Background: Noncompression monocortical miniplate fixation of the mandibular angle is an accepted and reliable method for providing rigid internal fixation. High complication rates have been reported for internal fixation of angle fractures.

Objective: To analyze the outcome and complications in cases in which patients were treated with 2-miniplate fixation at the mandibular angle.

Design: A retrospective analysis of outcomes for a case series.

Setting: Treatment performed at a level 1 trauma-rated teaching hospital.

Methods: From May 1992 to September 2001, a total of 88 patients with angle fractures of the mandible were treated with 2-miniplate fixation. Sixty-eight of the 88 patients, with 70 angle fractures, were included in the study; 13 were unavailable for follow-up and 7 had less than the minimum follow-up of 6 weeks. The time of trauma to treatment, cause of injury, and associated fractures were recorded. Postoperative complications, including infection, malunion, nonunion, dehiscence, osteomyelitis, and nerve injury due to surgical manipulation, were tabulated. Follow-up examinations were performed up to 12 weeks after surgery, with additional examinations if necessary. Postreduction panoramic radiographs were obtained in most cases.

Results: No patients treated with monocortical 2-miniplate fixation had malunion, nonunion, or osteomyelitis. Twelve (17.6%) of the 68 patients were identified as having at least 1 postoperative complication. Postoperative infection occurred in 2 patients (2.9%). Infection was controlled with oral antibiotic therapy. One patient required removal of miniplates after the acute phase resolved. Occlusal disturbances were noted in 4 patients (5.9%) (2 with a slight anterior open bite, 1 with a crossbite, and 1 with premature contact of a molar) after surgery. Three of the 4 patients had associated midfacial or multiple mandibular fractures. None required further surgery. Wound dehiscence, with exposure of an underlying plate, occurred in 4 patients (5.9%); the wounds were treated conservatively and subsequently resolved. Nerve injury due to surgical manipulation occurred in 3 patients (4.4%).

Conclusions: Monocortical 2-miniplate fixation of the mandibular angle is a reliable and effective technique for providing rigid fixation. The complications were minimal in our study, and the infection rate was 2.9%, which is comparable to or better than the infection rate reported with the use of a single miniplate fixation technique in other studies. Disturbances of occlusion were associated with midfacial or additional mandibular fractures. In view of the contradictory published results, further studies are needed to determine the ideal approach for noncompression monocortical plate fixation of angle fractures.

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The way in which mandibular fractures are treated and repaired has undergone a gradual evolution. Over the years, many techniques for the repair of mandibular fractures have been introduced. The methods have ranged from maxillomandibular fixation (MMF) to combinations of MMF and wire osteosynthesis, lag screw, and plate fixation. Today, rigid internal fixation using compression and noncompression plating systems has gained widespread popularity. Advantages of rigid internal fixation include avoidance of MMF, early functioning of the mandible, increased patient satisfaction, shorter periods of hospitalization, and earlier return to the workplace, among others. The use of noncompression monocortical miniplate fixation for osteosynthesis of mandibular fractures was introduced by Michelet et al and further advanced by Champy et al. Miniplate osteosynthesis is accomplished by placement of a plate along the so-called ideal line of osteosynthesis, thereby countering distraction forces that occur along the fracture line during mandibular function. In the mandibular angle region, this line indicates that a plate may be placed either along or just below the oblique line of the mandible. However, experimental
in vitro study, Choi et al demonstrated that a second along Champy and colleagues’ “ideal line.” In a similar construction inferior distraction of the lower mandibular mar-

Despite advances, treatment of mandibular fractures has continued to be associated with multiple complications. Mandibular angle fractures, in particular, have been fraught with high postsurgical complication rates. In 1991, however, Levy et al demonstrated a low complication rate using 2 monocortical miniplates for internal fixation of angle fractures vs a higher complication rate when a single miniplate was used, while Ellis and Walker suggested that the use of a single miniplate at the angle provided a lower complication rate than the use of 2 miniplates. The objectives of the present study were (1) to evaluate our results in cases in which 2 monocortical miniplates were used to repair angle fractures of the mandible at our institution and (2) to compare our results with those of earlier studies.

