

# EVALUATION OF DYNAMIC COMPRESSION MINIPLATES IN TREATMENT OF MANDIBULAR ANGLE FRACTURES USING TROCAR

Wakuloba G<sup>1</sup> BDS, Mahallawy A<sup>2</sup> PhD, Ragab H<sup>3</sup> PhD

## Abstract:

**Introduction:** Mandibular angle fractures (MAFs) account for 23% to 42% of all mandibular fractures. The frequent involvement of the angle in mandibular fractures can be attributed to its thin cross-sectional bone area and the presence of a third molar

**Objectives:** The aim of this study was to evaluate clinically and radiologically the use of two dynamic compression miniplates in treatment of mandibular angle fractures using Trocar instrumentation

**Materials and methods:** The study was conducted on ten patients diagnosed with a single mandibular angle fracture indicated for open reduction and internal fixation. The fracture was exposed through transoral vestibular incision and reduced under general anesthesia. Third molar tooth in the fracture line was extracted. Temporary Maxillomandibular fixation was done using 26gauge stainless steel wires with arch bars. One dynamic compression miniplate was fixed on the external oblique ridge. The second miniplate was fixed on the lower border of the mandible using Trocar instrumentation.

**Results:** Pain, edema and trismus decreased significantly over the follow up period. Maximum interincisal mouth opening and bone density along the fracture line increased significantly over the follow up period. Five patients had parasthesia of the inferior alveolar and mental nerve preoperatively. The parasthesia decreased progressively from the fourth week. Postoperative panorama radiographs showed adequate reduction and increase in bone density along the fracture line. No postoperative complication occurred.

**Conclusion:** Two 2.0 mm dynamic compression miniplates are suitable for treatment of mandibular angle fractures using Trocar instrumentation.

**Key words:** Dynamic compression miniplates, mandibular angle fractures, Trocar.

1. Visiting resident, Department of Oral and Maxillofacial Surgery, Faculty of Dentistry, Alexandria University.
2. Professor of Oral and Maxillofacial Surgery, Faculty of Dentistry, Alexandria University.
3. Assistant Professor of Oral and Maxillofacial Surgery, Faculty of Dentistry, Alexandria University

## INTRODUCTION

Mandibular angle fractures (MAFs) account for 23% to 42% of all mandibular fractures (1). The frequent involvement of the angle in mandibular fractures can be attributed to its thin cross-sectional bone area and the presence of a third molar (2). The treatment of these mandibular fractures has changed dramatically in recent years. Traditional 6-week treatment of closed reduction with Maxillomandibular fixation (MMF) or open reduction with wire osteosynthesis and MMF has given way to Open Reduction and internal fixation (ORIF) osteosynthesis techniques with early mobilization and restoration of jaw function, improved airway control, nutrition, patient comfort and hygiene, and an early return to work (3). In treatment planning for a mandibular fracture, there are two schools of plate osteosynthesis, one advocating compression osteosynthesis and the other favoring the miniplate osteosynthesis (4).

The technique of rigid internal fixation was developed and popularized by Arbeitsgemeinschaft für Osteosynthesefragen (AO) in Europe in the 1970s. It showed primary bone healing under conditions of absolute stability (5). It has been shown that two segments of cortical bone brought into direct contact and fixed with absolute stability will heal without the formation of an external callus. Primary bone healing is rarely achieved with rigid fixation due to incomplete reduction of the fracture. The (AO) Swiss Association for internal fixation (ASIF) introduced the idea of axial compression into the limb fractures. As applied to the

mandible, the idea of compression osteosynthesis was fortified with dynamic compression miniplates (DCP) (4, 6). During function the balanced side of the mandible is subject to bending, which exerts tensile forces on alveolar part of the mandible (7). Rigid internal fixation must neutralize all forces (tension, compression, torsion and shearing) developed during function. Multiple fixation techniques were developed to achieve this goal including lag screw, and miniplate osteosynthesis (8).

The reduced size of miniplate system offers several advantages over the larger mandibular compression plate. Small incisions and minimal soft tissue dissection are necessary for their placement. Miniplates can be easily contoured in three dimensions. Special plate-bending pliers are used to achieve passive adaptation of the plate to the bone. Due to their small size, they will not be palpable extraorally and hence will not require a second operation for plate removal. Mini DCPs are a smaller version of the standard mandibular compression plates. The use of mini DCPs merges the principles of miniplate osteosynthesis and compression osteosynthesis (9).

