ABSTRACT

INTRODUCTION: Mandible fractures are among the most common facial bones to occur.Intermaxillary fixation (IMF) is a fundamental principle in the management of mandibular fractures but with recent advent of open reduction and internal fixation (ORIF), use of IMF is almost limited intraoperatively. Therefore, we compared the efficacy of Erich arch bar versus embrasure wires for intraoperative IMF in mandibular fractures.

Objectives: To assess and compare the efficacy of embrasure wire versus Erich arch bar as two techniques for intraoperative maxillomandibular wiring fixation in mandibular fracture.

Materials and methods: This prospective study comprised of twenty patients with mandibular fractures who required ORIF with intraoperative IMF. Patients were categorized into two groups of 5 patients each: Erich arch bar technique was used for group A and embrasure wire technique for group B. Parameters were time taken for IMF, needle stick injury, occlusal stability, iatrogenic complications, and periodontal status of patients.

Results: there were significant difference in Time taken for application , Injury to the operator , Injury to the patient , and Periodontal Health . While tater was no significant difference in Occlusion and Occlusal stability , Stability of IMF technique , and bone density over the follow up period.

Conclusion: Embrasure wire technique is a quick, easy, and reliable technique for minimally or moderately displaced fractured mandible and had better clinical outcomes than did patients that underwent the Erich arch bar technique.

Keywords: Bone denisty ,CBCT, Erich arch bar , embrasure wire , IMF , Mandibular ,Fracture .

INTRODUCTION

Among the most frequent face bone fractures, mandible fractures are frequently observed in emergency departments. Mandible fractures, in contrast to many face fractures, seldom need surgery.(1)

Wound contamination with oral flora by teeth in the fracture line is a common outcome of mandibular fractures, which are moveable, U-shaped bones that commonly fracture in many locations and endanger the patient's airway.(2)

A mandibular fracture can result from a wide range of circumstances, such as falls, sports injuries, industrial mishaps, and hostile relationships. Although interpersonal violence is the primary cause in rural areas and developing countries, traffic accidents are the primary contributing factor in wealthy countries.(3)

The most common causes of mandibular fractures are auto accidents and violent altercations. In urban trauma settings, where altercations account for the majority of fractures (50%) and 29%, motor vehicle accidents are less frequent. Statistics show that males are more likely than women to have mandible fractures, with the majority occurring in the third decade of life.(4)

The ring-like structure of the bone causes numerous fractures in over 50% of patients. A parasymphyseal fracture combined with a subcondylar or angle fracture on the opposite side is the most common combination of injuries. Although studies have shown different fracture frequencies, the body, condyle, and angle are the most often fractured individual regions. The symphyseal/parasymphyseal area is less commonly damaged, and the ramus and coronoid process are rarely affected. The symphysis was the most common fracture site in motorcycle accidents, whereas the condyle was the most common fracture site in auto accidents. The most often broken area in assault cases is the angle.(5)

For solitary mandibular fractures, both surgical and nonsurgical approaches may be taken into consideration. There are several opinions on the best time to have surgery. It was discovered that

there was no difference in the incidence of complications between reconstructions done within the first 72 hours and those done beyond.(6)

There are now two primary treatment paradigms for mandibular fractures that are fixed with plates and screws. The first is the AO/ASIF idea, which promotes sufficient stiffness at the fracture site to prevent mobility between fragments when the mandible is in motion. The second philosophy, popularized by Champy et al., minimizes strain by using non-compression mono-cortical mini-plates in the area of optimum stress and emphasizes "the perfect lines of osteosynthesis" in the jaw. In order to properly stabilize fractures in the symphysis and parasymphysis region, two plates must be utilized because of the optimal force distribution that this concept requires. For a fracture to be successfully stabilized, at least two factors must be present: the amount of bone contact and the stiffness of the fixation device.(7)

IMF devices are still the best and most cost-effective way to treat fractures, but they are limited to being a temporary fixation in trauma or orthognathic surgery. Open reduction and internal fixation (ORIF), which uses plating systems and screws to make surgery much easier, has replaced conservative treatment.(8)

Despite being widely used and distributed, these IMF devices have a number of drawbacks, including the possibility of traumatic injury to the periodontium surrounding teeth, the risk of needle stick injuries to both the patient and the operator, infection, neurosensory disturbances, prolonged application or removal, difficulty maintaining proper oral hygiene, a tight feeling when the wire is twisted around teeth, and the possibility of tooth avulsion if the force is high.(9)

Physicians are compelled to discover a straightforward, dependable, and IMF-compliant alternative way for intermaxillary fixation as a result of their awareness of the issues with IMF devices.

