, Inferior Border Plating, Lateral Border Plating, Mandibular Angle Fracture, Superior Border Plating

1. Introduction

Approximately 20-22% of all the mandibular fractures consist of angle fractures [1]. Angle fractures result in more complications than other mandibular fractures, owing to the biomechanics of the angle, making addressing this area complicated [2]. The intricate biomechanics of this area result from a narrow cross-sectional dimension, sudden shifts in curvature, the connection of masticatory muscles, and the existence of third molars [3].

The conventional biomechanical model which identifies tension along the upper edge and compression along the lower

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edge has been questioned revealing that these tension-compression areas shift as the position of the load moves backward [4, 5]. Various methods for treating fractures in the angle region are documented in the literature. These include both intraoral and extraoral approaches, such as the transbuccal and submandibular techniques [1]. The treatment of angle fractures is brimming with controversy. There are different plating positions in mandibular angle fractures which includes, plating in the superior border of angle region, lateral border of angle and in the inferior border of the mandible

The aim of our study is to compare the rehabilitative periods and functional outcomes of three different plating positions in mandibular angle fractures. This helps us to draw a comparison of bite forces, neuro-sensory deficits, MIO (maximal interincisal opening), and occlusion between the different plating positions.

2. Material and Methods

All individuals diagnosed with a mandibular angle fracture at the Department of Facio Maxillary Surgery were invited to participate in this prospective study. The study duration was between February 2024 and November 2024 covering duration of 9 months after obtaining clearance from Institutional Review Board IRB of the Institute. Participants had to give informed consent or choose not to partake in the study. They were informed about the requirement to attend a follow up evaluation upto 3 months. Patient information was documented on a consent form. Participants received comprehensive information regarding the potential advantages and disadvantages related to both treatment alternatives. Identical sized titanium mini plates obtained from the same manufacturer were used in all three study groups. Randomization was carried out using SPSS program version 20 for randomizing 30 patients and allocating each patient into any of the three groups based on the patient's enrolment number in the study. The study design and randomization procedures were approved by the institutional ethics committee before the study commenced. The inclusion criteria required the presence of a mandibular angle fracture in accordance with the Association for Osteosynthesis (AO classification). The exclusion criteria included infected fractures, comminuted fractures, individuals younger than 18 years, pan facial fractures and those who were edentulous. A total of 30 patients with mandibular angle fractures were categorized into three groups.

Group I superior border plating - 10 patients

Group II lateral border plating - 10 patients

Group III lower border plating - 10 patients

A single 2 mm four-hole titanium mini plate with a gap and 2 mm screws measuring 8 mm in length was used in all instances regardless of the surgical approach and technique used. Patients were chosen for the surgical procedure using a 1:1:1 ratio corresponding to the various techniques. All individuals underwent treatment as inpatients under general anesthesia following required investigations and pre anesthetic assessments.

For the intra oral technique a local anesthetic with a vasoconstrictor was administered before making the incision. A vestibular incision was created through the mucosa approximately 5 mm from the attached gingiva extending towards the external oblique ridge when the third molar was absent. In situations where the third molar was present a modified Ward's incision was employed to aid informing a mucoperiosteal flap for access to the fracture site [1, 6, 7]. Preoperative and post-operative radiographs of superior border plating done via intra oral approach is shown in Figures 1 and 2.

