Comparative Analysis of Osteosynthesis of Mandibular Anterior Fractures Following Open Reduction Using ‘Stainless Steel Lag Screws and Mini Plates’

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Abstract

Introduction The purpose of this study was to compare the outcome of open treatment of mandibular fracture (symphysis or parasymphysis) using lag screw or mini plate clinically as well as radiologically in young (age range 12–45 years) and healthy individuals of poor socioeconomic status.

Method This prospective study was conducted on 30 patients diagnosed as cases of displaced mandibular anterior fractures treated with open reduction and internal fixation. The patients were then randomly allocated to either of two groups—*Group A*: Two 2.5 mm stainless steel lag screws were placed in 15 patients. *Group B*: Two 2.5 mm stainless steel mini plates were placed in 15 patients for the fixation of fractures. Subsequent follow up was done on 2nd, 4th, 6th and 8th week postoperatively. During every follow up patient was assessed clinically for infection, malocclusion, loosening of plate/screw, sensory disturbance, plate fracture, malunion/non-union, devitalisation of associated dentoalveolar segment and masticatory efficiency. Radiographs were taken if necessary and patients were further assessed for any complaint. Pain was objectively measured using a visual analogue scale, bite force was measured using a bite force transducer at biweekly interval. The data collected was subjected to unpaired *t* test and paired *t* test for statistical analysis.

Results During follow up period a significant improvement in bite force was present in both the groups, with more improvement seen in the lag screw group ($p < 0.01$). There was a significant pain reduction present in the lag screw group ($p < 0.01$) and also masticatory efficiency showed a steadier improvement in lag screw group while mini plate group patients showed a tendency to masticate only food items of medium hard consistency.

Conclusion The sample size is small to conclude lag screws are better than mini plates but the result of our study provides a basis for further studies done to conclude that the application of LAG SCREW is an effective, inexpensive, quick treatment modality to accelerate healing of fresh, displaced mandibular anterior fracture.

Keywords Mandibular anterior fracture · Lag screw · Miniplates · Bite force

Introduction

Management of trauma has always been one of the surgical subsets in which oral and maxillofacial surgeons have excelled over the years [1]. Fractures of the mandible are common. Prevalence rates reported by epidemiological studies is between 60 and 81 % [2]. Although there is a wide variance in the reported percentage of fractures of mandibular anterior region, aggregate analysis places this at 17 % of all the mandibular fractures [3].

The goal of treatment of mandible fractures should be to return the patient to a preinjury state of function and aesthetics, restore proper function by ensuring union of the fractured segments and re-establishing preinjury strength; to restore any contour defect that might arise as a result of the injury; and to prevent infection at the fracture site [4]. As with other surgical

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advances, modalities for treatment of mandibular anterior fracture have evolved based on patient need and scientific advances. Although each of the techniques of fixation of mandibular fracture offer unique advantages and disadvantages, side by side comparison of them for repair of mandibular anterior fracture do not exist in surgical literature [5].

Although comparison of biomechanical behavior do exist for angle, body, condyle fracture, the mandibular anterior fracture has not been explored much. So the purpose of the present study was to compare the outcome of osteosynthesis of mandibular anterior fracture by two different modalities of open reduction i.e., stainless steel lag screw and mini plate as in indian scenario poor socioeconomic status of patient makes them seek an economical mode of treatment. This study aims to compare the clinical and radiologic outcome of the open treatment of the less explored mandibular anterior fracture.

Material and Method

Thirty patients were included in this study and were randomly divided in two groups. The study was approved by Ethical Committee of Subharti Institute of Medical Sciences, Meerut. In group A—two 2.5 mm lag screws were placed in 15 patients and in group B—two 2.5 mm mini plates were placed in 15 patients. The thirty patients included in the study were of poor socioeconomic status, had displaced mandibular anterior fracture with no associated condylar fracture where performing osteosynthesis would have resulted in greater stability of fracture (Figs. 1, 3). Immune status was not compromised, had dentulous upper and lower arches and were highly interested for unrestricted jaw movement immediately after treatment.

The criterions assessed in the study were: pain, timing of surgery, masticatory efficiency, bite force, post operative complications if any.

Surgical Protocol

The entire surgical method consisted of the following steps—diagnostic work up, pre operative preparation of the patients, surgical technique, post operative management and follow up.

