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Original Article

Dentistry Section

Comparative Assessment of Efficiency and Patient Tolerance of Hybrid Arch Bar, Erich's Arch Bar and Maxillomandibular Fixation Screw Placement in Treatment of Jaw Fractures: A Prospective, Single Blinded, Parallel Group, Controlled, Clinical Study

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ABSTRACT

Introduction: Intermaxillary fixation, otherwise known as Maxillomandibular Fixation (MMF), is a time-tested technique used to stabilise occlusion when one or both of the jaws are fractured. There are different methods available for MMF, among which Erich's arch bar, MMF screws, and hybrid arch bars are the most commonly used. The presence of these different methods warrants a study to evaluate the efficiency, advantages, and disadvantages of each method.

Aim: To assess the efficiency and patient tolerance of hybrid arch bars, Erich's arch bars, and MMF screw placement in the treatment of jaw fractures.

Materials and Methods: This prospective, single-blinded, parallel-group, controlled clinical study was carried out in the Department of Oral and Maxillofacial Surgery at Dr. D. Y. Patil Dental College and Hospital, Dr. D. Y. Patil Vidyapeeth (Deemed to be University), Pimpri, Pune, from April 2023 to December 2023. Three parallel groups were designed with 15 participants who had mandibular fractures requiring MMF in each group. Patients in Group A were treated with Erich arch bars, patients in Group B with MMF screws, and patients in Group C with hybrid arch bars. Factors assessed included gingival inflammation on the day of removal and seven days post-removal of the MMF appliance using the modified gingival index, time taken for placement and removal in minutes, and patient discomfort using a visual analog scale. The observed values were subjected to statistical analysis using ANOVA for comparison of means and the Bonferroni test for intergroup comparison, with the significance level set at $p<0.001$.

Results: This was a prospective, single-blinded, parallel-group, controlled clinical study conducted on 45 patients, of which 37 were male and eight were female. All patients were within the age group of 22 to 62 years. The mean value for gingival inflammation on the day of removal of MMF was highest for the hybrid arch (3.14±0.0770) and lowest for MMF screws (0.57±0.6), with a p-value <0.001. The mean value for gingival inflammation seven days post-removal of MMF was highest for Erich's arch bar (1.57±0.732) and lowest for MMF screws (0.29±0.4), with a p-value <0.001. The mean application time was highest for Erich's arch bar (42.36±5.2 minutes) and lowest for MMF screws (20.57±2.8 minutes), with a p-value <0.001. The mean removal time was highest for the hybrid arch bar (18.14±1.5 minutes) and lowest for MMF screws (6.93±1.4 minutes), with a p-value <0.001. The mean patient discomfort was observed to be highest with Erich's arch bar (6.21±1.4) and lowest for MMF screws (5.00±1.4), with a p-value <0.001.

Conclusion: In terms of time efficiency during the placement of appliances, gingival inflammation, and patient comfort, the best choice would be MMF screws. Although Erich arch bars consumed more time during placement, they caused less severe gingival inflammation compared to the hybrid arch bar, making them the second-best option for dentulous or partially dentulous patients whose dental arches allow for their placement.

Keywords: Intermaxillary fixation, Occlusion, Oral hygiene

INTRODUCTION

Intermaxillary fixation, otherwise known as MMF, is a technique used to stabilise occlusion when one or both of the jaws are fractured. It is a time-tested technique that has evolved into various forms used as indicated. Intermaxillary fixation can serve as a foundation for facial reconstruction for a maxillofacial surgeon when handling complex maxillofacial traumas and orthognathic surgeries [1].

History records that jaw fractures have been treated using various methods. From linen threads to strands of metal, a wide array of techniques have been documented throughout literature. Steps to reposition a dislocated condyle were noted in Egyptian literature around 1600 BC, the same period when Sushruta in India was experimenting with facial flaps for lip and nose deformities. Simple jaw fractures were treated using bandages employed by embalmers, soaked in egg white and honey. In cases of associated soft-tissue wounds, fresh meat was applied to the surface on the first day [1].

Asklepios suggested that teeth loosened post-trauma should be tightened, along with adjacent teeth, using gold or, if unavailable, linen thread until bone healing occurs. The first recorded instance in literature regarding the fixation of the teeth of an injured jaw to a stable one was documented in an edition of Salicetti's treatise in AD 1492. "Maladies Chirurgicales" in 1779 described the use of a splint consisting of a shallow iron trough facing the occlusal surfaces of the teeth, connected in the submental region extraorally by a screw that, when tightened, applied compression forces across the occlusal surfaces of the teeth and the inferior border of the mandible, bringing the fractured segments together.

