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COMPARATIVE STUDY

Management of Mandibular Angle Fractures: Single Stainless Steel Linear Miniplate Versus Rectangular Grid Plate—A Prospective Randomised Study

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Abstract
Purpose This prospective study was conducted to evaluate the efficacy of stainless steel single linear miniplate with rectangular grid plate in the treatment of mandibular angle fractures.
Methods This study included 30 patients who were allocated randomly into two groups of each. Group 1 patients were treated with single 2 mm × 4 hole linear stainless steel miniplate and group 2 patients with 2 mm × 4 hole rectangular grid plate. Patients were evaluated for fracture stability, occlusion, mouth opening, and complications at 1st week, 1 and 3 months post operatively.
Results There were no significant differences between the two groups with respective variables statistically. In group 1 20 % (n = 3) had mild occlussal derangement 6.66 % (n = 1) patient had deranged occlusion at 1 week post operatively and 13.3 % (n = 2) had mild derangement at 1 month post operatively. In group 2 6.66 % (n = 1) had mild derangement at 1 week postoperatively. 20 % (n = 3) had limited mouth opening at 1 week in group 1 and 13.3 % (n = 2) in group 2. All patients in both groups achieved adequate mouth opening by the end of 3 month. None of the patients in both groups had plate fracture, screw loosening, non union or mal-union.
Conclusion Within the limits of the study, use of rectangular grid plates for fixation of mandibular angle fractures was reliable with low complication rates, easy adaptation and an effective alternative to conventional miniplates. Further clinical studies with larger sample size can derive a more comprehensive conclusion.

Keywords Angle fracture · Fracture · Grid plate · Mandible fracture · Miniplate osteosynthesis

Abbreviations

3-D	Three dimensional
RTA	Road traffic accident
OPG	Orthopantomograph
PA	Posterioanterior view
MMF	Maxillomandibular fixation
SPSS	Statistical package for the social sciences

Introduction

Mandibular angle fractures comprise a representative share (30 %) among all mandible fractures [1]. Even with the advancements in methods of internal fixation, management of these fractures is still controversial due to varying anatomical and biomechanical considerations. Various treatment modalities have been studied with differences in complications, but no consensus has been reached leading to debate on ideal method of treatment [2–4].

Use of single monocortical miniplate at the superior border was considered as the standard method of treatment with minimal complications, but based on recent clinical and experimental studies several surgeons had a point of contention regarding stability due to splaying of inferior border during application of loading forces [5].

Farmand and Dupoirieux [6] developed 3-D plates considering these factors. The stability of the 3-D plate does not derive from the thickness of the plate but from the

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combination of the screws fixed monocortically to the outer cortex forming cuboid. 3-D plate holds fracture segments rigidly by resisting the shearing, bending, torsional forces acting around the fracture and minimizes the buccolingual splaying and gap formation in lower border [7].

This study was performed to compare and analyze internal fixation of mandibular angle fractures clinically by using single stainless steel linear miniplate with rectangular grid plate.

Materials and Methods

A prospective study was done in 30 patients with mandibular angle fractures reporting to the Department of Oral and Maxillofacial Surgery, from November 2012 to September 2014. Inclusion criteria of this study were: unilateral mandibular angle fractures, unilateral mandibular angle fracture along with other fractures of mandible, fractures of maxillofacial region not involving occlusion. Patients who are medically compromised, edentulous and not willing for surgery were excluded from the study. Detailed case history was recorded and all necessary hematological and radiological investigations were done.

Ethical committee approval from institutional review board was obtained and a structured informed consent was taken from the patients. Patients were randomly categorized into two groups with 15 patients in each. Submandibular approach was used in both groups. Group I patients were treated with single 2.0 mm × 4 hole linear stainless steel miniplate on lateral cortex (Fig. 1) and group II patients were treated with single 2.0 mm × 4 hole rectangular grid plate on lateral cortex (Fig. 2).

Erich arch bars were placed preoperatively with placement of guiding elastics to achieve best possible occlusion.