Surgical Technique

In Group A Lag screws were placed in accordance with the principles of lag screw fixation. The ideal angle of placement of the screw was between a perpendicular to the fracture and a perpendicular to the bone surface. Beveled end of 2 mm drill bit was placed 10 mm beyond the fracture line in near cortex contacting the bone, drilling was done near cortex to prepare the pilot hole, countersinking done for the screw head, then drilling through the entire bone was done with 1.5 mm drill bit to prepare the traction hole. Appropriate sized 2.5 mm screw 20 mm in length was tightened in the prepared holes and compression of fracture site was achieved by passage of screw through a larger gliding hole to a smaller traction hole on each side of the fracture. Second screw was placed in a similar fashion in the same or opposite direction to avoid rotation of the compressed fracture site.

In Group B mini plate fixation was done in accordance with the principles of mini plates placement. With a modeling pliers and levers the miniplate was adapted to the outer cortical surface at the level of the osteosynthesis line. After drilling a hole the screw was inserted and only then next hole was drilled. After that the plate was fixed with two screws on one side of the fracture and care was taken to drill the first hole in the other fragment so that optimal adaptation of fracture fragments was achieved. The drill was held perpendicular to the bone surface, an angulation of only up to 30° was done. To neutralize the torsional forces two parallel plates were used with a gap of 4–10 mm.

Fig. 1 Preoperative radiograph of left parasymphysis of mandible

The lower plate was fixed first using the bicortical screws and then the subapical plate was placed and fixed with monocortical screws. After fixation was done in both the groups IMF was released and occlusion was checked. Post operative radiographs were for both the groups were taken (Figs. 2, 4).

Measurements

Masticatory Efficiency

The food items were selected and designated as Soft, Medium and Hard according to their consistency and were recorded at each follow up visit after asking the patient.

Measurement of Bite Force

It was measured in kilograms using a bite force transducer (Fig. 1). The instrument works on the principle of levers. Results are displayed in N/mm² or Kg/cm². The measurements were taken 2nd, 4th, 6th and 8th week post operatively (Table 1).

Measurement of Pain

It was measured according to the visual analog scale and the measurements were taken preoperatively, 2nd, 4th, 8th week post operatively (Table 2).

Results

In our study at 2nd week postoperative period bite force was measured at three sites namely anterior teeth, right posterior and left posterior teeth for both the groups and more bite force

was observed in Group A (lag screw) mean = 4.137 kg/cm² for anterior teeth, mean = 6.09 kg/cm² for right posterior and mean = 6.21 kg/cm² for left posterior teeth as compared to Group B (mini plate) mean = 2.6 kg/cm² for anterior teeth, mean = 3.43 kg/cm² for right posterior and mean = 3.81 kg/cm² for left posterior teeth (Table 1). Eighth week post-operative values revealed improvement in bite force score in both the groups with more improvement score in Group A mean = 16.614 kg/cm² for anterior teeth, mean = 17.061 kg/cm² for right posterior and mean = 17.125 kg/cm² for left posterior teeth as compared to Group B mean = 11.749 kg/cm² for anterior teeth, mean = 13.0219 kg/cm² for right posterior and mean = 13.049 kg/cm² for left posterior teeth. The improvement in bite force for both the groups was found to be significant from 2nd to 8th week postoperatively. In our study there was a steady increase in bite force from second post operative to eighth post operative week unlike previous studies where there was a significant decrease in fourth and sixth post operative week which could be attributed to the fact that fracture line lies anterior to both the mental foramina.

In our study no patients were kept on MMF, so their nutritional status was maintained. Their masticatory efficiency was evaluated and a general trend towards intake of soft diet was seen in both the groups for the first two weeks. In the total healing period of 6–8 weeks patients of Group A showed a tendency towards masticating hard objects like almonds and nuts where as patients in Group B still had difficulty in chewing hard food items but were able to masticate their regular meals of vegetables and bread properly. Reduced masticatory efficiency and bite force has been also attributed to pain experienced by the patient. In our study pain score was recorded for the patient during the entire follow up period (Table 2). The pain score reduced in both the groups from the preoperative value and was statistically significant. The reduction in the pain score,