Modifications of this contraption have also been developed into head harnesses [1].

The first craniomaxillary suspension device was described by von Graefe in 1823. After this, intraoral and extraoral splints retained by wires and other means were developed for the stabilisation of jaw fracture segments. The use of per circumferential wiring was derived from a technique introduced by Baudens in 1840. Transosseous wiring using iron wire was first performed by Buck in 1847 and with silver wire by Kinloch in 1858. Gilmer, in 1887, introduced the technique of wiring individual teeth of the upper and lower arches together to achieve intermaxillary fixation. The use of ligature wire with a loop was introduced by Oliver in 1910 and then improved upon by Ivy and Eby in 1922 and 1920, respectively. Gilmer also introduced the technique of arch bars. Angle, in 1980, suggested MMF with the use of modified orthodontic brackets [1].

MMF is contemporarily used as a postoperative adjunct for stabilisation following semi-rigid fixation of jaw fractures. Temporary MMF is utilised intraoperatively to stabilise occlusion prior to fixation. Isolated unilateral high condylar fractures or intracapsular fractures, along with minimally displaced or undisplaced mandibular angle fractures, are cases in which MMF alone is found to be an effective treatment [2].

Different wiring techniques for MMF include the conventional technique, embrasure anchorage technique, Ernst ligature, pearl steel wire, inter-arch straight tie wires or ligatures, Ivy loops/eyelet wiring, arch bars, and modified orthodontic brackets and screws [2]. Among the aforementioned methods, MMF with Erich's arch bar and MMF screws are the two most commonly used techniques. The Erich arch bar is often considered the most reliable method of MMF. This is because, apart from holding the teeth together, it provides a shape to which the mobile teeth in the arch can be confined, restoring the contour to the best occlusion attainable for the patient [2]. It also provides a tension band for stabilising the forces acting on the fractured mandible. Disadvantages include extended surgery time, a high chance of needle prick injuries, gingival inflammation [3], patient discomfort, and loosening of wires.

MMF screws are placed onto the maxilla or mandible and drilled between the tooth roots into the bone to provide bone-anchored stability to the MMF. MMF screws are usually made of stainless steel or high-grade titanium, and their shafts have a pointed tip with a reduced thread diameter [4]. Self-tapping variants are available, which have a drill-shaped point for easier bone penetration. The screws are designed with a hole at the head that is to be placed above the mucosa, allowing for wire passage through it. This wire can then be tightened after passing through the head of another MMF screw on the opposite arch to achieve MMF. They are mostly used with a specially designed screwdriver blade [4]. Problems commonly encountered while using these screws include the risk of injury to tooth roots, screw breakage, drill bit breakage, infection, loosening of screws [5], and mucosal coverage over the screws [6].

Hybrid arch bars provide a combination of the positive effects of both MMF screws and the Erich arch bar. They offer bone support from the screws, as well as the arch-aligning property of the Erich arch bar, which also provides the tension band effect. This is especially useful in partially edentulous patients. Its advantages include shorter application time and a decreased risk of wire stick injuries. Complications may include tooth or mucosal injury, screw loosening, and hardware failure [7].

There have been studies conducted comparing different aspects of placement, treatment phases, and complications of the three modalities of MMF in various forms [5,8]. There is a need to compare certain aspects of the three modalities of MMF to assess which one is more efficient in handling and providing better patient comfort. The purpose of this original study is to evaluate and compare the efficiency of the three methods of MMF and the tolerance of patients toward each.

MATERIALS AND METHODS

Materials: This was a prospective, single-blinded, parallel-group, controlled clinical study conducted in the Department of Oral and Maxillofacial Surgery at Dr. D. Y. Patil Dental College and Hospital, Dr. D. Y. Patil Vidyapeeth (Deemed to be University), Pimpri, Pune, from April 2023 to December 2023. Approval was obtained from the institutional ethics committee (DYPDCH/DPU/ECI582/123/2023). Forty-five patients with mandibular fractures indicated for MMF were included in this study. The study was designed as a prospective clinical study, with 45 patients allocated to three groups of 15 participants each. Group A was designated for Erich's arch bar, Group B for MMF screws, and Group C for the hybrid arch bar.

