Efficacy of Locking Plates & Screw System in Mandibular Fracture Surgery-A Prospective, Comparative Study

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Abstract

Objectives: The purpose of this study was to determine the efficacy of locking plates and screw system in the treatment of mandibular fracture surgery, by comparing them with the conventional system.

Patients & Methods:A protocol for selection of patients with mandibular fractures was developed. To evaluate results of this protocol, 10 patients were treated by locking plates and screw system and 10 patients were treated with the conventional system. The patients were prospectively evaluated for the duration of surgery, location of the fracture, presence of additional fractures,presence of tooth in the line of fracture,difficulties encountered during surgery,neurologic changes,post surgical occlusal relationship,adequacy of reduction and post surgical complications. Data were compared for statistical significance with T- test and Fishers exact test.

Results: There was statistically significant difference between the posterior facial height between the locking plate and screw systemand the conventional miniplate group, but no significant difference between their post treatment occlusion and interincisal maximal opening, but fewer incidence of complications in locking plate group was observed as compared to the closed group.

Conclusion: Using the locking plates and screws, we found adecreased incidence of post-operative mobility and infection. The incidence of complications was also fewer in case of locking plate group. The operative duration was however more in case of Locking plates and screws group.

Key Word: Mandibular fracture,locking plates, miniplates

Introduction

Techniques for treatment of mandibular fractures have evolved significantly in the past decade.These techniques have ranged from closed reduction with maxillo-mandibular-fixation,open reduction with wire osteosynthesisto open reduction with either rigid internal fixation or adaptive miniplate fixation.

Since the development of osteosynthesis in maxillofacial surgery, various reconstruction plate designs have improved intraoperative handling as well as postsurgical results in the management of mandibular fractures.

While the introduction of miniplates in the treatment of mandibular fracture surgery led to a notable decrease in surgical soft tissue trauma and improved ease of handling, loosening of screws due to transmission of pressure to the underlying bone leads to loss of fracture stability and fixation failure. A disadvantage of conventional bone plate /screw system is that the plate must be perfectly adapted to the underlying bone to prevent alterations in the alignment of the segments and changes in the occlusal relationship.[1]

Advantages of the locking system are the ease of plate adaptation, enhanced stability without transmitting excessive pressure to the underlying bone.[1]These plates function as internal fixators, achieving stability by locking the screw to the plate. A unique advantage to locking plate /screw systems is that it becomes unnecessary for the plate to have intimate contact with the underlying bone,making plate adaptation easier.

In the locking plate /screw system, the hole in the bone plate is so engineered so as to accept screws that lock to it by a second thread under the head of the screw. The purpose of this prospective study is to evaluate the efficacy of the locking plate and screw system.

Patients & Methods

The study was conducted on patients reporting to Department of Oral and Maxillofacial Surgery of our institution. The study group comprised of twenty individuals with mandibular fractures treated over a period of two years.

- Patients fulfilling the following criteria were included in the study-
- Individuals with mandibular fractures
- Patients aged between 16-70 years.
- Individuals with at least 6 weeks of follow up post surgery
- Patients who are medically fit to undergo surgical intervention.
- Patients consenting to participate in the study.

Patients with panfacial fractures or comminuted fractures of the mandible and coronoid,condylar or ascending ramus fracture, and with mixed dentition (below 14 years of age) were excluded from the study. Medically compromised patients and those with poor dental hygiene were also excluded.

The patients were divided into two groups:

Group I: Thosepatients who underwent osteosynthesis of the mandibular fracture by non compressionmonocorticallocking miniplate and screw system.

Group II: Those patients who underwent osteosynthesis of the mandibular fracture by conventional miniplates and screw system .

In all cases a thorough patient history was recorded to rule out significant systemic conditions that could have a bearing on patients' treatment protocol.

Detailed clinical examination was carried out as per the protocol. The face and mandible was examined for any abnormal contours. Mandibular movements were checked for any abnormalities along with recording of maximum interincisal opening. The occlusion was checked for any discrepancy. Any intraoral or extraoral lacerations were thoroughly examined and debrided prior to treatment. Any evidence of buccal and sublingual echymosis was noted.

