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ORIGINAL ARTICLE

Comparative Evaluation of Efficacy of Conventional Arch Bar, Intermaxillary Fixation Screws, and Modified Arch Bar for Intermaxillary Fixation

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Abstract

Aim Comparative evaluation of efficacy of conventional arch bar, intermaxillary fixation screws, and modified arch bar with respect to plaque accumulation, time required for procedure, postoperative stability after achieving the intermaxillary fixation, mucosal growth, and complication encountered for intermaxillary fixation.

Materials and methods This study is a randomized clinical trial in which participants were divided into three groups of 10 each, and designated as Group A, Group B, and Group C. In Group A, intermaxillary fixation was achieved by the conventional method using Erich arch bar, fastened with 26-gauge stainless-steel wires. In Group B, intermaxillary fixation was achieved by the use of 2 mm × 8 mm 4–6 stainless-steel intermaxillary fixation screws. In Group C, intermaxillary fixation was achieved by modified screw arch bar. A conventional arch bar was modified by making perforations in the spaces between the winglets along the entire extension of the bar which was then adapted to the vestibular surface of the maxilla and mandible, close to the cervical portion of the teeth, and perforations were made in the inter-radicular spaces with a 1.1-mm bur, and after this, 1.5-mm screws were placed to fix the bar.

Results In the present study, a total of 30 patients were analyzed. The average working time for Group A, Group B, and Group C were 110, 16, and 29 min respectively. Oral hygiene scores through modified Turskey Gilmore plaque index which was taken at immediate postoperative, 15, 30, and at 45 days. Maximum hygiene was maintained in intermaxillary fixation screw group followed by modified arch bar group and conventional arch bar group. Maximum stability was seen in the conventional arch bar group followed by modified arch bar group and intermaxillary fixation screw group. With respect to mucosal coverage, maximum mucosal growth was seen in intermaxillary fixation screws group. When complications were taken into consideration, maximum complications were reported in Group A followed by Group B and Group C.

Conclusion This study emphasizes that the use of modified arch bar is quick and easy method than conventional arch bar with least chances of glove puncture and needle stick injury to the operator. Oral hygiene maintenance is comparatively better in patients with modified arch bar than with conventional arch bars. Modified arch bar was significantly stable when compared with IMF screws, and therefore, for the patients who require long-term intermaxillary fixation, modified arch bars can be a viable option.

Keywords Arch bar · Intermaxillary fixation screws · Modified arch bar · Intermaxillary fixation

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Introduction

Successful treatment of maxillary and mandibular fractures depends on reduction and fixation by using open or closed techniques and on restoration of normal occlusion. Before

fracture reduction, temporary intermaxillary fixation with correct registration of occlusion is necessary.

Materials and Methods

All the procedures were performed by the same operator under local anesthesia. The study was conducted in following steps. The patients with fracture of mandible like parasymphysis, symphysis, and condylar fracture who needed intermaxillary fixation and agreed to participate in the study were included in this study. The patients with pan facial and comminuted fractures, angle or body fracture of mandible, maxillary fracture, edentulous arch, respiratory problems, primary and mixed dentition, mobile teeth in upper and lower arch, bone pathology, history of radiation therapy and partially dentate patients whose dentition precluded were excluded in this study.

A detailed case history was taken with clinical examination. Pretreatment OPG was obtained. The selected patients were divided on the basis of lottery system into three groups of 10 each, and designated as Group A, Group B, and Group C.

In Group A, intermaxillary fixation was achieved by the conventional method using Erich arch bar (Fig. 1), fastened with 26-gauge stainless-steel wires under local anesthesia.

In Group B, intermaxillary fixation was achieved by the use of 2 mm × 8 mm 4–6 stainless-steel intermaxillary fixation screws (Fig. 2).

- After appropriate local anesthesia, holes were drilled through mucosa without any gingival incision between the canine and first premolar in each quadrant.
- Four to six screws were used; the third pair was used in the same way over the dental midline and its need being dictated by the clinical condition.
- Self-drilling stainless-steel intermaxillary fixation screws, 2 mm in diameter and 8 mm in length, were inserted through the pre-drilled holes, taking care not to penetrate palatal or lingual mucosa.
- Intermaxillary fixation was achieved using wires or elastic bands.
- The intended surgical procedure was carried out.
- Screws were left in place to enable postoperative traction to correct small discrepancies in occlusion.
- All procedures were done under antibiotic coverage.