Several studies have been done using conventional miniplates for fixation of the fracture of the angle of the mandible by extra oral approach (4, 10). Treatment of mandibular angle fractures by using Trocar instrumentation to fix dynamic compression mini plates offers the advantages of compression and miniplate osteosynthesis. The transbuccal technique involves the use transoral incision

for fracture reduction and Trocar instrumentation for fixation of the DCPs. This study set out to evaluate the use of two 2.0 mm DCPs in treatment of mandibular angle fractures by Trocar instrumentation.

## MATERIALS AND METHODS

This was a prospective clinical and radiographic study. It received clearance by the institutional ethics committee of the Faculty of Dentistry Alexandria University. It was conducted on patients selected from the emergency room in main Hospital-Alexandria University and treated in Oral and Maxillofacial Surgery Department. They were then followed up in the outpatient clinic.

### Patients

A sample of ten patients who met the inclusion criteria were selected purposefully and a written informed consent obtained before treatment.

### Inclusion criteria

- Patients with recent isolated fracture angle of the mandible.
- Dentate or partially edentulous.
- Adult patients with age range between 18 to 50 years old.
- Male and female patients

### Exclusion criteria

- Patients who were medically or immunologically compromised.
- Patients with comminuted fractures.
- Patients presenting with infection at the fracture site.
- Smokers

### Materials used for intervention

- 1- Trocar set (Jeil Medical Corporation, Seoul, Korea). Titanium mini dynamic compression plates and screws. (Figure 1)
- 2- Erich arch bars, 24 gauge Stainless Steel wire, and Wire cutter.
- 3- Complete Oral and Maxillofacial trauma surgical set.



**Fig. 1:** Trocar set, Titanium mini dynamic compression plates and screws.

### Preoperative Preparation

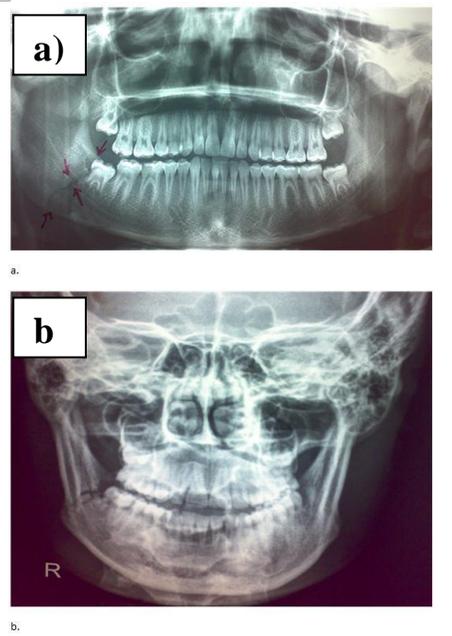
The selected patients were evaluated by taking history and conducting thorough clinical and radiographic examination. Information about events immediately after injury such as loss of consciousness, bleeding from the ear, nose, mouth or any other part of the body, emergency treatment and

medicine received was recorded. The patient's past dental and medical history including previous treatment, chronic diseases, anticoagulants, drug allergies, transfusion, smoking and alcohol use were recorded.

On extraoral inspection, presence or absence of a swelling, ecchymosis, facial asymmetry or deformity, laceration especially on the chin area, or deviation of the mandible during opening and closing of the mouth were noted. Palpation was done starting medially and proceeding laterally with the fingertips of both hands. Any step deformity, alteration in bony contour, tenderness, and bony crepitus indicated the site of fracture. Condylar movements during opening and closing of the mouth were checked to rule out dislocation or any derangement. Anterior open bite, deviation of mandible and malocclusion were checked. The degree of mouth opening was checked as well as tongue movement.

Intraorally, bimanual palpation of the buccal and lingual sulci was done for the presence of tenderness and step deformity. The area innervated by the mental nerve was checked for numbness by pricking using a sharp dental probe. The left side was compared to the right to decide presence of anaesthesia or parasthesia. Presence of blood stained saliva, lingual haematoma or ecchymosis in the buccal sulcus pointed to the likely position of the fracture. The position of the teeth thus bent, missing or filled or over erupted was noted, and then the patient was told to close the mouth in a relaxed centric occlusion to check for malocclusion.

Standard Orthopantomogram (OPG) and a Posterior Anterior (PA) radiographs were done pre-operatively (Figure 2 (a) and (b) respectively). A final diagnosis and indication for ORIF was made. Prophylactic antibiotic were administered in the form of Amoxicillin/Clavulanic acid (Augmentin 625 mg, GlaxoSmithKline, Hungary) orally three times daily for three days.



