Treatment Outcome Comparison between Tooth Borne vs Bone Borne Intermaxillary Fixation Devices: A Systematic Review

Lilies Dwi Sulistyani[1], Vera Julia[1], Dwi Ariawan[1], Mohammad Adhitya Latief[1], Yudy Ardilla Utomo[1], Maudina Dwi Heriasti[1], Sherly Santiago[1], Dessy Dwi Utami[1], Iwan Ristiawan[1]

1. Department of Oral and Maxillofacial Surgery, Faculty of Dentistry, Universitas Indonesia, Jakarta – Indonesia.

Abstract

Intermaxillary fixation (IMF) using the arch bar has been the standard technique for a long time in the management of mandibular fracture. However, tooth borne IMF may cause several complications, hence intermaxillary fixation with screws has been introduced and adopted to use. This investigation compared the treatment outcomes and complications between the traditional IMF and modified intermaxillary fixation with screws technique.

This review was done according to PRISMA Guidelines. We searched through PubMed, Science Direct, Scopus, EMBASE, and Cochrane. The keywords used were of "intermaxillary fixation", "arch bar", "screw", "maxillofacial fracture", "outcome", "occlusion". Inclusion criteria encompassed clinical trials, observational studies, and retrospective analyses comparing treatment outcomes between tooth-borne and bone-borne IMF devices.

1,391 studies were identified, after eliminating process of the duplicates and irrelevant studies, the remaining 13 studies were included and assessed for qualitative analysis. The treatment outcome indicators were divided into group; intraoperative, postoperative, and complications.

Both types of IMF are significantly beneficial, however, each type has their own challenges. In choosing the type of device, surgeon's preference, and experience, also a thorough case-by-case selection are important in achieving occlusal goals in treating maxillofacial fractures.

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Introduction

Intermaxillary fixation (IMF) is a crucial technique employed in oral and maxillofacial surgery to stabilize and immobilize fractured jaw segments.[1] The primary goal of IMF is to facilitate the healing process by preventing unnecessary movement of the fractured bones. This stabilization is achieved by temporarily fixing the upper and lower jaws together using various devices such as wires, screws, or elastics.[1,2] The process of IMF involves careful alignment of the fractured bone segments, followed by the application of fixation devices to maintain the desired position. This immobilization allows for proper bone healing, reduces the risk of complications, and ensures optimal functional and aesthetic outcomes for the patient.[3]

Common types of jaw fractures that may require intermaxillary fixation include mandibular fractures (fractures of the lower jaw) and midface fractures (involving the upper jaw and surrounding facial structures). The decision to use IMF depends on the specific characteristics of the fracture, the patient's overall health, and the surgeon's assessment of the best approach for optimal recovery. Intermaxillary fixation may be accomplished using arch bars, interdental wiring, or external fixation devices, and the choice of method depends on the nature and location of the fracture.[4,5]

Currently, there are two types of immobilization devices, tooth-borne type and bone-borne type. The tooth borne fixation device, such as arch bar, has been the conventional method for intermaxillary fixation (IMF) in treating mandibular fractures for an extended period.[6] These devices consist of metal bars conforming to the dental arches, usually the maxillary and mandibular arches, and are affixed to the teeth

Corresponding author:
Lilies Dwi Sulistyani,
Department of Oral and Maxillofacial Surgery, Faculty of Dentistry, Universitas Indonesia. Jalan Salemba Raya No.4, Jakarta Pusat, Jakarta 10430, Indonesia.
E-mail: liliesdwi_s@yahoo.co.id

with wires or ligatures. The primary objective of arch bars is to immobilize the jaws in a specific relationship, allowing for proper alignment and healing of fractured facial bones. However, this method presented challenges such as patient discomfort, difficulty in maintaining proper occlusion, and the risk of complications such as gingival damage and infection. [6,7]

The bone borne screw intermaxillary fixation involves the use of screws and plates to directly secure the maxilla and mandible, bypassing the teeth. This method is particularly useful when dental anchorage is compromised or when teeth are not suitable for attachment due to extensive damage.[8] Screw IMF allows for immobilization without relying on the condition of the teeth, making it suitable for cases involving dental avulsions or fractures. Moreover, it increases in stability as the direct fixation of screws provides enhanced stability, especially in cases where tooth-borne methods may be less secure. [8,9]

	Inclusion	Exclusion
Source	Pubmed, ScienceDirect, Cochrane Library, Scopus, Clinical Key	Grey Literature
Date	November 2013 - 2023	Before the period
Language	English	Other
Type of publication	Observational studies, clinical trial, retrospective analysis	

Table 1. Inclusion and Exclusion Criteria.

