Nasal Morphology as an Indicator of Maxillomandibular Skeletal Pattern

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ABSTRACT

Objective: To determine the correlation of nasal morphology with maxillary and mandibular patterns.

Study Design: Descriptive cross-sectional study.

Place and Duration of the Study: Department of Orthodontics, Liaquat College of Medicine and Dentistry and Qamar Dental Hospital, Karachi, Pakistan, from January to June, 2022.

Methodology: The pre-treatment lateral cephalograms of 120 patients, aged 18–35 years were included in the study. Eleven nasal parameters were traced on lateral cephalograms and correlated with four maxillary and mandibular skeletal parameters by Pearson correlation coefficient test using SPSS version 26.0.

Results: Nasal bone length and nasal base angle showed a negative correlation with maxillary and mandibular position. Nasal upward tip angle was correlated positively with maxillary position whereas nasal tip angle was found to be negatively correlated with maxillary length. A negative correlation was observed between nasolabial angle and mandibular position. Nasal bone angle depicted a positive correlation with maxillary position and a negative correlation with jaw lengths and mandibular inclination.

Conclusion: Nasal morphology has a strong correlation with maxillary as well as mandibular base lengths and position but not with inclination of the jaws. The acquaintance of the relationship of different nasal parameters with jaw parameters might be helpful in diagnosis and treatment planning and to attain the favourable treatment outcomes in patients undergoing orthodontic treatment, orthopedic interventions, orthognathic, genioplasty, rhinoplasty, profiloplasty and other procedures.

Key Words: *Nasal morphology, Maxillomandibular skeletal pattern, Jaw length, Jaw position, Jaw inclination.*

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INTRODUCTION

A face can be said to be well-balanced and attractive only if an appropriate coordination, among all the elements of the face, is found.[1] The main goal of orthodontic treatment and orthognathic surgical procedures, is to attain a pleasant and well-balanced face.[2] For evaluation of facial synchronisation and attractiveness, most of the previous studies were focused on relationships among nasal tip, lips, and chin.[3,4] However, the latest investigations have emphasised on evaluation of total facial profile which includes association among forehead, zygoma, nose, lips, jaws, and throat. Nose is considered to be the keystone of facial aesthetics as it is found in the middle portion of the face.[5]

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Khan *et al*. and Wisth, found that nose grows in a forward (horizontal) and downward direction with approximately 1.5 mm increase in length per year.[6,7] Nasal development is found to be completed at the age of 16 and 18 years in girls and boys, respectively.[8] Prasad *et al*. found that most of the nasal parameters depicted a significant correlation with the maxillary anteroposterior length but not with the maxillary anteroposterior position.[9] Furthermore, Krishnaveni *et al.* found that different nasal dimensions including nasal form, prominence, and length are associated with maxillary skeletal parameters.[10] Nehra *et al*. concluded that an upturned nose in a person is significantly correlated to inclination of palatal plane and anti--clockwise rotation of maxilla.[11] Khare *et al*. analysed the influence of maxillary vertical growth on nasal morphology in hyperdivergent and hypodivergent cases and found that nasal length, depth, and form are seen to be significantly associated to palatal plane inclination and upper anterior facial height.[12]

All of the earlier studies have focused on comparing nasal structure with maxillary vertical growth pattern and rotation.[11,12] However, the correlation of nasal morphology with maxillary as well as mandibular sagittal position, lengths, and inclinations have yet not been well-investigated. Thorough understanding of the relationship between these facial structures, is

essential for an orthodontist, maxillofacial and plastic surgeon as it can help in treatment planning of patients undergoing orthodontic treatment, dentofacial orthopedic interventions, orthognathic, genioplastic, rhinoplastic, profiloplastic and other surgical as well as non-surgical procedures and hence, attain the desired post-treatment outcomes. Therefore, the objective of the present study was to detect the correlation between nasal morphology and sagittal maxillary and mandibular skeletal pattern (angular and linear position, base lengths and inclination).

