MAXILLOMANDIBULAR FIXATION USING ORTHODONTIC MINI-IMPLANTS IN MANAGEMENT OF MANDIBULAR FRACTURES

Mohamed M. Shokry[1], Riham M. Eldibany[2]

ABSTRACT

INTRODUCTION: The use of intermaxillary fixation (IMF) in the treatment of maxillofacial trauma represents the cornerstone of fracture reduction and immobilization. Many modalities of IMF have been described. Recently, to overcome the cumbersome procedure of tooth borne appliances, mini-implants have been introduced into clinical practice.
OBJECTIVES: To evaluate the effectiveness of using mini-implants for IMF for the treatment of mandibular fractures.
MATERIALS AND METHODS: This clinical trial was performed on ten patients with mandibular fractures. The diagnosis, duration of IMF, mini-implants site, bite force recovery, bone density around the fracture line and any associated complications were recorded. Clinical and radiographic follow-up examinations were performed immediately, 3 and 6 months post-operatively until fracture healing was complete.
CONCLUSIONS: The use of mini-implants for IMF has shown to be a useful and safe modality to establish maxillo-mandibular fixation following mandibular fractures.
KEYWORDS: Intermaxillary Fixation, Maxillo-mandibular fixation, Mini-implants, Mandibular Fracture

1- Assist. Prof. of Oral and Maxillofacial Surgery, Faculty of Dentistry, Beirut Arab University, Lebanon and Lecturer of Oral & Maxillofacial Surgery, Faculty of Dentistry, Alexandria University, Egypt.
2- Professor of Oral & Maxillofacial Surgery, Faculty of Dentistry, Alexandria University, Egypt

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INTRODUCTION

The mandible is the second most commonly fractured part of the maxillofacial skeleton because of its position and prominence (1,2). Injury to the maxillofacial skeleton may be caused by a variety of mechanisms and causes which includes motor vehicle accident, interpersonal violence, work related incidents, sporting accidents and falls. The type of fracture produced following an injury depends on the age of the patient and is affected by the direction and magnitude of the force (1-3).

Maxillo-mandibular fixation (MMF) is regarded as the crucial step in the management of maxillofacial trauma since it secures the interrelationship of the occlusal surfaces, which is the absolute essential step in reduction of fragments in both jaws (4).

The introduction of bone plating system has reduced the prolonged periods of MMF. However, there is a need for temporary MMF intra-operatively to assist in reduction of fractures with the teeth in correct occlusion and post operatively to assist in fixation or to correct minor occlusal discrepancies (5).

Different methods have been used for MMF including arch bars, dental and interdental wiring, metallic and nonmetallic splints. However tooth borne devices are always associated with problems like poor oral hygiene, periodontal health, extrusion of teeth, loss of tooth vitality, traumatic ulcer of buccal and labial mucosa and wire stick injury to the operator. Besides this, the procedure is time consuming. It is also not suitable in patients having multiple missing teeth, grossly carious teeth, crown and bridge work, extensively restored and periodontally weakened teeth (6, 7).

Nowadays, these traditional techniques are challenged by cortical bone screws inserted into the alveolar process of the mandible and maxilla, providing anchor points for MMF linkage with specialized screw heads. The increasingly popular usage of conventional bone screws with the heads kept at 4 to 5 mm above the mucosa or bone level paved the way for the commercial manufacturing of explicitly designed self-tapping or self-drilling MMF screws during recent years (4).

Orthodontic mini-implants for skeletal anchorage are becoming increasingly more common in clinical practice (5, 6). Clinical reports demonstrate the viability of using mini-implants for skeletal anchorage to support a variety of orthodontic tooth movement (8-14).

In the light of the above information, the objective of this study was to evaluate both clinically and radiographically the use of orthodontic mini-implants as an alternative technique to achieve MMF in mandibular fractures.

MATERIALS AND METHODS

Patients

This study has been carried as a clinical trial, in which ten patients with isolated mandibular fractures who attended the Oral and Maxillofacial Surgery Department, Faculty of Dentistry, Alexandria University, were selected to participate in this study. The selection was based on the following criteria: 1) patients of either gender, aged 20 years or more, non-smoker, non-alcoholic, and non-substance or intravenous drug abuser; 2) fracture involving the body, symphysis or parasymphysis of the mandible with sufficient occluding teeth present on either side of the fracture; 3) no infection at the fracture site; 4) patients with comminuted mandible or alveolar fractures were excluded, and 5) no systemic problems. This study was approved by the institutional ethical committee, and an informed consent was obtained from the patients before their inclusion in the study.

