Comparison of miniplate versus lag-screw osteosynthesis for fractures of the mandibular angle

Heidrun Schaaf, MD, DDS,a Steffen Kaubruegge, DDS,b Philipp Streckbein, MD, DDS,a Jan-Falco Wilbrand, MD, DDS,a Heiko Kerkmann, MD, DDS,a and Hans-Peter Howaldt, MD, DDS, PhD,c Giessen, Germany
UNIVERSITY HOSPITAL GIESEN AND MARBURG GMBH

Objectives. Treating mandibular angle fractures is common in maxillofacial surgery. The aim of this study was to compare lag screw fixation and miniplates.

Study design. This retrospective investigation compared patients treated with miniplates (n = 24) and with lag screws (n = 21). Inclusion criteria were a solitary angle fracture without comminution or other reasons for load-bearing osteosynthesis. The main parameters for the outcome analysis were fracture gaps at 4 defined measuring points on postoperative radiography. Postsurgical complications were recorded.

Results. Fracture gaps measured in panoramic radiographs differed significantly between the lag-screw (average 0.56 mm) group and the group using 1 miniplate (average 0.85 mm) and 2 miniplates (1.40 mm). Miniplate fixation resulted in a wider fracture gap, especially in the region of the lower margin of the mandible.


The exposed position of the human head in relation to the body seems to be why the facial skeleton is frequently affected in traumatic events. The angle of the mandible is the second most frequent region for fractures caused by alleged assaults and the third most fractured region in cases of falls.1 Among mandibular fractures, the angle region is more often affected by complications, and management is challenging. Osteosynthesis compression was invented by Luhr in 1968.2 Toward the end of the 1980s, a clear change appeared in fracture treatment. In the course of this decade, the type of osteosynthesis changed from wire and miniplates to compression plates and lag screws.3

Although there is a widely accepted consensus about the need for surgical reduction and fixation of a mandibular angle fracture, a variety of different treatment modalities have been described. Among them are closed or open reduction, extraoral open reduction and internal fixation with a reconstruction plate, intraoral open reduction and internal fixation using different mini-dynamic compression or noncompression plates, and an intraoral approach with lag-screw fixation.4

Miniplate osteosynthesis has caused a revolution in mandibular fracture treatment. Modern systems provide better handling, higher stability, and less pressure on the bone.5 The application of a static compression system has been transformed into a dynamic plating system. Miniaturized osteosynthesis was introduced to maxillofacial surgery by Michelet et al.6 Anatomical and biomechanical considerations for placing these miniplates improved this method. Osteosynthesis can be reduced to a tension band plate on the upper border of the mandible.7,8

A more recent development has been introduced with the lag screw principle,9 and publications about this very different treatment method using only a screw for fixation followed.10,11 The principle of the lag screw is based on axial compression of the bone fragments. The screw glides through the fragment located near the screw head (gliding hole) and seizes the fragment distant from the screw head (threaded hole).

Lag-screw fixation is a safe and effective method that has a number of advantages over plate osteosynthesis. Besides supplying compression between the fragments to support healing, fracture stabilization is firm, and tissue exposure is reduced. A unique advantage of lag screw over 1-plate fixation is that it can be applied more rapidly.12 Lag screws should be placed at a 90-degree angle to the load-bearing fragment. A fundamental difficulty with the lag screw is that pressure is exerted on
a very small area of bone. The use of a conventional spherical screw head can damage the bone, acting like a wedge, whereas a concave screw head or a spherical screw head combined with a biconcave washer according to Krenkel can effectively reduce this pressure load. The force vector under the screw head can be transformed from a wedgelike centrifugal force into centripetal force pressure, which is better tolerated by the bone. The screw placement technique must consider the dense cortical bone on the lingual aspect of the ramus, so the insertion path should be approximately 10 to 20 degrees from the buccal corridor. Inclination of the coronal plane should be from caudal to cranial, so a transbuccal approach through a stab incision is necessary.

Use of the lag screw technique for the mandible is ideal after a sagittal split osteotomy, for oblique fractures of the body, for chin fractures, and for more complicated applications such as the mandibular angle. However, for routine clinical use, lag screws are generally applied to oblique fractures of the anterior mandible.

This study investigated 2 surgical internal fixation methods for the mandibular angle: the miniplate and the lag screw. For better reproducibility, only unifocal mandibular fractures were included. The aim of the present study was to compare different methods for the treatment of mandibular angle fractures using the miniplate and lag screw.

