Mandible Fractures
Discussion and Debate

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KEYWORDS

• Mandible fracture repair • Miniplates • Maxillomandibular fixation • Panel discussion

Mandible Fractures Panel Discussion

Oneida Arosarena, Yadro Ducic, and Travis T. Tollefson address questions for discussion and debate:

1. Is rigid fixation essential for the treatment of angle fractures, or is a single plate along the superior border sufficient?
2. Does the presence of teeth in the fracture line (particularly the third molar in angle fractures) contribute to stability of the fixation, or is it a nidus for infection?
3. What is the role of postoperative antibiotics? Are they always necessary?
4. Do you believe that applying MMF is an important part of mandibular fracture repair? If you do not use MMF in all cases, how do you decide which cases require intraoperative and/or postoperative MMF? Do you believe that the techniques/methods of applying MMF make a difference?
5. How do you manage edentulous mandible fractures?
6. *Analysis:* Over the past 5 years, how has your technique or approach changed or what is the most important thing you have learned in dealing with mandible fractures?

Is rigid fixation essential for the treatment of angle fractures, or is a single plate along the superior border sufficient?

AROSARENA

Because of the biomechanics of the mandible, mandibular angle fractures have a high incidence of postsurgical complications. There are currently 2 philosophies espoused by practitioners who use open reduction and internal fixation (ORIF) in the treatment of mandibular angle fractures.

Philosophy 1. The goal of the first group is rigid fixation with 2 miniplates resulting in primary bone union, which necessitates absolute immobility of the fracture fragments according to older Arbeitsgemeinschaft für Osteosynthesefragen–Association for the Study of Internal Fixation guidelines.

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Philosophy 2. The second group advocates the use of a single miniplate along the ideal line of osteosynthesis as described by Champy. Although this method does not result in rigid fixation, its proponents list benefits of decreased soft-tissue stripping that maintains blood supply to the mandible, the lack of an external incision, and cost savings related to decreased operative time and savings in hardware.[1] Because bite forces do not return to premorbid levels for several weeks after fracture treatment, proponents of the Champy technique argue that absolute rigid fixation may not be necessary for angle fractures.[2]

Several biomechanical studies have demonstrated that the Champy technique has less favorable biomechanical behavior than biplanar plating techniques.[3–7] Two studies revealed that a 3-dimensional plate at the superior border of the mandible resulted in increased stability with torsional loading when compared with other commonly used mandibular angle fixation techniques, effecting biplanar fixation with a single plate.[3,6] However, these studies may represent oversimplified depictions of fractured mandible biomechanics, not taking into account the stabilizing effects of surrounding tissues, particularly muscles.[5,8] Moreover, these models do not take into account the possibility of stress shielding in the healing mandible that could be attributed to rigid fixation.[8,9]

In a prospective, randomized trial of 54 patients with unilateral, isolated mandibular angle fractures, Danda[10] found that the use of 2 noncompression miniplates had no advantage over the use of 1 superior border plate, and that the use of 2 miniplates resulted in scarring at the transcutaneous incision in 18% of patients. However, Danda used 2 weeks of interdental fixation in all patients. Similarly, in a study of 185 patients with isolated unilateral angle fractures, Ellis[1] found no significant difference in treatment outcomes for patients treated with rigid versus nonrigid fixation, although patients treated with rigid fixation in this study had longer operative times and more wound problems. A recent meta-analysis of mandibular angle fixation techniques found lower complication rates with the use of 1 superior border plate compared with the use of 2 plates.[11]

DUCIC

The decision as to which method of fixation is most appropriate will, of course, be determined by the specific type of injury present. There are several options in treating these injuries with respect to fixation modality. Closed reduction is still an option. However, there is a prolonged period of immobilization that may be associated with increased rate of long-term temporomandibular joint problems. Closed reduction is relatively contraindicated in comminuted angle fractures because of the increased risk of complications. Rigid load-bearing plating of angle fractures is needed in comminuted fractures. Compression plating and lag screw fixation is not appropriate in these circumstances, because of the potential for fragmentary telescoping. Studies performed in noncomminuted angle fractures demonstrate a decreased risk of complications with a single superior border monocortical miniplate placed along Champy's ideal line of osteosynthesis, slightly greater complication rate with an inferior border bicortical plate, and the greatest rate of complications with 2 separate plates.[1–5]

TOLLEFSON

In treatment of fractures of craniomaxillofacial skeleton, is it not rigid truth that 2 plates are better than 1? Unfortunately, the relationship of bioengineering concepts to the clinical application of rigid fixation is not as linear as we would expect. Practice patterns in mandible fracture management have steadily evolved over the last century, with surges of major advances from both bioengineering and clinical fields. Ellis[1] recently reported superiority of the single miniplate technique for mandibular angle fractures over either maxillomandibular fixation after closed reduction or 2-plate fixation. He cited fewer complications and shorter operative time. I concur with the application of a single plate at the mandibular oblique line for treatment of angle fractures in the following circumstances:

1. Adequate bone stock is available
2. Comminution or bone defect (eg, gunshot wound) is not present
3. Nonedentulous
4. In the presence of adequate dentition to restore occlusion.

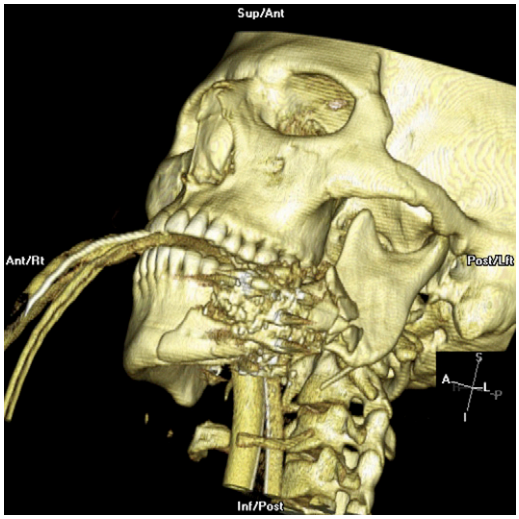

Fig. 1. Mandibular angle fracture open reduction and internal fixation with a single miniplate on the oblique line.

I will briefly introduce the state of the science by reviewing the theories of rigid versus adaptive fixation and the reports of the outcomes of their application.

