Plate removal following orthognathic surgery

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Objectives. The objectives of this study were to analyze outcomes with miniplates in orthognathic surgery and define risk factors resulting in plate removal.

Study design. Clinical files of 570 orthognathic surgery patients operated between 2004 and 2009 were reviewed: 203 had a bimaxillary operation, 310 a lower jaw osteotomy, and 57 an upper jaw osteotomy. Age, sex, and jaw movement were analyzed. Reasons for hardware removal were recorded.

Results. Hardware was removed in 157 patients (27.5%). Seventy-eight patients (13.7%) needed removal because of plate-related infection; 66 (11.6%) because of clinical irritation; 5 (0.9%) for dental implant placement; and 8 (1.4%) for other reasons. Average time between operation and removal was 9.9 months. More women (31.7%) than men (20.3%) had plates removed, but age was not a factor except with infection.

Conclusions. More than a quarter of patients developed complications from plates and screws, necessitating their removal, and infection occurred in 13.7%. Prompt removal constituted adequate management. (Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2011;112:737-743)

Miniplates have been widely used in the osteosynthesis of the lower and upper jaws during orthognathic surgery since Champy et al.1 adapted the technique in 1978, as described by Michelet et al. 2 In most units, it is routine policy not to remove plates and screws following bony union unless doing so is clinically indicated.3 In some units, however, the routine policy is to remove plates and screws because late removal becomes very difficult as a result of bony overgrowth of the plates.4 Many studies have investigated the removal of miniplates in trauma cases, but relatively few studies have focused exclusively on orthognathic surgery operations. The reported incidence to date of plate removal per patient in orthognathic surgery ranges from 10.0% to 18.5%5-9 in mandibular osteotomies and from 1.0% to 11.1%10-12 in maxillary osteotomies (Table I).

This retrospective study examined the rate of plate removal from the maxilla and mandible, and the risk factors that may contribute to it. The purpose was to analyze the outcome of miniplate usage in orthognathic surgery and to define risk factors leading to signs or symptoms that eventually result in plate removal.

MATERIAL AND METHODS

Records for 570 consecutive patients operated between 2004 and 2009 were reviewed retrospectively (Table II). All patients had undergone either a bimaxillary, a Le Fort I, or bilateral sagittal split ramus osteotomies (BSSO) performed by 1 of the 3 senior staff members of the Department of Oral and Maxillofacial Surgery at St. John’s Hospital in Genk. Records were included only of orthognathic patients for which the same operative technique and the same postoperative clinical attitude toward removal of osteosynthesis material were applied.

The patients included 363 females and 207 males, with a mean age at surgery of 26.7 years (Table III). A total of 513 mandibular and 260 maxillary osteotomies were evaluated, and 203 of the patients had a bimaxillary operation. We studied the operative charts for age, sex, the direction of the movement of the jaw, the incidence of plate removal, and the type of plate that was placed. Within the group that underwent plate removal, we noted the indication for the removal, the interval between operation and removal, if removal was indicated in the upper or the lower jaw, and the side (left/right) of the jaw that needed a removal.

This retrospective study had institutional review board approval, and was conducted in compliance with the Helsinki Declaration guidelines.

Operative technique

All of the BSSOs included in this study were performed by 1 of 3 resident surgeon staff members. We
performed the modified sagittal split osteotomy as described by Epker and Falter et al.

After completing the osteotomies on both sides in the lower jaw, a wafer was introduced onto the lower jaw, and intermaxillary fixation was ensured. Internal fixation was established with titanium miniplates and monocortical screws of the 2.0 system, as described by Tulasne and Schendel. Almost all of the miniplates used, with the exception of 12 Tekka-plates (Tekka, Brignais, France), were from the Leibinger miniplate system (Leibinger, Tuttlingen, Germany). The monocortical screws placed before 2008 were from the Leibinger system (4.0 mm); after that time, we used screws distributed by Stryker (Kalamazoo, MI, USA) (5.0 mm).

