IDEAS AND INNOVATIONS

Dynamic Presurgical Nasal Remodeling in Patients With Unilateral and Bilateral Cleft Lip and Palate: Modification to the Original Technique

Ricardo D. Bennun, M.D., M.S., Ph.D., Alvaro A. Figueroa, D.D.S., M.S.

Objective: **To present technical modifications to the original presurgical nasal remodeling appliance introduced in 1991. The purpose of the modifications is to improve the cleft nasal deformity before unilateral and bilateral cleft lip repair.**

Method: **The principle behind this technique, known as dynamic presurgical nasal remodeling (DPNR), is the use of the force generated during suction and swallowing. A conventional intraoral plate is built with a nasal extension added to the labial vestibular flange. The nasal extension was modified and consists of three components. The palatal plate is left loose in the mouth to generate a discontinuous but controlled impact directed to the affected nasal structures during suction and swallowing. The principle aim of the DPNR technique in unilateral cases is to improve the deformation of nasal structures by straightening the columella, elevating the nasal tip, and remodeling the depressed cleft side alar cartilages. In bilateral cases, the aims are to elongate the columella and to obtain nasal tip projection.**

Conclusions: **The modifications introduced in the appliance enhance the original DPNR technique and are effective in ameliorating the initial cleft nasal deformity. This facilitates primary surgical cleft lip and nose correction and improves surgical outcomes in patients with complete unilateral and bilateral cleft lip and palate.**

KEY WORDS: *cleft nasal deformity, dynamic presurgical nasoalveolar remodeling, presurgical infant orthopedics, unilateral and bilateral cleft lip and palate*

Most surgeons agree that primary correction of the nasal deformity is important. Dissatisfaction with the long-term results, obtained with any of the available surgical techniques, stimulated us to modify conventional surgical strategies.

To improve the chances for better nasal outcomes after cleft lip surgery, during the past 18 years, an intraoral plate with a nasal extension has been used to reshape and improve the primary nasal deformity in patients with unilateral and bilateral cleft lip and palate (Dogliotti et al., 1991). The original technique consists of an intraoral palatal plate to which an acrylic extension is attached to the vestibular flange on the side of the cleft and directed toward the nose (Fig. 1). Once the plate is in the mouth, it remains loose. When the patient prepares to swallow, suction is created after a seal is achieved in the mouth by the plate obturating the cleft. In addition, the action generated by the tongue and nipple assists in elevating the plate. The nasal extension of the plate pushes cranially, applying pressure to the underside of the nasal cartilage on the affected side (Fig. 1). This pressure remodels the nasal structures, improving nasal form by straightening of the columella in patients with unilateral clefts. In addition, it stretches the nasal and labial soft tissues (Fig. 1). In patients with bilateral clefts, two extensions are used, which result in elevating and narrowing the nasal tip, rounding the nasal cartilages, and elongating the columella (Fig. 2). These changes follow established principles and morphological parameters for evaluating and treating patients with bilateral cleft lip and palate (Mulliken, 2001; Mulliken et al., 2001). In addition, the internal aspect of the plate can be adjusted by selectively adding and removing acrylic to reposition the alveolar segments and narrow the palatal cleft.

Dr. Bennun is Director, Cleft Lip/Palate and Craniofacial Programs, Asociación PIEL and Hospital de Clinicas, National University of Buenos Aires, Argentina. Dr. Figueroa is Professor and Co-director, Rush Craniofacial Center, Chicago, Illinois.

This work was presented, in part, at the 62nd annual meeting of the American Cleft Palate-Craniofacial Association, Myrtle Beach, South Carolina, April 4–9, 2005.

Submitted December 2005; Accepted February 2006.

Address correspondence to: Dr. Ricardo D. Bennun, Asociación PIEL, Palaa 536, Avellaneda, Buenos Aires, Argentina. E-mail rbennun@asociacion-piel.org.ar.

