Original Article

Single linear miniplate versus rectangular grid plate in the treatment of mandibular angle fractures: A prospective, clinico-radiographic, comparative study

ABSTRACT

Study Design: Randomized Control Trial.

Objective: A prospective, clinico-radiographic, comparative study was planned to evaluate the treatment outcome and postoperative complications in isolated mandibular angle fractures using 2.0-mm system single linear 4 hole with gap miniplate versus 4 hole rectangular grid plate, both stabilized with 4 8-mm monocortical screws.

Methods: Thirty patients with isolated mandibular angle fractures were randomly categorized into two groups with 15 patients each. Group 1 patients were treated with single 2.0 mm   4 hole linear miniplate along the superior border and Group 2 patients were treated with a 2.0 mm   4 hole rectangular grid plate on lateral cortex of mandible. Pain, swelling, occlusion, bite force, maximum inter-incisal opening, intraoperative time, facial nerve injury, fracture stability, and postoperative complications were assessed and compared at regular intervals up to 12 months.

Results: There was no major difference in terms of treatment outcome in both systems and both were equally effective without any statistically significant difference in any of the parameters. None of the patients presented with any of the complications except for postoperative infection which was reported by 1 patient from each group at 3 months postoperatively and were managed conservatively.

Conclusion: Both plating systems are equally effective; however, the rectangular grid plate could be a safe and effective alternative to the single miniplate when adaptation and fixation is not possible along the external oblique ridge of the mandible (e.g., fracture with bone loss along the superior border).

Keywords: Grid plate, isolated mandibular angle fractures, miniplate osteosynthesis, open reduction and internal fixation, three-dimesional miniplates

INTRODUCTION

Mandibular angle fractures (MAFs) can be defined as a fracture line starting in the area where the anterior border of the mandibular ramus meets the body of the mandible, usually in the region of the third molar.[1] These fractures account for 23%-42% of all mandibular fractures. The posterior position and biomechanics of the angle make the treatment of the fractures in this region difficult, and MAFs generate more complications than other mandibular fractures.[2]

Road traffic accidents (RTA) and assaults are the primary causes of MAFs.[1] Panoramic radiographs, Lateral Oblique view, and Occlusal view of the mandible and computed tomography (CT) scans and Cone Beam Computed Tomography

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Manthan Kumar Das, Madan Mishra, Gaurav Singh, Shubhamoy Mondal

Department of Oral and Maxillofacial Surgery, Sardar Patel Post Graduate Institute of Dental and Medical Sciences, Lucknow, Uttar Pradesh, India

Address for correspondence: Dr. Madan Mishra, Department of Oral and Maxillofacial Surgery, Sardar Patel Post Graduate Institute of Dental and Medical Sciences, Lucknow, Uttar Pradesh, India.
E-mail: mm.15mds@gmail.com

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scans are the most informative diagnostic methods used in identifying MAFs.[3]

Miniplate fixation of mandibular fractures has become the standard treatment of providing rigid internal fixation and eliminating the need for prolonged intermaxillary fixation. The frequent involvement of the mandibular angle in facial fractures can be attributed to its thin cross-sectional bone area and the presence of a third molar. Rigid internal fixation of MAFs is accomplished by a 4-hole or 6-hole miniplate ventral to the oblique line of the buccal cortex of the mandible and many authors have documented low complication rates associated with monocortical miniplate fixation.[4]

However, questions concerning the stability provided by miniplate fixation of MAFs have become a point of contention among surgeons, based on clinical and experimental studies. In an experimental study, Kroon *et al.*[5] described inferior distraction of the lower mandibular margin caused by loading forces close to the fracture line. The short coming of this rigid and semi rigid fixation leads to the development of three-dimensional (3D) miniplates. In combination with the screws monocortically fixed to the lateral cortex, the rectangular plate forms a cubid which possess 3D stability.[6]