Radiographic examination included the postero-anterior view of mandible and the orthopantogram. Pre and post treatment radiographs were taken at Department of Oral Radiology .

Non corrosive heat resistant titanium locking plates and screws ensuring good flexibility were used in this study. For the control group, 4 hole with gap titanium miniplates were used. These plates had screw holes with diameter of 2mm. Screw lengths were 8mm or 6mm depending on the thickness of the underlying bone.

In most of the cases, upper Erich arch bar and lower Ivy loops wiring was done. Manual reduction or intermaxillary elastic traction was done preoperatively to achieve maximum possible occlusion.

In case of intra oral approach, a degloving incision was given in symphysis and parasymphysisregion with No. 15 blade on Bard Parker handle No. 3. In case of extra oral approach, incision with similar surgical knife was given parallel to the lower border of mandible and at least 1 to 1.5 cm below it to prevent damage to marginal mandibular branch of the facial nerve.

In case of intra oral approach, Local infiltration was performed with xylocaine 2%, after irrigating the oral cavity with betadine. An incision was made on oral mucosa 5mm below the level of attached gingival. It was extended parallel to the alveolar process and was slightly superiorly placed near the premolar region to prevent injury to the mental nerve. The incision was made so as to provide adequateexposure of fracture site. Mucoperiosteal flap was raised. Mental nerve was separated through blunt dissection in the vicinity of mental foramina. When the nerve was found, it was freed along its main branch with fine forceps and dissection scissors.

In case of extra oral approach, after an initial skin incision, layer by layer dissection was carried out to expose the platysma muscle, which was divided and retracted upward so deep fascia becomes exposed. After incising the deep fascia blunt dissection was carried out with the help of artery forceps and dissection scissor, to expose the underlying musculature. Some muscle fibers were left attachedtobone to facilitateclosure, tissue reattachment and early vascularization. Now periosteum was cut and detached to expose the bone fragment.Fracture site was identified, and curetted with the help of curette to remove any trapped muscle, granulation tissue and blood clots. The fracture site was flushed with 5% povidine iodine followed by normal saline. The fragments were reduced manually in correct anatomical position. Occlusion was checked and temporary intermaxillary fixation done, in such a way so as to achieve the maximum apposition of the fracture fragments.

In Group I patients, locking plates and screws were used. The technique for application of the locking plates/screw system is not different than the application of any other non compression type of miniplate.the only exception is that one should use a drill guide to “center” the drill hole with the bone plate to facilitate screw locking with the plate. When applying a plate across the external oblique ridge for angle fractures, application could be facilitated by first applying one non locking screw to hold the plate to bone while the other screws were placed. After plate fixation, surgical site was copiously irrigated with 5% povidine iodine and followed by normal saline. Haemostasis was achieved and suturing was done with 3-0 vicryl& 3-0 silk in layers.

In Group II patients, following reduction, miniplates were applied along the osteosynthesis line as described by Champy. In symphyseal/ parasymphyseal fractures, two plates were placed to overcome the torsional forces. One plate is placed above the imaginary line joining the mental foramina and one below the line with a 5 mm distance betweenthe two plates. The plate below the line was placed first, followed by the plate above the line, to prevent development of diathesis at the lower border due to action of masticatory muscles. In angle region a single plate was adapted across the fracture line at external oblique ridge . The 2 mm titaniumminiplates were adapted over the surface of the mandible with the help of modeling pliers and bar modeling levers. During drilling, the adapted plate was held firmly against the bone with the plate holding forceps. The drilling was then performed by 1.5mm stainless steel drill bit perpendicular to the surface of bone. Plates were fixed with 2 × 8 mm titanium screws at symphyseal/ parasymphyseal fractures and with 2 x 6 mmtitanium screws at angle region.

Suitable antibiotic, analgesic and anti-inflammatory drugs are administered by parental route for next 72 hours then all these drugs are started as oral administration for next 3 days. Patients were kept on high caloric liquid diet and supportive vitamin therapy for 7 - 10 days.

