Techniques for maxillomandibular fixation: old and new

Sarah Rathnam Akkina[a], *Scott Eric Bevans*[b] *and Alan Wellington Johnson*[c]

Purpose of review
Maxillomandibular fixation (MMF) is essential for many surgeries on the bony middle and lower face. MMF techniques have multiplied in recent years, each with unique benefits and drawbacks. This review catalogs MMF trends and evidence for and against the most prevalent MMF methods.

Recent findings
Traditional Erich arch bars remain the most robust technique in establishing MMF, particularly for comminuted/complicated fractures. Drawbacks are increased operative time required, wire stick injuries, poor oral hygiene, and gingival trauma. Screw-based techniques save considerable time but cannot stabilize comminuted fractures as adequately and risk tooth root and nerve damage. Embrasure wires offer time and cost savings but are solely for intraoperative use and uncomplicated fractures. Similarly, dental occlusion ties provide the benefits of reduced time and wire sticks, with the added capability of postoperative use, but require adequate dentition and minimally displaced fractures. Recent studies show decreased use of wire-based techniques, with increased adoption of hybrid systems and dental occlusion ties.

Summary
MMF techniques each have unique advantages and weaknesses. Selection should depend on surgical goals, including the severity of fractures, the need to maintain occlusion postoperatively, application/removal time, safety, and patient comfort.

Keywords
facial fracture, facial trauma, intermaxillary fixation, maxillomandibular fixation

INTRODUCTION

Maxillomandibular fixation (MMF) immobilizes the upper and lower dentition in occlusion for therapeutic purposes. MMF is most commonly employed for managing mandible and maxilla fractures but is also frequently used for orthognathic surgery, temporomandibular joint (TMJ) surgery, and management of TMJ dislocations. Techniques for achieving and maintaining MMF have become numerous, each with unique advantages and disadvantages. This review analyzes the most common techniques in use today and where advances may be seen in the near future. Evidence has grown to suggest that traditional MMF methods still likely hold dominance in maintaining superior occlusion for complex fractures. However, these methods lag behind newer technologies in ease of application and some more comprehensive patient factors (e.g., application time, wire stick injuries, gingival trauma, and ease of dental hygiene). These drawbacks have continued to spur the development of new technologies and provide more options for surgeons. Overall, there remains a lack of high-quality evidence to support a single technology to achieve MMF in every patient, given the clinical diversity of patient pathologies, variability in assessment tools, and challenge in grading outcomes. However, several recent studies help clarify and quantify the strengths and drawbacks of these various techniques.

TRADITIONAL ARCH BARS

Erich's arch bars (EABs) have been the mainstay technique for establishing MMF in the past century. They are still generally considered to be the most robust MMF technique in terms of establishing and

[a]Department of Otolaryngology-Head and Neck Surgery, University of Utah Health, [b]Department of Otolaryngology-Head and Neck Surgery, Tripler Army Medical Center and [c]Department of Otolaryngology-Head and Neck Surgery, Hennepin Healthcare, Minneapolis, Minnesota, USA

Correspondence to Sarah Rathnam Akkina, 30 North Mario Capecchi Drive – 4th Floor, Salt Lake City, UT 84112, USA. Tel: +1 801 581 8471; e-mail: sarah.akkina@hsc.utah.edu

Curr Opin Otolaryngol Head Neck Surg 2025, 33:000–000
DOI:10.1097/MOO.0000000000001043

KEY POINTS

- Appropriate maxillomandibular fixation is critical to establish proper reduction and healing in surgeries of the middle and lower bony face
- While Erich arch bars (EABs) still provide the most robust stabilization overall, they also have the most significant drawbacks, including the longest application time, the highest sharps injuries, increased gingival trauma, and worse dental hygiene sequelae.
- IMF screws and Hybrid arch bar systems provide improved patient comfort and hygiene and significantly reduced operative time; however, they carry a risk of tooth root injury.
- Wire-based and screw-based techniques, as well as dental occlusion ties, improve upon the main drawbacks of EABs, but they may not be the best choice in complex/comminuted fractures.

maintaining occlusion. EABs first emerged in the 1940s and utilize thin metal bars with brackets secured to dentition with wires, wires, or elastic bands spanning between inferior and superior brackets used to set occlusion (Fig. 1) [1–3]. EABs remain the gold standard for MMF due to their ability to provide fixation across multiple teeth and provide both vertical and horizontal vectors of stabilization. In a recent bench study comparing the ability to maintain occlusion in simulated orthognathic surgery models, EABs still provided the highest level of stability when compared to MMF screws and embrasure wires [4▪▪]. Interestingly, a combination of wires and elastics was found to be optimal during an evaluation of the best material to create a stable occlusal framework between maxillary and mandibular EABs [5].