The comparison between tooth-borne and bone-borne IMF devices involves considerations such as stability, ease of application, patient comfort, and potential complications. Tooth-borne fixation is often quicker to implement and may be more cost-effective, but it relies on the integrity of the dentition and may cause discomfort to the patient. In contrast, bone-borne fixation offers a more rigid stabilization, potentially reducing the risk of malocclusion or other dental complications, but it requires additional surgical steps and may carry a higher risk of infection. This comparison is crucial in the decision-making process for oral and maxillofacial surgeons when selecting the appropriate IMF device for a specific case. Factors such as the location and complexity of the fracture, patient compliance, and the surgeon's expertise play a significant role in determining the most suitable fixation method. As technology and surgical techniques continue to advance, ongoing research aims to refine and improve both tooth-borne and bone-borne IMF devices, ultimately enhancing patient outcomes in oral and maxillofacial surgery.

Materials and methods

Protocol & Registration

This literature review was conducted following the "Cochrane Handbook for Systematic Reviews of Interventions" guidelines. Afterwards, reports were made in accordance with the "Preferred Reporting Project Guidelines for Systematic Review and Meta-analysis" (PRISMA) statement.

Research Question and Objective

This question to this review was: How is the comparison of efficacy between Tooth Borne vs Bone Borne Intermaxillary Fixation Devices in treating maxillofacial fractures? with population: patient with oral and maxillofacial fractures, intervention: the use of intermaxillary fixation, comparison: between tooth-borne and bone-borne devices, outcome: treatment outcome, and study tipe: clinical trial, observational studies, retrospective analysis.

Data Inclusion and Exclusion Criteria

To collect such database, the inclusion and exclusion criteria was as shown in Table 1.

Search Strategy

Searches of literature were conducted on four electronic databases, PubMed, Science Direct, Scopus, EMBASE, and Cochrane. Keywords used to identify eligible studies were combination of ((fracture) AND ((maxillofacial) OR (mandible))) AND ((Intermaxillary fixation) OR (tooth borne) OR (arch bar) OR (bone borne) OR (screw)) AND ((outcome))). Strategies and keyword arrangements were adjusted according to each database's advanced search guidelines.

Data Extraction

Data extracted after a full paper reviewed by the authors. The extracted data were (1) first author name and publication year, (2) study type, (3) number of study participants, (4) population characteristics, (5) fracture locations, (6) types of IMF used, and (7) any outcomes measured.

Quality Assessment

The risk of bias was assessed using the revised Cochrane Risk of Bias Tool for randomized controlled trials (RoB 2.0) in Figure 2. Domains included for assessment were selection bias, performance bias, attrition bias, detection bias, and reporting bias.[5] Three reviewers (D, M.H., S.S., I.S.) assessed included studies

independently. Rach study was rated as low, with some concerns or high risk of bias based on the guideline. If all domains were rated as low, the study's overall quality assessment was rated as low risk of bias. Moreover, studies with at least one domain rated with some concerns of bias will be rated to have some concerns risk of bias, and studies at least one domain with a high bias, will be rated as high risk of bias.

Results

Results of Literature Search

We identified 1,391 studies from the five electronic databases. Then, 642 duplicates were removed, and the remaining 749 articles were screened, and 711 irrelevant articles were excluded based on the title and abstract. Then, 38 full texts were taken and assessed for eligibility, of which 22 articles did not meet the eligibility criteria for different comparison, outcome measurement, and wrong study design, also 3 studies are not available to be retrieved. The remaining 13 studies were included and assessed for qualitative analysis. The study selection process is presented as a PRISMA flowchart in Figure 1.

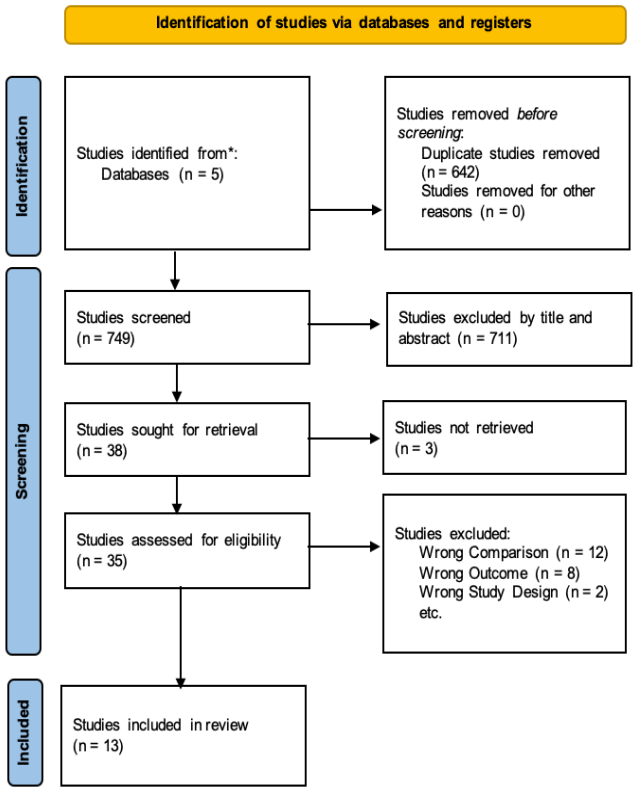

Figure 1. PRISMA Flowchart. Quality Assessment.