The rectangular grid plate is small in size having only 2 vertical bars and 4 eccentric nonlocking screw holes, one at each corner of the plate. This 2.0-mm titanium 3D grid plate allows for almost no movement at the superior and inferior borders by the torsional and bending forces, whereas when only a single linear plate is placed on the superior border (Champy's technique);[7] torsional and bending forces usually cause movement along the axis of the plate with buccal-lingual splaying and gap formation at the inferior border, respectively. Because the screws are placed in a "box" configuration of 2.0-mm grid plate on both sides of fracture rather than on a single line, broad plate forms are created that increase the resistance to torsional forces along the axis of the plate.[8,9]

The aim of this study was to evaluate the efficacy and treatment outcome of 2.0-mm system single linear 4 hole with gap miniplate versus 2.0 mm system 4-hole rectangular grid plate stabilized with 4 monocortical screws in isolated MAFs.

MATERIAL AND METHODS

A prospective study was carried out on 30 patients (power of the study was found to be 98%) with isolated MAFs attending the Out-Patient Department (OPD) of Oral and Maxillofacial Surgery, with permission from Institutional Ethical Committee (IEC) [Protocol No.:- OMFS/04/241920/IEC]. Protocol number provided is as per the Certificate issued by Institutional Ethical Committee of No: OMFS/04/241920/IEC dated 18/12/2019. Inclusion criteria of this study were American Society of Anesthesiologists (ASA) Group I and II patients having isolated MAFs, aged >18 years. Medically compromised patients, edentulous patients, patients not willing for surgery, and patients with a previous history of irradiation of head and neck area were excluded from the study.

Patients were randomly categorized into two groups with 15 patients each. A detailed case history of the selected patients was recorded and all necessary hematological and radiological investigations [Figures 1 and 5] were done. Preoperatively erich arch bar fixation was done under local anesthesia under antibiotic coverage. All the patients were operated by the same surgeon.

General anesthesia was administered with nasotracheal intubation under aseptic condition. For Group 1, an intraoral approach was used for reduction of the fracture, plate adaptation, and screw fixation; for Group 2 patients, an intraoral approach was used for fracture reduction and plate fixation, whereas screws were fixed using transbuccal trocar and cannula via an extraoral stab incision. To identify a safety zone for transbuccal trocar placement, a triangle-shaped zone was created following three anatomical lines based on the study by Gulses A *et al.*[10] A drill sleeve was used as a percutaneous-transbuccal way for admission and conduction of microdrill shaft and screw driver directly to the fracture in Group 2 patients.

In Group 1, a single linear titanium miniplate of 2.0 mm * 4 hole was adapted on the superior border in angle region and fixed with 2.0 mm * 8 mm monocortical screws. In Group 2, a single 2.0 mm * 4-hole rectangular grid plate was adapted over the reduced fracture such that horizontal cross bars were perpendicular to the fracture line and vertical bars

Figure 1: Preoperative orthopantomogram (OPG)

were parallel to the fracture line and secured with 2.0 mm * 8 mm monocortical screws [Figures 3 and 4]. The occlusion was checked in all patients by releasing maxillomandibular fixation (MMF).

After achievement of adequate hemostasis, in Group 2 patients, the extraoral incision was closed using 3-0 vicryl in deep layers and 4-0 prolene on skin and the intraoral incision was closed using 3-0 vicryl; For group 1 patients, only 3-0 vicryl was used for the closure of intraoral incision.

Patients were prescribed antibiotics and analgesics postoperatively. MMF was done using elastics on all the patients from second postoperative day for 3 weeks. Patients were advised strict soft diet for 3 to 4 weeks and to maintain oral hygiene by rinsing with 0.2% chlorhexidine gluconate mouthwash and warm saline 24 hours after surgery. All the patients were reviewed at immediate postoperative period, 1st week, 1st month, 3rd month, 6th month, and 1 year postoperatively. MMF was released 3 weeks after surgery, and arch bars were removed after the sixth postsurgical week. Postoperative radiographs [Figures 2 and 6] were taken.