Orthodontic Mini-implants

Forty orthodontic mini-implants (Vectortas™ Ormco Corporation, West Collins, Orange, CA, USA) having a diameter of 2 mm and a length of 10-12 mm, were used in this study. These mini-implants have the following characteristics: (fig. 1 a-b)

- They are made of titanium for maximum strength and biocompatibility.
- They are self-drilling inserted using a screwdriver. This eliminates overheating of the surrounding bone during the drilling process and results in higher insertion torques than the pre-drilling method which can lead to greater primary stability and success rates as a result of increased bone-to-implant contact ratio.
- They have patented double-delta head to hold the wire away from the mucosa for greater comfort and treatment flexibility.
- They have eyelets for effective indirect anchorage ligation.
- They have a circumferential groove on the surface of the head to accommodate elastics or wires.
- Tissue-suppression stops to prevent tissue overgrowth.

Figure (1): a- Orthodontic mini-implant
b- Screwdriver used to self-drill the mini-implant

Methods

Pre-operative phase

Routine clinical and radiographic examinations were performed to locate the fracture line, determine the degree and direction of the displacement, to ensure the presence of good general condition of the teeth and periodontium, and the presence or absence of mobility in the fracture area. A standardized orthopantomogram was performed for all patients (fig. 2); they were also used for visualization and pre-operative planning of mini-implants placement, thus minimizing the possibility of their insertion into important anatomic structures or into the roots of the teeth.

Operative phase

Nasoendotracheal intubation with general anesthesia was initiated. Appropriate dental extractions were performed on grossly carious or decayed teeth in the fracture line, devitalized teeth with root fractures, and subtotally avulsed teeth. Stable teeth within the fracture line were preserved. Intraoral incision sites were infiltrated with lidocaine hydrochloride, 1%, with 1:100 000 epinephrine.

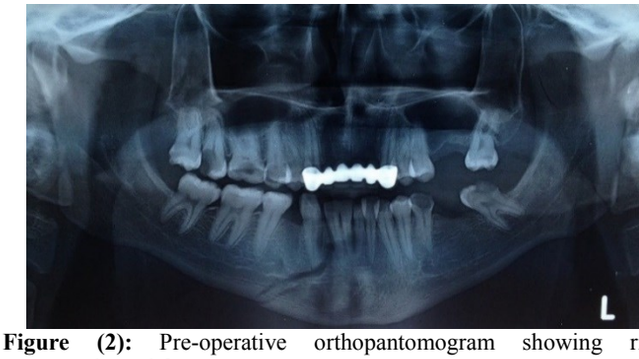

Figure (2): Pre-operative orthopantomogram showing right parasymphyseal fracture.

To achieve proper occlusion, an orthodontic mini-implant was inserted between each canine and first premolar in a self-drilling manner using a screwdriver. The mini-implant was placed just beyond the junction where the attached gingiva reflects to become the labial mucosa. They were inserted in a self-drilling manner until enough monocortical bone has been engaged for stable insertion. This is performed in all 4 quadrants. Because the screws are inserted beyond the teeth roots and are mesial to the mental foramen, tooth root damage and inferior alveolar nerve injury are avoided. A 0.5 mm wire was passed through the holes in the screw heads on each side, maxillary to mandibular, and twisted to achieve intermaxillary fixation. Another wire was passed circumferentially surrounding the implants´ heads in an X pattern and twisted to increase the stability of the MMF (fig. 3). Open reduction and internal fixation was then performed using only one 2 mm miniplates with monocortical screws (KLS Martin, Germany). The time for placing the MMF was recorded, as well as the occurrence of any complication during surgery.