METHODS

Cases involving mandibular angle fractures treated at Upstate Medical University, Syracuse, NY, between May 1992 and September 2001 were reviewed retrospectively. Only mandibular angle fractures treated with two 2-0 noncompression monocortical miniplate fixation were included in the study. Compared or infected fractures were not treated with miniplates.

The time from trauma until treatment, cause of injury, and associated fractures were recorded. Also, postoperative complications, including infection, malocclusion, nonunion, dehiscence, osteomyelitis, and nerve injury due to surgical manipulation, were evaluated. The need for and duration of postoperative MMF, as well as any dental extractions, were identified and recorded. Monoplanar (lateral) and biplanar (oblique lines and superior or inferior buccal cortex) placement of the miniplates were also noted.

Follow-up examinations were performed up to 12 weeks after surgery (typically at intervals of 1, 2, 4, 6, and 12 weeks), with additional examinations if necessary. Patients with less than 6 weeks of follow-up were excluded from the study. Postreduction mandible series or panoramic radiographs were obtained in most cases.

Surgical repair of mandibular fractures was performed as soon as possible after the injury. All patients received oral antibiotics and a 0.1% chlorhexidine gluconate oral rinse at the time of presentation to the emergency department or otolaryngology clinic of the Upstate Medical University. Intravenous antibiotics were administered to all patients at least 30 minutes before surgery and at least 8 to 12 hours after surgery. Treatment with both oral antibiotics and a 0.1% chlorhexidine oral rinse was continued for 7 to 10 days after surgery.

Dental evaluation was performed in patients with significant carious or injured teeth. Our approach to dentition is conservative, and only teeth meeting the following limited criteria were extracted: (1) teeth that are devitalized as a result of the fracture (eg, teeth with fractured roots); (2) teeth that are unsalvageable as a result of caries or infection in the region of the fracture; and (3) teeth within the fracture line that are loose or unstable. Stable teeth within the fracture line are preserved for added reduction stability.

General anesthesia is administered via nasotracheal intubation. The teeth are brushed with half-strength hydrogen peroxide and/or povidone-iodine (Betadine) solution; the remainder of the oral cavity is irrigated with povidone-iodine solution. Premorbid occlusion is reestablished with bimanual manipulation. Maxillomandibular fixation is then achieved through application of Erich arch bars, Ivy loops, or, rarely, screw MMF.

The mucosa is infiltrated with 1% lidocaine hydrochloride with 1:100000 epinephrine. An incision is made beginning with the first molar and is carried over the external oblique line and up the ascending ramus on the buccal side. The periosteum is then elevated, exposing the fracture. A Kocher or bone-holding forceps is then applied, if necessary, to assist in bony reduction and stabilization.

Four-, 5-, or 6-hole 2-0 noncompression miniplates are then placed through the intraoral incision. The plates are bent to conform to the mandible and are applied to the external oblique line and/or to the buccal cortex. A transbuccal trocar is placed through the skin adjacent to the fracture site. The 2-0 plates are positioned in a monoplanar or biplanar fashion (Figures 1, 2, 3, and 4).

The screw holes are then created with a low-speed drill and copious irrigation. Next, the miniplate is secured to the external oblique line with monocortical self-tapping screws. At least 2 screws are placed on each side of the fracture line. When other fractures are present, the order of fracture fixation is individualized in each case. After placement of the plates, MMF is released; both occlusion and the stability of the fracture line are rechecked. Maxillomandibular fixation is restored if there are further fractures that require closed reduction (eg, subcondylar fractures). The intraoral incision site is then copiously irrigated and subsequently closed with an interrupted 2-0 or 3-0 chromic suture. The external stab incision for the trocar is then closed with a 5-0 or 6-0 nylon su-
ture. A pressure dressing is subsequently applied to the surgical area. Arch bars are left in place for approximately 6 weeks after surgery and are removed in the clinic at that time.

