Fixation of Mandibular Fractures With 2.0-mm Miniplates: Review of 191 Cases

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Purpose: Our goal was to study the use of 2.0-mm miniplates for the fixation of mandibular fractures.

Patients and Methods: Records of 191 patients who experienced a total of 280 mandibular fractures that were treated with 2.0-mm miniplates were reviewed. One hundred twelve of those patients, presenting 160 fractures, who attended a late follow-up were also clinically evaluated. Miniplates were used in the same positions described by AO/ASIF. No intermaxillary fixation was used. All patients included had a minimum follow-up of 6 months. Demographic data, procedures, postoperative results, and complications were analyzed.

Results: Mandibular fractures occurred mainly in males (mean age, 30.3 years). Mean follow-up was 21.92 months. The main etiology was motor vehicle accident. The most common fracture was the angle fracture (28.21%). Twenty-two fractures developed infection, for an overall incidence of 7.85%. When only angle fractures are considered, that incidence is increased to 18.98%. Although only 1 patient (0.89%) described inferior alveolar nerve paresthesia, objective testing revealed sensitivity alterations in 31.52% of the patients who had fractures in regions related to the inferior alveolar nerve. Temporary mild deficit of the marginal mandibular branch was observed in 2.56% of the extraoral approaches performed and 2.48% presented with hypertrophic scars. Incidence of occlusal alterations was 4.0%. Facial asymmetry was observed in 2.67% of the patients, whereas malunion incidence was 1.78%. Fibrous union, mostly partial, occurred in 2.38% of the fractures, but only 1 of those presented with mobility (0.59%). Condylar resorption developed in 6.25% of the fixated condylar fractures. Mean mouth opening was 42.08 mm.

Conclusion: The overall incidence of complications, including infections, was similar to those described for more rigid methods of fixation.

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Rigid internal fixation of mandibular fractures eliminates the need for intermaxillary fixation and facilitates stable anatomic reduction while reducing the risk of postoperative displacement of the fractured fragments, allowing immediate return to function. It is not always easy to define what is adequate fixation for a given mandibular fracture. This is dependent on the characteristics of the fracture, patient, and kind of postoperative function desired for the particular case. It is usually accepted that noncomminuted symphyseal and parasymphyseal fractures, as well as condylar fractures, can be treated with two 2.0-mm miniplates and that selected angle linear fractures can be treated with an upper border 2.0-mm miniplate and still allow immediate function. In the present study, we reviewed 191 patients treated for different kinds of mandibular fractures with a 2.0-mm miniplate system.

Patients and Methods:

PATIENTS

One hundred ninety-one facial trauma patients with mandible fractures who were treated in the hospitals...
Santa Casa de Misericórdia, Beneficiência Portuguesa, and Hospital São Paulo, in Araraquara, São Paulo, Brazil, by the same oral and maxillofacial surgeons were included in this study. All patients were operated on between January 1990 and November 1998 and had mandible fractures treated with a 2.0-mm miniplate system (Engimplan, Rio Claro, São Paulo, Brazil). The thickness of the plates in that system was 0.90 mm; the width was 4.63 mm. The head diameter of the screws was 2.98 mm; the core diameter, 1.92 mm; and the thread; 1.98 mm. The minimum postoperative follow-up required for inclusion in this retrospective study was 6 months.

FRACTURE FIXATION

Fracture treatment was undertaken under general anesthesia. Intermaxillary fixation was used in all dentate patients before fixation of the fractures. In the edentulous patients, the reduction was anatomic, without use of surgical guides or splints, except when dentures were available or could be repaired. No postoperative intermaxillary fixation was used in either dentate or edentulous patients. In some cases, postoperative elastics were used, 1 on each side, to guide the occlusion.

Fractures of the symphysis and of the anterior body region were treated through an intraoral approach. All other regions received extraoral approaches as described by Ellis and Zide.3 When teeth in the line of fracture had to be extracted, this was done after fixation of the fracture. With the exception of condyle and ramus fractures, all others were stabilized, most of the time, with a 6-hole plate at the inferior border and bicortical screws combined with an upper border 4-hole plate and bicortical screws wherever possible. Otherwise, monocortical screws were used. In cases where an arch bar could function as a tension band, only the lower border plate was used. Fractures of the condyle were stabilized with one or two 4-hole plates and bicortical screws.