Fig. 2 IMF screws

In Group C, intermaxillary fixation was achieved by modified screw arch bar.

- A conventional arch bar was modified by making perforations in the spaces between the winglets along the entire extension of the bar (Fig. 3).
- In the patient under local anesthesia, the arch bar was adapted to the vestibular surface of the maxilla and mandible, close to the cervical portion of the teeth, and perforations were made in the inter-radicular spaces with a 1.1-mm bur, taking care to avoid perforation of the tooth root.
- After this, 1.5-mm screws were placed to fix the bar. It was not necessary to tighten the screw much, just enough to achieve stabilization of the arch bar, so that the gingival tissue was not compressed, which could lead to ischemia and necrosis. Screws (2 anterior and 2 posterior) are sufficient for good stabilization of the

Fig. 1 Conventional arch bar

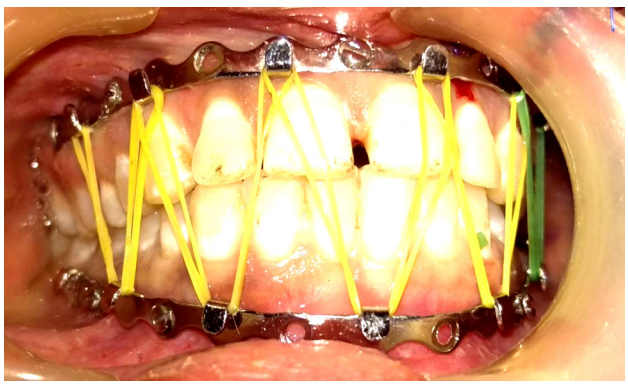

Fig. 3 Modified arch bar

arch bar in order to perform the intermaxillary fixation. Additional screws were used, whenever necessary.

Oral hygiene scored through modified Turskey Gilmore plaque index (Table 1) which was taken at immediately after placement of arch bar or IMF screws, after 15, 30 and at 45 days.

Results

In the present study total of 30 patients were analyzed, among which 10 patients with conventional arch bar (Group A), 10 patients with IMF screws (Group B), and 10 patients with modified arch bar (Group C) were divided. Each group consists of two female and eight male patients. The average working time for Group A (conventional Erich arch bar), Group B (IMF screws), and Group C (modified arch bar) were 110, 16, and 29 min, respectively. Oral hygiene scores through modified Turskey Gilmore plaque index which was taken at immediate postoperative, 15, 30, and at 45 days. The mean score for conventional arch bar at immediate postoperative was 1.55 ± 0.45 which was increased significantly at 15 days to 2.72 =\− 0.29 which was slightly reduced to 2.28 ± 0.32, the difference from immediate postoperative to 45 days was statistically significant with p value < 0.001. Significant improvement was shown in IMF screw group, which was improved to 1.73 ± 0.39 from 2.12 ± 0.50 with the p value of < 0.001. No statically significant difference was seen in modified arch bar from immediate postoperative to 45 days postoperatively, and P value came to be 0.12. Thus, we can say that maximum hygiene was maintained in IMF screw group followed by modified arch bar group and conventional arch bar group. After the placement of IMF screw, conventional arch bar and modified arch bar shows significant statistical difference in the stability, maximum stability was seen in the conventional arch bar group followed by modified arch bar group and IMF screw group. In one patient, IMF screws became unstable after 15 days, while two patient reported with unstable IMF screws post 30 days, and after 45 days there was a single reported case of IMF screws loosening in Group B. Entire group of conventional arch bar was found to be stable throughout the follow-up period. When Group C was evaluated, it was found that there were two cases of unstable arch bar post 30 days and no cases of instability thereafter. Thus we found that on stability parameter, conventional arch bar was found to be significantly stable, with the p value of 0.04 followed by modified arch bar and IMF screws, respectively. In respect to mucosal coverage, maximum mucosal growth was seen in IMF screws group with partial coverage in all patients after 15 days and 2 cases of full mucosal coverage after 30 days. Two more patients were reported with full mucosal coverage after 45 days, whereas there was a single reported case with partial coverage seen after 45 days with modified arch bar and no reported case with mucosal growth in conventional arch bar group. On evaluation of result, we found that least amount of mucosal growth was seen in Group A followed by Group C and Group B, respectively. When complications were taken into consideration, maximum complications were reported in Group A with six patients reported cases of gloves puncture, whereas Group B and Group C reported with one case of complication each which was tooth root injury while placing the screws.