While EABs may still demonstrate superiority in achieving robust occlusion, application, and additional patient factor drawbacks to EABs are among the most significant. Operative time to apply the arch bars has always been a major limitation, with many comparison studies showing at least twice the time for EAB application compared to all other contemporary techniques [6,7,8▪▪,9▪▪]. In Erich's original description, he conceded, "Although proper attachment of arch bars to the teeth requires much time (the one disadvantage of this method), this procedure insures perfect dental occlusion [1]."

The risk of sharps injuries from the wires that attach EABs to dentition is among the most frequently recognized drawbacks [9▪▪,10–13]. When evaluating patient factors, gingival trauma during application and difficulty with adequate dental hygiene during postoperative care are significant

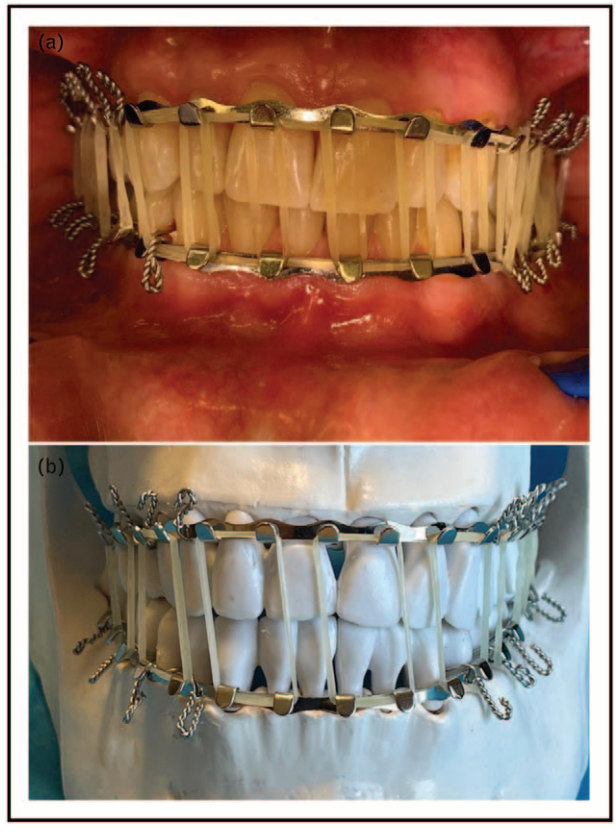

FIGURE 1. Erich arch bars with guiding elastics, patient application (a), model (b).

downsides of EABs [9▪▪,14,15▪]. A recent randomized trial measured the worsening of dental hygiene in patients with EABs compared to IMF screws and quantified a significantly higher presence of biofilm [16▪▪]. In this small study, no statistically significant difference was found between occlusal stability or wire stick injuries between these methods, although it did confirm significantly longer application time of EABs. recent meta-analysis by Kalluri *et al.* confirmed findings of increased wire puncture injuries and glove perforations, total operative time, time to achieve MMF, and incidence of poor oral hygiene in the EAB group compared to alternative MMF techniques [9▪▪]. Because of these recognized limitations, the use of arch bars relative to newer methods of achieving MMF has decreased over the past decade [17]. Ultimately, these limitations have spurred the evolution of different techniques, which can be broadly divided between screw-based and wire-based techniques.

SCREW-BASED TECHNIQUES

Intermaxillary fixation (IMF) screws, also called MMF screws, consist of screws placed into the maxillary and mandibular bone, typically between the

premolar and molar tooth roots. Occlusion is achieved by wiring or banding between the screw heads (Fig. 2a). First described in 1989, IMF screws save considerable operating room time when compared to EABs but place the tooth and tooth root at risk of injury and/or devitalization [14,15▪,18–24]. As alluded to previously, one of the few randomized controlled trials comparing IMF screws to EAB in mild to moderate mandibular fractures undergoing ORIF found significantly more biofilm formation (measured by visual plaque index) in the EAB group relative to the IMF group [16▪▪]. Their subjective surgeon grading system also found no decreased occlusal stability, higher patient postoperative quality of life scores, and minimal increase in gingival overgrowth and screw loosening. The study did not comment on specific testing but did not observe tooth root damage.