Without considering the extremes of treatment trends, the contemporary history of mandible fracture treatment paradigms can be simplified into 2 different schools:

1. Treatment patterns restricting function and movement (with external fixation, wires, and load-bearing internal fixation)
2. Shift to near immediate return to function with limited, site-directed internal plate fixation.

The latter incorporates the concept of adaptive osteosynthesis, which has come to be colloquially referred to as the Champy technique in reference

Fig. 2. Preoperative Panorex demonstrating right body and left angle fractures. Note presence of impacted third molar in fracture line.

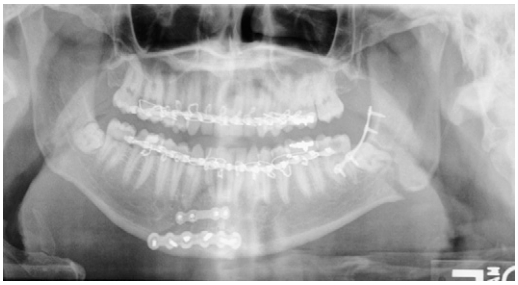

Fig. 3. Following ORIF of both fractures, note persistent lack of reduction at left angle fracture, due to retention of the impacted third molar.

to his expansion on the work of Michelet (**Fig. 1**).[2] The former, adapted from Association for Osteosynthesis/Association for the Study of Internal Fixation (AO-ASIF) orthopedic management principles of long bone fractures, is supported because of the establishment of rigid fixation for primary bone healing by limiting motion around the fracture (**Figs. 1–4**).[3]

Conflicting clinical outcomes have been reported using principles of either school, but the fracture site, complexity of the forces applied to the fracture, and independent patient characteristics must be considered. Ellis and Walker[4] reported on angle fracture fixation with 2 miniplates, but later suggested a lower complication rate with a single miniplate.[5] The investigators partially attributed this difference to the additional dissection needed for the second plate. Fox and Kellman[6] contrasted this report with a 2.9% complication rate in 70 angle fractures treated with 2 monocortical miniplates,

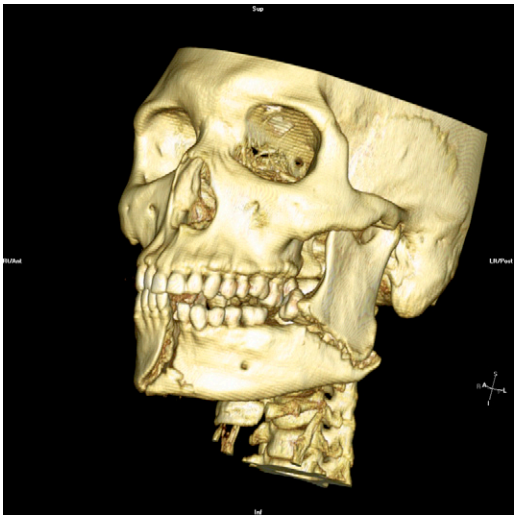

Fig. 4. 3D CT Scan image of demonstrating exposure of the left third molar in the left mandibular angle fracture. A right parasymphyseal fracture is also present.

and also clarified that the 1994 Ellis and Walker study included bicortical application of the inferior border plate. As with any comparative effectiveness research, a direct, randomized prospective study of sufficient power would be ideal, but is unlikely. It is plausible that these contrasting clinical experiences may be clarified by studying outcomes in a multi-institutional database with sufficient collection of fracture details and related secondary factors of bone healing, such as soft-tissue dissection, approaches, technique, and duration of maxillomandibular fixation, and the general patient's general "protoplasm" or health (eg, diabetes, alcoholism, malnutrition, tobacco abuse).

Although the contrasting clinical reports can be difficult to directly compare, I am comfortable with the relative success using either 1 or 2 miniplates on the mandibular angle. I strongly concur with Rudderman and colleagues in that fixation should "provide for a functional construct that can adequately heal while the patient participates in near normal activities."[37] It may seem contradictory to suggest that less fixation is better in some circumstances, but applying functionally stable fixation while allowing dental loads to be applied to the healing mandible may improve bone density, as described by Julius Wolff in 1892 in the law of transformation of bone.[7] The 1-plate technique on the oblique line is my preference for the uncomplicated mandibular angle fracture because it adequately minimizes interfragmentary movement via a limited soft-tissue dissection.

Does the presence of teeth in the fracture line (particularly the third molar in angle fractures) contribute to stability of the fixation, or is it a nidus for infection?

AROSARENA

The prophylactic removal of teeth in the line of fracture was advocated before the widespread use of antibiotics and rigid internal fixation, both of which have significantly reduced the infection rate associated with repair of mandible fractures.[15,16] Retained teeth historically were believed to act as foreign bodies, providing communication between the oral cavity and the periodontal space. The trend over time has been retention of viable teeth in the fracture line.[12,15–19]

Ellis[20] reported a trend toward increased complication rates when molars, particularly the third molar, are involved in the fracture line. However, at least 3 retrospective series demonstrated no difference in outcome of fracture management whether the teeth were routinely extracted or retained, and regardless of whether the fracture was in the anterior or posterior dentition.[17,19,21] The third molar may represent a different situation because it is in a region where debris tends to collect. In a retrospective analysis of 105 mandible fractures associated with incompletely erupted third molars, Rubin and colleagues[22] found a trend toward increased complication rates in cases treated with open reduction when the third molar was retained. Other investigators recommend retention of healthy third molars that do not interfere with fracture reduction, particularly unerupted third molars. They argue that extraction of the third molar reduces contact area in the already thin angular region of the mandible, which may reduce the stability of osteosynthesis and cause micromobility after fixation.[16]

Extraction of viable teeth may induce additional trauma to the adjacent bone and destabilize the fracture. In addition, healthy retained teeth provide a posterior stop, permit proper alignment of the dental arch, and prevent collapsing or telescoping of the fragments. Moreover, a normal coagulum does not always form after tooth extraction, occasionally leading to alveolitis and wound infection.[12,16] According to Spinnato and Alberto,[18] conditions for preserving teeth in the fracture line are antibiotic therapy, strict oral hygiene, radiologic and clinical monitoring for evidence of periapical infection and pulp necrosis, and endodontic therapy for teeth that require treatment. Widely accepted indications for removal of the teeth in the line of fracture include[12,16,18]:

- Significant periodontal disease with gross mobility and periapical pathology
- Partially erupted or erupted third molars with pericoronitis or cystic areas
- Teeth preventing the reduction of fractures
- Teeth with fractured roots
- Teeth with exposed root apices or teeth in which the entire root surface from the apex to the gingival margin is exposed
- Excessive delay from the time of fracture to the time of definitive treatment
- Recurring abscess at the fracture site despite antibiotic therapy.