Table 1 Modified Turskey Gilmore plaque index

Score	Criteria
0	No plaque
1	Isolated areas of plaque at gingival margin
2	Thin band of plaque at gingival margin (< 1 mm)
3	Plaque covering up to 1/3rd of tooth surface
4	Plaque covering up to 2/3rd of tooth surface
5	Plaque covering up to > 2/3rd of tooth surface

Discussion

The treatment of mandibular fractures has been in a constant state of evolution over the last few decades [1]. The main aim of treating mandibular fractures includes: fracture site reduction, stabilization, and achievement of correct dental occlusion. During these processes, it is also advantageous to use methods that decrease the risk of percutaneous transmission of blood-borne diseases, operating time and duration of general anesthesia, and hospital costs. The management of maxillofacial fractures includes different techniques from closed reduction to open reduction and internal fixation (ORIF) and requires control of the dental occlusion with the help of IMF which is time-consuming with the use of conventional technique [2]. The arch bar has been the backbone for the administration of maxillary mandibular fracture since First World War [7]. The originators of this technique, Gilmer in USA and Sauer in Germany, used a regular round bar flattened on one side that was ligated by using brass ligature wires to the teeth [3]. Ivy and Blair's modification was "flattened on one side" which was about 2 mm in width to confine better to the teeth and provide greater stability. Introduction of "bone plating system" has reduced the duration of IMF though there is often a need for temporary intermaxillary fixation intra-operatively and sometimes postoperatively to

correct dental occlusal discrepancies by elastic traction. [2].

Erich arch bar or eyelet wires are the most common methods of achieving IMF, although other techniques are described. These methods are relatively time-consuming for application and removal of arch bars besides having an inherent risk of perforation of the surgeons gloves and consequent "needle stick injury" caused by the sharp-ended wires [4]. Moreover, this technique is difficult to use when the teeth are grossly carious, periodontally compromised, crowded, and extensive crown and bridgework in oral cavity [5]. Final tightening of wires during the placement of conventional arch bars around the teeth may cause "necrosis of the mucosa," "extrusion," and subsequent loss of vitality of the tooth. It is also not easy to maintain the gingival health [6]. To overcome drawbacks of conventional arch bars, IMF screws technique was described by "Arthur and Berardo in 1989" which utilizes at least four "self-tapping titanium or stainless-steel screws" inserted through the mucosa, one for each quadrant [7]. The screws were 8 mm in length and 2 mm in diameter which were inserted at the "junction of the attached gingiva" and "mobile mucosa" between the canines and first premolars [8]. Reference to the radiographs may give significant information regarding the space available for insertion of the intermaxillary fixation screws. There are many advantages to this procedure, with respect to the use of conventional arch bars. Arthur and Berardo suggested the use of "threaded titanium screws of 2 mm diameter and 10–16 mm in length" for IMF, which was later modified by Carl Jones [8]. He designed the screws with capstan shaped head which allowed the wires and elastics to be held "away from the gingival tissue" [9]. These screws are "quick and easy" to insert and have fewer risks of needle stick injury than traditional methods. The operating time is also reduced from hours to minutes, hence these screws are recommended for temporary intraoperative IMF and postoperative elastic traction [10]. The preferred site for screw placement was the alveolar bone between canine and first premolar but the cases having fracture line in canine and premolar region, the screw position needs to be changed depending on the fracture site and line of incision. Screw placement within the confines of the maxillary or mandibular alveolar process between inter-radicular spaces was suggested [11]. The width of the "inter-dental bony septa" converges toward the occlusal surface, while the root circumference of the adjacent teeth enlarges, for that reason the risk of hitting a tooth root increases progressively by placing the screws closer to the coronal third of the root [12]. In the mandibular premolar region, the loose soft tissue envelopes the tooth "immediately surrounding the mental foramen" Hence the placement of IMF screws has to be avoided to prevent injury to neurovascular bundle [5]. The muco-gingival line and the attached gingiva give a reliable guidance to the intermediate third of the tooth roots both in the maxilla and mandible. While using IMF screws there may be chance of tooth root injury, mucosal coverage after 4–6 weeks partially or completely, and it starts loosening after 5–6 weeks [8].