A straightforward type of intraoperative IMF known as "embrasure wire" was reported by Hollows and Brennan (10) in 1999. It allows direct view to occlusion during surgery, has low needle prick injuries, is inexpensive, and takes less time.

This study objective was to evaluate and contrast two distinct intraoperative IMF wiring techniques—the Erich arch bar and the embrasure wire—when treating mandibular fractures.

MATERIALS AND METHODS

This was a prospective randomized controlled clinical trial with a 1:1 allocation ratio that was carried out after ethical approval from the Suez Canal University Faculty of Dentistry's Research Ethics Committee.

Patients

This study included twenty patients from the Suez Canal University Faculty Ismaillia, Egypt and Specialized Dental Hospital of Kobri Al Kobba Military Medical Complex who had simple linear mandibular fractures. Prior to the procedure, all patients signed an informed consent form at Suez Canal Faculty of Dentistry's Oral and Maxillofacial Surgery Department. Patients were divided on two groups, Group A (Control group) patients were treated using Erich arch bar technique. Group B (Study group) patients were treated using embrasure wire technique .

Inclusion criteria were patients suffering from displaced symphyseal and / or para-symphyseal mandibular fractures and Simple linear mandibular fracture who are indicated for open reduction and internal fixation, under general anesthesia and adult patients with age between 18-60 years with no gender predilection ,and with accessible interdental spaces .

Edentulous patients with primary and mixed dentition , gross dental mobility , gross generalized spacing in dentition , unilateral or bilateral mandibular condylar fracture , with gunshot injuries , and Pathologic mandibular fracture were excluded from this study .

Methods

Pre-operative assessment and examinations

Clinical examination

Full medical and dental histories were taken followed by extra-oral and intra-oral inspection to confirm the presence or absence of swelling, ecchymosis, facial asymmetry or deformity, laceration especially on the chin area, or deviation of the mandible during opening and closing of the mouth. Moreover, palpation was done to detect any step deformity, alteration in bony contour, tenderness, and bony crepitus.

Radiographic examination

Cone Beam Computed tomography (CBCT) was done pre-operatively to detect fracture line extension, degree of displacement and for the purpose of treatment planning (Figure).

Surgical phase

Preoperative medications

Prophylactic antibiotic and analgesics were administered in the form of unictam 1500mg (Ampicillin 1 gm. and Sulbactam 500mg) every 12 hours intravenously after performing sensitivity test to prevent postoperative infection.

Surgical procedure

An hour before surgery, a broad-spectrum antibiotic unictam (each vial contains (Ampicillin 1 gm. Sulbactam 500mg), MUP Group) and Dexamethasone sodium phosphate(8mg/2ml: each vial contain sodium phosphate, Ameria Pharmaceuticals) were administered intravenously. Patients on both groups were treated by open reduction and internal fixation done under general anesthesia with nasoendotracheal intubation, which was administered through induction, maintenance, and recovery phases. Intravenous line was started and endotracheal tube was inserted to secure airway. Induction phase was done by using hypnotic (propofol 2-2.5 mg/kg*Diprivan vial*: 10mg/ml, Astrazeneca S.P.A , Italy) and muscle relaxant (Atracurium 0.5ml/kg *injection USP* 100mg /10 ml, Phizer , USA.). Maintenance phase was initiated by inhalation (Forane 0.5-1.0 kg Al kahira, Pharma. & Chemo. Ind, Co. Cairo, Egypt) while recovery phase was achieved by a reverse agent (Neostigmine 0.5-2 mg/kg Amoun, El-Obour City, Cairo, Egypt and Atropine 0.5-1.0 mg/kg Misr, Co. for Pharm. Ind. Cairo,

Egypt). Aseptic surgical technique was achieved by disinfecting the surgical field by betadine surgical scrub (Nile co. for pharmaceuticals &chemical industries, Cairo, Egypt), and then the patient was draped with sterile towels secured by towel clips. Over-drape was used to cover the patient leaving only the prepared site exposed.Inter maxillary fixation (IMF) was temporarily secured to provide proper occlusion that serves as a guide for fracture reduction according to each group.