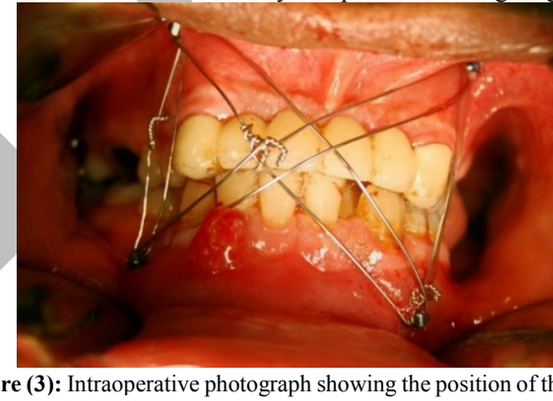

Figure (3): Intraoperative photograph showing the position of the mini-implants and MMF

Post-operative phase

Postoperative care included a soft diet for 42 days, a strict oral hygiene regimen, and regular evaluations every week for the first month, then at 3 and 6 months' intervals. The orthodontics mini-implants and the IMF were removed after 6 weeks from the operation under local anesthesia after being sure about the appropriate reduction and healing of the fracture. The follow-up parameters considered were, both clinical and radiographic. The clinical parameters included the assessment of proper occlusion and normal jaw movement, stability of fractured segments, absence of post-operative complications and bite force recovery. On the other hand, the radiographic evaluation criteria included; the assessment of proper bone alignment and the disappearance of fracture line.

Measurement of the bite force recovery

The bite force recovery was measured by Pressure Indicating Film (Pressurex®, Sensor Products INC, New Jersey, USA) at

the day of IMF removal (6 weeks); this reading was served as a baseline reading then two weeks later (2 months post-surgery) then at 3 and 6 months. The pressure indicating films are Mylar based films that contain a layer of tiny microcapsules. The application of force upon the film causes the microcapsules to rupture, producing an instantaneous and permanent high resolution "topographical" image of pressure variation across the contact area. The film was placed between the maxillary and mandibular teeth and patients were instructed to bite as hard as possible for 5 seconds with heads held up in an upright position.

In order to determine the force applied across the Pressure indicating film, the following steps were followed: The processed pressure indicating Films & color calibration swatch were scanned. Photoshop CS2 program (Adobe® Photoshop® CS2, Version 9, USA) was used to get the color density on the film and correlate it with the color swatch to determine the amount of pressure applied over the film, the surface area of the exposed points was measured by matching the number of pixels to a known surface area, the force was determined as: Force = Pressure × Surface area, and the force on each tooth was calculated as the sum of force on the tooth (fig. 4 a-d).

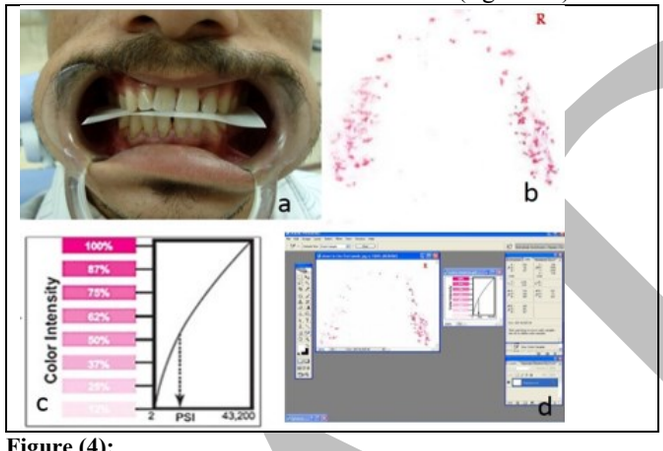

Figure (4):

a- Pressure indicating film placed between maxillary and mandibular teeth
b- The scanned pressure indicating film
c- The color swatch
d- Measuring the color density using the Photoshop CS2

Measurement of the bone density within the fracture line

Image J software (Image J software, version 1.42 image processing and analysis in Java http://rsbweb.nih.gov/ij/) was used to evaluate radiographic bone density within a selected standardized area around the fracture on the orthopantomogram throughout the follow-up period extending till 6 months post-surgically.

Measurements were taken as follows:

- From the area of selection tools on the tool bar, the rectangular selection tool was used to specify the area.
- A standardized square with a dimension area (33*33 pixels) was made just in the centre of the fracture line along the lower border of the mandible including an area of the mandibular bone mesial and distal to the fracture line.
- The status bar gives the location of the selection (xxx,yyy) and its dimensions in pixels.
- The ROI (region of interest) manager, which is a tool supplied by the software for working with multiple area selection, was used to add the selected area (current ROI) to the list and saved as files.
- The selection was measured by using the measure tool which was expressed in numbers from 0 (darkest) to 255 (lightest) that represent the brightness level of any individual pixel stored in the file.
- Descriptive statistics were calculated as mean and standard deviation of bone density in pixel line, immediately post-operative, at 3 months and at 6 months post-operatively.
- The mean, standard deviation, minimum and maximum readings were automatically displayed by the system.