Patients were clinically evaluated for (a) pain (as per Visual Analogue Scale or VAS),[11] (b) swelling (as per Pollman 1983),[12] (c) occlusion (intact/deranged), (d) bite force (in Newton using Bite Force recording device), (e) maximum interincisal opening (in millimetres), (f) intraoperative time (in minutes), (g) facial nerve injury (House-Brackman Grading System),[13] (h) perceptibility of scar (Patient and Observer Scar Assessment Scale),[14] (i) fracture stability (stable/unstable), and (j) postoperative complications like infection and paresthesia (using Pin Prick method).

The radiographic evaluation criteria included complications such as plate fracture, screw loosening, malunion, and nonunion.

Data were analysed using SPSS software version 20.0 and statistics were plotted with Mann-Whitney U test. The results were considered statistically significant if $P < .05$.

Figure 2: Postoperative orthopantomogram (OPG)

Figure 3: 2.0-mm system rectangular grid plate

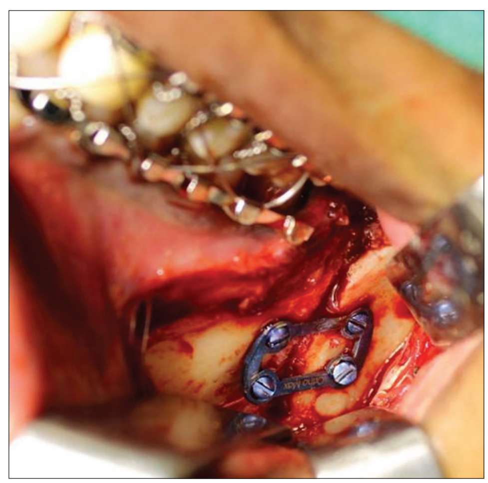


Figure 4: Fixation of the grid plate at the fractured site

RESULTS

The mean age of the entire population was 28.03 years with a standard deviation of 8.11 years with a minimum of 17 and a maximum of 42 years. Altogether, 30 patients were included in the study among which 66% of the patients were male (N = 20) and 33% (N = 10) were female. Causes for the mandibular fractures were RTI - 63.35% (N = 19); Sports injuries - 6.7% (N = 2); Fall - 20.0% (N = 6); and Assault - 10.0% (N = 3). Isolated fracture in right angle of the mandible was reported by 53.35% (N = 16) and left angle of the mandible was reported by 46.65% (N = 14) of the total population [Table 1].

The overall operation time (from incision to complete closure) for Group 1 was 41.2.00 ± 3.668 minutes and for Group 2

Figure 5: Preoperative orthopantomogram (OPG)

it was 42.00 ± 4.943 minutes. There was no significant difference between the groups (*P* =0.775) [Table 2].

Group 1 had a mean postoperative 1st day pain VAS score of 5.67 ± 1.234 and Group 2 had 4.80 ± 0.775. For the postoperative 3rd day pain comparisons for the groups, it was seen that the mean pain VAS score reduced to be 2.20 ± 0.862 and 1.60 ± 0.737 in Group 1 and Group 2, respectively. The postoperative 1-week pain comparisons for the groups showed that Group 1 had a mean VAS score of 0.33 ± 0.488 and Group 2 had 0.20 ± 0.414 which were almost negligible. There was no statistically significant difference found between the groups in any of the follow-ups (*P* =0.220) [Table 3].

The extraoral swelling (Tragus-Pogonion) comparisons for both the groups showed that preoperatively, Group 1 had a mean score of 17.547 ± 0.1407 mm and Group 2 had 17.620 ± 0.1265 mm. The postoperative swelling at different follow-ups, that is, 1st day, 3rd day, 1 month, and 3 months comparisons for the groups showed that Group 1 had a mean score of 16.38 ± 7.45 mm with a maximum value of 18.9 ± 19.9 mm on the 3rd day and Group 2 had 16.46 ± 7.43 mm with a maximum score on 3rd day, that is, 19.4 ± 19.9 mm. There was no statistically significant difference found between the groups in any of the visits (*P* = 0.165) [Table 3].