In group A Erich arch bar was used. A prefabricated arch bar (Dentaurum , Germany) with hooks incorporated on the outer surface with flat malleable stainless steel metal strip was cut accurately to the length of both upper and lower dental arches. On the upper jaw, the hooks were arranged in an upward direction and to the lower jaw in a downward direction. The arch bar was adapted to the buccal surface from 1st molar to 1st molar in both arches. It was fixed to each tooth, using prestretched 26- gauge stainless steel wire (Dentaurum , Germany), which is passed from the mesial surface of teeth to the lingual side and back on the buccal side from the distal surface of the tooth, making sure that one end of the wire is passing above the arch bar and the other below it. After this, both ends of the wire were twisted together in a clockwise manner and the arch bar was attached securely and firmly to the necks of each tooth on the buccal surface of the arch (Figures).In group B Embrasure wires were used. The number and position of the embrasure wires to be inserted was determined according to the type and location of the fracture. A single prestretched 22 -gauge wire (Dentaurum , Germany) of 15-cm length was passed through the facial embrasure between maxillary first molar and second premolar, and then, the palatal end of the wire was looped and passed through the opposite lingual embrasure in the mandible. Similar procedure was repeated on the contralateral side to achieve intermaxillary fixation. After achieving the occlusion, the ends of the wire were twisted together on the buccal surface of the lower premolar and molar teeth on both sides and intermaxillary fixation was achieved (Figures).An intraoral mandibular vestibular approach was made to provide wide exposure to the planned surgical site in all patients. The incision line was marked using a marker pen. Using (Articaine 4% ARTINIBSA, Spain) with vasoconstrictor (Epinephrine 1/100,000) as a local anathetic agent to achieve hemostasis during the surgical procedure infiltrated into the surgical site

submucosally (Figure).Using a blade No.15 for Incision. An incision was done through the mucosa in the vestibule to expose the fracture site. The incision is made 10-15 mm away from the attached gingiva in a curvilinear fashion. Posterior to the canine the incision is only 5 mm away from the attached gingiva, staying superior to the mental nerve (Figures).Controlled and careful dissection and reflection of the mental neurovascular bundle was achieved in order to facilitate retraction of the soft tissue away from the mandible and clearly visualize the fracture. The periosteum was totally freed circumferentially around the mental foramen and nerve (Figure). The surgical field was irrigated using saline (sodium chloride 0.9% 500ml bottle, elmotaheda group) for better vision for surgical field; haemostasis achieved by compressing sterile gauze or through using of diathermy carefully and the fracture line was exposed. The fractured segments were reduced into their correct position.Once the reduction of the fracture and the maximum intercuspation of teeth were assured, two 2.0mm miniplates (*Stryker*, Berchtold GmbH and Co. KG, Germany)were cut, and passively contoured and adapted to the inferior and superior borders of the outer surface of the mandible and checked their position (figure).After manual stabilization of the contoured miniplates, the location of drilling was assured, drilling was done using 2.0 specific drill pits according to the manufacturer instruction.Once the drill hole was irrigated, miniscrews on hand screwdriver was is inserted to the hole and twisted in a clockwise direction to fixed miniplates in position (Figures). The same protocol was followed to the remaining miniplates holes, where the superior monocortical tension zone and inferior bicortical compression zone miniplates. Any bleeding points were controlled, then the wound was thoroughly debrided, irrigated with saline solution and sutured back in layers with 3-0 polyglycolic resorbable sutures material (AssuCryl, Assut, Switzerland) (Figures). The underlying muscles were firmly reattached to their origin and the overlying mucosa was then closed in a running continues suture manner.Removing IMF Immediately after surgery to allow anaesthesiologist to remove oral pack and suction fluids to recover the patient from G.A.

Postoperative phase

The patients were monitored for 24 hours then reviewed after one and twelve weeks post-operatively. Sutures were removed after seven days.

Postoperative medications

All patients were given a 5-days course of systemic antibiotics; intravenous Augmentin 1200 mg/12 hours (Amoxicillin 1gm + Clavulanic acid 200 mg: GlaxoSmithKline, UK) for the first day followed by Amoxicillin + clavulanate 1 gm tablets (Augmentin 1 g, GlaxoSmithKline, UK) twice daily for the next 5 days.Metronidazole500mg tablets (Flagyl500mg: GlaxoSmithKline, UK) every eight hours for 5 days, α-chemo-trypsin ampoules (Leurquin France, packed by Amoun pharmaceutical CO.S.A. E-Egypt) as antiedematous once daily for 5 days, and Diclofenac potassium 50mg tab (Cataflam50mg: Novartis-Switzerland) every eight hours for 5 days and Chlorhexidine (Hexitol 125mg/100ml, concentration 0.125%: Arabic drug company, ADCO) antiseptic mouth wash. Patients were instructed to follow a soft, fluid, high protein, high calorie diet were for 4 weeks postoperatively and to maintain a good oral hygiene.

Follow up phase

Clinical followup

Time taken for application of technique

Time was recorded in minutes from the beginning of the device fixation till the end of IMF.