The quality assessment of all the included studies is presented using Cochrane RoB Tool in Figure 2.

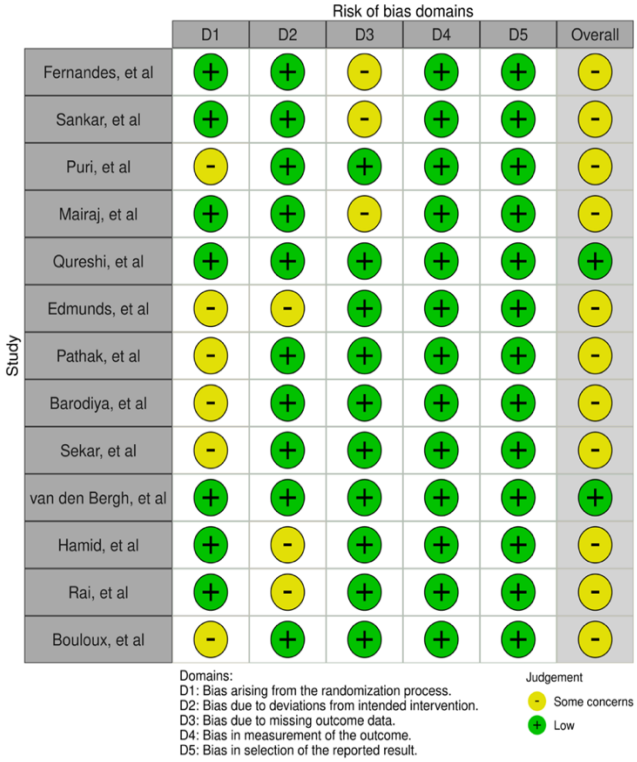

Figure 2. Risk of Bias Tools.

The overall risk of bias was some concerns in five out of thirteen studies (38.46%) and eight of thirteen being low risk of bias (61.54%). The randomization method was not clearly defined in three studies, while in the other two studies randomization is not available due to a non-randomized clinical trial study design. Interventions were clearly stated in all the included studies. Each studies reported all their participant's data, selective report was not found in any study, and the risk for measurement of outcome was low in all studies.

Results of Variable Outcomes

All studies were published between 2011-2023. Ten out of thirteen included studies were randomized clinical trials (RCT), with 2-arm parallel type in nine studies and 3-arm parallel type in one study. The other three studies comprise of other non-RCT study design, including two prospective comparative study and one retrospective study. All studies compare the tooth-borne with the bone-borne intermaxillary fixation. Nine studies used Erich arch bar (EAB) as the tooth-borne fixation device, while the other

three stating only arch bar without any specific type, and only one study using eyelet wiring as the tooth-borne fixation. Bone-borne fixation device varied between studies, including IMF screws in eight studies, hybrid arch bar (HAE) or bone-supported arch bar in five studies.

There were five hundred eighty-three patients with tooth-borne or bone-borne fixation device placed to treat mandibular fractures in various sites, including 92 mandibular angle fracture, 6 mandibular ramus fracture, 57 body of mandible fractures, 32 symphysis fractures, 91 parasymphysis fractures, and 83 condylar or subcondylar fractures. Some studies did not mention the specific fracture sites of each patient.

The average age from the sample of the studies is in the third decade, with

Characteristics of these studies is shown in Table 2.

Treatment Outcome Measurement

Measurements of outcome are divided into intraoperative, postoperative, and post op complications. Intraoperative outcome was measured by the time (in minute) of application and removal of the device, and accidents occurred to operator. Post operative outcome measurement was done by evaluating the hardware stability. Complications consisted of malocclusion, tooth damage, root injury, infection, pain, and mucosal damage. All indicators are shown in Table 3.

Intraoperative Treatment Outcome

Several intraoperative outcomes were measured in all the included studies. Twelve of thirteen studies report the comparison of application time of each intermaxillary fixation (IMF) device, only one study did not report the application time of the fixation device. Regarding the removal time of the IMF device, only eight studies reported and compare the time consumed for removal of the device. Ten studies reported the surgical accidents recorded while fixing the device by assessing gloves perforation and operator's fingers injury.