Figure 1. *Pre-operative OPG of Mandibular Right Angle fracture.*

Figure 2. *Postoperative OPG of superior border plating of Mandibular Right Angle fracture.*

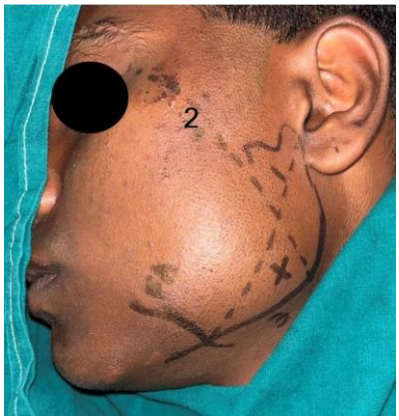

Figure 3. *Safe zone trocar placement marking for transbuccal approach with Mandible and Facial Artery marked and lines drawn to form a triangle.*

The transbuccal method involved making an incision that mimicked the intra oral technique along the angle and ascending ramus to expose the fracture area. Extra orally, a small stab incision was performed using a scalpel aligned with the relaxed resting skin tension lines RSTL for the placement of a transbuccal trocar tool following the approach described by Gulses et al as shown in Figure 3.

Line 1 - extending from tragus of ear to Facial artery exit on to the mandible

Line 2 - extending from lateral can thus of the eye to gonium

Line 3- lower border of the Mandible

X- Marking for trocar puncture wound on the skin

The site for osteosynthesis was identified by placing and marking the index finger on the cheek while a thumb was positioned intra orally perpendicular to the index finger. The cannula with the trocar was advanced through the facial tissue until reaching the bone which was then removed to allow for drilling and screw placement. Access to the fracture site was achieved and stability was secured by reducing the affected area through intra operative inter maxillary fixation [3, 8]. Pre-operative and postoperative radiographs of lateral border plating done via trans buccal approach is shown in Figures 4 and 5.

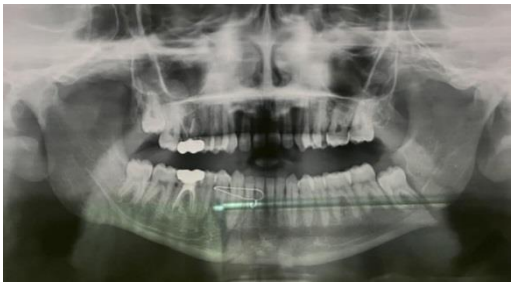

Figure 4. *Pre-operative OPG of Mandibular Left Angle and Right Parasymphysis fracture planned for Transbuccal approach.*

Figure 5. *Postoperative OPG depicting Lateral Border Plating in Mandibular Left Angle fracture.*

Risdon described the submandibular or extraoral method. An incision was made 2 cm above the lower edge of the jaw adhering to the skin crease beneath the mandible. The area surrounding the incision was administered with a combination of 2% Lignocaine Hydrochloride and adrenaline as a vasoconstrictor 1:80,000. After the skin was incised with a no.15 BP blade, the subcutaneous tissue and the overlying platysma muscle were revealed. These tissues were then carefully undermined through blunt dissection sectioned at the level of the skin incision and pulled upwards to allow better access. The facial artery and vein were located and ligated. The pterygomasseteric sling was cut at its lower border as shown in Figure 6 providing entry to the fracture site.

Figure 6. *Intra-operative photograph of Inferior Border plating using extraoral approach.*

After the fracture was reduced, fixation of the fracture segments was executed along the lower border per Champy's principle using Titanium mini plates across all three surgical methods. Pre-operative and postoperative radiographs of inferior border plating done via extra oral approach are shown in figures 7 and 8. Post operatively all patients were administered intravenous antibiotics [6, 9].

Figure 7. *Pre-operative Orthopantomograms (OPG) of patient with Mandibular Left Angle and Right Parasymphysis fracture.*

Figure 8. *Post-operative OPG of inferior border plating of Mandibular Left Angle fracture.*

All patients with mandibular angle fractures underwent OPG or computed tomography (CT) scans before and after ORIF. Group 1 consisting of 10 patients will undergo open reduction and internal fixation at superior border plating through a buccogingival incision. Group 2 composed of another 10 patients will undergo open reduction and internal fixation at lateral aspect of mandibular through transbuccal approach. Group 3 consisting of 10 patients will undergo open reduction and internal fixation at inferior border plating through a extraoral incision. Clinically all the patients will be assessed as a part of follow-up protocol at one week, 4 weeks, 12 weeks after the procedure for the following factors:

