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Photogrammetric Assessment of Nasal Symmetry in UCLP Infants Following Presurgical NAM and Primary Cheilorhinoplasty

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A B S T R A C T

Introduction: Unilateral cleft lip and palate (UCLP) causes nasal asymmetry due to cartilage malposition and tissue deficiency, impacting esthetics and function. Presurgical nasoalveolar molding (NAM) helps improve nasal form before surgery, but few studies have used 2D photogrammetry to assess its impact.

Objective: To evaluate nasolabial changes in infants with unilateral cleft lip and palate (UCLP) using two-dimensional photogrammetry, by comparing nasal parameters before and after presurgical nasoalveolar molding (NAM) and following primary cheilorhinoplasty.

Methods: A prospective analysis was conducted on infants with UCLP undergoing NAM therapy. The treatment involved weekly adjustments to the NAM plate with stent from 0–6 months of age to align the alveolar segments and reshape the nasal cartilage. Nasal parameters, including nasal symmetry, nostril width, columellar length, and proportion of outer to inner nasal width, were assessed at three time points during the treatment using standardized photographic methods. Statistical comparisons were performed to quantify improvements at the 3 different time points and between the cleft and non-cleft sides.

Results: NAM therapy significantly improved nasolabial symmetry in UCLP infants. Pre-treatment evaluations highlighted pronounced asymmetry, with a wide alveolar gap and a flattened nasal dome. Post-treatment, there was a marked improvement as shown by elongation of the columella, improved shape of nostrils, and increased nasal aperture at the base ($p < 0.05$).

Conclusion: Significant improvements in nasal symmetry, columella length, and nasal width were observed. A favorable reshaping of the nose after Presurgical Nasoalveolar Molding was achieved, resulting in an improvement in the form before lip surgery. These changes lead to improved nasal symmetry before primary lip and nasal reconstruction in UCLP patients

Keywords: Unilateral cleft lip and palate, Nasoalveolar Molding, Photogrammetry, NAM

Introduction:

Unilateral cleft lip and palate (UCLP) is a complex congenital anomaly characterized by disruption of the upper lip, alveolus, and palate, frequently accompanied by significant nasal deformity that adversely affects esthetics and function.[1] Nasal asymmetry in UCLP arises from malpositioned alar cartilages, deficient soft tissues, and failure of medial nasal growth, often resulting in a flattened nasal tip, short columella, and widened nostril base on the cleft side.[2,3] Early interventions aim to improve nasal form and symmetry, thereby facilitating surgical repair and reducing the extent of cartilage dissection at primary cheilorhinoplasty.[4]

Since Millard’s rotation‐advancement technique in the 1950s, surgeons have refined primary rhinoplasty approaches to address cleft‐associated nasal deformities; however, postoperative relapse and scarring remain challenges when cartilage manipulation is postponed until lip repair.[5] In 1999, Grayson et al. introduced presurgical nasoalveolar molding (NAM), which applies light continuous forces via an intraoral and nasal appliance to mold both alveolar segments and nasal cartilages, thereby achieving improved nostril height and columella length prior to cheilorhinoplasty.[6] Subsequent studies have documented three‐dimensional gains in nasal symmetry following NAM, with some evidence of stability into early childhood.[7,8]

Assessment of nasal changes has traditionally relied on anthropometric and stereophotogrammetric techniques, offering three‐dimensional evaluation but at the cost of equipment complexity and expense.[9] Two‐dimensional (2D) photogrammetry, by contrast, is more accessible and has demonstrated adequate reliability for measuring alar base width, columella angle, and nostril height when standardized protocols are employed.[10] Despite its advantages, few studies have systematically applied 2D analysis to quantify nasal soft‐tissue changes after NAM in UCLP infants.

The present study therefore aimed to perform a two‐dimensional assessment of nasal changes following presurgical NAM and subsequent primary cheilorhinoplasty in infants with UCLP. By comparing metric parameters—including nostril width, nasal tip projection, and columella length—at baseline, post‐NAM, and post‐surgery, we sought to elucidate the effectiveness of this combined approach within the constraints of 2D imaging and to correlate our findings with existing literature on nasal symmetry outcomes in cleft care.