STATISTICAL ANALYSIS

The variables included in this study were tested for normality using Kolmogorov-Smirnov test. Because the data were normally distributed; paired t-test was used to compare between results among the different follow-up periods. Significance level was set at the 5% level. Data were statistically analyzed with SPSS statistical software version 20.0 (SPSS, Chicago, IL). Complications in terms of infection, wound dehiscence, malocclusion, delayed union (mobility at the fracture site after 6 weeks of treatment), nonunion (presence of mobility after 6 months of treatment) and evidence of screw damaged roots on the postoperative orthopantomogram were recorded.

RESULTS

Clinical follow-up

This study was performed on six males and four females with a mean age of 27± 2.89 years (fig. 5 a). Six patients had mandibular body fractures, one patient had parasymphyseal fracture, one had symphyseal fracture and two patients had bilateral body fractures (fig. 5 b). The average time for placing the mini-implants and MMF was 14.3 minutes (range: 7.5 – 16.2 minutes). There were no complications associated with the placement of the mini-implants or any incident of gloves puncture with the wire.

All the fractures healed uneventfully with no post-operative complications.

Bite force recovery

Bite force measurement was calculated and averaged at the anterior region, the premolar region (right & left) and the molar region (right & left) (tables 1 – 4).

The mean bite force in Newton was recovered and increased steadily among all the studied areas from baseline which was set to be the day of IMF removal (6 weeks post-operatively) till the end of follow-up period at 6 months. The increase in bite force was statistically insignificant throughout the whole follow up periods along the studied regions, however when comparing the mean bite force at six months with the baseline readings a statically significant increase was observed ($p<0.05$).

The mean percentage change was used for the assessment of the recovery of the bite force; by this method the gradual increase in bite force was easily noticed (Table 5 & fig.6).

Radiographic follow-up

Absence of roots injury and proper segments alignment were detected in all patients throughout the follow-up period; immediately post-operative, and on the 3rd and 6th months post-operatively. Moreover, the progression of fracture healing for cases involved in this study was evaluated through the calculation of bone density within the fracture line at the follow up intervals. As for bone density, it was noted that it increased throughout the whole follow up period. This increase was statistically insignificant. The increase in the level of bone density throughout the follow-up periods indicates the adequate stability of the bony segments throughout the follow up period and the bony healing along the fracture line (fig.7, 8 a-c).

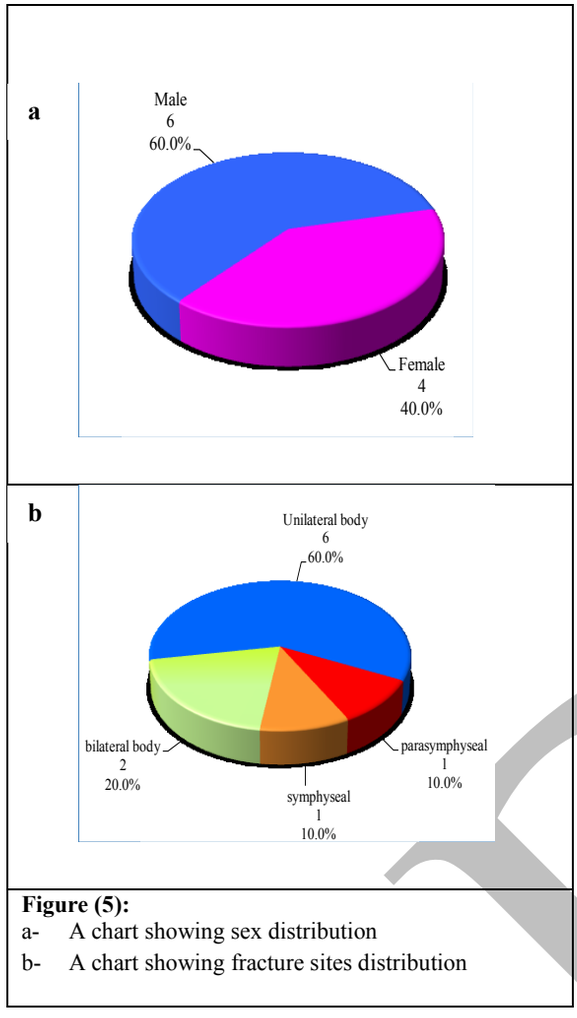

Figure (5):
a- A chart showing sex distribution
b- A chart showing fracture sites distribution

Table 1: Bite force in Newton at the right premolars area.