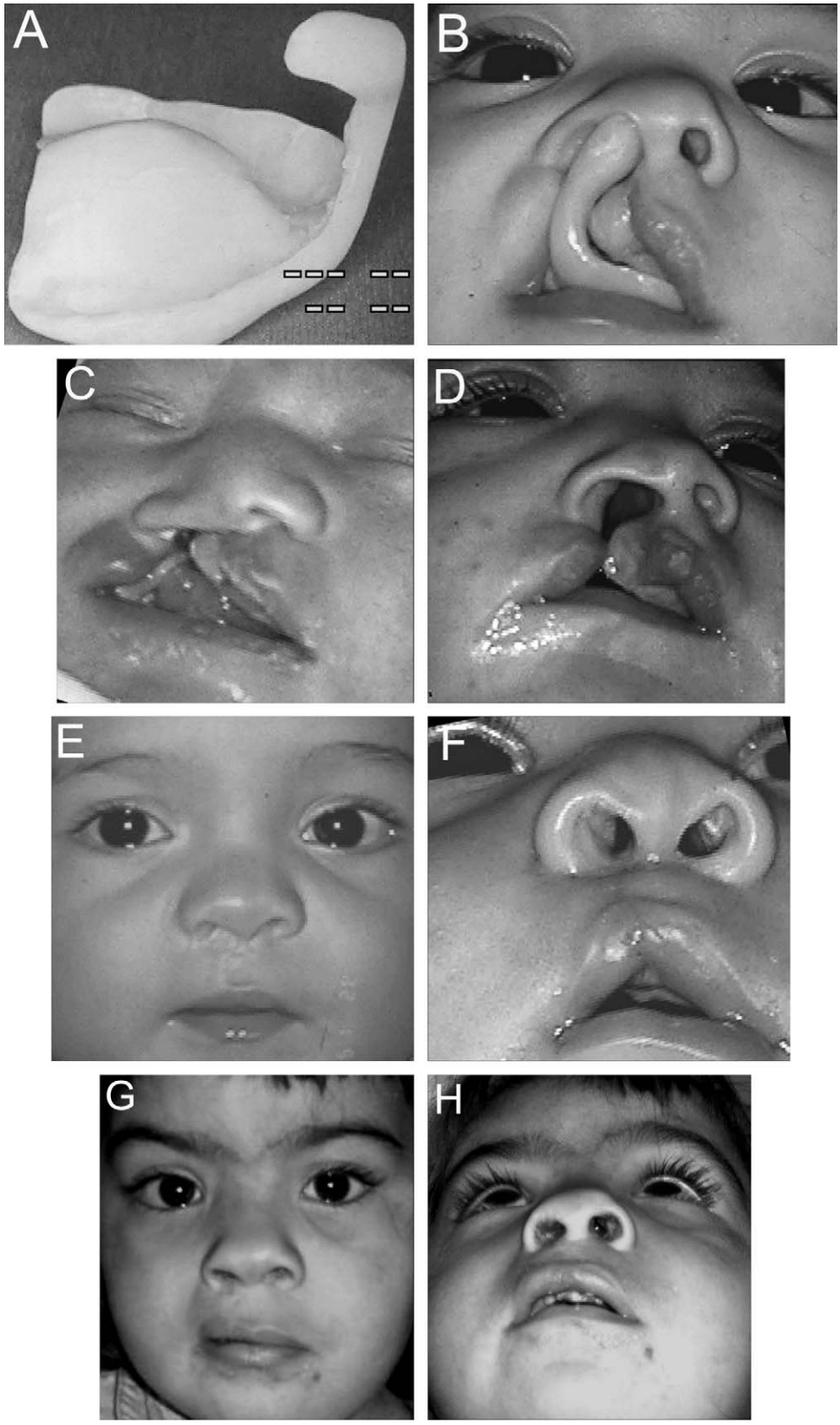

FIGURE 1 Patient with complete unilateral cleft lip and palate. A and B: Original appliance and patient undergoing nasal remodelling. C and D: Before and after remodeling. E and F: After lip surgery. G and H: After 6 years. Note the transformation of the nose after dynamic presurgical nasal remodeling and the good nasal symmetry after lip repair and 6 years of follow-up.

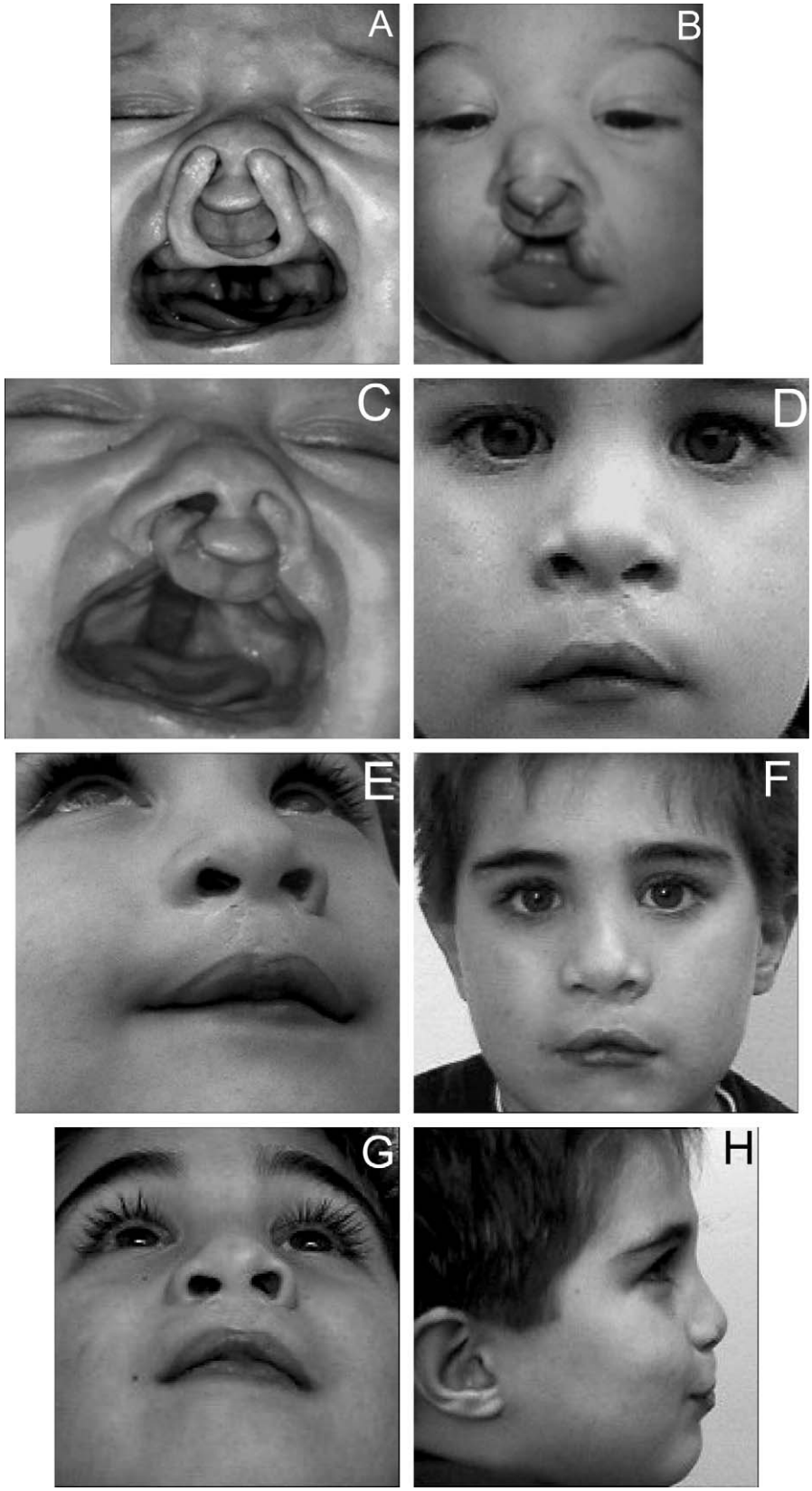

FIGURE 2 Patient with complete bilateral cleft lip and palate. A: Undergoing bilateral nasal remodeling with the original appliance. B and C: Before and after remodeling. D through F: After lip repair. G and H: After 5 years. Note the elevation of the nasal tip with significant elongation of the columella after dynamic presurgical nasal remodeling and the excellent nasal symmetry and projection after lip repair and 5 years of follow-up.