Describing the extraoral swelling (Tragus-Subnasale) comparisons for the groups, it was seen that preoperatively Group 1 had a mean score of 17.24 ± 0.1352 mm and Group 2 had 17.32 ± 0.1265 mm. The postoperative swelling on 1st day comparisons for the groups showed that Group 1 had a mean score of 18.387 ± 0.2774 mm and Group 2 had 18.387 ± 0.2475 mm, whereas on 3rd day comparisons for the groups showed that Group 1 had a mean score of 18.9 ± 19.9 mm and Group 2 had 19.4 ± 19.9 mm which were maximum in both the groups. The postoperative swelling on 1st week and 1 month comparisons for the groups showed that Group 1 had a mean score of 18.9 ± 19.9 mm and Group 2 had 19.4 ± 19.9 mm, whereas Group 1 had a mean score of 13.72 ± 0.1265 mm and Group 2 had 13.70 ± 0.1069 mm, respectively. The postoperative swelling on 3rd month comparisons for the groups showed that Group 1 had a mean score of 13.72 ± 0.1265 mm and Group 2 had 13.70 ± 0.1069 mm. There was no statistically significant difference between the groups (*P* = 0.806) [Table 3].

Comparing the bite force of the fractured side, it was seen that Group 1 on 1st month had a mean score of 123.47 ± 14.020 N and Group 2 had 122.07 ± 10.707 N which further increased to be 237.67 ± 11.406 N and 240.13 ± 8.618 N for Group 1 and 2, respectively, on 3rd postoperative month. The bite force on 6th postoperative month comparisons for the groups showed that Group 1 had a mean score of 432.13 ± 24.871 N and Group 2 had 423.13 ± 20.220 N. After 1 year of follow-up, the bite force comparisons for the groups showed that Group 1 had a mean score of 541.13 ± 53.423 N and Group 2 had 539.93 ± 52.709 N. There was no statistically significant difference between the groups in any of the follow-ups (*P* = 0.324) [Graph 1].

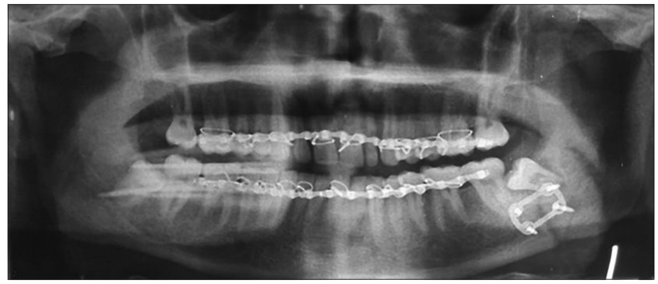


Figure 6: Postoperative orthopantomogram (OPG)

Table 1: Groupwise Distribution of Patient Age, Gender, Fracture etiology, and Fracture site

Parameters	Group 1 (*n*=15)	Group 2 (*n*=15)
Age (Years)	28.93 (17-42)	27.13 (18-42)
Gender		
Males	9	11
Females	6	4
Etiology		
RTA	10	9
Sports Injury	1	1
Fall	2	4
Assault	2	1
Fractured Site		
Right side	9	7
Left side	6	8

Table 2: Intraoperative Time (In minutes)

