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A novel digital nasoalvеolar molding approach for cleft lip and palate

Presurgical nasoalveolar molding (PNAM) is a widely accepted approach applied before cheiloplasty for infants with unilateral cleft lip and palate (UCLP), which can effectively reduce the width of the cleft gap, to align and approximate the intraoral alveolar segments, and to improve surgical outcomes. However, the treatment is time-consuming, which requires weekly visits over a period of 2-3 months to complete the appliance modification manually.

Three-dimensional (3D) printing has been hailed as a disruptive technology that will change manufacturing. New applications are being developed in orthodontics. For example, computed models can suggest stages be tween current and desired teeth positions, and aligners are designed and created precisely for each stage. Inspired by this application, Zheng et al. (2019) attempted to apply digital technology to presurgical orthopedics for infants and they reported a UCLP neonate who received the novel PNAM treatment. First, they modifified the integrated structure of the traditional PNAM into a split type. Then they designed and printed the intraoral molding plates (Fig. 1). To reduce the number of follow-up visits, they used 3D software and equipment to precisely compensate for the alveolar growth in each appliance. Meanwhile, the authors creatively used a nasal hook to replace the traditional nasal stent to support the deformed nasal alar cartilage adequately. A nasal hook was used synchronously with the intraoral molding plate (Fig. 2).

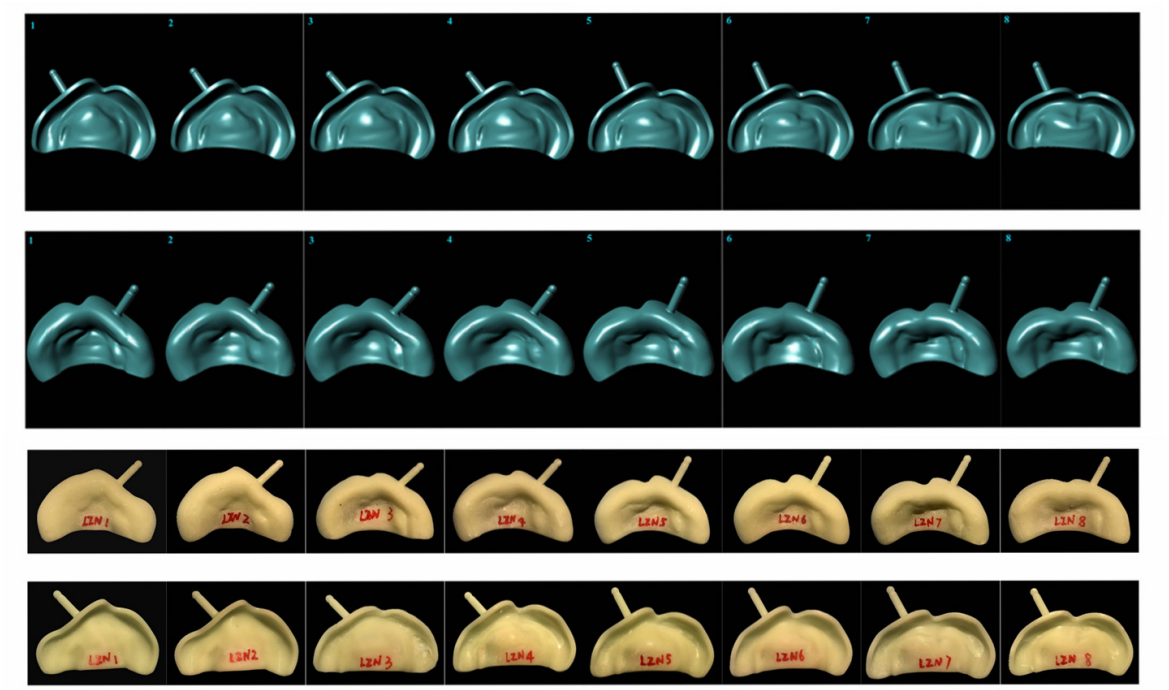

Fig. 1. Computer-aided design of a series of alveolar molding plate (upper) and 3D printed plates (lower).

After treatment, the width of the alveolar cleft and the sagittal arch length of the anterior arch decreased with the use of split-type PNAM appliances. The upper denture midline deviation was also corrected. The contour of the alveolus was normalized without collapsing the alveolar segments. The relative width of the nose was generally perceived to be narrowed by the nasal hook treatment, with a simultaneous lengthening of the columella. The alignment of the nasal base region was achieved by bringing the columella to ward the midsagittal plane, and the symmetry of the nostril apertures was improved. As Figure 2 showed.

The team proposed that the application of split-type 3D-printed PNAM has three advantages, which can be summarized as precision, personalization, and simplicity.

Precision. By applying the digital technology to the manufacture of the molding plate, expected movement distance and rotation angle of the alveolar segments can be precisely designed before treatment. A nasal hook independent from the intraoral device is used synchronously with the molding plate, which props up the nasal tip stably in the right direction.

Personalization. The patient's personalization is represented by days of birth, cleft type, width of cleft gap, etc. Personalized treatment plan should be designed considering neonate's initial state. Patients with a narrow cleft gap, for example, need alveolus outward growth first and rotation behind to avoid the overlapping of 2 alveolar segments; although it is diametrically opposite for neonates with a wider cleft gap. Personalization of the surgeon also needs to be considered. Different surgeons have different surgical characteristics. A number of surgeons require a total closure of the gap before cheiloplasty whereas some others want a certain gap to be reserved to facilitate a vomer flap operation. Application of digital technology in 3D printing of PNAMs can set the final state of alveolar molding in the initial stage to meet the individual needs.

Fig. 2. A UCLP neonate treated with digital PNAM appliances. In left-to-right order, pre-treatment, mid-treatment, post-treatment and after cheiloplasty.

Simplicity. As mentioned above, weekly visits of PNAM treatment are inconvenient for CLP families in remote regions. Digital technology assists physicians in designing and printing all of the intraoral molding plates before treatment. Under this circumstance, the digital approach can greatly decrease the subsequent visit frequency. Moreover, even inexperienced physicians in remote areas can treat CLP patients via assistance provided by cleft lip and palate centers in advanced cities.

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