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Comparison of hybrid arch bar versus conventional arch bar for temporary maxillomandibular fixation during treatment of jaw fractures: a prospective comparative study

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Abstract (J Korean Assoc Oral Maxillofac Surg 2023;49:332-338)

Objectives: This study aimed to compare the effectiveness of a hybrid arch bar (hAB) with the conventional Erich arch bar (EAB) for the management of jaw fractures, focusing on their use for temporary fixation in patients undergoing open reduction and internal fixation (ORIF).

Materials and Methods: Patients presenting with maxillary and mandibular fractures at our institution were included in this prospective, comparative study. Placement time and ease of occlusal reproducibility were recorded intraoperatively for Group A (hAB patients) and Group B (EAB patients). The primary outcome was comparison of the postoperative stability of the two arch bars. Postoperative measurements also included mucosal overgrowth, screw loosening or wire retightening, and replacement rates. The data were tabulated and computed with a $P<0.05$ considered statistically significant.

Results: The study included 41 patients. A statistically significant difference was observed in postoperative stability scores (3) between Group A and Group B (85.0% vs 9.5%, $P=0.001$). The mean placement time in Group A (23.3 minutes) significantly differed from that in Group B (86.4 minutes) ($P<0.001$). The ease of intraoperative occlusion was not different between the two groups ($P=0.413$). Mucosal overgrowth was observed in 75.0% of patients (15 of 20) in Group A.

Conclusion: The hAB was superior to EAB in clinical efficiency, maxillomandibular fixation time reduction, stability, versatility, and safety. Despite temporary mucosal overgrowth, the benefits of hAB outweigh the disadvantages. The choice between hAB and EAB should be based on specific clinical requirements.

Key words: Maxillomandibular fixation, Mandibular fractures, Maxillofacial injuries, Maxillofacial procedure, Jaw fixation technique

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I. Introduction

In a one year cross-sectional study of over 1,000 cases of facial trauma in a tertiary care center in India, mandibular fractures (33.57%) were the most common, followed by maxilla (31.13%), nasal (28.33%), and zygoma (24.36%)[1]. The treatment goal for jaw fractures is to restore proper jaw function and anatomy by ensuring correct union of the fractured segments. Re-establishing occlusion intraoperatively using maxillomandibular fixation (MMF), although temporary, is a critical but rate-limiting step in proper fracture reduction[2]. The conventional MMF procedure uses arch bars of malleable strips of steel-bearing hooks, allowing hands-free achievement and maintenance of excellent intraoperative occlusion with reproducibility[3]. However, certain disadvantages exist such as increased operative time for placement under general anesthesia, loosening of the arch bar ligature wires over time, and unsuitability for patients with multiple missing teeth, grossly carious teeth, periodontally weakened teeth, or those with extensive crown-and-bridge work. Hardware in the mouth compromises oral hygiene, damages periodontal tissues causing gingivitis, and poses a high risk of injuries from sharp hardware to the clinician and assistant. A hybrid arch bar (hAB) for MMF has been introduced to overcome some disadvantages of conventional arch bars, also known

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as Erich arch bars (EABs)[4]. The hAB differs from the EAB because they are secured directly to the alveolar bone with screws rather than using teeth for anchorage[5]. In the present study, hAB and EAB were compared as temporary fixation for jaw fractures in patients undergoing open reduction and internal fixation (ORIF). Stability, operative time, and ease of pre-traumatic occlusion were assessed to determine arch bar effectiveness.