All wounds were sutured with polyglactin (Vicryl) in 2 layers. During all of 2009, all sagittal split wounds were perioperatively rinsed with a 10% povidone-iodine (iso betadine) solution with careful closure of the periosteum to achieve a 3-layered closure of the operation wound. This change did not improve the rate of plate removal and was abandoned again in 2010. No suction drainage was used in any case of a sagittal split osteotomy.

The Le Fort I osteotomy was performed as described by Epker and Fish. All patients received perioperative intravenous antibiotics, as well as a dose of methylprednisolone 125 mg intravenously. A second dose of methylprednisolone was administered 8 hours after the first dose. Postoperatively, antibiotic treatment was continued for 5 days. No intermaxillary fixation was used, except for light elastics on surgical hooks to guide the patient into the right occlusion during jaw movements.

The follow-up always lasted at least 18 months and included 1 consultation every week during the first 6 weeks and 1 at 3 months, 6 months, and 1 year postoperatively. During the first 6 weeks, a wafer (occlusal splint) was retained in the mouth. Guiding elastics were placed only during these 6 weeks if the occlusion deviated from the desired result. If any inflammatory wound reaction was seen at the operation site during the first 6 weeks, a removal of the plates was planned at 3 months after the operation date. An “infectious” reaction was considered to be present whenever wound dehiscence over the plates, granulation tissue at the plate site, or an intraoral fistula with pus at the plate site was observed. No wound cultures were obtained in any case. A persistent swelling and redness at the osteosynthesis site

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**Table I.** Review of reported incidence of plate removal after bilateral sagittal split ramus osteotomy and Le Fort I procedures

<table>
<thead>
<tr>
<th>First author</th>
<th>Year</th>
<th>No. of patients receiving plates</th>
<th>Orthogn/trauma</th>
<th>Area of jaw</th>
<th>No. of patients w/ plate removal</th>
<th>% patients w/ plate removal</th>
<th>No. of plates inserted</th>
<th>No. of plates removed</th>
<th>% plates removed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beals</td>
<td>1987</td>
<td>53</td>
<td>Orthogn</td>
<td>Maxilla</td>
<td>—</td>
<td>—</td>
<td>200</td>
<td>2</td>
<td>1.0%</td>
</tr>
<tr>
<td>Schmidt</td>
<td>1998</td>
<td>190</td>
<td>Orthogn</td>
<td>Maxilla</td>
<td>21</td>
<td>11.1%</td>
<td>738</td>
<td>70</td>
<td>9.5%</td>
</tr>
<tr>
<td>Manor</td>
<td>1999</td>
<td>70</td>
<td>Orthogn</td>
<td>Maxilla</td>
<td>—</td>
<td>18.3%</td>
<td>260</td>
<td>31</td>
<td>12%</td>
</tr>
<tr>
<td>Bhat</td>
<td>2003</td>
<td>172</td>
<td>Trauma</td>
<td>Mandible</td>
<td>28</td>
<td>13.3%</td>
<td>308</td>
<td>51</td>
<td>16.6%</td>
</tr>
<tr>
<td>Bhat</td>
<td>2005</td>
<td>153</td>
<td>Trauma</td>
<td>Mandible</td>
<td>21</td>
<td>13.3%</td>
<td>308</td>
<td>32</td>
<td>—</td>
</tr>
<tr>
<td>Nagase</td>
<td>2005</td>
<td>266</td>
<td>Trauma</td>
<td>Maxilla mandible</td>
<td>45</td>
<td>33.3%</td>
<td>497</td>
<td>135</td>
<td>27.2%</td>
</tr>
<tr>
<td>Theodossy</td>
<td>2006</td>
<td>80</td>
<td>Orthogn</td>
<td>Mandible</td>
<td>16</td>
<td>—</td>
<td>160</td>
<td>25</td>
<td>15.6%</td>
</tr>
<tr>
<td>Alpha</td>
<td>2006</td>
<td>533</td>
<td>Orthogn</td>
<td>Mandible</td>
<td>—</td>
<td>10.0%</td>
<td>—</td>
<td>—</td>
<td>6.5%</td>
</tr>
<tr>
<td>Kuhlefelt</td>
<td>2010</td>
<td>153</td>
<td>Orthogn</td>
<td>Mandible</td>
<td>29</td>
<td>18.6%</td>
<td>308</td>
<td>56</td>
<td>18.2%</td>
</tr>
<tr>
<td>Falter</td>
<td>Present data</td>
<td>570</td>
<td>Orthogn</td>
<td>Maxilla mandible</td>
<td>157</td>
<td>27.5%</td>
<td>3197</td>
<td>622</td>
<td>19.5%</td>
</tr>
</tbody>
</table>

