Original Article

Retrospective study of mandibular angle fractures treated with three different fixation systems

Department of Oral and Maxillofacial Surgery, Center for Dental Education and Research, All India Institute of Medical Sciences, New Delhi, India

Krushna Bhatt, Satyavrat Arya, Ongkila Bhutia, Sandeep Pandey, Ajoy Roychoudhury

ABSTRACT

Aim: To evaluate the outcomes of mandibular angle fractures treated with metal 2.0 mm locking, metal 2.0 mm nonlocking, and 2.5 mm resorbable systems. **Study Design:** Retrospective cohort study. **Materials and Methods:** Trauma records were screened for linear angle fractures treated with open-reduction and internal semi-rigid fixation with single metal/bioresorbable plates, and baseline variables were tabulated. The outcome variable was the presence or absence of any complication. **Statistical Analysis Used:** The Fisher's exact test and analysis of covariance (ANCOVA) using STATA 11. **Results:** A total of 60 case records of over four years were included. The mean age of the patients was 27.4 (SD 9.7) years. Fifty-five were male and five female. There were 20 nonlocking and 16 locking metal miniplates and 24 bioresorbable plates. In 55 (91.6%) cases there was a third molar in the fracture line. In 51/55 (92.7%) cases the third molar was retained. In seven patients postoperative complications were seen. There was no difference between the complication rates of the three treatment groups. Infection was the most common complication followed by delayed union and hardware failure. **Conclusions:** This retrospective study found no difference in the complication rate when fractures of the mandibular angle were treated with locking or nonlocking miniplates or bioresorbable plates.

Address for correspondence:
Dr. Ajoy Roychoudhury, Department of Oral and Maxillofacial Surgery, Center for Dental Education and Research, All India Institute of Medical Sciences, New Delhi - 110 029, India.
E-mail: ajoyroy@hotmail.com

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Introduction

The mandibular angle shows the maximum number of complications among all mandibular fracture sites.[1-3] The topics of discussion are, the amount of rigidity required, type of plates, surgical approaches, and third molar in the fracture line, as related to the complication rate.[4-12] The hardware can be 2.4 mm, 2.0 mm locking, 2.0 mm nonlocking metal plating systems or a 2.5 mm bioresorbable system, which has shown comparable efficacy.[13,14] The objective of this retrospective study is to evaluate the complication rate of 2.0 mm titanium locking, 2.0 mm titanium nonlocking, and 2.5 mm bioresorbable plates and screws, in the management of mandibular angle fractures.

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Materials and Methods

This was a retrospective cohort study. Trauma records of patients treated at our unit were maintained in a register. Every time a registered patient visited the unit, his data was updated. The register included demographic details, etiology and type of fracture, treatment given, complications, and notes on each follow-up visit. The register was screened for consecutive cases of mandibular linear angle fractures treated with

open-reduction and internal fixation, from 2007 to 2010. Comminuted fractures and those treated with reconstruction plates or with an extraoral surgical approach were excluded. Patients who had two miniplate fixations or those who had additional post-operation maxillomandibular fixations were also excluded. Patients with less than six months follow up/lost to follow-up were also excluded. As this was a retrospective study of the standard treatment modalities, the institute ethical clearance was exempt.

Preoperatively all the patients were placed into maxillomandibular fixation using arch bars, till open reduction and internal fixation of the fracture was performed. The period ranged from 24 to 96 hours. This was due to the logistic delays in the issue of plates and screws, operation theater slot, and the requisite investigations. All fractures were treated using either a standard intraoral approach alone or an intraoral combined with a transbuccal approach depending on the operator preference. Intraoperatively a single plate was applied either at the superior border lateral cortex or at the external oblique ridge. Plates and screws used were of 2.0 mm nonlocking, 2.0 mm locking (Synthes, GmBh, Oberdorf, Switzerland), and 2.5 mm bioresorbable (Inion, Tem-pere, Finland) systems. Selection of the type of fixation system used was governed by the availability of plates and screws from the hospital supply and operator preference. The study being a retrospective one, no randomization was done. In all but four cases, four-hole plates were used. In the other four cases six-hole plates were used. In cases with an associated second fracture line, the anterior fracture was treated with a more rigid fixation using two miniplates, with application of bicortical screws at the inferior plate. As per the unit protocol, the criteria used for removal of a tooth in the fracture line were, fractured, mobile or infected teeth, and teeth interfering with reduction. All the patients were given perioperative oral antibiotics (Amoxicillin + Clavulanate) for five days as per the unit protocol. No patient was kept on maxillomandibular fixation postoperatively. They were kept on a liquid diet for one week, gradually switching to semi-solid intake in the coming weeks. Eight weeks postoperatively all the patients were allowed to masticate, as in the pre-injury status.