**Fig. 2:** a. Preoperative OPG x-ray,  
b. Preoperative posterior anterior view x-ray (PA)

### Operative procedure

General anesthesia was given to all patients by Nasotracheal intubation. The oral cavity was disinfected and then all the extraoral areas. The patient was draped with sterile towels. Management of the tooth in the fracture line was done according to each case. Ivy loops or arch bars were fixed to the teeth present according to the case. The fracture was exposed through intraoral extended vestibular incision which was made three to five millimeters from the mucogingival margin. A full mucoperiosteal flap was elevated and hemostasis achieved by use of diathermy. The fracture segments were reduced manually and held temporarily into perfect anatomic position in normal occlusion. MMF was secured to line up the teeth into the normal occlusion of the patient. Fixation of the fractured segment using two 2.0 mm dynamic compression miniplates was done. The first plate was placed Transorally on the external oblique ridge following Champy's line of ideal osteosynthesis (12) and fixed by use of monocortical screw. A stab incision was made perpendicular to the fracture and trocar with cannula secured in place by holding the Handle. The intraoral retractor was attached to the handle and the intraoral mucogingival flap retracted (Figure 3a).

The second miniplate was placed at the lower border of the mandible transorally. It was secured using transbuccal Trocar instrumentation to fix bicortical screws (Figure 3b). The MMF was removed and the fixation tested manually. The trocar was removed.

### Postoperative follow up

The patients were monitored for 24 hours then reviewed after one, two, four, six and twelve weeks post-operatively. Antibiotics were continued post-operatively for 5 days.

Analgesics and anti-inflammatory drug in the form of diclofenac potassium 50 mg tablets (Cataflam50 mg, Novartis company) was given three times daily for five days. Anti-edematous drug in the form of  $\alpha$ -chymotrypsin ampoules intramuscular injection ( $\alpha$ - Chymotrypsin 5 mg, Amoun, Egypt) was given once daily for three days. Pain was measured using verbal Numeric rating Scale (VNS) (13) as follows: The patient was shown a ruler labeled with numbers from zero to nine. The patients were explained the pain experience represented by each number. No pain was indicated by 0, mild pain indicated by 1, 2 and 3, moderate pain indicated by 4, 5, and 6, and severe pain indicated by 7, 8, and 9. The patients were told to point on ruler where the patient's pain experience could be. The number was recorded as level of pain experience for that day.

Edema was evaluated by using the index finger to press on the swelling as deep as possible then approximate the depth in millimeters and the time the indentation takes to return to normal. The result was recorded using a scale used in patients with edema (14) where;

- +1 (Trace) indicated slight indentation, rapid return to normal
- +2 (Mild) indicated 4 mm indentation, rebound in few seconds
- +3 (Moderate) indicated 6 mm indentation, rebound after 10-20 seconds
- +4 (Severe) indicated 8 mm indentation and needs >30

seconds to return to normal. (Figure 5)

The maximum interincisal mouth opening was measured using calipers. The intra oral incision was examined and followed up throughout the postoperative period for signs of infection including redness, tenderness and pus discharge. Sutures were removed after seven days. The stab incision healed with discernible scar (Figure 3d)

The state of occlusion was checked throughout the postoperative period to ensure the normal occlusion of the patient in terms of molar relation and midline centralization returned to the way it was before injury (Figure 3c).



**Fig. 3:** a. Trocar handle and retractor secured in place  
b. Fixation of the DCP using the Trocar on the lower border of the mandible  
c. Occlusion after six weeks  
d. Indiscernible postoperative scar

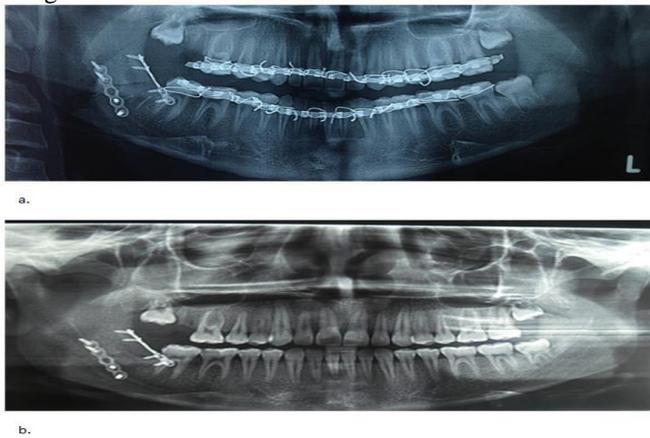
All the patients were assessed preoperatively and postoperatively for subjective symptoms related to the inferior alveolar and mental nerve by asking them about any alteration in sensation in the lower lip and the mandibular teeth on the affected side. Then objective examination of the mandibular teeth and lower lip was done using a dental probe to detect changes in the distribution of the inferior alveolar nerve compared with the contra lateral side.