Time of application was faster in all the intervention (bone-borne) group of each study, with eleven out of twelve study reporting significant difference (p<0.05). The fastest application time was reported in a study by Sekar, et al[14] which only took 10.17±2.918 minutes to apply bone-borne IMF transmucosal screw.

Duration of removal time was also shorter in the bone-borne group in each study, with the shortest reported in a study by Fernandes, et al in 4.63±2.56 minutes. Each removal time was also had significant difference between the intervention and control group. However, contradictory result was reported in the study by Hamid, et al[16] where bone-borne IMF removal time was longer (14.2±3.0 mins) than the tooth-borne group (11.1±2.0 mins) with significant difference (p<0.05). Only five out of thirteen studies reported the duration of removal time of the IMF.

Accidents occurring intraoperatively was recorded by the frequency of gloves perforation and operator's finger injuries. Ten studies reported a more frequent accidents occurring in the control (tooth-borne) group with total of accidents occurrence is 112 accidents during the tooth-borne IMF application. The highest frequency of accident occurrence was reported in a study by Puri, et al[8] with 73% occurrence of all tooth-borne IMF application.

Postoperative Treatment Outcome

Postoperative outcomes were measured by the assessment of the hardware stability, screw loosening and post operative occlusal stability. Hardware stability was assessed by measuring the stability of the fixation device in the jaw after some follow up period. Nine studies reported the hardware stability of the IMF used. Screw loosening was only assessed for the intervention bone-borne group. However, only five study assessed the screw loosening postoperatively. Hardware stability was achieved evenly in the control and intervention group in most studies. A study by van den Bergh, et al, Hamid, et al, and Rai, et al reported a loosening of IMF device only in the intervention bone-borne group. However, no significant differences were found in these studies (p>0.05).

A study by Mairaj, et al[9] reported that hardware stability achieved more frequently in the bone-borne group, where 90% of all the bone-borne IMF achieved stability with a significant difference (p<0.05). Screw loosening was reported only in five out of all the studies included. Screw breakage only occurs below 10% out of all bone-borne IMF cases in each study. There was no significant difference found in this comparison. Post operative occlusal stability was found in most studies. Only 1-2 cases reported changes in occlusion on each study.

Treatment Complication

The primary outcome measurement of this systematic review was the comparison of the treatment outcome of the tooth-borne IMF in comparison to the bone-borne IMF. The treatment complication involves the assessment of various factors, including malocclusion, infection, tooth, and mucosal damage. Some of these factors were reported in the included studies.

Treatment complications was recorded through various indicators, including malocclusion, pain, root injury, infections, tooth damage, and mucosal damage. From the studies collected, Malocclusions were assessed in 18 out of all the included studies. All the studies reporting the occurrence of malocclusions reported no significant difference (p>0.05) in between the tooth-borne and the bone-borne IMF devices. However, highest frequency of malocclusion occurrence was reported in a study by Edmunds, et al[11] with a total of 10 reported cases of malocclusion, in which 7 of them coming from the bone-borne IMF.

Infections were also only reported in small amount of study, covering three out of thirteen studies, with highest occurrence of infection was reported by a study by Rai, et al[17]. However, there are no significant differences (p>0.05) found in comparing the occurrence of infection in each reporting studies.

Damage to adjacent structure was divided into damage to soft tissue or mucosal damage, and damage to hard tissue including tooth and root injury. There are 7 studies that assess tooth injury, with a total of 32 reported cases of such kind of injury from all the reporting studies. The bone-borne device found to be more prevalent in causing tooth or root injury. Highest tooth or root injury occurrence was reported by Rai, et al[17], reporting 14 cases of tooth/root injury coming from the bone-borne IMF group. However, there are no significant difference between both groups regarding to tooth or root injury despite the high occurrence. Mucosal damage was reported in four studies, with the highest occurrence, incorporating 45.8%, was reported by van den Bergh, et al[15]. In contrast with damage to the tooth or root, mucosal or soft tissue damage most likely occurs in the tooth-borne group. Nonetheless, there are no significant differences found in the mucosal damage assessment between the application of tooth-borne and bone-borne IMF.