Fig. 1 Stainless steel linear miniplate

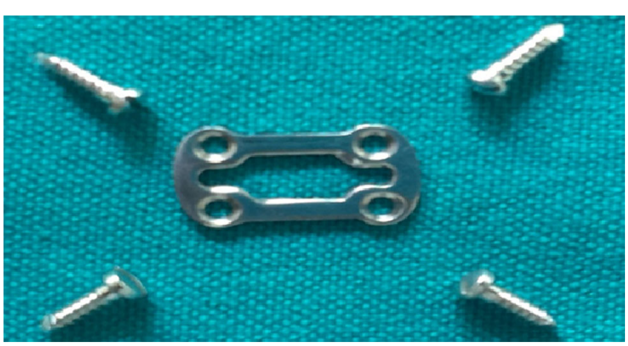

Fig. 2 Stainless steel rectangular grid plate

Fig. 3 Preoperative OPG

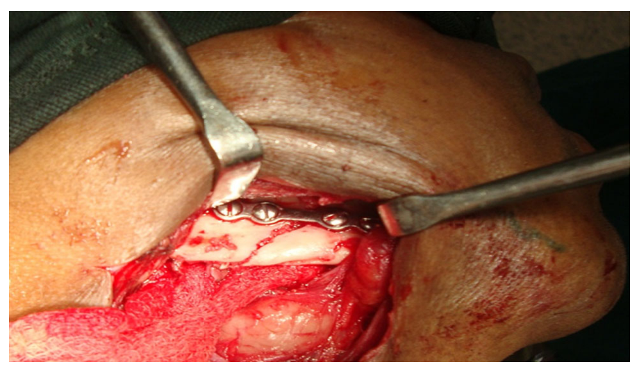

Fig. 4 Fixation with stainless steel linear miniplate

Fig. 5 Post operative OPG

Fig. 6 Preoperative OPG

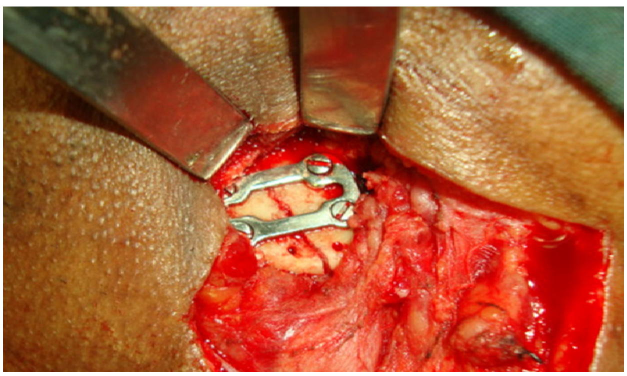

Fig. 7 Fixation with rectangular grid plate

General anesthesia was administered with nasotracheal intubation and under aseptic conditions submandibular incision was placed. A sub platysmal flap was raised to expose the lower border of mandible, masseter muscle was stripped along with the periosteum over the lateral cortex of mandible exposing the fracture site, fracture was reduced and the occlusion was established with MMF.

In group I a single linear stainless steel miniplate of 2 mm × 4 hole was adapted to the lateral cortical bone ventral to oblique ridge in angle region and fixed with 2 mm × 8 mm monocortical screws in upper border (tension zone) (Figs. 3, 4, 5). In group II a single 2 mm × 4 hole rectangular grid plate was adapted such that horizontal cross bars were perpendicular to the fracture line and vertical bars were parallel to the fracture line and secured with 2 mm × 8 mm monocortical screws (Figs. 6, 7, 8). The occlusion was checked in all patients by releasing MMF. Closure was done with 3-0 vicryl for periosteum and muscle. Skin was closed by sub-cuticular suturing with 3-0 proline.

Patients were evaluated on 1st week, 1 and 3 months post operatively for (a) fracture stability—assessed by single operator by digital palpation with the help of thumb and index finger of both hands, considered to be stable if there was no inter-fragmentary mobility and unstable if

