RESEARCH PAPER

Evaluation of Nasal Morphology in predicting vertical and sagittal discrepancies in Rajasthan Population: Cephalometric Study

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Submitted: 12 May 2026, **Accepted:**01 July 2026, Published: 15th July 2026

Abstract

Background: Nasal morphology contributes substantially to facial profile and may be related to underlying maxillary development. This study evaluated the association of soft-tissue nasal morphology with vertical and sagittal maxillary skeletal parameters in a Rajasthani population and assessed differences between sexes.

Methods: This retrospective cephalometric study included 170 pretreatment lateral cephalograms of individuals aged 16–28 years, comprising 85 males and 85 females. Eight maxillary skeletal and eight soft-tissue nasal parameters were measured manually using standardized landmarks. Associations were assessed using Pearson's correlation coefficient, while sex-related differences were evaluated using the independent-samples *t*-test. A two-sided p-value <0.05 was considered statistically significant.

Results: The mean nasal length and nasal depth were 40.53 ± 4.92 mm and 13.83 ± 2.09 mm, respectively. Nasal length showed its strongest positive correlation with N–ANS (r=0.72), followed by PNS–Point A (r=0.51), S–PNS (r=0.45), and Co–Point A (r=0.45). Nasal depth was positively correlated with N–ANS (r=0.38), S–PNS (r=0.33), PNS–Point A (r=0.27), and Co–Point A (r=0.25), and negatively correlated with maxillary inclination (r=−0.29). Other nasal parameters showed weak or negligible correlations. No significant differences were observed between males and females (all p>0.05).

Conclusion: Nasal length and depth were associated with vertical and sagittal maxillary dimensions. Their assessment may provide additional information during orthodontic diagnosis and facial-profile evaluation.

Keywords: Cephalometry; facial profile; maxilla; nasal morphology; orthodontic diagnosis; soft tissue.

How to cite this article: Keshav Mansinghka, PiyuBolya, Smarika Jain, Neetachini Kalita, Aromal S, Rahul Majumdar. Evaluation of Nasal Morphology in predicting vertical and sagittal discrepancies in Rajasthan Population: Cephalometric Study. Int J Drug Deliv Technol. 2026;16(80s):167-172. DOI: 10.25258/ijddt.16.80s.19

INTRODUCTION

Facial aesthetics is an important consideration in orthodontic diagnosis and treatment planning. Although orthodontic assessment traditionally focuses on dental and skeletal relationships, the appearance of the face is also strongly influenced by the overlying soft tissues. Differences in soft-tissue thickness and form can alter the facial profile even among individuals with similar underlying skeletal patterns. Therefore, evaluating the soft-tissue profile is essential for achieving a balanced and harmonious treatment outcome.[1]

The nose occupies a central position on the face and, together with the lips and chin, contributes substantially to an individual's facial appearance. Nasal shape depends on the size and relationship of its bony and cartilaginous structures, muscles, and overlying skin. It also influences facial convexity and the overall perception of profile aesthetics.The nasal septum may additionally contribute to the downward and forward growth of the midface, suggesting a developmental relationship between nasal morphology and the maxillary skeleton.[2,3]

Soft-tissue structures continue to change during growth and adulthood. Nasal growth generally continues into late adolescence, while further changes may occur during adult life. Vertical facial growth may also persist beyond puberty. These changes should be considered during orthodontic diagnosis because the nose lies close to the dentoskeletal structures affected by treatment, although orthodontic therapy does not directly modify nasal shape.[4,5]

Many commonly used cephalometric norms have been developed from Caucasian populations and may not be directly applicable to individuals from other ethnic or regional groups.[6] Population-specific evaluation is therefore necessary. The present study aimed to assess nasal morphology and examine its relationship with sagittal and vertical maxillary skeletal patterns in a Rajasthani population. It also evaluated sex-related differences in nasal proportions and explored the clinical value of nasal parameters in orthodontic diagnosis and treatment planning.