The inclusion criteria consisted of patients with dentulous and partially edentulous arches aged 18 to 70 years who presented with mandibular fractures requiring MMF. Patients with panfacial fractures, pathological fractures, pregnant patients, and those with coagulation disorders, metabolic disorders, drug-induced gingival hyperplasia, or a history of radiotherapy or chemotherapy were excluded from this study.

Erich arch bar: The arch bar used in this study was 30 cm in length and made of stainless steel, obtained from Loyal Surgical Pvt. Ltd. Before placement, the patient's occlusion is brought into the best possible state, accounting for any pre-existing malocclusions. The size of the arch bar is cut according to the extent of the case. It should be placed between the horizontal line passing through the middle of the teeth and the gingiva, ensuring that it does not rest on the gingiva. The hooks are placed facing away from the occlusal surface, with an opposing hook on the opposite arch to facilitate the proper direction of forces on both bars. The arch bar is secured by passing 24-gauge stainless steel wires (Loyal Surgical Pvt. Ltd.) through the interdental spaces between each tooth and tightening them, with one wire passing above and one below the arch bar. Once tightened, the excess wire is cut off, and the end is made into a rosette and tucked in such a way that it does not injure the surrounding soft tissues. As needed, wires or elastics are used to provide MMF [2].

MMF screws: The design of the screw head resembles that of a spool. Its borders restrict any sliding movements of wires passing through them. Screws are made of stainless steel or titanium, with Phillips heads or a cruciform recess most commonly. They possess either self-drilling or self-tapping abilities and can be used accordingly. The MMF screws used in this study were 2×8 mm from Loyal Surgicals Pvt. Ltd.

Screw site selection is of utmost importance, as the major complication of these screws is inadvertent iatrogenic damage to the tooth roots. For placement in the maxilla, the height of the vestibule is at the proper level for placing the screws, as the bone at this level is suitable for placement, being far enough from the roots. The frenum is the only structure to avoid. For the mandible, in the lower anterior region, the area from canine to canine requires special attention, as the screws tend to be submerged beneath the mucosa here. The screws should be angulated downwards toward the mental protuberance, so that they remain above the mucosa. The screw head should be aimed to be at the mid-root level. For the posterior teeth, the region just below the mucogingival junction, where there is firm adherent mucosa, serves as a good location for screw placement. Wires can be inserted through the holes provided in the screw head into the opposing screws in opposing arches and tightened [4].

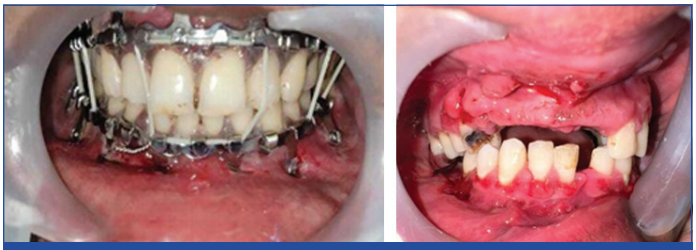
Hybrid arch bar: The hybrid arch bar provides the bone-borne stability of MMF screws combined with the arch stability of the Erich arch bar. They were obtained from SK Surgicals®, measuring 30 cm in length and made of stainless steel. The hybrid arch bar

is cut to the desired length and positioned in such a way that the middle screw is oriented between the roots of the central incisors. The hooks are placed facing away from the occlusal surface of the teeth. A 2×6 mm screw is drilled and placed through the provided holes perpendicular to the bone to fix the arch bar. The holes throughout the length of the arch bar can be adjusted appropriately to avoid the tooth roots. Wire loops can be passed over the hooks and tightened, similar to an Erich bar, to achieve MMF, or elastics can be placed over them [9].

Methodology: In a span of 9 months, 67 patients were screened, and 45 patients who met the criteria for the study were chosen and allocated into their respective groups. The sample size was calculated using OpenEpi software version 3. Detailed case histories were taken for the patients participating in the study, including age, gender, case, and site matching.

All necessary preoperative radiographs, such as Orthopantomograms/CT scans, were taken. Preoperative workups, including a complete blood profile and other indicated tests, were performed for all patients. The patients were sequentially allocated into each of the groups, one in each group. Afterward, the cycle was repeated until the sample size was satisfied.

