

Maxillo-Mandibular Fixation: Utility and Current Techniques in Modern Practice

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ABSTRACT

BACKGROUND: There appears to be a gradual relegation of maxillo-mandibular fixation (MMF) from the frontline of oral and maxillofacial surgical techniques because of the evolution and increasing sophistication of rigid internal fixation techniques.

AIM: To highlight the residual relevance, utility, and current techniques of achieving MMF in modern practice.

METHODS: A rigorous search of the maxillofacial literature was undertaken to identify recent articles that discuss the techniques, usefulness, limitations, merits, demerits and cost effectiveness of MMF. A narrative review of the selected literature was done to provide concise and current evidence on MMF in modern maxillofacial surgery. The cost effectiveness of MMF as a modality in the treatment of maxillofacial fractures is also compared with that of open reduction and internal fixation (ORIF).

RESULTS: MMF is employed as temporary intraoperative adjunct to rigid fixation techniques or as a supplement for postoperative stabilization after semi-rigid fixation. It is an adequate and more cost effective method in some types of mandibular fractures. Other indications are patients' refusal of open surgery, refusal of hardware insertion and lack of medical fitness for extensive surgical operation. Many innovative techniques of achieving MMF are now available and are in this article, categorized into MMF with direct wiring techniques, MMF with inter-arch straight tie wires or elastics, and MMF with Special devices.

CONCLUSION: In spite of the growing enthusiasm for ORIF, MMF remains a relevant technique in maxillofacial surgery and in some cases is more cost effective than rigid internal fixation.

KEYWORDS: Rigid fixation, Maxillofacial surgery, MMF Techniques, Cost effectiveness.

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INTRODUCTION

Maxillo-mandibular fixation (MMF); also known as intermaxillary fixation (IMF), is a time-honoured method of immobilizing the jaws in occlusion. It is a cornerstone of maxillofacial reconstruction, providing a stable base from which facial form and function can be restored.¹ It re-establishes patient's pre-morbid occlusion assisting in the reduction and fixation of simple and complex facial fractures, in jaw reconstructions and orthognathic surgery.^{1,2,3,4}

Despite its versatility, MMF is fraught with many disadvantages such as masticatory and feeding disturbances, speech disturbances, inadequate oral hygiene, and in some cases, reduced respiratory efficiency.³ For these reasons, there have been relentless effort to avoid MMF in maxillofacial surgical practice.

The advent of rigid internal fixation techniques in the 18th century and the subsequent introduction to oral and maxillofacial surgery during the 19th century, were part of the efforts to eliminate MMF.³ Rigid internal fixation techniques provide better anatomical fracture reduction, greater stabilization at osteotomy sites and more stable restoration of bony defects^{2,3} while circumventing many of the disadvantages associated with MMF. The technique, which is based on screw and plate osteosynthesis has currently swooped on the fields of maxillofacial trauma care, facial bone reconstructions and orthognathic surgery where wire osteosynthesis and MMF had been the mainstay. But, has MMF been consigned to the archive?

In this article, the current relevance and utility of MMF in modern practice are highlighted and comprehensive descriptions of the various techniques of achieving MMF are provided. Also, cost-effectiveness analysis of MMF in comparison to rigid fixation in maxillofacial fracture management is discussed based on reports in the literature.

RELEVANCE AND UTILITY OF MMF IN MODERN PRACTICE

Traditionally, MMF has been applied in the treatment of all forms of jaw fractures, in the stabilization of free non-vascularized bone grafts to bridge mandibular defects, following enucleation of large mandibular cyst or related lesions whereby a thin inferior cortex remains, following mandibular and maxillary osteotomies to correct jaw deformities, and as adjunct in the control of body weight of obese patients.¹⁻⁶ In modern practice, the use of rigid plates and screws is now favoured in most of these clinical scenarios.³