MATERIALS AND METHODS

This retrospective, descriptive cephalometric study was conducted in the Department of Orthodontics and Dentofacial Orthopaedics, Pacific Dental College and Research Centre, Udaipur, Rajasthan. The study protocol was approved by the Institutional Ethics Committee of Pacific Medical College and Hospital, Udaipur (Protocol No. IEC/240/2024; Ref. No. PMU/PMCH/IEC/2023–24/240). The study included 170 pretreatment lateral cephalograms selected from the departmental records.

Lateral cephalograms of individuals aged 16–28 years with permanent dentition and no previous orthodontic treatment were included. Radiographs were excluded when patients had a congenital craniofacial anomaly, cleft lip or palate, gross nasal deformity, previous orthodontic treatment or maxillofacial surgery, or a history of trauma involving the orofacial region. Distorted radiographs and images lacking adequate clarity for reliable identification of cephalometric landmarks were also excluded.

The final sample was divided according to sex into two equal groups: Group 1 comprised 85 males, and Group 2 comprised 85 females. Lateral cephalograms had been obtained in the natural head position using a standardized cephalometric technique. All radiographs were traced manually by a single investigator to maintain consistency. Tracings were performed on 36-µm (0.003-inch) transparent cellulose acetate sheets placed over the radiographs on an illuminated tracing table. Cephalometric landmarks were identified using a 0.3-mm HB lead pencil, and linear and angular measurements were recorded using a ruler and protractor.

Eight skeletal maxillary parameters were evaluated: SNA angle, perpendicular distance from Point A to the nasion perpendicular on the Frankfort horizontal plane, PNS–Point A, N–ANS, S–PNS, maxillary inclination angle, Co–Point A, and the angle between the SN and palatal planes.

Eight soft-tissue nasal and facial parameters were also assessed. These included nasal length (N′–Pr), nasal depth, nasolabial angle (Cm–Sn–Ls), nasal tip angle (N–Pr–Cm), columellar convexity, nasal hump, perpendicular distance from pronasale to the H-line, and soft-tissue facial convexity angle (G′–Sn–Pog′). Standard definitions of the landmarks and measurement techniques were followed for all linear and angular variables (**Figure 1**).

The measurements were used to evaluate the relationship of nasal morphology with sagittal and vertical maxillary skeletal patterns and to identify differences in nasal proportions between males and females. All observations were entered into a structured data sheet before statistical analysis. Continuous variables were summarized as mean, standard deviation, minimum, and maximum. The relationships between soft-tissue nasal parameters and maxillary skeletal measurements were assessed using Pearson's correlation coefficient. Differences in nasal measurements between males and females were evaluated using the independent-samples *t*-test. All tests were two-sided, and a p-value <0.05 was considered statistically significant.

Figure 1. Cephalometric landmarks and measurements used in the study. (A) Maxillary skeletal parameters. (B) Soft-tissue nasal parameters.

RESULTS

A total of 170 lateral cephalograms were analysed. The mean SNA angle was 80.28 ± 4.41°, while the mean N–ANS and Co–Point A measurements were 44.46 ± 4.80 mm and 74.63 ± 10.65 mm, respectively. The mean nasal length was 40.53 ± 4.92 mm, and the mean nasal depth was 13.83 ± 2.09 mm. The nasolabial and nasal tip angles were 99.11 ± 13.65° and 110.00 ± 10.18°, respectively (**Table 1**).

Nasal length demonstrated its strongest positive correlation with N–ANS (r=0.72), followed by PNS–Point A (r=0.51), S–PNS (r=0.45), and Co–Point A (r=0.45). Nasal depth was positively correlated with N–ANS (r=0.38), S–PNS (r=0.33), PNS–Point A (r=0.27), and Co–Point A (r=0.25), but negatively correlated with N′–SeN′–PP (r=−0.29). Other nasal parameters generally showed weak or negligible correlations with maxillary skeletal measurements (**Table 2**).

Males showed slightly greater nasal length, nasal depth, columellar convexity, nasal hump, and Pr–H-line distance, whereas females had marginally greater nasolabial and nasal tip angles. However, none of the soft-tissue nasal parameters differed significantly between males and females (all p>0.05), indicating no statistically significant sexual dimorphism in the evaluated sample (**Table 3**).