(1) Stability and Rehabilitative periods using Bite Force Device in kgs shown in Figures 9,10 and11
(2) Maximal Inter-incisal Opening
(3) Occlusion
(4) Neurosensory deficits using House and Brackmann classification
(5) Pre-operative and post-operative radiographs (OPG)

Figure 9. *Bite Force value reading in inferior border plating group.*

Figure 10. *Measuring Bite force using bite force device in kgs.*

Figure 11. *Bite Force Device.*

3. Statistical Analysis

Statistical Package for Social Sciences [SPSS] for Windows Version22. 0Released 2013. Armonk, NY: IBMCorp., was used to perform statistical analyses.

3.1. Descriptive Statistics

Descriptive analysis of all the explanatory and outcome parameters was done using mean and standard deviation (SD) for quantitative variables, frequency and proportions for categorical variables.

3.2. Inferential Statistics

One way ANOVA test followed by Tukeys post hoc analysis Kruskal Wallis Test followed by Dunns post hoc test based on data distribution was used to compare the mean percentage of bite force. Post operative MIO between 3 groups.

Repeated Measures of ANOVA Test Friedman's Test followed by Wilcox on Signed Rank Post Test was used to compare the mean percentage of bite force. Post operative MIO between different time intervals in each group.

Chi Square Test was used to compare the status of occlusion Neurosensory deficit and other radiographic findings during the post operative periods between 3 groups.

The level of significance P Value will be set at $P<0.001$

4. Results

Pre-operatively, the bite forces in kg were similar across all types: 6.7 for superior border plating, 7.5 for lateral border plating and 6.6 for inferior border plating with no significant difference ($p=0.428$). However, post-operatively, at Week 1, Month 1 and Month 3, the bite force increased significantly for all groups ($p=0.001$). At Week 1, the lateral

border plating group had the highest mean bite force (15.6 kg), followed by the superior border plating (11.8 kg) and inferior border plating (11 kg). At Month 1, the superior border plating group showed the highest mean bite force (23.5 kg), while the inferior border plating group had the lowest (13.4 kg). By Month 3, superior border plating still had the highest bite force (32.7 kg), with lateral border plating at 23.7 kg and inferior border plating at 15.7 kg given in Table 1. All intra group changes overtime were statistically significant (p=0.001) shown in a linear graph in Figure 12.

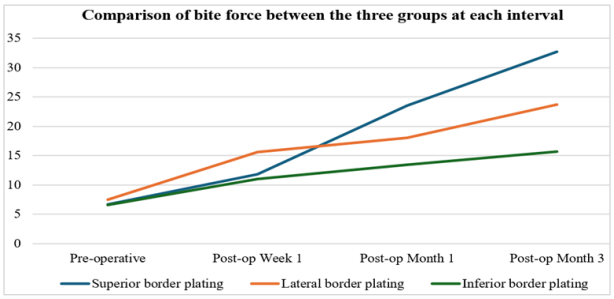

Figure 12. *A line graph comparing the biteforces of three different plating positions pre-operatively and post-operatively at week 1, 1 month and 3 months.*

Table 1. *Comparison of biteforce between the three groups at each interval (N=30).*

Biteforce (kgs)	Mean (SD)			p-value
	Superior border plating (kg)	Lateral border plating (kg)	Inferior border plating (kg)	
Pre-operative	6.7(1.56)	7.5(1.71)	6.6(1.71)	0.428
Post-op Week1	11.8(1.47)	15.6(1.95)	11(1.33)	<0.001
Post-op Month1	23.5(4.19)	18(1.63)	13.4(1.42)	<0.001
Post-op Month3	32.7(2.26)	23.7(1.63)	15.7(2.45)	<0.001
p-value (Intra-group)	<0.001	<0.001	<0.001	

SD-Standard Deviation
ANOVA test

Pre-operatively, the superior border plating group had a mean opening of 22.33 mm, the lateral border plating group had 23 mm, and the inferior border plating group had 20.55 mm. post-operatively, all groups showed significant improvements. The intra-group differences were statistically significant for all groups (p = 0.001 for superior and lateral border plating, p = 0.024 for inferior border plating). The inter-group comparison revealed a significant difference preoperatively (p = 0.039) and post-operatively (p < 0.001) given in Table 2.