However, MMF is still employed; sometimes, as a temporary intraoperative adjunct to secure occlusion before final fixation of fractures, or during placement of bone grafts to bridge mandibular defects.^{2,3} Often, supplemental MMF is employed for postoperative stabilization when semi-rigid system is employed in fracture fixation or in orthognathic surgery.⁷⁻¹⁰ The

arguments in favour of supplemental MMF with semi-rigid systems are the facts that it reduces postoperative pain from TMJ trauma and pterygomasseteric spasm, and also allows for improved soft tissue and bone healing.⁷ However, there are clinical scenarios for which MMF is perhaps the first choice of treatment.¹¹ An example is isolated unilateral high condylar neck or intracapsular fractures in which there is no absolute indication for open reduction.^{2,11,12} Also, in cases of undisplaced/minimally displaced mandibular body/angle fractures, MMF for a variable period of 3-6 weeks has been found to be adequate and much more cost effective.^{13,14} Arguably, MMF should be preferred to rigid internal fixation in such situation.^{7,13} Other reasons for which MMF may be preferred to rigid internal fixation are patients' refusal of open surgery, refusal of hardware insertion and lack of medical fitness for extensive surgical operation.¹⁵

In some developing countries, MMF and interosseous wiring remains the most popular techniques of treating all types of jaw fractures and for immobilizing the jaws after bone grafting of mandibular defects.^{8,16-18} High cost of armamentaria, coupled with lack of expertise in osteosynthesis techniques are some of the reasons for the retained popularity of MMF in such places.^{16,18}

TECHNIQUES FOR ACHIEVING MMF

The traditional techniques for achieving MMF include the use of direct wiring, ivy loops or eyelet wires, dimac wires, arch bars and cap splints.^{1,12} These techniques are still employed in modern practice despite the introduction of newer techniques. Newer techniques are aimed at circumventing some of the limitations and complications associated with the traditional ones.

MMF WITH DIRECT WIRING TECHNIQUES

The conventional direct wiring technique is described in most textbooks of maxillofacial trauma.^{10,15} It involves the use of 0.35mm - 0.50mm, hard-drawn stainless steel wires to embrace a single, firm standing tooth around the cervical margin and twisting the free ends together on the vestibular side of the tooth (fig. 1). A similar maneuver is performed on the corresponding tooth in the opposing dental arch, following which, the twisted segments in the two arches are twisted together to bring into occlusion.

It is a rapid method for achieving MMF and can be used in partially edentulous arch, especially with isolated standing tooth.^{11,12} However, it does not provide sufficient rigidity and the possibility of the wires sliding off an isolated tooth is a setback.¹¹ The twisted intermaxillary fixation segment is relatively too bulky, consisting of four strands of wires. It may cause significant irritation to the surrounding soft tissue. To overcome some of these limitations, some other modifications of direct wiring techniques have been described. These include, embrasure anchorage, Ernst ligature and Pearl steel wire techniques.^{19,20}

The embrasure anchorage technique relies on tight interdental contacts for anchorage. Hence, it is only applicable in complete permanent dentition with tight interdental contact points. A straight, hard-drawn stainless steel wire of appropriate gauge (0.35mm - 0.5mm) is passed continuously through opposing embrasure, using the interdental contact area as anchorage, the free ends of the wire are twisted together to bring into occlusion (fig. 2). It is a more rapid technique but has the disadvantages of less rigidity and limited application because of total dependency on tight interdental contacts. It can be used as a temporary means of MMF while rigid internal fixation of simple mandibular fractures is being done.

The Ernst ligature is popularized by the AO/ASIF organization.¹⁹ The wire is passed across the vestibular surface of two adjacent, firm standing teeth. Either ends of the wire are tucked through the embrasure at the far sides of the teeth in a vestibular to lingual direction. The two free ends are then looped backwards in a lingual to vestibular direction through the common embrasure of the two teeth, one limb above and the other below the horizontal wire across the vestibular side of the teeth. The free ends are then twisted together (fig. 3). This is repeated on the corresponding teeth in the opposing arch. The twisted segments in the upper and lower dental arches are further twisted together to achieve occlusion.