Table 1. Descriptive statistics for maxillary skeletal and soft-tissue nasal parameters

Domain	Measurement	Mean ± SD	Minimum	Maximum
Maxillary	SNA	80.28 ±	68°	91°

skeletal		4.41°		
	N-perpendicular–Point A	−1.72 ± 4.17 mm	−16 mm	8 mm
	PNS–Point A	42.27 ± 4.60 mm	32 mm	54 mm
	N–ANS	44.46 ± 4.80 mm	33 mm	56 mm
	S–PNS	40.71 ± 5.90 mm	30 mm	79 mm
	N′–SeN′–PP	85.50 ± 17.40°	32°	164°
	Co–Point A	74.63 ± 10.65 mm	7 mm	94 mm
	SN–PP	7.45 ± 3.38 °	−4°	16°
Soft-tissue nasal	Nasal length (N′–Pr)	40.53 ± 4.92 mm	30 mm	54 mm
	Nasal depth (Pr perpendicular to N′–Sn)	13.83 ± 2.09 mm	9.5 mm	19 mm
	Nasolabial angle (Cm–Sn–Ls)	99.11 ± 13.65°	59°	128°
	Nasal tip angle (N–Pr–Cm)	110.00 ± 10.18°	15°	129°
	Columellar convexity	2.19 ± 0.87 mm	0.5 mm	6 mm
	Nasal hump	19.14 ± 6.67 mm	6 mm	34 mm
	Pr–H-line	1.81 ± 4.34 mm	−11 mm	15 mm
	Soft-tissue facial convexity (G′–Sn–Pog′)	163.83 ± 6.80 °	145°	185°

Data are presented as mean ± standard deviation and range; N=170.

Table 2. Correlations between soft-tissue nasal and maxillary skeletal measurements

Nasal measurement	**SNA**	**N□–A**	**PNS–A**	**N–ANS**	**S–PNS**	**N′–SeN′–PP**	**Co–A**	**SN–PP**
Nasal length	0.09	0.10	**0.51**	**0.72**	**0.45**	−0.10	**0.45**	0.07

Nasal depth	−0.03	−0.08	**0.27**	**0.38**	**0.33**	**−0.29**	**0.25**	0.02
Nasolabial angle	0.14	0.05	0.02	−0.04	−0.01	0.02	−0.02	−0.08
Nasal tip angle	0.02	−0.03	0.00	0.12	0.13	−0.10	0.02	0.01
Columellar convexity	−0.05	−0.14	0.14	0.10	0.05	−0.03	0.13	−0.06
Nasal hump	0.03	0.01	0.12	0.15	0.08	−0.02	0.14	0.03
Pr–H-line	**−0.20**	−0.15	−0.04	−0.02	−0.02	−0.05	−0.13	−0.01
Soft-tissue facial convexity	−0.11	−0.15	−0.01	−0.09	0.00	0.01	−0.07	−0.14

Values are Pearson correlation coefficients (r). Bold values were reported as statistically significant at p<0.05.

Table 3. Comparison of soft-tissue nasal parameters between males and females

Parameter	Male (n=85) Mean ± SD	Female (n=85) Mean ± SD	Mean difference (Male–Female)	p-value
Nasal length, N′–Pr	40.97 ± 4.87 mm	40.09 ± 4.97 mm	0.88 mm	0.246
Nasal depth, Pr□ to N′–Sn	13.99 ± 2.09 mm	13.68 ± 2.10 mm	0.31 mm	0.336
Nasolabial angle, Cm–Sn–Ls	98.24 ± 14.83°	99.99 ± 12.58°	−1.75°	0.408
Nasal tip angle, N–Pr–Cm	109.04 ± 12.39°	110.96 ± 7.30°	−1.92°	0.220
Columellar convexity	2.29 ± 0.99 mm	2.09 ± 0.71 mm	0.20 mm	0.132
Nasal hump	19.18 ± 6.89 mm	19.11 ± 6.50 mm	0.07 mm	0.946
Pr–H-line	2.19 ± 4.53 mm	1.44 ± 4.15 mm	0.75 mm	0.262
Soft-tissue facial convexity, G′–Sn–Pog′	164.08 ± 8.05°	163.59 ± 5.32°	0.49°	0.640

Comparisons were performed using the independent-samples t-test. A two-sided p-value <0.05 was considered statistically significant.

