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# Virtual Surgical Planning for Mandibular Distraction in Infants with Robin Sequence

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**Summary:** Mandibular distraction osteogenesis (MDO) successfully relieves obstructive sleep apnea in many infants with Robin sequence. Preoperative virtual surgical planning and fabrication of three-dimensionally printed cutting guides may lead to further improvements in the MDO technique and decrease the risk for damage to adjacent structures such as developing teeth and the inferior alveolar nerve. This report presents an algorithm for virtual surgical planning and three-dimensionally printing of cutting guides for MDO in infants with RS. *(Plast Reconstr Surg Glob Open 2017;5:e1379; doi: 10.1097/GOX.0000000000001379; Published online 16 June 2017.)*

## INTRODUCTION

Mandibular distraction osteogenesis (MDO) is commonly used to relieve retroglossal airway obstruction in infants with Robin sequence (RS).[1] Virtual surgical planning (VSP) may aid in device selection and placement, facilitate vector management, simplify the operation, improve precision, and decrease complications such as damage to adjacent developing teeth and nerves.[2] This report describes an algorithm for VSP and three-dimensional (3D) printing of cutting guides for MDO in infants with RS.

## VSP AND DEVICE PREPARATION

A preoperative maxillofacial CT is obtained utilizing head stabilization with or without sedation and intubation to reduce motion artifact. The images are uploaded to a third-party vendor, and a Web-based planning session is scheduled between the surgeon and a biomedical engineer. Virtual bone cuts to simulate the planned osteotomies are applied to the 3D images. Goals for osteotomy design include (1) minimize damage to developing dental structures, (2) avoid binding of the distal segment against the proximal segment during distraction, (3) avoid advancing the coronoid process, as this could lead to impingement with the zygoma during distraction, (4) provide sufficient bone in each segment for device fixation, (5) achieve the desired distraction vector, and (6) match the vector between sides.

Digital versions of the devices to be used are applied and angled to produce the desired distraction vector. Cutting guides are designed such that they will register in position against the mandibular inferior border and angle and guide holes are configured to correspond to screw positions (Fig. 1). Measurements of mandibular width and distances from the buccal cortex to underlying structures are indicated (Fig. 2). Guides and a to-scale mandibular model are then 3D printed and used to customize the device plates preoperatively.

## OPERATION AND DISTRACTION PROTOCOL

A 1 cm incision is created 2 cm below the mandible within a natural skin tension line, and the inferior border of the mandible is exposed. The guide is inserted and fit is confirmed. The buccal cortex is scored with a piezoelectric saw used through the guide. Selected screw holes are predrilled through the guide to index the planned device position, and the guide is removed.

A full thickness osteotomy is created through the mandible at the superior and inferior borders. In the location of the inferior alveolar nerve, as determined from the preoperative imaging, only a buccal corticotomy is performed. The activation arm is passed within a rubber catheter to an infraauricular exit site. The device is then applied in the position corresponding to the predrilled screw holes and is secured with 3–4 monocortical screws in each plate.

The device is activated and the osteotomy observed for separation. If tension is noted, the cut is then complet-

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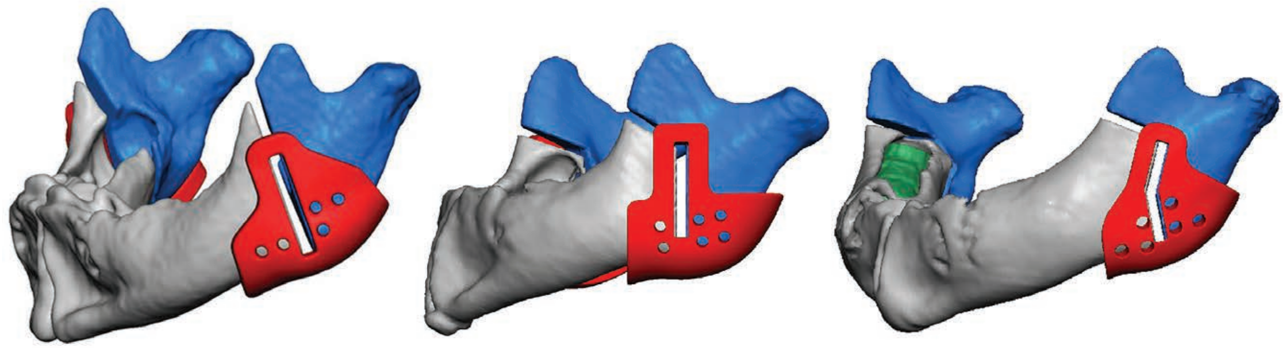

**Fig. 1.** Cutting guides are custom designed to register to the mandible and dictate the angle and position of the osteotomy and device screws.