The Ernst ligature provides more stable immobilization than the former two techniques but not as much as arch bar splintage.¹⁹ It is also applicable as a temporary means of MMF during rigid internal fixation. The disadvantage is bulkiness of the twisted wire and the consequent soft tissue irritation. The technique cannot be used in complex cases such as comminuted mandibular fractures.¹⁹

The pearl steel wire was described by Aldegheri and Blanc.²⁰ The technique also requires tight interdental contact. The pearl steel wire consists of a 0.5mm stainless steel wire with a small necklace-like pearl attached to one end using resin (fig. 4). Before MMF, 412 pearl steel wires are passed into the interdental space from the lingual side to the vestibular side. The terminal end of the wire is retained by the resin at the lingual embrasure. MMF is performed by connecting the opposite ends of the maxillary and mandibular pearl steel wires.

It is another rapid technique, but its dependence on tight interdental contact is a short coming. Also, accidental dislodgement of the acrylic resin in the lingual embrasures will lead to failure. It has been used for short-period immobilization in permanent teeth.²⁰ It is also applicable for temporary intraoperative immobilization during rigid internal fixation procedures.

MMF with inter-arch straight tie wires or elastics

Some other techniques of achieving MMF involve the attachment of hardware to individual dental arches while

a separate wire or elastic band is anchored on the hardware to bring the opposing dental arches into occlusion. Examples of this technique are described subsequently.

The advantage is that the tie wires or elastics may be removed and replaced with relative ease to allow for intermittent jaw exercise while the fracture remains splinted. The use of elastic bands particularly permits some degree of movement at the temporomandibular joint while still accomplishing intermaxillary fixation.¹¹ This option is preferred where the risk of joint ankylosis is a concern.^{11,12}

Ivy loops or eyelet wires are applied around paired adjacent teeth in the upper and lower dental arches.¹² Straight stainless steel wires are then passed through the eyes (or loop) from one arch to the other. The two ends are finally twisted together to bring the jaws into occlusion (fig. 5).

This technique provides stable fixation. It is useful in different types of mandibular and maxillary fractures. The eyelets splints could be retained further across a fracture line after removal of the inter-arch tie wires. The technique can be used to facilitate the treatment of middle third fractures whereby, it is combined with internal suspension wires. However, it provides less rigid splinting compared to arch bar when applied across a fracture line.^{11,12} It cannot be used with elastics.

MMF with arch bar/ orthodontic brackets is another technique of intermaxillary fixation involving splintage of a dental arch with an arch bar or orthodontic wires and brackets.^{12, 21-24} Conventionally, the arch bar is secured to the teeth by wiring, but in some cases, arch bars, like the brackets, are anchored to the dentition using adhesive bonding techniques.^{25,26} A straight stainless steel tie wire is looped around the arch bars or orthodontic wire in the upper and lower arches and occlusion is achieved by twisting the two ends of the wire together (fig. 6).

Commercially available arch bars are of different materials and designs. Materials such as stainless steel, cobalt chromium and titanium have been used.²¹⁻²⁴ Some designs incorporate hooks for anchorage of intermaxillary tie wires or elastics.^{12,21} Arch bars provide more stable fixation, they can be used to provide tension banding at the alveolar segment during rigid internal fixation of mandibular fractures.^{12,27} Some practitioners apply cold cure acrylic to cover the arch bar and wires to reduce the irritative effect of the metals on surrounding soft tissue.²⁸

Arch bar MMF is the standard in modern practice, it is recommended where very stable occlusion is required; either temporarily during internal fixation or as a definitive treatment of jaw fractures.^{1,27} It is applicable in

primary, mixed or permanent dentition as well as in partially edentulous arch.¹² The technique can also be combined with internal suspension in the treatment of middle third fractures.¹²

MMF with Special devices

The MMF techniques described so far involve the use of wire or metal attachments to standing teeth. They are fraught with several disadvantages such as the risk of penetrating injury to the surgeon, risk of cross infection, increased surgical time both in placement and removal, trauma to the periodontium and surrounding soft tissue, risk of dental avulsion due to traction from wire twisting, risk of ischaemic necrosis of gingival due to pressure from arch bar and wires, and compromised oral hygiene.²⁷

²⁹⁻³² Some special devices have now been developed to overcome most of these deleterious effects.

