

# Miniplate Fixation of Fractures of the Symphyseal and Parasymphyseal Regions of the Mandible

## A Review of 218 Patients

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**Objective:** To review our experience with miniplate fixation of fractures of the symphyseal and parasymphyseal regions of the mandible.

**Methods:** A retrospective review of all mandible fractures treated from July 1, 1999, through July 31, 2011, by one of us (Y.D.) was performed. Intraoral, open rigid fixation of noncomminuted symphyseal and parasymphyseal fractures was performed using a combination of 2 miniplates that were either a 4-hole or a 6-hole miniplate using monocortical screws. The miniplates were 1-mm thick with a 2-mm screw diameter.

**Results:** A total of 218 patients with noncomminuted symphyseal and parasymphyseal mandible fractures were included in this study. Eighteen patients (8.3%) with concurrent panfacial fractures and other indications were left in postoperative maxillomandibular fixation (MMF), whereas 200 patients (91.7%) did not require postoperative MMF. All patients in this series achieved bony

union. The following complications were noted: plate exposure, 2.3%; malocclusion, 1.4%; wound infection, 1.4%; and tooth root injury, 0.9%. The use of postoperative antibiotics and either a nonlocking or locking system was not associated with significant differences in the rates of complications.

**Conclusions:** For noncomminuted symphyseal and parasymphyseal mandible fractures, the application of 2 miniplates with monocortical screws offers good surgical outcomes in most patients with minimal complications. The advantages of using miniplates include easy plate adaptability, no need for MMF unless indicated, small screw diameter, and provision of adequate load-sharing rigid fixation for simple, noncomminuted symphyseal and parasymphyseal mandible fractures.

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**M**ANDIBLE FRACTURES are one of the most common types of craniofacial fractures undergoing surgical intervention, comprising 55.9% of facial fractures treated with surgical reduction in nationwide sample data.<sup>1</sup> Most mandible fractures have traditionally been noted in young males, resulting from assaults, motor vehicle crashes, or falls. The unique shape of the mandible, resembling a hunting bow, results in increased strength found at the symphysis, whereas condyles located at the distal ends are structurally weak. The frequency of different types of mandible fractures reflects this, with condylar fractures (26%-37%) being one of the most common types of fractures, followed by body (18%-29%), angle (20%-25%), symphyseal or parasymphyseal (14%-19%), ramus (2%-4%), and coronoid (1%-3%) fractures.<sup>2,3</sup>

With ongoing advancement in hardware technology, cumbersome, nonfor-

giving dynamic-compression plates have been largely replaced with various types of noncompression plating systems. Currently, numerous types of noncompression plating systems are being used for mandible fractures. These plates have various thicknesses, ranging from 0.55-mm microplates to thicker load-bearing reconstruction plates, and locking systems and resorbable plating systems are gaining wider acceptance.

One of the challenges for physicians who manage mandible fractures is interpreting sometimes conflicting findings found in biomechanical and clinical outcome studies for a single type of fracture. For symphyseal and parasymphyseal fractures, the ideal fixation technique is still being debated, similar to the ongoing debate in other regions of the mandible. For instance, the debate over ideal management of angle fractures centers around comparing either a single 6-hole superior plate application along the oblique line or the application of 2 plates.<sup>4</sup> Although biomechanical studies<sup>3</sup> support

**Table. Complications in 13 of 218 Patients With Noncomminuted Symphyseal and Parasymphyseal Fractures Treated With 2 Miniplates and Monocortical Screws**

Complication	No. (%) of Patients
Nonunion	0
Malocclusion	3 (1.4)
Wound infection <sup>a</sup>	3 (1.4)
Dental injury	2 (0.9)
Plate exposure	5 (2.3)
<b>Total</b>	<b>13 (6.0)</b>

<sup>a</sup>All wound infections were successfully treated with antibiotics and did not require hardware removal.

increased stability afforded by having a second inferior plate, clinical studies comparing the 2 different techniques have not proven clinical benefit in reducing complications by using more rigid or thicker hardware. Similarly, in symphyseal and parasymphyseal fractures, conflicting biomechanical and clinical studies have compared different rigid fixation techniques.

