International Journal of Pediatric Otorhinolaryngology 78 (2014) 381–384

Contents lists available at ScienceDirect

International Journal of Pediatric Otorhinolaryngology

journal homepage: www.elsevier.com/locate/ijporl

Case Report

Neonatal mandibular distraction osteogenesis: Converting virtual surgical planning into an operative reality

Matthew E. Doscher [a], Evan S. Garfein [a,b,d], John Bent [b], Oren M. Tepper [a,c,*]

[a] Department of Surgery, Division of Plastic and Reconstructive Surgery, Albert Einstein College of Medicine, Montefiore Medical Center, Bronx, NY, United States
[b] Department of Otorhinolaryngolgy, Albert Einstein College of Medicine, Montefiore Medical Center, Bronx, NY, United States
[c] Montefiore Advanced Reconstruction Care Program, Bronx, NY, United States
[d] Director, Montefiore Advanced Reconstruction Care Program, Bronx, NY, United States

ARTICLE INFO

Article history:
Received 6 August 2013
Received in revised form 21 November 2013
Accepted 21 November 2013
Available online 3 December 2013

Keywords:
Mandibular distraction osteogenesis
Virtual surgical planning
Neonate

ABSTRACT

Mandibular distraction osteogenesis (DO) has become an accepted method to manage severe cases of micrognathia-induced airway obstruction in neonates. Current imaging used to plan these procedures aids in surgical planning, but offers only a rough guide for the operating room. To our knowledge the following report offers the first description of virtual surgery used to guide DO in the mandible of a neonate. The plan provided a valuable link between the simulated procedure and the actual operative steps. Such technology can serve an important role in DO and offers objective guidance in device selection, vector planning and operative guide positioning.

1. Introduction

Mandibular distraction osteogenesis (DO) has become an acceptable method to manage airway obstruction in neonates born with severe micrognathia. By resulting in airway enlargement, DO can potentially avoid the need for tracheostomy [1–4]. Currently, two-dimensional X-rays or computed tomography (CT) scans are used for surgical planning, but these are limited by their inability to serve as a true intraoperative guide.

New developments in three-dimensional (3D) virtual surgical planning have the potential to bridge this gap [5–7]. Building from previous experience with head and neck reconstruction and facial trauma, we present the first reported use of virtual surgical planning to guide distraction osteogenesis of the mandible in a neonate.

2. Patients and methods

A female born at full term was noted to have glossoptosis, micrognathia and airway compromise consistent with Pierre Robin sequence (she did not have a cleft palate). After persistent failure to thrive and respiratory compromise, she required intubation on day of life (DOL) #15. Both MRI and CT imaging confirmed a hypoplastic mandible with significant retroglossal airway obstruction (Fig. 1). Based on her condition and anatomy, mandibular DO was offered as a treatment modality.

2.1. Virtual web meeting

CT scans of the craniofacial skeleton and a 3D data set of KLS MARTIN (Jacksonville, FL) distractors (16 mm × 16 mm × 0.6 mm in the closed position) were forwarded to Medical Modeling, Inc. (Golden, CO) for rendering. The goals of the web meeting between the surgeon (OT) and biomedical engineers were to determine (1) feasibility of device placement on the hypoplastic mandible, (2) device type, and (3) appropriate distraction vector.

The meeting also focused on creating guides/jigs to facilitate device implementation in the operating room. Cutting guides were designed to fit on the virtual mandible to reproduce the planned osteotomy. Next, we devised a system that would allow us to achieve the planned distraction vector. True parallel placement of the devices was particularly important in this child because of the lack of bony fusions at the mandibular symphysis; this posed an increased risk of fracturing or displacing the mandibular segment if the devices were placed in divergent paths. To ensure parallel positioning, distraction plates were overlaid on the mandible, which allowed the surgeon to identify the slots in the devices and

* Corresponding author at: Department of Surgery Division of Plastic and Reconstructive Surgery Albert Einstein College of Medicine, Montefiore Medical Center, 1625 Poplar Street, Suite 200, Bronx, NY 10461, United States.
Tel.: +1 718 405 8444; fax: +1 718 405 8345.
E-mail addresses: orenteppermd@yahoo.com, otepper@montefiore.org (O.M. Tepper).