MMF with screws

To get around the problems associated with wire and arch bar MMF, Otten in 1981 introduced the use of screws for intermaxillary fixation.³³ In his method, he inserted AO miniscrews into the nasal spine and into the parasymphyseal region. The screws were used to attach elastic bands or wires for intermaxillary fixation. However, the use of dedicated cortical screws for intermaxillary fixation was first described by Arthur and Berardo in 1989.³⁴ They utilized at least four self tapping screws inserted transmucosally, one for each quadrant. The screws were inserted into a drilled hole at the junction of the attached and reflected mucosa between the canine and first premolar (fig. 7)

The main risk of using screws is the possibility of damaging dental roots while drilling the hole.^{35,36} There are also reports of other complications such as screw breakage, loss of screws, screws being covered by mucosa, infection, loss of teeth, anaesthesia of mental or inferior alveolar nerves, screw hole necrosis and sequestration.^{27,37-39} Some authors asserted that MMF with screws does not permit postoperative directional traction and cannot provide the "tension band" effect that can be achieved by means of arch bars.⁴⁰ Most of these complications and limitations were observed during the early phase of introduction of the screw technique and many of them are largely being overcome by current improvements in techniques, screw materials and screw designs.

The first generation of IMF screws were simply modified monocortical self tapping screws, they required a drilled hole for placement and so were associated with damage to dental roots by power drills as well as suboptimal placement with resultant screw loosening/loss.^{41,42} This has been improved upon by the introduction of the second generation bicortical self drilling/self tapping screws.¹ These required no power drilling and offer improved tactile sensation during placement thus allows prompt

detection of root contact during placement thereby limiting the possibility of root damage.⁴⁰

IMF screws are currently available in titanium materials and stainless steel.^{1,40,43} Titanium screw is generally preferred because its tensile strength is comparable to that of bone, it is compatible with modern osteosynthesis plating systems, and probably, for its potential to osseointegrate, thereby offering firm holding in bone while in-situ^{27,37}. However, it is less appropriate in extremely dense bone because of its tendency to shear. Stainless steel screws is preferred in such situations because of its comparatively greater shear strength.¹

To achieve optimal fixation and avoid most of the complications with MMF screws, it is appropriate to make proper judgment in terms of type and number of screws, screw positions and technique of placement on a case by case basis.^{1,27,37} Self drilling/self tapping screw is generally recommended.¹ Although four screws are often adequate and placement between the canine and first premolar is generally recommended in the mandible to avoid injury to inferior alveolar/ mental nerve, while a position between lateral incisor and canine in the upper dental arch is recommended.^{1,6,43} Some manufacturers recommend subapical screw placement, this has been associated with mucosa overgrowth therefore screw placement in safe positions at the mucogingiva junction is preferred.^{1,27} However, a preoperative dental panoramic tomograph or where possible, 3-D or reconstructed computerized tomograph is recommended to determine the best and safest screw position.^{1,27,37} This is especially more important where more than four screws is to be placed or in grossly resorbed ridges as in edentulous patients¹. It is important that screws are placed in locations that support vectors needed for fracture reduction^{1,27}