The perioperative variables were age, sex, number of fracture lines, site of the second fracture, if present, type and location of the plate, number of screws, presence or absence of the third molar in the fracture-line, and whether it was removed or retained. The outcome was evaluated in two ways; either the fracture had healed uneventfully or had encountered a complication. The complications included secondary loss of reduction, delayed union, malunion, infection, and the need for plate removal surgery. Secondary loss of reduction was defined as deranged occlusion in the early postoperative period due to masticatory forces. This required maxillomandibular fixation/guiding elastics to correct the occlusion. Delayed union was defined as the presence of fracture site mobility beyond eight weeks of fixation. Malunion was evident as a malocclusion and fracture healing in a displaced position. Infection was defined as purulent discharge from the site or a need for incision and drainage. Plate removal surgeries were performed only if there was gross loosening of a screw or if the panoramic x-ray showed radiolucency around the screws, suggestive of loosening of hardware and/or infection.

The data was tabulated and analyzed using the SPSS 11 software. The Fisher's exact test was calculated for the three plating system groups versus other preoperative and intraoperative variables, and the three plating system groups versus the outcome variables. The *P* value was adjusted for a possible confounding factor using the analysis of covariance.

Results

A total of 60 case records, over four years, were included in the study. The mean age of the patients was 27.4 years (SD 9.7 years; range 15 – 56 years). Fifty-five patients were male and five were females. Out of the 60, 23 were isolated angle fractures, whereas, 37 were combined with other fractures. Out of these 37 cases, 31 had another fracture at the contralateral parasymphyseal region, two had associated ipsilateral parasymphysis fractures, three had contralateral body fractures, and one had a contralateral condyle fracture.

In 20 patients (33.3%), metal nonlocking miniplates were placed [Figure 1a-c]; in 24 patients, (40.0%) bioresorbable plating was done [Figure 2a and b]; and in 16 patients (26.7%), 2.0 mm locking plates were used [Figure 3a and b]. All the preoperative variables (age, sex, number of fracture lines/lines, and location of the second fracture line in combined fractures) were equally distributed among the three treatment groups [Table 1].

In 36 (12 metal and 24 bioresorbable) patients (60% patients) the plate was applied with the use of a transbuccal device and in 24 patients (40%) the plate was applied on the external oblique ridge via the intraoral route alone. In all but four cases, four-hole plates with two screws on either side of fracture line were used. Three cases in the nonlocking metal-plate group and one in the locking metal-plate group received six-hole plates with three screws on either side of the fracture

line. In 55 (91.6%) cases there was a third molar in the fracture line. In 51/55 (92.7%) cases the third molar was retained. Details of intraoperative variables, as distributed among the three plating groups, are given in Table 2. All the intraoperative variables were also equally distributed among the three plating groups, except for the surgical approach. All the cases with bioresorbable plate fixations were treated with an intraoral combined with transbuccal approach.

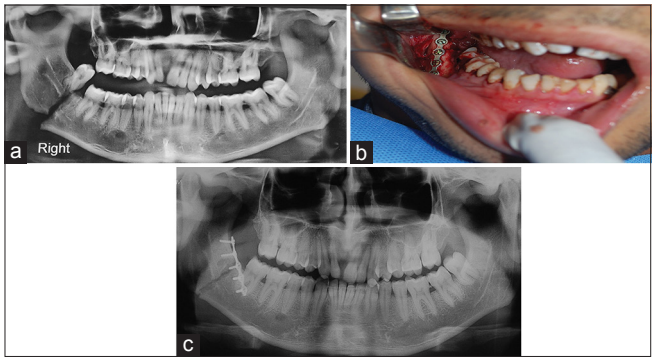

Figure 1: (a) Panoramic radiograph showing fracture of the mandibular angle (Right side); (b) nonlocking plate and screw applied on the superior border; (c) postoperative panoramic radiograph showing adequate reduction and fixation