0165-5876/$ – see front matter
http://dx.doi.org/10.1016/j.ijporl.2013.11.029

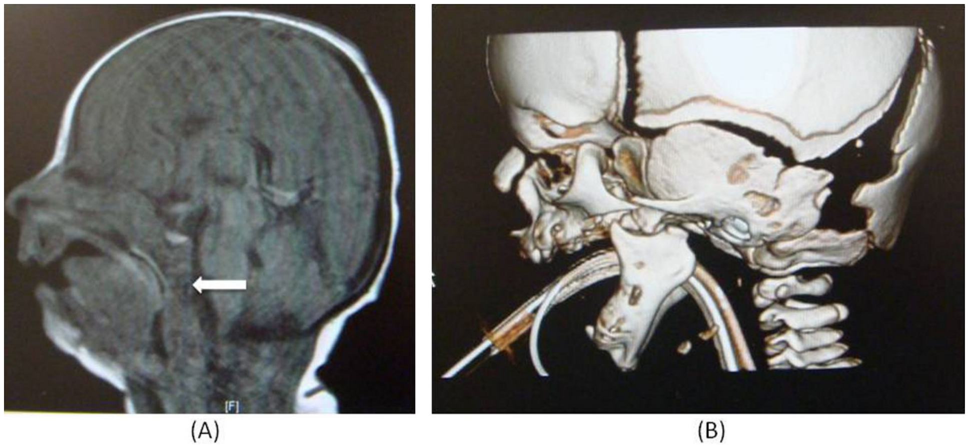

Fig. 1. (A) MRI demonstrating significant retroglossal airspace obstruction (arrow). (B) CT of the craniofacial skeleton demonstrating a hypoplastic mandible, shortened vertical ramus, with a slightly flattened condylar head (Pruzansky IIB).

their counterparts in the cutting guides (Fig. 2). Other key features identified at each slot position included measurements of mandibular thickness and areas at risk for injury to the inferior alveolar nerve.

3. Results

3.1. Operative course

Direct laryngoscopy by the otolaryngology service (JB) confirmed a narrow retroglossal airspace that improved with advancement of the lower jaw. We therefore proceeded with distraction on DOL #26. Two 0.028 K wires were placed across the mandibular midline to temporarily secure the lower jaw across the synchondrosis. The jaw was accessed via bilateral Risdon incisions, and the sterilized cutting guides were positioned on the mandible as planned. As predicted from testing on the stereolithographic model, the morphology/topography of the mandible was unique such that the guide would only "snap-on" if appropriately placed in the planned position. The guide was secured with two 0.028 K wires at the preplanned sites, and the osteotomy was performed. The guide was then replaced with the distraction device by sliding this over the K wires using the preplanned holes in a technique similar to the Seldinger method used for angiocatheter placement (the K wires and distraction plate holes were 0.7 mm and 1 mm in diameter, respectively) [8]. The device was secured with screws based on the measured bone depth and the K wires were removed (Fig. 3). Activation of the device was initiated on postoperative day 1, and performed at a rate of 1.5 mm/day. A total advancement of 20 mm was performed bilaterally.

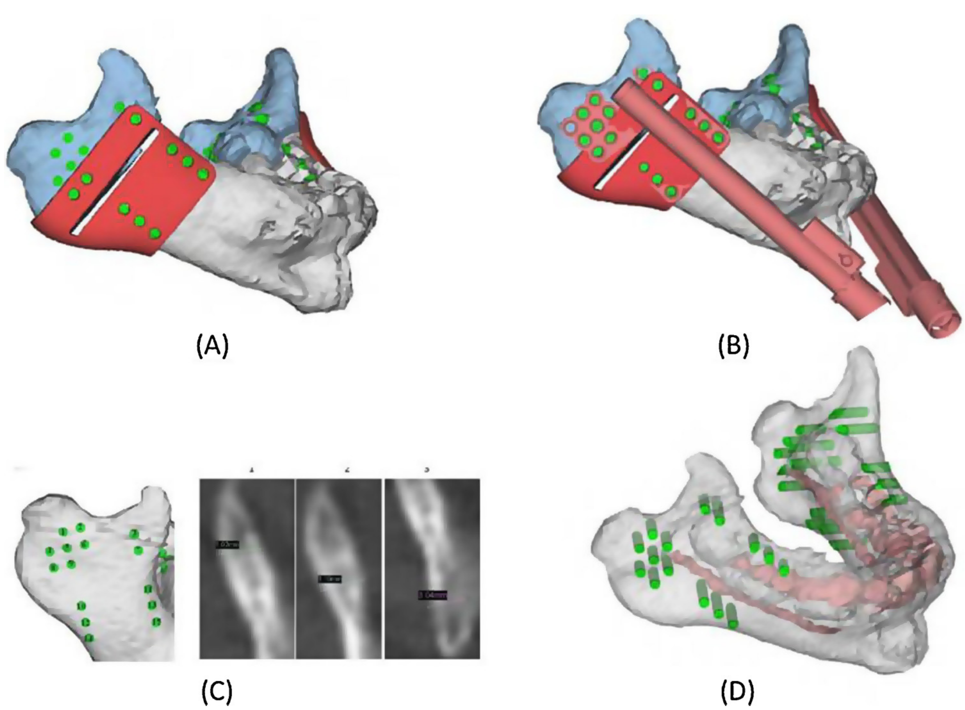

Fig. 2. (A) 3D virtual model of the patient's mandible with the cutting guide in place – green areas represent potential screw position. (B) Virtual model showing both the distraction device and cutting guide overlaid on one another. This allows one to see the relationship between the guides and the mandible. (C) For each of the preplanned screw positions, the thickness was measured so that we could pre-plan the appropriate screw to use for a bicortical bite. (D) With virtual demonstration of the nerve position, one could identify which screw positions should be avoided in the operating room. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of the article.)