By avoiding the drilling system, the risk of screw hole necrosis and sequestration can be grossly reduced.^{1,37} Placement in appropriate vector position reduces screw loosening resulting from unfavourable transmitted forces from muscle actions on the implanted screws¹. Whenever resistance is met during screw placement an alternative insertion site or intermittent counterclockwise half turn has been recommended to prevent breakage^{1,27}. The incidence of screw hole infection is very low in recent studies.^{27,37,43}

In modern practice, IMF screws have been used in various modifications adapted to different clinical situations. Jang et al⁴⁴ described a technique for MMF using patient's denture and anchorage screw in a patient with comminuted fractures of the mandible (fig. 8). After closed reduction of the multiple fragments, the denture was applied to splint the fractures while maintaining occlusion and facial dimension. Screws were inserted

through the vestibular flanges of the dentures into the bone thus retaining the denture in position while at the same time providing anchorage for intermaxillary fixation. MMF miniscrews have also been used to provide orthodontic anchorage while keeping the jaws in intermaxillary fixation following orthognathic surgery.⁶

MMF with screws has gained wide applications because of its relative advantages over the traditional arch bar and wire techniques.^{1,27,39,40,41,43} Insertion is easy, it takes 10-13 minutes with significant intraoperative savings in time and cost. They are equally easy to remove without anaesthesia or under local anaesthesia where the screw has been covered by mucosa. The risk of percutaneous injury and cross infection associated with wires is practically eliminated. In addition, the risk of damage to dental papillae and oral mucosa are considerably reduced; the teeth and dental prosthesis are not subjected to traction, and it is easier to maintain oral hygiene. The development of titanium screws makes compatible with any plating system.

In spite of its versatility, Jones⁴⁰ stated that while MMF with screws is adequate for temporary intraoperative fixation and postoperative elastic traction, it is not strong enough to allow prolonged postoperative intermaxillary fixation. Contrarily however, the technique has been used successfully as sole fixation technique in single or double mandibular fractures with minimal displacement, compound condylar fractures, and fractures in edentulous jaws, in addition to its adjunctive use with load sharing osteosynthesis in trauma and orthognathic surgeries.^{1,6,27,43} However, it should be used with caution in crowded dental arch, it cannot be used in too grossly resorbed edentulous ridges especially of the maxilla and in osteoporotic bones. Also its inability to provide tension banding at the alveolar segment during mandibular bone plating is a setback for which arch bar MMF should be preferred.^{1,27}

MMF with plates

A 2-hole miniplates is screwed to the maxilla around the zygomatic buttress and a similar plate is applied at the mandibular buttress. Additional plates may be included lateral to the pyriform aperture on the maxilla and apical to the canine on the mandible. The plates are oriented in a vertical direction such that one hole is screwed to bone while the other abuts the opposing plate. The second holes are then looped together with 0.4-0.5mm stainless steel wire to bring into occlusion (fig. 9a).¹⁹

This technique is used only as an interim measure of maintaining occlusion during open reduction and rigid internal fixation. It requires complete subperiosteal exposure of the bone for placement.¹⁹ Alternatively, especially in case of grossly resorbed ridges, an interarch bridging plate may be placed. These are screwed to the maxillary and mandibular ridges transmucosally after

bringing the ridges into centric occlusal relation (Fig. 9b).

MMF with thermoforming plates

This new technique of intermaxillary fixation was described in 2002.^{45,46} It is an adaptation of the systems used for fabrication of periodontal splints, night guards, and bite splints. Impressions of the upper and lower dentitions were taken preoperatively, and then model surgery performed to establish desirable occlusion and appropriate intermaxillary relationship. Using a pressure molding machine, bilayer thermoformed sheets are adapted to the plaster model. The models are then mounted on an articulator to establish centric occlusion. The occlusal surfaces are then planed and the upper and lower thermoformed plates are connected with acrylic resin. The joined plate is transferred to the patient's mouth to fix the lower and upper jaw in occlusion (fig. 10). The retention therefore is provided by the snug frictional fit of the adapted thermoformed plate to the axial surfaces of the standing teeth. Self cure acrylic may be added to the fitting surface to improve retention while the non fitting surface are smoothed out and polished to avoid irritation and injuries to the surrounding soft tissue.