In this study, we examined the experience of the senior author (Y.D.) with the use of 2 miniplates with monocortical screws using an intraoral approach to provide rigid fixation of noncomminuted symphyseal and parasymphyseal fractures. The unique advantage of miniplates is their easy plate adaptability, which sometimes allows in situ plate molding to the bony contour. This in turn provides necessary hardware stability and decreases operative time spent on bending plates to proper bony contour. We examine other studies that analyze different rigid fixation techniques for symphyseal and parasymphyseal fractures and compare our complication rates.

## METHODS

Medical records were reviewed for all patients who underwent open reduction with internal fixation of either symphyseal or parasymphyseal fractures with the use of 2 monocortical miniplates from July 1, 1999, through July 31, 2011. The miniplates were obtained from either Synthes CMF or Stryker Leibinger Inc, with a relatively even distribution of use. Nonlocking plates were used for patients in the early part of this study but then were later switched to locking plates when they became available in the miniplate format. Miniplates were bent to proper bony contour using plate benders. The plates were then introduced in the wound in situ across a fracture line to check for adequate plate contouring, and, if necessary, small instruments (ie, No. 9 elevator) were used to bend the plate to minimize any gap between the plate and the bone before drilling screw holes. Four-hole plates, with 2 holes on either side of the fracture, were the routine choice for the superior and inferior plates except in cases where the bone was deemed to be of poor stock or there was poor dentition near the fracture site. In these cases, a 6-hole plate was routinely chosen with 3 screws placed on each side of the fracture line. Four-hole plates measure 1-mm thick and 25- to 30-mm long. The 6-hole plates are also 1-mm thick but are 42.5-mm long. The screw hole diameter is 2 mm for all plates. Screws placed in the inferior plate varied in screw lengths from 4 to 6 mm, whereas the superior plate received screws that measured 4 to 5 mm in length. All operations were performed by one of us (Y.D.), and institutional review board approval was obtained. The data gathered

from the medical record review were composed of patient demographics, fracture diagnosis, preoperative and postoperative radiologic imaging studies, maxillomandibular fixation (MMF) use, postoperative antibiotic prescription and actual antibiotic use, and postoperative complications, including plate exposure, wound infections, tooth injury, malunion, nonunion, and malocclusion.

## RESULTS

A total of 218 patients were treated. There was a male predominance, with 165 males and 53 females. The mean age of the patients was 28.3 years (age range, 16-72 years). Intraoperative MMF was performed on 202 patients, whereas the rest of the patients were either edentulous or had non-serviceable dentition. Postoperative MMF was performed in 18 patients only because of concurrent fractures. Eight of these patients had panfacial trauma, whereas 4 patients had condylar fractures, 4 patients had angle fractures, and 2 patients had midface trauma. The rest of the patients did not undergo MMF postoperatively and were prescribed a soft, no-chewing diet for 6 weeks.

Patients had follow-up periods ranging from 6 weeks to 2 years, with a mean follow-up of 6.8 months. Patients with less than 6 weeks of follow-up were excluded from the study to assess for long-term outcome and complication results from this technique. Most patients who had less than 6 weeks of follow-up had at least 1 unremarkable, normal postoperative follow-up but failed to follow up further after the initial postoperative visit. The 2-miniplate technique was used for noncomminuted symphyseal and parasymphyseal fractures and was associated with satisfactory surgical outcome with minimal complications (**Table**). All patients achieved bony union, but 3 patients had malocclusion. Other minor complications occurred, including plate exposures in 5 patients, wound infections in 3 patients, and tooth root injuries in 2 patients. Both of these tooth root injuries involved superior plates and occurred in elderly female patients.

