Presurgical Orthopedic Treatment Ameliorates Postoperative Nasal Deformity After Cheiloplasty

(術前矯正による口唇裂術後の鼻変形の改善)

2014

筑波大学

足立孝二

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博 士 （医 学） 学 位 論 文

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CONTENTS

ABSTRACT

The author assessed the postoperative nasal form and symmetry after presurgical use of a Hotz plate (HP) in patients with unilateral complete cleft lip and palate (UCLP). The subjects were 28 infants with UCLP who underwent cheiloplasty. Of these subjects, 14 underwent presurgical orthopedic treatment using the HP (HP group), and 14 underwent the same treatment without the HP (non-HP group). Photographic records were obtained 1 and 6 months after cheiloplasty, and the results of anthropometric analysis were compared between the two groups. The nasal inclination and the ratio of the width of the nasal base to the total width of the nose were significantly improved in the HP group compared with the non-HP group at both post-operative time points. Thus, presurgical use of the HP significantly improved the nasal asymmetry and deformity in UCLP patients after primary cheiloplasty and nasal repair.

INTRODUCTION

Correction of the nasal deformity in unilateral cleft lip and palate remains challenging for surgeons. Treatment regimens have ranged from nonsurgical methods to extensive surgical procedures. Recently, an increasing number of surgeons has advocated early partial or complete surgical repair of the cleft lip and nose.

Various presurgical orthopedic methods intended to improve the surgical outcome are available for infants with cleft lip and palate. An early maxillary orthopedic device, the Hotz plate (HP), has been used to align and approximate the maxillary alveolar segments preoperatively in cleft lip and palate patients. The HP is applied to maintain or improve the dental arch form, and to control the effects of surgical lip closure (1-2). It encourages a passive orthopedic guidance of maxillary growth (3) and importantly, prevents the tongue from slipping between the cleft segment (4-5). Furthermore, continuous use of the HP until the time of palatoplasty seems to be effective for improving postoperative articulatory function (6). Preoperative treatment with the HP causes the dimensions of the upper part of the oral cavity of an infant with unilateral complete cleft lip and palate (UCLP) to approach those of infants without a cleft (7). Millard also reported that presurgical orthopedics can be of great value in aligning the cleft alveolus, reducing the width of the cleft, and correcting the depression of the cleft alar base (8).

The author has been using the HP since 2005. The author find that use of the HP to prevent lateral deviation of the lesser segment leads to the appropriate nasal morphology and nasal inclination after primary cheiloplasty and nasal repair. HP is also likely to improve the vertical deviation of the maxillary bone, so that the nasal inclination of the cleft lip and palate move closer to the normal positions. However, the effect of the HP on the nasal form after surgery has not been well established.

One report stated that, although it is generally agreed that a narrow cleft is easier to repair, it has not been proven that presurgical orthopedics facilitate nose and lip repair (9). Others reported that the use of presurgical orthopedics reduces the deformity of the nasal septum and improves the shape of the alar base (10), but an anthropometric assessment has not been performed. The purpose of this study was to assess the nasal

form and symmetry in infants with UCLP after primary cheiloplasty/nasal repair with and without prior HP treatment, using measurements from photographs of the patients.

MATERIALS AND METHODS

The author treated 179 infants with alveolar and palatal cleft between 2000 and 2008 at Tsukuba University Hospital. Of the total, 112 had unilateral cleft lip, 27 had bilateral cleft lip, and 40 had cleft palate only. Of the 112 infants with unilateral cleft lip, 28 had UCLP. Of these, the 14 consecutive patients whose first visit was between March 2000 and March 2005, who were not treated with an HP, were assigned to the non-HP group. The 14 consecutive patients who first visited between April 2005 and August 2008 underwent presurgical treatment with an HP, and were assigned to the HP group. The patients were Japanese infants who were newborn to 3 months old and had not undergone any previous surgical intervention. None of the patients had other craniofacial malformations or systemic disease. There were 11 infant boys and 17 infant girls. The clefts were on the left side in 20 patients and on the right side in 8 (see Table 1 for patient clinical data).

Presurgical orthopedics

The presurgical orthopedic treatment using the HP was performed at the Department of Oral and Maxillofacial Surgery of Tsukuba University. The HP is an acrylic plate that covers the alveolus and hard palate, mimicking a normal alveolus in the region of the cleft with no extension into the nose (Fig. 1). An oral impression was taken at the first examination, 1 to 33 days (mean, 8.4 days) after birth, and the HP was fitted 0 to 5 days (mean, 2.8 days) later. After a few days, they checked the patient for pressure ulcerations, especially in the region of the labial frenum. The HP was modified at weekly intervals to gradually approximate the alveolar segments and to reduce the size of the intraoral cleft gap, until cheiloplasty was performed, at the age of approximately 3 months. Parents were instructed to keep the HP in place at all times except for daily cleaning.

