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Technical Note
Orthognathic Surgery

A reversed approach for simultaneous mandibular symphyseal split osteotomy and genioplasty

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Abstract. Performing a mandibular symphyseal split and genioplasty simultaneously and accurately is a technical challenge for the surgeon. The aim of this study was to validate a reversed approach for simultaneous symphyseal split and genioplasty. A cutting guide and a repositioning guide were designed and printed three-dimensionally in titanium. The symphyseal split and genioplasty were performed successfully. The accuracy of the technique appears to be appropriate for clinical application.

Key words: mandibular symphyseal split osteotomy; genioplasty; 3D printing.

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The mandibular symphyseal split osteotomy is a useful procedure to correct a transverse discrepancy between the maxilla and mandible, especially in the situation of a normal maxilla and a widened mandible[1]. When performed together with genioplasty, this is technically challenging for the surgeon with regard to accurately performing the osteotomy and repositioning each bony segment in the desired position. Traditionally, the surgeon has had to manually place the two distal segments into an ‘ideal’ position with an occlusal splint, while the position of the chin segment has depended on the surgeon’s experience.

There have been reports on the use of computer-aided design and computer-aided manufacturing (CAD/CAM) templates for genioplasty[2–4]. However, it appears that there has been no report on the use of CAD/CAM surgical templates for simultaneous symphyseal split and genioplasty. The purpose of this article is to present a reversed approach for simultaneous mandibular symphyseal split osteotomy and genioplasty using a three-dimensionally (3D) printed titanium template/plating system. The design concept of the system is based on a previously reported genioplasty template system[2].

Materials and methods

The ultimate goal of the technique is to automatically reposition the bony segments in the planned position. A ‘reversed’ approach is used to achieve this goal, in which the osteotomies of the symphyseal split and genioplasty are guided by a CAD/CAM cutting guide, while repositioning of the two distal segments and the chin segment is automatically completed by a repositioning guide. Since the guides are 3D printed in titanium, the repositioning guide also serves as the fixation plate.

Design procedure

The technique is illustrated in a patient with a mandibular excess and maxillomandibular transverse discrepancy (widened mandibular body). His treatment plan included a maxillary Le Fort I osteotomy, bilateral sagittal split osteotomy (BSSO), mandibular symphyseal split osteotomy, and genioplasty. A computed tomography (CT) scan was acquired and a surgical simulation was completed following a computer-aided surgical simulation (CASS) protocol[5–9], using surgical planning software (ProPlan 2.0; Materialise Medical, Leuven, Belgium).

After the surgical simulation had been finalized, the cutting and positioning guides were designed in the computer (3-Matic software; Materialise NV, Leuven, Belgium) (Fig. 1). They were designed in a ‘reversed’ fashion. The key design element in both guides was the screw holes. They served as the bony reference landmarks. The repositioning guide plate was designed first, with the three bony segments in their final positions. The repositioning guide was divided into an upper and a lower portion, with a thickness of 1 mm, to rigidly hold the three segments together as planned. The upper portion of the repositioning guide included six screw holes, three for each distal segment. The lower portion of the guide included two screw holes for the chin segment (Fig. 1A).

To design the cutting guide, the screw holes, represented by cylinders, were digitally linked to their corresponding bony segments after the repositioning guide had been designed (Fig. 1B). Each segment was then sent back to its original position, taking the screw holes with it (Fig. 1C). This was done by perfect alignment to the original mandible. Thus, the cutting lines and screws were accurately mapped onto the original mandible prior to the osteotomy. The cutting guide was then designed on the original mandibular surface, for mapping the cutting lines, as well as covering the eight screw holes (Fig. 1D). Finally, both guides were fabricated using a 3D titanium printer (EBM A1, Arcam, Mölndal, Sweden).

An intermediate splint was designed in the computer and fabricated using a 3D printer (3D System ProJet 3510s; 3D Systems, Rock Hill, SC, USA) in the routine fashion[6]. The final splint was also printed, but was only used for cross-verification to ensure that the repositioning template worked as designed.

Surgical procedure

A routine intraoral incision was performed to expose the anterior surface of the mandible and the cutting guide was adapted to the mandibular surface as planned after the eight screws had been placed (Fig. 2A). The cutting lines for the symphyseal split osteotomy and genioplasty were marked. The cutting guide and the screws were then removed and the osteotomy was completed as routine, to split the distal mandible into three segments (Fig. 2B). After the bony collisions between the right and left distal segments had been removed, the repositioning guide was firmly installed onto the two distal segments by aligning the six screw holes of the distal segments to the corresponding holes on the guide, three pairs for each side. Next, the two screw holes on the chin segment were aligned to the corresponding holes on the guide. As the screws were placed and tightened, all three segments moved automatically into their final planned positions and the repositioning guide was seamlessly attached to them (Fig. 2C). Since the repositioning guide was printed in titanium, it was used as the fixation plate. As described earlier, the final splint was not used in the surgery to reposition the bony segments. Instead, it was used only to verify the final occlusion that was achieved with the repositioning guide. Finally, the surgical wound was closed in the routine manner.