Orthogn, orthognathic surgery; —, data not reported.

**Table II.** Number of patients with plate removal according to the type of surgery

<table>
<thead>
<tr>
<th></th>
<th>BSSO only</th>
<th>Bimaxillary only</th>
<th>Le Fort only</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of patients w/ an osteotomy</td>
<td>310</td>
<td>203</td>
<td>57</td>
<td>570</td>
</tr>
<tr>
<td>No. of patients w/ plate removal</td>
<td>80</td>
<td>63</td>
<td>14</td>
<td>157</td>
</tr>
<tr>
<td>% of plate removal</td>
<td>25.8%</td>
<td>31.0%</td>
<td>24.6%</td>
<td>27.5%</td>
</tr>
</tbody>
</table>

BSSO, bilateral sagittal split ramus osteotomy.

**Table III.** Analysis of the need for plate removal for different variables

<table>
<thead>
<tr>
<th></th>
<th>Total</th>
<th>Plate removal</th>
<th>Non-plate removal</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of patients</td>
<td>570</td>
<td>157</td>
<td>413</td>
<td>27.5</td>
</tr>
<tr>
<td>Male</td>
<td>207</td>
<td>42</td>
<td>165</td>
<td>20.3</td>
</tr>
<tr>
<td>Female</td>
<td>363</td>
<td>115</td>
<td>248</td>
<td>31.7</td>
</tr>
<tr>
<td>Average age</td>
<td>26.7</td>
<td>26.9</td>
<td>26.6</td>
<td>—</td>
</tr>
</tbody>
</table>

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was considered to constitute an “inflammatory” reaction necessitating removal of the plates, whether it was accompanied by tenderness over the area or not. In the results section, this indication is defined as “clinical irritation.” No single case of extraoral infection was seen. We did not encounter cold intolerance to the plates, which Nagase and Courtemanche\textsuperscript{13} mentioned as an indication for plate removal.

**Statistical methodology**

Survival analysis techniques were used for the data analysis. The Kaplan-Meier estimator was used to describe the removal rate over time and the proportional hazard model (PH model or Cox model) for the analysis of the effect of the covariates. The SAS procedures LIFETEST and PHREG were used, part of Version 9.2 of the SAS System for Windows (SAS Institute Inc., Cary, NC, USA).

**RESULTS**

A total of 157 (27.5%) of the 570 patients had at least a portion of the hardware removed because they either requested removal or required removal secondary to complications related to the plates or screws. Of the 3197 plates that were placed, 622 (19.5%) were removed. The patients having hardware removal consisted of 115 females (31.7% of all female patients) and 42 males (20.3% of all male patients). This difference was significant ($P = .0091$).

In 78 patients (13.7%), the plates were removed because of an infectious episode related to the presence of the plates (Fig. 2). Sixty-six patients (11.6%) had...
plates removed because of clinical irritation. All patients with complaints during the initial 6 weeks after the operation had their plates removed after a healing period of at least 10 weeks. In those cases, the removal of the plates was bilateral, even if the occurrence of the problems was unilateral. Eight patients (1.4%) requested removal for various reasons, including required removal to enter the army, removal for a tooth extraction, wound dehiscence, dysesthesia of the nerve, or a malpositioning of the osteosynthesis material too close to the inferior border of the mandible. One of the patients had a fracture of both plates in the left mandible. In 5 patients (0.9%), the plates were removed before placement of a dental implant. Dental root injuries, which require miniplate removal, did not occur.