Discussion

The choice between tooth-borne intermaxillary fixation (IMF) devices using arch bars and bone-borne fixation methods using screws, in maxillofacial surgery is a subtle decision that involves considerations of biomechanics, patient comfort, surgical technique, and overall treatment outcomes. Both approaches have their advantages and limitations, which a comprehensive understanding of their characteristics is essential for clinicians to make substantial decision based on the specific needs of each patient.[19] Tooth-borne intermaxillary fixation (IMF) devices are commonly used in maxillofacial surgery for the treatment of fractures involving the maxillomandibular complex. Conventionally, various tooth-mounted devices like arch bars, dental and interdental wiring, and metallic and nonmetallic splints have been used to achieve IMF. The use of arch bars is the gold standard for establishing maxillomandibular fixation (MMF) in dentate patients.[20]

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One important and major consideration includes biomechanics and stability. Tooth-borne IMF devices distribute forces across multiple teeth, relying on the dental arch as a stable

foundation. Arch bars, for instance, are secured to the teeth using wires or ligatures, providing a reliable means of immobilizing the maxilla and mandible.[21] However, occlusal stability achieved in the included studies showed that the tooth-borne or arch bars group have the same score as the bone-borne screws group. There are only three studies reporting the occlusal stability intraoperatively, one of them stating all the participants achieved occlusal stability, the other two not stating the precise stability score but three of them showing no significant difference (p>0.05). Hence, the use of bone-borne device in IMF did not affect the occlusal stability.

The surgical duration including the application and removal of the IMF device also falls into the surgical consideration category. The application and removal of tooth-borne IMF are more time-consuming. The longer application time for arch bars is attributed to the process of wiring and adapting the bars to the dental arch, which is a more intricate procedure compared to screw fixation.[22] This is in accordance in this current systematic review, where all the tooth-borne group have a longer application and removal time in comparison with the bone-borne group. Most of the comparison in each study also shows a significant difference (p<0.05). The mean application time for arch bars can range from 37.29 to 98.6 minutes, while the mean removal time is around 11.1 to 33.83 minutes from the included studies. In contrast, screws offer advantages such as ease of application and removal and will ultimately reduce operating room time. The reported mean application time for screws range only from 11.41 to 56.1 minutes, while the mean for removal time is around 4.63 to 16.17 minutes. Therefore, the choice between arch bars and screws can be heavily considered by the ease of application and removal as it will affect the duration of the surgery.

Operators' injury due to accidents intraoperatively also needs to be weighed down in surgical consideration. The application of tooth-borne IMF (arch bars) during oral and maxillofacial surgical procedures can lead to glove perforations, posing risk to operators. Glove perforation during arch bar application can be caused by various factors, including the use of sharp instruments like wires, handling of rough-edged arch bars, and the type of surgical procedure. The handling of sharp instruments and the use of arch bars with rough edges can significantly increase the risk of glove perforation. Additionally, the type of surgical procedure, such as intermaxillary fixation with wire placement, has been associated with an increased risk of glove perforations.[22] Glove perforation during arch bar application can have several consequences, including an increased risk of needle stick injuries.[23] Additionally, the type of arch bar used can impact the rate of glove perforations, with certain methods of application resulting in more glove tears or penetrations than others. Our current study compared the incident of gloves perforation between the tooth-borne group and the control group. It was reported that the tooth-borne IMF has a greater incidence of gloves perforation with significant difference (p<0.05) notable in several studies. However, it is important for operators to be mindful of these factors and take precautions to minimize glove perforations during such procedures.

Occlusal stability was achieved in most studies. However, a few cases reported a post operative occlusal change, especially in the bone-borne IMF device. This occurred in various forms of malocclusion such as class II, class III, open bite, cross bite, and nonunion. Occlusal stability factor might be related to the severity of fracture, and inadequate reduction intraoperatively. Loss of screws can also lead to occlusion changes post operatively. In the tooth-borne devices, inadequate tightening of the wires can also contribute to the occlusion stability.[10,11]

Surgical considerations play a crucial role in comparing the tooth-borne and bone-borne IMF. Tooth-borne fixation devices are generally less morbid during placement, as they involve attaching arch bars to existing dentition, while bone-borne fixation, however, requires careful preoperative planning, precise screw placement, and may involve a more intricate surgical procedure due to its bone penetrating procedure.[24]

Moreover, bone-borne IMF complications are related to the fracture of the screws itself and damage to surrounding bone tissue leading to infection. Nevertheless, tooth-borne IMF still penetrate soft tissue in the interdental area, which the bone-borne IMF did not. This procedure somewhat cause damage to surrounding soft tissues, potentially leading to inflammation and ultimately will lead to other complication.[25] In this current systematic review, adjacent structure morbidity was compared by

analyzing mucosal damage and tooth or root injury.

Mucosal damage was recorded in four studies, occurring in both tooth- and bone-borne group. Wires tightened during the application of arch bars around the teeth may cause ischemic necrosis of the mucosa.[26] The use of conventional arch bars can also result in mucosal overgrowth.[21,27] The presence of arch bars in the oral cavity can lead to friction and irritation against the soft tissues, including the gingiva and oral mucosa. Prolonged contact and rubbing can result in chronic irritation, leading to an inflammatory response. Chronic inflammation may contribute to mucosal overgrowth.[28] However, the occurrence of mucosal damage in both groups in all the included studies did not show any significant difference (p>0.05). This shows that both methods will cause mucosal damage inevitably.