Table 2. *Comparison of maximal inter incisal opening between the three groups (N=30).*

Maximal inter-incisal opening (MIO)	Mean (SD)		p-value
	Pre-operative (mm)	Post-operative (mm)	
Superior border plating	22.33(1.32)	31.11(2.15)	<0.001
Lateral border plating	23(2.34)	28.66(1.73)	<0.001
Inferior border plate	20.55(2.06)	22.33(1.22)	0.024
p-value (Inter-group)	0.039	<0.001	

SD-Standard Deviation
One-way ANOVA

Pre-operatively most patients had stable occlusion: 70% for superior border plating, 60% for lateral border plating and 50% for inferior border plating. After surgery, the majority of patients in all groups had stable occlusion: 90% for superior and lateral border plating and 80% for inferior border plating. Only 10% of the inferior border plating group had deranged occlusion post operatively but again no significant inter group difference was found (p = 0.354).

Pre-operatively, no patients in any group had a neuro sensory deficit (0%), and all patients were reported as having no deficit (90%) across the groups. However, post-operatively, no patients in the superior or lateral border plating groups experienced an neuro sensory deficit whereas 30 of the patients in the inferior border plating group did. The inter-group comparison showed a significant difference post operatively (p = 0.034) shown in Figure 13.

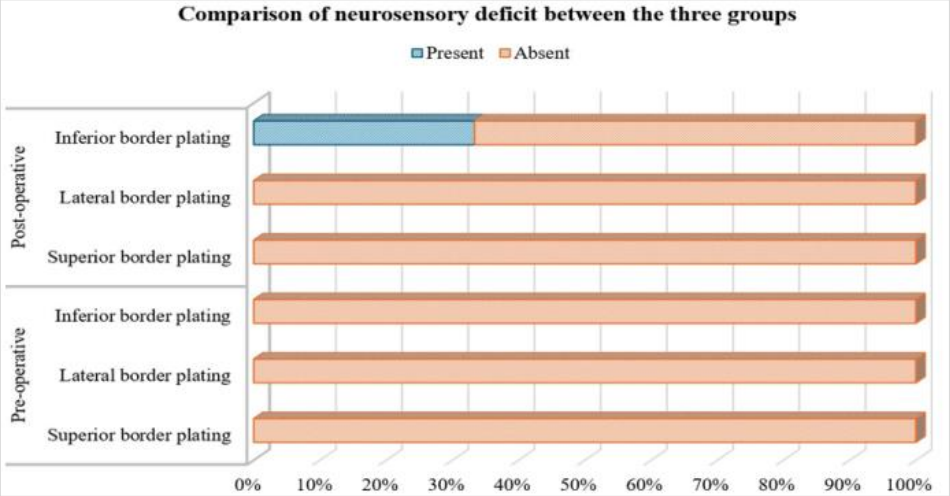

Figure 13. *A horizontal bar graph comparing the neuro sensory deficits between the three groups preoperatively and post operatively.*

Pre-operatively, radiographic reduction was present in 30% of the superior border plating group, 20% of the lateral border plating group and none (0%) in the inferior border plating group, with no significant inter group difference (p = 0.179). Post-operatively, radiographic reduction was present in 80% of the superior and lateral border plating groups and 90% of the inferior border plating group with no significant inter-group difference (p = 0.583).