DUCIC

The presence of a third molar doubles the risk of mandible fracture because of the sheer volume of bone it occupies, effectively diminishing the height of the remaining mandible.[6] There does exist some controversy as to the need for third molar extraction in the setting of mandibular angle fractures. Indications for removal are generally accepted to include the presence of a fractured tooth, a carious tooth, grossly loose or displaced tooth, an impacted third molar that would meet criteria for removal on its own merit, and a tooth preventing adequate fracture reduction. This latter scenario is most often seen with a preoperatively impacted third molar (**Figs. 2** and **3**). If none of these criteria are met then one may consider retaining the tooth based on intraoperative factors. Removing third molars may further diminish the amount of bone remaining across the fracture site and may make the stability of the reduction less stable; this is an intraoperative decision. Several studies support this approach.[7]

TOLLEFSON

Controversy persists over whether to remove a third molar that is in a mandibular angle fracture line. Before the advent of antibiotics, infections in fractures along the tooth-bearing mandible were common. Tooth extraction from the fracture site theoretically decreased bacterial load, but the advent of antibiotics shifted the paradigm.[8] My practice is to retain healthy, erupted molars in mandibular angle fractures with the exception of the indications that I will further describe.

As infection-related complications decreased with the routine use of preoperative and perioperative antibiotics, surgeons began to sort through the effectiveness of different practice patterns: tooth extraction, duration of maxillomandibular fixation, rigid versus adaptive osteosynthesis, and surgical approaches. The debate over third molar extraction in angle fractures excludes an abscessed or severely decayed tooth, which should be extracted in fractures of any area of the mandible. This clinical debate is also partially fueled by the routine practice of preventive extraction of third molar or wisdom teeth, which have had evolving indications and justifications in the oral surgery literature.[9]

Third molars, occupying significant cross-sectional area of the mandibular angle, have been shown to predispose patients to up to 3.8 times the risk of angle fractures than those without third molars.[10–12] Once the fracture is present, some surgeons choose to extract, whereas others retain the third molar. I concur with the theory that extraction of the third molar from a fracture line may destabilize and limit the interfragmentary buttressing required for bone healing (**Fig. 4**).

The literature has support for both extraction and retention of the third molars in angle fractures. The support in the literature for retention is strong. Neal and colleagues[13] and Amaratunga[14] found that removing teeth in the line of a fracture did not change infection rates. The investigators included other tooth-bearing fracture locations in the studies, so we must infer how the angle fractures would behave. Iizuka and Lindqvist[15] went further to suggest that tooth extraction can contribute to postoperative infection. These investigators purport that the tooth extraction may make the fracture site unstable because of diminished bone stock, whereas retaining a tooth may add to stability. In a later study of 121 angle fractures, infection risk was higher after tooth extraction in the fracture line and when compression plate technique was used.[16] The latter practice is now rare.

The support for routine third molar extraction from the fracture line is less convincing. In 1964, Muller[17] supported extraction of teeth with multiple roots from fracture lines. Ellis[18] recently reviewed 400 cases in which third molar extraction from the angle fracture was routine practice. Third molars in the fracture line were present in 85% of the fractures, and 75% of these teeth were removed. Although the difference in infection and

Fig. 5. 3D CT Scan image of demonstrating comminuted fracture of the left left mandibular angle fracture with resulting dental root fractures necessitating extractions.

complication rates failed to reach statistical significance, he concludes that the "difficulty that remains involves determining the appropriate criteria for the removal of teeth in the line of fracture."[18(p865)]

Determining the criteria for extraction remains challenging. My current practice is to retain the third molar in the mandibular fracture line except when the roots are fractured, (**Fig. 5**) severe dental caries and mobility are present, or in the presence of pericoronitis, abscess, or infection. If extraction of the third molar is required, it can be removed after bone healing, as suggested by Iizuka and Lindquist.[15,16]

What is the role of postoperative antibiotics? Are they always necessary?

AROSARENA

Although the efficacy of perioperative antibiotics in the prevention of orthopedic fracture infections has been established, their use in the treatment of mandibular fractures may not be comparable, due to the increased blood supply to the face but also because mandible fractures involving the tooth-bearing segments of the mandible are, by nature, contaminated wounds. Moreover, the use of postoperative antibiotics in some surgical disciplines has been associated with increased incidence of postoperative infection attributed to the selection of resistant organisms.[23,24] The role of preoperative and intraoperative antibiotics in preventing postoperative infections in the treatment of mandible fractures involving dentate segments is established.[24–26] However, the amount and quality of the existing data on the efficacy of prophylactic postoperative antibiotics in cases of uncomplicated mandible fracture repair is insufficient for formal quantitative synthesis or meta-analysis.[27]

Only 9 randomized controlled trials have addressed the need for postoperative antibiotics after repair of uncomplicated mandible fractures. These trials are limited by being underpowered, and most did not ensure allocation concealment.[26,27] Also, several of the trials utilized various antibiotic regimens and fracture treatment techniques, including closed treatment, within the trial. In a systematic review of 6 of these trials, Andreasen and colleagues[24] determined that antibiotic prophylaxis had no influence on the infection rate when fractures were treated by closed reduction, but significantly reduced the incidence of infection in patients treated with open reduction, because open reduction increases contamination and decreases blood supply to the injured site. None of these studies supported the use of antibiotics beyond the first 48 postoperative hours.[23,24,26]

A randomized, double-blind controlled trial by Abubaker and Rollert[23] studied patients who received postoperative penicillin for 5 days postoperatively in comparison with patients who received placebo. The study demonstrated no benefits to the use of postoperative antibiotics, but included only 30 patients. Other limitations of this study were the exclusion of individuals with immunocompromised states and exclusion of patients who were noncompliant with postoperative medications. Moreover, twice as many patients in the group receiving postoperative antibiotics than those receiving placebo were treated with closed reduction. All of the patients who developed infections were treated with open reduction. The investigators also noted that none of the patients with fractures not involving the angle developed infections.[23]

In a randomized trial including 181 patients, Miles and colleagues[26] noted that of the patients who developed postoperative infections, the use of postoperative antibiotics only delayed the time to presentation with infectious symptoms. In this study the investigators included patients with comminuted fractures, used only open reduction/internal fixation for treatment, and found no benefit to the use of postoperative antibiotics. However, these results should be interpreted with caution because the investigators reported a significant attrition rate (38%), attributed to the patient population (urban, low-income).[26]

In a retrospective study of patients treated for uncomplicated mandible fractures where patients received a variety of antibiotic regimens for varying time periods postoperatively (up to 10 days), Lovato and Wagner[28] found that the use of postoperative antibiotics did not affect postoperative infection rates.