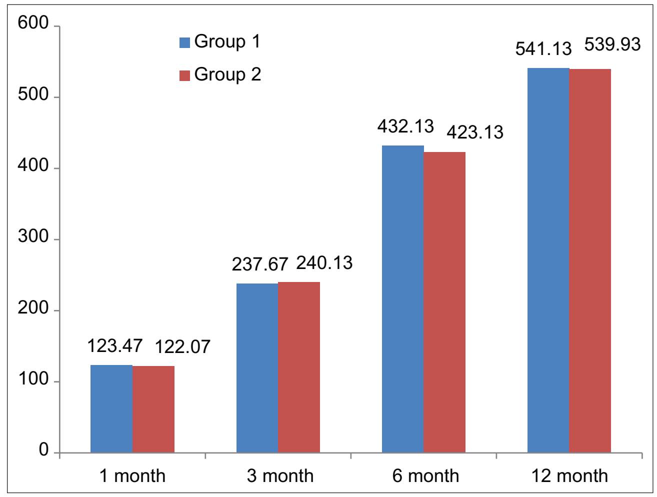
Group 1	Group 2
41.20 (35-46)	42.00 (35-55)

Table 3: Pain and Swelling at different intervals

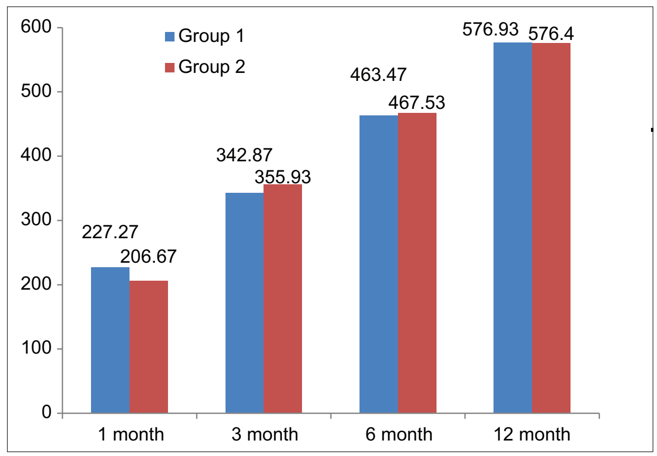
	Group 1		Group 2		*P*
	Mean	SD	Mean	SD	
Postoperative Pain					
1st day	5.67	1.234	4.80	0.775	0.056
3rd day	2.20	0.862	1.60	0.737	0.067
1 week	0.33	0.488	0.20	0.414	0.539
	Group 1		**Group 2**		***P***
	Mean	**SD**	**Mean**	**SD**	
Swelling (Tragus to Pogonion)					
Preoperative	17.547	0.1407	17.620	0.1265	0.161
1st day	18.667	0.2440	18.727	0.2086	0.305
3rd day	18.9	19.9	19.4	19.9	0.126
1 week	16.4	16.9	16.4	16.8	0.148
1 month	13.987	0.1246	13.920	0.1146	0.161
3 month	13.940	0.1056	13.853	0.1302	0.089
	Group 1		**Group 2**		***P***
	Mean	**SD**	**Mean**	**SD**	
Swelling (Tragus to Subnasale)					
Preoperative	17.24	0.1352	17.32	0.1265	0.116
1st day	18.387	0.2774	18.387	0.2475	0.683
3rd day	18.9	19.9	19.4	19.9	0.217
1 week	16.66	0.1454	16.58	0.1373	0.480
1 month	13.72	0.1265	13.70	0.1069	0.713
3 month	13.8	14.1	13.6	14.0	0.806

The bite force of the nonfractured side on 1st month showed that Group 1 had a mean score of 227.27 ± 25.516 N and Group 2 had 206.67 ± 33.049 N. On 3rd month comparisons for the groups, it showed that Group 1 had a mean score of 342.87 ± 19.431 N and Group 2 had 355.93 ± 18.760 N. The bite force on 6th month and 1 year comparisons for the groups showed the gradual improvement, that is, Group 1 had a mean score of 463.47 ± 26.194 N and 576.93 ± 63.620 N, whereas Group 2 had 467.53 ± 14.436 N and 576.40 ± 61.939 N, respectively. There was no statistically significant difference between the groups in any of the follow-ups ($P = 0.324$) [Graph 2].