Primary cheiloplasty and rhinoplasty

All the patients underwent cheiloplasty at 3 months (mean, 117.9 days) by a rotation-advancement plus small triangular flap method (Onizuka's procedure) with anatomical reconstruction of the orbicular oris muscle, as described previously (11). After all the muscles and flaps were sutured, the nasal cartilage was corrected. Minimum subcutaneous undermining was carried out over both alar cartilages by a reverse-U incision (12). A silicon nostril retainer (Koken Co, Tokyo, Japan) was used for more than 1 month. The same surgeon performed all the surgeries.

Photography and measurements

A series of frontal view photographs was taken for each patient, at one and six months after the primary cheiloplasty. All of the photographs were taken using a standardized handheld technique by the same investigator with the same digital camera. Indirect anthropometric measurements were made on the photographs. The anthropometric landmarks were determined as described by Nagy et al (13). The following landmarks were used to observe the nasal configuration: endocanthion point (En), nasal alar point (Al), nasal subalar point (Sa), and pronasal point (Pn) (Table 2, Fig. 2). To assess the perpendicular replacement of the maxillary bone, the author used the most superior point of the nasal alar groove (Gr). Anthropometric constructs were determined according to these landmarks (Table 3, Fig. 3). The most important line was the facial midline, which was determined as the line perpendicular to the Enc-Enn line that bisected it at the midpoint. The anthropometric landmarks and constructs were plotted on the photographs and analyzed using the Image J® (version 1.42) software (National Institutes of Mental Health, Maryland, USA).

Nasal width: The ratio of the width of the nasal base to the total width of the nose was calculated to assess the nasal correction and dislocation of the maxillary bone. As the nasal width index, the ratio of the distance between the endocanthion points to the total width of the nose was calculated.

Position of the nose in the face: The ratio of the distance between the En and the Al (or the Gr) on the cleft side to that on the non-cleft side was determined to assess the development and dislocation of the maxillary bone.

Nasal symmetry and inclination: The midalar width on the cleft side was compared to that on the non-cleft side. To assess the inclination of the nasal base, the angle between the line connecting the endocanthion points and the line connecting the subalar points was measured, and the angle between the line connecting the Gr (or Al) points and the facial midline (columellar axis) was measured. The measurements and anthropometric landmarks used to analyze the nasal form are summarized in Table 4.

Statistical analysis

Data are presented as the mean±standard deviation of the mean. Student's t-test was used to compare the mean values of the measurements. The significance of a difference was accepted when the p-value was less than 0.05. Neither the sex nor the side of the cleft seemed to be a confounding factor.

Method error

The method error was assessed for interobserver reliability. An author (K.A.) and co-author (N.I.) plotted and measured each photograph. The measurements were subjected to intraclass correlation coefficient (ICC) determination.

RESULTS

A highly significant correlation (ICC=0.919) was found for the interobserver ratings (Table 5), and the mean values of the anthropometric measurements for the two groups are shown in Table 6.

Nasal width: The ratio of the width of the nasal base to the total width of the nose (Alc-Aln/Sac-San) was significantly higher in the HP group than in the non-HP group both 1 month (1.37±0.10 and 1.26±0.09 in the HP and non-HP groups, respectively: $P<0.01$) and 6 months (1.23±0.05 and 1.15±0.06 in the HP and non-HP groups, respectively: $P<0.01$) after surgery [Fig. 4A]. This difference indicated that the alar base deviation in the HP group was operatively corrected to a more appropriate position within the face, compared with the non-HP group.

The nasal width index was 1.02±0.07 (1 month), and 1.03±0.08 (6 months) in the HP group and 0.97±0.14 and 1.01±0.06 in the non-HP group, which were not significantly different. This result indicated that the total width of the nose in relation to the distance between the endocanthion points was unchanged by the HP pretreatment.

Position of the nose in the face: The Alc-Enc/Aln-Enn ratio was similar between the HP and non-HP groups at one month (0.91±0.18, 0.99±0.05 for HP and non-HP, respectively) and six months (1.07±0.07, 1.09±0.06) The Grc-Enc/Grn-Enn ratio was also similar between the HP and non-HP groups at one month (0.91±0.28, 0.87±0.05) and six months (1.11±0.07 and 1.15±0.08). Thus, there were no significant differences between the two groups in the nasal position in the face.