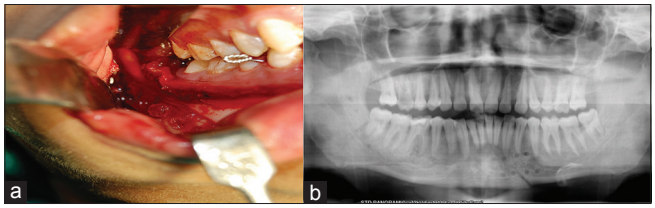

Figure 2: (a) Bioresorbable plate applied at the angle fracture; (b) postoperative orthopantomogram showing reduction and fixation, as evidenced by drill-holes across the fracture lines

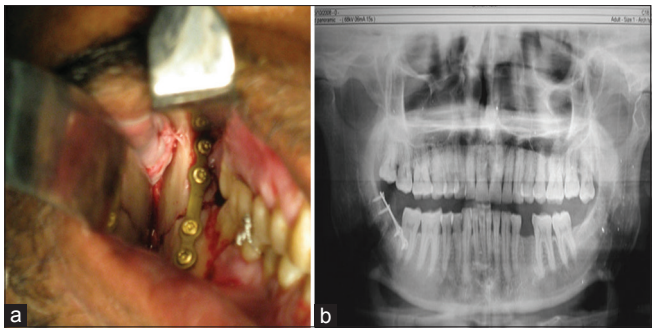

Figure 3: (a) Open reduction and internal fixation by locking plate and screw; (b) follow-up radiograph showing adequate reduction

In seven (11.6%) patients postoperative complications were noted. None of these patients had an immunocompromised status. Out of these, two were in the bioresorbable group, three in the locking metal-plate group, and two in the nonlocking metal-plate group. Two cases were isolated angle fracture cases and five were angle combined with parasymphysis fractures. Delayed union was noted in one case, which was treated with the bioresorbable system. Secondary loss of reduction and malocclusion was noted in one patient, which was treated with nonlocking metal plates. These two patients required extended maxillomandibular fixation. At the end of eight weeks all the patients had satisfactory occlusion. Infection was noted in five cases: Three in the locking metal plate group and one each in the nonlocking metal and the resorbable groups. Three metal plate removal surgeries were required, due to the infection. In the other two cases, the infection resolved with antibiotic treatment. There were two other cases in the metal group, where the hardware had to be removed on patients request. [Table 3]. In comparing the three groups for postoperative complications, there was no statistically significant difference ($P > 0.05$) [Table 4]. This result was again adjusted for an intraoperative variable of surgical approach, using the analysis of covariance, but there was no significant difference found among the complication rates of the three treatment groups. The surgical approach (solely intraoral or combined with transbuccal) or fixation with four versus six screws did not show any correlation with the occurrence of complication (P value using Fisher's exact test > 0.05). All seven complications occurred in fractures involving the third molar, but extraction (1/7) versus conservation (6/7), did not show any statistical correlation with the outcome of the complication.

Discussion

In the present study, all the three treatment groups were comparable in the perioperative variables

Table 1: Comparison of preoperative variables in the three groups

Preoperative variable	Locking 2.0 mm system (*f* %)	Nonlocking 2.0 mm system (*f* %)	Resorbable 2.5 mm system (*f* %)	*P*
Age (mean ± S.D.)	29.5 ± 10.9	26.4 ± 10.1	26.9 ± 8.6	0.56
Sex	Male: 15 (93.7)	Male: 19 (95.0)	Male: 21 (88.0)	0.72
	Female: 1 (6.3)	Female: 1 (5.0)	Female: 3 (12.0)	
Isolated fractures	4 (25.0)	8 (40.0)	11 (47.8)	0.35
Combined fractures	12 (75.0)	13 (60.0)	12 (52.2)	
Location of the	11: Parasymphysis	13: Parasymphysis	9: Parasymphysis	
other fracture line	1: Condyle		3: Body	
Total	16	20	24	