For patients in Group A, MMF was done using Erich's arch bar. For patients in Group B, MMF was done using MMF screws. For Group C, MMF was performed using a hybrid arch bar. Prior to the commencement of the procedure, valid written informed consent was obtained from all the patients in a language they understood. Patients were taken for surgery and intubated by the indicated means. Surgical scrubbing, painting, and draping were performed. The fracture site was then exposed, and the patient's occlusion was manipulated into a stable position. MMF was carried out using the allocated method. The patient was placed on semi-rigid MMF with elastics as long as indicated. The patient was monitored as an inpatient until deemed fit for discharge. Upon discharge, the required medications were provided, along with oral hygiene instructions [Table/Fig-1-4].



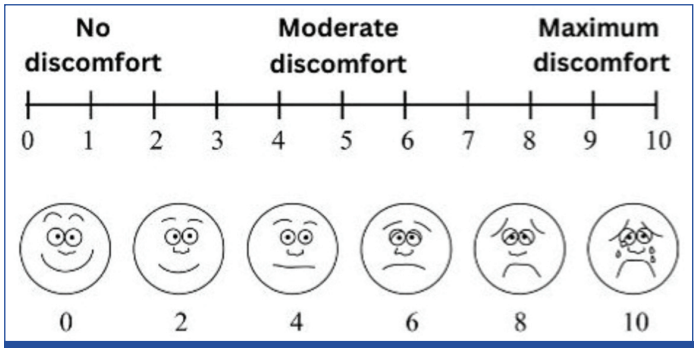
[Table/Fig-1]: Hybrid arch bar.
[Table/Fig-2]: Hybrid arch bar post removal. (Images from left to right)

[Table/Fig-3]: Erich's arch bar.
[Table/Fig-4]: MMF screw post removal. (Images from left to right)

Patients were recalled for follow-up, and the required information was gathered. The factors evaluated included gingival inflammation on the day of removal of the MMF appliance and seven days post-removal, the time taken for placement and removal of the MMF appliance in minutes, and patient comfort on the day of removal of the MMF. The Modified Gingival Index [10] was used to measure the level of gingival inflammation on one tooth in each arch for each patient, focusing on the tooth that presented with the most symptoms. The highest score obtained in any region was utilised for statistical analysis. Patient discomfort was measured on a linear scale with values ranging from 0 to 10, where 0 indicated no discomfort and 10 indicated maximum discomfort [Table/Fig-5,6] [11].

Score	Inflammation	Appearance
0	Healthy	Normal
1	Mild inflammation (partial unit)	Slight change in colour or texture of any portion but not entire marginal or papillary gingival unit.
2	Mild inflammation (entire unit)	Criteria as above but involving the entire marginal or papillary gingival unit.
3	Moderate inflammation	Glazing, erythema, oedema and/or hypertrophy of the marginal or papillary gingival unit.
4	Severe inflammation	Marked erythema, oedema, and/or hypertrophy of the marginal or papillary gingival unit, spontaneous bleeding, congestion or ulceration.

[Table/Fig-5]: Modified Gingival Index [10].



[Table/Fig-6]: Visual analog scale for evaluating patient discomfort [11].

STATISTICAL ANALYSIS

The statistical tests used for analysis were the ANOVA test for comparison of means and the Bonferroni test for intergroup comparison. SPSS software version 19 (SPSS Inc, Chicago, IL, USA) was used to process and analyse the data.

RESULTS

There were 45 patients, among which 37 were male and eight were female. All patients were within the age group of 22 to 62 years. The ANOVA test was used to compare gingival inflammation across the three groups on the day of removal. The mean value was greatest for Group C, with the greatest variation occurring in Group A. Group A showed a statistically significant difference in values compared to the other two groups. Intergroup comparison of gingival inflammation on the day of removal of MMF using the Bonferroni test showed statistically significant differences between Group A and Group B, Group B and Group C ($p<0.001$), and between Groups A and C (p-value 0.025) [Table/Fig-7,8].