Nasal symmetry and inclination: The ratio of the midalar width on the cleft to that on the non-cleft side was 1.08±0.11 and 0.91±0.06 at one and six months, respectively, in the HP group and 1.07±0.10 and 0.94±0.07 in the non-HP group. There was no significant difference between the two groups. This result indicated that the postoperative nostril width of the cleft side and non-cleft side was almost equal with or without HP.

The inclination of the nasal base was 1.44±1.33 and 1.17±0.95 and one and six month, respectively, in the HP group and 1.42±1.13 and 1.45±0.78 in the non-HP group. There was no significant difference between the two groups. In most of the infants in both

groups, a nearly horizontal nasal base was achieved.

In the HP group, the angle between the line connecting the Gr points and the facial midline (Grc-Grn line∠midline) was significantly smaller than that of the non-HP group at both 1 month (93.7±2.50 and 96.1±3.29 in the HP and non-HP groups, respectively: $P<0.05$) and 6 months (92.9±2.62 and 96.1±2.32 in the HP and non-HP groups, respectively: $P<0.01$) after surgery [Fig. 4B]. This difference indicated that the nasal inclination in the HP group was closer to perpendicularity within the face compared to the non-HP group.

However, the difference in the angle between the line connecting the Al points and the facial midline in the HP group (92.7±1.87, 92.6±2.88) versus the non-HP (93.0±3.84, 93.8±1.65) group was not significant.

There were no differences between the two groups in the angle formed by the line connecting the Gr points and the columellar axis at one month (90.1±3.77 and 91.7±5.24 for the HP and non-HP groups, respectively) or six months (87.7±2.83 and 85.3±4.26). There was also no difference in the angle formed by the line connecting the Al points and the columellar axis at one month (88.9±3.37 and 89.1±5.69 for the HP and non-HP groups, respectively) and six months (87.3±3.27 and 84.0±4.92). The line connecting the Al or Gr points was almost at a right angle to the nasal axis in both groups 1 month after surgery, but this angle became slightly less perpendicular with the passing months.

The angle between the facial midline and the columellar axis 1 month after surgery was 4.30±3.85 in the HP group and 4.12±3.01 in the non-HP group, which was not significantly different. The average inclination of the nose 1 month after surgery in both groups was 4 degrees from the facial midline. However, the inclination 6 months after surgery was 5.66±2.67 in the HP group and 10.5±3.74 in the non-HP group, which was significantly different [Fig 4C]. In both groups, this angle was noticeable in the facial appearance, but the angle in the HP group was much closer to the facial midline than that in the non-HP group.

DISCUSSION

In the present study, the author founds that the ratio of the width of the nasal base to the total width of the nose was lower in the HP group than in the non-HP group, and the angle between the line connecting the Gr points (the most superior point of the nasal alar groove) and the facial midline was closer to a right angle in the HP group than in the non-HP group. In addition, the angle between the facial midline and the columellar axis was larger in the non-HP group than in the HP group. These results indicate that presurgical orthopedic treatment using the HP leads to a morphologically appropriate nasal inclination in infants with cleft lip and palate, and suggest that using the HP improves the outcome after primary nasal repair.

Although the HP has been applied for several decades, it is still unclear if its use improves the postoperative outcome, particularly of nasal deformities, in cases of unilateral cleft. On the other hand, the unilateral cleft nasal deformity itself has spurred much interest in the literature because of the difficulty in obtaining a good result with normal function and development. The nasolabial region can be collapsed, imbalanced, or asymmetric after primary repair. Facial proportion indices that relate to the clinical appearance of the nose are important measures of facial deformity, according to several reports (14-15). Mommaerts et al. reported that the most troubling deformity of cleft patients according to their parents is the asymmetric position of the nose within the face (16). Therefore, the proper positioning of the nose postoperatively is a focus of not only the surgeons but also the patient's family.

The use of modern presurgical orthopedic appliances for treating oral deformities is usually attributed to McNeil (17-18). During the second half of the 20th century, the HP became widely used for infants with cleft lip and palate. The HP separates the oral cavity from the nasal cavity, minimizes growth disturbance, and creates optimal conditions for the maxillary segments to develop their entire growth potential (1). Moreover, the HP is effective for improving postoperative articulatory function (6).