DUCIC

There remains a defined role for perioperative antibiotic therapy in the treatment of mandible fractures. Although postoperative antibiotics are widely as well, studies have not shown them to be

necessary or helpful in this patient population.[8,9] In an acutely infected fracture, postoperative antibiotics, covering usual oral pathogens including anaerobes, are generally recommended.[10] In the setting of a chronically infected mandible fracture with osteomyelitis, a prolonged course of antibiotic therapy that may extend as long as 6 weeks is recommended.

TOLLEFSON

To answer this question, we must clarify the current practice trends that differ by surgeon, geography, specialty, and even individual case. An infected mandible fracture site demonstrating erythema, purulence, cutaneous fistula, or malunion/nonunion is a clear indication for antibiotics. However, we must consider the utility of the postoperative antibiotic course, especially involving fractures of the dentoalveolar segments caused by the inherent oral bacterial contamination.[20,22,23]

Antibiotic usage can by administered at different time points in treatment, including time of diagnosis, immediately preoperatively, for a 24-hour postoperative period, and as extended postoperative treatment (7–10 days). The doctrine of using of preoperative antibiotics given 1 hour before surgery comes from the general surgery literature.[26,27] Antibiotic prophylaxis for orthopedic fractures are often discontinued within 24 hours postoperatively.[24,25] The value of preoperative antibiotics when the fracture involves a tooth-bearing segment is strongly supported.[23,29] The study by Zallen and Curry[22] compared exposure to either no antibiotics or any antibiotics in open and closed reduction treatments of a variety of mandible fracture locations, and they reported a strikingly higher infection rate in the nonantibiotic groups (50.33%) compared with receiving any antibiotic (6.25%). None of these studies provided specific information on the value of postoperative antibiotics.

Abubaker and Rollert[21] designed a prospective, double-blind, clinical study to investigate the effect of postoperative antibiotics. All patients received penicillin G perioperatively and for 12 hours postoperatively while the second arm received additional penicillin VK orally for 5 days, and the control group received placebo. The investigators found that "postoperative oral antibiotics in uncomplicated fractures of the mandible had no benefit in reducing the incidence of infection."[21] These findings concur with those of Furr and colleagues,[19] who also noted no difference in those cases that had delayed treatment. However, alcohol and tobacco abuse was associated with increased complications such as abscess, infection, nonunion/malunion, and hardware exposure. It may be that algorithms for antibiotic use will need to consider these as well as other patient-specific risk factors.

This difficult clinical question is fueled by conflicting evidence from mostly experiential data that may not be generalizable. Kyzas[28] recently called for large, randomized controlled trials after performing a systematic review of 31 studies, which included 9 randomized control trials and more than 5000 cases. This analysis failed to answer the question of the effectiveness of antibiotic use in mandible fractures. Lovato and Wagner[29] reported no difference in infection rate when patients with mandible fractures were treated only perioperatively (13.33%) or for up to 7 days postoperatively (10.67%). Of note, this case-control study of 150 cases included closed reduction cases, which may have risks different to those of ORIF.

In reviewing the available literature, the retrospective approach has many limitations, not the least of which include a lack of consistent data collection. The ideal study would include the following factors:

1. Timing of surgery after injury
2. Site of mandible fractures (eg, decreased infection risk in non–tooth-bearing condylar and ramus fractures)
3. Type and dosage of antibiotic
4. Timing of antibiotic administration including presurgical, intraoperative, and postoperative
5. Duration of antibiotic course
6. Surgical approach (external or intraoral)
7. Fixation technique (ORIF or closed reduction with maxillomandibular fixation).

Although multi-institutional, randomized control trials would be valuable for antibiotics in facial fracture treatment, the study design is often deemed impractical or unfeasible. The best alternative comparative study would need to account for the differences in patient demographics, health status, tobacco and alcohol use, and dental health.

My preference for antibiotic use will continue to include pre-, peri-, and postoperative as we await potential definitive, future studies that may include more of the 7 factors listed above. My protocol includes giving antibiotics at the time of presentation until the repair, relaying on oral clindamycin or penicillin or intravenous clindamycin or cefazolin. The dosage given an hour before surgery is given intravenously and then repeated until conversion to the oral equivalent, which, along with 0.1% chlorhexidine rinses, is continued for 7 days.

There seems to be a recent trend toward repairing mandible fractures without applying MMF. Do you believe that applying MMF is an important part of mandibular fracture repair? If you do not use MMF in all cases, how do you decide which cases require intraoperative and/or postoperative MMF? Do you believe that the techniques/methods of applying MMF make a difference?

AROSARENA

While there is a trend toward repairing mandible fractures without applying maxillomandibular fixation (MMF), I believe that MMF is important in dentulous patients, to establish normal occlusion in fractures involving the dental arch. In cases of fractures distal to the dental arch, when there is postoperative malocclusion due to masticator muscle dysfunction or soft-tissue swelling, I also use elastic interdental fixation to guide the patient into normal occlusion. Interdental fixation, obviously, is also used for subcondylar or condylar fractures treated with closed reduction. I do not typically use MMF if the mandible is edentulous or has so few teeth that occlusion cannot be established; in these cases I believe that dentures can be adjusted to address postoperative malocclusion, if present. Although I have used MMF screws in the past, my preference is the traditional arch bars with circumdental wiring. I have found difficulty with maintaining stable occlusion with MMF screws, and they cannot be used for postoperative elastic interdental fixation if necessary. Moreover, arch bars are effective at reducing and stabilizing comminuted fractures involving the alveolar ridge.

DUCIC

Maintaining or reestablishing proper occlusion is one of the most important goals in mandible fracture repair. Multiple methods exist for this purpose. Intraoperative MMF such as with MMF screws is a rapid and effective method we use in 2 scenarios:

1. Where the patient's dentition is too poor or inadequate to accept proper arch bar fixation.
2. Where there is no anticipation of needing postoperative guiding elastics.