Extra - oral wound dressing with Neosporin skin ointment and intra oral flushing with chlorhexidine 0.2% was done daily. Patient was strictly instructed to maintain oral hygiene and to abstain from any destructive oral habit. Suture removal was done on 7th post operative day. Assessment for any post - operative complication like wound dehiscence, infection or occlusal disturbance was carried out daily and before the patient was discharged from the ward.

The sutures were removed and the patients were discharged on the 8th post operative day.They were put on semi solid diet for 15 days and mouth-opening exercises. Subsequent followup was done at 1 month, 3 months, and 6 months. During each follow up, occlusion, wound healing, oral hygiene, mouth opening, as well as other complications were looked for. The required radiographs were taken and the patients were assessed for any further complaints. The plates were not routinely removed and their efficacy was judged after the follow up period.

All the patients were evaluated on the first post operative day, 1 week post operatively and after 1 month. Patients were further kept on a follow up for a period of 6 months and evaluated clinically as well as radiographically.

Occlusion was checked preoperatively and post operatively at 1 week, 1 month , 3months, and 6months interval. The fracture site was examined for signs of mobility preoperatively and post operatively at 1 week and 1 month, 3 month and 6 month interval.

Patient's complaint of post operative pain was graded as mild, moderate and severe based upon the patient's response to the 'Visual Analogue Scale'. This scale was used for the subjective assessment of the intensity or magnitude of the pain felt by the patient.
The scale consisted of a straight line of length 10 cm with verbal descriptors at each end. The scale was placed horizontally and was marked 0-10.

This linear scale had 0 signifying no pain and 10 signifying the worst pain the patient could experience.

The scale was explained thoroughly to the patient. Patients were instructed to place a mark on the line to report the intensity or magnitude of pain being experienced. Thus the subjective assessment of the degree of pain was made on a scale of 0-10.

Visual Analogue Scale

Score of 0-3 was considered mild; 4-6 moderate and 7-10 severe. Pain was noted on all the appointments post operatively.
Patients were evaluated for the presence of infection preoperatively, 1 week postoperatively and at 1 month interval, 3 month and 6month interval.

Radiographic examination was carried out for the evidence of impingement of the screw on the tooth with the help of an OPG. To rule out operator bias this assessment was done by two different observers.

The observers were asked to grade their findings as:

- No contact
- Minor contact
- Major contact

The holes were judged to have missed the tooth, if there were no signs of overlap of the

hole and the tooth root. If there was overlap, the screw was judged to have come in contact with the tooth root. The contacts were further categorized into 'Major' and 'Minor' contacts. When the overlap was seen to be more than 50%, it was categorized as a major contact and if less than 50% then as minor contact.

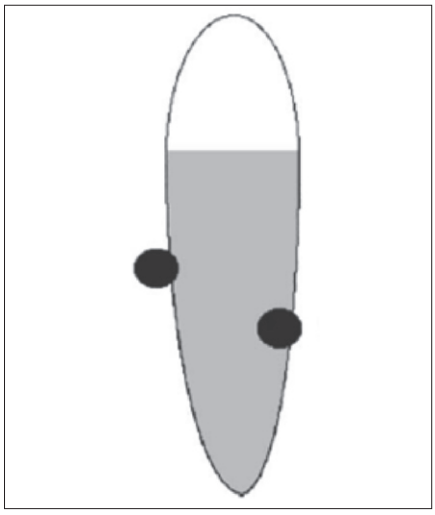


Diagram for assessment of tooth injury

Results

The present study was conducted in twenty patients having mandibular fractures. 10 patients were treated with locking titanium miniplates and screws and 10 were treated with conventional miniplates plates& screws. Twenty Eight mandibular fractures were treated in all. One patient who had a deformed mandible was treated with an ileac crest graft to recontour the inferior border of the mandible. The graft was stabilised using a locking miniplate/ screw system.

There were no intraoperative difficulties associated with the application of plates and screws. Fracture reductions were considered to be excellent in all cases.