Recently, presurgical nasoalveolar molding (NAM) was also introduced for the preoperative correction of nasal deformities (19). This is an effective adjunctive therapy for correcting nasal deformities both preoperatively and postoperatively (20). Liou

reported that nasal asymmetry was significantly improved after NAM therapy and was further corrected to symmetry after primary cheiloplasty (21). However, they added that the nasal asymmetry significantly relapsed in the first year after the primary cheiloplasty. Furthermore, Chang et al reported that NAM therapy alone is insufficient to obtain long-term nasal correction (22). In addition, this method requires a great deal of cooperation by the parents or caregivers, and can lead to ulceration of the nasal lining, nasal bleeding, mega-nostril, and contact dermatitis by the surgical tape (23-24). If the postoperative effect of the HP is similar to that of NAM, HP would be the preferable method with respect to patient comfort and compliance.

In 1986, Salyer described the potential beneficial effect of using the presurgical appliance to guide the maxillary segments into the appropriate position before cheiloplasty (25). He suggested that the presurgical appliance helped improve the horizontal and vertical skeletal deficiencies by stimulating bone production before and after lip closure.

Mishima et al. reported that the degree of curvature of the palatal surface was smaller in a group treated with the HP than in a group without it (26). The HP principally helps to prevent lateral deviation of the segments caused by outward forces exerted by the orbicularis oris muscle. Therefore, the alar cartilage may be repositioned, and the width of the nasal base decreased postoperatively, as shown in the present study. In other words, HP facilitates both the primary cheiloplasty and nasal repair.

It is noted that the low growth of the lesser segments of the maxillary bone causes nasal asymmetry in infants with cleft lip and palate. Correction of the nasal inclination requires vertical correction of the maxillary bone by the HP, and our results indicate that using the HP encourages vertical development of the maxillary bone. Hotz et al. applied this treatment to encourage proper growth in patients from a very early age (1-2). The author confirmed the effectiveness of this use in our present analysis.

Suspecting that the HP has a similar effect as the hard palate, the author also performed our anthropometric analysis on 11 infants with cleft lip but without cleft palate. Interestingly, the angle between the line connecting the Gr points and the facial midline in these infants was much closer to that of the HP group (Mean±Standard Deviation: 93.9±2.19) (Data not shown) than of the non-HP group. There was no

significant difference between the nasal inclination of the HP group and that of the 11 cleft lip infants. This result suggests that, when used early in the treatment process for UCLP in infants, the HP functions much like the hard palate does in normal infants.

No matter how excellent the nasal repair, there is often an unavoidable return of the nasal asymmetry. To retain nasal symmetry, continuous treatment with an HP is very important. If a nasal deformity appears with growth, revisional surgery needs to be considered. In fact, the author performed revisional surgery of the nose in all of the patients of the non-HP group patients at the time of palatoplasty.

The landmarks the author used in this study have been widely used for clinical facial analyses, except for the Gr point (the most superior point of the nasal alar groove) (13, 21, 27-29). The cartilaginous structures of Asian noses are substantially different from those of whites in terms of their shape, size, thickness, and relationship with the underlying structures (30). The Gr is an important point, because the Asian nasal lobule, the movable lower third, is rounded, wide, and projects slightly laterally because of the greater intercanthal width (31-32). To analyze the inclination of the Asian nose, the line connecting the Gr points and the one connecting the alar bases are both important.

Photographs taken with a digital camera have several advantages for anthropometric studies (33-35). Digital cameras are simple to use without an extensive knowledge of lenses. The pictures can be checked immediately to determine the proper position and lighting, and transferred to computers more easily than traditional analogue films. Computer-screen analysis enables the easy and accurate enlargement of anatomical details, which improves the identification of landmarks (36). Photographic assessment is easier than live measurements for children or uncooperative subjects, on whom the identification of landmarks and measurement can be difficult. In addition, a number of different software packages are available for performing anthropometric analyses.

The influence of our procedures on nasal symmetry and proportion is an important issue. Our observation term was only six months after cheiloplasty, so its long-term implications are not yet clear. Nevertheless, the results clearly show that the HP played an invaluable role in improving the outcomes of primary cheiloplasty and nasal repair. A further direction of this study will be to strengthen our results using three-dimensional computed tomography.

In conclusion, nasal asymmetry and deformity were significantly improved after primary cheiloplasty and nasal repair in an HP-treated group compared with a non-HP group. These findings support the use of the Hotz plate for ameliorating postoperative nasal deformity after cheiloplasty.

This study was approved by the ethical committee of Tsukuba University Hospital.

Conflict of Interest

The author declares that they have no conflicts of interest.