Follow-up Periods	MEAN ± SD
Week 6 (Baseline)	150.74 ± 12.28
Week 8	274.91 ± 10.91
3 Months	317.51 ± 8.27
6 Months	335.17 ± 10.71

Table 2: Bite force in Newton at the left premolars area.

Follow-up Periods	MEAN ± SD
Week 6 (Baseline)	152.89 ± 10.57
Week 8	274.60 ± 13.92
3 Months	316.61 ± 5.11
6 Months	341.32 ± 11.39

Table 3: Bite force in Newton at the right molars area.

Follow-up Periods	MEAN ± SD
Week 6 (Baseline)	161.13 ± 17.62
Week 8	306.56± 7.77
3 Months	404.77± 7.69
6 Months	412.97 ± 3.75

Table 4: Bite force in in Newton at the left molars area.

Follow-up Periods	MEAN ± SD
Week 6 (Baseline)	166.27 ± 18.24
Week 8	308.04 ± 10.61
3 Months	397.04 ± 13.32
6 Months	412.60 ± 5.56

Table 5: Mean percent change in bite force in the anterior, premolars and molars area.

REGIONS	MEAN ± SD
Anterior	86.86 ± 32.12
Right Premolar	131.31 ± 16.37
Left Premolar	131.91 ± 12.50
Right Molar	160.00 ± 28.76
Left Molar	152.01 ± 34.49

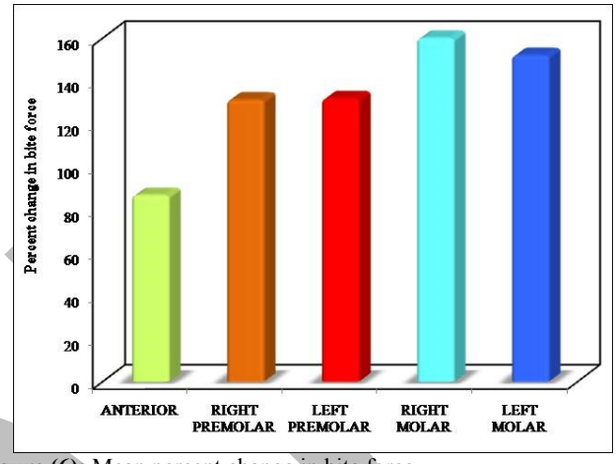

Figure (6): Mean percent change in bite force

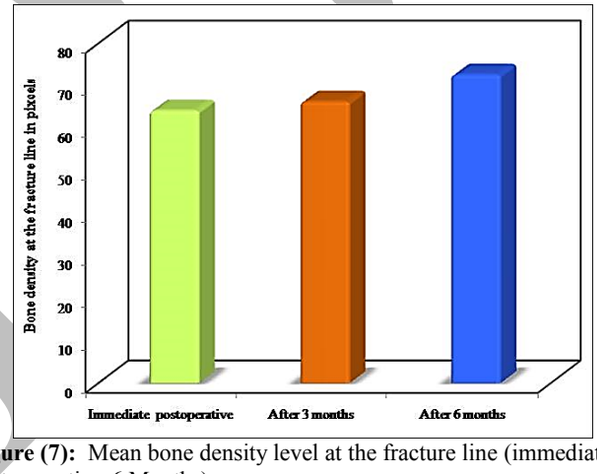

Figure (7): Mean bone density level at the fracture line (immediate post-operative-6 Months)

DISCUSSION

As mentioned previously, the use of screws for IMF provides many benefits to patients and surgeons. Some researchers believe that the IMF screw is a reliable alternative to the arch bar in trauma and orthognathic patients (4-6).