Although this technique is effective, it has some shortcomings, including (1) partial nasal obstruction due to the size of the nasal component; (2) a rebound effect from the displaced nasal structures that tends to displace the plate, reducing the time in contact of the nasal extension with the nasal tissues; (3) irritation and ulceration of the nasal mucosa that the nasal extension contacts, because the extension has no give or flexibility; (4) the need for frequent follow-up visits to prevent these undesirable effects, and (5) adjustments to the plate that require significant time. Therefore, it became clear that the presurgical nasal remodeling appliance had to be modified. The purpose of this paper is to present modifications to the original dynamic presurgical nasal remodeling (DPNR) appliance. The goal was to improve the DPNR technique and to develop a protocol that improves the outcome of the cleft nasal deformity.

Evolution of the DPNR Protocol

McNeil (1950) introduced the concept of early maxillary orthopedic treatment for cleft patients. Matsuo et al. (1984) reported that the use of a stent in the deformed neonate auricular cartilage reduced the need for otoplasty. Also, later, Matsuo et al. (1989) suggested the use of nasal conformers before and after cleft lip surgery to improve nasal form.

The literature on fetal wound healing indicates that, in neonates, the blood levels of maternal estrogens are high during the first days of life, giving neonate tissues elastic properties at the time of delivery. The elasticity of tissues is due to increased blood levels of hyaluronic acid, which cause intercellular material to remain disconnected (Hardingham and Muir, 1972; Kenny et al., 1973). From these studies, it appears that to permanently remodel the nasal cartilages and avoid relapse after intervention, treatment should be instituted during this early period.

The use of presurgical rigid nasal stents in newborns with unilateral or bilateral cleft lip and palate was initiated as early as 1987. The DPNR protocol used in a group of 80 patients was first published in the Spanish medical literature in 1991 (Dogliotti et al., 1991). These patients were followed up for 6 years (Bennun et al., 1999).

The idea of using a presurgical nasal component in cleft rehabilitation was adopted by other groups (Grayson et al., 1993; Yeow et al., 1999; Yang et al., 2003; Liou et al., 2004; Figueroa and Polley, 2006) and was popularized as the technique of naso alveolar molding (NAM; Grayson et al., 1999). However, DPNR differs from NAM because DPNR takes advantage of the dynamic force, originated during suction and swallowing, to produce the remodeling effects on the nasal structures. The DPNR technique does not rely on the relatively static force exerted by the orthopedic plate held in place by means of tape or adhesives.

In the last decade, it has been shown that correction of nasal cartilage deformity, lengthening of the vestibular skin, and nonsurgical elongation of the columella are possible (Bennun et al., 1999; Grayson et al., 1993, 1999; Maull et al., 1999; Yeow et al., 1999; Liou et al., 2004; Pai et al., 2005; Singh et al., 2005). A presurgical interdisciplinary approach to the cleft nasal deformity can lead to fewer surgeries and better outcomes, as well as the consequent social and economic benefits (Cutting et al., 1998; Santiago et al., 1998; Pfeifer et al., 2002).

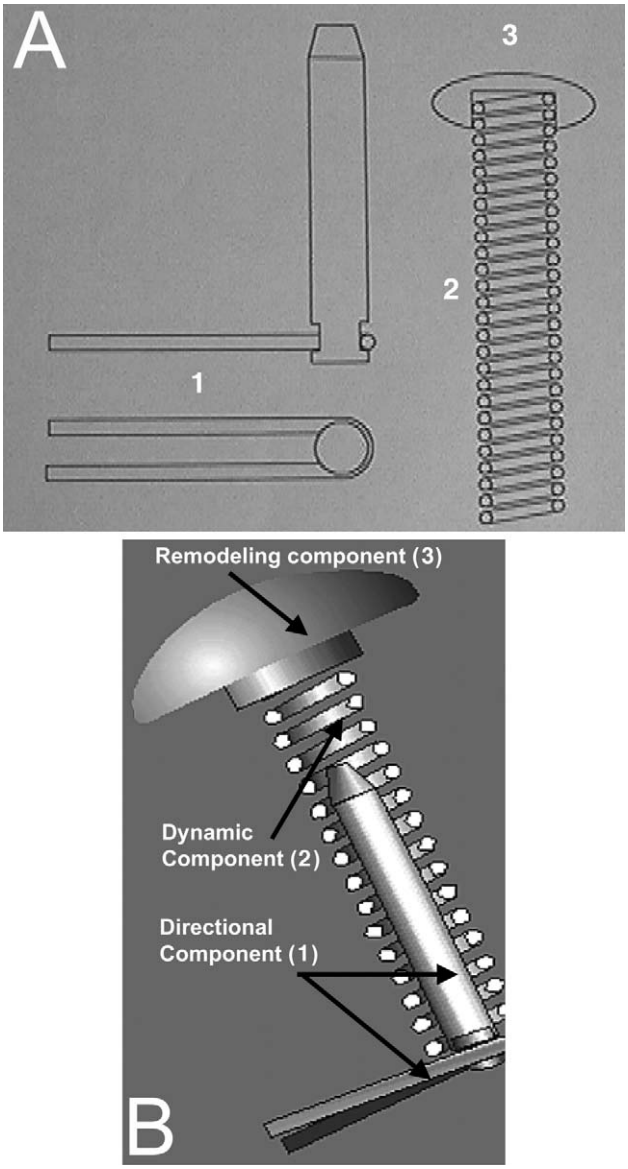

FIGURE 3 Diagram (A, B) illustrating all the components of the nasal extension of the new DPNR appliance. 1: Directional component ("U" wire and stent). 2: Dynamic component (spring). 3: Remodeling component (soft silicone "bumper").