Fig. 2 Post operative OPG depicting mini plate fixation

Table 1 Showing the bite force measured on different weeks

Time period	Mean $\pm$ SD		Difference from the base value				<i>p</i> value		Significance
	A	R	L	A	R	L	A	L	
2nd week (<i>N</i> = 10)	4.137 $\pm$ 1.995	6.09 $\pm$ 1.839	6.21 $\pm$ 2.0684						<i>p</i> > 0.01 (N.S.)
4th week (<i>N</i> = 10)	8.312 $\pm$ 3.06	9.4 $\pm$ 2.987	9.47 $\pm$ 3.509	4.17 $\pm$ 2.47	3.305 $\pm$ 1.353	3.264 $\pm$ 1.9104	0.00047	0.000029	<i>p</i> < 0.01 (S)
6th week (<i>N</i> = 10)	12.09 $\pm$ 4.165	13.558 $\pm$ 4.415	13.256 $\pm$ 4.438	7.961 $\pm$ 3.698	7.463 $\pm$ 2.873	7.041 $\pm$ 3.049	<i>p</i> < 0.01	<i>p</i> < 0.01	<i>p</i> < 0.01 (S)
8th week (<i>N</i> = 10)	16.614 $\pm$ 4.537	17.061 $\pm$ 4.471	17.125 $\pm$ 4.458	12.477 $\pm$ 4.247	10.966 $\pm$ 3.238	10.91 $\pm$ 3.165	0.000094	0.000074	<i>p</i> < 0.01 (S)
							<i>p</i> < 0.01	<i>p</i> < 0.01	<i>p</i> < 0.01 (S)
							0.00015	0.000046	<i>p</i> < 0.01 (S)
							<i>p</i> < 0.01	<i>p</i> < 0.01	<i>p</i> < 0.01 (S)

increase in the masticatory efficiency and steady rise in the bite force can be attributed to the compression osteosynthesis achieved in the lag screw group i.e., Group A.

In our study only 2 out of 15 patients in both the groups had their lag screws and mini plates removed after 4 months so the removal rate of implants in both the groups remained the same (13.33 %).

In our study eight patients reported with local infection which was found related to devitalized tooth in fracture line, all the teeth were retained and infection subsided with the successful completion of endodontic treatment and infection had no relation to the type of osteosynthesis used for fracture repair.

Discussion

The goal of each of the operative treatment of mandibular fracture is to be functionally stable osteosynthesis which permits.

- Firm binding of fracture fragments.
- Quick healing without complications.
- Acceptable function and esthetics [2, 6–9].

The rigidity of direct fixation can range from a simple osteosynthesis wire across the fracture (i.e., non rigid fixation) to a mini plate at the area of fracture tension (i.e., semi rigid fixation) or a compression bone plate (i.e., rigid fixation) to compression screws alone (lag screw technique). Indirect fixation is the stabilization of the proximal and distal fragments of the bone at a site distant from the fracture line [1]. Towards the end of the 1980s, a clear change appeared in fracture treatment. In the course of this decade, the type of osteosynthesis changed from wire and miniplates to compression plates and lag screws [8]. More recently the use of internal fixation utilizing plates has shown the highest success rates with the lowest incidence of nonunions and postoperative infections. When a fracture is compressed, absolute interfragmentary immobilization is achieved with no resorption of the fragment ends, no callus formation, and intracortical remodeling across the fracture site whereby the fractured bone cortex is gradually replaced by new haversian systems. However, in other studies it has been shown that absolute rigidity and intimate fracture interdigitation is far from mandatory for adequate bony healing. Compression is not necessary at the fracture site for healing, and it is questionable whether compression stimulates osteogenesis [1]. So in our study we compared the efficacy of two load sharing type of osteosynthesis (mini plate which is a semi rigid type of fixation and lag screw which is based on compression of fractures) in management of oblique anterior mandibular fracture. The cortical bone in the chin region is thick and

Table 2 data on comparison between both groups for pain measured on different weeks

Time period	Mean $\pm$ SD		Difference from the base value		Paired <i>t</i> test
	Group A	Group B	Group A	Group B	
Pre-op (<i>N</i> = 15)	8.533 $\pm$ 1.552	8.933 $\pm$ 0.883	–	–	
2nd week (<i>N</i> = 15)	6 $\pm$ 1.647	8 $\pm$ 1.195	2.533 $\pm$ 0.915	0.933 $\pm$ 0.961	10.72 <i>p</i> < 0.01 S
4th week (<i>N</i> = 15)	4 $\pm$ 2.035	6.533 $\pm$ 1.457	4.533 $\pm$ 1.726	2.4 $\pm$ 1.298	10.18 <i>p</i> < 0.01 S
8th week (<i>N</i> = 15)	1.933 $\pm$ 2.433	5.266 $\pm$ 1.334	6.6 $\pm$ 2.229	3.666 $\pm$ 1.290	11.47 <i>p</i> < 0.01 S

provides sound anchorage for osteosynthesis screws [5, 9]. Due to the presence of torsional forces in anterior mandible [1, 5] placement of two miniplates (Figs. 2, 3) or two lag screws (Figs. 4, 5) have been recommended.

The origin of plating as a treatment option for fractures can be traced to Dannis and colleagues, who reported the successful use of plates and screws for fracture repair in 1947. Later refinement of this technique is credited to Allgower and colleagues at the University of Basel, who successfully used the first compression plate for extremity fracture repair in 1969. However, it was not until 1973 that Michelet and colleagues reported on the use of this treatment modality for fractures of the facial skeleton.