IMF techniques have evolved over the years, from the use of splints, Erich arch bars, direct wiring and eyelets wiring. The use of orthodontic mini-implants for the purpose of IMF results in shorter operating time, allowing good stabilization of the occlusion (5, 14).

In the present study, the use of orthodontic mini-implants originally designed for skeletal anchorage in IMF was proven their ease of application, improved patient tolerance, good mechanical performance, low cost, reduced trauma to the buccal mucosa, ideal for use when teeth have been heavily restored, ease of maintaining gingival health compared to arch bars and eyelet wires, and painless removal without anesthesia in the outpatient department.

In orthodontics, these devices are inserted into the jaws and a significant orthodontic force is exerted over them. Thus, one may speculate whether they could be used in facial trauma management to achieve proper IMF. Surgeons have improved

their skills in handling these mini-implants, because orthodontists increasingly use these devices to optimize orthodontic treatment (15). Prolonged periods with these mini-implants in the oral cavity have been observed, and they appear to be well tolerated and to allow proper oral hygiene, without causing trauma to tissues, and over time, patients may not even realize their presence in the mouth (14).

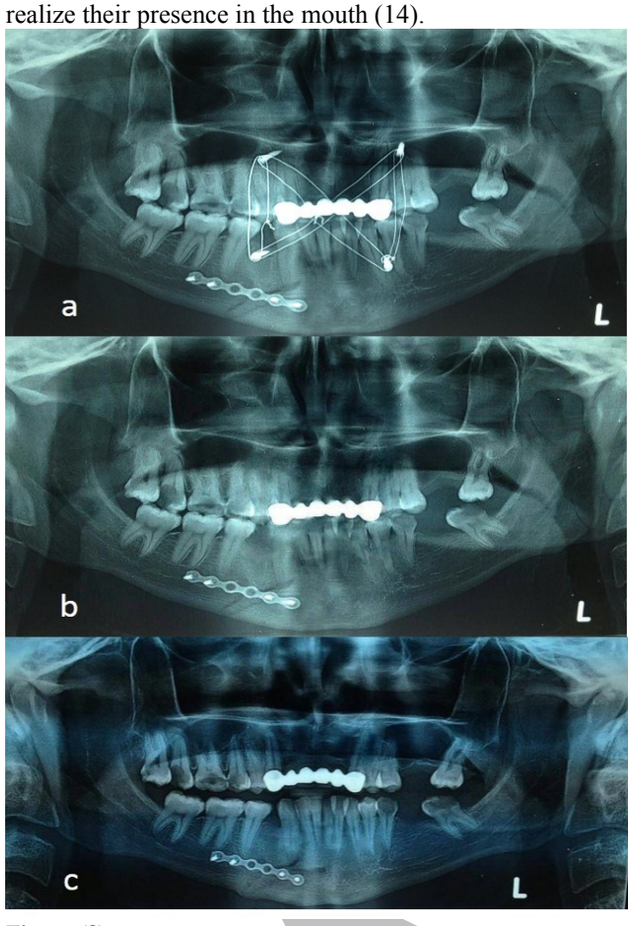

Figure (8):

a- Immediate Post-operative orthopantomogram showing IMF using orthodontic mini-implants.

b- 3 months Post-operative orthopantomogram showing the progression of healing along the fracture line

c- 6 months Post-operative orthopantomogram showing the healing and increased bone density along the fracture line.

There are some reports analyzed that the use of intraoral cortical bone screws for intermaxillary fixation is a valid alternative to arch bars in the treatment of mandibular fractures, but objective data was not presented (7, 16). There are also some clinical reports that demonstrated the viability of using a mini-implant for skeletal anchorage to support a variety of orthodontic tooth movements (17, 18). However, these reports did not describe the usefulness of an orthodontic mini-implant in IMF for treatment of fracture mandible.

The clinical results taken from this study was in accordance with those of Ueki and his co-workers (16) who used the IMF screws technique following mandibular setback surgery, he concluded that the use of IMF screw was helpful for orthognathic surgery as a rigid anchor of IMF. Results from this study revealed the usefulness, time saving and feasibility of the technique to perform a fast yet effective IMF.