RESULTS

Of 88 patients who were treated with two 2-0 monocortical noncompression miniplates, 68 patients, with 70 mandibular angle fractures, were included in this study. Thirteen patients were unavailable for follow-up within the first week after surgery, and 7 had less than the minimum follow-up of 6 weeks. Fifty-eight patients were male and 10 were female, with ages ranging from 16 to 54 years (mean age, 28.2 years). The most common cause of mandibular angle fracture was assault (n = 47 [69.1%]), followed by motor vehicle crashes (16.2%) and sports-related injuries (10.3%).

Forty-one patients (60.3%) had 1 associated mandible fracture, 4 (5.9%) had 2 associated fractures, and 3 (3.8%) had associated midfacial fractures (eg, Le Fort). The most common location of associated mandible fractures was the contralateral parasympathetic region (36.8%) (Table 1).

Fifty-four patients (63.2%) had left-sided angle fracture, and 21 patients (30.9%) had a right-sided angle fracture. Four patients (5.9%) had bilateral angle fractures.

All patients were dentulous. Two patients had teeth extracted (No. 17 and No. 32). The average follow-up was 13.6 weeks (range, 6-83 weeks). A minimum follow-up time of 6 weeks was accepted.

Associated mandibular fractures were treated with miniplates, compression plates, or reconstruction plates.
Of seven patients with associated subcondylar fractures, 6 were treated with MMF for 10 to 14 days. The interval of time between the date of injury and the date of repair ranged from less than 24 hours to 18 days (mean, 7.2 days).

Complications evaluated were defined as infection, malocclusion, dehiscence, nonunion, osteomyelitis, or nerve injury due to surgical manipulation. Of the 68 patients, 12 (17.6%) were identified as having at least 1 postoperative complication. One patient in this group had 2 concurrent complications (dehiscence and malocclusion). All complications occurred 1 to 4 weeks after surgery. Four patients (5.9%) were noted to have malocclusion (1 with a slight crossbite, 1 with premature contact of a molar, and 2 with a slight anterior open bite). Three of these patients had associated Le Fort fractures and/or multiple mandibular fractures. One patient had an isolated angle fracture. None of these patients had been kept in MMF immediately after surgery; however, they all received rubber band training on identification...

Table 1. Associated Fractures in 68 Patients With Mandibular Angle Fractures

<table>
<thead>
<tr>
<th>Site</th>
<th>Ipsilateral</th>
<th>Contralateral</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subcondylar</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>Angle</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>Body</td>
<td>0</td>
<td>6</td>
</tr>
<tr>
<td>Parasymphyseal</td>
<td>4</td>
<td>25</td>
</tr>
<tr>
<td>Coronoid</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Sympysis</td>
<td>2</td>
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</tr>
</tbody>
</table>

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of malocclusion at their postoperative visits. None required further surgery, although 1 patient was evaluated for orthodontia owing to the presence of premorbid problems.

Two patients (2.9%) developed infection. One patient was noted to have a serous yellow-tan drainage at the incision within the first week after surgery. This complication resolved with intraoral incision and drainage, a 10-day course of oral antibiotics, and 0.1% chlorhexidine rinses for 2 weeks. The infection cleared and the wound healed without further sequelae. The plates did not require removal. Of note, this patient failed to obtain antibiotics in the first week after surgery. Another patient, in whom a wound infection developed approximately 4 weeks after surgery, was treated with a 10-day course of oral antibiotics and 0.1% chlorhexidine rinses. After antibiotic treatment, the infection resolved; however, despite continued local wound care, the incision site failed to heal. The miniplates were subsequently removed; the mandible was stable at the time of the plate removal; and the wound healed without further event. It should be noted that tooth No. 32 was devitalized and extracted at the initial surgery.

In this study, 64 of 68 patients (representing 66 of the 70 angle fractures) had a panoramic radiograph or mandible series available for review. The x-ray films of 4 patients were unable to be obtained. A tooth in the line of fracture was identified in 39 (59%) of 66 angle fractures; the remaining 27 angle fractures (41%) did not have a tooth in the line of fracture. Teeth were left in the line of fracture in 38 of 39 angle fractures identified. Of the 2 patients who developed infections, both had a tooth within the line of fracture, 1 of which was extracted at the time of surgery because of a fractured root.