P value is given using Fisher's exact test. S.D: Standard deviation

Table 2: Comparison of intraoperative variables for the three groups

Intra-operative variables	Locking 2.0 mm system (*f* %)	Nonlocking 2.0 mm system (*f* %)	Resorbable 2.5 mm system (*f* %)	*P*
Intraoral	11 (68.7)	12 (60.0)	0 (00)	<0.001
Transbuccal	5 (31.3)	8 (40.0)	24 (100)	
Four screws	13 (81.3)	19 (95.0)	24 (100)	0.06
Six screws	3 (18.7)	1 (5.0)	0 (00)	
Third molar in line of fracture*	P: 16 (100)	P: 18 (90.0)	P: 21 (91.3)	0.43
	A: 0 (00)	A: 2 (10.0)	A: 3 (8.7)	
Third molar extraction	Ext: 3 (18.8)	Ext: 1 (5.5)	Ext: 0 (00)	0.06
Versus conservation[§]	Cons: 13 (81.2)	Cons: 17 (94.4)	Cons: 21 (100)	
Total	16	20	24	

P value is given using Fisher's exact test,*P: Third molar in line of fracture present, A: Absence of Third molar in fracture line, [§]Ext: Third molar extraction cases, Cons: Third molar conservation cases

Table 3: Details of complications in the three treatment groups

Complications	Locking 2.0 mm system (*n* = 16)	Nonlocking 2.0 mm system (*n* = 20)	Resorbable 2.5 mm system (*n* = 24)	Total (*n* = 60)
Secondary loss of reduction/malocclusion	0	1	0	1
Delayed union	0	0	1	1
Infection	3	1	1	5
Plate removal due to infection	2	1	0	3
Plate removal due to patient's will	1	1	0	2
Total cases with complications	3 (18.7%)	2 (10%)	2 (8.3%)	7 (11.6%)

Frequency of complications

Table 4: Comparison of the three groups for postoperative complications

Follow-up	Locking 2.0 (%)	Nonlocking 2.0 (%)	Resorbable 2.5 (%)	*P*
No complications	13 (81.3)	18 (90.00)	22 (91.6)	0.60
Complications	3 (18.7)	2 (10.00)	2 (8.3)	
Total	16 (100)	20 (100)	24 (100)	

P value is given using Fisher's exact test

of, age, sex distribution, number of fracture lines, number of screws applied, presence or absence of a tooth in the fracture line, and its management. The surgical techniques were similar for all the three treatment groups. Two consultants and eight residents were involved in the surgeries. As for the surgical approaches — intraoral and intraoral combined with transbuccal technique — the residents could learn both quickly. Thus, we believe that the operator bias would be small, if at all present. The study showed no statistically significant difference between the locking and nonlocking titanium miniplates, in terms of complication rates. The 2.5 mm bioresorbable system also did not show any significant difference from the metal systems in the complication rate.

In the past, there were many bench test studies in favor of more rigid fixation for the treatment of mandibular angle fractures.[4,5,15] However, the current trend is to use a single non-compression 2.0 mm miniplate, with monocortical screws at the superior border.[7,8] Within the semi-rigid fixation we have the locking and nonlocking varieties of metal miniplates and an option for bioresorbable plating also. Some studies have shown that locking plates are better in terms of maintenance of reduction, due to the leeway in adaptation of the plate, less interruption of perfusion to the bone, and reduced chances of infection.[16,17] Two issues, however, show conflicting results in the literature. (1) Do locking miniplates provide more rigidity than nonlocking miniplates of the same dimensions? (2) Do theoretical/laboratory model benefits of the locking hardware reflect significantly in the clinical scenario also? Schmelzeisen *et al.*,[18,19] reported a higher stability of locking plates in a cadaveric study and in a clinical retrospective study of 56 fractures. A biomechanical study by Haug *et al.*,[16] showed that 2.0 mm locking plates performed much better than 2.0 mm nonlocking plates when they were intentionally maladapted. In contrast to these reports, a laboratory model presented by Chiodo *et al.*,[20] showed no significant differences between the two systems. They attributed failures to bone quality and the surgical technique, rather than the type of fixation system. Even as the good performance of the locking system has been acknowledged, some other clinical studies have shown it to be just comparable to the conventional nonlocking system rather than being superior to that.[21,22] Results of the present study also show no difference in the clinical performances of the two systems. The 2.5 mm bioresorbable plates are recommended for use in the mandible. They are not available as locking plates. Reports suggest that they may be a suitable alternative to metal miniplates, for treatment of mandibular fractures.[13,14,23] Fixation with the use of bioresorbable plates is shown in [Figure 2a and b]. In a majority of the studies they have been used with one to two weeks of maxillomandibular fixation after open-reduction and internal fixation (ORIF). In the present study, they have been found to be a good alternative, even without any post-ORIF maxillomandibular fixation.