The age of the patients included in the study ranges from 11 to 65 yrs. 2 patients (10%) were in the age group of 11-20yrs, 10 were in the age group of 21-40yrs (50%), 5 were in age group of 41-60yrs (25%), 3 were in age group of 60+yrs(15%).Maximum number of patients involved in study belonged to the age group of 21-40yrs (50%)

TABLE I: Age wise distribution of patients.

Age Group	No. of patients	Percentage
11-20 years	2	10%
21-40 years	10	50%
40-60 years	5	25%
60+ years	3	15%
Total	20	100%

15 patients (75%) were males and 5 patients (25%) were females out of the total 20 patients.Male :female ratio was 3:1.

Road traffic accidents (RTA) was found to be the most common etiological factor with 15 patients (75%).Interpersonal violence account for 3 cases (15%) and Fall accounts for 2 cases (10%).

In this study of the total 20 patients treated, Unilateral fractures accounted in 10 (50%) cases of mandible fractures and bilateral fractures accounted in 10(50%) cases. Of the bilateral fractures of the mandible, Parasymphysis with Angle fracture was most common.

In this study, 28 mandibular fractures were treated in which 12 were parasymphysisfractures which was found to be most common site of mandible fracture (42.86%) followed by 8 angle fractures (28.57%), 6 Body fractures (21.42%) and 2 symphysis fractures (7.14%).

TABLE II: Anatomical site wise distribution of the mandible fractures

Location of fracture	No. of fractures	Percentage
Symphysis	2	5.12%
Parasymphysis	12	42.86%
Body	6	21.42%
Angle	8	28.57%
Total	28	100%

Out of the 20 patients, 10 patients (50%) were operated by only the extraoral approach, 4 patients (20%) were operated by only the intraoral approach and 6 patients (30%) were operated by both intraoral and extraoral approach.Extraoral approach was used for fractures which were badly displaced and reduction was not possible intraorally.2 patients were operated under local anaesthesia

All the operated patients were kept on follow up at regular intervals of 1month, 3months, and 6months.None of these patients developedanaesthesia or paraesthesia of the inferior alveolar nerve.Healing of skin incision was found to be satisfactory in all patients.

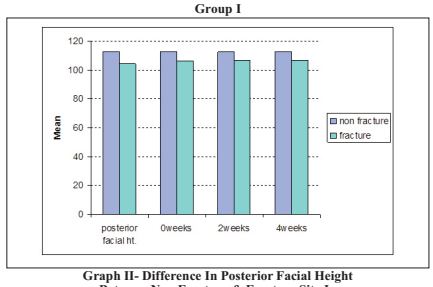
Out of 10 patients treated using conventional miniplates and screws, two patients developed plate failure and one developed subsequent infection which was treated by removal of plate and heavy antibiotics.

Two patients treated by conventional miniplates developed mild occlusal discrepancy, while one patient developedmild occlusal discrepancy when treated by locking plates.None of the patients treated by locking miniplates and screws developed post-operative infection. The significant fact was that the average working time was considerably more in locking plate system when compared to the conventional type. This was because it is absolutely essential to "center" the drill hole with the center of the bone plate to facilitate screw locking with the plate

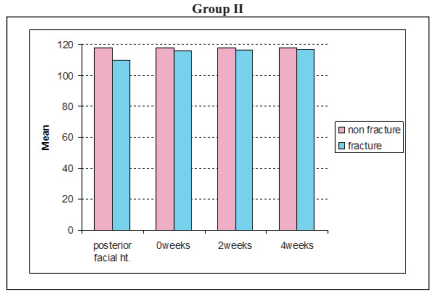
TABLE III Comparative evaluation of various parameter between locking plates & screws and conventional system

Parameter	Locking plates/ screws	Conventional
Average working time	54.2min	45.4min
Post operative Occlusal disturbance	1	2
Infection	0	1
Postoperative mobility	0	2
Postoperative pain score	Mild	Moderate
Screw loosening/ Plate fracture	0	2