II. Materials and Methods

This was a prospective, comparative study performed after obtaining approval from the Institute Ethics Committee (591/IEC-AIIMSRPR/2019) of the All Institute of Medical Sciences (AIIMS), Raipur. Because the decision to use hAB or EAB depended solely on patient affordability, randomization was not performed. Patients 18-50 years of age who underwent ORIF of maxilla and mandible fractures between May 2019 and September 2020 at the Department of Dentistry, AIIMS Raipur, and consented to participate were included in this study. The patients were divided into two groups. Group A consisted of patients who received hAB (Ezy Bar; Ortho Max) and Group B included patients who received EAB (Arch Bar; Ortho Max). Exclusion criteria were based on several factors to eliminate potential confounding variables. Patients presenting with pathological fractures of the jaw or fractures older than two weeks were excluded. In addition, subjects requiring concurrent procedures other than dental extractions during mandible ORIF were not considered for this study. Cases where different arch bar devices were used for the maxilla and mandible were also excluded. Furthermore, individuals who underwent the transcervical or transfacial approach were excluded. Additional health conditions leading to exclusion included poorly controlled diabetes mellitus, history of chemotherapy or radiation therapy targeted at the jaw area, immunocompromising conditions, risk factors for BRONJ (bisphosphonate-related osteonecrosis of the jaw), overt psychological disturbances, heavy alcohol consumption, periodontally compromised teeth, and history of seizures. Both arch bars were left in situ postoperatively for four weeks to allow elastic traction for fine-tuning of occlusion.

The duration (minutes) from adaptation of hAB to dental arch and placement of the last screw was recorded separately for the upper and lower arch bar and totalled for final analysis by an impartial observer not involved in the study. Similarly, time from start of adaptation of EAB to either dental arch was measured, and placement of last circum-dental wire was recorded by an impartial observer using a stopwatch for both the upper and lower arch bar separately and then totalled for final analysis. Intraoperatively, reproducible pre-traumatic occlusion was observed, characterized by interdigitation of occlusion facets and categorized based on the ease of reduction of occlusion.

The primary outcome variable was stability measured at three points at four weeks after arch bar placement: incisors and right and left first molars. The principal investigator clinically evaluated mobility at the time of removal using a standardized heavy wire twister for all arch bars. Any mobility in the vertical plane ≥1 mm (measured with callipers) was considered unstable and graded based on a stability scoring system. Table 1 shows the stability scoring system uniquely designed for this study. The grading system included different levels of stability with a score of 0, 1, or 2 with corresponding criteria for each category based on the degree of movement observed at the specified measurement points.

The postoperative complications included mucosal overgrowth of >3/4 of the screw head covered with mucosa or screw removal requiring minor incision. For the hAB, screw loosening was measured both clinically and radiographically on orthopantomogram (OPG) at the time of removal (after four weeks) as any displacement of the screw from its initial placement site. For the EAB, wire loosening was recorded if any circum-dental wire was loose and above the cingulum of anterior teeth and cementoenamel junction for posterior teeth and radiographically on OPG as any loss of wire.

1. Data collection

The baseline demographic data, pre-morbid conditions, mode of injury, site of fracture, and relevant clinical data were obtained. OPG and non-contrast computed tomography (CT) were obtained preoperatively. Placement time and occlusal reproducibility scores were recorded intraoperatively. Postoperative measurements of screw retightening in the

Table 1. Stability of the arch bar

Mobility	Score
No mobility at right and left molars and central incisor	3
Mobility at 1 point	2
Mobility at 2 points	1
Mobility at 3 points	0

Samriddhi Burman et al: Comparison of hybrid arch bar versus conventional arch bar for temporary maxillomandibular fixation during treatment of jaw fractures: a prospective comparative study. J Korean Assoc Oral Maxillofac Surg 2023

Table 2. Demographic data

Demographic variable	Group A (hAB) (n=20)	Group B (EAB) (n=21)
Mean age (yr)	31.6±10.5	30.5±12.1
Sex, female/male	3/17	2/19
Type of anesthesia, GA/LA	95.0/5.0	47.6/52.4
Pre-morbid conditions	9.6	5.0
Etiology of trauma (MVA)	90.0	90.5

(hAB: hybrid arch bar, EAB: Erich arch bar, GA: general anesthesia, LA: local anesthesia, MVA: motor vehicle accident)
Values are presented as mean±standard deviation, number, or %.
Samriddhi Burman et al: Comparison of hybrid arch bar versus conventional arch bar for temporary maxillomandibular fixation during treatment of jaw fractures: a prospective comparative study. J Korean Assoc Oral Maxillofac Surg 2023