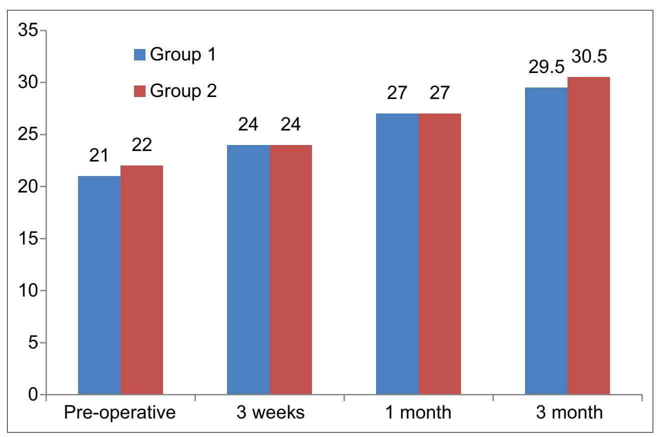
Measuring Maximum Interincisal Opening (MIO), it was seen that Group 1 had a mean score of 21 ± 29 millimeters (mm) and Group 2 had 22 ± 28 millimeters (mm) preoperatively. The postoperative MIO at an interval of 3 weeks showed that Group 1 had a mean score of 24 ± 32 millimeters (mm) and Group 2 had 24 ± 30 millimeters (mm). The postoperative MIO at an interval of 1 month comparisons for the group showed an improved result of 24 ± 32 millimeters (mm) for Group 1 and 24 ± 30 millimeters (mm) for Group 2. The postoperative MIO at 3rd month comparisons for the groups showed that Group 1 had a mean score of 24 ± 32 millimeters (mm) and Group 2 had 24 ± 30 millimeters (mm). There was no statistically significant difference between the groups ($P = 0.148$) [Graph 3].



Graph 1: Molar bite force of fractured side (in newton)

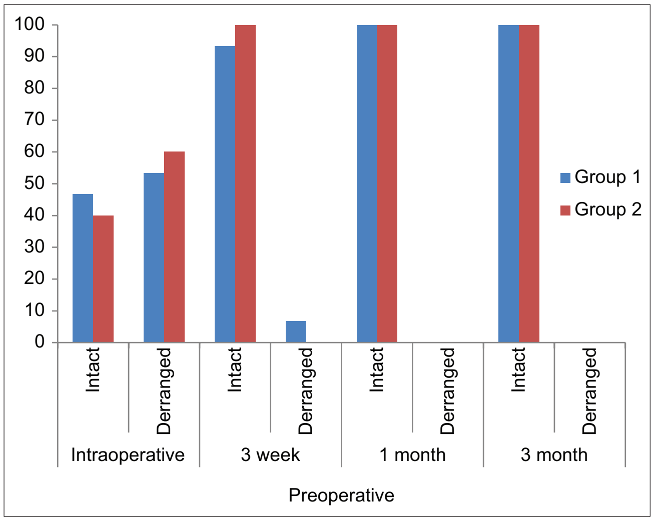


Graph 2: Molar bite force of nonfractured side (in newton)



Graph 3: Maximum interincisal opening (MIO) (in millimeters)

The occlusion at several intervals has been represented in Graph 4. Intraoperative occlusion was found to be deranged in 8 (53.3%) and 9 (60.0%) patients for Group 1 and Group 2, respectively. After 3 weeks, occlusion in 1 patient (6.7%) was found to be deranged for Group 1, whereas none of the patients showed occlusal discrepancy in Group 2. No



Graph 4: Occlusion

derangement of occlusion was found at 1-month and 3-month interval for both the groups. There was no statistically significant difference between the groups.

The facial nerve functions were intact in each of the patient of Group 2, whereas initially inferior alveolar nerve paresthesia was seen in 5 patients from Group 1 and 3 patients from Group 2 at 1st week (P =0.417); later on all of the patients were recovered after 1 month [Table 4].

When evaluating other postoperative complications, infection was reported postoperatively at an interval of 3 months in 1 of the patient from each group which were managed using broad spectrum antibiotic therapy. There was no incidence of other postoperative complications like unstable fracture, plate fracture, screw loosening, malunion, and nonunion reported in any of the patients [Table 4].