REFERENCES

1. Hotz MM, Gnoinski WM. Effects of early maxillary orthopaedics in coordination with delayed surgery for cleft lip and palate. *J Maxillofac Surg* 1979;7:201-210
2. Hotz MM, Gnoinski WM, Nussbaumer H, et al. Early maxillary orthopedics in CLP cases: guidelines for surgery. *Cleft Palate J* 1978;15:405-411
3. Hochban W, Austermann KH. Presurgical orthopaedic treatment using hard plates. *J Craniomaxillofac Surg* 1989;17 Suppl 1:2-4
4. Bornert H, Dannhauer KH, Schmalzried D. Vertical changes in the positions of the cleft segments of patients with unilateral cleft lip and palate. Changes from birth to palatoplasty at the age of 10-14 months. *J Orofac Orthop* 2002;63:51-61
5. Durwald J, Dannhauer KH. Vertical development of the cleft segments in infants with bilateral cleft lip and palate: effect of dentofacial orthopedic and surgical treatment on maxillary morphology from birth to the age of 11 months. *J Orofac Orthop* 2007;68:183-197
6. Suzuki K, Yamazaki Y, Sezaki K, et al. The effect of preoperative use of an orthopedic plate on articulatory function in children with cleft lip and palate. *Cleft Palate Craniofac J* 2006;43:406-414
7. Kozelj V. Changes produced by presurgical orthopedic treatment before cheiloplasty in cleft lip and palate patients. *Cleft Palate Craniofac J* 1999;36:515-521
8. Millard DR, Jr. Earlier correction of the unilateral cleft lip nose. *Plast Reconstr Surg* 1982;70:64-73
9. Winters JC, Hurwitz DJ. Presurgical orthopedics in the surgical management of unilateral cleft lip and palate. *Plast Reconstr Surg* 1995;95:755-764
10. Kozelj V. The basis for presurgical orthopedic treatment of infants with unilateral complete cleft lip and palate. *Cleft Palate Craniofac J* 2000;37:26-32
11. Onizuka T. A new method for the primary repair of unilateral cleft lip. *Ann Plast Surg* 1980;4:516-524
12. Tajima S, Maruyama M. Reverse-U incision for secondary repair of cleft lip nose. *Plast Reconstr Surg* 1977;60:256-261
13. Nagy K, Mommaerts MY. Analysis of the cleft-lip nose in submental-vertical view, Part I--reliability of a new measurement instrument. *J Craniomaxillofac Surg* 2007;35:265-277
14. Borman H, Ozgur F, Gursu G. Evaluation of soft-tissue morphology of the face in 1,050 young adults. *Ann Plast Surg* 1999;42:280-288
15. Choe KS, Yalamanchili HR, Litner JA, et al. The Korean American woman's nose: an in-depth nasal photogrammatic analysis. *Arch Facial Plast Surg* 2006;8:319-323
16. Mommaerts MY, Nagy K. Analysis of the cleft lip-nose in the submental-vertical

view. Part II. Panel study: which is the most important deformity? *J Craniomaxillofac Surg* 2008;36:315-320

17. McNeil C. Orthodontic procedures in the treatment of congenital cleft plate. *Dent Rec* 1950;70:126

18. McNeil C. Congenital oral deformities. *Br Dent J* 1956;101:191

19. Grayson BH, Santiago PE, Brecht LE, et al. Presurgical nasoalveolar molding in infants with cleft lip and palate. *Cleft Palate Craniofac J* 1999;36:486-498

20. Nakamura N, Sasaguri M, Nozoe E, et al. Postoperative nasal forms after presurgical nasoalveolar molding followed by medial-upward advancement of nasolabial components with vestibular expansion for children with unilateral complete cleft lip and palate. *J Oral Maxillofac Surg* 2009;67:2222-2231

21. Liou EJ, Subramanian M, Chen PK, et al. The progressive changes of nasal symmetry and growth after nasoalveolar molding: a three-year follow-up study. *Plast Reconstr Surg* 2004;114:858-864

22. Chang CS, Por YC, Liou EJ, et al. Long-term comparison of four techniques for obtaining nasal symmetry in unilateral complete cleft lip patients: a single surgeon's experience. *Plast Reconstr Surg* 2010;126:1276-1284

23. Levy-Bercowski D, Abreu A, DeLeon E, et al. Complications and solutions in presurgical nasoalveolar molding therapy. *Cleft Palate Craniofac J* 2009;46:521-528

24. Barillas I, Dec W, Warren SM, et al. Nasoalveolar molding improves long-term nasal symmetry in complete unilateral cleft lip-cleft palate patients. *Plast Reconstr Surg* 2009;123:1002-1006

25. Salyer KE. Primary correction of the unilateral cleft lip nose: a 15-year experience. *Plast Reconstr Surg* 1986;77:558-568