Materials and methodology:

A prospective longitudinal study was conducted in the Department of Orthodontics and Dentofacial Orthopaedics of a tertiary dental hospital at Belagavi, spanning a period from March 2023 to February 2025. The primary objective was to assess nasal soft-tissue changes in infants diagnosed with unilateral cleft lip and palate (UCLP) who underwent presurgical nasoalveolar molding (NAM), followed by primary cheilorhinoplasty.

A total of 18 infants meeting the following inclusion criteria were enrolled: age ≤4 weeks at the time of presentation, birth weight greater than 2 kg, and either gender. Enrollment was conditional upon the provision of written informed consent by the parents or legal guardians. Infants were excluded if they had bilateral clefts, were older than 4 weeks at the time of first evaluation, or presented with any systemic illnesses or syndromic conditions.

Standardized basal-view facial photographs were captured at three key stages of treatment: prior to initiation of NAM therapy (T0), 1–2 weeks after completion of NAM (T1), and 1–2 days following primary cheilorhinoplasty (T2). All photographic images were acquired using uniform lighting, camera settings, and patient positioning protocols to ensure consistency and minimize measurement error.

Eleven pre-defined nasal soft-tissue landmarks were identified and manually digitized on each photograph using Digimizer software. Linear measurements were recorded on both the cleft and non-cleft sides of the nose, focusing on parameters such as nostril width, columella length, and nasal tip projection. To allow for standardized comparisons irrespective of cleft laterality, cleft-to-non-cleft side ratios were calculated for each parameter.

Anthropometric Landmarks:

Sr. No	Landmark	Abbreviation	Description
1.	Pronasale/nasal tip	prn	Midline landmark- Most anterior point of the nasal tip
2.	Columella	cm	Bilateral landmark - Inferior-most point on the columella
3.	Alar Base	al	Bilateral landmark - The most lateral point at the base of each nostril
4.	Alar Curvature Point	ac	Bilateral landmark - Most convex point along the outer curvature of each ala
5.	Subalare	sbal	Bilateral landmark - Inferior-most point of the alar base at the junction with the upper lip
6.	Columella insertion	sn	Bilateral landmark - columella insertion on either side

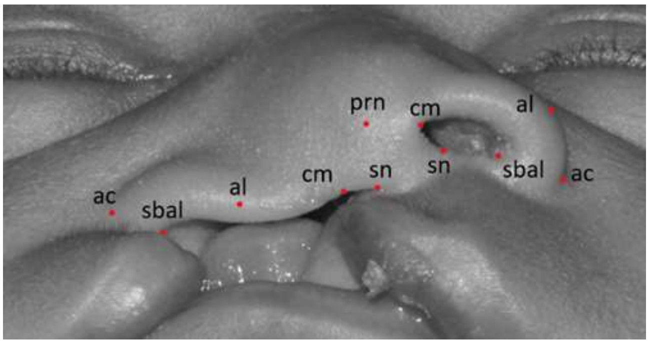

Figure 1. Eleven Anatomical landmarks identified in the photograph

Anthropometric Measurements:

Sr No	Parameter	Abbreviation	Figure
	Vertical paired		
1.	Alar length	prn-ac	2A
2.	Columella length	cm-sn	2B

	Horizontal		
3.	Maximum nasal width at base	ac-ac	2A
4.	Outer nasal width	al-al	2D
5.	Inner nasal width at base	sbal-sbal	2D
	Horizontal paired		
6.	Nasal aperture base width	sbal-sn	2C