After the procedure was completed, intermaxillary fixation was removed, leaving the arch bars in place, and the occlusion was verified. Intraoral incisions were closed with resorbable sutures, whereas extraoral wounds were closed in layers. All patients received postoperative antibiotics for 7 days and were instructed to maintain a soft diet for 30 days. Chlorhexidine mouth rinses (0.12%) were used postoperatively for 7 days.

RADIOGRAPHIC EVALUATION

Panoramic, Towne’s view, and posteroanterior mandibular radiographs were obtained preoperatively, as well as after 7, 30, and 45 days and 3, 6, and 12 months postoperatively in 191 patients. These films were obtained to document outcomes of this technique. The fractures were classified as nondisplaced, displaced (<5 mm), severely displaced (>5 mm), and comminuted. Teeth in the line of fracture were evaluated, as was the dental status of the patient. In the postoperative radiographs, reductions were classified as adequate or inadequate. The presence of bone resorption, signs of infection, bone-healing quality, removal of fixation material, and tooth extractions were also assessed.

CLINICAL EVALUATION

All patients were asked to return for a clinical examination to collect data for this study. The clinical evaluation assessed in 112 patients the presence of paresthesia, facial palsy, malocclusion, facial symmetry, surgical scars, infection, postoperative endodontic treatment or loss of teeth, exposed fixation material or need for plate removal, presence of bone or soft tissue lesions, and pseudoarthrosis or malunion. Paresthesia was evaluated by pinprick and light touch with a cotton mesh, also comparing with the nonoperated side when the fracture was unilateral. Facial nerve dysfunction was assessed by clinical observation of movement and comparison of symmetry.

Results

Mandibular fractures occurred in 151 male patients (79.06%) and 40 females (20.94%). Age varied from 6 to 87 years old, with a mean of 30.3 years (Fig 1). Mean follow-up was 21.92 months, ranging from 6 months to 8 years.

The causes were motor vehicle accidents (51.82%), aggravated assaults (24.61%), falls from the ground (12.57%), sports (3.66%), accidents with animals (2.62%), falls from heights above 2 m (2.10%), working accidents (1.05 %), gunshot wounds (1.05%), and truck tire explosion (1.05%).

Ninety-eight patients (51.31%) had 2 or more mandible fractures. Thirty-four fractures (12.14%) in 20
patients (10.47%) occurred in edentulous mandibles, 129 fractures (46.07%) in 87 patients (45.55%) occurred in partially edentulous mandibles, and 117 fractures (41.79%) in 84 patients (43.98%) occurred in mandibles with complete dentitions. The distribution of the fractures according to site is shown in Table 1. Thirty-eight patients (19.89%) had also middle third fractures as shown in Table 2.

Radiographic evaluation revealed 66 fractures (23.57%) were severely displaced (>5 mm), 129 (46.07%) were displaced (<5 mm), and 26 (9.29%) were comminuted. Of the 79 angle fractures (28.21%), 56 (70.88%) were associated with third molars in the line of fracture. Twenty-one third molars were removed. In 14 cases, those teeth were removed during the fracture treatment. Eight were totally erupted and 6 were partially impacted. In 7 cases, 5 erupted and 2 partially impacted teeth, all involved with varying degrees of infection, were removed post-operatively. In one case the tooth involved was treated endodontically.

All patients (n = 191) were considered in the retrospective evaluation of the incidence of infection. Twenty-one patients (10.99%) presented a total of 22 (7.85%) infected fractures. Most infections occurred in the angle region. Figure 2 shows the number of infected fractures according to region. The earliest infection was seen 7 days after treatment and the latest after 1 year, with a mean of 64.33 days. When the 79 angle fractures are considered, 15 (18.98%) were associated with infections, although in only 6 cases (7.59%), the bone was actually infected (Fig 3).

Removal of the fixation material was required in 13 patients (14 fractures), due to infection. Plates and screws were removed from 10 fracture sites in 9 patients and only screws from 4 patients. Two patients needed a secondary surgical procedure and fixation with 2.4-mm reconstruction plates, 2 received reconstruction plates with bone grafts, 1 was treated with a longer 2.0-mm plate, and another received wire osteosynthesis and intermaxillary fixation for 6 weeks. In addition to the patients with infection, 2 had internal fixation material removed. One had fractures of the plates bilaterally, which were used to treat body fractures on an edentulous mandible. This was treated with longer 2.0-mm plates, and fortunately the fractures healed although the material was inadequate. One patient had the fixation removed to install osseointegrated implants. Thus, 15 patients (7.85%), with 17 fractures (6.07%), had internal fixation hardware removed. Among those, the most common region for removal was the angle region with 9 fractures (52.98%) of all infected cases. Four body fractures, of which 2 were infected, had the fixation removed, as well as 4 symphysis fractures (23.54%).