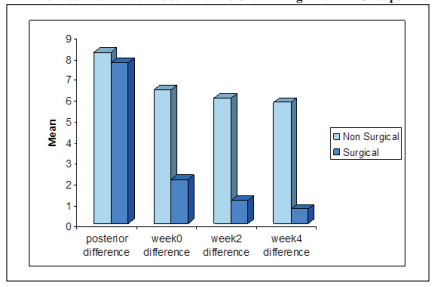
Graph I- Difference In Posterior Facial Height Between Non Fracture & Fracture Site In Group I



Graph II- Difference In Posterior Facial Height Between Non Fracture & Fracture Site In Group II



Graph III- Comparison Of Difference In Posterior Facial Height Between Non Fracture & Fracture Site Among The Two Groups



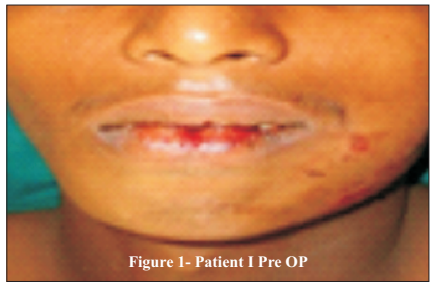


Figure 1- Patient I Pre OP

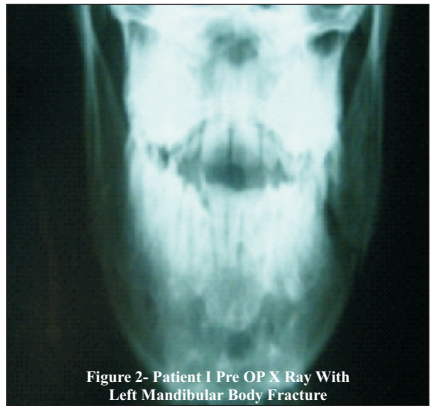


Figure 2- Patient I Pre OP X Ray With Left Mandibular Body Fracture

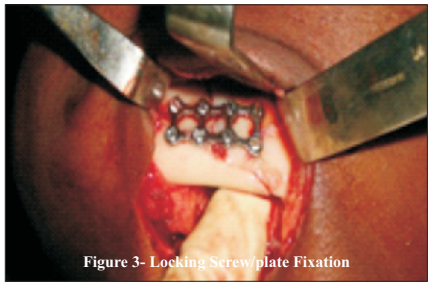


Figure 3- Locking Screw/plate Fixation

Figure 4- Patient 2 Pre Op

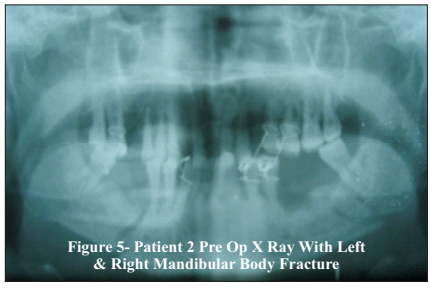


Figure 5- Patient 2 Pre Op X Ray With Left & Right Mandibular Body Fracture

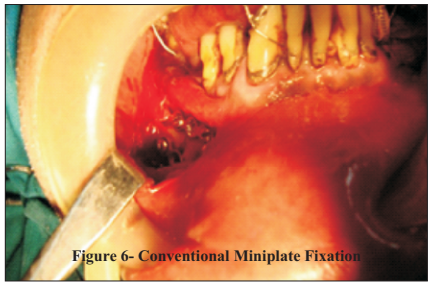


Figure 6- Conventional Miniplate Fixation

Discussion

Conventional bone plate/screw systems require precise adaptation of the plate to the underlying bone. Without this intimate contact, tightening of the screws will draw the bone segments toward the plate, resulting in alterations in the position of the osseous segments and the occlusal relationship. Locking plate/screw systems offer certain advantages over other plates in this regard; the most significant advantage may be that it becomes unnecessary for the plate to have intimate contact with the underlying bone in all areas. As the screws are tightened, they "lock" to the plate, thus stabilizing the segments without the need to compress the bone to the plate. This obviates the risk that screw insertion will alter reduction

According to Ellis & Graham[1], another theoretical advantage to the use of locking bone plate/screw systems is that the screws are unlikely to loosen from the bone plate. This means that even if a screw is inserted into a fracture gap, loosening of the screw will not occur. The possible advantage to this property of a locking plate /screw system is a decreased incidence of inflammatory complications from loosening of the hardware. It is known that loose hardware propagates an inflammatory response and promotes infection. For the hardware or a locking plate/screw system to loosen, loosening of a screw from the plate or loosening of all the screws from their bony insertions would have to occur. Both of these are unlikely events.