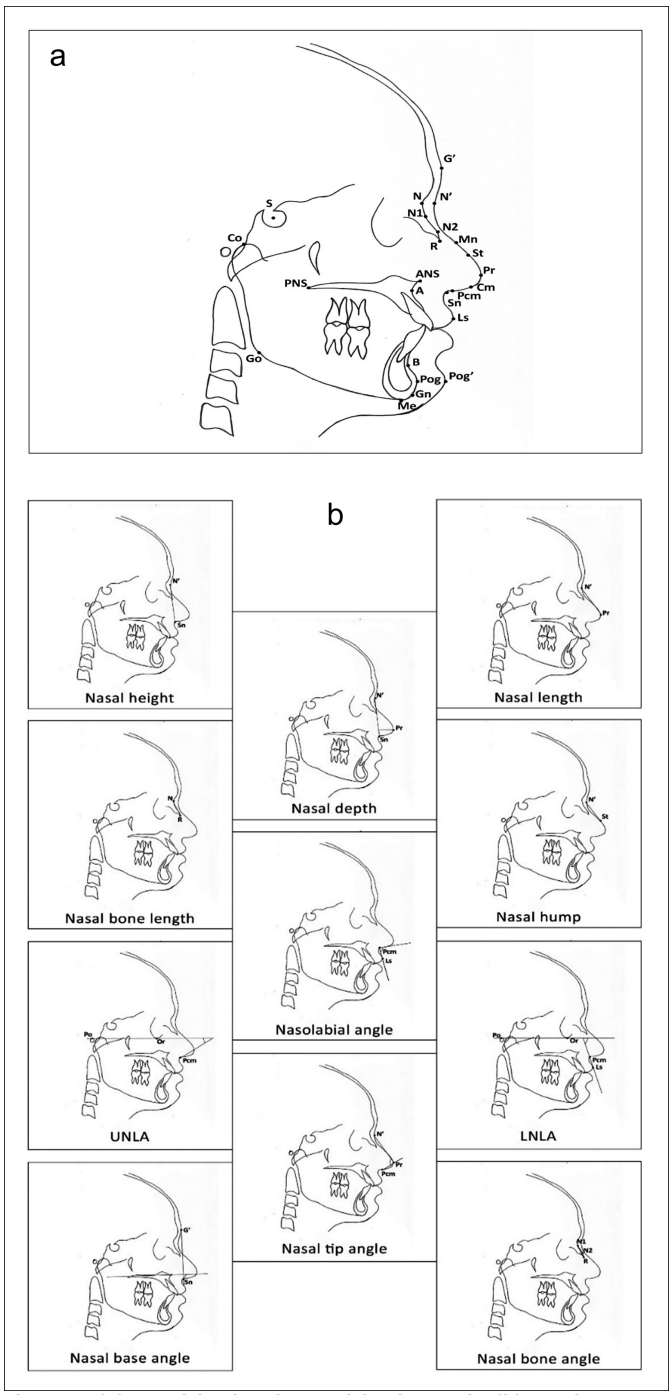

Figure 1: (a) Nasal landmarks used in the study. (b) Nasal parameters used in the study.

METHODOLOGY

The current study was a descriptive cross-sectional study which was conducted at the Department of Orthodontics, Liaquat College of Medicine and Dentistry and Qamar Dental Hospital, Karachi, Pakistan from January to June 2022. This was approved by the institutional review board of the hospital and college (Ref.no.IRB/D-000020/21). The pre-treatment lateral cephalograms of 120 patients were included. The sample size was determined by using PASS version 15 with the results of Krishnaveni *et al.* which reported the correlation between N perp. A and NLA to be -0.251.[10] By using non-probability consecutive sampling technique, a total sample size of 120 patients with 95% confidence interval and 80% power were included. Before using the patients' records, they were informed and written consent was taken from all of them.

The patients (aged 18-35 years) having pre-treatment lateral cephalograms with high quality and without any history of orthopaedic intervention, orthodontic treatment and orthognathic surgery were included in the study. However, patients with orofacial trauma, gross nasal deformity, craniofacial syndromes, and facial asymmetries were excluded from the present study.