Four patients (5.9%) were noted to have wound dehiscence at the first postoperative visit (7-10 days after surgery). There was no evidence of infection. Treatment consisted of 0.1% chlorhexidine rinses 4 times daily for 14 to 21 days. All wounds healed without further event. No plates were removed.

Three patients (4.4%) were noted to have trigeminal nerve (V3) impairment. These patients were followed up for several weeks after surgery, without improvement. It is unclear if their symptoms would have improved if they had been followed up for a longer period. Of the 70 angle fractures that were treated, 36 had miniplates placed in a monoplanar distribution (lateral buccal cortex), 30 had plates placed along the oblique line and superior buccal cortex, and 4 had plates placed along the oblique line and inferior border.

On further statistical evaluation using the Pearson χ² test, no association was found between each of the possible bialar plate orientations (Figure 1) and the postoperative complications (P = .15; Spearman correlation coefficient, 0.12). There was also no statistically significant association between bialar (n = 34) vs monoplanar (n = 36) plate orientation and postoperative complications (Pearson χ² test, P > .05; Fisher exact test, P > .05).

There was no statistically significant association between malocclusion and complex fractures (ie, more than 1 osteosynthesis and/or midfacial fracture) (Fisher exact test, P > .05). No statistically significant association was identified between time delay from onset of injury to surgery and postoperative complications (t-test, P > .05).

Fractures of the angle account for 23% to 42% of all mandibular fractures. The frequent involvement of the angle in mandibular fractures can in part be attributed to its thin cross-sectional bone area and the presence of a third molar. Other variables, such as bone density and mass, severity, direction, and point of impact, also influence the site of fracture. The bone in the mandibular angle area is thin inferiorly, and the fracture is generally posterior to the dentition, preventing adequate stabilization by MMF. Unstable rotation or distraction of the proximal and distal fracture segments often occurs as a result of the opposing muscular forces of the elevator group of muscles (ie, masseter, medial and lateral pterygoids, and temporals muscles) and the depressor group of muscles (ie, genioglossus, genioglossus, mylohyoid, and digastric muscles). Furthermore, the presence of a third molar may inhibit or impair reduction, decrease bony contact, alter the vascularity of the fracture site, or be a source of pathogenic organisms.

Maxillomandibular fixation can pose a number of potential problems in cases involving the repair of mandible fractures, including oral airway compromise, poor nutrition, temporomandibular joint disorders, patient dissatisfaction, noncompliance, and social inconvenience. The use of rigid internal fixation, however, may obviate some of the difficulties associated with MMF. Passeri et al performed a retrospective review of complications in 96 patients, with 99 angle fractures, treated with either closed or nonrigid fixation combined with MMF. An overall complication rate of 17% was found, with infection being the most common. James et al reviewed nonrigid treatment of 253 patients; 136 fractures were through the angle. Nine infections occurred at the angle, accounting for an infection rate of 7%.

The use of noncompression monocortical miniplate fixation for the osteosynthesis of mandibular fractures was advocated both by Michelet et al and by Champy et al. Based on the results of further biomechanical studies, Champy and colleagues described 2 lines of osteosynthesis located along the external oblique line and the superior buccal cortex. Since the work of Michelet and coworkers and Champy and colleagues, noncompression miniplate fixation of angle fractures has gained popularity. Some of the advantages of monocortical miniplate osteosynthesis over other means of rigid internal fixation (eg, reconstruction or compression plates) include the following: (1) intraoral incisions minimize or eliminate the need for a large external scar; (2) potential risk to the inferior alveolar nerve and marginal mandibular nerve is decreased; (3) simultaneous observation of fracture line reduction and occlusal relationships is possible; (4) miniplates are easier to adapt to bony curvatures than compression or reconstruction plates; and (5) an intraoral approach may be technically less demanding than an extraoral approach.