A study by Sauerbier et al showed good results from the UniLock 2.0 system with only 1.9% of major complications and loosening of only one screw, discovered during plate removal.[2]56mandibular fractures in 53 patients were treated with the Unilock 2.0 system. Provided the unilock 2.0 plates are inserted correctly, risk of screw loosening is minimal. In conventional systems with similar dimensions, fixation is provided by the screw thread inserted into the bone, creating a friction lock between the plate and the bone which is essential to achieve stability after the reduction. Torsional forces between the bony fragments may lead to a loss of this friction lock and result in reduced primary stability. Cordeyet al[3] stated that the friction between the screw head & plate is the main weak point of the entire fixation. In the locking plate / screw system, the thread on the screw head locks into the congruent thread of the plate,transforming the screws and plate into a unit, creating a rigid splint with higher mechanical stability.

As the human mandible shows an uneven surface, adapting conventional miniplates to the contours of the bone can compensate for such incongruities. Repeated bending may cause material fatigue and create predetermined breaking points.[4] Moreover inaccurate adaptation of conventional plates causes displacement of the mobile bony fragments when the screws are tightened and can decrease primary stability. In contrast the locking plate principle allows the mobile fragments of the bone to stay in the reduced position when tightening the screws, even if the plate is not precisely adapted. Therefore, exact plate adaptation is no longer necessary.[1] In our study, no incidence of screw loosening was reported in the locking plate/ screw system, whereas there were two incidences (20%) of screw loosening reported in the conventional system .

A third advantage to a locking screw/plate system is that the amount of stability provided across the fracture/ osteotomy gap is greater than when standard non-locking screws are used. An in vitro study by Gutwald et al has shown that a 2.0mm locking screw /plate system provides more stability to simulated mandibular fractures than does a standard 2.0mm miniplate for which the screws do not lock to the plate. In our study, no incidence of post-operative mobility was noted in the locking screw/plate system, whereas 2 incidences were noted in the conventional system.[5]

A study by Ellis & Walker subdivided complications into minor and major complications.[6] Minor complications were defined as wound dehiscence and infection,and occurred in 7.5 % of cases of the study. Half of minor complications occurred in mandibular angle fractures. This may be explained by the presence of the pterygomasseteric sling, transmitting dynamic forces to this anatomical localization. Other risk factors for the occurrence of minor complications in this study are a history of alcohol or tobacco use, concomitant facial fractures and the presence of dental infections. Major complications are considered to be specific disorders of fracture healing which require re-plating. Only one patient presented with a major complication that needed re-osteosynthesis. This complication, a plate fracture, occurred in a cerebral palsy patient with epilepsy and a reconstruction plate was placed during the surgical procedure. The incidence of major complications encountered during this study was therefore 1.9%. In our study, no postoperative infection was found in the locking plate/screw system, whereas one case reported with infection in the conventional system .

Conclusion

Irrespective of the modality of treatment used (Closed and Open) to treat the condylar fracture, the functional aspects of occlusal stability were comparable in both groups, and maximuminterincisal opening posttreatment was marginally higher in the patients treated with open method, (32.3mm and 31.3mm) whereas the chronic pain associated with maximal mouth opening persisted in patients treated conservatively, lateral movements were better in patients treated with open methods.

All patients treated were in accordance with Zide and Kent criteria, the relative indication of patients being treated by open method based on displacement of the proximal segment and their prognosis were not comparable with our results.

Using the locking plates and screws, we found a decreased incidence of post-operative mobility and infection. The incidence of complications was also fewer in case of locking plate group. The operative duration was however more in case of Locking plates and screws group.

References

References are available on request at editor@healtalkht.com