Hybrid systems were developed to combine the stability achieved from horizontal metal bars across dentition similar to EABs with the greater ease and rapidity of screw-based technologies similar to IMF screws. They rely on screws driven into the maxillary and mandibular bones instead of dentition wires to attach the bracketed metal bars to the patient, with occlusion maintained through either wiring or banding across the bars (Fig. 2b). First appearing in 2012, hybrid systems have been shown to reduce sharps risk and operating room time compared to EABs but have similar risks to MMF screws, including mucosal overgrowth, screw loosening, screw loss, tooth root and nerve injury, and tooth devitalization [8▪▪,9▪▪,25–27]. A recent randomized study evaluated several factors and confirmed favorable reductions in operative time, preserved stability, and improved hygiene using hybrid systems compared to EABs [28]. Although it did not reach statistical significance, the authors provided data demonstrating zero cases of decreased pulp vitality in the arches treated with EABs with multiple teeth showing loss of pulp vitality in arches treated with the hybrid system (where predrilling was performed during placement).

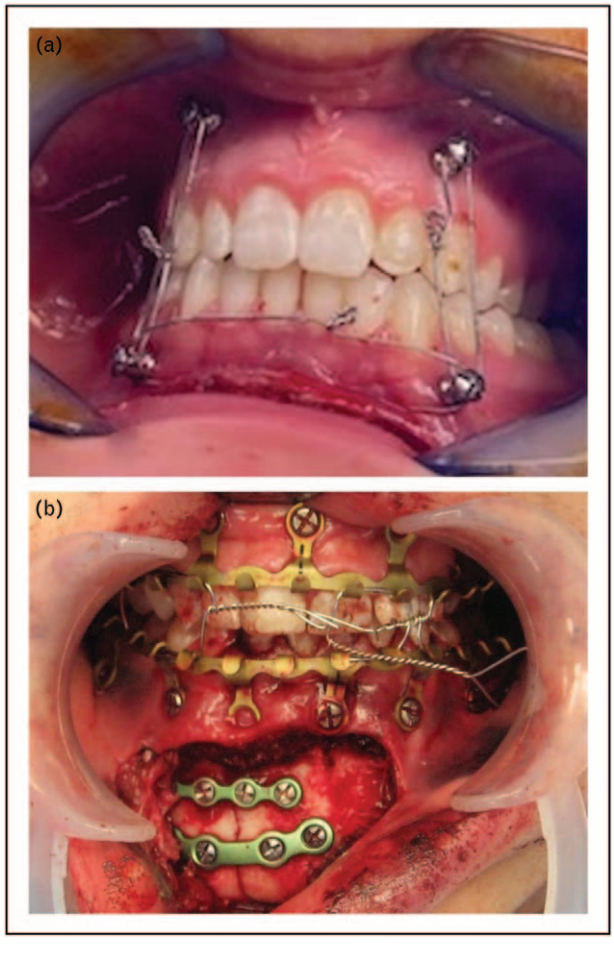

FIGURE 2. (a) IMF screws application, (b) hybrid arch bar system (SmartLock).

WIRE-BASED TECHNIQUES

Wire-based techniques dominated the previous century and are also still in use today. Ernst ligatures, Risdon cables, Erich arch bars, Ivy loops, and embrasure wires all retain value today. Examples are shown in Figs. 1 and 3. In particular, Risdon cables and Ivy loops can be very effective forms of MMF in the pediatric population as they can be invaluable in primary and mixed dentition [29,30]. Excellent reviews of these approaches have been recently published. The authors recommend McGinn & Fedok for a general overview of traditional wire-based techniques, Marschall *et al.* for use in the pediatric population, and Meara for a detailed discussion of how these techniques impact occlusion [15▪,31▪,32].

While the older wire-based techniques can be beneficial in unique circumstances, a newer method of using embrasure wires has become increasingly popular with the increased use and reliability of open reduction and internal fixation (ORIF) approaches [6,33,34]. Introduced in 1999, this elegant technique (Fig. 3d) offers time and cost savings but is solely for intra-operative MMF as patients cannot release themselves in cases of nausea/vomiting. As such, they need to be removed before leaving the OR and, therefore, are reserved solely for uncomplicated fractures that can rely entirely on the stability of the ORIF reconstruction.