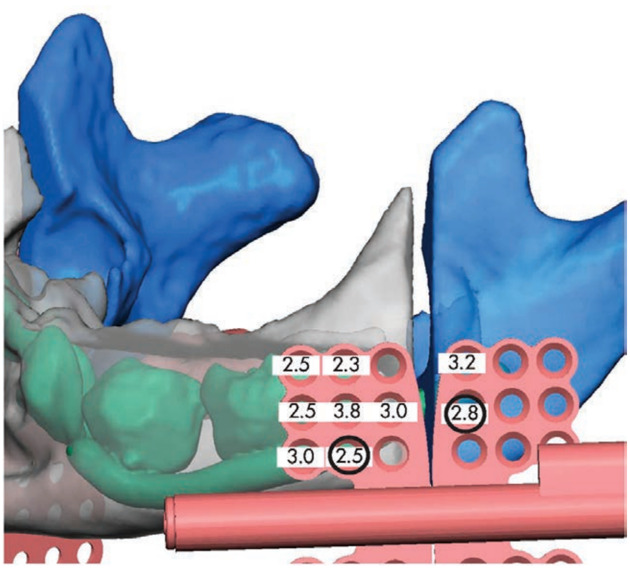


**Fig. 2.** Virtual surgical plan for a 26-day-old boy with RS. Measurements indicate distances from the buccal cortex to developing teeth and the inferior alveolar nerve (green structures).

ed through the lingual cortex with an osteotome. Once tension-free separation of the segments is achieved, the device is deactivated until it remains open 2 mm. The wound is irrigated and closed in layers. The operation is repeated on the other side.

The patient remains intubated postoperatively for 3–4 days to allow airway swelling to subside. Distraction begins on the first postoperative day, with 1 mm of activation per side twice daily (2 mm per day on each side). When the mandibular alveolar ridge is 2–4 mm anterior to the maxillary alveolar ridge, a postoperative polysomnogram is obtained. Based on the result of the polysomnogram, the decision is made either to discontinue distraction or to continue advancement. After distraction is completed, the activation arms are then removed at the bedside. Devices are removed 6–8 weeks later.

## FINDINGS

In experience with this technique at Boston Children's Hospital, cutting guides tended to fit well and directed the osteotomy and device placement as planned. Common osteotomy designs include linear oblique, inverted-L, and multiangular (Fig. 3). The inferior alveolar nerve was typically visualized within the distraction gap and intact (Fig. 4). At the time of device removal, bone was predictably found to be uniting the proximal and distal segments.

## DISCUSSION

VSP and 3D printing of guides for transfer of the virtual plan to the patient have revolutionized craniomaxillofacial surgery.[3–8] These techniques may enable similar benefits for infants with RS undergoing mandibular distraction.[2] This report describes an algorithm for virtual planning and execution of MDO in these infants.

VSP allows osteotomy design to be customized to the patient's anatomy, thereby minimizing damage to surrounding structures. Visualization of the mandibular anatomy via a 3D model and preoperative adaptation of the distraction device footplates shortens operative time. The use of intraoperative cutting guides improves precision and decreases the need for wide tissue dissection. Finally, virtual simulation assists in achieving the desired vector for distraction.

Disadvantages to VSP include exposure to ionizing radiation, possible need for anesthesia and intubation to obtain the CT imaging, and a potential delay in treatment due to the time required to perform the planning and fabricate the guides.

In conclusion, VSP and 3D printing of cutting guides for intraoperative use likely improves precision, decreases operative time, and improves outcomes for infants with RS undergoing mandibular distraction. These techniques are predictable and easy to apply.

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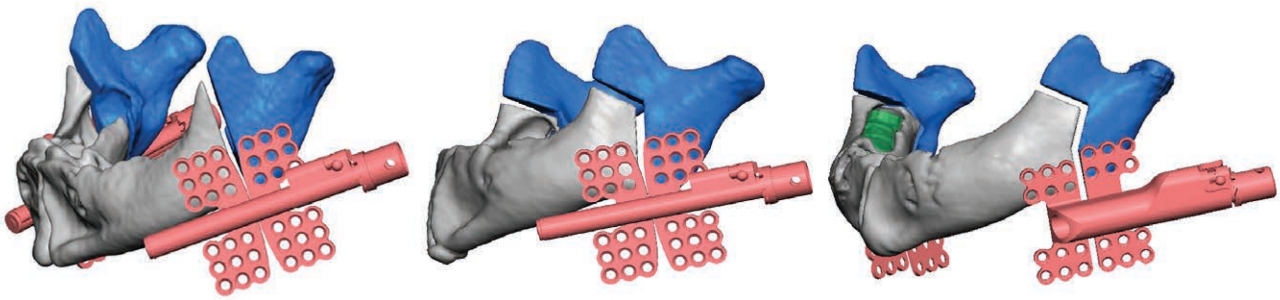

**Fig. 3.** Linear oblique (left), inverted-L (middle), and multiangular (right) osteotomy designs for mandibular distraction.

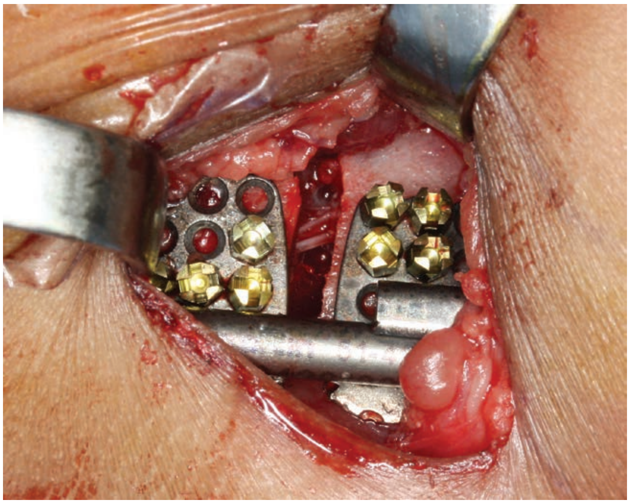

**Fig. 4.** The inferior alveolar nerve is preserved within the osteotomy after the segments are distracted.

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