To minimize the drawback of IMF screws and conventional arch bar, the modified arch bar was introduced in the year 2013, by S. B. F. de Queiroz. He modified the conventional arch bar by using a No. 701 bur and making perforations between the winglet spaces along the entire extension of arch bar. It can be said that the modified arch bar is a mixture of two techniques namely IMF screws and conventional arch bars and hence can be used for a longer period of time than IMF screws. Modified arch bar utilizes the positive aspect of IMF screws and conventional arch bars. This modified arch bar can also be used in edentulous spaces where conventional arch bar is not possible. Moreover, it can also be fixed in completely edentulous patient [13]. However, the perforations in the original arch bar may lead to weakening of modified arch bar. Anshul Rai studied the comparison between IMF screws and conventional Erich arch bar and he found that the oral hygiene maintenance is better in patients with IMF screws than with conventional arch bars with fewer complications and required less operating time, but conventional Erich arch bars are the preferred choice in patients who required long-term intermaxillary fixation, because the screws start loosening after 5–6 weeks [8].

G. D. Nandini also studied comparison between the Erich arch bar and self-tapping IMF screws. The parameters were considered, duration, perforations in the gloves, and acceptance in patients, oral hygiene, iatrogenic tooth root injuries, and needle stick injuries during intermaxillary fixation with both the techniques. The author concludes that the intermaxillary fixation by using self-tapping intermaxillary fixation screws is effective technique as compared to the conventional arch bars in the management of mandibular fractures as it shows less number of gloves perforations and comparatively better oral hygiene status [2].

In this study, we compared the efficacy of conventional arch bar, intermaxillary fixation screws, and modified arch bar with respect to plaque accumulation, time required for procedure, postoperative stability after achieving the intermaxillary fixation, mucosal growth and complications encountered for intermaxillary fixation. The average working time for Group A (conventional Erich arch bar), Group B (IMF screws), and Group C (modified arch bar) were 110, 16, and 29 min respectively, in which Group A has taken significantly more working time. Moreover, it was confirmed that the IMF screws technique is the quick

method to achieve intermaxillary fixation [4]. Anshul Rai et al. reported the average working time for placement of IMF screws was 18.67 min and for arch bars was 95.06 min which was quite similar with our study. Gibbons et al. [5] also suggested that IMF screws were a quick and easy technique for intermaxillary fixation.

Oral hygiene of the patients was assessed by using Turskey Gilmore Glickman modification of the Quigley Hein plaque index. Plaque was assessed on the labial, buccal, and lingual surfaces at the gingival third of all the teeth. Oral hygiene scores through modified Turskey Gilmore plaque index which was taken at postoperative, 15, 30, and at 45 days. The mean score for conventional arch bar at postoperative was 1.55 ± 0.45 which was increased significantly at 15 days to 2.72 ± 0.29 which was slightly reduced to 2.28 ± 0.32, the difference from postoperative to 45 days was statistically significant with p value < 0.001. Significant improvement was shown in IMF screw group, which was improved to 1.73 ± 0.39 from 2.12 ± 0.50 with the p value of < 0.001. Modified arch bar was statistically not significant difference from postoperative to 45 days with the p value of 0.12. Thus, we can say that maximum hygiene was maintained in IMF screw group followed by modified arch bar group and conventional arch bar group, respectively. Anshul Rai et al. reported the mean value of Turskey Gilmore Glickman modification of the Quigley–Hein plaque index in IMF screws was 1.88 and in conventional arch bar was 2.69 suggestive that IMF screws have better oral hygiene than conventional arch bar, and same findings were noted in our study. Oral hygiene maintenance is not easy when IMF is achieved by using conventional arch bar or modified arch bar; however, oral hygiene was not maintained by the patient properly in all the groups due to pain during first 15 days. Stability was checked in all the three groups and a statistically significant difference was seen in the stability, with maximum stability seen in the conventional arch bar group followed by modified arch bar group and IMF screws group, respectively. In one patient, IMF screws became unstable after 15 days, while two patients reported unstable IMF screws post 30 days, and after 45 days there was a single reported case of IMF screws loosening in Group B. Entire group of conventional arch bar was found to be stable throughout the follow-up period. When the Group C was evaluated, it was found that there were two cases of unstable arch bar post 30 days and no cases of instability thereafter. Thus we found that on stability parameter, conventional arch bar was found to be significantly stable, with the p value of 0.04 followed by modified arch bar and IMF screws, respectively.