All patients were routinely prescribed postoperative antibiotics for 1 week. Clindamycin was used unless the patient was allergic, in which case, cephalexin and metronidazole were prescribed instead. Eighty-nine patients (40.8%) who were prescribed antibiotics did not take antibiotics for various reasons, the most common being financial. When comparing the wound infection rates between patients who took antibiotics and those who took no antibiotics, no significant difference was found. Two patients (1.6%) in the antibiotics group and 1 patient (1.1%) in the no-antibiotics group developed wound infection. In addition, no notable difference was found in the infection rate between nonlocking (used early in the study) and locking (used later in the study) systems. There were 4 more patients with complications in the locking system group than in the nonlocking system group.

## COMMENT

Surgeons managing mandible fractures have a wide range of treatment options available. Determining the ideal treatment option that is both cost-effective yet minimizes po-

tential complications is a continuing challenge. For symphyseal and parasymphyseal fractures, numerous surgical techniques have been successfully applied, including closed reduction with MMF, lag screws, dynamic compression plates, and noncompression plates. There are ongoing controversies regarding the optimal rigid fixation technique for symphyseal and parasymphyseal fractures. This study demonstrates that applying 2 miniplates with monocortical screws for the treatment of noncomminuted symphyseal and parasymphyseal fractures is a safe, effective technique with minimal complications.

There is an increasing body of biomechanical studies aimed at identifying an ideal rigid fixation technique for symphyseal and parasymphyseal fractures. On the basis of a 3-dimensional analysis of different types of mandible fractures, it was found that symphyseal, parasymphyseal, and anterior body fractures share similar fracture displacement patterns, with a tendency for the inferior border of the mandible fracture segment to widen from masticatory forces.<sup>6</sup> Tension occurs along the inferior border of the mandible, whereas compression manifests along the superior border. For symphyseal or parasymphyseal mandible fractures, the tendency for widening the inferior border fracture with masticatory forces highlights the importance of providing sufficient rigidity to the inferior border. The posterior body and angle fractures have contrasting fracture displacement properties; tension occurs along the superior border of the mandible, whereas compression rises along the inferior border. However, with molar loading close to the fracture line, additional widening of the inferior border fracture occurs.<sup>6</sup> Different bite-loading locations in respect to the fracture site can drastically alter the biophysical properties of a fracture and associated fracture stability due to multivector stress forces that exist within the mandible and its surrounding soft tissue.<sup>5,6</sup> It is crucial for surgeons treating mandible fractures to understand how different mandibular subunits and changing bite-loading locations are prone to different patterns of fracture displacement so that they can provide adequate rigid fixation.

When comparing different 2-miniplate configurations for symphyseal and parasymphyseal fractures in a functional element analysis model, there is a trend toward using a combination of a thicker 1.5-mm-thick inferior miniplate and 1-mm-thick superior miniplate, which offers greater stability and more uniform hardware strain than a combination of a thinner 1-mm-thick inferior miniplate and 1-mm-thick superior plate.<sup>7</sup> An acrylic model studying different plate configurations has shown that using 2 miniplates provided greater torsional stability than when only 1 miniplate was applied. Both techniques of using a combination of two 1-mm-thick miniplates or a combination of 0.5-mm-thick microplate and 1-mm-thick miniplate was significantly better at tolerating torsional displacement than when only one 1-mm-thick miniplate was used alone.<sup>8</sup> Last, when miniplating techniques are compared with two 2.4-mm lag screws in a polyurethane mandible model study,<sup>9</sup> the 2-miniplate technique appeared to offer less stability for a molar-loading condition while successfully tolerating an incisor-loading condition.