DISCUSSION

MAFs comprise up to 23% to 42% of all fractures in the mandible.[8] Fractures of the mandibular angle are most commonly associated with blunt trauma. In the present study, the most common etiology for fracture was RTA, that is, 64%. Paza AO *et al*.[3] observed similar findings in their study where they included 114 patients and RTA (31%) being one of the most common cause of mandibular fractures.

The mean age for MAFs was found to be 28 years with a male predilection (60% in Group 1 and 73% in Group 2) ranging between 17 and 42 years in this study. Similar results were observed in a study by Al Moraissi *et al*.[1] where 16 patients were male and 4 were female with a mean age of 26.2 ± 3.85 years. This can be explained by the fact that young male individuals of this age group are more involved in rash driving, interpersonal violence due to immaturity, and lack of responsibility and overenthusiasm.

Table 4: Postoperative Complications

	Group 1	Group 2
Facial Nerve Weakness	NIL	NIL
Unstable Fracture	NIL	NIL
Infection	*n*=1 (3.3%)	*n*=1 (3.3%)
Inferior Alveolar Nerve Paresthesia	*n*=5 (16.6%)	*n*=3 (10%)
Plate Fracture	NIL	NIL
Screw Loosening	NIL	NIL
Malunion	NIL	NIL
Nonunion	NIL	NIL

Presence of additional fracture acts as a confounding factor which may contribute to the fracture instability, impaired bone healing, and malocclusion. Thus, the isolated MAF allows investigators to establish the true complication rate for these fractures.[15] In our study also, all the patients were of isolated unilateral MAF.

Intraoperative time was assessed as the time from the placement of incision till the complete closure. It was seen that Group 1 had 41.20 ± 3.668 minutes and Group 2 had 42.00 ± 4.943 minutes mean scores. There was no significant difference between the groups. The results of our study correlate with the study done by Al Moraissi EA *et al*.[1] as they observed the mean duration of the procedure to be 39.7 ± 9.1 minutes for fixation using 3D miniplates and 33 ± 4.6 minutes for fixation using standard miniplate in the management of MAFs.

No significant difference in postoperative pain (measured using 10 cm VAS) was noted between both groups at any of the follow-ups and it was seen that Group 1 had a mean VAS score of 5.67 ± 1.234, whereas Group 2 had 4.80 ± 0.775. These findings were similar to the studies done by Singh V *et al*.[16] and Hofer SH *et al*.[17] as they also did not found any significant difference between the groups regarding postoperative pain.

Postoperative swelling was measured as per Pollman 1983 criteria[11] using a silk thread and rubber stoppers. The distances between Tragus-Pogonion and Tragus-Subnasale were measured and the mean value was taken. Maximum swelling was observed on 3rd postoperative day perhaps due to the surgical exposure required for the adaptation and manipulation of the plates which was gradually decreased later on. After a follow-up of 3 months, no statistical significance was observed between both the groups. The results coincide with the study done by Rastogi S *et al*.[18] as the authors did not find any statistically significant difference regarding extraoral swelling between the groups.

Bite force or maximum occlusal force is one of the parameter of masticatory function that is relatively easy to measure. In all the cases, the ipsilateral side or the fractured side showed lesser values of bite forces due to body's own defense mechanism. The findings recorded in our study correlated well with mentioned findings of Singh G *et al*.[19] where they found bite force in the molar region on the nonfractured side to be more than the fractured one.

MIO was assessed by measuring interincisal distance with metric gauze. The postoperative MIO after 3 months shows that Group 1 had a mean score of 30 cm and Group 2 had 30.5 cm. There was no statistically significant difference between the groups regarding this parameter. In a study done by Kanubaddy SR *et al*.,[20] maximum interincisal opening in rectangular grid plate group showed >30 mm when compared to miniplate group in which 20% ($n = 3$) showed <30 mm. There was no significant statistical difference after 3 months in both groups which strongly supports our results.