Modification to the Original DPNR Appliance

The newly designed intraoral appliance has been described in the Spanish medical literature (Bennun et al., 2002) and consists of two elements: (1) a perfectly adapted conventional acrylic intraoral plate, which is left loose in the mouth of the neonate, and (2) a dynamic nasal bumper attached to the vestibular flange of the intraoral plate. It is placed lateral to the

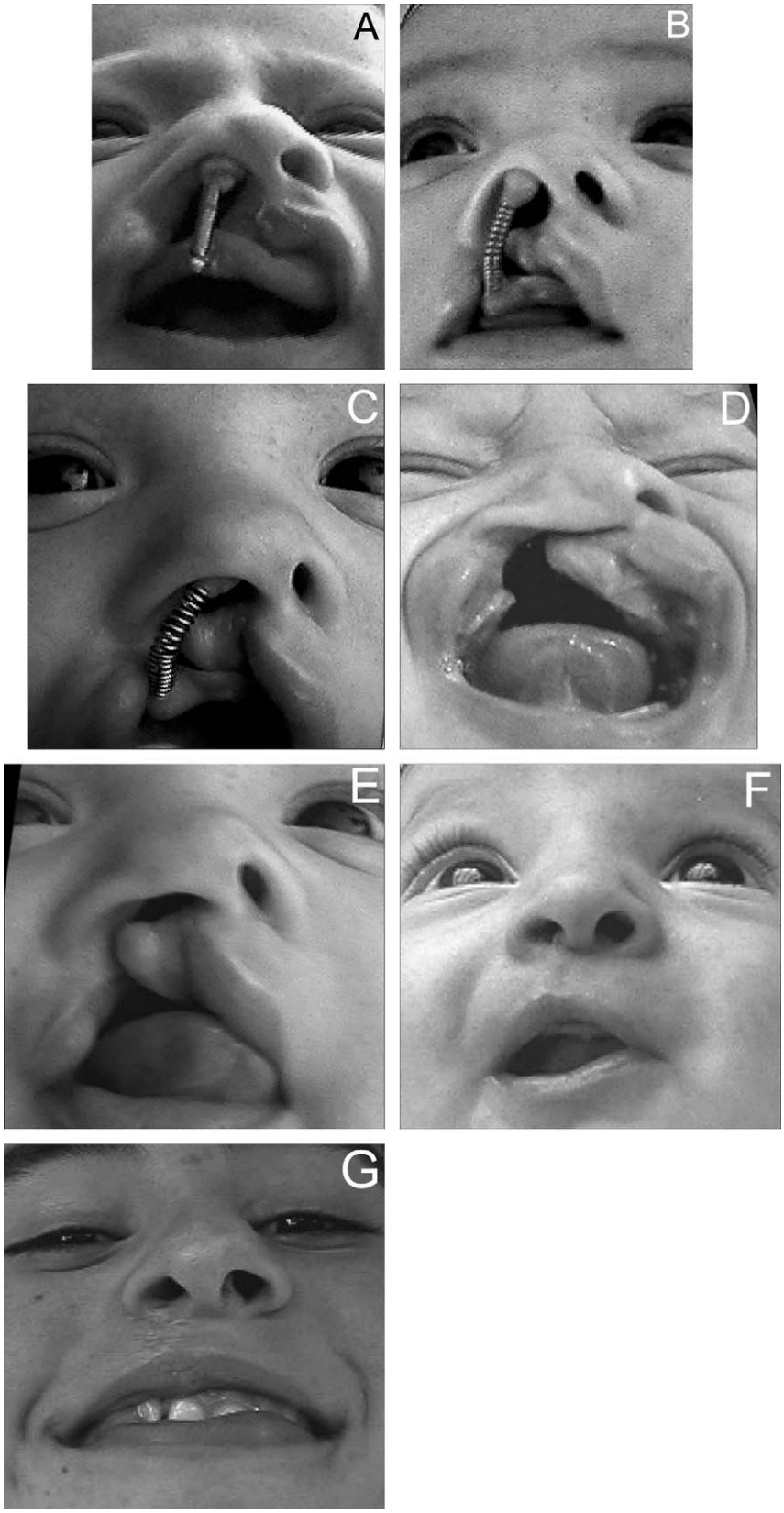

FIGURE 4 Patient with unilateral cleft lip and palate undergoing DPNR with the new appliance. A through C: Note the position changes on the directional component as treatment progressed. D and E: Nasal views before and after remodeling. F: View after lip repair. G: View after 16 years. Note the changes in alar cartilage convexity after DPNR and the excellent nasal symmetry and nostril form after 16 years of follow-up.