The indications for removal also differed according to sex: 52 of the 363 females (14.3%) needed plate removal because of an infectious episode, 55 (15.2%) because of clinical irritation; 3 (0.8%) before placement of an implant, and 5 (1.4%) for other reasons. Among male patients, 26 (12.6%) of the 207 patients had removal of plates because of an infectious episode and only 11 (5.3%) because of clinical irritation; 2 patients had a removal (1.0%) before placement of an implant, and 3 (1.4%) for other reasons.

If we focus on removal because of an infectious episode, there was no significantly higher risk for female patients than for male patients ($P = .54$). Of the 157 patients with plate removal, 54 had the plates removed because a problem occurred on the left side, 41 because a problem occurred on the right side, and 62 patients had a problem on both sides.

The average age in the removal group was 26.9 years (range 15-65 years) compared with 26.6 years (range 14-65) for patients who had no removal (Table III). Generally speaking, age had no influence ($P = .74$) on the removal of miniplates (Fig. 3); however, it did significantly affect removal caused by an infectious episode ($P = .0013$). This finding was, rather remarkably, not a linear phenomenon. It was especially the case in the age category of people between 25 and 35 years old and less so in those older than 35 and younger than 25 (Table IV). We also noted in general a slightly higher risk for plate removal within the 25- to 35-year age group, but this was not a significant finding ($P = .17$).

The average time from hardware placement to removal was 9.9 months (range 2-65 months). Of the removals, 79.6% occurred within the first year after the operation. The average follow-up time was always at least 18 months.

When osteosynthesis material becomes more prominent with aging, because of soft tissue changes, this could be an additional reason for removal 1 or 2 decades after surgery. The follow-up period of this study did not allow inclusion of these cases. The reported incidence of removal is therefore an underestimation.

Of the 157 patients with plate removal, 50 patients (19.2% of the 260 maxillary osteotomies) had a removal of the plates from the upper jaw, and 127 (24.8% of the 513 mandibular osteotomies) needed removal from the lower jaw. Twenty of these patients needed a removal in the upper and lower jaws, and were counted within both groups. Also, 80 of the 157 patients

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**Table IV.** Occurrence of all plate removals and occurrence of plate removals because of infections according to patient age (3 age categories)

<table>
<thead>
<tr>
<th>Age groups, y</th>
<th>No. osteotomies</th>
<th>Patients w/ plate removal, n (%)</th>
<th>Patients w/ plate removal because of infection, n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;25</td>
<td>327</td>
<td>87 (26.6)</td>
<td>36 (11.0)</td>
</tr>
<tr>
<td>25-34</td>
<td>98</td>
<td>35 (35.7)</td>
<td>25 (25.5)</td>
</tr>
<tr>
<td>&gt;34</td>
<td>145</td>
<td>35 (24.1)</td>
<td>17 (11.7)</td>
</tr>
<tr>
<td>Total</td>
<td>570</td>
<td>157 (27.5)</td>
<td>78 (13.7)</td>
</tr>
</tbody>
</table>

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![Fig. 2. The reasons for plate removal and the number of patients with plates removed.](image2.png)

![Fig. 3. Number of patients with plate removal according to age group.](image3.png)
had undergone exclusively a mandibular osteotomy (25.8%), 63 a bimaxillary surgery (31.0%), and 14 (24.6%) exclusively a Le Fort operation (Table II).

Within the group of the mandibular osteotomies, bimaxillary operations excluded, 279 patients had a mandibular advancement, and 72 (25.8%) of these had their plates removed. Twenty-one patients had a setback, and 6 patients had their plates removed (28.6%). If a rotation in the movement of the lower jaw was done, then the risk for plate removal was 29.0% (9/31).

In examining the patient records per year, we noted a higher percentage of plates removed with patients operated in 2008 and 2009 than in the previous years of 2004 to 2007 (Table V). This timing coincided with a change in the screw design of the Leibinger screws. The incidence of plate removal resulting from an infectious episode showed no significant changes within time (P = 0.53).