In situations where there may be a need for postoperative guiding elastics such as subcondylar fractures, comminuted fractures, or multiple fractures of the mandible, it would be the unusual patient who would not benefit from traditional MMF with arch bars. This approach remains the gold standard.

TOLLEFSON

I choose to use MMF for mandible fracture stabilization in:

1. Nearly all isolated condyle, ramus, angle, and body fractures
2. Those patients with 2 or more fracture sites (**Fig. 6**).

In patients with adequate dentition I prefer an open approach for fracture reduction, which affords intraoperative visualization of the fracture segments while reproducing the dental occlusion (based on wear facets and classic definitions). MMF is maintained to stabilize occlusion during ORIF. I prefer to leave the arch bars in place and apply guiding elastics for up to 4 weeks.

There are 3 broad categories in which I will defer MMF: isolated anterior fractures; pediatric cases; and when absent, diseased dentition precludes its use. I choose Ernst ligatures in those cases where only one fracture in the anterior mandible (symphyseal/parasymphyseal fractures) is present, and then remove them after ORIF. Similarly in pediatric cases, ligatures or MMF will be removed after ORIF except when addressing condylar fractures with functional adaptation.

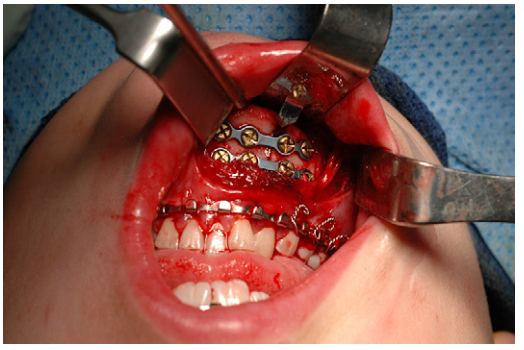

Fig. 6. Intraoperative photograph of erich arch bars and two miniplates used for fixation of a right mandibular parasymphyseal fracture. Maxillomandibular fixation was used due to a concomitant left mandibular angle fracture. Guiding elastics were used post-operatively.

Although some surgeons support the use of intermaxillary fixation (IMF) screws for fixation, I rarely use this option.[30] The screws can become mobile in the maxillary segment and are not intended to allow long-term fixation or guiding elastic capability. The risk of tooth-bud injury with IMF screw placement makes circumdental wires my preference in pediatric cases.

How do you manage edentulous mandible fractures?

AROSARENA

The edentulous mandible is typically atrophic. I usually manage angle and body fractures in the edentulous mandible with a single 2.4-mm locking reconstruction plate for stability. I treat unilateral condylar and subcondylar fractures in the edentulous mandible conservatively (soft mechanical diet or liquid diet). In the few instances when I have treated edentulous patients with bilateral condylar and subcondylar fractures, I have approached these through the parotid, with care being taken to dissect and preserve the facial nerve, and have rigidly fixed the fractures with 2.0-mm plates (one at each fracture site).

DUCIC

This would depend mostly on the patient's mandible height across the fracture line. If the height is at least 20 mm, it is treated as for any mandible fracture in the nonedentulous patient. If the height is between 10 and 19 mm, we will use rigid fixation with iliac or other bone graft packed around the fracture site. If the height is less than 10 mm then a weight-bearing fixation method with a large locking screw plate and major bone grafting is often required. Subperiosteal versus supraperiosteal plate placement seems not to be important when the studies are compared in this regard. Controlling underlying medical problems that are often seen in the elderly edentulous patient population is important, as these may also affect healing.

TOLLEFSON

I believe that the use of soft diet and conservative observation for edentulous mandible fractures should only be used in the frailest patients, who would not tolerate general anesthesia. Otherwise, the premorbid jaw position can be estimated by using the patient's dentures, but these nearly always need to be altered or refabricated after the large 2.4-mm mandibular locking plate is applied to the fracture(s) through an external approach. In a rare case where complex maxillary fractures and an edentulous mandible fracture are present, I will complete MMF by modifying the patient's dentures with drill holes, or our dentist will fabricate a Gunning splint. These cases often receive a tracheotomy, obviating the urge to remove the MMF in the immediate postoperative period. I advocate an external approach to complete the load-bearing ORIF of edentulous mandible fractures. In cases with 2 fractures, I choose a large plate that extends through both fractures with 3 or more screws on each side of the fracture. In the primary setting, if the fracture segments involve "pencil-thin" or osteoporotic bone, I prefer the iliac crest as the cancellous bone graft harvest site.

Analysis: Over the past 5 years, how has your technique or approach changed or what is the most important thing you have learned in dealing with mandible fractures?

AROSARENA

Contemplation on mandibular angle fractures

The method of fixation of mandibular angle fractures that I have used and that has resulted in the fewest postoperative complications in terms of infection is a transcutaneous approach with a noncompression, 6-hole miniplate placed along the inferior border and secured with bicortical screws, in conjunction with a 4-hole tension band secured with monocortical screws so as not to injure the inferior alveolar nerve (**Fig. 7**). I believe that this approach minimizes the exposure of the bone to the contaminated oral cavity, and because a drain is placed, the risk of hematoma is minimized. However, because I have had patients develop hypertrophic scarring and transient facial nerve

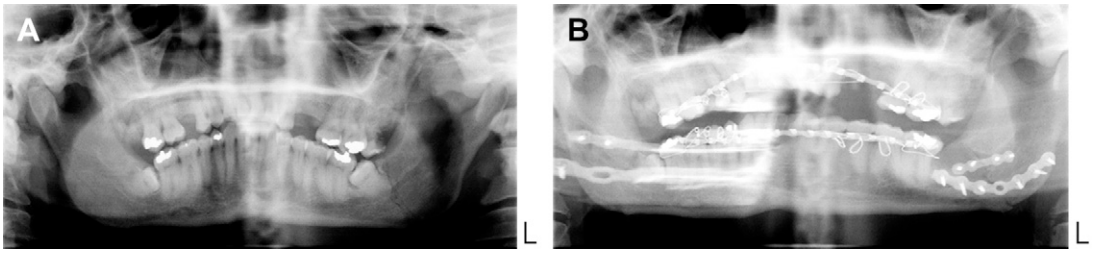

Fig. 7. Orthopantograms of a 46-year-old man with an isolated left mandibular angle fracture. (*A*) Preoperative orthopantogram. (*B*) Postoperative orthopantogram showing fracture fixation with a 7-hole miniplate placed near the inferior border with a 4-hole tension band. The approach was transcutaneous.