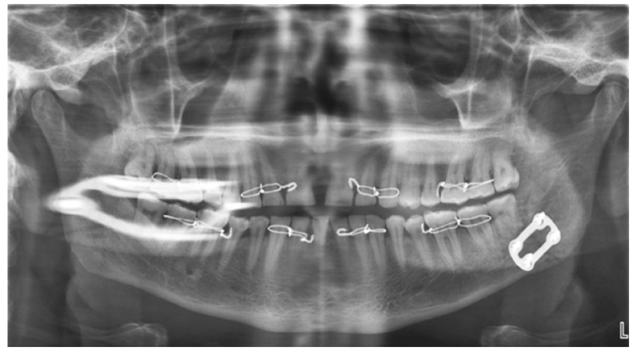

Fig. 8 Post operative OPG

mobility was present. (b) Occlusion—measured with help of metric gauze in mm by measuring the gap between upper and lower molars, categorized into satisfactory (no gap), mild derangement (1–2 mm) and deranged (more than 2 mm). (c) Mouth opening—measured with help of metric gauze and categorized into adequate (>30 mm) and inadequate (<30 mm). (d) Ease of plate fixation—operative time was measured with digital clock. (e) Complications such as infection, paresthesia, plate fracture, screw loosening, malunion and non union were assessed and recorded. OPG and PA view of the skull were taken for all the patients' pre and post operatively.

Data was analyzed using SPSS software version 19 and statistics were plotted with Mann–Whitney U test. The results were considered statistically significant if $P < 0.05$.

Results

A total of 30 patients were observed. 89 % of patients (n = 27) were males and 11 % (n = 3) were females. The age ranged from 15 to 60 years, with increased incidence in 15–20 years age group 80 % (n = 24) with male predilection.

RTA was the principle cause of fracture of mandibular angle in 80 % (n = 24) patients, followed by fall in 10 % (n = 3) patients, and assault in 10 % (n = 3) patients. 40 % (n = 12) patients had isolated angle fractures, out of which isolated left angle was 23.3 % (n = 7) patients and isolated right angle was 16.6 % (n = 5) patients and remaining 56.6 % (n = 17) patients were associated with other fractures of mandible, out of which 40 % (n = 12) patients had right parasymphysis, 10 % (n = 3)patients had left parasymphysis, 6.66 % (n = 2) had left body of mandible and 3.33 % (n = 1) had a right zygoma fracture.

In group I about 13.3 % (n = 2) of patients had fracture instability on 1st week whereas in group II 13.3 % (n = 2) showed fracture instability (Table 1).

Table 1 Comparison among both the groups with respect to fracture stability at all time intervals was found to be statistically not significant, i.e. on 1st week, 1st and 3rd month

	Stability 1 week		Stability 1 month		Stability 3 months	
	Stable	Unstable	Stable	Unstable	Stable	Unstable
Mini plates (n = 15)	13 (86.6 %)	2 (13.3 %)	14 (93.3 %)	1 (6.66 %)	15 (100.0 %)	0
Rectangular grid plates (n = 15)	13 (86.6 %)	2 (13.3 %)	15 (100.0 %)	0	15 (100.0 %)	0
Total (n = 30)	26 (86.6 %)	4 (13.3 %)	29 (96.6 %)	1 (3.33 %)	30 (100.0 %)	0
P value	0.073		–		–	

Significant at $P < 0.05$

Table 2 Comparison among both the groups with respect to occlusion at all time intervals was found to be statistically not significant, i.e. on 1st week, 1st and 3rd month

	Occlusion 1 week		Occlusion 1 month		Occlusion 3 months	
	Satisfactory	Mild derangement	Satisfactory	Mild derangement	Satisfactory	Mild derangement
Mini plates (n = 15)	11 (73.3 %)	3 (20 %) 1 (6.66 %)	13 (86.6 %)	2 (13.3 %)	15 (100.0 %)	0
Rectangular grid plates (n = 15)	14 (93.3 %)	1 (6.66 %)	15 (100.0 %)	0	15 (100.0 %)	0
Total (n = 30)	25 (83.3 %)	4 (13.33 %) 1 (3.33 %)	28 (93.33 %)	2 (6.66 %)	30 (100.0 %)	0
P value	0.809		–		–	

Significant at $P < 0.05$

Table 3 Comparison among both the groups with respect to mouth opening at all time intervals was found to be statistically not significant, i.e. on 1st week, 1st and 3rd month