Table 3. Stability scores in the two groups

Stability score	Group A (hAB)	Group B (EAB)	Total	*P*-value
0	0 (0)	1 (4.8)	1 (2.4)	<0.05
1	0 (0)	2 (9.5)	2 (4.9)	
2	3 (15.0)	16 (76.2)	19 (46.3)	
3	17 (85.0)	2 (9.5)	19 (46.3)	

(hAB: hybrid arch bar, EAB: Erich arch bar)
Values are presented as number (%).
P-value by chi-square/Fisher's exact test.
Samriddhi Burman et al: Comparison of hybrid arch bar versus conventional arch bar for temporary maxillomandibular fixation during treatment of jaw fractures: a prospective comparative study. J Korean Assoc Oral Maxillofac Surg 2023

hAB and wire retightening in the EAB were measured at the first and second weeks. The patients were followed up both clinically and radiographically using OPG to record late postoperative measurements.

2. Data analysis

IBM SPSS Statistics for Windows (ver. 21; IBM) software was used for statistical analysis. Continuous data were analyzed using Student's *t*-test and categorical data were analyzed using the chi-square or Fisher's exact test. A *P*-value <0.05 was considered statistically significant.

III. Results

For the study period, 41 patients met the inclusion criteria; 20 were allocated to Group A (treated with hAB) and 21 to Group B (treated with EAB). Table 2 shows comparison of demographic variables for both arch bars. Significant difference was not observed in age, sex distribution, or etiology of trauma between the two groups. However, placement of hAB required general anesthesia in 95.0% of patients. The majority (75.0%) of patients who received the hAB had mandibular trauma, and patients who received the EAB were equally divided into mandibular and midface fractures.

Table 4. Risk ratio for instability of arch bars in the two groups

	Unstable arch bars (score=0, 1, 2)	Stable arch bars (score=3)	Total
EAB	19 (a)	2 (b)	21 (a+b)
hAB	6 (c)	14 (d)	20 (c+d)
Relative risk	(a/a+b)/(c/c+d)		3.016

(EAB: Erich arch bar, hAB: hybrid arch bar)
Samriddhi Burman et al: Comparison of hybrid arch bar versus conventional arch bar for temporary maxillomandibular fixation during treatment of jaw fractures: a prospective comparative study. J Korean Assoc Oral Maxillofac Surg 2023

The intraoperative placement times differed significantly (*P*<0.001) between the groups; Group A (received hAB) averaged 23.3±8.1 minutes and Group B (received EAB) averaged 86.4±26.5 minutes. However, significant difference was not observed in ease of occlusion perioperatively between the two groups (*P*=0.413); 90% and 81% of patients achieved the best reproduction of occlusion perioperatively in Group A and Group B, respectively.

Table 3 shows the stability scores calculated for the two groups. When the stability scores were compared, a significant difference was observed in postoperative stability (*P*<0.05); 17 patients (85.0%) in Group A had a score of 3, indicating most cases were stable postoperatively. Patients in Group B were 3.016-fold more likely to have unstable arch bars compared with patients in Group A.(Table 4)

Mucosal overgrowth was defined as mucosa covering >3/4 of the screw head or necessitating a minor incision for removal. In the present study, 75.0% of patients (15 of 20) in Group A experienced mucosal overgrowth. The mean removal time for hAB was 30.05 minutes, significantly longer than for EAB with a mean of 19 minutes. Six patients (30%) in Group A exhibited screw loosening, and in Group B, 52% of patients required wire retightening or replacement.

IV. Discussion

In the present study, bone-retained hAB was compared with conventional tooth-retained EAB using several clinically relevant parameters to identify a quick and stable method for achieving MMF. Due to their anchorage in bone, MMF screws appear similar to hABs[6]. However, MMF screws have an inherent limitation because elastics or wires can only be attached to the screw heads (usually a total of four screws for both jaws)[7]. The hAB uses a maximum of 18 screws (nine per arch) and permits application of elastics or wires in a greater variety of directions because the arrangement

of hooks is identical to conventional arch bars[6]. With fewer intermaxillary fixation (IMF) screws, a larger diameter is needed, restricting their placement to areas without risk of root damage[8]. If IMF screws were more numerous and thinner, they would shear off or pull out under traction[9]. Therefore, arch bars are preferable to IMF screws when versatility in elastic force direction is needed. Thus, evaluating a new hAB system that combines placement of IMF screws with the multiple-hook versatility of conventional EABs is warranted.