Of the 191 patients included in the study, 112 responded to the call for clinical examination, presenting with 168 fractures treated with 2.0-mm miniplates. Among those, 124 fractures were treated through extraoral approaches. Motor deficits were observed in 3 patients with 4 fractures (3.41%) from the 117 fractures in regions related to the facial nerve, which were treated through 3 (2.56%) extraoral approaches. Two were angle fractures and the other was a comminuted fracture involving the angle and

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<th>Table 1. DISTRIBUTION OF FRACTURES ACCORDING TO SITE</th>
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<td>Site of Fracture</td>
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<td>Angle</td>
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<td>Parasymphyscal</td>
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<td>Body</td>
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<th>Table 2. ASSOCIATED FACIAL FRACTURES</th>
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<td>Fractures of the Middle and Upper Third</td>
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<td>No. of Patients</td>
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Abbreviation: NOE, naso-orbital-ethmoid.
Hypoesthesia of the skin or mucosa in the mental region or lower lip was observed in association with 33 fractures (23.24%) of the 142 fractures located at the symphysis, body, ramus, and angle. Thus, 29 patients (31.52%) presented with some kind of somatosensory disorder.

All sensitivity alterations were noted through objective testing by the examiner. However, when questioned, only 1 patient (0.89%) perceived the sensitivity deficit at the 6-month follow-up. The sensitivity disturbances were more frequently related with fractures of the body, angle, and symphyseal region. No postoperative radiograph showed fixation material impaling the inferior alveolar nerve.

Four patients (4%) among the 100 who were dentate or partially edentulous presented with malocclusion related to the treatment. One of those was not treated, 2 received selective grinding of teeth and occlusal guidance with elastics, and 1 went to preoperative orthodontic treatment for mandibular osteotomies. Mean mouth opening for this group of 112 patients was 42.08 mm, ranging from 32 to 56 mm. Two patients presented with discreet facial asymmetry due to medial or lateral dislocation of the mandibular ramus, both related to angle fractures associated with body fractures on the opposite side. One patient with bilateral condyle fractures and a symphysis fracture had an increase in the bigonial width, for a total of 3 patients with postoperative asymmetries (2.67%). The quality of the resulting scars for the 124 extraoral accesses used is shown (Fig 4).

Fibrous union or mobility was found in 4 patients (3.57%) with 4 fractures (2.38%). Three were angle fractures, and 1 was a body fracture. However, only 1 of those fractures was mobile (0.59%), and the other 3 were partially consolidated and without mobility. Two cases of malunion were observed. The first resulted from bilateral condyle fractures associated with a comminuted symphysis fracture, resulting in medial inclination of the condyles and asymmetry. One patient had fractures of the right angle and left body, which were reduced with rotation of the right ascending ramus and lateralization of the condyle, resulting in some enlargement of that angle and bigonial width, without altering the occlusion.

Of the 48 condyle fractures stabilized with 2.0-mm miniplates, there was 1 case of bilateral partial resorption of the fractured fragments, which stabilized after 3 months. Another patient had complete resorption of the condyle after 3 months and was treated with a costochondral graft.

**Discussion**

The incidence of 79.06% in male patients with mandibular fractures is similar to that of other studies, as well as the mean age of 30.3 years.4-8 That population is economically and socially active and usually needs to return promptly to normal activity. The main causes for mandibular fractures were motor vehicle accidents, followed by assault. Several studies show physical aggression as the first cause for those fractures, followed by motor vehicle accidents and falls.4,9,10 The most common site of fracture was the mandibular angle, as described elsewhere.9,11,12 Ellis et al4 found the most common sites of fracture to be the body, condyle, and angle, respectively, depending on the etiology, with 17.2% of the patients presenting with other associated facial fractures, mainly in the zygomatic process. The present study found 19.89% of patients with associated fractures, the most common being the zygomatic complex fracture, followed by Le Fort and nasal fractures.

Some authors state that the use of rigid fixation increases the frequency of postoperative complications. Although in many instances those are due to the injury sustained or to factors related to the patient, they are frequently described as resulting from the method of treatment. It is important to point out that in many studies the fractures treated with open reduction and internal fixation are the most complex or
the ones that happen to occur in patients who are either noncompliant or have deleterious habits. Infections are some of the most troublesome complications. Incidence varies from 3% to 32%\(^{13-15}\) when rigid fixation is used. However, it is very difficult to compare those data because the methods of treatment are different, as well as the characteristics and behavior of the studied populations. The literature also disagrees as to what is considered to be a complication. For instance, dehiscence and plate exposure are not always considered as complications in centers where the fixation material is routinely removed.