Biomechanical analysis by Kroon et al demonstrated that when an occlusal load was placed on the ip-
silateral molars, splaying was produced along the inferior border of the angle in a model of a single miniplate angle fracture. This study as well as in vitro studies by Choi et al. and a clinical study by Levy et al. have provided evidence that paired miniplate fixation may provide superior fixation of angle fractures over the method of Champy et al. Levy and coworkers reported on 32 angle fractures treated with paired miniplates in which there was 1 complication (3.1%) (infection) compared with 5 complications (26.3%) in 19 patients treated with a single miniplate across the oblique line (infection, n=3 [15.7%]; delayed union, n=1 [5.3%]; and malocclusion, n=1 [5.3%]).

The findings of these studies, however, are in contrast to the high infection rate (25%) and overall complication rate (28%) found by Ellis and Walker with the use of paired miniplates. A total of 16 of 69 fractures required hardware removal for infection. Ellis and Walker suggested that the high infection rate may in part be attributable to the extraction of teeth in the line of fracture; however, other variables may play a role. In another study, Ellis and Walker evaluated the results of treatment of mandibular angle fractures using 1 noncompression miniplate. Thirteen patients (16%) experienced complications: 4 had minor infections; 2 had major infections requiring intravenous antibiotic therapy; 4 had swelling over the mandibular angle, without noted drainage; and 3 had postoperative pain. All 13 patients underwent plate removal.

At Upstate Medical University, a total of 68 patients were included for evaluation of 70 mandibular angle fractures treated with noncompression monocortical 2-miniplate fixation. Complications evaluated included infection (2.9%), dehiscence (5.9%), malocclusion (5.9%), and inferior alveolar nerve injury due to surgical manipulation (4.4%). There was no evidence of nonunion or osteomyelitis. Infection occurred in 2 patients. One patient who developed infection within the first week after surgery was unable to obtain antibiotics immediately after discharge. The infection cleared after oral antibiotics were administered; no further sequelae were observed. The other patient, who developed an infection 4 weeks after surgery, had tooth No. 32 extracted at the time of surgery.

All of our patients were treated with antibiotics and 0.1% chlorhexidine rinses from the time of presentation to approximately 7 to 10 days after surgery. This management approach may have contributed to the low infection rates seen in our study. Furthermore, the time to treatment (mean, 7.2 days) did not influence the likelihood of infection or other complications in this study. Proper antibiotic use and oral hygiene may have resulted in improved infection outcome and allowed a greater delay to treatment, without adverse consequences. It is unclear whether antibiotics were used similarly in other studies in which complications or infections of the mandibular angle were evaluated. The finding that delay in treatment was not associated with a difference in complication rates is consistent with the observation of other authors.

A study by Izuka and Lindqvist evaluated the outcome in 113 patients with 121 angle fractures treated with either lag screw fixation, compression plates, or neutral reconstruction plates. A postoperative infection was identified in 8 cases (6.6%). The authors found an association with infection and the use of compression plates at the angle after tooth extraction in the fracture line. Several other studies have found high infection rates after internal fixation of the mandibular angle, especially when a tooth has been extracted from the fracture line. As noted, several authors have suggested that extraction of a tooth in the fracture line may contribute to postoperative infection. It is believed that extraction may make the fracture site unstable and perhaps reduce more difficult. Conversely, retaining a tooth within the fracture line may add to stability. In our study, only 2 patients had a tooth extracted from within the fracture line; the teeth in the fracture site were left in place in the rest of the patients. The low extraction rate may have minimized the destabilization of the fracture sites and may have contributed to the overall low infection rate seen in our study. While it is generally believed that the presence of a third molar is a likely risk factor for infection, there is little evidence that extraction reduces that risk.

In our study, 4 cases of dehiscence also occurred. There was no association between delay of treatment and dehiscence. A multitude of variables may have contributed to this complication. However, a technical error in wound closure most likely caused the dehiscence. There was no evidence of infection in these 4 cases, and all resolved with conservative oral care without further sequelae.