DISCUSSION

The present study examined the relationship between soft-tissue nasal morphology and maxillary skeletal dimensions in 170 individuals from Rajasthan. Nasal length and nasal depth showed the most meaningful associations with maxillary measurements, whereas the angular and contour-related nasal variables generally demonstrated weak or negligible relationships. These findings highlight the close developmental relationship between the nose and maxilla while also showing that nasal appearance cannot be explained by skeletal morphology alone.

Nasal length had the strongest positive correlation with N–ANS (r=0.72), indicating that individuals with greater anterior vertical maxillary height tended to have longer noses. It was also positively correlated with PNS–Point A (r=0.51), S–PNS (r=0.45), and Co–Point A (r=0.45). These relationships suggest that nasal length develops in coordination with the vertical and anteroposterior dimensions of the maxilla. Similar patterns of coordinated nasal and maxillary growth have been described by Meng et al.[7], Genecov et al.[8], and Chen et al.[9]. The anatomical proximity of the nasal floor, anterior nasal spine, and maxillary complex may partly explain these associations.

In contrast, nasal length was weakly related to SNA, N-perpendicular–Point A, and SN–PP. Thus, nasal length appears to be associated more closely with maxillary dimensions than with the angular position of the maxilla relative to the cranial base. This finding is consistent with the observations of Robinson et al.[10] and Perović et al.[11].

Nasal depth showed positive correlations with N–ANS, PNS–Point A, S–PNS, and Co–Point A. Greater vertical and sagittal maxillary dimensions may therefore be accompanied by increased nasal projection. Comparable relationships have been reported by Rynn et al.[12], Chen et al.[9], and Mommaerts et al.[13]. Nasal depth was negatively correlated with maxillary inclination, suggesting that skeletal orientation may influence nasal projection differently from skeletal size. Similar interactions between skeletal orientation and nasal morphology were discussed by Jankowska et al.[14] and Tanikawa et al.[15].

The nasolabial angle, nasal tip angle, columellar convexity, nasal hump, and soft-tissue facial convexity showed no meaningful correlations with most skeletal measurements. These features may depend more on cartilage, lip posture, soft-tissue thickness, muscle tone, and genetic variation. Similar conclusions were reported by Fitzgerald et al.[16], and Gupta et al.[17]. The weak negative association between Pr–H-line and SNA should be interpreted cautiously because its magnitude was small.

No statistically significant differences in nasal measurements were found between males and females. Although males had slightly greater nasal length, depth, columellar convexity, and nasal prominence, the differences were small and clinically limited. Females showed marginally larger nasolabial and nasal tip angles. The absence of significant sexual dimorphism agrees with findings reported by Meng et al.[7], Ferrario et al.[18], and Rynn et al.[12], although population differences should be considered.

Clinically, nasal length and depth may provide useful additional information during facial-profile assessment. However, the cross-sectional, single-centre design limits causal interpretation and generalizability. Manual tracing may also introduce measurement error, and multiple correlation testing increases the possibility of chance findings. Therefore, the results should not be interpreted as proof that skeletal dimensions predict nasal morphology. Larger multicentre studies using digital measurements, reliability testing, multivariable modelling, and population-specific validation are needed before these parameters can be used as predictive indicators.

CONCLUSION

This study found that nasal length and depth were significantly associated with vertical and sagittal maxillary dimensions, supporting their relevance in facial-profile assessment. Other nasal variables showed weak or nonsignificant relationships with skeletal measurements, indicating greater influence from cartilaginous and soft-tissue characteristics. These findings may assist individualized orthodontic diagnosis and treatment planning. However, the two-dimensional, single-centre design and Rajasthan-based sample limit generalizability. Larger multicentre studies using three-dimensional imaging and multivariable analysis are required to validate population-specific standards for wider application.

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