26. Mishima K, Mori Y, Sugahara T, et al. Comparison between palatal configurations in UCLP infants with and without a Hotz plate until four years of age. *Cleft Palate Craniofac J* 2000;37:185-190

27. Horswell BB, Pospisil OA. Nasal symmetry after primary cleft lip repair: comparison between Delaire cheilorhinoplasty and modified rotation-advancement. *J Oral Maxillofac Surg* 1995;53:1025-1030; discussion 1031-1022

28. Li CH, Shi B, He X, et al. Evaluation of facial growth in non-cleft patients using the analysis method for patients after a cleft lip and/or palate repair. *J Plast Reconstr Aesthet Surg* 2010;63:277-281

29. Russell KA, Orthod D, Tompson B, et al. Correlation between facial morphology and esthetics in patients with repaired complete unilateral cleft lip and palate. *Cleft Palate Craniofac J* 2009;46:319-325

30. Kim CH, Jung DH, Park MN, et al. Surgical anatomy of cartilaginous structures of the Asian nose: clinical implications in rhinoplasty. *Laryngoscope* 2010;120:914-919

31. He ZJ, Jian XC, Wu XS, et al. Anthropometric measurement and analysis of the external nasal soft tissue in 119 young Han Chinese adults. *J Craniofac Surg* 2009;20:1347-1351

32. Watanabe K. New ideas to improve the shape of the ala of the Oriental nose. *Aesthetic Plast Surg* 1994;18:337-344

33. Bearn DR, Sandy JR, Shaw WC. Photogrammetric assessment of the soft tissue profile in unilateral cleft lip and palate. *Cleft Palate Craniofac J* 2002;39:597-603

34. Guyot L, Dubuc M, Richard O, et al. Comparison between direct clinical and digital photogrammetric measurements in patients with 22q11 microdeletion. *Int J Oral Maxillofac Surg* 2003;32:246-252

35. Polat-Ozsoy O, Gokcelik A, Toygar Memikoglu TU. Differences in cephalometric measurements: a comparison of digital versus hand-tracing methods. *Eur J Orthod* 2009;31:254-259

36. Shaner DJ, Bamforth JS, Peterson AE, et al. Technical note: Different techniques, different results--a comparison of photogrammetric and caliper-derived measurements. *Am J Phys Anthropol* 1998;106:547-552

FIGURE 1. The Hotz plate is an acrylic plate prepared from oral impressions that covers the alveolus and hard palate.

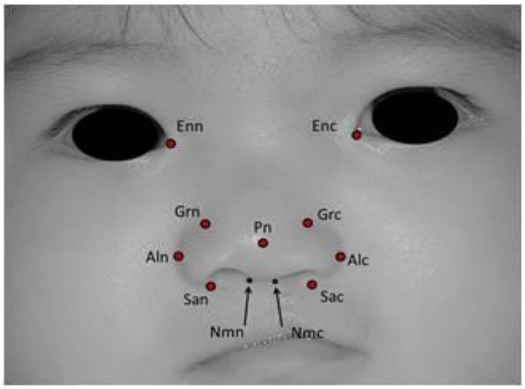

FIGURE 2. Anthropometric landmarks: Endocanthion, point on the cleft and non-cleft side (Enc and Enn); top of alar groove on the cleft and non-cleft side (Grc and Grn); alar point, on the cleft (Alc) and non-cleft (Aln) side; subalar point, on the cleft (Sac) and non-cleft (San) side; pronasal point (Pn); nostril medial point, on the cleft (Nmr) and non-cleft side (Nmn).

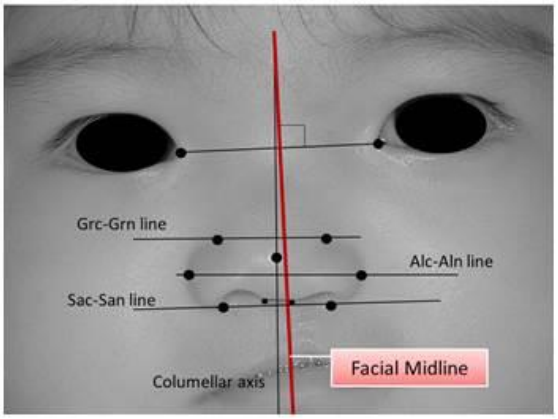

FIGURE 3. Anthropometric constructs: Enc-Enn, the line connecting the inner commissure of the palpebral fissures; Grc-Grn, the line connecting the superior points of the nasal alar groove; Alc-Aln, the line connecting the Al points; Sac-San, the line connecting the Sa points; facial midline, the line perpendicular to the Enc-Enn line and bisecting it at the midpoint; Columellar axis, the line connecting the Pn and the midpoint of the Nmc-Nmn line.