In light of a vast number of biomechanical and clinical outcome studies on symphyseal and parasymphy-

seal fractures, deciding on an individualized treatment option can be challenging. Such a treatment decision should be individualized based on the fracture type and the presence of significant factors reportedly associated with nonunion and increased postoperative complications. The incidence of nonunion for mandible fractures ranges greatly in the literature from 2% to 32%.<sup>10</sup> Factors associated with complications include improper rigid fixation, smoking, alcohol or substance abuse history, comminuted fractures, double unilateral fractures, and atrophic mandibles.<sup>10-13</sup> Closed reduction with MMF in carefully selected, adherent patients can be used successfully. However, there are inherent disadvantages in relying completely on patient adherence for treatment success. In improperly selected patients, MMF can be poorly tolerated, and patients may sometimes remove the fixture on their own. In addition, MMF can lead to oral airway compromise, patient dissatisfaction, temporomandibular joint disorders, and malnutrition. By not visualizing the fracture, one may also underestimate its instability, which can lead to improper reduction and thus result in nonunion. Open rigid fixation overcomes most of these issues, with the added benefit of early mobility. With advancements in hardware technology, there is an increasing national trend toward most mandible fractures being treated with an open-reduction approach alone or in combination with closed reduction.<sup>1</sup> In a biomechanical study<sup>14</sup> on symphyseal and parasymphyseal fractures, lag screws offered superior stability rather than using 2 miniplates during the molar-loading condition, whereas 2 miniplates still provided sufficient stability during the incisor-loading condition. Although the 2-lag screw technique can be safe and effective, the use of lag screws requires surgical experience, and there is an approximately 6% reported risk of a drill bit breaking when a traction hole is being created.

This study retrospectively analyzed 218 patients with symphyseal and parasymphyseal fractures who were treated using 2 miniplates and monocortical screws. The 2-miniplate technique was not applied for atrophic mandibles or nonunion or comminuted fractures. Four-hole miniplates were used if there was good bone stock; however, in those with poor dentition or poor bone stock, 6-hole miniplates were used instead. A biomechanical study<sup>15</sup> demonstrated that placing 3 screws in each fracture segment using a 6-hole, 2-mm plate has greater hardware stability than placing 2 screws in each segment using a 4-hole plate. Screw length did not matter for loading capacity for non-compression adaptation plates. An 8-hole plate (4 screws per segment) provided no additional stability than a 6-hole plate despite the additional screws. Postoperative MMF was maintained in 18 patients (8.3%) with severe concurrent panfacial fractures or a condylar fracture. All patients in our study achieved bony union. Three patients (1.4%) had postoperative malocclusion despite having postoperative MMF. These patients had either concurrent panfacial fractures or a condylar fracture. Wound infections occurred in 3 patients (1.4%), and they were all successfully treated with antibiotics and did not require hardware removal. Other studies<sup>1</sup> report a hardware removal rate of 5%. In our study, routine use of postoperative antibiotics did not appear to affect the wound infection rate between those

who received antibiotics and those who did not. This lack of statistically significant benefit in the routine use of postoperative antibiotics for mandible fractures, in the absence of nonunion or active infection, has also been reported by other studies.<sup>12,16</sup>

The main advantage of using miniplates is their easy plate adaptability. In this patient sample, both nonlocking and locking monocortical screws were used. In a biomechanical study, nonlocking and locking systems showed no notable difference in the force required for hardware failure when both plates were adequately applied. However, improper plate adaptation occurring during rigid fixation can potentially lead to a significant difference in the degree of hardware stability, depending on which system is used. Although the locking systems rely on the interaction between locking screws and the locking plate for hardware stability, nonlocking systems rely on the interaction between the plate and bone for hardware stability. As such, for the nonlocking system, the ability of a plate to be molded to the contour of the mandible is critical to achieve adequate rigid fixation. The biomechanical study by Haug et al<sup>17</sup> demonstrated that nonlocking systems have a significant decrease in loading stability even with 1 mm of plate offset distance from the bony contour. Interestingly, the locking system's stability was not affected up to a 2-mm plate offset, supporting the theoretical advantage of the locking system. A combination of nonlocking and locking screws were used in this study, which did not reveal significant differences in complication rates between the 2 systems. This clinical finding agrees with the growing body of clinical outcome studies<sup>18,19</sup> that failed to identify a clinical advantage of the locking system over the nonlocking system. To demonstrate such a clinical difference, it will most likely require a study with a large sample size and improper use of the nonlocking system. Despite the lack of a clinical difference, it is hard to refute the significant theoretical advantages of the locking system seen in biomechanical studies and the decreased operative time reported when a locking system is used.<sup>18</sup> At the same time, the increased cost of the locking system over the nonlocking system may influence some surgeons to be selective and defer universal application of the locking system. In our study, the use of miniplates promoted easy plate adaptability, which allowed efficient plate contouring with minimal bony offset. In return, miniplates provided proper rigid fixation and avoided extended operative time spent on plate contouring.