In 1976 following Michelet's success, a group of French surgeons headed by Champy developed the protocol that is now used for the modern treatment of mandibular fractures. But it was not until 1978 that these findings were published in the English literature. Miniplates (Champy type) have been used during the last decade to facilitate the stability between bony fragments in the maxillofacial region and are nowadays the preferred surgical method for the fixation of fractures and osteotomies. The advantages of miniplate use are: easy

handling, avoiding an external incision, eliminating potential nerve damage, simultaneous surveillance of fractures line reduction and occlusal relationships, eliminating the need for intermaxillary fixation and its complications.

Kallela et al. [10] in 1996 suggested that in contrast to orthopedic surgery, lag screws play a minor role in maxillofacial osteosynthesis. Lag screw was first introduced by Brons and Boering in 1970 who cautioned the use of 2 screws in the oblique fracture mandible [10]. The use of two lag screws has been advocated in mandibular symphysis fractures by Ellis et al. in 1991. Kallela et al. used lag screws in management of angle and parasymphyseal fracture of mandible and stated that use of single screws instead of plates and screws seemed likely to be associated with several advantages. Less implant material, lower costs, technique was simple (no need to bend plates), and surgical exposure was limited [10]. Similar advantages were observed in our study where less implant material and less cost made lag screws to be the chosen mode of treatment by the patient. In our study 2 drill bits were broken while drilling but were retrieved and then the fixation was carried out. In the review by various authors it has been concluded

Fig. 3 Preoperative OPG of symphysis fracture of mandible

Fig. 4 Postoperative OPG depicting lag screw fixation

that even though breakage of drill bits is problematic, it should not cause the technique to be abandoned. If one disregards the broken drill bits as an operator error, stabilization of fractures of anterior mandible by the use of compression lag screws was found to be an efficient, inexpensive and predictable method of rigid internal fixation.

Postoperative mastication is of great importance to the fracture patients. Bite force is an essential factor in mastication activity. Previous studies have reported a reduction in bite force occurring for several weeks post injury, the assumption was that the protective neuromuscular mechanisms and damage to muscles of mastication could account for this phenomena. The other findings were that loss of mandibular continuity also led to a decrease in bite force. Guaranteeing an effective method of fracture stabilization and improved fracture stability to provide a secure joint of fracture segments have an advantage of restoring bite force. Furthermore the patient's willingness to bite hard is also a major factor [11]. This is related both to mental attitude and to the comfort of the teeth, so some patients especially within the first postoperative weeks are afraid to use their jaws vigorously. Gerlach, Schwarz [12] in their study recorded the biting forces between the molars to be 90 N (9 kg/cm²) at 1 week and 148 N (14.8 kg/cm²) at 6 weeks postoperatively. They found that average biting force for each single power stroke when masticating was 16.5 N (1.65 kg/cm²) for a cracker, 22.2 N (2.2 kg/cm²) for whole-meal bread, 16.7 N (1.67 kg/cm²) for hard sausage and 34 N (3.4 kg/cm²) for bacon. However, they found an unexpected significant decrease between the 4th and 6th week [12]. One of the possible reasons for this phenomenon is the regeneration of the inferior alveolar nerve and reinnervation of the reflected periosteum with return of pain sensations. Maximal biting forces were evaluated by them in 22 patients with mandibular angle fractures treated with mini plate osteosynthesis according to Champy [12].

Similarly in our patients in the total healing period of 6–8 weeks patients of lag screw showed a tendency towards masticating hard objects like almonds and nuts coinciding with a steady rise in bite force 4.137–16.614 kg/cm² in the anterior region where as patients in mini plate group still had difficulty in chewing hard food items but were able to masticate their regular meals of vegetables and bread properly and their bite force was also less improved in comparison from 2.6 to 11.749 kg/cm² in anterior region.

Niederdehlman et al. stated that lag screw was not meant to replace osteosynthesis with plates [6]. In our study we found that it is an extremely useful supplement to plate osteosynthesis, it shortens the time of operation, reduces the pain and increases the masticatory efficiency and bite force of the patient and has a comparable complication rate.

Conclusion

In conclusion, though the sample size is less to reach to any conclusion, the results of our study suggest that the use of lag screws in the fixation of mandibular fractures can be a very demanding procedures and may not always be successfully accomplished. So one has to be prepared to abandon it and proceed to other well established technique of fixations (mini plates) if stability with lag screws is not achieved. However, for those who are adept with the instrumentation and experienced in applying the screws, the system offers an approach to fracture treatment that is very much appreciated by surgeon and the patient as well and an inexpensive way to treat mandibular fractures without the use of intermaxillary fixation. However, anterior mandible is still a less explored field so further studies need to assess the best means of internal fixation.

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