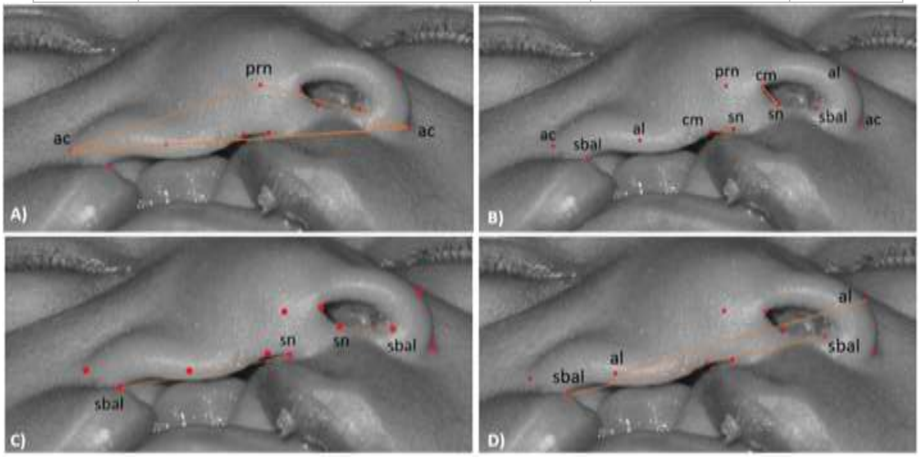

Figure 2. Anthropometric measurements in the photograph

Statistical analysis involved paired comparisons across the three time points: T0 vs T1 (effect of NAM), T0 vs T2 (cumulative effect of NAM and surgery), and T1 vs T2 (surgical effect post-NAM). Mean differences for each stage (T1–T0, T2–T1, and T2–T0) were computed to assess incremental improvements in nasal symmetry across the treatment phases.

Results:

Table 1: Descriptive statistics of different parameters showing soft tissue nasal changes amongst Cases at three time intervals

Measure	T0 Mean (SD)	T1 Mean (SD)	T2 Mean (SD)
Alar length ratio	0.732 (0.048)	0.831 (0.046)	0.937 (0.041)
Columella length ratio	0.546 (0.110)	0.733 (0.068)	0.942 (0.102)
Outer-to-inner width ratio	1.188 (0.109)	1.309 (0.089)	1.563 (0.090)
Nostril width ratio	3.879 (0.520)	2.934 (0.578)	1.142 (0.520)

Table 1 demonstrates a progressive improvement in nasal symmetry among UCLP infants across the three time points. The alar length ratio increased from 0.732 at T0 to 0.831 post-NAM (T1) and 0.937 post-cheilorhinoplasty (T2), indicating gradual correction of alar base asymmetry. Similarly, the columella length ratio improved significantly from 0.546 at baseline to 0.733 at T1 and 0.942 at T2, reflecting effective elongation of the columella. The outer-to-inner nostril width ratio increased from 1.188 to 1.309 and 1.563, suggesting progressive improvement in nostril contour. In contrast, the nostril width ratio decreased markedly from 3.879 at T0 to 2.934 at T1 and 1.142 at T2, indicating substantial narrowing of the cleft-side nostril.

Table 2: Intragroup comparison of different parameters showing soft tissue nasal changes in Cases at different time intervals (T0 vs T1, T1 vs T2, and T0 vs T2)

Ratios	Comparison	Mean Difference	95% CI	t (df)	p-value
Alar length ratios	**T0 vs T1**	-0.103	[-0.163, -0.043]	-3.96 (8)	0.0042*
	T1 vs T2	-0.107	[-0.157, -0.056]	-4.89 (8)	0.0012*
	T0 vs T2	-0.21	[-0.265, -0.155]	-8.74 (8)	0.0*
	T0 vs T1	-0.192	[-0.270, -0.114]	-5.68 (8)	0.0005*

Columella ratios	**T1 vs T2**	-0.168	[-0.254, -0.081]	-4.48 (8)	0.0021*
	T0 vs T2	-0.36	[-0.443, -0.277]	-10.01 (8)	0.0*
Outer-to-inner width ratio	**T0 vs T1**	-0.1	[-0.244, 0.044]	-1.60 (8)	0.1472
	T1 vs T2	-0.28	[-0.380, -0.180]	-6.49 (8)	0.0002*
	T0 vs T2	-0.38	[-0.522, -0.238]	-6.19 (8)	0.0003*
Nostril width ratios	**T0 vs T1**	1.218	[0.751, 1.684]	6.02 (8)	0.0003*
	T1 vs T2	1.478	[1.180, 1.776]	11.43 (8)	0.0*
	T0 vs T2	2.696	[2.175, 3.216]	11.94 (8)	0.0*