Occlusion and Occlusal stability

Postoperative occlusion was recorded 24 h after the surgery and third month postoperatively as stable or unstable occlusion. The maximal intercuspal position (centric occlusion) to ensure proper occlusal relationship including molar relation, canine relation, and midline centralization were checked. Any occlusal disturbance including open bite or improper tooth contact was noted after 24-hours, and 3 months. (Figures)

Stability of IMF technique

Stability of the MMF device during procedure was considered as failure when there was gross separation of the occlusion during open reduction and internal fixation of fracture.

Injury to the operator

The wire stick injury, the incidence of perforations in the gloves of operators, was divided into direct gloves perforation seen by single observer in both group and indirect gloves perforation identified by water inflation method of double gloving system using single observer for both groups. (Figures)

Periodontal Health

Oral hygiene index (simplified OHI) given by Greene and Vermillion was used to evaluate the oral hygiene status of the patient after the surgery, and it was recorded as good, fair, and poor.

Injury to the patient

An iatrogenic injury such as tooth avulsion, teeth fracture, injury to interdental papilla, and tooth mobility, any mucosal tear or lacerations during the placement of wires were recorded after completion of the procedure. (Figures)

Radiological followup

CBCT scan program (OnDemand3D Cybermed South Korea) and machine (J.MORITA R100 Japan) were used for all patients , the exposure parameters for all patients were 90 kV and 8 mA for 9.4 seconds . CBCT was carried out to assess the radiodensitometric bone changes in the fracture site for both groups immediate postoperatively, and three months postoperatively. (Figure)

Bone density along the fracture line was measured at six different points along the fracture line and the mean was calculated.

Statistical analysis

Data Management and Analysis:

i. Descriptive statistics:

1. Mean, Standard deviation (± SD) and range for parametric numerical data, while Median and Interquartile range (IQR) for non-parametric numerical data.
2. Frequency and percentage of non-numerical data.

ii. Analytical statistics:

Student T Test was used to assess the statistical significance of the difference between two study group means. Mann Whitney Test (U test) was used to assess the statistical significance of the difference of a non-parametric variable between two study groups.Chi-Square test was used to examine the relationship between two qualitative variables.Fisher's exact test was used to examine the relationship between two qualitative variables when the expected count is less than 5 in more than 20% of cells.Paired t-test was used to assess the statistical significance of the difference between two means measured twice for the same study group.

P-value: level of significance.P>0.05: Non-significant (NS).P< 0.05: Significant (S).P< 0.001: Highly significant (HS).

RESULTS

Biodata

The patients included twenty patients . Their age ranged between 20-24 years with a mean of 22.2 ± 1.14 years for group A (arch bar) and 22.5 ± 1.27 for group B (embrasure wire) and thus there was no statistical significance between the age of the two groups as P-value 0.584. Throughout the study, Regarding cause of injury most patients had road traffic accident (RTA) in both groups, without statistically significant difference between two groups as P-value 1.00.

Clinical Evaluation

Time taken for application of technique

In terms of time taken for application of technique time was recorded in minutes from the beginning of the device fixation till the end of IMF, there was highly statistically significant increase in time of operation ($p<0.001$).

The time of the operation ranged from (17.108) in minutes with the mean time of arch bar group (group A) was 33.01±4.74 minutes , while the meantime of Embrasure wire group (group B) was 6.44±1.29 minutes (Table).

Occlusion and occlusion stability

The maximal intercuspal position (centric occlusion) to ensure proper occlusal relationship including molar relation, canine relation, and midline centralization were checked. Any occlusal disturbance including open bite or improper tooth contact was noted after 24-hours, and 3 months.

Postoperative occlusion was recorded 24 h after the surgery and third month postoperatively as stable or unstable occlusion.

In Arch bar group (Group A), one case had occlusal disturbance. The occlusal review revealed that the rest of the patients had normal occlusal and intercuspal relations. There was no need for selective grinding during the follow-up period.

Regarding occlusion after 24 hours and after 3 months there was no statistically significant difference in occlusion as P-value 1.00 (Table).

Stability of IMF technique

Stability of the MMF device during procedure was considered as failure when there was gross separation of the occlusion or any mobility of the fractured segments during open reduction and internal fixation of fracture.

In Arch bar (Group A) one case was unstable while in Embrasure wire (group B) two case were unstable. The occlusal review revealed that the rest of the patients had normal occlusal and intercuspal relations. There was no statistically significant difference between the two groups as P-value 1.00

Injury to the operator

The wire stick injury, the incidence of perforations in the gloves of surgeon and the first assistant, was identified by water inflation method of double gloving system.

There was highly statistically significant increase in gloves perforation (direct) among the Arch bar group (Group A) as P-value <0.001, while there was statistically significant increase in gloves perforation (indirect) among the Arch bar group (Group A) as P-value 0.005 (Table).