Tooth injury was not reported in any single case of tooth-borne IMF application in all the included studies. All the tooth injury only occurs on the bone-borne IMF group, which ranging from 0.8-10% occurrence without significant difference (p>0.05). Tooth and root injury commonly caused by improper angulations of drill bit during drilling of hole for insertion of IMF screw resulting in root impingement.[29,30] Prevention of such injury can be done by careful planning of screw placement.

Infection may have occurred due to various factors such as inadequate sterilization of the screw, contamination during the placement procedure, or postoperative complications leading to infection. Additionally, the use of screws may have caused trauma to the surrounding soft tissues, leading to a higher risk of infection compared to the use of arch bars.[17] There is so little evidence of infection occurring after the placement of a bone-borne IMF device. The included studies also did not mention the potential cause of the infection. However, antibiotic therapy was given to manage the infection.

Screw loosening during the use of intermaxillary fixation (IMF) screws can be prevented by ensuring convergent angulation of the screws and threading wire loops through the ligature holes in the screw heads to prevent them from slipping. Additionally, burying the screws under soft tissue should be avoided, and any screws buried under soft tissue should be exposed under local anesthesia and removed. It is also important to ensure that the screw tips fully penetrate the bone and that the ligature holes in the screw head are easily accessible. Using screws with increased torque transfer during insertion and resistance to cam out can also help prevent screw loosening. Power tools are unsuitable for the insertion of IMF screws because a torque limiter would be needed. Furthermore, ensuring a sufficient thickness of alveolar bone around the screw is important for good periodontal health, other than ensuring good oral hygiene, daily prophylaxis treatment, and patient's self-motivation to reduce the risk of infection of the periodontal tissue, to prevent mineralization of biofilm around the gingiva and screw.[31]

There are advantages and limitations to both of maxillomandibular fixation devices, where the tooth-borne device remains as a gold standard that meets the expected post operative results. However, the use of these devices could be options for various types of maxillofacial fractures. In a case where a tooth-borne device, such as arch bars, is not suitable because of the lack of dentate area, bone-borne devices could be used. In reverse, in cases where bone-borne devices might not be suitable, dental anchorage points could be a viable option. Other than that, the surgeon's preference, experience, and a wise case-selection in choosing the type of IMF play an important role in achieving success in treating maxillofacial fractures. It is necessary to acknowledge the challenges, advantages, and the disadvantages of each type of devices.

Conclusions

Tooth-borne devices for intermaxillary fixation (IMF) are associated with problems such as causing inevitable mucosal damage, having risk of needle stick injury from surgical accidents, and time-consuming as it has a longer application and removal time. The use of bone screws is an easier and quicker as well as considerably safe alternative for achieving satisfactory IMF. However, bone-borne IMF appliances are associated with hard tissue injury, including the tooth, root and bone injury which may lead to infection, as well as specific complication such as screw loosening and breakage. The use of IMF type, whether it is a tooth-borne or a bone-borne, provides their own

benefits and disadvantages, measured from the time of application and removal, stability of the hardware, and the post operative complications. In choosing the type of device, surgeon's preference, and experience, also a thorough case-by-case selection are important in achieving occlusal goals in treating maxillofacial fractures.

Declaration of Interest

The authors report no conflict of interest.