	Mouth opening 1 week		Mouth opening 1 month		Mouth opening 3 months	
	Adequate	Inadequate	Adequate	Inadequate	Adequate	Inadequate
Mini plates (n = 15)	12 (80.0 %)	3 (20.0 %)	14 (93.3 %)	1 (6.66 %)	15 (100.0 %)	0
Rectangular grid plates (n = 15)	13 (86.6 %)	2 (13.3 %)	15 (100.0 %)	0	15 (100.0 %)	0
Total (n = 30)	25 (83.3 %)	5 (16.6 %)	29 (96.6 %)	1 (3.33 %)	30 (100.0 %)	0
P value	0.655		–		–	

Significant at $P < 0.05$

In group 1, 20 % (n = 3) had mild occlusal derangement 6.66 % (n = 1) patients had deranged occlusion at 1 week post operatively and 13.3 % (n = 2) had mild derangement at 1 month post operatively. In group 2, 6.66 % (n = 1) had mild derangement at 1 week postoperatively (Table 2).

Patients in both groups had inadequate mouth opening on immediate post operative day, 20 % (n = 3) had limited mouth opening at 1 week in group 1 and 13.3 % (n = 2) in group 2 (Table 3). The mean time taken for fixation of plate was 47.40 min in group I, with a minimum of 45 min and a maximum 48 min. The mean time taken for fixation of the grid plate in group 2 was 44.00 min, with a minimum of 40 min and a maximum of 46 min (Table 4).

All patients in both groups achieved adequate mouth opening by the end of 3 months. None of the patients in both groups had plate fracture, screw loosening, non union or mal-union (Table 5).

Discussion

Mandibular angle fractures are plagued with widespread complications ranging from 0 to 32 % [8–10]. Several factors play significant role in the incidence of

Table 4 Comparison among both the groups with respect to ease of fraction fixation (min.)

Plates	N	Mean	SD	SE	Mean diff.	*t* value	*P* value
Mini plates	15	47.40	5.33	1.38	3.40	1.93	0.064
Rectangular grid plates	15	44.00	4.28	1.10			
Total	30	45.70	5.05	0.92			

Independent sample *t* test $P < 0.05$

Table 5 Comparison among both the groups with respect to complications at all time intervals was found to be statistically significant, i.e. on 1st week, 1st and 3rd month

Complications	Group 1 (n = 15)	Group 2 (n = 15)	*P* value
Infection	6.66 % (n = 1)	0	0.035
Malunion	0	0	
Non-union	0	0	
Plate fracture	0	0	
Screw loosening	0	0	

Significant at $P < 0.05$

complications, but the key factor was the rigidity of fixation applied across the fracture which is inversely proportional [9]. Two points of fixation had higher complications than one point of fixation for mandibular angle fractures [8, 11–13]. Levy et al. [14] reported 15.7 % infection rate with single miniplate placed across oblique ridge. Ellis and Walker [15] reported 7.4 % infection rate. In our study post operative infection from retained tooth at the fracture site intra orally was noted in 6.66 % (n = 1) in group I and none in group II.

The use of 3-D plates was less widespread in the management of mandibular angle fractures [4]. To the best of our knowledge only six comparative clinical studies [16–21] and one systematic review [22] have been reported in literature but the parameters assessed, dimension of the plates and number of screws used for fixation varied compared to present study.

Al-Moraissi et al. [22] systematic review and meta-analysis illustrated statistically higher complication rate with use of standard miniplates where as 3-D plates decreased the complication rate by 58 %.

Rectangular grid plate is a 3-D strut plate with two miniplates buttressed with perpendicular strut plates and screws are placed in quadrangular or cuboid configuration monocortically thus resisting forces across the fracture three dimensionally [23] i.e. compression, tension and torsion, where as 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 causing reduction in stability of fixation [24].

Stability was assessed through simple digital palpation on either side of the fracture line bimanually in both the groups. Although there was no statistical difference between the two groups, rectangular grid plate demonstrated better inter-fragmentary stability over single miniplate. The stability gained over a defined surface area in 3-D plate is due to its configuration rather than its thickness or length. The geometrical configuration of the rectangular grid plate makes it easy to adapt three dimensionally to a plane across the fracture rather than to a fracture line along the uneven surface of the mandibular angle whereas the linear plate will adapt two dimensionally.