PATIENTS AND METHOD

From 1997 to 2006, 549 patients were treated in our department for a mandibular fracture. Among them were 167 patients who had a fracture of the mandibular angle, and 59 patients had isolated mandibular angle fractures.

The inclusion criterion for this investigation was an isolated mandibular fracture of the angle treated with either miniplates or lag screws. Exclusion criteria were multiple fractures of the lower jaw or those in which other osteosynthesis materials such as compression plates or rigid plates with bicortical screws were used. The decision whether to use miniplate or lag-screw fixation was made by the surgeon. Until 1999, all mandibular angle fractures were stabilized using miniplates, using the 2.0-mm Leibinger System (Leibinger Stryker, Freiburg, Germany) and later on the 2.0-mm System by Synthes (Synthes, Solothurn, Switzerland). The application of lag screws was introduced in 1999. The size of the lag screw used is 2.0 mm with biconcave washer (Normed GmbH, Tuttlingen, Germany).

Clinical and radiological data of these patients were evaluated retrospectively. The gap between the fractured fragments of the mandible in the pre- and postoperative radiographic panoramic view and in the reversed Towne’s view was the main parameter for this evaluation. These x-rays were performed within 2 days after surgery.

On the radiographs, a line was drawn along the fracture and it was divided into 3 equal parts. Perpendicular lines were projected onto the fracture line for reproducible measure points (Fig. 1). Measurements of the fracture gap were conducted on these 4 defined points by only one clinician using a precision Mitutoyo (Mitutoyo Measuring Instruments GmbH, Neuss, Germany) “Diamond” caliper 150 mm long and with 0.05-mm accuracy. Because of the radiograph projections, enlargement with a factor of about 1.2 was considered. For every radiograph of every patient, the enlargement scale was given on the image, so that a specific factor could be calculated. With this informa-
tion, the real values of the measurements were generated. Statistical evaluation was performed using the unpaired 2-sample *t* test. The information at the time of trauma included the patient’s age, gender, fracture site, trauma etiology, and the kind of osteosynthesis used. The local ethics committee approved this study protocol.

**RESULTS**

The 45 patients who met the inclusion criteria were classified into groups. Fig. 2 shows the clinical aspect and pre- and postoperative panoramic views of a study patient. Miniplates were used in 24 patients and the lag-screw method in 21 cases. Solitary mandibular fractures treated with load-bearing osteosynthesis with bicortical screws partly in combination with miniplates were described as “other” *n* = 13 and excluded from the study (Fig. 3). Missing values resulted from missing radiographs during the time before digital storage or from an overlap of plates or screws.

The median age of patients was 27 years (range, 17-70 years) in the lag-screw group and 23 years...
Fig. 3. Osteosynthesis methods for treating solitary mandibular angle fractures. The different methods were 1 or 2 lag screws, 1 or 2 miniplates, and the term “other” summarizes the combination of materials, for example lag screw and miniplate or compression plates.

(range, 13-78 years) in the miniplate group. The lag screw group comprised 19 male and 2 female (n = 21) patients, and the miniplate group included 22 males and 2 females. Both groups showed a preference for the left side. In the group treated with lag screws, the left side was affected in 16 patients and right side in 5, whereas in the miniplate group, 15 and 9 patients were affected on the left and right side, respectively. Causes of mandibular fractures in the group treated with lag screws (miniplates) were an accident in 6 patients (10), alleged assaults in 10 patients (6), removal of lower third molar in 1 patient (4), and unexplained in 4 patients (4).

Main parameter: fracture gap in panoramic view

The main parameter, the fracture gap, showed a significant difference in the postoperative measurements on the orthopantomogram. This general statement is supported by the following detailed values. In the comparison between 1 miniplate and lag screw, the t test gave evidence of difference: for measuring point 1 (P < .03), point 2 (P < .15), point 3 (P < .01), and point 4 (P < .06). Statistical analysis between the fixation using 2 miniplates versus lag screw showed a significant difference: for measuring point 1 (P < .002), point 2 (P < .02), point 3 (P < .001), and point 4 (P < .001). The comparison of 1 miniplate versus 2 miniplates resulted in P < .04 for point 1, P < .09 for point 2, P < .02 for point 3, and P < .095 for measuring point 4.