In a study involving 90 patients, King and Christensen[10] reported the mean application time for conventional arch bars was significantly longer than for hABs (31.3±9.3 minutes vs 6.9±3.1 minutes, P<0.0001). These findings were validated in the present study in which significantly shorter placement time was observed for hAB (23.3±8.1 minutes) than for EAB (86.4±26.5 minutes). Although King and Christensen[10] reported a shorter placement time for EAB than the time observed in the present study, the time used in our study was comparable to that reported by Nandini et al.[11] (100 minutes) and Chao and Hulsen[12] (62 minutes). The hAB placement was likely faster because the constant risk of injury from sharp hardware was not present, and screws were quicker to place than wire ligatures. The placement times might influence the choice of IMF fixation due to cost and time benefits[10,13].

Significant difference was not observed between the two groups in achieving the best intraoperative reproduction of occlusion. This finding is similar to that reported in a retrospective review of 29 patients by Roeder et al.[13]. EAB allows manipulation of fractured jaw segments because wires can be tightened after satisfactory reduction. The rigidity of hABs after screw tightening limits accurate correction of minor discrepancies in fracture reduction. Due to the non-homogeneous distribution of cases in the two groups, we cannot infer the superiority of hAB over EAB in achieving occlusion.

Decreased stability of arch bars will decrease the accuracy of IMF over time, affecting occlusion. A higher stability score of 3 was observed in the majority of patients with hAB (85%) than in subjects with EAB (76% had a score of 2, categorized as unstable). These findings are comparable to those by Pathak et al.[14] who found that 90% of patients in the screw-retained arch bar group had appropriate stability compared with 80% of patients in the conventional arch bar group. Conversely, in a study by Rothe et al.[15] that included 30 patients, the conventional arch bar group had greater stability, followed by the modified arch bar group and the IMF screw group, with statistical difference of P=0.04. However, objective criteria for assessing stability were not presented in these studies. The hAB gains rigidity and additional stability when the screw is locked into the arch bar. Locking screws are feasible when placed perpendicular to the screw hole. However, in the present study, non-locking screws were used for all hAB patients, angling the drill bit occasionally to avoid damage to the tooth roots. In addition, locking screws increase the cost of hABs. Therefore, locking screws might offer even more stability with the hAB system if utilized.

In terms of complications associated with gingiva, EAB and hAB differ. The EAB wires complicates maintenance of gingival health due to debris deposition and can cause gingivitis. The EAB wires that are secured around the teeth during the arch bar application can also cause ischemic necrosis of the mucosa, extrusion, and subsequent loss of tooth vitality. In contrast, screw-based approaches, such as the hABs, can cause gingival trauma and stimulate mucosal overgrowth over the screws. In a study by van den Bergh et al.[16] in which IMF with screws or arch bars was compared, gingival complications were termed “mucosal disturbances” and were observed in 22 patients equally distributed in the 2 groups. The authors reported 11 screws (5.8%) in 11 patients (45.8%) in the IMF screw group showing partial mucosal overgrowth. In the arch bar group, 11 patients (42.3%) showed gingival hyperplasia, mainly located at the interdental papillae and diffusely located in the oral cavity. Similarly, Rothe et al.[15] reported the smallest amount of mucosal growth in the conventional EAB, followed by modified arch bar and IMF screws. In a review of MMF screws, Cornelius and Ehrenfeld[17] stated that soft tissue burying or mucosal overgrowth of MMF screws was only encountered in studies with screw placement adjacent to or within the mobile mucosa, suggesting mucosal overgrowth largely as an MMF screw-specific complication.