Occlusion was deranged in majority of the cases preoperatively; ipsilateral posterior open bite was seen in 53.3% of cases. The method of evaluating occlusion was by visualizing clinically whether occlusion was intact or not. All patients were then kept on intermaxillary fixation for a duration of 3 weeks. At 3rd week postoperatively, occlusion was found to be deranged in 1 patient from Group 2 (3.3%) and the patient was kept on intermaxillary fixation using elastics for an additional 1 week. At the end of 3 months, all patients in the study had intact occlusion. This closely coincides with the study by Jain MK *et al*.[9] as all the patients in their study had satisfactory postoperative occlusion.

In our study, all the patients in Group 2 were treated using a 3D rectangular grid plate on the lateral cortex of mandible via an extraoral stab incision and none of the patient reported with facial nerve damage postoperatively. Initially, paresthesia was seen in 5 patients from Group 1 and 3 patients from Group 2 at 1st week (26.6%); later on all of the patients were recovered during regular follow-ups. Incidence of inferior alveolar nerve paresthesia was also seen in the study by Guimond *et al*.[21] (78.1%) while using 3D plates and in the study by Barry CP *et al*.[22] (19%) while using single linear miniplate on the superior border for the management of MAFs.

Rectangular grid plate is a 3D strut plate with two curved miniplates connected with perpendicular bars and screws are placed in quadrangular or cuboid configuration monocortically, thus resisting forces across the fracture three-dimensionally.[23] When a single miniplate is placed across the tension zone in superior border of mandible, it might lead to splaying of fracture ends in the lower border of mandible due to decreased resistance to shearing and tensional forces across the plate.[24] In our study, the fracture stability was clinically assessed after fixation and the fractures were stable postoperatively in all of the patients. This was in contrary to the study by Choi BH *et al*.[25] where they reported that the fractures were not stable postoperatively in 4% to 5.9% of the cases during single miniplate application for the management of MAFs.

MAFs are plagued with widespread complications ranging from 0% to 32% and several factors play a significant role in the incidence of complications, but the key factor is the rigidity of fixation applied across the fracture and it is inversely proportional to the episode of complications.[26] Two points of fixation had higher complications than one point of fixation for MAFs.[27] Levy *et al*.[28] reported a 15.7% infection rate with a single miniplate placed across oblique ridge. In our study also a total of two patients showed infection at 3 months postoperatively (6.6%) which were managed conservatively using antibiotics and plate removal was not required. Incidence of infection following rectangular grid plate and linear miniplate fixation for the management of MAFs was also observed by Zix J *et al*.[29] (10%) and Fox AJ *et al*.[30] (5.4%), respectively.

In this study, we also evaluated postoperative complications like dysocclusion, plate fracture, screw loosening, malunion, and nonunion. None of the patients in Group 1 and Group 2 reported with any of the complications listed above, which closely resembles with the results obtained by Jain MK *et al*.[9] as the incidence of postoperative complications (10%) was nonsignificant in their study.

There was no major difference in terms of treatment outcome in both systems and both were equally effective in managing MAFs. The 3D plating system using a rectangular grid plate was suitable for fixation of simple MAFs and it proved to be an easy-to-use alternative to conventional miniplates with no statistically significant difference.

CONCLUSION

The surgical outcome of MAF fixation using the rectangular grid plate on the lateral cortex is comparable with the single linear miniplate along the superior border. The rectangular grid plate could be a safe and effective alternative to the single miniplate when adaptation and fixation is not possible along the external oblique ridge of the mandible (e.g., fracture with bone loss along the superior border). Apart from relatively high cost, the only concern while using rectangular grid plate is the use of extraoral stab incision, although the scar becomes inconspicuous after a short period of time. Further prospective randomized controlled clinical studies with larger sample size comparing the two techniques are required to derive more fruitful inference for use of these plates.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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