injury with this approach, my current preference is a biplanar technique with a miniplate placed at the internal oblique line with monocortical screws, and a second miniplate placed just below this on the buccal cortex with bicortical screws using a transbuccal trocar (**Fig. 8**). Although this has resulted in noticeable scars in a few patients, I believe that this technique affords enough stability to overcome distractive and torsional forces, especially if the third molar has to be removed because it is carious, has broken roots, or is impeding fracture reduction. Removal of the third molar significantly reduces the stability of the mandible in the angle region, and I do not believe that a single miniplate can restore adequate stability for uncomplicated bone healing when the third molar has to be extracted.[9,12] I have used the Champy technique in instances when the fracture was minimally displaced and the third molar did not have to be extracted, and I have also used a single miniplate along the buccal cortex (**Fig. 9**). Like other investigators, I have not noted an increase in complications whether 1 miniplate or 2 miniplates were used for angle fracture management.[7,10,13,14]

Contemplation on teeth in the fracture line

Despite the trend in the literature to retain teeth in the line of fracture, I find that the criteria for preserving teeth (strict oral hygiene, radiologic and clinical monitoring) often cannot be met in the patient population I serve at an inner-city, tertiary care, academic medical center. Moreover, many of my patients have no access to endodontic therapy given their uninsured status. Thus, the viability of

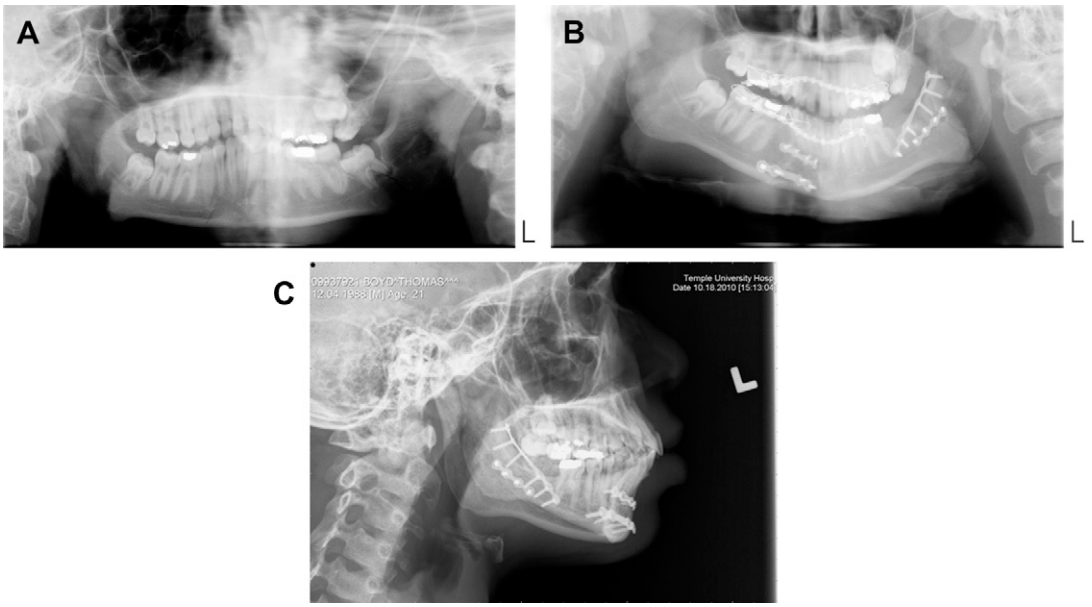

Fig. 8. Radiographs of a 19-year-old man with a left mandibular angle and right parasymphyseal mandibular fractures. (*A*) Preoperative orthopantogram. (*B*) Postoperative orthopantogram demonstrating placement of a miniplate along the oblique line with a second plate placed just below this along the buccal cortex. (*C*) Lateral mandibular radiograph taken 2 years after the initial injury, demonstrating healing of the fracture.

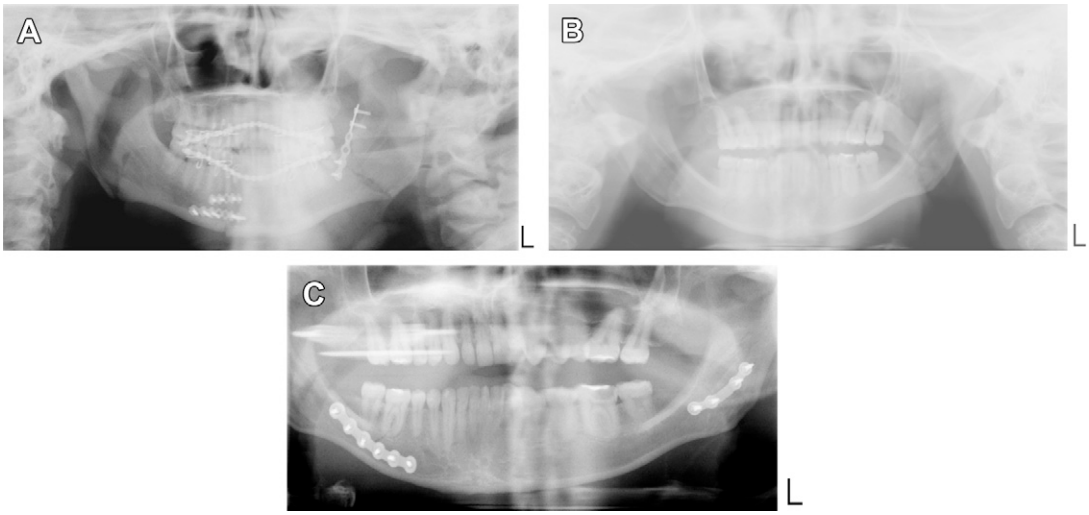

Fig. 9. Orthopantograms demonstrating fixation of mandibular angle fractures with a single miniplate. (*A*) Postoperative orthopantogram demonstrating fixation of a left mandibular angle fracture with the Champy technique in a 33-year-old man. (*B*) Preoperative orthopantogram of a 22-year-old man with left angle and right body mandibular fractures. (*C*) Orthopantogram of patient in *B* taken 1 month after fixation of angle fracture with a single plate along the buccal cortex.

the tooth is only one consideration in my decisions to preserve or extract teeth in the line of fracture. In fact, I believe that a tendency on my part to be too conservative with tooth extraction has resulted in some unnecessary complications. At least 2 cases of postsurgical infection resulted from my decision to preserve viable-appearing, stable teeth despite the roots being partially exposed (**Figs. 10** and **11**). I am now more aggressive with removal of teeth with exposed roots.