Postoperative OPG x-rays (Figure 4(a) and (b)) were used to assess the mean bone density at the fracture line using image J (Java-based image processing program) (16).

This was done for each OPG view as an aid to monitor and evaluate healing fracture bone mineral density (BMD). Every postoperative OPG was studied using image J.

The collected data were analyzed using the Scientific Program for Statistical Solutions (SPSS) version 17.0 (37). Qualitative variables were described using numbers and percentages. Quantitative data were described using measures of central tendency. The distribution of Quantitative variables was tested for normality. For normally distributed data comparison between different periods using Analysis of Variance (ANOVA) with repeated measures and Post Hoc test was assessed using Bonferroni adjusted test. For ordinal data comparison between the different periods, a Wilcoxon signed rank test was applied.

Significance tests for the results are quoted as two-tailed probabilities. The obtained results were judged at 5% level of significance.



**Fig. 4:** a. Immediate postoperative OPG x-ray  
b. Postoperative OPG x-ray after 12 weeks

**RESULTS**

**Biodata**

The patients included nine males and one female. Their age ranged between 16-50 years with a mean of  $26.3 \pm 10.133$  years. The period of time that elapsed from day of injury to ORIF ranged between 1- 4 days with a mean of  $2.4 \pm 1.07$ . The age of the patients was analyzed using grouped data with an age interval of ten (10) years. Fifty percent of the patients were in the age group of 20.5 to 30.5 (Table 1).

**Table 1:** Distribution of gender, age and the period of time from injury to open reduction and internal fixation Etiological factors

	No	%
<b>Sex</b>		
Male	9	90.0
Female	1	10.0
<b>Age</b>		
<20.5	3	30.0
20.5 – 30.5	5	50.0
30.5 – 40.5	1	10.0
40.5 – 50.5	1	10.0
Min. –Max.	16.0 – 50.0	
Mean $\pm$ SD	$26.3 \pm 10.133$	
<b>Number of days before operation</b>		
Min. –Max.	1.0 – 4.0	
Mean $\pm$ SD	$2.4 \pm 1.07$	

The most common etiologic factor was road traffic accident (RTA) 40% followed closely by interpersonal violence (IPV) at 30%. Sports injuries were experienced by two patients (20%).

**Preoperative clinical findings**

Fractures of the right mandibular angle constituted 60% as compared to the left (40%). All patients presented with facial asymmetry due to swelling, trismus and tenderness on the affected side. 80% of patients had malocclusion and a tooth in the fracture line. 60% of the patients presented with mouth deviated to the affected side. 50% of the patients

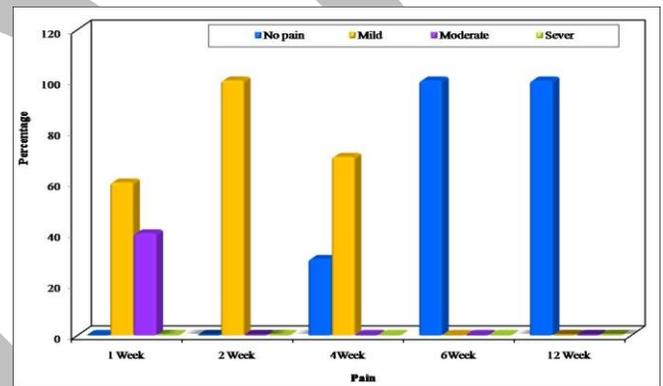
presented with inferior alveolar /mental nerve parasthesia or anaesthesia (Table 2).

**Table 2:** Preoperative clinical data

Clinical sign	No	%
Swelling/Edema	10	100
Ecchymosis	3	30
Tenderness	10	100
Mouth deviation	6	60
TMJ Pain	1	10
Crepitus	6	60
Lingual Hematoma	4	40
Malocclusion	8	80
Presence of tooth in fracture line	8	80
Parasthesia of IAN/Mental Nerve	5	50
Trismus	10	100

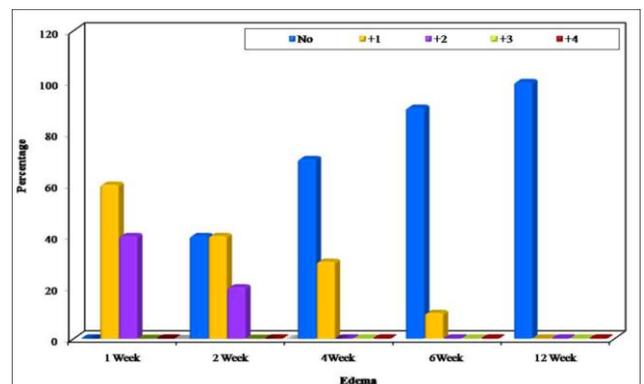
**Postoperative clinical findings**

Postoperatively pain experience decreased in all cases across the follow up period. Decreasing in pain intensity scores across the follow up period was statistically significant as P value was 0.005. ( $P \leq 0.05$ ) (Figure 5).



