# Angled Screws With Locking Plates—An Alternative Fixation for Minimally Invasive Mandibular Orthognathic Surgery

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**Purpose:** The purpose of this study was to evaluate the short-term behavior of angled screws with locking plates after bilateral sagittal split osteotomy using the anterior oblique technique within the concept of minimally invasive orthognathic surgery (MIOS).

**Materials and Methods:** Twenty patients who underwent bimaxillary surgery with mandibular advancement were included in this preliminary and retrospective study. All patients underwent computed tomography preoperatively and 1 day postoperatively. The incidence of neurosensory dysfunction, clinical evaluation of the occlusion and temporomandibular joint, and overall complications were recorded during a minimum follow-up of 4 months.

**Results:** The mean extent of sagittal mandibular advancement movements was 7.2 mm (2.5–13.2 mm). All patients had stable occlusion without evidence of temporomandibular joint dysfunction. None of the patients presented with dysaesthesia, hyperaesthesia, or anesthesia after four months of follow-up.

**Conclusion:** The overall results of this study are very satisfactory with no major or minor complications. The new design of mandibular plates with locking screws can be an alternative in all orthognathic surgeries, but especially interesting for minimally invasive approaches where stronger fixation is needed. Long-term studies are needed to draw further conclusions.

**Keywords:** Mandibular osteotomy, orthognathic surgery, orthognathic surgical procedures

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Since the description of the intraoral bilateral sagittal split osteotomy (BSSO) in 1957,[1] several modifications have been proposed, most of them offering a larger osteotomy more focused on the application of rigid internal fixation, making the technique safer and consequently more popular.[2,3]

More recently, the concept of minimally invasive orthognathic surgery (MIOS) has become a trend.[4–11] Although there are few studies reporting the mandibular procedure within the MIOS concept, most of the papers on MIOS mainly discussed approaches and osteotomies using the same fixation systems used in conventional orthognathic surgery. Therefore, there is a need to discuss the development of new instruments and fixation systems for surgeons wishing to perform MIOS.

A new internal rigid fixation alternative has been developed using a combination of angled screws and locking plates. The purpose of this paper is to report the preliminary results of this system within the concept of MIOS for mandibular procedures.

## METHODS

This retrospective study included 20 consecutive patients, mean age 25 years (range 17–45), 14 females and 6 males who had occlusal class I (n = 6), class II (n = 10), and class III (n = 4). The demographic and baseline characteristics and planned mandibular advancement are shown in Supplemental Table 1, Supplemental Digital Content 1, http://links.lww.com/SCS/G914.

All patients enrolled in the study had undergone a bimaxillary surgery. Syndromic patients with a history of trauma or previous surgery were excluded from the sample. Computed tomography for radiographic follow-up was performed preoperatively (T0, <1 mo before surgery) and immediately postoperative (T1, 1 d after surgery).

All procedures were performed using mandible first protocol. Mandibular osteotomies were performed on each side using the anterior oblique technique, preserving the mandibular inferior border, according to Cordier et al,[12] using the MIOS approach.[8,10,11] After splitting the mandible, intermaxillary fixation was achieved using the intermediate splint.

The mandibular plate fixation was started with the proximal segment, using a modified plate (2.0 locking system) manufactured by Traumec (Rio Claro, São Paulo, Brazil), with three independent posterior slots for locking and angulated screws (Fig. 1). The angulation of these posterior orifices is 30 degrees in a superior and anterior direction facilitating the insertion of the monocortical screws using intraoral approaches (Fig. 2).

The next step was the insertion of the screws in the distal segment, again with locking screws. Considering that this area is already more anterior and superior, there is no need for angulation of the screws. But the locking system is even more important to avoid any compression between the plate and the bone that may result in condylar torque.

After the locking plate was properly fixed with monocortical screws, two options were considered. One was the insertion of an additional bicortical screw as conventionally used in hybrid fixations. A second option was to remove the most superior monocortical screw on the proximal segment and replace it with a bicortical screw. Considering that this screw is also locking, there is zero risk of bone compression and/or condylar torque, as the compression of the insertion of this screw is locked by the plate.

Postoperatively, no intermaxillary fixation was used and all patients were followed up for a minimal of 4 months. Possible disorders of the TMJ, pain or neurosensory disturbances were

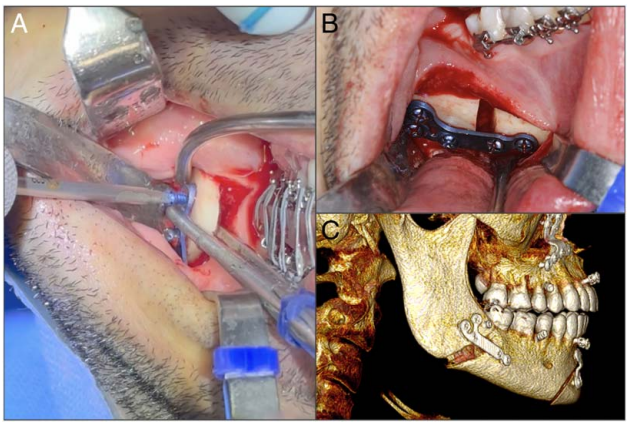


**FIGURE 1.** (A) Transoperative view during insertion of the monocortical locking screw. Note the superior and anterior angulation of the plate, which allows easy insertion through an intraoral minimally invasive approach. (B) Mandibular advancement after fixation with 5 monocortical locking screws using a stronger plate. (C) Immediate postoperative 3D CT reconstruction showing the position of an additional conventional bicortical screw. 3D indicates 3 dimensional; CT computed tomography.