No.	Author (Year)	Study Design	Fracture Site	Control Intervention	n (%)	Age (Mean±SD)	Gender (M:F)
1	Fernandes, et al[6] (2023)	RCT	Mandible Fracture Angle (12) Body (9) Symphysis (7)	Erich Arch Bar (tooth-borne)	14 (50%)	27.71±9.30	13 (93%) : 1 (7%)
				IMF Screw (bone-borne)	14 (50%)	29.14±10.41	12 (86%) : 2 (14%)
2	Sankar, et al (2023)	RCT	Mandible Fracture Angle (18) Body (14) Symphysis (12)	Erich Arch Bar (tooth-borne)	23 (52.2%)	26.91±8.83	21 (91%) : 2 (9%)
				Hybrid Arch Bar (bone-borne)	21 (47.8%)	32.30±7.79	17 (81%) : 4 (19%)
3	Puri, et al (2022)	RCT	Mandible Fracture Symphysis (77%) Angle, Condyle, Body (23%)	Eyelet Wiring (tooth-borne)	15 (50%)	18-60	15 : 0
				IMF Screw (bone-borne)	15 (50%)		13 : 2
4	Sankar, et al[7] (2023)	RCT	Mandible Fracture (44)	Arch Bar (tooth-borne)	22 (50%)	31.7±11.98	32 (73%) : 12 (27%)
				IMF Screw (bone-borne)	22 (50%)		
5	Qureshi, et al (2016)	RCT	Mandible Fracture Parasymphysis (60)	Erich Arch Bar (tooth-borne)	30 (50%)	37.53	21 (70%) : 9 (30%)
				IMF Screw (bone-borne)	30 (50%)	37.96	23 (76%) : 7 (24%)
6	Edmunds, et al (2019) Puri, et al[8] (2022) Puri, et al[8] (2022)	Retrospective Study	Mandible Fracture Symphisis (10) Body (13) Angle (24) Ramus (5) Condylar (40) Alveolar (1)	Erich Arch Ba (tooth-borne)	27 (29%)	27.0	21 (78%) : 6 (22%)
				4-point Fixation (bone-borne)	51 (55%)	31.0	42 (82%) : 9 (18%)
				Bone-Supported Arch Bar (bone-bone)	15 (16%)	24.0	12 (80%) : 3 (20%)
7	Pathak, et al (2019)	Prospective Study	-	Erich Arch Bar (tooth-borne)	10 (50%)	18-60	-
				Screw Retained Arch Bar (bone-borne)	10 (50%)		
8	Barodiya, et al (2017)	RCT	Mandible Fracture Symphysis (1) Parasymphisis (3) Angle (8) Body (2) Subcondylar (6)	Erich Arch Bar (tooth-borne)	10 (50%)	17-68	20 (100%) : 0 (0%)
				IMF Screw (bone-borne)	10 (50%)		
9	Mairaj, et al[9] (2021)	Prospective Study	-	Arch Bar (tooth-borne)	12 (33.3%)	38.50±12.681	12 (100%) : 0 (0%)
				Eyelet Wiring (tooth-borne)	12 (33.3%)	28.75±11.315	9 (75%) : 3 (25%)
				Transmucosal Screw (bone-borne)	12 (33.3%)	28.58±9.385	11 (92%) : 1 (8%)
10	van den Bergh, et al (2015) Qureshi, et al[10] (2016) Qureshi, et al[10] (2016)	RCT	Mandible Fracture Condylar (7) Concomitant Mandibular (34) Bilateral Condylar (2) Combined Bilateral Condylar (7)	Arch Bar (tooth-borne)	26 (52%)	31.8±13.9	30 (60%) : 20 (40%)
				IMF Screw (bone-borne)	24 (48%)		
11	Hamid, et al (2022)	RCT	Mandible Fracture Condylar (2) Angle (4) Body (5) Parasymphysis (7)	Erich Arch Bar (tooth-borne)	10 (55.5%)	28.20±7.86	7 (70%) : 3 (30%)
				Hybrid Arch Bar (bone-borne)	8 (44.5%)	27.75±8.63	5 (63%) : 3 (37%)
12	Rai, et al (2011) Edmunds, et al[11] (2019) Edmunds, et al[11] (2019)	RCT	Mandible & Condyle Fracture (90)	Erich Arch Bar (tooth-borne)	30 (33.3%)	28	84 (93%) : 6 (7%)
				MMF Screws (bone-borne)	60 (66.6%)		
13	Bouloux, et al (2018)	RCT	Mandible Fracture Subcondyle (19) Ramus (1) Angle (26) Body (14) Parasymphysis (21) Symphysis (2)	Erich Arch Bar (tooth-borne)	24 (48%)	36.2±10.7	20 (83%) : 4 (17%)
				Hybrid Arch Bar (bone-borne)	26 (52%)	36.4±12.3	22 (85%) : 4 (15%)

Table 2. Study characteristics.