**Fig. 5:** Comparison of pain experience over the follow up period.

No bandage was used postoperatively to reduce edema. The edema resolved on treatment such that by the end of one week only 60% (6 cases) had mild edema. After two weeks 80% of the patients had trace levels or no edema at all. By the end of the fourth week edema had resolved in majority of the patients. By the end of twelve weeks all patients were free of swelling and facial asymmetry. Decreasing edema after one week, four weeks, six weeks and twelve weeks follow up period was found to be statistically significant as P value was 0.004 ( $P \leq 0.05$ ).(Figure 6)



**Fig. 6:** Comparison of edema over the follow up period.

The mean maximum interincisal mouth opening reduced from the preoperative level one day postoperative. Then it increased from the first week to the twelfth week in all cases. The percentage increment from the first, second, fourth, sixth to the twelfth week was 26.8%, 52.6%, 77.0%, 86.6% and 132.0% respectively. Increase in maximum interincisal mouth opening from the first week throughout the follow up period was found to be statistically significant as P values were  $\leq 0.05$  ( $P \leq 0.05$ ).

The measurements for maximum interincisal mouth opening was grouped and used to classify trismus according to scale for trismus (15). Using this scale, 60% of the cases had moderate trismus and the other (40%) had severe trismus prior to operation. One day post operation the number of patients with severe trismus increased to 60% and the other just had moderate trismus (40%). The severity of the trismus reduced during the follow up period. The decrease in trismus over the follow up period compared to the preoperative period was found to be statistically significant as P value was  $\leq 0.05$ . By the sixth week, over 80% of the patients could open their mouth more than 30.0 mm which is essentially normal. The transoral incision healed well in all cases. The skin stab incision healed uneventfully as well.

All patients maintained their normal occlusion throughout the postoperative period. Majority of the patients (90%) had Angle's class I molar relation.

Five patients were found to have inferior alveolar and mental nerve parasthesia preoperatively. No patient developed iatrogenic parasthesia postoperatively. The parasthesia progressively reduced during the follow up period and by the twelfth week only one case still had incompletely resolved parasthesia of the lower lip. The motor activity of the facial nerve was assessed on all patients pre- and postoperatively. All patients had no facial nerve abnormality.

Eight patients presented with a third molar tooth in the fracture area. All patients had the molar tooth extracted intraoperatively as was indicated in each case due to infection, communication with the mouth or severe mobility. Extraction of the third molars did not displace the fracture nor make the reduction difficult in all the cases.

**Table 3:** Comparison of differences in mean pixel densities immediately, six and twelve weeks postoperatively.

	Post-operative	6Week	12 Week
<b>Difference in pixel density</b>			
Min. -Max.	9.0 – 42.0	8.0 – 29.0	3.0 – 14.0
Mean $\pm$ SD	26.60 $\pm$ 10.06	18.20 $\pm$ 6.94	9.20 $\pm$ 3.33
Median	28.0	19.0	9.50
<b>P</b>		<0.001*	<0.001*
<b>% of change</b>		↓31.2	↓64.0

p: Stands for adjusted Bonferroni p-value for ANOVA with repeated measures for comparison between preoperative with each other period

\*: Statistically significant at  $p \leq 0.05$

The accuracy of reduction was evaluated on the OPG done immediately post- operation. The reduction was accurate in all patients. Patients were advised to use 0.2% chlorhexidine mouthwash.

The mean difference in pixel density decreased in all radiographs. The decrease in mean difference in pixel density from immediate postoperative, six weeks and twelve weeks was found to be statistically significant with a p value of 0.001 ( $P \leq 0.05$ ) (Table 3)

## DISCUSSION

There are two ways of miniplate osteosynthesis in treatment of mandibular angle fractures using the intraoral incision. It can either be a single non-compression miniplate technique proposed by Michelet et al (18) and supported by Champy et al (12) or two miniplates as proposed by Kroon et al (19), Choi et al (20) and Levy et al (21). This study set out to evaluate the use of two 2.0mm dynamic compression miniplates in treatment of mandibular angle fractures using Trocar instrumentation. Majority of the patients were males (90%). The age ranged from 16 to 50 years with a mean of 26.3 years. Fifty percent (50%) of the patients were aged between 20.5 and 30.5 years. This result was in agreement with other studies by Gamal Eldin (2014) (22). The high incidence of fractures in this age group is associated with the high population of young people in Egypt who are the most active.