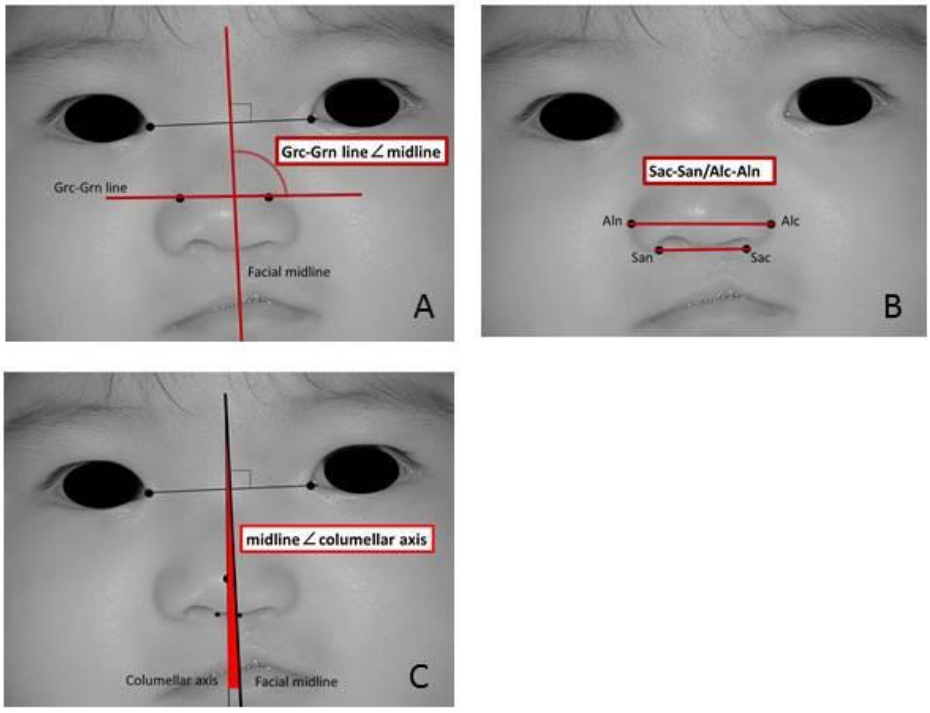

FIGURE 4. Anthropometric measurements with statistically significant differences; A, Sac-San/Alc-Aln: the anthropometric ratio of the width of the nasal base to the total width of the nose. B, Grc-Grn line ∠ midline: the anthropometric angle between the line connecting the Gr points and the facial midline. C, midline ∠ columellar axis: the angle between the facial midline and the columellar axis.

TABLE 1. Patient Sex and Cleft Side Affected

	Sex (Male/Female)	Cleft side (Right/Left)	Total
HP	5/9	4/10	14
non-HP	6/8	4/10	14

TABLE 2. List of Anthropometric Landmarks for Analyzing the Nasal Form

Landmark	Description
Endocanthion of cleft and non-cleft side (Enc and Enn)	The inner commissure of palpebral fissures
Top of alar groove of cleft and non-cleft side (Grc and Grn)	The most superior point of nasal alar groove
Alar of cleft and non-cleft side (Alc and Aln)	The most lateral point on the outline of nasal alar
Subalar of cleft and non-cleft side (Sac and San)	The most inferior point of nasal alar groove
Pronasale (Pn)	The most superior point on the outline of the tip of the nose
Nostril medial of cleft and non-cleft side (Nmc and Nmn)	The most medial point of the inner border of the nostril

TABLE 3. List of Anthropometric Constructs for Analyzing the Nasal Form

Construct	Description
Enc-Enn line	Horizontal reference line, line connecting the inner commissure of palpebral fissures cleft and non-cleft side
Grc-Grn line	Line connecting the superior point of nasal alar groove cleft and non-cleft side
Alc-Aln line	Line connecting the Al points on the cleft and non-cleft side
Sac-San line	Line connecting the Sa points on the cleft and non-cleft side
Facial midline	Line perpendicular to the Enc-Enn line, bisecting it at midpoint
Columellar axis	Line connecting the Pn and midpoint of the Nmc-Nmn line

TABLE 4. List of Measurment and Anthropometric Ratios Used for Analyzing Nasal Form