DENTAL OCCLUSION TIES

A newer MMF technology, dental occlusion ties (DOTs, Minne Ties), were first described in 2017

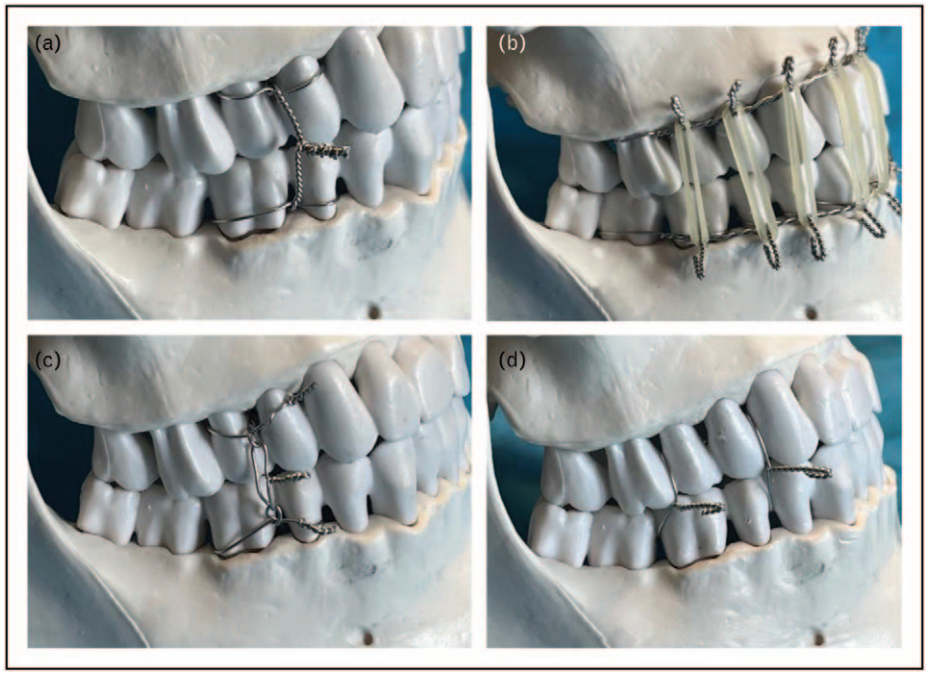

FIGURE 3. Wire-based MMF techniques. (a) ernst ligature, (b) Risdon cable with elastics, (c) ivy loops, (d) embrasure wires.

as rapid, safe, and noninvasive (Johnson) [35]. These blunt-tipped "zip-tie" style devices are applied similarly to embrasure wires (Fig. 4). They feature a blunt-tipped introducer, markedly reducing sharps risk. The polymer-coated suture is designed to slide between teeth more readily than wire and can be cut with suture scissors. These features allow surgeons in the clinic to remove them with minimal effort. Further, as patients can cut them with simple suture scissors, they can be worn postoperatively, unlike embrasure wires. Schopper *et al.* showed increasing adoptions of DOTs with a consistently decreasing reliance on Erich arch bars over a decade-long review [36]. They cited speed of application, reduced sharps risk, and ease of removal as key technology features. Given DOT's ease of application, Jenzer *et al.* concluded that DOTs are "as fast or faster than" other MMF techniques in temporomandibular joint surgeries [37]. They note appropriately that DOTs are inadequate in patients with missing or loose dentition or comminuted fractures. Still, the decreased sharps risk for the surgical team and reduced gingival trauma for the patient were emphasized compared to other MMF techniques. Lastly, as demonstrated in Fig. 4a, the low profile of DOTs allows maximal access to fractures for ORIF. Whereas Erich arch bars, IMF screws, and hybrid systems compete for space on the face of the mandible and/or maxilla, DOTs tight conformation to the teeth avoids this issue allowing for easier plate and screw placement and suturing of incisions.