The mean waiting time before ORIF was 2.4 $\pm$  1.07 days with a range of 1 to 4 days. This period was used for stabilization of the patients from trauma and reduction of edema. This result is in agreement with Ellis E III and Karas (1992) in their study on the treatment of MAFs using two 2.0mm minidynamic compression plates. They reported that the time from injury to open reduction and internal fixation ranged between a few hours to 7 days, with a mean of 2.5 days (23).

In this study, road traffic accident (RTA) was the main etiological factor (40%) followed closely by interpersonal violence (IPV) at (30%). The other factor was sports activities and a fall. This result is in agreement with many studies which show RTA as the main etiological factor of mandibular fractures in adults followed by interpersonal violence (24). However it differs with other studies that have found interpersonal violence (IPV) as the main cause of MAFs. Terfre et al (1991) (25) found that the etiology of maxillofacial fractures vary markedly from one country to another and even within the same country but RTAs were the main etiology. Kellman et al (2003) (26) found that the most common cause of mandibular angle fracture was assault (n = 47 [69.1%]), followed by motor vehicle crashes (16.2%) and sports-related injuries (10.3%).

Preoperative antibiotics were given to all patients. This was in agreement with the findings of Zallen and Curry (1975) (17), who showed that dentate patients with compound fractures who receive antibiotic prior to ORIF resulted in a low (6%) infection rate compared to high (50%) for those who do not use preoperative antibiotics. In this study, no postoperative infection occurred.

In this study two, 2.0 mm mini DCPs were used on each

patient. One was placed on the external oblique ridge. The other was fixed on the lower border and fixed after reduction of the fracture to anatomical alignment and securing MMF. Mishira et al (1998) (27) found the use of two DCPs to give good anatomic reduction of the MAF segments and allowed full range of mandibular movement. Therefore, this technique followed the AO/ASIF principles by providing rigid fixation and stimulating primary bone healing.

The third molar tooth in the area of fracture was extracted intraoperatively due to different indications for each case. This was in agreement with Shetty et al (28) and Ellis III (2009) (29).

All the patients were reviewed after every two weeks postoperatively for twelve weeks. Pain, edema, trismus, occlusion, surgical incision, parasthesia, and occurrence of infection were evaluated.

The mean pain intensity score decreased from mild pain in the first week to no pain by the sixth week. The decrease was experienced by all patients and can be explained by the proper reduction and fixation done that was rigid enough not to allow interfragmentary mobility. Furthermore, the soft tissue injury was minimal.

Regarding edema, by the first week 60% of the patients had mild edema and the rest had trace amounts. The edema decreased significantly such that by the sixth week 80% of the patients had no edema at all. The decrease in edema reflected the degree of soft tissue manipulation as significantly less traumatic. This is in agreement with the study done by Kale et al (2010) (30)

Maximum interincisal mouth opening (MIMO) was used to classify trismus into severe, moderate, mild and normal (15). Majority of the patients had moderate to severe trismus preoperatively ( $MIMO \leq 30mm$ ). The trismus decreased significantly during the postoperative weeks so that by the sixth week majority (80%) of the patients just had mild trismus ( $30mm \leq MIMO \leq 45mm$ ).

Majority of the patients (90%) had class I molar relation. One patient had class III molar relation. MMF was done intraoperatively before ORIF in all cases. No patient remained with MMF postoperatively. All patients maintained normal occlusion throughout the follow up period. Maintaining normal occlusion postoperatively was attributed to the strength and stability of the two dynamic compression miniplates against the forces of mandibular movement. This was in agreement with the finding of Ellis III (1999) (31).

The inferior alveolar nerve was evaluated preoperatively and postoperatively. 50% of the patients were found to have parasthesia preoperatively. No incidence of iatrogenic sensory disturbance was found postoperatively for those who did not have prior to ORIF. The parasthesia decreased progressively so that by the twelfth week only one patient still had parasthesia of the mental nerve. Parasthesia due inferior alveolar nerve is attributed to displacement of bony fragments after trauma rather than the surgery itself. Most are neuropraxias which heal completely. The same result was reported by Rahpeyma et al (2014) (32). No incidence of postoperative marginal mandibular nerve disturbance occurred in all the cases. The technique used to

determine the zone for placement of the Trocar differed with the one proposed by Guilse et al in (2012) (33). They reported the safety zone as the region made by three lines at the angle of the mandible. In our study we made the skin puncture perpendicular to the fracture in the relaxed skin crease.