There were two cases in arch bar (group A) in direct gloves perforation, and one case in indirect glove perforation to the operator. While there was no case in both direct and indirect gloves perforation in Embrasure wire (group B).

Injury to the patient

An iatrogenic injury such as tooth avulsion, teeth fracture, interdental papilla striping, and tooth mobility, any mucosal tear or lacerations during the placement of wires were recorded after completion of the procedure.

There was highly statistically significant increase in injury to patient among the arch bar (Group A) as P-value <0.001.

There were eight cases in arch bar (group A) had wire injury. While two cases in embrasure wire (group B) had wire injury (Table, Figure).

Periodontal Health

Oral hygiene index (simplified OHI) given by Greene and Vermillion was used to evaluate the oral hygiene status of the patient after surgery, and it was recorded as good, fair, and poor.

Regarding oral hygiene index there was statistically significant increase in oral hygiene index among the study group; most patients had good index as P-value 0.001 (Table , Figure).

In Arch bar (group A) two cases showed a poor oral hygiene, eight cases showed oral fair hygiene, and there was no case showed good oral hygiene. While in Embrasure wire (group B) no case showed a poor oral hygiene, two cases showed fair oral hygiene and eight cases showed good oral hygiene.

Radiographic Evaluation

An immediate CBCT scan was assessed for the bone density in the fracture line after fixation, and then another CBCT was taken at 12th week to estimate the mean bone density at the fracture line in comparison with the immediate postoperative scan.

On the CBCT, bone mineral density was measured in Hounsfield Unit (HU) using sidexis software. Six measurements were taken on the fracture line, then the mean was calculated per patient.

Bone density (HU) at different time points (Day 1 and after 3 months) between two study groups, the mean of bone density (HU) at normal side (after 24 hours) was 960.4 ± 166.97 among arch bar group (Group A), but it was 969.6 ± 148.06 among Embrasure wire group (Group B), while (after 3 months) it was 963.1 ± 170.01 and 977.2 ± 140.56 among arch bar and embrasure wire group respectively (Table , Figure).

Regarding the mean of bone density (HU) at fracture side (after 24 hours) was 430.7 ± 95.18 among arch bar group, but it was 436.5 ± 90.98 among embrasure wire group, while (after 3 months)

it was 517.7 ± 83.05 and 550.2 ± 101.25 among arch bar and embrasure wire group respectively (Table , Figure).

There was no statistically significant difference between two groups at any time point or side in bone density (HU), or between two measures among arch bar and embrasure wire individually as P-value was 0.213 and 0.458 respectively, but there was a highly statistically significant increase in bone density at fracture side between two measures as P-value was <0.001 (Table, Figure).

DISCUSSION

Immobilization using intermaxillary fixation (IMF) is the cornerstone of care for patients with maxillofacial injuries[11].

A key goal of treating mandibular fractures is function restoration. The first immobilization device used in ancient Greece was bandaging the fractured mandible; since then, numerous techniques and methods of varying in sizes and shapes have been developed to bring and maintain teeth into proper occlusion for reduction of fracture segments in patients with maxillofacial trauma[12].

In oral and maxillofacial surgery, intermaxillary fixation (IMF) has been utilized to immobilize fracture segments, apply traction force to reduce fracture segments, and preserve occlusion[13].

The arch bar was initially used in oral and maxillofacial surgery by Hammond in 1870 to treat maxillomandibular bone fractures. Following that, a straightforward circular bar that was fitted to the teeth using brass ligature wires was applied by Sauer in Germany and Gilmer in the United States[14].

Subsequently, **Pal et al.,** [15] changed the original spherical arch bar into a flattened arch bar on one side in order to improve stability and better fit the teeth. The conventional MMF technique has been to use arch bars with eyelet wires.

Nevertheless, there are a number of drawbacks to the approach, the most frequent being the length of time needed for application. Costs rise as a result of the longer application times for general anesthesia. In addition, a number of additional factors have been identified, including the possibility

of dental cavities, the danger of disease transmission by wire pricks, the existence of periodontal disease, and a metal allergy[16].

Numerous writers have put forward numerous changes throughout time to get around the arch bar's drawbacks[17].

The aim of this study was to compare between two different types of IMF wiring technique including Erich arch bar and embrasure wire during management and fixation of mandibular fracture.

In this study, exclusion criteria included Edentulous above 60 years old patients, patients with primary and mixed dentition, pathologic mandibular fracture and with gross generalized spacing in dentition. This correlates to **Rastogi S et al.,**[17] who excluded patients with generalized interdental spacing, and a history of diabetes, uncontrolled hypertension, prolonged steroid therapy, compromised immunity, or associated bone pathologic features. While the inclusion criteria of this study included patients with mandibular fractures, and fit for surgery with age ranging between 18-60 years old age. Also agreeing with **Rastogi S et al.,**[17] who included patients isolated mandibular fractures (single or multiple) which require open reduction and internal fixation, and patients age range from 17-60 years old.