Presence of additional fracture acts as a confounding factor [19]. It may contribute to fracture instability, impaired bone healing and malocclusion. Thus the isolated mandibular angle fracture allows us to establish the true complication rate for these fractures [19]. In the present study, 40 % (n = 12) patients had right parasymphysis, 10 % (n = 3) had left parasymphysis, 6.66 % (n = 2) had left body of mandible and 3.33 % (n = 1) had a right zygoma fracture. All the associated fractures were treated with stainless steel miniplate 2 mm × 4 hole with gap and 2 mm × 2 hole with gap. Mild occlusal discrepancy was seen in both groups of patients who had an associated fracture. This was corrected by MMF for 2 weeks in both the groups.

The incidence of occlusal changes with various treatment modalities ranged from 0 to 8 %, whereas with 3-D plates it was 0–20 % [20]. In the present study, in group I, 20 % (n = 3) showed mild occlusal derangement 6.66 % (n = 1) patients had deranged occlusion at 1 week post operatively and 13.3 % (n = 2) had mild derangement at 1 month post operatively. In group II, 6.66 % (n = 1) had mild derangement at 1 week postoperatively. 13.3 % (n = 2) patients in group I required post operative MMF for 2 weeks to attain satisfactory occlusion and further in two patients figure of 8 wiring was done to prevent splaying inferior border prior to fixation of miniplate (Fig. 9). The results obtained were comparable to reported literature.

Maximal mouth opening was assessed by measuring inter-cuspal distance with metric gauze, rectangular grid plate group showed >30 mm when compared to miniplate group in which 20 % (n = 3) showed <30 mm on initial

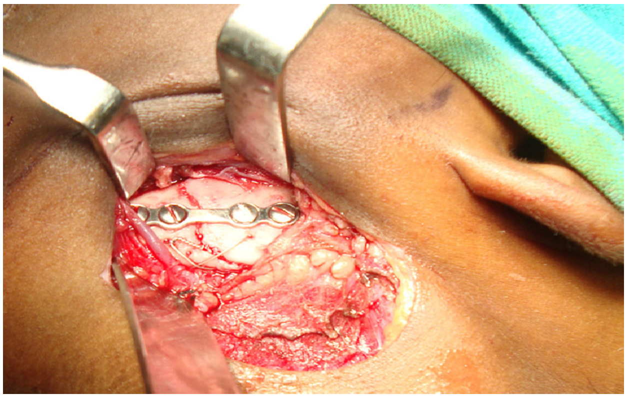

Fig. 9 Lower border wiring

assessment after 1 week. There was no significant statistical difference after 3 months in both groups.

Operative time from placement of incision till the placement of last screw was recorded in both groups. The time taken for the linear miniplate group was 47.40 min, minimally longer than that of rectangular grid plate which was 44.00 min, without any significant statistical difference. Several clinical comparative studies also report decrease in operating time with the use of 3-D plates [16–21].

Fracture reduction and fixation were assessed postoperatively using digital OPG. In group I patients 13.3 % (n = 2) patients showed a poor reduction of fractured segments and in group II all the patients had good reduction. Presence of gap between fractured segments was noted between two groups pre and post operatively after fixation. The presence or absence of separation between fracture segments immediately after surgery did not have any correlation with the surgical outcome. All the patients with occlusal discrepancies who required further MMF had near normal occlusion with no inconsistency in their fracture stability after 2 week interval on clinical and radiological reassessment. The patients were advised to be on soft diet for 2 more weeks and thereafter progress to their regular diet.

In both the groups there were cases of unfavourable and severely displaced fractures with considerable inter-fragmentary gap, intra operatively reduction was done manually to minimise the displacement but adaptation and placement of miniplate was more difficult and time consuming when compared to grid plate which was easier and quicker. There were no significant changes noted either in alignment or occlusion with placement of grid plate where as single miniplate placement required an additional lower border wiring to reduce the displacement and MMF for 2 weeks was necessitated to correct posterior open bite. None of the patients in either group had non-union, malunion, screw loosening or plate fracture and no further surgical intervention was required.

Conclusion

Rectangular grid plates used in this study not only showed similar benefits of conventional miniplate but also satisfied biomechanical requirements for occlusal loading and preventing inferior border splaying with additional advantages of reduced operative time and fewer complications. This study was promising but had its limitations like smaller sample size and short follow up period. Comprehensive clinical prospective studies should be done to derive an effectual inference for use of these plates.

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