In the present study, 15 of 20 subjects (75.0%) in Group A had mucosal overgrowth.(Fig. 1. B) A screw head is a circle with four quadrants as seen en-face.(Fig. 1. C) When more than three quadrants (>3/4 or >75%) of the screw head were covered with mucosa, mucosal overgrowth was recorded. In addition, if the screw removal required minor incision, this was also recorded as mucosal overgrowth. A scale to quantitatively score mucosal overgrowth could have been designed; however, difficulty in removal would not have been taken into consideration. Kendrick et al.[18] observed mucosal

Fig. 1. A. Intraoperative image of hybrid arch bar showing bendable flanges. B. Mucosal overgrowth over screw head (75%-100% coverage) after 4 weeks of hybrid arch bar placement. C. Mucosal overgrowth over screw head (<50% coverage) after 4 weeks of hybrid arch bar placement.
Samriddhi Burman et al: Comparison of hybrid arch bar versus conventional arch bar for temporary maxillomandibular fixation during treatment of jaw fractures: a prospective comparative study. J Korean Assoc Oral Maxillofac Surg 2023

overgrowth in 38% of patients. The difference in mucosal overgrowth (75% vs 38%) may be due to the material of the arch bar; they used titanium and we used stainless steel hAB. In addition, the locking system used by Kendrick et al.[18] allows use of a screw spacer, which prevents impingement of the arch bar on mucosa and avoids mucosa migration over the screw head. Kiwanuka et al.[19] used another hAB system (MatrixWAVE) and found no cases of mucosal overgrowth. The authors attributed this success to the self-drilling screws with heads that sit above the bar securing the Synthes MatrixWAVE bone anchored MMF system in place, reducing the likelihood of mucosal overgrowth. Removal of hAB was performed under local anesthesia and only when screw heads were covered with mucosa.

In the present study, based on the chair-side test of non-vitality and on postoperative OPG, tooth injury was not observed in patients with hAB. This finding is consistent with other studies[12,19,20]. However, using cone-beam CT analysis, Kendrick et al.[18] observed screws causing dentin or pulp injury in 7.5% of patients. In the present study, the follow-up period was not sufficiently long to detect the late onset of symptoms of root damage. Screw loosening was present in 6 subjects in Group A (30.0%). The presence of screw loosening ranged from 0%-17% in other studies[12,18]. We hypothesized this difference was due to the non-locking screws used in the present study.

Vestibular discomfort was observed during the study, with 1 severe case attributed to long flanges of the hAB. To address this, the vertical flanges of the hAB were bent, which also helped prevent tooth root injury.(Fig. 1. A) For hABs used in ORIF, mucosal incisions were positioned slightly more apically into the sulcus to ensure sufficient tissue cuff for suturing, avoiding interference with screws during wound closure. In our experience, placing hAB in patients with shallow vestibule and tooth attrition is challenging. Because injuries from sharp hardware are considered a risk for transmission of blood-born diseases, adequate care to prevent glove tear or injury to the operator's hands would further decrease the time required for placement. Because operative time is billed by the hour at some centers, identifying a method of achieving IMF that is both rapid and safe would be desirable and warranted[21].

The present study had several limitations, including a limited sample size and non-random assignment of study participants, which prevented evaluating whether a fracture pattern affects the time required for arch bar placement. The stability of the arch bar should have been measured at the first week and then at the fourth week to compare decrease in stability of arch bars over time or when wires/screws were retightened for maintaining elastic traction. Interpreting the higher stability of hAB in terms of actual patient outcomes requires further prospective randomized trials.

V. Conclusion

The hAB offers distinct advantages over EABs in terms of clinical convenience, reduced time required for MMF, enhanced stability, versatility in directing elastic force, and preventing risk of injuries posed by wires. The observed disadvantages, such as mucosal overgrowth, healed spontaneously over time after the removal of screws. The authors suggest the hAB is overall superior to the conventional arch bar; however, individual choice between hAB and EAB should be based on specific clinical needs, such as time-

saving situations, cost, and benefits to the patient for better outcome.

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Authors' Contributions

S.B. participated in data collection and wrote the manuscript. N.U. participated in the conceptualisation of the study design, data collection and helped to draft the manuscript. S.R. participated in the study design and data collection. A.A. performed the statistical analysis and manuscript editing. All authors read and approved the final manuscript.

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Ethics Approval and Consent to Participate

This study was a prospective, comparative study performed after obtaining approval from the Institute Ethics Committee (591/IEC-AIIMSRPR/2019) of the AIIMS, Raipur, and the written informed consent was obtained from all patients.

Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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