In terms of time taken for the placement of MMF using embrasure wires/arch bars revealed a statistically highly significant difference ($p<0.001$), thereby making embrasure wires a comparatively much quicker procedure. The mean time (minutes) taken for group A (arch bars) was 33.01±4.74 minutes, whereas for group B (embrasure wires) it was 6.44±1.29 minutes. **Engelstad and Kelly**[18] found that the time difference between the embrasure wires and the arch bar was also statistically significant (25.5 vs. 2.5 minutes). Furthermore, **Rastogi S et al**.[17] reported (7.85±0.81) minutes for embrasure wires, but (45.05±5.96) minutes was recorded for arch bars. Also, **Satpute A et al,**[13] reported that average of time taken was 48.08 minutes for arch bar group versus 3.48 minutes for embrasure wire group. According to **Kaur et al,**[19] average time taken was recorded (41.32±8.32) minutes for arch bar group while time was (3.47±0.85) minutes in embrasure wire group.

Therefore, the research and current literature support the use of embrasure wires in cases where intraoperative time is more important.

In terms of Occlusion and occlusion stability, a statistical comparison of the postoperative complications in respect of hardware failure and occlusal disturbance in both the groups (A and B) was found to be nonsignificant (P-value 1.00). In (group A) arch bars, one case had occlusal disturbance, while. The occlusal review revealed that the rest of the patients had normal occlusal and intercuspal relations. There was no need for selective grinding during the follow-up period.

According to **Rastogi S. et al.**[17], embrasure wire and an arch bar can stabilize broken segments enough during intraoperative segment reduction. Numerous reasons for surgical failure have been identified, including malocclusion brought on by instability[6,9]. Compared to our results, **Satpute et al.**[13] found that 72% of patients in the embrasure wire group and 100% of patients in the Erich arch bar group had stable occlusion. The authors went on to say that occlusal stability is dependent on the kind and displacement of fractures, and they linked individuals with numerous fractures, comminuted fractures, and highly displaced fractures to unstable occlusion. In a thorough review analysis involving 86 patients, **Tracy and Gutta**[20] found that hardware failure was the most frequent consequence in both groups: 15% in the arch bar group and 12% in the embrasure group. This was not the case with our findings. Additionally, compared to the embrasure group (6%), the patients in the arch bar group (7.5%) experienced a little higher rate of postoperative malocclusion. Compared to the embrasure group (9%), the arch bar group (13%) had a higher incidence of infection problems. These results, however, did not line up with our research.

In terms of Injury to the operator/assistant there was highly statistically significant increase in gloves perforation (direct) among the arch bars (group A) as P-value <0.001, while there was statistically significant increase in gloves perforation (indirect) and injury to operators among the arch bars (group A) as P-value 0.005. There were two cases in arch bars (group A) in direct gloves perforation, and one case in indirect glove perforation. While there was no case in both direct or indirect gloves perforation in embrasure wires (group B).

The incidence of glove perforation is in agreement with **Kaur et al**.[19] The mean rate of glove perforation in group A (5.13±1.30) was comparable to the observations of **Pieper et al.**[21] and **Avery et al.**[22], who reported 5.07 and 4.62 ± 3.25, respectively. On the other hand, while using Erich arch bar wiring for MMF, **Gaujac et al.**[23] found a low rate per operation of 2.45 when using arch bar for IMF. The study conducted by **Kaur et al,**[19] found that the rate per operation for glove perforation in embrasure wires was (1.80 ± 1.47), which was 2.85 times lower than the rate for arch bars group. This suggested that, in comparison to Erich arch bars, embrasure wire resulted in fewer gloves perforations, lowering the risk of occupational hazards and blood borne disease transmission.

Regarding wire prick injuries, in this study we found prick injures due to sharp edges of the wire used ranging (1-3) in arch bars (Group A) while there is no wire prick injuries in embrasure wires (Group B) which is highly significant ($p < 0.001$). The result of this study has the same observation as in **Rastogi S et al.**[17] study, as no surgeon or assistant surgeon suffered a prick injury due to sharp ends of the wire used while placing the embrasure wire intraoperatively, on the other hand, a high incidence of wire injury during MMF was reported in arch bars, accounting for 4 cases out of 20 (20%), which is deemed statistically significant ($p < 0.05$).