A postoperative CT scan was acquired 3 days after the surgery. The 3D models of the midface maxilla and mandible were generated and imported into the same design software. The accuracy of the 3D printed titanium plates system was then assessed by comparing the actual postoperative outcome to the planned outcome using a surface deviation colour map[10].

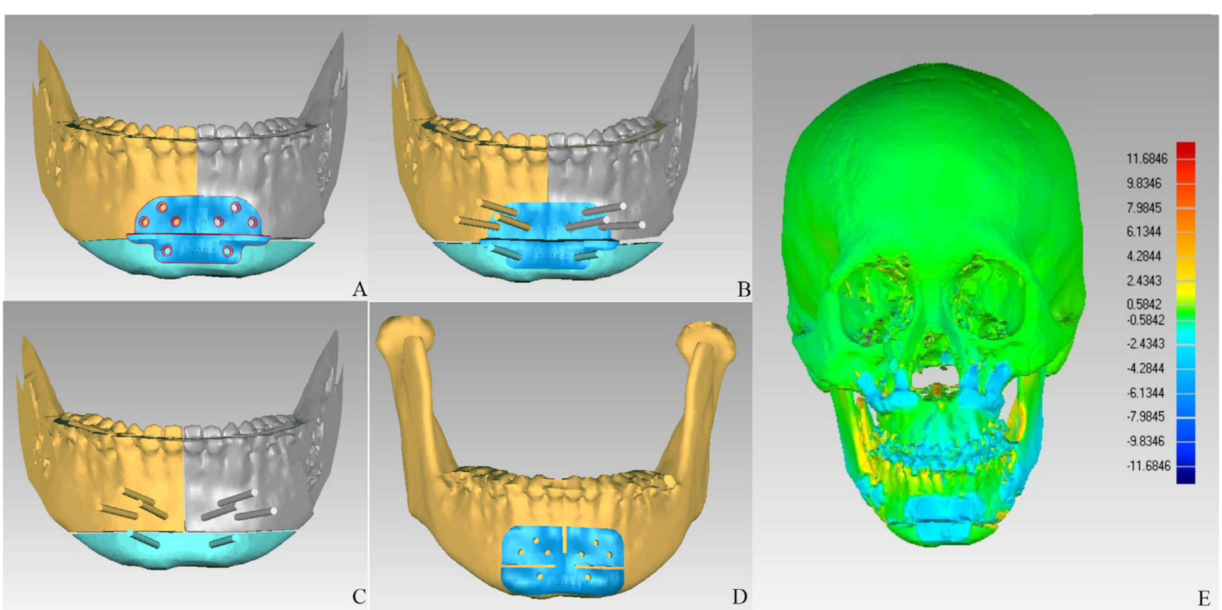

Fig. 1. The design procedure: (A) the repositioning guide was designed with eight screw holes, to cover the two distal segments and the chin segment in their final positions. (B) Cylinders were used to represent the screw holes and were digitally linked to their corresponding bony segments. (C) Each segment was sent back to its original position, taking the cylinders with it. (D) The cutting guide was designed to cover the two distal segments and the chin segment in their original positions, and not extended to the mental foreman. (E) A surface deviation technique (colour distance mapping) was used to assess the difference between the actual postoperative outcome and the planned outcome, and the results showed exceptional accuracy.