Table 2 presents statistically significant intragroup changes in nasal soft tissue parameters among UCLP infants across three treatment intervals. The alar length ratio showed significant improvement from T0 to T1 ($p = 0.0042$), T1 to T2 ($p = 0.0012$), and T0 to T2 ($p < 0.001$), indicating progressive correction of alar asymmetry. The columella length ratio also improved significantly at each stage ($p < 0.01$), with the greatest mean difference observed between T0 and T2 (-0.36, $p < 0.001$), reflecting effective elongation of the columella. The outer-to-inner nostril width ratio showed a non-significant change between T0 and T1 ($p = 0.1472$) but became statistically significant from T1 to T2 and T0 to T2 ($p < 0.001$), suggesting a delayed but meaningful improvement in nostril shape. The nostril width ratio demonstrated highly significant reductions at all intervals ($p \leqslant 0.0003$), with the largest mean difference between T0 and T2 (2.696, $p < 0.001$), confirming substantial narrowing and normalization of the cleft-side nostril width**.**

Discussion:

In this study, we observed that presurgical nasoalveolar molding (NAM) led to significant improvements in nasal symmetry parameters—particularly columella length and nasal width—before primary cheilorhinoplasty, with further refinement achieved post-surgery. Historically, attempts to correct cleft-related nasal deformities date back to the early twentieth century, when Gillies and Millard introduced rotation-advancement techniques to restore lip continuity, yet nasal asymmetry often persisted due to inadequate support of cartilaginous structures.[5] In the 1990s, McComb and Cutting described primary rhinoplasty at the time of lip repair, aiming for immediate cartilage repositioning, but risked relapse and scarring from extensive dissection.[11,12] Grayson et al. later pioneered NAM in 1999, harnessing controlled force vectors to mold both alveolar segments and nasal cartilage, thus minimizing surgical trauma and improving soft-tissue contours before definitive repair.[6]

Numerous investigations have since corroborated the efficacy of NAM. Maull et al. demonstrated that infants treated with NAM showed sustained three-dimensional nasal shape improvements at a mean follow-up of 3 years, particularly in columella length and nostril symmetry.[13] Similarly, Gomez et al. reported significant decreases in nostril height discrepancy and alar base width following presurgical NAM in unilateral clefts, findings mirrored in our increase in outer-to-inner nasal width ratio by 0.18 at T1.[14] Mancini et al. utilized stereophotogrammetry to quantify soft-tissue changes and found that 50–70 percent of nasal symmetry correction was achieved before the surgery, with the remainder accomplished via cheilorhinoplasty—closely aligning with our ratio improvements of 0.17 (NAM) versus 0.14 (surgery) for columella length.[15]

Primary cheilorhinoplasty remains integral to achieving the final nasal form. Chang et al. compared four surgical techniques for nasal symmetry and noted that combining NAM with an inverted-V primary rhinoplasty yielded superior nostril shape and projection long term [8]. Ponsky and Guyuron underscored that alar base harmonization at surgery can only fine-tune, but not replace, the foundational molding achieved by NAM.[16] Our data echo this synergy: NAM established near-normalized inner nasal base widths (sbalr–sball) by T1, while surgery equalized residual asymmetries by T2.

Long-term outcomes in unilateral cleft lip repair have also been encouraging. Maull et al. reported minimal relapse of nasal improvements at 5 years after the repair in NAM-treated cohorts[5], and Nakamura et al. observed stable nasal form into adolescence when presurgical molding was combined with medial-upward advancement rhinoplasty.[17] More recently, Stebel et al. demonstrated that three-dimensional assessments of nasolabial appearance consistently favor protocols including NAM over traditional approaches, with reduced scarring and improved patient satisfaction at 7 years.[18] Our findings, albeit limited to the early postoperative period, align with this trend of durable correction.

Conclusion:

The historical evolution from purely surgical correction to an integrated presurgical NAM and primary rhinoplasty protocol reflects a paradigm shift toward tissue-preserving, growth-compatible interventions. Our results substantiate that NAM yields substantial initial nasal symmetry gains, which are consolidated by subsequent cheilorhinoplasty, and are consistent with long-term stability reported in the literature. Future studies with larger cohorts and extended follow-up will further elucidate the lasting impact of this combined approach on nasal form and function in unilateral cleft lip and palate patients.

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