Infection occurred in 7.85% of the studied fractures, corresponding to 22 fractures in 21 patients (10.99%). In 13 patients, the infection can be attributed to failure of the fixation system or to the indication for the use of a 2.0-mm miniplate system. Although rigid plates and compression provide more rigidity than malleable noncompressive plates, the general incidence of infection found in the present study (7.85%) is very close to the 6.1% described by Iizuka et al\(^{18}\) and Iizuka and Lindqvist,\(^{5}\) using the AO/ASIF technique. It seems that either treatment has factors that may result in failure and infection. The infected fractures due to direct failure of the fixation included 7 comminuted fractures, 3 severely displaced fractures, and 4 displaced fractures, of which 1 was treated late and 1 was extensively exposed intraorally. The literature shows that grossly displaced or comminuted fractures need treatment with more rigid systems.\(^{1,6}\) At least for the comminuted fractures, the problem was caused by inadequate indication for the kind of fixation system, which was used in those cases due to economic reasons. Of 26 comminuted fractures included in the study, 7 became infected, for an incidence of 26.92%. Bone fragments were found in 6 infected fractures, most likely related to the initial comminution and postoperative mobility and not due to sequestration. In general, the treatment of such patients was incision and drainage of abscesses, removal of loose fixation material, bone fragments, and involved teeth. Four patients received fixation with more rigid methods, and 1 was treated with intermaxillary fixation. Mandibular reconstruction plates have proved to be an efficient method for treatment of infected fractures,\(^{17-20}\) whereas instability is directly associated with infection.\(^{7,21}\)

When only angle fractures are considered, the infection rate was 18.98%, corresponding to 15 fractures or 68.18% of the total of 22 fractures that became infected. Ellis and Sinn,\(^{14}\) using two 2.4-mm compression plates in the treatment of angle fractures, found that 32% of them became infected. Ellis and Karas\(^ {22}\) found that 29% of angle fractures developed complications, all related to infection with 1 exception, using two 2.0-mm mini dynamic compression plates. Ellis and Walker\(^ {23}\) found a 28% rate of complications when using 2 noncompressive 2.0-mm miniplates. Reconstruction plates resulted in a 7.5% incidence of infection for angle fractures according to Ellis.\(^ {24}\) It is possible that rigidity of the system is not the only factor that defines the incidence of infection in the treatment of angle fractures. The angle and posterior body region present a smaller amount of bone due to the reduced transverse thickness. The angle region may be more sensible to the use of compressive osteosynthesis, screw insertion, vascular rupture, periosteal elevation, and superficial pressure by the plates than other mandibular regions, while offering a smaller surface for interfragmentary contact.

Biomechanical forces that occur during mastication in the angle region also contribute to a greater incidence of complications.\(^{25-27}\) Several studies suggest that 2 miniplates should be used when treating mandibular angle fractures, 1 at the base and another at the superior border, to resist to forces of tension and compression.\(^ {21,28,29}\) Although it has been suggested that the reduction of bite force at the molar region for several weeks after rigid fixation in relation to the normal side would allow use of less fixation,\(^ {30}\) the incidence of forces on the side that was not fractured will generate considerable load on the affected side.\(^ {31}\)

Fracture of the plate was seen in 1 of the studied patients who had bilateral body fractures in an atrophic mandible. Prein\(^ {1}\) stated that 2.0-mm miniplates do not provide adequate stability for atrophic mandibles. Those cases need longer and more rigid plates that allow insertion of screws in stronger regions away from the fracture.

The influence of teeth in the line of fracture on infection is not easy to determine due to interaction with other factors. Seventeen infected fractures were associated with the presence of teeth (77.27%). However, in 13 of those the most probable cause for infection was insufficient fixation. Both situations probably act interactively. Also, it is not possible to conclude that infection would not have occurred had fixation been adequate. Treatment of teeth in the line of fracture evolved from routine removal\(^ {32}\) to removal of those severely mobile or infected to keeping all those that are useful, provided that antibiotics are used.\(^ {33,34}\) Third molars involved in angle fractures receive special attention. Their removal may impair installation of a tension band plate and sometimes the stability of the fixation, as well as interfragmentary contact.\(^ {1,35}\)