Anshul Rai studied the comparison between IMF screws and conventional Erich arch bar and found that conventional Erich arch bars are the preferred choice in patients who required long-term intermaxillary fixation, because the screws start loosening after 5 to 6 weeks [8]. Coletti et al. [14] studied retrospectively on 49 patients and indicated that the most common complication was screw loosening (6.5%). The reason for screw loosening was due to the force of the musculature, which was exerted while the patient was in IMF, or in patients where the direction of screw was not perpendicular to the occlusal plane. Busch [11] also reported a similar complication in his study. He recommended the use of greater-diameter screws placed away from root apices.

Coburn et al. [15] reported fracture of screws in 3 of 122 patients (2.4%) treated for mandibular fracture by using IMF screws. In our study, there was no incidence of screw breakage during the procedure. Main purpose of intermaxillary fixation is occlusion stability. We found that IMF screws are as good as arch bar for occlusion stability, but major drawback was difficulty in maintaining it for longer duration (5–6 weeks) due to the chance of screw loosening [8]. In our study, we can say that modified arch bar was significantly stable when compared with IMF screws, and therefore, for the patients who require long-term intermaxillary fixation, modified arch bars can be a viable option.

In respect to mucosal coverage, maximum mucosal growth was seen in IMF screw group with the reported cases of full mucosal coverage seen in 1, 2, and 4 cases on 15th 30th and 45th days, respectively, whereas there was a single reported case with partial coverage seen after 45 days with modified arch bar and no reported case with mucosal growth in conventional arch bar group. On evaluation of result, we found that least amount of mucosal growth was seen in Group A followed by Group C and Group B, respectively.

According to Sahoo et al., mucosal coverage over the IMF screws was 2.04% at the time of removal, but we reported four patients with total of six screws having with full mucosal coverage after 45 days while all screws were partially covered with oral mucosa. Ueki et al. [16] assessed the skeletal stability after mandibular setback surgery with and without an IMF screw and reported that six IMF screws were covered by oral mucosa in 122 patients. Roccia et al. [4] noted that 4.9% of the screws were covered by oral mucosa. Carl-Peter Cornelius mentioned that soft tissue burying or mucosal overgrowth of IMF screws was only encountered in studies with screw placement adjacent to or within the mobile mucosa [12]. During the postoperative follow-up period, none of the conventional arch bar was covered with oral mucosa, while only 1 modified arch bar was partially covered with oral mucosa after 45 days. Furthermore, the problem of mucosa covering the screws could be eliminated using customized IMF screws. Anshul Rai suggested the customized IMF

screws that he modified the intermaxillary fixation screws by adding stainless-steel washer, which keeps the oral mucosa away from the IMF screw and avoided the necessity for a second surgical procedure to explore the IMF screw [17].

The most common complication faced in conventional arch bar group was glove perforations. The gloves perforation was identified by water retention test after the procedure in which water was filled within the used gloves, to check for perforation within the gloves. This test was positive in 60% of patients in Group A, while negative in all patients of IMF screw group and modified arch bar group. During the procedures, the complication of tooth root injury was noted in IMF screw group and modified arch bar group, and it was 10%, i.e., one patient in Group B and Group C.