MMF modality	Mean	Standard deviation	F-value	p-value
Erich's arch bar (A)	2.29	0.994	36.00	<0.001
MMF screws (B)	0.57	0.646		
Hybrid arch bar (C)	3.14	.0770		
	2.00	1.343		

[Table/Fig-7]: Comparison of means for gingival inflammation on day of removal of MMF.
Comparison of means by ANOVA test showed statistically significant results between the groups ($F=36.00$, $p<0.001$)

The ANOVA test was used to compare gingival inflammation across the three groups on day 7 after the removal of the MMF appliance. The mean value was greatest in the hybrid arch bar group. Intergroup comparison of gingival inflammation seven days post-removal of the MMF using the Bonferroni test showed statistically significant differences between Groups A and B, B and C ($p<0.001$), and A and C (p-value 0.009) [Table/Fig-9,10].

The time for placement of the MMF appliance was measured in minutes. The ANOVA test was used to compare the times among

Dependent variable	(I) group	(J) group	Mean difference (I-J)	Std. Error	p-value	95% confidence interval	
						Lower bound	Upper bound
Gingival inflammation on day of removal	A	B	1.714*	0.309	<0.001	0.94	2.49
		C	-0.857*	0.309	0.025	-1.63	-0.09
	B	A	-1.714*	0.309	<0.001	-2.49	-0.94
		C	-2.571*	0.309	<0.001	-3.34	-1.80
	C	A	0.857*	0.309	0.025	0.09	1.63
		B	2.571*	0.309	<0.001	1.80	3.34

[Table/Fig-8]: Intergroup comparison of gingival inflammation on the day of removal of MMF.
Test applied- Bonferroni test showed, statistically significant value set - p<0.001

MMF modality	Mean	Standard deviation	F	p-value
Erich's arch bar (A)	1.57	0.938	28.381	<0.001
MMF screws (B)	0.29	0.469		
Hybrid arch bar (C)	2.50	0.855		
	1.45	1.194		

[Table/Fig-9]: Comparison of means for gingival inflammation 7 days post removal of MMF.
Test applied – ANOVA test, statistically significant value set - p<0.05

Dependent variable	(I) group	(J) group	Mean difference (I-J)	Std. Error	p-value	95% confidence interval	
						Lower bound	Upper bound
Gingival inflammation 7 days post removal	A	B	1.286*	0.295	**<0.001**	0.55	2.02
		C	-0.929*	0.295	**0.009**	-1.67	-0.19
	B	A	-1.286*	0.295	**<0.001**	-2.02	-0.55
		C	-2.214*	0.295	**<0.001**	-2.95	-1.48
	C	1	0.929*	0.295	**0.009**	0.19	1.67
		2	2.214*	0.295	**<0.001**	1.48	2.95

[Table/Fig-10]: Intergroup comparison of gingival inflammation seven days post removal of MMF.
Test applied - Bonferroni test showed, statistically significant value set - p<0.05; *The mean difference is significant at the 0.05 level

the three groups. Group A required a statistically significant amount of time more than the other two groups, with a mean placement time of 42 minutes. Comparison of mean scores showed statistically significant results between the groups (F=119.963, p<0.001). Intergroup comparison of placement times using the Bonferroni test revealed statistically significant differences between Groups A and B, A and C, and B and C (p-value <0.001) [Table/Fig-11,12].

MMF modality	Mean	Standard deviation	F	p-value
Erich's arch bar (A)	42.36	5.227	119.963	<0.001
MMF screws (B)	20.57	2.848		
Hybrid arch bar (C)	28.86	2.627		
	30.60	9.798		

[Table/Fig-11]: Comparison of means for time taken for placement of MMF in minutes.
Test applied- ANOVA test, statistically significant value set – p<0.05

Dependent variable	(I) group	(J) group	Mean difference (I-J)	Std. Error	p-value	95% confidence interval	
						Lower bound	Upper bound
Time taken for placement	A	B	21.786*	1.420	**<0.001**	18.23	25.34
		C	13.500*	1.420	**<0.001**	9.95	17.05
	B	A	-21.786*	1.420	**<0.001**	-25.34	-18.23
		C	-8.286*	1.420	**<0.001**	-11.84	-4.73
	C	A	-13.500*	1.420	**<0.001**	-17.05	-9.95
		B	8.286*	1.420	**<0.001**	4.73	11.84

[Table/Fig-12]: Intergroup comparison of time taken for placement of MMF in minutes.
Test applied- Bonferroni test showed, statistically significant value set - p<0.05; *The mean difference is significant at the 0.05 level

The time for removal of the MMF appliance was also measured in minutes, using the ANOVA test for comparison among the three groups. Group C required the maximum time for removal, with a mean removal time of 18.14 minutes, followed by Group A, which had a mean removal time of 17.5 minutes. The comparison of mean scores by ANOVA test showed statistically significant results between the groups (F=150.20, p<0.001). Intergroup comparison of removal times using the Bonferroni test showed statistically significant differences between Groups A and B, and B and C (p-value <0.001) [Table/Fig-13,14].