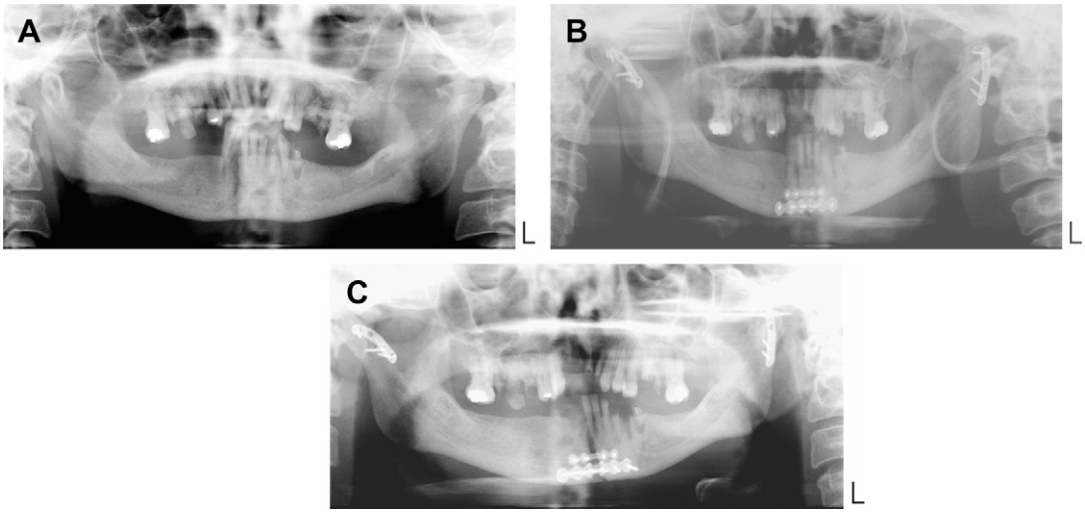

Fig. 10. Orthopantograms of a 38-year-old woman with bilateral subcondylar and right parasymphyseal mandibular fractures. (*A*) Preoperative orthopantogram. (*B*) Postoperative orthopantogram demonstrating ORIF of fractures. The subcondylar fractures were repaired via transparotid approaches given the patient's poor dentition. During repair of the right parasymphyseal fracture, the decision was made to retain the tooth mesial to the fracture because it seemed stable and healthy. (*C*) Orthopantogram taken 2 weeks after fracture repair when patient returned with infection at the fracture line. The nonunion healed with removal of the tooth at the fracture line and conservative treatment with antibiotics.

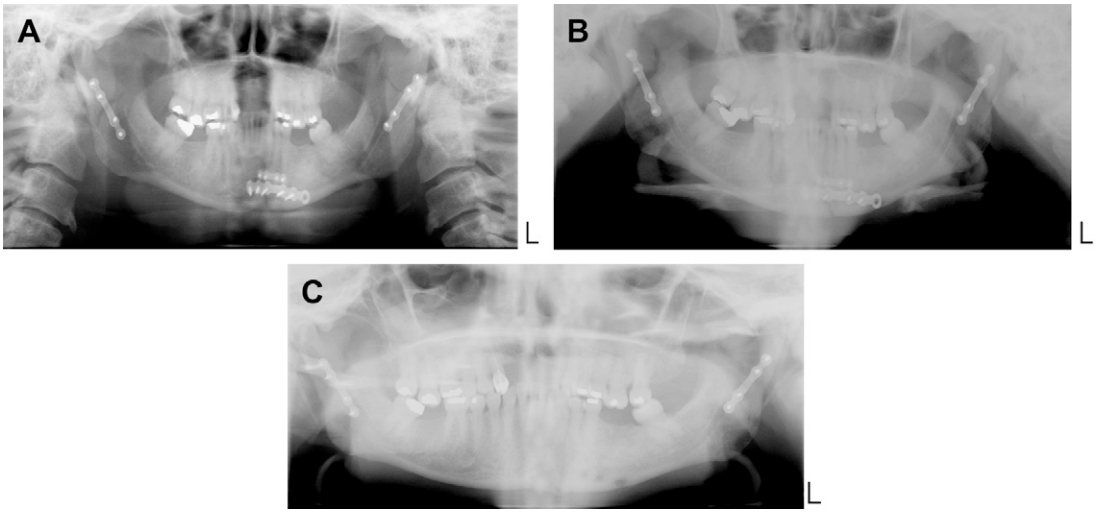

Fig. 11. Orthopantograms of a 51-year-old man with bilateral subcondylar and left parasymphyseal mandibular fractures. (*A*) Immediate postoperative orthopantogram demonstrating good reduction of fractures. The subcondylar fractures were repaired via a transparotid approach. (*B*) The patient presented with pain and granulation tissue at the site of the parasymphyseal fracture 2 months after repair, and this orthopantogram demonstrated nonunion of that fracture. (*C*) Orthopantogram taken 7 months after initial repair. In the interim between this radiograph and that in *B*, the patient was taken to the operating room where he was found to have partial union of the lingual cortex of the mandible at the parasymphyseal fracture site. The decision was made to remove the hardware and do nothing more.

Contemplation on postoperative antibiotics

Orthognathic surgery is analogous to the treatment of mandible fractures in that osteotomies are made within the same contaminated oral cavity environment, although the infection rates with orthognathic surgery are considerably lower than those with mandible fracture treatment, and most studies have not shown prophylactic antibiotics to be preventive in orthognathic surgery.[24] This finding indicates that factors beside the contaminated field are operative in the pathogenesis of infections associated with mandible fractures. It is impossible for studies to control for all of these factors, which include, but are not limited to: (1) delay in treatment, (2) periodontal disease, (3) other comorbidities, (4) imperfect social situation, (5) patient noncompliance, and (6) teeth in the line of fracture. In my practice, most patients with facial trauma present with several of the aforementioned factors, so the use of prophylactic postoperative antibiotics must be individualized.