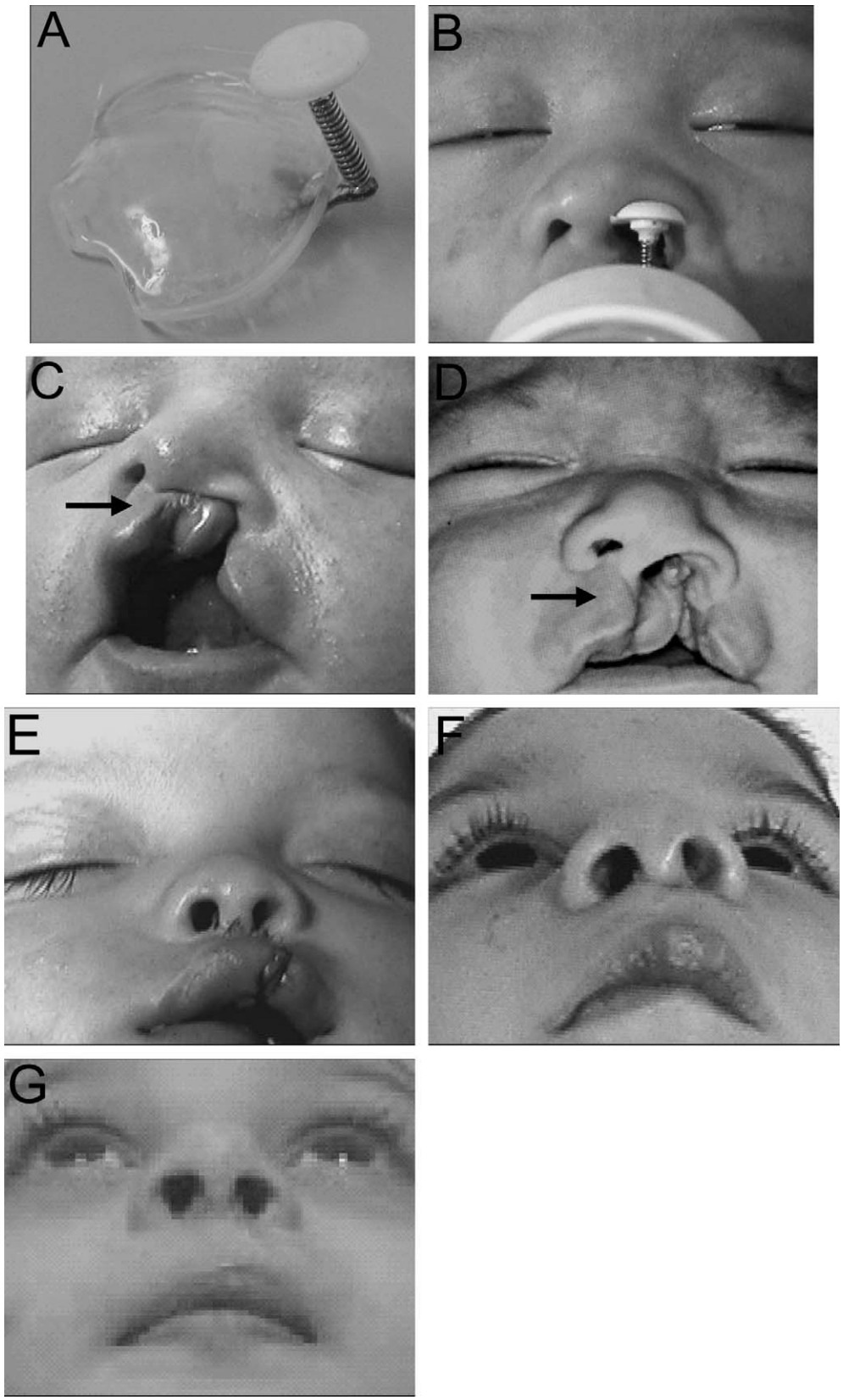

FIGURE 5 Patient with unilateral cleft lip and palate. A and B: The new appliance and patient undergoing DPNR. C and D: Before and after nasal remodeling. E: Soon after lip repair. F: After 3 years. G: After 8 years. Note the posttreatment height increase of the cleft side lip element (arrow), as well as remodeled nasal structures (C, D).