Plate bending for mediolateral application at an angle is difficult in the bioresorbable system due to the bulk of the hardware and soft tissue coverage problems.[14] Hence, all the resorbable plates are applied on the lateral surface using a transbuccal trocar. In the metal miniplates, 23 were applied on the external oblique ridge and 13 were applied on the lateral surface. The segregation of all bioresorbable cases with the transbuccal approach could act as a confounder in the final outcome of the complication rates among the treatment groups. However, no difference was found even after statistically adjusting for this factor. In the present study, it was noted that patients somehow tolerated the intraoral technique better than the transbuccal technique, as less retraction was required while operating under local anesthesia. In terms of operator ease, however, both approaches were found to be equal.

In addition to the types of fixation and surgical approaches, the third molar in the fracture line has been a topic of controversy. In the days of non-rigid wire fixation and the pre-antibiotic period, the approach to teeth in the line of fracture was to remove all such teeth.[24,25] Later on, a conservative approach for teeth in the line of fracture became prevalent. Muller[26] advocated retaining a single rooted tooth in the fracture line, but implicated multi-rooted teeth in causing infection at the fracture site. Following this, many reports have shown uncomplicated healing for mandibular angle fractures associated with erupted or impacted third molars, when the molars were retained and closed reduction was used.[27,28] Similarly, completely impacted third molars were retained in miniplate osteosynthesis, without unfavorable results. It was stated that a fully, bony, impacted third molar could facilitate the application of a tension band principle and provide a larger repositioning surface.[24] However, management philosophies for a partially or fully erupted third molar in the line of fracture had some gray areas when the treatment modality was open reduction and fixation. Wagner, *et al*.,[29] found a high complication rate when extraoral fixation of the angle fracture was carried out with extraction of the associated third molar. On the other hand, Ellis[11] and Bui, *et al*.,[30] reported a statistically insignificant difference between the complication rates of the third molar extraction versus conservation groups when the fractures were treated with ORIF intraorally.

There is a general consensus on extraction of a tooth in the fracture line, which is associated with deep caries, periapical pathology, pericoronitis, mobility or root fracture. However, at many centers a vast number of third molars in the fracture line are removed based on root surface area exposed and even when not affected by any of the above.[11,30] In our unit only the fractured, dislocated, deeply carious teeth, teeth with periapical pathology or pericoronitis, and those interfering with the reduction are removed. The remaining, partially or fully erupted non-mobile teeth in the fracture line are retained and monitored. In the present study, the third molar in the fracture line was present in 91.7% of the cases (n = 55) and 92.7% of them (n = 51) were retained. The complication rate was 12.7% for fractures with a third molar in the fracture-line. There were, however, only five cases in the study group which did not have a third molar in the fracture line and none of them developed any complication; however, due to the low numbers it is meaningless to apply any statistical test to evaluate the presence of a third molar as a risk factor for complication. A larger study by Ellis,[11] reports a 19.1% complication rate for angle fractures associated with a tooth in the fracture line and 15.8% for fractures not associated with a tooth in the fracture line. A major difference in the present study and the study by Ellis[11] is the percentage of third molars removed. In their study, 75% of the teeth in fracture line were removed, whereas, in the present study 92.7% of them were retained. In their study no statistically significant difference was found between the third molar extraction group versus conservation group.[11] In the present study, although a comparison of tooth retention versus removal groups was not possible, due to the very low number of cases in the extraction group; it could easily be seen that even with 92.7% retention of the third molars in the fracture line, the complication rate was similar to the previous studies.

In conclusion, this retrospective study found no difference in the complication rates of mandibular angle fractures treated with locking or nonlocking single 2.0 mm metal miniplates or single 2.5 mm bioresorbable plates. It found minimal complications even with retention of healthy, non-mobile third molars in the fracture line when ORIF was used. However, the study had inherent drawbacks of a retrospective study design, the sample size was small, and other confounding factors like smoking were not taken into consideration. All the bioresorbable plates were applied using a transbuccal trocar in contrast to metal-miniplates, which could be applied only intraorally as well. The study questions on the comparison of locking and nonlocking miniplates and those on metal miniplates and bioresorbable plates applied via the same approach should be separately addressed in larger prospective trials, as the question of the effect of extraction versus retention of the third molar on the complication rates.

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