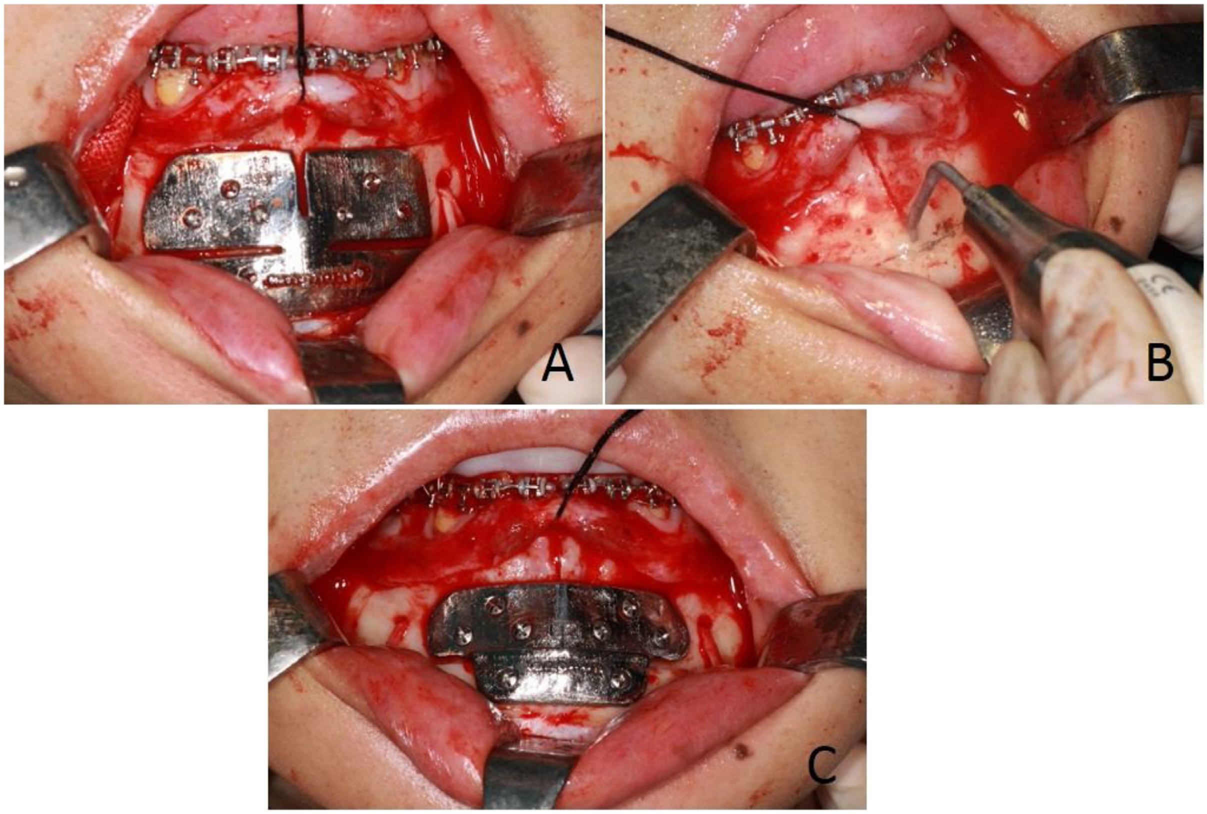

Fig. 2. (A) The cutting guide was adapted to the mandibular surface as planned. (B) The mandibular symphyseal split osteotomy was completed by piezoelectric surgery. (C) The two distal segments and chin segment were automatically repositioned, guided by the repositioning plate. The final splint fitted perfectly to the upper and lower dental arches after the final occlusion had been achieved by the repositioning guide.

The results showed exceptional accuracy between the planned results and those that were achieved (Fig. 1E).

Discussion

The mandibular symphyseal osteotomy was first reported in 1976, known as the midline osteotomy[1]. It quickly became a valuable technique for correcting transverse discrepancies of a wide mandible. However, the surgery is technically challenging, as the surgeon has to place the distal segments and chin segment into an 'ideal' position based on visual clues. The actual outcome is often inaccurate. The new technique presented here provides a simple and accurate method for simultaneous symphyseal split osteotomy and genioplasty. The results of this study showed exceptional agreement between the planned and actual outcomes.

The use of the CAD/CAM titanium template/plating system made it possible to perform osteotomies exactly as planned and reposition the two distal segments and chin segment automatically and simultaneously without the need for the surgeon's subjective judgment. This is a major advantage over the conventional procedure, in which intermaxillary fixation and an occlusal splint are used to reposition the two distal segments. The bony collisions, if removed incompletely, may directly affect the fitting of the lingual cusps of the lower teeth into the occlusal splint, thus leading to deviations in the mandibular width from the plan. Furthermore, when a separate genioplasty template system is used for genioplasty using 3D printed resin templates, the chin segment often has a larger pitch deviation from the plan. Due to the limited surgical access for the genioplasty, the design of the template is often thin, causing the template to be flexible. On the other hand, if the template is designed to be thicker, it becomes bulky and difficult to use intraoperatively.

There are significant advantages to the CAD/CAM titanium template/plating system presented here. With the reversed approach, bony collisions between the right and left distal segments are calculated and marked with the cutting guide for accurate osteotomy. In addition, all three bony segments are automatically repositioned into their final planned positions using the repositioning guide after the bony collisions have been removed. Moreover, unlike the conventional method, this method uses the repositioning guide, instead of intermaxillary fixation and the occlusal splint, to reposition the distal segments. This reduces the chance of a poor fit between the splint and the teeth, especially the lingual cusps. Furthermore, the incisor roots can be marked clearly to avoid tooth injuries during the mandibular symphyseal split and removal of bony collisions. Finally, the 3D printed titanium repositioning guide is also used as a custom fixation plate. As it is relatively thin at 1 mm in thickness, it is possible for the surgeon to accurately assess the lower third facial soft tissue intraoperatively.

In conclusion, this technical note presents a reversed approach for simultaneous mandibular symphyseal split and genioplasty using a CAD/CAM template/plating system. In the future, it is planned to perform a clinical study, involving a large patient sample, to study the accuracy of this method and draw definitive conclusions.

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Competing interests

None.

Ethical approval

Ethical approval was obtained from the hospital prior to initiation (2016-131-T80).

Patient consent

Not required.

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