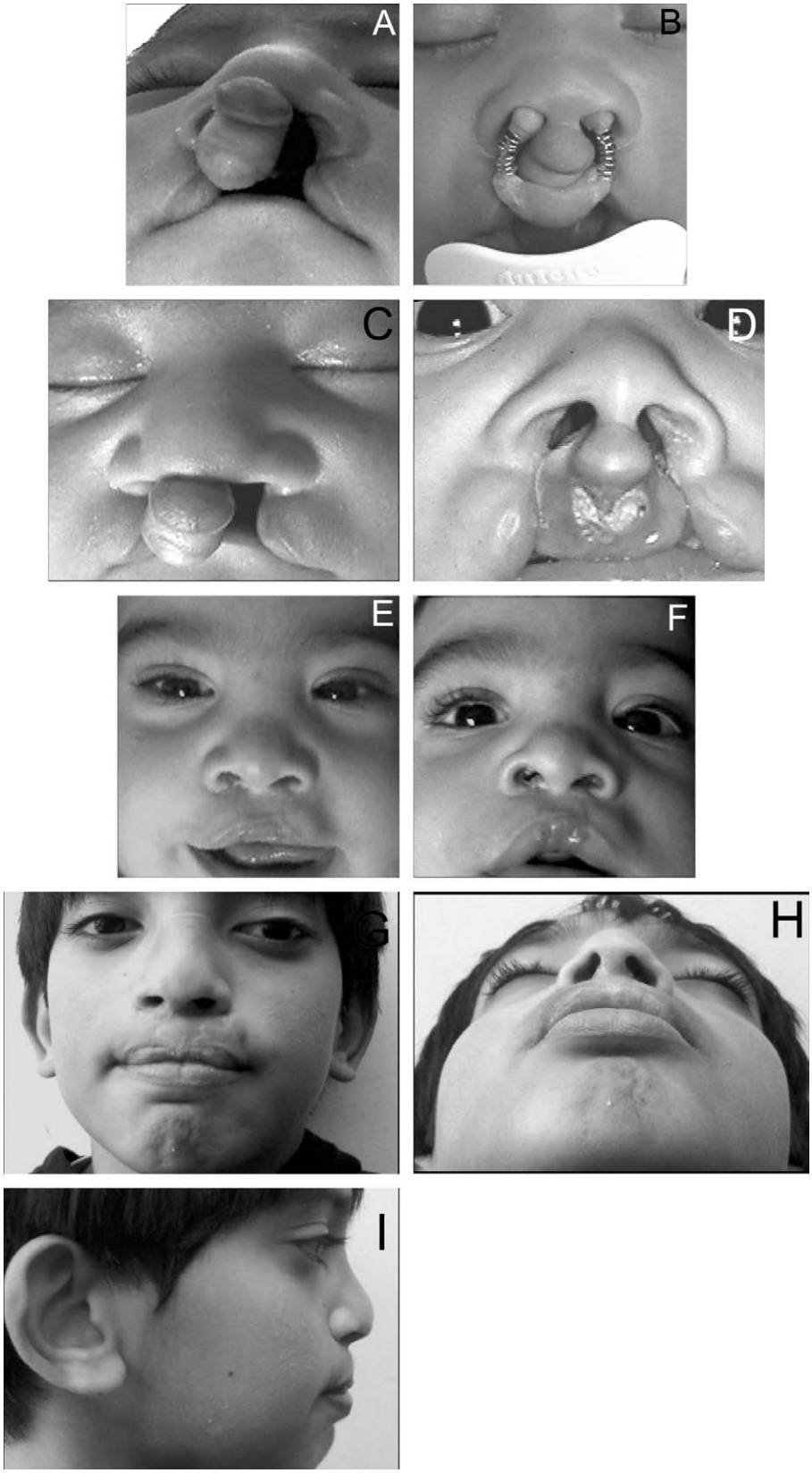

FIGURE 6 Patient with bilateral cleft lip and palate. A and B: Before treatment and undergoing DPNR with the newly designed appliance. C and D: Before and after nasal remodeling. E and F: After lip repair. G through I: After 11 years. Note the excellent tip projection, columella length, and nostril symmetry, without additional surgery since the primary lip repair.

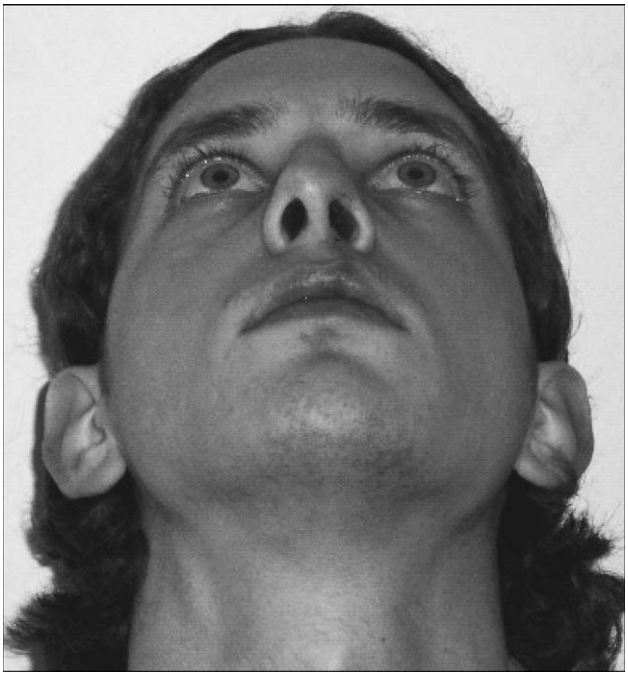

FIGURE 7 Nineteen-year-old male patient with repaired complete unilateral cleft lip and palate treated with the original DPNR appliance after final rhinoplasty. Note the excellent nasal projection, columellar length, and nasal and nostril symmetry.

plate midline, in line with the lip and alveolar cleft. In bilateral cases, two stents are used. It is manufactured from these three components (Fig. 3):

1. A directional component is introduced into the cleft side vestibular flange of the plate. It is made of a U-shaped wire that can easily be bent. The two free ends are secured to the plate, and the base of the ''U'' of the directional wire holds a soldered, vertical stainless steel bar or stent 2 mm in diameter. The bar is notched at its base, above the solder joint. The vertical bar comes in different lengths and can easily be replaced by removing the U-shaped wire from the plate and placing a new one with a vertical bar of the desired length. The easily bent U-shaped wire allows modification of the vector of impact during swallowing and suction (Fig. 4).
2. A dynamic component, a stainless steel open coil spring (2.2-mm diameter), is inserted over the stent. It is used to regulate the impact force and to reduce rebound of the nasal extension or bumper. The coil exerts a force of 70 g/m for each millimeter of compression. The coil is approximately 3 mm longer than the stent. Full compression of the stent

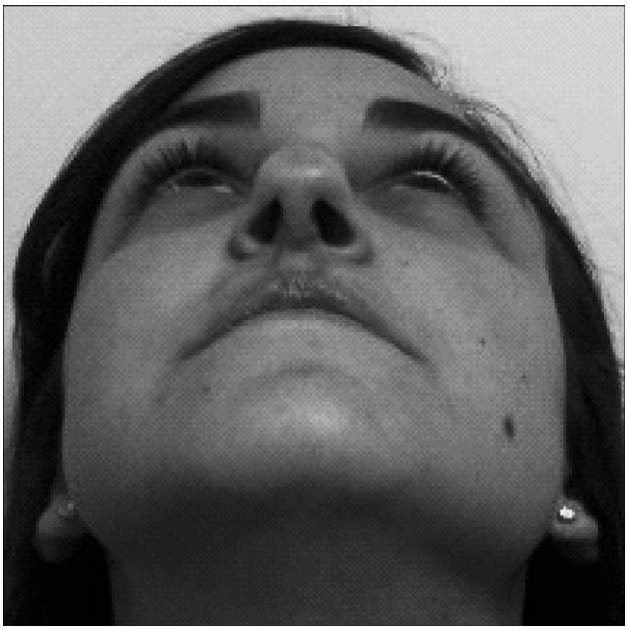

FIGURE 8 Nineteen-year-old female patient with repaired complete bilateral cleft lip and palate treated with the original DPNR appliance after final rhinoplasty and lip revision. Note the excellent nasal projection, columellar length, tip, definition, and nasal and nostril symmetry.