Anthropometric ratios and Angular measurement	Analyses
Ratios	
Alc-Aln/Sac-San	Ratio of the width of the nasal base to the total width of the nose
Enc-Enn/Alc-Aln	Nasal width index, ratio of the distance between the endocanthion points to the total width of the nose
Alc-Enc/Aln-Enn	Position of the nose in the face, ratio between the distance of the En to the Al on the cleft and non-cleft side
Grc-Enc/Grn-Enn	Position of the nose in the face, ratio between the distance of the En to the Gr on the cleft and non-cleft side
Alc-columellar axis/Aln-columellar axis	Ratio between midalar width on the cleft and non-cleft side
Angles	
Sac-San line ∠ Enc-Enn line	Inclination of nasal base. Angle between the line connecting the endocanthion points and the line connecting the subalar points
Grc-Grn line ∠ midline	Angle between the line connecting the Gr points and the facial midline
Grc-Grn line ∠ columellar axis	Angle between the line connecting the Gr points and the columellar axis
Alc-Aln line ∠ midline	Angle between the line connecting the Al points and the facial midline
Alc-Aln line ∠ columellar axis	Angle between the line connecting the Al points and the columellar axis
midline ∠ columellar axis	Angle between the facial midline and the columellar axis

TABLE 5. Statistical Analysis for Inter-observer Reliability

		Mean (K.A.)	Mean (N.I.)	ICC
Ratios				
Alc-Aln/Sac-San	1 month	1.370	1.347	0.957
	6 months	1.226	1.228	0.902
Enc-Enn/Alc-Aln	1 month	1.024	1.010	0.982
	6 months	1.030	1.035	0.970
Alc-Enc/Aln-Enn	1 month	0.964	0.964	0.910
	6 months	1.072	1.076	0.900
Grc-Enc/Grn-Enn	1 month	0.867	0.867	0.916
	6 months	1.140	1.126	0.924
Alc-columellar axis/Aln-columellar axis	1 month	1.075	1.106	0.974
	6 months	0.910	0.903	0.953
Angles				
Sac-San line ∠Enc-Enn line	1 month	1.44	1.50	0.873
	6 months	1.17	1.43	0.780
Grc-Grn line ∠midline	1 month	93.69	93.64	0.952
	6 months	92.92	92.89	0.931
Grc-Grn line ∠columellar axis	1 month	90.15	88.98	0.880
	6 months	87.75	88.29	0.939
Alc-Aln line ∠midline	1 month	92.73	92.47	0.929
	6 months	92.58	92.78	0.835
Alc-Aln line ∠columellar axis	1 month	88.88	87.47	0.929
	6 months	87.32	86.92	0.831
midline ∠columellar axis	1 month	4.30	4.91	0.964
	6 months	5.66	5.84	0.985
				Mean, 0.919

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TABLE 6. Anthropometric Measurement

Anthropometric ratios and Angular measurement		HP	non-HP	P
Ratios				
Alc-Aln/Sac-San	1 month	1.37±0.10	1.26±0.09	Significant (P<0.01)
	6 months	1.23±0.05	1.15±0.06	Significant (P<0.01)
Enc-Enn/Alc-Aln	1 month	1.02±0.07	0.97±0.14	NS
	6 months	1.03±0.08	1.01±0.06	NS
Alc-Enc/Aln-Enn	1 month	0.91±0.18	0.99±0.05	NS
	6 months	1.07±0.07	1.09±0.06	NS
Grc-Enc/Grn-Enn	1 month	0.91±0.28	0.87±0.05	NS
	6 months	1.11±0.07	1.15±0.08	NS
Alc-columellar axis/Aln-columellar axis	1 month	1.08±0.11	1.07±0.10	NS
	6 months	0.91±0.06	0.94±0.07	NS
Angles				
Sac-San line∠Enc-Enn line	1 month	1.44±1.33	1.42±1.13	NS
	6 months	1.17±0.95	1.45±0.78	NS
Grc-Grn line∠midline	1 month	93.7±2.50	96.1±3.29	Significant (P<0.05)
	6 months	92.9±2.62	96.1±2.32	Significant (P<0.01)
Grc-Grn line∠columellar axis	1 month	90.1±3.77	91.7±5.24	NS
	6 months	87.7±2.83	85.3±4.26	NS
Alc-Aln line∠midline	1 month	92.7±1.87	93.0±3.84	NS
	6 months	92.6±2.88	93.8±1.65	NS
Alc-Aln line∠columellar axis	1 month	88.9±3.37	89.1±5.69	NS
	6 months	87.3±3.27	84.0±4.92	NS
midline∠columellar axis	1 month	4.30±3.85	4.12±3.01	NS
	6 months	5.66±2.67	10.5±3.74	Significant (P<0.01)