There was no correlation between the amount of advancement and the risk of plate removal, but removal rates differed according to the type of miniplate used (Fig. 4). The statistical analysis revealed no significant difference between the use of regular or long miniplates.

**DISCUSSION**

Various complications can arise after miniplate and screw fixation, such as infection, miniplate fracture, nonunion, and mental nerve paralysis or dysesthesia. Plate removal after orthognathic surgery varies between 1.0% and 18.6% of patients. Some German centers advocate routine removal of titanium osteosynthesis material after treatment of fractures or operations for dysgnathia.

Alpha et al. reported plate removal in only 10% of its BSSOs, although they described “disturbance of healing” in 26% of their patients. In our study, “disturbance of healing” was one of the indications to pursue surgery (42% of all removals). Borstlap et al. reported that 55% of plates were taken out within 8 months after an operation, but only 7% of these had to be removed because of inflammation. They did not further specify the reasons for removal among the other 48%. Kramer et al. described the removal of osteosynthesis material in 90% of their 1000 Le Fort I osteotomies but did not include the indications for removal. Theodossy et al. reported a removal rate of 15.6%, but all of the plates had to be removed because of infection. They defined infection as pain, swelling, wound dehiscence, and pus discharge in the region of the plates, which includes both the indications of “inflammation” and “infection” in our series.

We prefer to use miniplates for fixation of our osteotomies, which appears to be a safe and reliable procedure and excludes certain disadvantages that are seen with the use of bicortical screws, as has been described by Borstlap et al. Some authors support the use of 2 miniplates for 1 osteotomy site to reduce complications, but others do not agree. In our series, we used 2 miniplates for 1 osteotomy site.

This study shows a high incidence of plate removal compared with the literature (Table I). One possible reason could be that the placement of 2 plates per side provokes a higher risk for plate removal. The placement of the proximal segment screws away from the inferior border of the mandible could raise the risk of a disturbed healing. Our operative charts do not allow comment on this issue. Whenever a disturbed healing was encountered at an osteotomy site, both plates were removed without notation of which screws were loose and which were not. The placement of 2 plates necessitates more stripping of soft tissues, both at the upper border and at the lower border of the mandible, which could affect the vascularization of the bone at the osteotomy margin of the proximal segment.

Another reason for the high incidence of plate removal in this study could be that the decision to remove

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**Table V.** Occurrence of plate removal according to the number of patients and the year of the osteotomy

<table>
<thead>
<tr>
<th>Year</th>
<th>No. patients</th>
<th>Patients w/ plate removal, n (%)</th>
<th>% bimaxillary osteotomies compared with total</th>
<th>% removals because of infectious episode</th>
</tr>
</thead>
<tbody>
<tr>
<td>2004</td>
<td>45</td>
<td>11 (24.4)</td>
<td>40.0</td>
<td>20.0</td>
</tr>
<tr>
<td>2005</td>
<td>83</td>
<td>23 (27.7)</td>
<td>38.6</td>
<td>12.0</td>
</tr>
<tr>
<td>2006</td>
<td>118</td>
<td>27 (22.9)</td>
<td>28.0</td>
<td>12.7</td>
</tr>
<tr>
<td>2007</td>
<td>122</td>
<td>27 (22.1)</td>
<td>32.8</td>
<td>10.7</td>
</tr>
<tr>
<td>2008</td>
<td>103</td>
<td>35 (34.0)</td>
<td>37.9</td>
<td>17.5</td>
</tr>
<tr>
<td>2009</td>
<td>99</td>
<td>32 (32.3)</td>
<td>40.4</td>
<td>13.1</td>
</tr>
</tbody>
</table>

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**Fig. 4.** Percentage of miniplates removed in the lower jaw according to the type of miniplate and the side of placement. 4H R, 4 holes regular; 4H M, 4 holes medium; 4H L, 4 holes large; 6H R, 6 holes regular.
the plates was made as soon as there was a minimal margin of complaint, and we note that the relative proportion of these indications differed between the sexes. By keeping this threshold for removal rather low, we were anticipating in most cases that any later removal would be more complicated because of bony overgrowth. Such overgrowth occurs in general when the interval between placement and removal is longer than 12 months.