5. Discussion

Moore has indicated that there is a shift in the orientation of the bone's grain at the vertical ascending ramus and the horizontal body of the mandible which weakens the angle region [10, 11]. The angle is geometrically a more slender structure compared to the front part of the mandible. The molar area operates with higher efficiency than the other areas. In the posterior body angle region, the masseter medial pterygoid sling is positioned to primarily deliver vertical force during activity [12].

It is crucial to highlight that there are two Champy lines located at the mandibular angle. It is sufficient to position the plate on just one of these lines [13]. Occasionally post placement of a superior plate there may be an unnoticed splay at the lower mandibular angle [2]. One benefit of positioning a plate superiorly behind the molar is that this splay tends to close overtime [7].

Since the 1970s, two primary philosophies have been promoted regarding the open reduction and fixation of fractures. The AO/Association for the Study of Internal Fixation (AO/ASIF) group advised that achieving ‘total rigidity’ and compression without any inter-fragmentary movement is essential for securing primary bone healing during active mandible use. The initial AO technique was subsequently revised through the use of a single non-compression tension band plate along with a compression plate at the inferior border, as it became evident that absolute/total rigidity was not a necessity [14].

Ellis, in his article, stated that the percentage of complications was higher in the group where two plates were used than in the single-plate group [6]. Other authors, in their studies, also found that using two plates in mandibular angle fractures did not have any added advantage [2, 15].

Literature suggests different plating positions for effective stabilization of the mandibular angle fracture, which include superior, lateral, and inferior border plating. The intraoral technique allows for good visibility of the superior oblique ridge; however, it has faced criticism due to challenges in accessing the inferior border [5, 16]. The extraoral technique offers straightforward access and clear visualization, but it carries risks of injury to the marginal mandibular nerve and may result in noticeable scarring [14]. The transbuccal method offers suitable access for lateral border plating by using a trocar and cannula system. Drilling and screw

placement can be carried out perpendicularly to the lateral mandibular surface through an extraoral stab incision while maintaining direct visibility of the surgical area transorally [7].

The goal of our research is to compare three distinct plating locations and determine the optimal placement to achieve the fastest rehabilitation time with minimal complications. The parameters taken into consideration are bite force value, maximal inter-incisal opening, occlusion, neurosensory deficit, and radiographic reduction.

Tate et al. noted a marked reduction in the masticatory forces exerted on the fracture area of the mandibular angle following the fracture and stated that fixation with a single miniplate can provide adequate union [6]. In a healthy adult, the average bite force in the molar area is 36 kg, while in the incisor area, it measures 15 kg [17]. According to the study by Gamit et al., the bite force in the molar region on the side with the fracture was measured at 10.72 kg during the first month and increased to 14.13 kg by the sixth month in the study group [18].

In our study, the bite force gradually increased over the follow-up periods in all groups, with the maximum bite force achieved by the superior border plate group and the least by the inferior border plating group. Singh et al., in his study, states that the elevated rate of complications may be linked to increased stripping of the periosteum and muscles in the angle area, which undermines the healing and stabilizing effects of the muscles [14]. Ellis, in his article, states that a 2 mm miniplate placed intraorally at the superior border is enough to neutralize the forces of angle fracture, restoring the tension and compression trajectories on the mandible [19].

Rudderman et al. found in their research that bite forces progressively grow stronger over time following an injury. Even after the fracture has completely healed, part of the load continues to be supported by the plate. The system does not revert to the stress levels seen before the injury as long as the plates are in place and securely attached [4].

If the plate is applied by means of an open extraoral approach, soft tissue must be dissected, and the pterygomasseteric sling in the posterior body-angle region—which is oriented to provide primarily vertical force during function—is transected for exposure and placement. The elevation and disruption of soft tissue limit its ability to aid in stability during function, unlike superior border plating or lateral border plating [4]. In the case of lateral border plating, it provides greater resistance to vertical loading forces while still permitting some degree of lateral movement. [5].