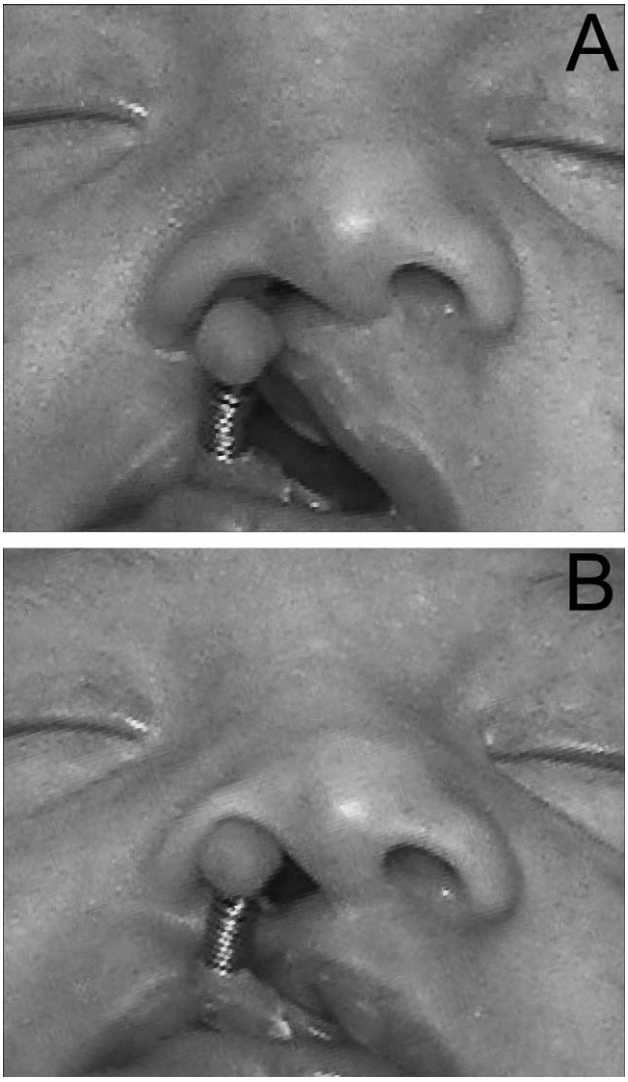

FIGURE 9 Patient with unilateral cleft lip and palate undergoing DPNR with the new appliance. A: Note the separation of the nasal bumper at rest. B: Note elevation of the nasal bumper during swallowing, exerting remodeling effect on the nasal structures.

can generate a force up to 210 g/m. The coil is crimped around the notch at the base of the vertical bar to prevent dislodging.

3. A remodeling silicone component (bumper) is mechanically attached to the cranial aspect of the open coil spring. It is in direct contact with the intranasal soft tissues. It was designed to avoid soft tissue lesions in the delicate nasal mucosa and to obtain a superior remodeling effect of the nasal structures. The bumpers are made of various diameters; larger sizes are usually utilized in the later stages of treatment.

Clinical Results

Since the introduction of this modification to the DPNR technique, 32 patients with unilateral cleft lip and palate and 19 patients with bilateral cleft lip and palate have been treated. Figures 4, 5, and 6 demonstrate typical results obtained with the modified DPNR appliance. With this appliance, it is possible to significantly alter and improve the original cleft nasal deformity. In addition, the tolerance and comfort of the patient has been improved, and the modifications needed during follow-up have been simplified, significantly reducing the time required to do adjustments and increasing the interval between appointments.

Discussion

The cleft nasal deformity in the infant born with a cleft lip and palate can be improved before the primary lip operation by using the concept of nasal remodeling. After remodeling, the challenging original nasal deformity is improved to such a degree that favorable nasal outcomes are expected regardless of the surgical technique used for primary lip and nasal repair. This remodeling is possible because of the ability of the infant-stage nasal cartilages to maintain new form after repositioning and remodeling. The DPNR technique using an intraoral plate with a nasal extension to remodel the cleft nasal deformity was first published in 1991 (Dogliotti et al., 1991). This technique has been applied in patients with unilateral and bilateral clefts, resulting in improved early outcomes after primary lip surgery (Figs. 1 and 2). A 6-year follow-up study of the original group of patients, with complete unilateral cleft lip and palate treated with the DPNR technique, demonstrated that these patients had better nasal morphology than those in which the technique was not used. This study revealed that nasal morphology differences remained between the DPNR-treated groups and the age-matched, sex-matched, noncleft, control group. However, these differences were significantly less than the differences encountered between the groups not treated with DPNR and the control group. This indicated that the nasal morphology became closer after DPNR to noncleft nasal morphology (Bennun et al., 1999). Others have also showed this improvement after nasal molding before cleft lip surgery (Liou et al., 2004; Pai et al., 2005; Singh et al., 2005) and after cleft lip surgery (Maull et al., 1999).

The original group of patients treated with the DPNR technique has been followed up long term, and it has been noted that the secondary nasal deformities have been less severe and that the patients have required less complicated finishing rhinoplasties, with excellent clinical outcomes (Figs. 7 and 8).

However, the original design of the presurgical remodeling nasal appliance had some problems, including partial nasal obstruction, a rebound effect from the displaced nasal structures, irritation and ulceration of the nasal mucosa, the need for frequent follow-up visits, and plate adjustments that require significant time. This design has been modified to minimize these problems, with the main modification being a nasal adjustable and dynamic component (Figs. 3 through 6). This new appliance has been effective, easily tolerated by the patients, and accepted by the parents; and it has limited the number of visits and the time required to adjust the plate at each visit.

Conclusion

The concept of DPNR is a viable option to improve the original cleft nasal deformity before primary lip repair and to facilitate surgical reconstruction and improve postsurgical outcomes (Bennun et al., 1999).