Regarding oral hygiene index in this study, there was statistically significant increase in oral hygiene index among the embrasure wires (group B); most patients had good index as (P-value 0.001). In arch bars (group A), two cases showed a poor oral hygiene, eight cases showed oral fair hygiene, and there was no case with good oral hygiene. While in embrasure wires (group B) no case showed a poor oral hygiene, two cases showed fair oral hygiene, and eight cases showed good oral hygiene. Similar findings were observed by **Satpute et al,**[13] all patients in arch bars group had decent oral hygiene, and 20 patients in embrasure wires group had good oral hygiene while 5 patients had fair oral hygiene. The chi-squared test results show that the difference between the two groups is 34.00 and statistically significant ($p < 0.05$).

Regarding the iatrogenic injury to patient such as tooth avulsion, teeth fracture, interdental papilla striping, and tooth mobility, any mucosal tear or lacerations during the placement of wires were

recorded after completion of the procedure. There was statistically significant increase in injury to patient among the Arch bars (Group A) as (P-value 0.023). There were two cases in embrasure wires (group B) had papilla injury. While eight cases in arch bars (group A) had papilla injury. Similar result were noted by **Satpute et al,**[13] as he reported eight patients had iatrogenic damage with the placement of a traditional Erich arch bar for IMF, while two patients experienced it during the placement of embrasure wires. Although patients with embrasure had more severe iatrogenic injuries, including as crown fractures and tooth avulsions, eight patients who had a traditional Erich arch bar inserted for IMF also suffered significant iatrogenic injuries. The two groups' difference is statistically significant. ($P < 0.05$).

Regarding the quality of bone healing at the fractured side, an immediate CBCT scan was assessed for the bone density in the fracture line after fixation, and then another CBCT was taken at 12th week to estimate the mean bone density at the fracture line in comparison with the immediate postoperative scan measured in Hounsfield Unit (HU) using the on-demand software. Bone density (HU) at different time points (Day 1 after fixation and after 3 months) between the two groups were estimated. The mean of bone density (HU) at normal side (day 1) was (960.4 ± 166.97) HU among arch bars (group A), but it was (969.6 ± 148.06) HU among Embrasure wires (group B). After 3 months it was (963.1 ± 170.01) and (977.2 ± 140.56) HU among arch bars and embrasure wires group respectively. Regarding the mean of bone density (HU) at fracture side (day 1) was (430.7 ± 95.18) among arch bars (group A), but it was (436.5 ± 90.98) HU among embrasure wires (group B). After 3 months it was (517.7 ± 83.05) and (550.2 ± 101.25) among arch bars and embrasure wires group respectively. There was no statistically significant difference between two groups at any time point or side in bone density (HU), or between two measures among arch bars and embrasure wires group individually as P-value was (0.213) and (0.458) respectively, but there was a highly statistically significant increase in bone density at fracture side between two measures as (P-value <0.001). No available data in the previous literature were found regarding assessed for the bone density in the fracture line after fixation using embrasure wires.

CONCLUSION

It was concluded that, for the treatment of simple mandibular fractures, the embrasure wire approach for intraoperative IMF offers a useful technique over the conventional arch bar technique regarding time taken for the procedure, maintaining safety of the surgeons and patients by reducing gloves perforation and lowering wire prick injuries and providing superior periodontal health. So, the embrasure wire technique had demonstrated a greater promising results.

CONFLICT OF INTEREST

The authors declare that they have no conflicts of interest.

FUNDING STATEMENT

The authors received no specific funding for the conduction of this study.

References

1. Yuen HW, Hohman MH, Mazzoni T. Mandible Fracture. [Updated 2021 Feb 17]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2021 Jan-.

2. Jin KS, Lee H, Sohn JB, Han YS, Jung DU, Sim HY, Kim HS. Fracture patterns and causes in the craniofacial region: an 8-year review of 2076 patients. Maxillofac Plast Reconstr Surg. 2018 Dec;40(1):29.

3. Van den Bergh B, Karagozoglu KH, Heymans MW, et al. Aetiology and incidence of maxillofacial trauma in Amsterdam: a retrospective analysis of 579 patients. J Craniomaxillofac Surg 2012; 40:165–169.

4. Louis M, Agrawal N, Truong TA. Midface Fractures II. Semin Plast Surg. 2017 May;31(2):94-99.

5. Amira Besbes, Yamina Elelmi, Faten Khanfir, Raja Belgacem, Hichem Ghedira, "Recurrent Oral Mucocele Management with Diode Laser", Case Reports in Dentistry, vol. 2020, Article ID 8855759, 5 pages, 2020.

6. Oruç M, Işik VM, Kankaya Y, et al. Analysis of Fractured Mandible Over Two Decades. J Craniofac Surg. 2016;27(6):1457-1461.