Although complications associated with the 2-miniplate technique for symphyseal and parasymphiseal fractures were rare, the few complications commonly involved superior miniplates. In this study, there were 2 elderly female patients (0.9%) with tooth root injuries occurring from the superior miniplates and 5 patients (2.3%) with superior plate exposure who did not require hardware removal. Similarly, the retrospective review by Ellis<sup>20</sup> of symphyseal and parasymphiseal fractures involving 682 patients found a statistically increased incidence in tooth root injuries (1.5%) and wound dehiscence (6%) with the superior plates when two 1.0-mm miniplates were used. However, when a single, thicker, 1.25-mm-thick, 6-hole miniplate was placed along the inferior mandibular border, fewer

complications occurred, with no plate exposure or tooth root injuries. Ellis concluded that a single, thicker inferior plate may offer sufficient load-sharing stability for symphyseal and parasymphiseal fractures while avoiding the superior plate-related complications. Future prospective clinical trials and biomechanical studies would be of interest to confirm this clinical finding. It remains to be seen whether this approach will gain wider acceptance similar to Champy's angle fracture plating technique using a superior 6-hole plate.

Another proposed approach to avoiding tooth root injury is to use even smaller-diameter monocortical screws found in the microplating system. Burm and Hansen<sup>21</sup> reported their experience using 0.55-mm-thick microplates and 1.2-mm-diameter monocortical microscrews with a 3- or 4-mm screw length in 35 patients with mandible fractures. No tooth root injuries were reported, but other notable complications were found: malocclusion, 8.5%; asymptomatic delayed union, 2.8%; and asymptomatic plate fracture, 2.8%. Because of the lack of sufficient biomechanical data, it is unclear whether a combination of 2 microplates can provide sufficient rigid fixation stability for different types of mandible fractures. Although the combination of 2 microplates was not analyzed, the biomechanical study by Feller et al<sup>8</sup> suggests that a combination of a miniplate and microplate for symphyseal and parasymphiseal fractures may have sufficient tolerance to torsional displacement and loading capacity to resist masticatory forces postoperatively. However, the combination of the microplate and miniplate had noticeably less loading capacity than a combination of 2 miniplates. Two 1-mm-thick miniplates resulted in a mean loading capacity of 470N, whereas the combination of a 0.5-mm-thick microplate and a 1-mm-thick miniplate resulted in a mean loading capacity of 267N. Both plate configurations exceeded the mean postoperative incisor bite force found after surgery.<sup>22</sup> As such, there is insufficient evidence for surgeons to conclusively decide whether the advantages of a microplating system with a smaller screw diameter and even easier plate adaptability than a miniplating system outweigh the potential risk of not providing adequate rigid fixation, especially if a combination of 2 microplates is used. Future biomechanical and clinical studies with a larger sample size comparing a miniplating system with a microplating system would be of benefit.

On the basis of a retrospective review of 218 patients, noncomminuted symphyseal and parasymphiseal mandible fractures can be treated effectively with 2 miniplates using monocortical screws. All patients in this series achieved bony union with minimal complications. The use of a nonlocking or locking system and the use of postoperative antibiotics were not significantly associated with complications. The advantages of using 2 miniplates on symphyseal and parasymphiseal fractures is easy plate adaptability, no need for prolonged MMF unless indicated, and provision of adequate rigid fixation with minimal complications.

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