The inter-group MIO was significantly more post-operatively in superior border plating, followed by lateral and inferior border plating, supported by Goparaju et al. in their study, which had an intraoral approach with MIO suggested early improvement and functioning [1]. Contradictorily, Singh et al. in his study states that mouth opening was greater in extraoral as compared to intraoral, due to less muscle manipulation in extraoral cases and direct access. [14].

Inferior border plating group had 30% of neurosensory deficit post-operatively compared to the other two groups in our study. In their research, Goparaju et al. note that two patients experienced facial nerve weakness, which was classified as Grade II on the House-Brackmann Scale in the extra-oral approach [1], whereas Singh et al. in his study contradicts that 15% of superior border plating cases had neurosensory deficit [14]. According to Mehra et al., using extraoral access can provide enhanced visualization and improved control over fractured segments; however, it also considerably increases the likelihood of facial nerve damage and the chance of noticeable scarring [20]. Siddiqui and colleagues documented a case involving injury to the marginal mandibular nerve due to a transbuccal instrument. This risk was nonexistent with the intraoral approach. [15].

The occlusion was deranged for the inferior border plating group in 10% of the patients in our study, in contrary to a study by Singh et al. where 10% occlusal discrepancy was observed in the intra-oral group, i.e., superior border plating [14]. Kim et al. in his study compared single, two plates, and MMF treatment options for mandibular angle fracture and found that malocclusion was prominent in the MMF group. [21].

In our study, the inter-group difference was not significant with respect to the radiographic reduction. S. Laverick et al. in their research back up this conclusion that the surgical method did not significantly influence the extent of postoperative fracture reduction as assessed through OP-G and PA skull radiographs. [22].

Laurent Joyee et al. emphasized that achieving manual reduction requires careful repositioning of the displaced bone fragment. Therefore, to attain anatomical reduction, it is important to ensure alignment at the lower edge and sufficient contact between the bony fragments; restoring normal occlusion is necessary for functional reduction [23]. Kotrashetti et al. conducted a comparative analysis of the transbuccal and extraoral methods for managing mandibular fractures, indicating that the extraoral approach offers greater versatility when addressing displaced and unfavorable angle fractures, particularly in terms of surgical access and the duration needed to complete the procedure. [24].

Wadolowski et al., in their investigation of finite element analysis concerning various plating techniques in mandibular angle fractures, indicate that applying the plate along the oblique line significantly enhances the invasiveness of the connection, though this is counterbalanced by improved connection stability. A dual plate system utilizing a combined fixation pattern with a slight initial compression appears to be the most effective connection method. [25].

6. Conclusion

The conclusion of this study is that superior border plating is more efficient in achieving the rehabilitation post-mandibular angle fracture, as the bite forces observed

were seen to improve exponentially in this group, followed by lateral border plating and lastly within inferior border plating. This can be majorly because of transection and dissection of the pterygomasseteric unit, which constitutes the main part of the posterior masticatory apparatus in inferior border plating group, leading to longer gaps in achieving rehabilitative periods. Maximal interincisal opening and occlusion were best seen in the superior border plating group. Neurosensory deficit was observed mainly in the inferior border plating group as the approach used involved encountering the marginal mandibular branch of the facial nerve. No differences were seen in radiographic reduction in all three plating positions.

Abbreviations

MIO	Maximal Interincisal Opening
OPG	Orthopantamogram
RSTL	Resting Skin Tension Lines
ORIF	Open Reduction and Internal Fixation
CT	Computed Tomogram
PA	Posteroanterior View
MMF	Maxillo-Mandibular Fixation

Author Contributions

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Girish Gowda: Methodology, Project administration

Siri Shetty: Conceptualization, Data curation, Writing - original draft

Preethi Bhat: Supervision, Visualization, Writing - review and editing

Sirisha Sampangi Pushpa: Data curation, Writing - review and editing

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Conflicts of Interest

The authors declare no conflict of interest.

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