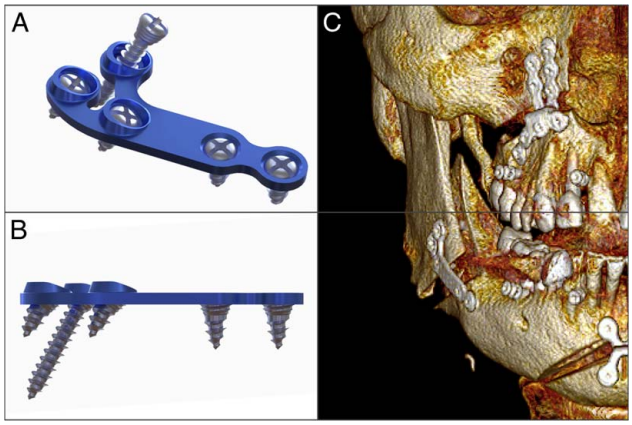


**FIGURE 2.** (A and B) 3D views of the mandibular plate showing the angle of inclination of the posterior locking screws. (C) Immediate postoperative 3D CT reconstruction showing the example of a bicortical locking screw in the most superior slot, which is the safest position in relation to the mandibular nerve. 3D indicates 3 dimensional; CT computed tomography.

subjectively recorded. Descriptive statistics were used to compare preoperative and postoperative results.

## RESULTS

The mean operation time from incision to wound closure was 35 minutes per side. All patients presented acceptable healing, without any wound dehiscence, infection, nonunion, or pseudarthrosis of the bone segments. No plate fracture occurred and no screw loosens were noticed.

There were 2 patients presenting minimally occlusal interferences treated with elastics in the first month. The clinical evaluation of the TMJ showed no disorders and none of the patient related any symptom during the follow-up period. There were no cases of condylar sag at T1.

The evaluation of sensory alterations in the lips or chin showed that all but 2 patients had normal sensory function within 48-hours after surgery, and none of the patients presented dysaesthesia, hyperesthesia or anesthesia after 4 months.

The mean extent of the sagittal mandibular advancement movements was 7.2 mm (2.5–13.2 mm). In all cases, the screws were placed intraorally, there was no need to use extraoral percutaneous. In 24 sides (12 cases), a bicortical locking screw was used (Fig. 1), and in 16 sides (8 cases), all locking screws were monocortical, with the one conventional bicortical screw placed outside the plate (Fig. 2).

## DISCUSSION

The evolution of orthognathic surgery is influenced by the demands and needs of patients. The current search for less invasive procedures in all medical fields has contributed to the introduction of MIOS.[6,8,10] As a result, there is an adaptation process that includes the learning curve of specialists, new protocols, and new instruments specific to the MIOS concept.

MIOS requires less dissection of the masticatory muscles to reduce the inflammatory response and sometimes provides less bone contact compared with conventional techniques. This combination is responsible for an increase in bone instability, which can lead to complications such as fixation failure and/or pseudoarthrosis.[8,13,14] For this reason, this new fixation system has been idealized: stronger plates with locking screws, designed to be used with the MIOS concept. Beyond the locking screws, the main design difference is the 30-degree angled screws for the proximal segment, which allows screw insertion without transbuccal devices, using a small intraoral approach.

Locking plates have long been used in maxillofacial procedures. The main advantage is the neutral relationship between the screw and the bone, as most of the forces from the screw insertion are neutralized by the plate. The biomechanical loads can be distributed along the plate, dissipating the axial forces. Another advantage is that locking plates do not require plate bending, as there is no risk of compression if the plate is not perfectly adapted to the bone. The features of the locking plate and screws offer greater occlusal stability, eliminating the need for postoperative intermaxillary fixation. In mandibular fixation, it offers neutralization of the fracture, which limits the forces transmitted to other structures, such as the temporomandibular joint.[15–17] The system described in this study also allows the use of a bicortical screw to increase the stability of the hybrid fixation.

The incidence of complications after mandibular advancements using MIOS concept is still unclear because it is a recent technique with very few centers routinely performing.[6] The potential causes are the smaller bone contact area; the increased muscle traction (less soft tissue detachment) and; the unappropriated application of osteosynthesis using smaller approaches. There is an inherent learning curve, like any technique, but also very dangerous considering the risk of catastrophic complications during mandibular procedures.

Even with the limitations of a small sample with a short follow-up, the overall results of this study are very satisfying without any major or minor complications. All the procedures in the current sample were performed by experienced surgeons, but the authors believe that this new design of mandibular plates with locking screws can be helpful even for less experienced professionals to increase their results in all orthognathic surgeries, especially for those that are trying to work with MIOS.

## CONCLUSION

Additional studies are needed to correlate conclusions regarding both topics: mandibular MIOS and locking angled screws. In the opinion of the authors, stronger fixation systems will pro-

vide a solution for surgeons seeking to perform mandibular MIOS through small surgical approaches with less bone contact and more muscle traction, allowing the same jaw stability achieved with traditional procedures.

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