Michelet et al. advocated a tight seal of the surgical site with emphasis on closure of the periosteum at fracture sites. As a meticulous closure was attempted in all cases during one period (throughout 2009) without any positive effect, this factor is not an issue in orthognathic surgery.

Although the standard removal of all osteosynthesis material is no longer promoted in the literature, controversy remains about the long-term effect of titanium miniplates, primarily in young adults. Despite their excellent clinical performance, doubts have emerged about their long-term behavior in tissues and their potential local and systemic side effects. Because most of our patients are younger than 30, we prefer to be cautious regarding the long-term placement of the plates. Further, because the removal of plates is associated with low comorbidity, we always choose to remove the plates within a minimal margin of complaint, as noted.

A third possible explanation for the high removal rates in this study is that our patients are not placed in intermaxillary fixation (IMF) postoperatively. Although the double-plating method gives a strong fixation that excludes the need for IMF, it is possible that this practice results in micromotions at the fracture site that provoke a reaction near the surgical wound.

From our results, we also note a significantly higher number of plates removed with patients operated on in 2008 and 2009 compared with 2004 through 2007. The screw design could be in play here. Monocortical fixation starts at the proximal segment with a first fixation point at the upper plate close to the osteotomy site. Whenever we found an infection of the plates, this screw was always involved, having lost its fixation, with or without a loose bony fragment. It could be that the manual tightening of this first screw was too tight, causing microfractures close to the osteotomy site. There also was a relatively higher number of bimaxillary operations in these years that accompanied a higher risk for plate removal, but this observation is not offered as a conclusive explanation but rather noted as a negative evolution.

The amount of advancement and the risk of plate removal showed no correlation, but we did note that removal rates differed according to the type of mini-plate that was used; however, analysis did not identify a significant difference between using regular or long miniplates. The length of the miniplate is a good measure for the dead space at the diastema of an advancement osteotomy of the lower jaw. The transverse approximation of the proximal and distal fragment was less with miniplates than with screw fixation of osteotomies. This could be an additional factor but was not evaluated here.

There can be dead space because of a lack of bony contacts between the proximal and distal bone fragments, along with a diminished vascularity of the proximal fragment at the osteotomy site. Under these conditions, overtightening of the first screw placed close to the osteotomy margin of the proximal bone fragment could initiate compromised healing, leading to early loss of tightening of the screw, which then could begin to act as a foreign body.

Problems that required plate removal seemed to start more on the left side than on the right, and it is possible that the right-handedness of the surgeon might be a factor. Dental root injuries resulting from miniplate osteosynthesis, which require a removal of the screws and plates, did not occur in our series, although the reported incidence can be as high as 7.6% of all patients. These dental root traumas occur only in the upper jaw or in the distal segment of the lower jaw.

In general, we found no significant correlation between age and the risk for plate removal, in line with what has been reported by Kuhlefelt et al. This finding is not, however, in line with Manor et al., who reported that age is a statistically significant linear risk factor for plate removal among patients who had undergone orthognathic surgery. It should be noted that we found a significant but nonlinear correlation between age and removal (for the 25-35 age group) in the specific group of cases in which infection necessitated the removal.

**CONCLUSIONS**

This study reports an important percentage of patients (27.6%) developing complications from plates and screws that required their removal. Bimaxillary operations had higher removal rates than monomaxillary operations, and women were more likely to have their plates removed than men. Age had no significant influence on miniplate removal, except in some cases when an infectious episode caused the removals.

Almost 80% of the removed plates are removed within the first year. One of the advantages of a rapid removal is that all plates can be technically easily removed in a procedure with low morbidity if they are removed within this “window of opportunity.”
REFERENCES

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