Of 56 third molars involved in angle fractures, 14 were removed during surgical treatment (25%), and 7 were removed postoperatively (12.5%). Only 1 of the fractures where the tooth was removed during fixation was infected. This was a comminuted fracture,
and there was no mobility or loose screws; infection was limited to the soft tissues and treated by incision and drainage. Infection was caused either by the presence or removal of the tooth, but removal of teeth in association with an extraoral approach did not increase the incidence of infection as stated elsewhere. Seven third molars were removed postoperatively (12.5%), mostly due to infection occurring in a period of 7 to 30 days postoperatively. All had dislocated fractures, and in 2 cases the main cause for infection was inadequate stability. The overall rate of infection was 7.14% when third molars were removed and 11.9% when they were not removed. Indications for removal of third molars include interference with fracture reduction, fractured roots, pericoronitis, periodontal disease, and periapical lesions.

Of 117 fractures occurring in other dentate regions of the mandible, only 5 (4.37%) developed infections. In 2 cases the main cause was failure of the fixation. The other 3 had soft tissue odontogenic infections and the fractures were healed, being treated by incision and drainage. One pediatric patient developed a dentigerous cyst in the premolar region after 6 months. That is one of the possible complications of mandible fractures in children and is probably due to the fracture and surgical trauma and not to the fixation unless a screw is driven into a tooth germ.

It is usually considered that fixation with plates and screws results in increased incidence of inferior alveolar nerve paresthesia. We were not able to precisely access the preoperative sensitivity deficit. On admission and in the immediate postoperative period, pain, edema, and lack of patient cooperation or correct chart information complicate precise evaluation. Postoperative paresthesia was found in 18 dislocated (<5 mm), 7 severely dislocated (>5 mm), and 18 comminuted fractures. Obviously an association of postoperative paresthesia with displacement and comminution was observed, not necessarily increased by dislocation greater than 5 mm as described elsewhere. Bochlogyros reviewed 1,521 mandible fractures and found 7.2% of sensory disturbances, but only 64% of those fractures occurred in regions related to the mandibular canal. The same happens in other studies.

Postoperative paresthesia found by objective testing was 31.52% in the present study. When questioned, the great majority of the patients answered that they did not have alteration of the sensitivity or that the deficit was so discreet that it was mostly not perceivable. This behavior has been previously described for mandible fractures and orthognathic surgery. The described incidence of sensory deficit runs around 47% after 1 year, with no relation with the preoperative status, and is supposed to be less when only monocortical screws are used.

Malleable plates are frequently thought to result in a smaller incidence of postoperative malocclusion because they are more malleable and easier to adapt. Four cases of malocclusion were found in the present study (4.0%). Three presented with anterior fractures, associated with bilateral condyle fractures. In 2 of those cases, it was clear that better reduction of the lingual cortex and use of stronger plates to maintain reduction would have prevented malocclusion.

Facial asymmetry was seen in 2 other patients who had angle fractures associated with contralateral body fractures, for a total of 2.67%. In these cases the problem was very mild. Several combinations of fractures may cause increase in the bignonal distance, such as symphysis fractures concurrent with condyle fractures. Also, 2.0-mm miniplates may not be sufficient to maintain reduction in some of those cases.

The great majority of patients (97.52%) found no aesthetic problems related to their extraoral incisions. Three presented with hypertrophic scars (2.48%), as may occur in up to 8.3% of young patients. Other studies describe even higher rates of unsatisfactory scars, which certainly can be avoided in most cases by careful technique but not totally eliminated due to individual factors.

Of 48 condyle fractures included in the study, 3 developed condylar resorption. These fractures were severely medially dislocated and disarticulated. Diverse factors may promote condylar resorption, such as systemic disease, tumors, orthodontic treatment, and trauma. Stripping of the soft tissue secondary to trauma or fracture reduction may induce condylar resorption. The occurrence of resorption relates more to soft tissue manipulation during fracture reduction than to the type of fixation.

When using 2.0-mm miniplates to treat condylar fractures, 2 plates should be used whenever possible. It is frequent to find bending of the plate postoperatively with some condylar inclination, usually without clinical relevance or impairment of fracture healing. That situation occurs even with the use of stronger plates.

Results obtained in the present study were not different from what is described with the use of stronger fixation of mandibular fractures. One has to have in mind that indications are different and that 2.0-mm fixation depends much more on the characteristics of the fracture, behavior of the patient, absence of systemic disease, postoperative care, and adherence to partial postoperative functional restrictions.

References