Patient discomfort was measured using the VAS. The comparison of means by ANOVA test showed statistically significant results between the groups (F=13.543, p<0.001). Intergroup comparison of patient comfort using the Bonferroni test displayed statistically significant differences between Groups A and B (p-value <0.001) and A and C (p-value=0.013) [Table/Fig-15,16].

MMF modality	Mean	Standard deviation	F	p-value
Erich's arch bar (A)	17.50	2.565	150.209	<0.001
MMF screws (B)	6.93	1.439		
Hybrid arch bar (C)	18.14	1.562		
	14.19	5.531		

[Table/Fig-13]: Comparison of means for time taken for removal of MMF in minutes.
Test applied- ANOVA test, statistically significant value set - p<0.05

Dependent variable	(I) group	(J) group	Mean difference (I-J)	Std. Error	p-value	95% confidence interval	
						Lower bound	Upper bound
Time taken for removal	A	B	10.571*	0.727	<0.001	8.75	12.39
		C	-0.643	0.727	1.000	-2.46	1.17
	B	A	-10.571*	0.727	<0.001	-12.39	-8.75
		C	-11.214*	0.727	<0.001	-13.03	-9.40
	C	A	0.643	0.727	1.000	-1.17	2.46
		B	11.214*	0.727	<0.001	9.40	13.03

[Table/Fig-14]: Intergroup comparison of time taken for removal of MMF in minutes.
Test applied- Bonferroni test showed, statistically significant value set - p<0.05; *The mean difference is significant at the 0.05 level

DISCUSSION

The necessity to achieve a proper maxillo-mandibular occlusal relationship is the essential driver behind the use of MMF appliances. This is a crucial step in restoring functional normalcy to the patient. Among all facial fractures, mandibular fractures are the

MMF modality	Mean	Std. Deviation	F	p-value
Erich's arch bar (A)	5.00	1.542	13.543	<0.001
MMF screws (B)	5.00	1.468		
Hybrid arch bar (C)	6.21	1.477		

[Table/Fig-15]: Comparison of means for patient discomfort as measured by visual analog scale.
Test applied – ANOVA test, statistically significant value set - p<0.05

Dependent variable	(I) group	(J) group	Mean difference (I-J)	Std. Error	p-value	95% confidence interval	
						Lower bound	Upper bound
Patient discomfort	A	B	2.929*	0.565	<0.001	1.51	4.34
		C	1.714*	0.565	0.013	0.30	3.13
	B	A	-2.929*	0.565	<0.001	-4.34	-1.51
		C	-1.214	0.565	0.114	-2.63	0.20
	C	A	-1.714*	0.565	0.013	-3.13	-0.30
		B	1.214	0.565	0.114	-0.20	2.63

[Table/Fig-16]: Intergroup comparison of patient discomfort as measured according by visual analog scale.
*Mean difference is significant at 0.05 level; Test applied - Bonferroni test showed, statistically significant value set - p<0.05

most common. Maximum malocclusion problems occur in cases of mandibular fractures. Prior to starting any treatment, the dental status must be examined for any avulsed teeth, intruded teeth, excessively decayed teeth, and Grade 3 mobile teeth, which should be extracted during surgery if necessary. Teeth remaining in the fracture line should also be assessed to determine whether they are to be retained or extracted [12].

Various methods of MMF have been used thus far, among which Erich's arch bar has stood the test of time and is considered the gold standard. The main goals of fracture treatment include the reduction of the fracture, followed by maintenance through immobilisation until stability is achieved [13].

The Erich arch bar has been used since before the advent of plates and screws for the closed reduction of maxillofacial fractures. It promoted better occlusal stability than other methods available at the time of its inception, and it continues to do so even with the advent of MMF screws and hybrid arch bars [4]. The versatility and stability it provides make it an invaluable tool in the arsenal of an oral and maxillofacial surgeon for setting the dentulous or partially edentulous arch in proper occlusion post-trauma or for MMF during any other procedure.