The plates may be removed intermittently to allow for soft diet.^{45,46} Although this device largely overcomes the shortcomings associated with wired arch bars, it is technically sensitive and it has limited applications because of its weaker fixation strength.⁴⁶ Hence, it is only applicable in simple, minimally displaced fractures of the mandible and maxilla.^{45,46}

Comparative cost effectiveness of MMF and Rigid internal fixation in oral and maxillofacial trauma

With increasing concern over the cost of health care services worldwide, it has become important to demonstrate the cost-effectiveness of the various available techniques.⁴⁷ During the past two decades, the use of rigid internal fixation has become widespread as a preference to traditional maxillo-mandibular fixation in the treatment of maxillofacial fractures.³ The growing popularity of ORIF derive from its putative advantages such as better fracture fixation, early return to function, better patient's acceptance, and less dependence on patient's compliance.^{48,49} Because resource limitations are the ultimate constraint underlying all health care decisions, it is important that clinician choices between rigid internal fixation and MMF for similar clinical scenarios be informed by the trade-offs in terms of clinical benefits and costs.⁴⁹

Up till now, only few studies in the oral and maxillofacial literature have analyzed the cost effectiveness of ORIF and MMF, yet, the findings have been contradictory.⁴⁷ Hoffman et al⁵⁰, Thaller et al⁵¹, and Dodson & Pfeffle⁵² have argued that rigid internal fixation may be the more cost effective approach for treating mandibular fractures, if the costs of treating potential complications are

considered. In contrast, El-Degwi & Mathog⁵³ and Schmidst et al⁴⁷ suggests that the use of MMF offer considerable cost savings over rigid internal fixation. The conflicting reports reflect the methodologic problems intrinsic to the studies.

Brown et al⁵⁴ in a British study compared the charge of MMF with miniplates osteosynthesis, they found that patients treated with closed reduction and MMF required longer hospital stay, increased use of intensive care units and greater number of outpatient visits thereby making MMF more expensive than ORIF. On the contrary, El-Degwi and Mathog⁵³, compared MMF and plating, they found that patients with MMF required fewer preoperative and postoperative inpatients days and fewer postoperative follow-up visits. Abubaker and Lyman⁵⁵ in an American study observed greater average cost of treatment with ORIF than with MMF, although the costs of treating complications were not incorporated. In a similar study in an American setting, Schmidst et al⁴⁷, evaluated total cost of treatment incorporating the cost of treating complications; they reported an average total cost of \$10,927 for MMF and \$34,636 for ORIF. Shetty et al⁴⁹ reported similar findings of \$7,206 for MMF versus \$26,089 for ORIF. These findings imply that ORIF could be three times more expensive than MMF.

True cost-effectiveness analyses are complex to perform and are fraught with many limitations. Some of the limitations relate to the fact that charges, admission policy, theatre usage and drug prescription policy are institution specific and so cannot be generalized. Also, treatment outcomes in terms of complications or optimal results should be incorporated but they are not easy to quantify. In addition, the effective economic losses incurred by the patient due to the incarceration imposed by the method of treatment and the consequent loss of man-hour in hospital stay and follow up visits are also difficult to evaluate. In a randomized controlled trial to assess the justification of the added cost of rigid internal fixation, Shetty et al⁴⁹ after considering many variables, showed that the gains for the patients in having ORIF of a moderately displaced mandibular fracture are negligible and difficult to justify given the substantive added cost. Hence, in a large public hospital serving an indigent population, it may be more cost effective to treat patients with moderately displaced fractures using MMF while ORIF should be reserved for complex cases.⁴⁷

CONCLUSION

In spite of the growing enthusiasm for ORIF, MMF remains a relevant technique in maxillofacial surgery. Many newer techniques have been described to circumvent many of the disadvantages associated with traditional MMF techniques. It is advisable for practitioners to be armed with skills in various methods of achieving MMF in order to choose the best approach in different clinical settings.