In this study fracture healing was evaluated radiographically by taking digital panoramic images of the patients immediately, six and twelve weeks postoperatively. The images were analyzed using image J computer program for pixel density at the fracture line compared the differences with an equal sized area adjacent to the fracture line.

In this study, the preoperative OPG was the baseline. The pixel density at the fracture line was found to increase progressively from one day to twelve weeks postoperative. This was shown by the progressive decrease in mean difference in pixel density over the follow up period. This was in agreement with Dobljar et al (2004) (34) on primary bone healing.

In this study, no patient showed any complication during the follow up period. This could be attributed to the small sample size ( $n=10$ ), strict inclusion and exclusion criteria, good reduction and fixation by dynamic compression miniplates.

These results are in disagreement with studies done by Ellis and Karas (1992) (23) and Ellis and Walker (1996) (35). Both studies reported the complication as 29% and 16% respectively

However, the results of this study are in agreement with Kale et al (2010) (30) who found the transbuccal technique to be superior to the extraoral approach.

Compressive fixation systems are biomechanically superior to adaptive systems and provide good immediate functional stability to reduce mandibular angle fractures. In this study dynamic compression miniplates were used to provide the compression, fixation and good stability of the fractured bone. This result is in agreement with the findings of Shetty V et al (1995) (36)

In this study we found the combined transbuccal instrumentation with intra-oral incision technique to be safe and effective. Furthermore, the technique provided good reduction and fixation without any mobility at the fracture line. There was no visible scar on the skin and no injury to the marginal mandibular nerve.

## CONCLUSIONS

1. Two 2.0 mm dynamic compression miniplates are suitable for treatment of mandibular angle fractures using Trocar instrumentation.
2. The use of Trocar instrumentation in management of mandibular angle fractures is a suitable technique for healing because there was no extraoral scar as happens in submandibular approach.
3. Bone and soft tissue healing was found to be acceptable.
4. The difficulties experienced in the use of Trocar instrumentation are acceptable in comparison to the complications that can occur in using extra oral submandibular technique.

## CONFLICT OF INTEREST

The authors declare that they have no conflicts of interest.