The simple design of the appliance makes it useful in patients with unilateral and bilateral cleft lip and palate (Figs. 1, 2, 4, 5, and 6). The DPNR appliance (original and new) acts during suction, producing nasal remodeling (Fig. 9). The nasal component is adjusted gradually, repositioning and correcting the positional alteration of the lateral nasal cartilages (Fig. 4). When the DPNR protocol is instituted early, it avoids memory cartilage fixation. Furthermore, the nasal component acts not only on the nasal structures but on lip function by stimulating labial muscle contraction. It has been observed that after the use of the DPNR appliance, the length of the cleft side lip element improves (Fig. 5). In addition, the plate can be modified to narrow the alveolar and palatal clefts. The lip action may also help to produce bone traction on the anterior maxilla, which in turn may be favorable to further approximate the alveolar cleft segments (Yang et al., 2003; Suri and Tompson, 2004). In the future, we plan to analyze patients that underwent the DPNR protocol, with the new appliance, before final cleft nasal reconstruction in the adolescent years.

References

Bennun RD, Perandones C, Sepliarsky VA, Chantiri SN, Ulfe Aguirre MI, Dogliotti PL. Nonsurgical correction of nasal deformity in unilateral complete cleft lip: a 6-year follow-up. *Plast Reconstr Surg.* 1999;3:616–630.

Bennun RD, Zaszczynski S, Celnik R. Remodelacion naso-labial pre-quirurgica en fisura labio alveolo palatina: nuevo diseño del componente nasal. *Rev Arg Ortodoncia.* 2002;66:16–21.

Cutting CB, Grayson BH, Brecht L, Santiago P, Wood R, Kwon S. Presurgical columellar elongation and primary retrograde nasal reconstruction in one-stage bilateral cleft lip and nose repair. *Plast Reconstr Surg.* 1998;101:630–639.

Dogliotti PL, Bennun RD, Losoviz E, Ganiewich E. Tratamiento no quirúrgico de la deformidad nasal en el paciente fisurado. *Rev Ateneo Argent Odontol.* 1991;27:31–35.

Figueroa AA, Polley JW. Orthodontics in cleft lip and palate management. In: Mathes S, Ventz V, eds. *Plastic Surgery.* Philadelphia: Elsevier, 2006;271–310. *Pediatric Plastic Surgery.* Vol. 4. 2nd ed.

Grayson BH, Cutting CB, Wood R. Preoperative columella lengthening in bilateral cleft lip and palate. *Plast Reconstr Surg.* 1993;92:1422–1423.

Grayson BH, Santiago P, Brecht L, Cutting CB. Presurgical naso-alveolar molding in patients with cleft and palate. *Cleft Palate Craniofac J.* 1999;36:486–498.

Hardingham TE, Muir H. The specific interaction of hyaluronic acid with cartilage proteoglycans. *Biochem Biophys Acta.* 1972;279:401–405.

Kenny FM, Angsusingha K, Stinson D, Hotchkiss J. Unconjugated estrogens in the perinatal period. *Pediatr Res.* 1973;7:826–831.

Liou EJ, Subramanian M, Chen PK, Huan CS. The progressive changes of nasal symmetry and growth after nasoalveolar molding: a three-year follow up study. *Plast Reconstr Surg.* 2004;10:976–981.

Matsuo K, Hirose T, Otagiri T, Norose N. Repair of cleft lip with nonsurgical of nasal deformity in the early neonatal period. *Plast Reconstr Surg.* 1989; 83:25–31.

Matsuo K, Hirose T, Tomono T. Nonsurgical correction of congenital auricular deformities in the early neonate: a preliminary report. *Plast Reconstr Surg.* 1984;73:38–50.

Maull DJ, Grayson BH, Cutting CB, Brecht LL, Bookstein FL, Khorrambadi D, Webb JA, Hurwitz DJ. Long-term effects of nasoalveolar molding on three-dimensional nasal shape in unilateral clefts. *Cleft Palate Craniofac J.* 1999;36:391–397.

McNeil CK. Orthodontic procedures in the treatment of congenital cleft palate. *Dent Rec.* 1950;70:126–132.

Mulliken JB. Primary repair of bilateral cleft lip and nasal deformity. *Plast Reconstr Surg.* 2001;108:181–194.

Mulliken JB, Burvin R, Farkas LG. Repair of bilateral complete cleft lip: intraoperative nasolabial anthropometry. *Plast Reconstr Surg.* 2001;107:307–312.

Pai BC-J, Ko EW-C, Huang CS, Liou EJW. Symmetry of the nose after presurgical nasoalveolar molding in infants with unilateral cleft lip and palate: a preliminary study. *Cleft Palate Craniofac J.* 2005;42:658–663.

Pfeifer TM, Grayson BH, Cutting CB. Nasoalveolar molding and gingivoperiosteoplasty versus alveolar bone graft: an outcome analysis of costs in the treatment of unilateral cleft alveolus. *Cleft Palate Craniofac J.* 2002;39:26–29.

Santiago PE, Grayson BH, Gianoutsos MP, Kwon SM, Brecht LE, Cutting CB. Reduced need for alveolar bone grafting by presurgical orthopedics and primary gingivoperiosteoplasty. *Cleft Palate Craniofac J.* 1998;35:77–80.

Singh GD, Levy-Berkowski D, Santiago PE. Three-dimensional nasal changes following nasoalveolar molding in patients with unilateral cleft lip and palate: geometric morphometrics. *Cleft Palate Craniofac J.* 2005;42:403–409.

Suri S, Tompson BD. A modified muscle-activated maxillary orthopedic appliance for presurgical nasoalveolar molding in infants with unilateral cleft lip and palate. *Clin Plast Surg.* 2004;2:149–158.

Yang S, Stelnicki EJ, Lee MN. Use of nasoalveolar molding appliance to direct growth in newborn patients with complete unilateral cleft lip and palate. *Pediatr Dent.* 2003;3:253–256.

Yeow VKL, Chen PKT, Chen Y, Noordhoff SM. The use of nasal splints in the primary management of unilateral cleft nasal deformity. *Plast Reconstr Surg.* 1999;103:1347–1354.