Fig. 1 Direct wiring

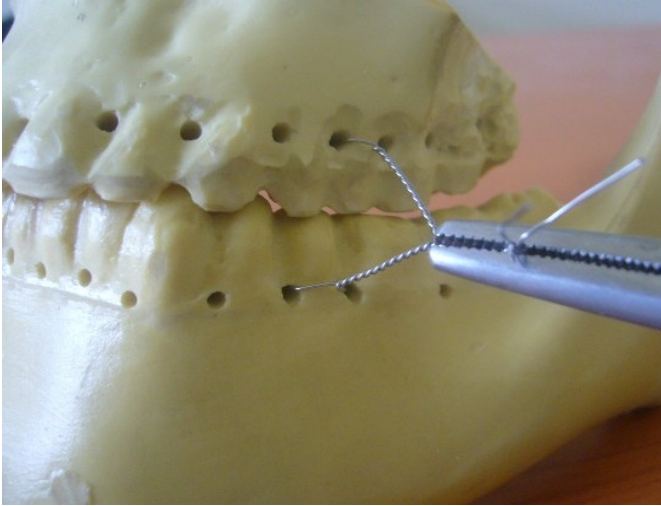


Fig. 2 Embrassure anchorage

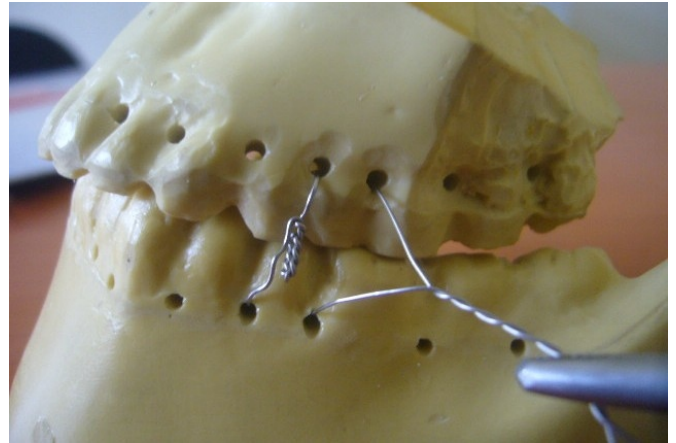


Fig.3: MMF with Ernst Ligature.

a. Ernst ligature wire applied around adjacent teeth ready for twisting.
b. Each ligature wire is twisted and ready for intermaxillary fixation by twisting the upper and lower twisted strands together



Fig. 5 Eyelet

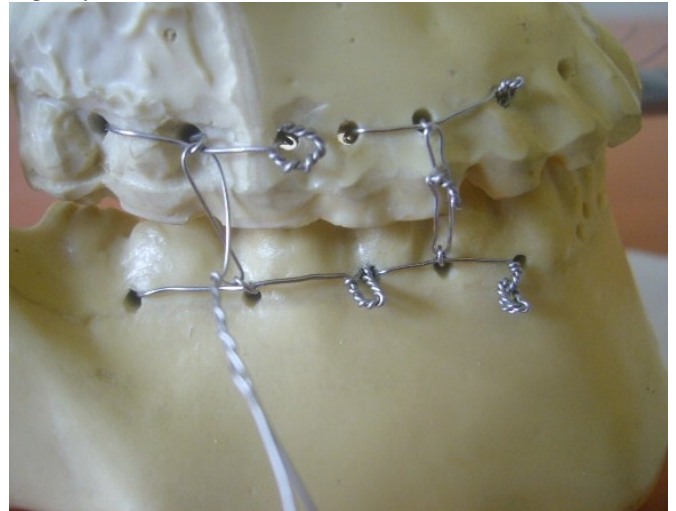


Fig. 6: MMF with arch bar

A. Upper and lower arch bars applied
B. The arch bars are brought together with interarch straight wires to achieve maxillomandibular fixation