In the present study, malocclusion appeared to be clinically associated with multiple osteosyntheses and/or midfacial (Le Fort) fractures. Statistically, however, the association was not found, likely because of the small numbers involved. Izuka and Lindqvist, however, reported that malocclusion was more frequent when 2 separate osteosyntheses were performed compared with 1 osteosynthesis (26.2% vs 8.3%). In our series, 1 patient with an isolated angle fracture and malocclusion was noted to have a significant number of supernumerary teeth, making intraoperative identification of his premorbid occlusion difficult. He was referred to orthodontics for further treatment.

The sensory disturbances identified after surgery were likely the result of manipulation at the fracture site during surgery. With monocortical screws, the likelihood for nerve injury is low. Furthermore, owing to the short period of follow-up in this group (mean, 7 weeks), it is unclear whether the sensory disturbances reported herein might in fact have actually been transient.

<p>| Table 2. Study Comparison of Infection and Nonunion Rates Using 1- or 2-Miniplate Fixation of Angle Fractures |
|---|---|---|---|---|---|</p>
<table>
<thead>
<tr>
<th>Study</th>
<th>No. of Patients</th>
<th>Infection Rate, %</th>
<th>Nonunion Rate, %</th>
</tr>
</thead>
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<tr>
<td><strong>2-Miniplate Fixation</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Present study</td>
<td>68</td>
<td>2.9</td>
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<tr>
<td>Levy et al.14 1991</td>
<td>32</td>
<td>3.1</td>
<td>0</td>
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<tr>
<td>Ellis and Walker27 1994</td>
<td>67</td>
<td>25.0</td>
<td>1.0</td>
</tr>
<tr>
<td><strong>1-Miniplate Fixation</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Levy et al.14 1991</td>
<td>19</td>
<td>15.8</td>
<td>5.3</td>
</tr>
<tr>
<td>Ellis and Walker27 1996</td>
<td>81</td>
<td>7.4</td>
<td>1.2</td>
</tr>
</tbody>
</table>

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Finally, plate orientation (monoplanar or biplanar) does not appear to affect the complication rate. However, an in vitro study evaluating plate orientation demonstrated that plate placement in a biplanar orientation provides a more stable fixation than a monoplanar orientation when applied with either a monocortical or a bicortical technique. It would be interesting to determine in a larger prospective randomized study whether plating orientation (ie, monoplanar vs biplanar) plays a role in postoperative morbidity.

It is necessary to point out several weaknesses of the present study. First, it is a retrospective review. Patient noncompliance and a relatively short follow-up period (mean, 13.6 weeks) also affected the strength of our study; often, once their arch bars were removed, the patients failed to show up for further visits. It is optimistically assumed that most of the complications would occur within the initial follow-up period and that had these patients developed any complications they would have returned for further treatment.

CONCLUSIONS

Overall, the findings of our study appear to support the use of noncompression monocortical 2-miniplate fixation of angle fractures. The low infection rate seen in this study is consistent with the findings of Levy et al. However, our results are in distinct contrast to those of the study performed by Ellis and Walker that demonstrated a high infection rate using 2 noncompression miniplates. In the latter study, however, the miniplate at the inferior border was placed with a bicortical technique; therefore, since all the miniplates in our study were applied using a monocortical technique, direct comparison between our study and that of Ellis and Walker may be difficult. Furthermore, while the 1996 study of Ellis and Walker, in which a single noncompression miniplate was used for the fixation of angle fractures, demonstrated a lower complication rate than their experience with 2 miniplates, our infection rate was lower using 2 miniplates (7.4% vs 2.9%, respectively) (Table 2). Also, if minor complications (eg, dehiscence and trigeminal nerve dysfunction) are excluded, our overall complication rate decreases to 8.8%. Only 1 of our 68 patients required plate removal. Further studies are needed to determine the morbidity associated with noncompression monocortical plate fixation of angle fractures, and prospective comparisons among the different treatment options would be valuable.

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