7. Raut R, Keerthi R, Vaibhav N, Ghosh A, Kamath Kateel S. Single Miniplate Fixation for Mandibular Symphysis and Parasymphysis Fracture as a Viable Alternative to Conventional Plating Based on Champy's Principles: A Prospective Comparative Clinical Study. J Maxillofac Oral Surg. 2017;16(1):113-117.

8. Oikarinen K, Altonen M, Kauppi H, Laitakari K. Treatment of mandibular fractures. Need for rigid internal fixation. J cranio-maxillo-facial Surg Off Publ Eur Assoc Cranio-Maxillo-Facial Surg. 1989 Jan;17(1):24–30.

9. Pal K. Comparison of Techniques of Closed Reduction - Arch Bar Versus Ivy Eyelet. Int J Contemp Med Res [IJCMR]. 2018;5(4):15–7.

10. Hollows P, Brennan J. Temporary intermaxillary fixation: a quick reliable method. Vol. 37, The British journal of oral & maxillofacial surgery. Scotland; 1999. p. 422–3.

11. Coletti DP, Salama A, Caccamese JFJ. Application of intermaxillary fixation screws in maxillofacial trauma. J oral Maxillofac Surg Off J Am Assoc Oral Maxillofac Surg. 2007 Sep;65(9):1746–50.

12. Hashemi HM, Parhiz A. Complications using intermaxillary fixation screws. J oral Maxillofac Surg Off J Am Assoc Oral Maxillofac Surg. 2011 May;69(5):1411–4.

13. Satpute AS, Mohiuddin SA, Doiphode AM, Kulkarni SS, Qureshi AA, Jadhav SB. Comparison of Erich arch bar versus embrasure wires for intraoperative intermaxillary fixation in mandibular fractures. Oral Maxillofac Surg. 2018;22(4):419–28.

14. Baurmash H, Farr D, Baurmash M. Direct bonding of arch bars in the management of maxillomandibular injuries. J oral Maxillofac Surg Off J Am Assoc Oral Maxillofac Surg. 1988 Sep;46(9):813–5.

15. Pal K. Comparison of Techniques of Closed Reduction - Arch Bar Versus Ivy Eyelet. Int J Contemp Med Res [IJCMR]. 2018;5(4):15–7.

16. Hashitani S, Maeda T, Okui S, Takaoka K, Honda K, Urade M. Allergy to metal caused by materials used for intermaxillary fixation: case report. Br J Oral Maxillofac Surg. 2008 Jun;46(4):315–6.

17. Rastogi S, Ahmed T, Giri K, Dandriyal R, Niranjana Prasad IB, Joshi A, et al. Comparative Evaluation of the Embrasure Wire versus Arch Bar Maxillomandibular Fixation in the Management of Mandibular Fractures: Are Arch Bars Replaceable? Craniomaxillofac Trauma Reconstr. 2018;11(2):118–23.

18. Engelstad ME, Kelly P. Embrasure wires for intraoperative maxillomandibular fixation are rapid and effective. J Oral Maxillofac Surg [Internet]. 2011;69(1):120–4. Available from: http://dx.doi.org/10.1016/j.joms.2010.06.209

19. Kaur T, Dhawan A, Bhullar RS, Kapila S, Gupta S, Resham R. Are Embrasure Wires Effective and Reliable Method for Intraoperative Maxillomandibular Fixation in Mandibular Fractures? J Maxillofac Oral Surg [Internet]. 2022;21(2):433–41. Available from: https://doi.org/10.1007/s12663-021-01528-x

20. Tracy K, Gutta R. Are embrasure wires better than arch bars for intermaxillary fixation? J Oral Maxillofac Surg [Internet]. 2015;73(1):117–22. Available from: http://dx.doi.org/ 10. 1016/ j.joms.2014.08.020

21. Pieper SP, Schimmele SR, Johnson JA, Harper JL. A prospective study of the efficacy of various gloving techniques in the application of Erich arch bars. J oral Maxillofac Surg Off J Am Assoc Oral Maxillofac Surg. 1995 Oct;53(10):1174–6; discussion 1177.

22. Avery CM, Taylor J, Johnson PA. Double gloving and a system for identifying glove perforations in maxillofacial trauma surgery. Br J Oral Maxillofac Surg. 1999 Aug;37(4):316–9.

23. Gaujac C, Ceccheti MM, Yonezaki F, Garcia IRJ, Peres MPSM. Comparative analysis of 2 techniques of double-gloving protection during arch bar placement for intermaxillary fixation. J oral Maxillofac Surg Off J Am Assoc Oral Maxillofac Surg. 2007 Oct;65(10):1922–5.