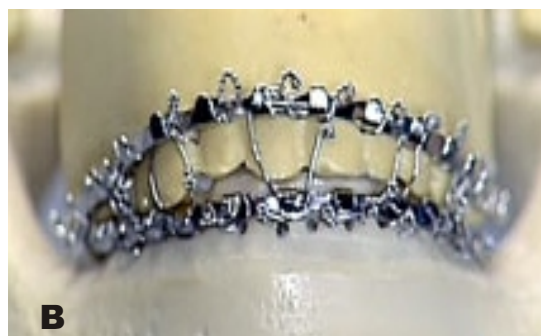


Fig. 4: MMF using Pearl steel wire

The pearl steel wire demonstrated on an upper and lower arch stone casts. Note that the straight wires are retained lingually by the acrylic resin pearls/beads. The casts are ready for intermaxillary fixation by twisting the upper and lower strands together.

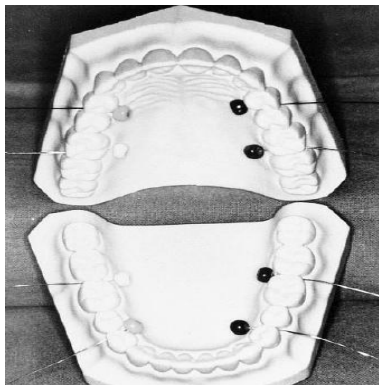


Fig. 7: MMF with Screw

A. The IMF screws are applied transmucosally and fixation achieved with elastics
 B. Demonstration of MMF achieved with X-pattern stainless steel tie wires for greater stability



Fig. 8 : MMF with screwed denture anchorage

Note that the screws are inserted through the denture flanges into the ridges and MMF is completed by using stainless steel wires to connect upper and lower screws in double reversed triangular version.



Fig. 9 MMF with interarch plate

a. 2-3 hole plates placed after periosteal stripping and MMF completed with interarch tie wires
 b. MMF using longer interarch bridging plates screwed into edentulous ridges transmucosally

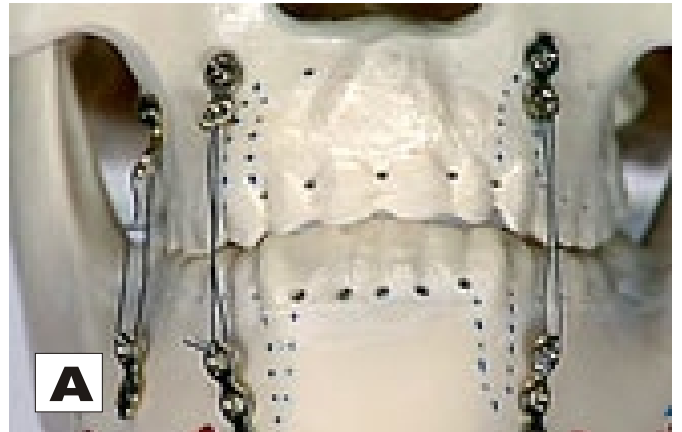
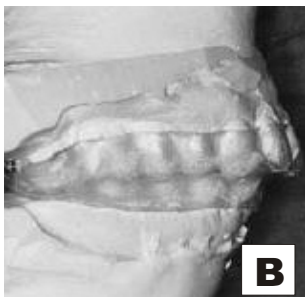


Fig 10 MMF with thermoforming plate

Note the upper and lower thermoformed plates adapted to the dentition on the dental arch models and sealed together with acrylic resin.
 a. Frontal view b. Lateral view



For effective management of health care resources, it is important to consider MMF for simple cases of maxillofacial fractures as cost effectiveness analysis has not justified the added cost of ORIF in such cases.

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