Pre- and postoperative fracture gap values are shown in Table I and Fig. 4. Applying lag screws achieved constant reduction in the fracture gaps as measured by all 4 measuring points. The miniplate fixations showed a wider fracture gap the closer the measuring point was to the caudal border of the mandibular angle.

The mean postoperative fracture gap over all 4 measuring points for the group using 1 miniplate was 0.85 mm, using 2 miniplates was 1.40 mm, and for the lag-screw group, it was 0.56 mm.

Fracture gap in the reversed Towne’s view

In the comparison between 1 miniplate and lag screw the fracture gap in the reversed Towne’s view showed no significance in the t-test comparison for measuring point 1 (P = .24), point 2 (P = .49), point 3 (P = .63), and point 4 (P = .17). In the comparison between 2 miniplates and lag screw there is an evidence-demonstrating difference: point 1 (P < .02), point 2 (P < .03), point 3 (P < .004), and point 4 (P = .45). The statistical evaluation between 1 and 2 miniplates showed P = .1 for measuring point 1, P < .02 for point 2 and point 3, and P = .48 for point 4. The available data were limited because of a small number of cases. Pre- and postoperative fracture gap values are shown in Table II and Fig. 5. The mean postoperative fracture gap in reversed Towne’s view over all 4 measuring points resulted in 0.76 mm for 1 miniplate, 0.98 mm for 2 miniplates, and 0.56 mm for the lag-screw group.

Side parameters

All mandibular angle fractures examined here were treated surgically. In some cases (n = 13), mandibular-maxillary arch-bars were used to position the occlusion. In these cases, operation time was increased.

Hospital stay and surgical intervention duration

Regardless of multiple injuries, the time of hospital stay did not differ between the 2 groups. The mean duration of hospital stay in the miniplate group was 6.5 days and in the lag-screw group, it was 6 days.

The mean duration of the surgical intervention suggested that the lag-screw method was faster than the miniplate method. The mean surgical duration for lag-screw fixation without mandibular-maxillary arch-bars was 50.08 minutes (89.20 minutes with arch-bars), whereas miniplate surgery lasted 69.09 minutes without arch-bars and 138.75 minutes with arch-bars.

Complications

In the lag-screw–treated group, 2 patients had loosening of screws, and these fractures had to be revised. In 1 case, fracture instability owing to noncompliance by the patient was treated with additional intermaxillary immobilization.

Patients treated with a solitary miniplate along the linea obliqua, according to Champy et al.,15 showed insufficient dental occlusion in 1 case (n = 1; 7%). If an additional miniplate was placed, a higher complication rate was observed. In 3 (30%) cases, loosening of the plates occurred. In 1 case, disturbing insufficient dental occlusion was detected (Table III).

Only 1 patient in the lag-screw group, who had loosening of a screw, developed an infection.
DISCUSSION

The overall number of 45 fractures included in this study seems low, compared with the total number of 549 lower jaw fractures in the period from 1997 to 2006 treated in one department. However, only single isolated mandibular angle fractures were analyzed to reach a high measure of comparability. Patients with multiple jaw fractures or the use of other materials or a combination of materials for osteosynthesis were excluded. In the literature, previous investigations have had similar or fewer cases or have described all mandibular fractures, with the disadvantage of an inhomogeneous patient population.

The inventors of the lag-screw system highlighted the possibility for primary bone healing. If the screws are aligned in a position perpendicular to the fracture line, the fracture segments are forced together, resulting in primary bone healing. Here, the main difference between the miniplate and lag-screw methods is obvious. The lag-screw method offers internal fixation for the tension zone of the mandible with good compression on the fragments to support bone healing. This compression can be demonstrated in the postoperative fracture gap. The compression effect of the lag screw over the entire fracture gap has been examined in biomechanical studies. Our radiographic analysis of the postoperative fracture gap demonstrated a significant reduction in fracture gap with lag-screw fixation when compared with the miniplate. Measurement of the fracture gap has not been performed regularly in studies reported in the literature.

The lag-screw method resulted in smaller fracture gaps than the miniplate groups. Smaller gap areas, when immobilized by neighboring contact zones, still permit direct lamellar ossification inside the gap. It is generally accepted that reduction and fixation of the fracture to align the fragments in contact promotes bone healing. Moreover, a direct correlation between the fracture-gap width and the healing process is given in the literature; if the fracture-gap width is larger than 2 mm, then bone healing is delayed. Large fracture gaps cause a delay in fracture healing, as demonstrated in experimental and clinical investigations. A good reduction of a fracture with small interfragmentary gaps is important for its revascularization and healing.