Coletti et al. reported tooth root injury in 2 patients out of 49 (4%) in their study. Coburn et al. used IMF screws in their study on 122 patients with mandibular fractures. Complications including fracture of the screws upon insertion and iatrogenic damage to teeth causing tooth loss and bony sequestra around the area of screw placement occurred in five patients (4%) [15].

In our study, no such sequestration occurred around the screws. During drilling, initial resistance was felt on penetrating the outer cortex followed by minimal resistance in the cancellous bone [15]. In case of continuous resistance, drilling may be abandoned and an alternate site may be selected to avoid tooth root injury [18]. Inadvertent penetration of the IMF screw shaft or tip into the maxillary sinus does not matter and will heal spontaneously unless the antrum wall is thin and fragile, the IMF screw will get loose and tilt downward when the wires are applied and tightened [12].

Atul Kusanale et al. reported a case of self-tapping intermaxillary fixation screws which displaced a sagittal parasymphyseal fracture after placement of IMF screw. Thus the author suggested a shorter length of screw which "prevents displacement of sagittal parasymphysis fracture" after placement of IMF screw, if the pattern of the fracture was appreciated [19]. We used 2 × 8 mm IMF screws for this study to avoid such complications.

During the placement of modified arch bar, we noticed that it was necessary that the arch bar holes and interradicular spaces of teeth coincide with each other which was not always possible. Mandibular anterior teeth have less inter-radicular space, and hence an injury can occur to the anterior tooth roots while placing screws in the modified arch bar. The placement of modified arch bar was more apical than conventional arch bar, so it was difficult to give an intra oral vestibular incision for mandibular fracture along with difficulty in the reduction of the fracture, in the symphysis, parasymphysis, and body of fractures of mandible. Modified arch bar was partially covered by mucosa near empty holes after 45 days while none of the screws of modified arch bar were covered with mucosa, so no additional procedure is required for its retrieval as in case of IMF screws where you need an additional procedure which is uncomfortable for the patient. However, modified arch bars do have consequences like tooth root injury particularly in mandibular anterior region due to crowding of teeth. In this study, one patient was reported with tooth root injury during placement of modified arch bars. We believe that along with experience iatrogenic cause can be avoided and can be quite useful in edentulous patients though modified arch bars cannot be used in pediatric patients with unerupted teeth as well as patients with crowding in anterior and/or posterior region. In severely displaced symphysis, parasymphysis, or body fracture of mandible, split (conventional) arch bar can be used to achieve proper dental occlusion during ORIF, but while using modified arch bar technique, splitting the arch bar was difficult. Modified arch bar is bone supported arch bar so while using in displaced fracture of parasymphysis, symphysis, and body of mandible, reduction in fracture site becomes difficult.

Thus, we can say that the modified arch bar is quick and easy method than conventional arch bar with least chances of glove puncture and needle stick injury to the operator. It can be of use in edentulous patient where conventional arch bar is not possible. Oral hygiene maintenance is comparatively better in patients with modified arch bar than with conventional arch bars. Modified arch bar was significantly stable when compared with IMF screws, and therefore, for the patients who require long-term intermaxillary fixation, modified arch bars can be a viable option.

To our knowledge, no such prospective or retrospective study had compared these three modalities for achieving the intermaxillary fixation, which makes the present study unique. However, the small sample size could be considered the limitation of this study.

Conclusion

This study emphasizes that the use of IMF screws was a quick and easy method followed by modified arch bar and conventional arch bar with least chances of needle stick injury to the operator. Oral hygiene maintenance was comparatively better in patients with IMF screws followed by modified arch bar. Conventional arch bar was significantly stable when compared with modified arch bar and IMF screws, and therefore, for patients who require long-term intermaxillary fixation, conventional arch bar followed by modified arch bars can be a viable option. The perforation in the original arch bar may lead to the

weakening of the arch bar, and the prefabricated modified arch bar, which is available, would be a better option; however, on non-availability of modified arch bar, this indigenous method may be tried upon.

Compliance with Ethical Standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical Approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards.

Informed Consent It was obtained from all individual participants included in the study.

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