MMF screws were introduced to overcome the disadvantages of the arch bar, which include needle prick injuries, extended surgery time, and patient discomfort. Damage to the marginal gingiva is less with MMF screws, and maintaining oral hygiene is also made easier [6]. MMF screws provide anchorage derived from the bone, which is considered to be more stable compared to tooth-borne anchorage. Common problems faced while using MMF screws include injury to tooth roots, soft-tissue coverage of screw heads—especially in the lower labial vestibule region—screw loosening, nerve injury, sinus penetration, and infection. Scoring, scratching, and even grooving of the root surfaces can occur if there is not direct penetration of the roots [4].

Hybrid arch bars combine the best properties of both Erich arch bars and MMF screws. They are retained in position by screws drilled into the cortices of the maxilla and mandible, while also providing the tension band and occlusal stability typical of the Erich arch bar. The time required for placement and the number of needle prick injuries were evaluated with the hybrid arch bar compared to the Erich arch bar. This study was conducted to assess and compare the efficiency of the Erich arch bar, MMF screws, and the hybrid arch bar by evaluating the parameters of time taken for application and removal, gingival status on the day of removal and seven days after removal, as well as patient comfort level on the day the appliance was removed.

The findings from this study reveal that MMF screws required the least time for both placement and removal, and they also showed the least gingival inflammation. The maximum time for placement and removal was observed with the Erich arch bar, which also exhibited more gingival inflammation compared to MMF screws. The hybrid arch bar took less time for placement and removal compared to the Erich arch bar but also demonstrated the highest level of gingival inflammation.

On assessing gingival inflammation on the day of removal of the MMF appliance, it was found that the highest level of gingival inflammation was observed in the hybrid arch bar group, with a score of four being the highest observed value in any region of the oral cavity according to the Modified Gingival Index. This value was seen more frequently in the hybrid arch bar group. The Erich arch bar group showed more variability within the values, which could indicate a difference between patients who maintained good oral hygiene and those who did not. This suggests that when the application of MMF allows for the maintenance of good hygiene and is strictly followed, gingival inflammation is reduced. The absence of wires through the teeth helps to avoid the accumulation of excessive plaque compared to the arch bar group. Maximum gingival inflammation was observed in the region where screws were placed, which had become submerged under mucosal overgrowth, resulting in increased severity of gingival inflammation.

Evaluation of gingival inflammation seven days post-removal of the appliance showed a reduction in values among both the hybrid and Erich arch bar groups. A decrease in value in the MMF screw group was not observed, as the inflammation on the day of removal was already low. Maximum inflammation was still noted in the hybrid arch bar group.

The mean time for placement of the appliance was longest for the Erich arch bar group at 42 minutes, followed by the hybrid arch bar group with 28 minutes, while the MMF screws group required an average time of 20 minutes. The lowest recorded time for Erich arch bar placement was 29 minutes, which was still greater than the maximum time taken for MMF screw placement. King et al., observed that the application of Erich's arch bar took a mean time of 32 minutes, while the hybrid arch bar took about 7 minutes. The mean time for removal was 11 minutes in the Erich arch bar group and 10.5 minutes in the hybrid arch bar group, suggesting that the hybrid arch bar was more efficient [7]. This aligns with the findings of our study, indicating that hybrid arch bars are more time-efficient compared to Erich arch bars.

The mean time for removal of the appliance was maximised in the hybrid arch bar group, taking 18.14 minutes, followed by 17.5 minutes for the Erich arch bar group. MMF screws required the least time for removal, averaging 6.9 minutes. The removal of screws that had been submerged under the inflamed mucosa took considerably longer and caused discomfort to the patient.

A meta-analysis conducted by Jain A et al., concluded that the hybrid arch bar was superior. This conclusion was based on the time saved by eliminating the need for wire placement through the teeth for support and the presence of screws anchoring the arch bar into the cortex, thereby providing bony anchorage [14]. Burman S et al., did not observe any significant difference between hybrid arch bars and Erich's arch bars in terms of achieving intraoperative occlusion [15]. Hamid ST and Bede SY reported that the time taken for the removal of the hybrid arch bar is significantly longer than that required for the Erich's arch bar [16].