Delay in treatment It is not unusual to have patients present for initial evaluation several weeks after suffering a mandible fracture. In other instances, patients with multiple injuries, particularly those with intracranial hemorrhages, cervical spine fractures, and other central nervous system insults, may have definitive treatment of facial fractures delayed several days until the patient's other conditions stabilize. In their study of 101 patients with facial fractures, Chole and Yee[25] did not find that delay of treatment affected infection rate, with or without the use of perioperative antibiotics. However, the average delay of treatment for patients in this study was less than 2 days, and the investigators conceded that the protocol was not designed to study the effects of treatment delay, so that these data were retrospective in nature.[25] Fox and Kellman[29] also noted that delay in treatment did not statistically increase the complication rate in their study, but did not specify the average delay period in their series. In a study where approximately 76% of patients presented after 3 days for treatment of facial fractures, and 36% presented between 3 and 10 days, Abiose[30] reported a 56% infection rate despite the use of perioperative antibiotics. The two cases of osteomyelitis of the mandible resulting from fractures that I treated occurred in patients who presented late for treatment, one of whom presented with an abscess. I routinely provide a 5-day course of postoperative antibiotics for patients with a treatment delay of several days.

Periodontal disease and other comorbidities Periodontal disease predisposes to postoperative infections in the treatment of mandible fractures, and is associated with poor dental hygiene.[18] Other

comorbidities such as diabetes, human immunodeficiency virus (HIV) disease, malnutrition, and substance abuse are also associated with infections, the latter being closely linked to patient noncompliance. In their study, in which patients were recruited from a population similar to the one I serve, Miles and colleagues[26] found that only 3 of the 22 patients who developed infections after open treatment of mandible fractures had past medical histories (HIV disease, hepatitis C infection with cirrhosis) that may have predisposed to infection. Again, these results may be skewed by the high attrition rate in this study. However, they did demonstrate that infections were more prevalent in patients with combined alcohol and tobacco use.[26] Similarly, Lovato and Wagner[28] found that the incidence of infection was higher in patients with a history of drug use. I prescribe postoperative antibiotics for patients with periodontal disease and other comorbidities.

Social situation Compliance with postoperative instructions, including the use of oral rinses, and dental hygiene is often difficult for populations that are transient, homeless, and indigent. I had one homeless patient who was discharged without antibiotics return 3 weeks later with a deep neck infection arising from his parasymphyseal fracture site. After successful treatment of the infection, the fracture went on to heal, although the patient did not return for follow-up after his second hospitalization until a year later because his arch bars were becoming a nuisance to him. As these are patients who also tend to have significant comorbidities, I discharge them with a short course of antibiotics.

Teeth in the line of fracture One of the stated conditions for maintenance of teeth in the line of fracture is antibiotic prophylaxis.[18] Before the antibiotic era routine extraction of teeth in the line of fracture was advocated, because of the risks of osteomyelitis and nonunion. Although teeth in the line of fracture may not increase these risks in patients with good dentition and dental hygiene, I am inclined to give antibiotic prophylaxis in patients with poor dentition and/or poor dental hygiene for the stated reasons.

DUCIC

Over the past few years I have transitioned to less and less need for MMF. There is a tendency to a greater use of intraoperative arch bars or MMF screws with removal at the completion of the procedure. In addition, very few patients require MMF postoperatively and most are mobilized as soon as possible. Also, greater reliance on 2 monocortical miniplates for noncomminuted body and symphyseal fractures and less reliance on more rigid techniques has been associated with increased ease of fixation and favorable postoperative outcomes.

TOLLEFSON

As surgeons shift toward a more objective, evidence-based analysis of surgical outcomes, the expert opinion will inherently affect practice trends to a diminishing degree. The experienced surgeon's opinion will still be valuable, as experiential learning is especially important in the less prevalent surgical treatments. However, the opinion will be shaped by research that draws from evidence-based medicine, emphasizing systematic reviews and prospective cohort studies over case reports and small retrospective reviews.[31,32] This process, similar to Epstein's description of observational analysis, will be "established by comparisons, by shifting shades of difference, turned over and teased out".[33]

My practice habits in mandible fracture management have changed in, at least, the following trends:

1. Increased use of functionally stable fixation[37]
2. Use of an envelope vestibular incision for angle fractures when the third molar is extracted
3. Approach and fixation in uncomplicated angle fractures
4. Immediate use of guiding elastics
5. Use of resorbable plates for pediatric cases.

The first 3 listed are thoroughly discussed in the discussion topics 1 and 2. As surgeons moved away from inferior border compression plates, the use of adaptive osteosynthesis has gained attention. My experience in using one miniplate on the oblique line in angle fractures is consistent with the other reports that support the theory of lines of osteosynthesis.[34–36] If an angle fracture has significant comminution, then traditional plating through an external approach is my preference. Five years ago, I used a transoral/transbuccal approach to place 2 plates on the lateral surface of angle with bicortical screws in the inferior border.

From exposure to oral surgery colleagues in the AO-ASIF, I began using an envelope vestibular incision for transoral angle fracture repair in cases

that necessitated the removal of a loose or decayed third molar in the fracture line. Using this incision, the gingiva is lifted directly from the molars and then extends posteriorly in the standard vestibular incision. This approach has the benefit of affording mucosal closure over the socket. In general, I attempt to limit periosteal dissection in uncomplicated fractures and will use 2 monocortical miniplates in nondisplaced, parasymphyseal fractures, instead of a larger inferior border, bicortical application.

I still prefer Erich arch bar application over 4-screw MMF screw systems, but have shifted away from wire fixation at the end of surgery. Guiding elastics are used immediately postoperatively and continued for 2 to 6 weeks depending on the patient's malocclusion potential. This practice theoretically promotes bone growth by applying an early load to the mandible during healing.[37] Lastly, in a limited number of pediatric mandible cases, I have found the absorbable plating systems to have both benefits and limitations. The absorbable plates certainly preclude the need for reoperation to remove titanium hardware in a growing mandible. However, if MMF is still used then the child needs a second anesthesia to remove the arch bars as well. Rigid fixation for pediatric cases ideally will be strong enough to obviate postoperative MMF, while absorbing rapidly enough to limit the time-limited edema from the implant.

Mandible fracture management trends have shifted from immobilization, to wire osteosynthesis, to ORIF with large, load-bearing plates. Current recommendations for some fractures support periosteal dissection, less plating, and early return to function. Discussions and collaborative studies between surgeons will help guide us to drive innovative practices at a pace that allows evolution, but with cautious investigation, as the bar continues to be set higher within facial fracture management.

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