## REFERENCES

- Schierle HP, Schmelzeisen R, Rahn B, Pytlik C. One- or two-plate fixation of mandibular angle fractures? *J Craniomaxillofac Surg* 1997; 25: 162- 8.
- Safdar N, Meechan JG. Relationship between fractures of the mandibular angle and the presence and state of eruption of the lower third molar. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 1995; 79: 680-4.
- Sorel B. Open versus closed reduction of mandible fractures. *Oral Maxillofac Surg Clin North Am* 1998; 10: 553.
- Lee JK. Angled eccentric osteosynthesis, a new technique for simple mandibular fracture. *Surgical Techniques Development* 2011; 1: 1-2.
- Mehra P, Van Heukeloom E, Cottrel DA. Rigid internal fixation of infected mandibular fracture. *J Oral Maxillofac Surg* 2009; 67: 1046-51.
- Scolozzi P, Ritchre M. Treatment of severe mandibular fracture using AO reconstruction plates. *J Oral Maxillofac Surg* 2003; 61: 458-61.
- Hylander WL. Mandibular function in Galago crassicaudatus and Macaca fascicularis: an in vivo approach to stress analysis of the mandible. *J Morphol* 1979; 159: 253-96.
- Lovald ST, Wanger JD, Baack B. Biomechanical optimization of bone plates used in rigid fixation of mandibular fracture. *J Oral Maxillofac Surg* 2009; 67: 1046-51.
- Ward BB, Edward SP, Feinberg SE. Healing of Traumatic Injury. In: Walker F, Powers BB. *Oral and Maxillofacial Trauma*. 3rd ed. Ch. 39. USA: Elsevier Saunders, 2005. 1140-48.
- Ellis E, Gltali GE. Lag screw fixation of anterior mandibular fracture. *J Oral Maxillofac Surg* 1991; 49: 13-21.
- Wan K, Williamson RA, Gebauer D, Hird K. Open reduction and internal fixation of mandibular angle fractures: does the transbuccal technique produce fewer complications after treatment than the transoral technique? *J Oral Maxillofac Surg* 2012; 70: 2620-8.
- Champy M, Loddé JP, Schmitt R, Jaeger JH, Muster D. Mandibular osteosynthesis by miniature screwed plates via a buccal approach. *J Maxillofac Surg* 1978; 6: 14-21.
- Numerical Rating Pain Scale. 2009. Available at: <http://pain.about.com/od/testingdiagnosis/ig/pain-scales/Numerical-Scale.htm>.
- Kindermann M, Meyer T, Kindermann W, Nickenin G. Exercise training in heart failure. *Herz* 2003; 28: 153-65.
- Rieder CE. Maximum mandibular opening in patients with and without a history of TMJ dysfunction. *J Prosthet Dent* 1978; 39: 441-6.
- Jensen, John R., and Kalmesh Lulla. "Introductory digital image processing: a remote sensing perspective." (1987): 65-65.
- Zallen RD, Curry JT. A study of antibiotic usage in compound mandibular fractures. *J Oral Surg* 1975; 33(6): 431-4.
- Michelet FX, Deymes J, Dessus B. Osteosynthesis with miniaturized screwed plates in maxillofacial surgery. *J Maxillofac Surg* 1973; 1(2): 79-84.
- Kroon F, Mathisson M, Cordey J, Rahn B. The use of miniplates in mandibular fractures. *J Craniomaxillofac Surg*. 1991; 19: 199-204.
- Choi BH, Yoo JH, Kim KN, Kang HS. Stability testing of a two miniplate fixation technique for mandibular angle fractures: an in vitro study. *J Craniomaxillofac Surg* 1995; 23: 123-5.
- Levy F, Smith R, Odland R, Marentette L. Monocortical miniplate fixation of mandibular angle fractures. *Arch Otolaryngol Head Neck Surg* 1991; 117: 149-54.
- Gamal Eldin E. The use of minidynamic compression plates in the treatment of fractures of the tooth bearing area. Thesis submitted for Master Degree in Oral Surgery, Alexandria University 2014.
- Ellis E, Karas N. Treatment of mandibular angle fractures using two mini dynamic compression plates. *J Oral Maxillofac Surg* 1992; 50: 958-63.
- Zakar K, Farag IA, Zeitoun IM. Review of 509 mandibular fractures treated at the University Hospital, Alexandria, Egypt. *Br J Oral Maxillofac surg* 2006; 44: 107-11.
- Telfer MR, Jones GM, Shepherd JP. Trends in the etiology of maxillofacial fractures in the United Kingdom. *Br J Oral Maxillofac Surg* 1991; 29: 250-5.
- Kellman MR, Fox JA. Mandibular Angle Fractures: Two-Miniplate Fixation and Complications. *Arch Facial Plast Surg* 2003; 5: 464-9.
- Mishra GS. Use of dynamic compression plates in rigid internal fixation of mandibular fractures. *Indian J of Otolaryngol Head and Neck Surg* 1998; 50: 326-32.
- Shetty V, Freymiller E. Teeth in the line of fracture: a review. *J Oral Maxillofac Surg* 1989;47:1303-6.
- Ellis III. Management of fractures through the angle of the mandible. *Oral Maxillofacial Surg Clin N Am* 2009; 21: 163-74.
- Kale PT, Baliga SD, Ahuja N, Kotrasheti SM.A comparison between transbuccal and extraoral approaches in treatment of mandibular angle fractures. *J Maxillofac Oral Surg* 2010; 9: 9-12.
- Ellis E 3rd. Treatment methods for fractures of mandibular angle. *Int J Oral Maxillofac Surg* 1999; 28: 243-52.
- Rahpeyma A, Khajehahmadi S, Bakhori Mehni S. Treatment of Mandibular Fractures by Two Perpendicular Mini-Plates Iran . *J otolaryngol* 2014; 26: 31-6.
- Gulses A, Kilic C, Sencimen M. Determination of a safety zone for transbuccal trocar placement: an anatomical study. *Int J Oral Maxillofac Surg* 2012; 41: 930-3.
- Doblar M, Garcia JM. Modelling bone tissue fracture and healing. *Omez Engine Frac Mech* 2004; 71: 1809-10.
- Ellis E, 3rd, Walker LR. Treatment of mandibular angle fractures using one noncompression miniplate. *J Oral Maxillofac Surg* 1996; 54: 864-71.

36. Shetty V, McBrearty D, Fourney M, Caputo A. Fracture line stability as a function of the internal fixation system: An in vitro comparison using a mandibular angle fracture model *Journal of Oral and Maxillofacial Surgery* .1995;53:791–801.
37. Green SB, Salkind NJ. *Using SPSS for Windows and Macintosh: Analyzing and understanding data*. Prentice Hall Press, 2010.

AJD