No.	Author (Year)	Control Intervention	n (%)	Time Application	Time Removal	Surgical Accidents	Hardware Stability	Screw Loosening	Occlusal Stability	Post op Complications
1	Fernandes, et al[6] (2023)	Tooth Borne (Erich Arch Bars)	14 (50%)	43.22±5.81	23.92±6.24	8 (57%)	N/A	N/A	Achieved	1 (tooth extrusion)
		Bone Borne (IMF Screw)	14 (50%)	11.41±2.66*	4.63±2.56*	3 (21%)	N/A	N/A	Achieved	N/A
2	Sankar, et al[7] (2023)	Tooth Borne (Erich Arch Bars)	23 (52.2%)	82.04±12.19	N/A	9 (39%)	p>0.05	N/A	N/A	N/A
		Bone Borne (Hybrid Arch Bars)	21 (47.8%)	55.66±17.86*	N/A	0 (0%)*	N/A	N/A	N/A	5 (pain, root injury, infection)
3	Puri, et al[8] (2022)	Tooth Borne (Eyelet Wiring)	15 (50%)	N/A	20 (10-12)	11 (73%)	N/A	N/A	N/A	1 (malocclusion)
		Bone Borne (IMF Screw)	15 (50%)	N/A'	7 (8-10)	2 (13%)*	N/A	N/A	N/A	3 (root injury, malocclusion)
4	Mairaj, et al[9] (2021)	Tooth Borne (Erich Arch Bars)	22 (50%)	<60 mins=15 (68.2%)	N/A	13 (65%)	8 (36.3%)	N/A	N/A	5 (Necrosis pulp, periodontitis)
		Bone Borne (IMF Screw)	22 (50%)	<20 mins=20 (90%)*	N/A	3 (13%)*	20 (90%)*	2 (9.1%)	N/A	5 (Necrosis pulp, periodontitis)
5	Qureshi, et al[10] (2016)	Tooth Borne (Erich Arch Bars)	30 (50%)	94.67	N/A	20 (66.6%)	22 (73%)	N/A	23 (76%)	2 (tooth damage)
		Bone Borne (IMF Screw)	30 (50%)	15.56*	N/A	2 (6.6%)*	24 (80%)	N/A	25 (83%)	3 (tooth damage)
6	Edmunds, et al[11] (2019)	To`oth Borne (Erich Arch Bars)	27 (29%)	98.6±29.6	N/A	N/A	N/A	N/A	24 (88%)	3 (malocclusion, wound dehiscence)
		Bone Borne (4-point Fixation)	51 (55%)	48.8±23.9	N/A	N/A	N/A	1 (2%)	49 (90%)	5 (malocclusion, tooth damage)
		Bone Borne (Bone-Supported Arch Bars)	15 (16%)	56.1±15.4	N/A	N/A	N/A	1 (7%)	13 (86%)	2 (malocclusion)
7	Pathak, et al[12] (2019)	Tooth Borne (Erich Arch Bars)	10 (50%)	82.50±18.85	N/A	3 (30%)	8 (80%)	N/A	N/A	0
		Bone Borne (Screw Retained Arch Bar)	10 (50%)	27.20±3.53*	N/A	0	9 (90%)	N/A	N/A	1 (root injury)
8	Barodiya, et al[13] (2017)	Tooth Borne (Erich Arch Bars)	10 (50%)	74.9±9.26	N/A	4 (40%)	N/A	N/A	Achieved	0
		Bone Borne (IMF Screw)	10 (50%)	16.1±3.75*	N/A	0 (0%)*	N/A	N/A	Achieved	1 (tooth damage)
9	Sekar, et al[14] (2017)	Tooth Borne (Erich Arch Bars)	12 (33.3%)	43.25±4.595	N/A	N/A	N/A	N/A	N/A	12 (mucosal damage)
		Tooth Borne (Eyelet Wiring)	12 (33.3%)	22.58±2.575*	16.17±1.697*	N/A	N/A	N/A	N/A	0
		Bone Borne (Transmucosal Screw)	12 (33.3%)	10.17±2.918*	6.58±1.165*	N/A	N/A	N/A	N/A	0
10	van den Bergh, et al[14,15] (2015)	Tooth Borne (Erich Arch Bars)	26 (52%)	69 (35-132)	N/A	26 (30.7%)	0 (0%)	N/A	24 (92%)	2 (malocclusion)
		Bone Borne (IMF Screw)	24 (48%)	17 (5-30)*	N/A	0 (0%)*	6 (3.2%)	1 (0.53%)	23 (95%)	1 (malocclusion)
11	Hamid, et al[16] (2022)	Tooth Borne (Erich Arch Bars)	10 (55.5%)	61.6±11.4	11.1±2.0	7 (70%)	0 (0%)	N/A	Achieved	0 (0%)
		Bone Borne (Hybrid Arch Bar)	8 (44.5%)	41.6±6.0*	14.2±3.0*	0 (0%)*	8 (12.5%)	0 (0%)	Achieved	0
12	Rai, et al [17](2011)	Tooth Borne (Erich Arch Bars)	30 (33.3%)	95.06±14.17	29.00±3.22	11 (36.6%)	0	N/A	N/A	0
		Bone Borne (MMF Screws)	60 (66.6%)	18.67±2.62*	10.20±1.97*	0 (0%)	10 (16.67%)	12 (20%)	2 (3.33%)	31 (root injury)
13	Boulou x, et al[18] (2018)	Tooth Borne (Erich Arch Bars)	24 (48%)	37.29±15.1	N/A	N/A	N/A	N/A	N/A	1 (malocclusion)
		Bone Borne (Hybrid Arch Bar)	26 (52%)	14.07±8.4*	N/A	N/A	N/A	N/A	N/A	2 (malocclusion, tooth damage)

Table 3. Treatment Outcome Measurement.

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