The miniplate uses the tension-banding principle as described by Champy et al. However, a distraction in the caudal area of the fracture is confirmed in the literature. A single miniplate seemed to be more successful (overall complication rate, 7%) than the lag screw (14%). However, when a second miniplate was used, the complication rate increased to 30%. Our results are intermediate when similar studies of mandibular angle fractures are compared. The complication rate for solitary lag-screw osteosynthesis of mandibular angle fractures was reported to be 4% infection, 2% occlusal disturbances, and 4% malposition of fragments in a study of 50 patients. In another investigation of 30 patients with mandibular angle fractures (14 unilateral, the rest combination angle fractures), an overall postsurgical infection of 23% was reported, and 13% required further intervention.

A second miniplate is contrary to the principle of tension banding by Champy et al. A high complica-

Table I. Pre- (pre) and postoperative (post) fracture gap measurements at different measuring points (Point) showing mean and standard error (SEM) for the methods using 1 miniplate, 2 miniplates, and the lag screw in the panoramic view

<table>
<thead>
<tr>
<th>Point</th>
<th>Panoramic view</th>
<th>One miniplate, mean (SEM), mm</th>
<th>Two miniplates, mean (SEM), mm</th>
<th>Lag screw, mean (SEM), mm</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>n pre</td>
<td>n post</td>
<td>n pre</td>
</tr>
<tr>
<td>1</td>
<td>12</td>
<td>0.85 (0.14)</td>
<td>13</td>
<td>0.67 (0.07)</td>
</tr>
<tr>
<td>2</td>
<td>13</td>
<td>0.98 (0.12)</td>
<td>14</td>
<td>0.79 (0.08)</td>
</tr>
<tr>
<td>3</td>
<td>13</td>
<td>0.98 (0.19)</td>
<td>14</td>
<td>0.91 (0.11)</td>
</tr>
<tr>
<td>4</td>
<td>13</td>
<td>0.87 (0.20)</td>
<td>14</td>
<td>1.01 (0.18)</td>
</tr>
</tbody>
</table>

Fig. 4. Postoperative fracture gap (mm) for different measuring points (1-4) for the 2 different treatment methods in the panoramic view.
tion rate of 28% has been reported when 2 miniplates were used at the mandibular angle. In a comparative study, a 16% complication rate was reported for the 1-miniplate method and 28% for 2 miniplates for mandibular angle fractures. On the other hand, an in vitro study measuring the fracture gap between 1 and 2 miniplates described better fixation with 2 plates. In the present clinical investigation, fracture gaps were significantly wider when using 2 miniplates. It can also be discussed if an additional miniplate was used because intraoperatively the gap was not in good reduction.

Treatment with a solitary lag screw resulted in a lower duration of surgical intervention than that for the miniplate method, which is an advantage of the lag-screw system. Similar results have been described previously, with approximately 20 minutes required to place a screw. Although lag-screw osteosynthesis requires a very precise approach, in most cases, a solitary lag screw with only 1 drilling procedure is sufficient for stable fixation. The osteosynthesis material does not need to be adapted to the bone surface. Sometimes a transdermal stab incision through the cheek is necessary to bring the screw to the proper angle, whereas several monocortical holes have to be drilled for miniplate fixation. Moreover, the miniplate must be contoured individually to the linea obliqua. Despite all these advantages, in our opinion lag-screw application seems to be a more delicate surgical intervention than the fixation using miniplates.

CONCLUSION

This study demonstrated a smaller fracture gap when using the lag screw. The fixation method using 2 miniplates showed wider fracture gaps when compared with 1 miniplate. The primary advantage of the lag screw lies in providing compression to the fragments so that primary bone healing can be achieved. The lag-screw system offers the advantages of a minimally invasive technique, short surgery duration, no plate contouring, and less osteosynthesis material, and hence, lower cost. An intraoral access is possible for lag-screw fixation, with a minimal transbuccal approach for correct screw angulation. This study gives evidence that lag screw application in mandibular angle fractures might be favorable, but randomized multicenter trials are necessary.

REFERENCES


Reprint requests:
Heidrun Schaaf, MD, DDS
Department of Maxillofacial Surgery
University Hospital Giessen
Klinikstr. 29
35385 Giessen, Germany
Heidrun.Schaaf@uniklinikum-giessen.de, heidrun.schaaf@gmx.net