In the previous studies regarding mandibular fracture, Coburn et al. (13) reported that one hundred and twenty-two patients with mandibular fractures had IMF screws. Five patients (4%) developed complications including fracture of the screws on insertion, iatrogenic damage to teeth causing tooth loss and bony sequestra around the area of screw placement. In our study no sequestration occurred around the screws nor fracture of the mini-implants during their placement.

Our results disagree with those of Roccia et al. (17) who noted that 4.9% of the installed screws were covered by oral mucosa, 1.9% were lost, and none were broken. He stated that the most important complication was iatrogenic damage to dental roots (1.5%). Malocclusion was observed in one patient (1.6%) and lack of consolidation of a displaced fracture of the mandible. In this study, breakage, loss of the screw and iatrogenic dental injuries were not encountered.

Because dental injury is a common finding among most studies on IMF screws, some researchers have tried to show how and where screws can be inserted in a safe manner. For example, Poggio et al (18) indicated that a 1-mm thickness of alveolar bone around the screw is sufficient for good periodontal health. Hernández et al (19) also showed that two possible places for IMF screw insertion in the mandible are the incisal area and the molar area.

In this study, IMF mini-implants were implanted between each canine and first premolar at the region of anterior alveolar bone. Screws placed in an interradicular location should not impinge on adjacent root structures. Published studies about mini-screws described the site of insertion as mid- root or at/beyond the root apex (8, 9, 18). However, regarding root injury, Asscherickx and his co-workers (20) stated that histological examination of three teeth damaged by mini-implants demonstrated an almost complete repair of the periodontal structure (e.g. cementum, periodontal ligament and bone).

The assessment of bite forces takes attention among authors. However, there is conflict in the findings and maximum value of bite forces presented by different researchers (21- 23). The reasons of this variation may be related to the device used to record the bite force, its reliability, and psychological state of volunteer. Also, geographical factors, genetic and ethnic, and food habits may be also responsible for this variation. Individual neuromuscular mechanism may itself be also an important factor for this difference (24, 25).

The present study showed an increase in bite force recovery steadily from baseline, 8 weeks, 3 months till 6 months post-surgically. This increase was statistically insignificant except when comparing the baseline readings with those taken at 6 months. During searching the literature, no articles were found evaluating the bite force recovery in patients with mandibular fractures treated by IMF, therefore the results were discussed with those taken from other studies evaluating the bite force recovery after management of mandibular fracture using different surgical protocols. Our results run parallel to those of Pepato et al (26) who examined individuals undergoing surgery for the treatment of the fractured mandibular angle, using bite force, mandibular mobility,

and electromyographic (EMG) analysis in many different clinical conditions, after 2 months postoperatively. They concluded that a good functional recovery was achieved by the individuals who had a mandible angle fracture or condylar process fracture, after 2 postoperative months. Furthermore in a study carried by Melek et al in 2014 (27) to compare the use of 3D plates and the conventional plates for management of mandibular angle fracture. Their results showed an increase in bite force recovery throughout the follow-up period and a statistically significant difference was encountered between the two groups at 2 and 4 weeks postoperatively with higher values

reported in the studied group who received 3D plate patients. In this work, the statistical significance was only seen when comparing the results between the six weeks and the six months post-operatively, this different findings may be attributed to the different types of plates used, different surgical protocol and to the limited sample size of the current work.

The results of this study showed that the increase in mean bone density was statistically insignificant from baseline to 6 months postoperatively. The increase in bone density was related to the proper reduction and fixation and consistent with the progress of fracture bone healing. The statistically insignificant results may be attributed to the fracture stability offered by the plates during the healing period and to the limited sample size. Again, in their work Melek et al reported that the increase in mean bone density was statistically significant in each of the groups from 6 weeks to 3 months but the difference in mean bone density between the two groups was statistically non -significant at 6 weeks postoperatively, however, it was significant at 3 months postoperatively, mostly due to the better fracture stability offered by the 3D plates during the healing period especially in displaced fractures (27).

CONCLUSIONS

Our experience in this study indicated that most of the complications encountered during mini-implants placement can be avoided by inserting screws carefully. The decision to use IMF mini-implants instead of an arch bar is certainly dependent on the surgeon's interest and skill. Clearly, the use mini-implants for IMF are increasing, and their ease of placement may be the most important factor in this trend.

CONFLICT OF INTEREST

The authors declare that they have no conflicts of interest.

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