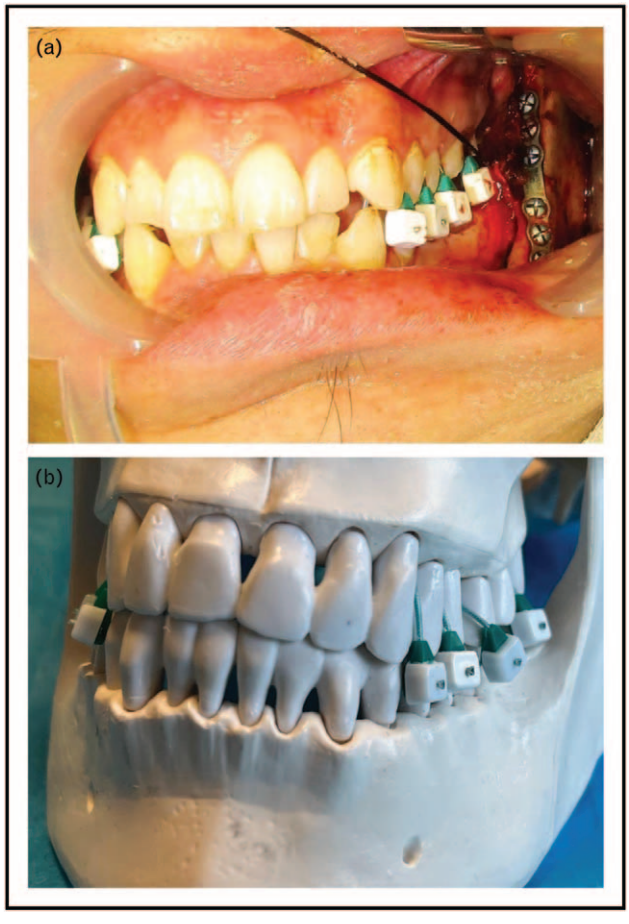

FIGURE 4. Dental occlusion ties, patient application (a), model (b).

DISCUSSION: COMPREHENSIVE MAXILLOMANDIBULAR FIXATION

Many MMF techniques from the 20th century have stood the test of time. While EABs persist as a favored MMF option, particularly for complex fractures, many new wire-based and screw-based techniques have propagated to address the significant downsides to EABs of longer operative time, wire stick injuries, gingival trauma, and poor oral hygiene. Risdon cables, Ivy loops, and Ernst ligatures are still used, particularly in pediatric patients with primary and mixed dentition. Ultimately, multiple factors influence a surgeon's choice of a particular MMF method for each patient, and indeed, various techniques can sometimes be used in the same patient depending on needs and circumstances. A 2025 publication by Johnson *et al.* provides a decision tree and detailed considerations when comparing the most contemporary techniques [38▪]. The AO Foundation also offers a thorough online reference for MMF options guidance [39▪▪]. In general, considering whether MMF must be maintained postoperatively is not without risks, specifically a reduction in oral hygiene. Interestingly, Aijima *et al.* found that cetylpyridinium chloride-, dipotassium glycyrrhizinate, and tranexamic acid-based mouthwash improved hygiene scores statistically significantly [40]. Considering these types of adjunctive care for patients requiring prolonged MMF is important in addressing all factors that affect overall patient health and healing.

As computer-assisted surgical planning becomes more prevalent, there is a question about how MMF will continue to be used [41]. Patient-specific implants and customized fixation help increase the accuracy of ORIF but can add significant cost and can only be as accurate as the initial surgical planning itself [42]. However, it is the authors' opinion that intraoperative situations can always force the need for adaptation, in which case a thorough knowledge of MMF techniques will always be an essential tool for the surgeon to be aware of in ensuring optimal surgical outcomes.

CONCLUSION

With many accepted options to achieve MMF, surgeons are charged with selecting techniques that maximize outcomes while minimizing discomfort, side effects, complications, risks to the surgical team and patient, and cost. Ultimately, surgeons must rely primarily on assessing patients' circumstances balanced with maximizing efficiency and safety to select the best technique for each situation.

Acknowledgements

The authors thank Dr Thomas Gal for providing the image in Fig. 2a.

Financial support and sponsorship

None.

Conflicts of interest

Dr Alan Johnson receives royalties from the University of Minnesota for inventing dental occlusion ties.
Dr Scott E Bevans is an AO Faculty. He does not receive honoraria or any direct payments for participation in AO courses. Dr Scott Bevans is in the United States Army. The views expressed here are those of the authors and do not reflect the official policy or position of the Department of the Army, Department of Defense, or the U.S. Government. Additionally, reference herein to any specific commercial products, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government.
Dr Sarah Akkina has no conflicts of interest.

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- ▪ of special interest
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