Complications encountered while using hybrid arch bars included loosening of screws, root damage, and challenges in maintaining

oral hygiene. They also noted that maintaining oral hygiene when using a hybrid arch bar was difficult, along with the potential for necrosis of the attached gingiva secondary to excessive compression from the arch bar [14]. Similar results were observed by Kendrick DE et al., in their study, where the most frequently occurring complication noted with hybrid arch bars was mucosal overgrowth [9].

Patient comfort was found to be highest in the MMF screws group, followed by the hybrid arch bar group, and lastly the Erich arch bar group. Discomfort was noted to be more significant in the MMF screws group, particularly among patients with loose screws.

Rothe TM et al., reported that the use of MMF screws was the most efficient method of MMF, as it is quick and easy. This was followed by the hybrid arch bar, which caused less injury to the operator compared to the Erich arch bar. The Erich arch bar was found to be the most stable of the three and is recommended in cases where long-term MMF is required. Maintenance of oral hygiene was easier for patients with MMF screws compared to those with hybrid arch bars, and lastly, compared to the Erich arch bar [6].

The maximum complications, which included glove perforations, increased time for placement, and oral hygiene concerns, were noted in the Erich arch bar group across studies [3,6,14,17].

In 2011, Rai A et al., in their randomised clinical trial, reported that the mean working time with MMF screws was considerably less compared to the arch bar. Placement and removal of MMF screws took 18.7 minutes and 10.2 minutes, respectively. In contrast, placement and removal of the Erich arch bar took 95.1 minutes and 29 minutes, respectively. The mean plaque index value measured using the TURESKY-GILMORE-GLICKMAN modification of the QUIGLEY-HEIN index was observed to be 2.69 with the Erich bar and 1.8 with MMF screws. This further indicates that maintaining oral hygiene was much easier when MMF screws were used. The main complications encountered while using MMF screws included mucosal coverage of the screws, damage to tooth roots, and screw loosening.

By the end of the fourth week, out of 240 screws, 48 were completely covered by mucosa, and 44 were partially covered. Damage to teeth was observed in 5.83% of patients, and screw breakage occurred in 3.33% of patients [5].

Taking into account the monetary aspect of this study, Erich arch bars cost Rs. 500 per unit. MMF screws cost Rs. 600 per screw, amounting to Rs. 6000 if 10 screws were used. Hybrid arch bars were obtained for Rs. 1400 per unit, along with Rs. 800 per screw, totaling Rs. 9450 when 10 screws were used, making it the most expensive modality among those studied. Although the costs incurred were relatively low in the region where this study was conducted, an effective study evaluating the costs associated with other expenses involved in the surgery, as done by Khelemsky R et al., would provide valuable insight for determining the choice of MMF based on material costs [18].

This clinical study assessed the efficiency and patient tolerance of three types of MMF appliances, considering the time required for application and removal, the level of gingival inflammation, and patient comfort. The results showed that MMF screws were the most efficient. MMF screws are indicated in conditions where a short period of MMF is necessary. Erich arch bars are indicated in situations that require a tension band or a longer duration of MMF, or when dentoalveolar fractures require stabilisation of the arch. Hybrid arch bars are indicated in cases where a partially edentulous arch is present.

The strength of this article includes the assessment of patient tolerance towards all three methods, as indicated by the level of discomfort.

Limitation(s)

In this study, the patients' maintenance of oral hygiene was not considered, which could be a confounding factor in the evaluation of gingival inflammation. The stability of each of the MMF appliances was not assessed.

CONCLUSION(S)

The purpose of the study was to assess and compare gingival inflammation, the time taken for placement and removal, and patient tolerance of hybrid arch bars, Erich arch bars, and MMF screws. In terms of time efficiency during the placement of appliances, gingival inflammation, and patient comfort, the best choice would be MMF screws. Although Erich arch bars required more time for placement, they would be the second-best option due to the severe gingival inflammation caused by the hybrid arch bar. Hybrid arch bars are invaluable in achieving a good maxillomandibular relationship in partially edentulous patients whose occlusion would not favor the placement of standard arch bars.

According to the results of this study, although the hybrid arch bar provides the advantages of the hooks of the Erich arch bar and the rigid fixation of MMF screws, it causes excessive gingival inflammation that reduces patient tolerance. However, in the case of partially edentulous dental arches, it has a definite role. The choice of MMF method depends on the presence or absence of teeth, the duration of MMF, the requirement for the management of tension bands, and the pre-existing periodontal health of the patient.

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