The tracing of all of the pre-treatment lateral cephalograms was performed on acetate matte tracing papers. Eleven nasal landmarks and parameters were identified as given in Figure 1 a and b.[13]

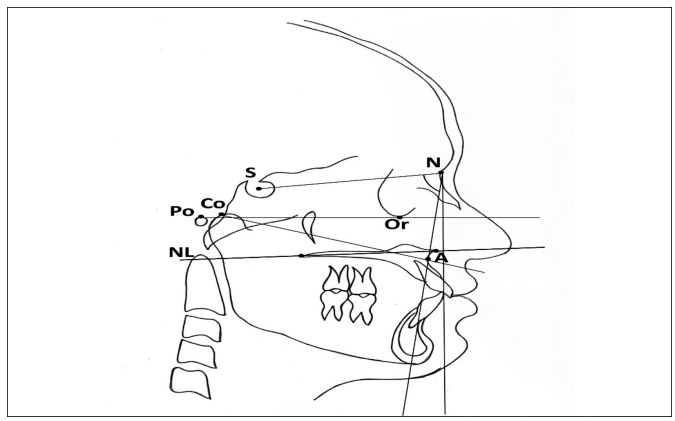

Figure 2: Maxillary parameters used in the study.

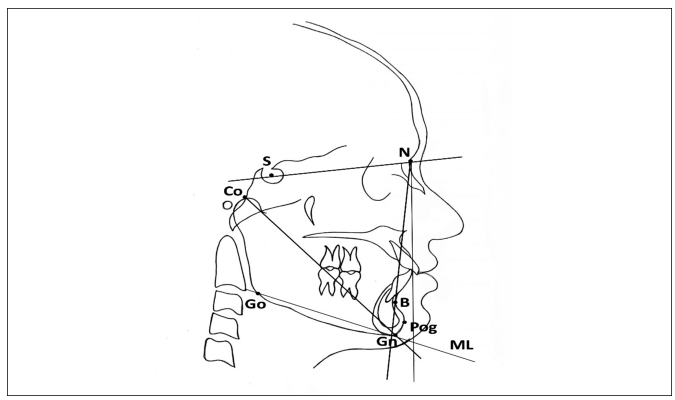

Figure 3: Mandibular parameters used in the study.

Nasal height (N-Height) was taken as the linear distance measured from subnasale (Sn) to soft tissue nasion (N') landmark. Nasal length (N-Length) was the linear distance measured from pronasale (Pr) to soft tissue nasion (N') landmark. Nasal depth was the perpendicular distance between pronasale (Pr) and the line drawn through soft tissue nasion (N') to subnasale (Sn). Nasal bone length (NBL) was the distance between nasion (N) and Rhinion (R). Nasal hump (Hump) was perpendicular linear distance measured between the axis of nasal dorsum and its most anterior soft tissue landmark. Nasolabial angle (NLA) was the angle which is formed by the intersection of a tangent to the upper lip (PCm-Ls line) and a tangent to the base of the nose (PCm tangent). Nasal upward tip angle / upper nasolabial angle (UNLA) was the posteroinferior angle which is formed when posterior columella (Pcm) tangent is extended to intersect the FH plane. Upper lip inclination / Lower nasolabial angle (LNLA) was the anteroinferior angle which is formed by a line tangent to posterior columella (Pcm) - *Labrale Superius* (Ls) line extended to intersect the FH plane. Nasal tip angle (NTA) was the angle which is formed by nasal dorsum axis and a line tangent to nasal base (PCm tangent). Nasal base angle (NBA) was the angle which is formed between nostril's long axis and Glabella (G') to Subnasale (Sn) line. Nasal bone angle (NBoneA) was posterior angle which is formed between the lines Nasion 1 and Nasion 2 (N1-N2) and Nasion 2 to Rhinion (N2-R).[14]

Four maxillary skeletal parameters (Figure 2) were measured.[12] Maxillary angular position (SNA) was the angle which is formed between sella to nasion (SN) line and nasion to A (NA) line which indicates the sagittal angular maxillary position in relation to cranial base. Maxillary linear position (N perp. A) was the linear distance measured from point A to nasion perpendicular which indicates the sagittal linear maxillary position in relation to the cranial base. Maxillary base length (Co-A) was the linear distance measured between Condylion to point A. Maxillary inclination (NL-NSL) was the angle formed between maxillary base line (NL) and nasion to sella line (NSL) which indicates maxillary inclination in relation to anterior cranial base.

Four mandibular skeletal parameters[12] (Figure 3) were then measured. Mandibular angular position (SNB) was the angle which is formed between sella to nasion (SN) line and the nasion to B (NB) line which indicates sagittal angular mandibular position in relation to the cranial base. Mandibular linear position (N perp. Pog) was the linear distance measured from Pogonion (Pog) to nasion (N) perpendicular which indicates the sagittal linear mandibular position in relation to the cranial base. Mandibular base length (Co-Gn) was the linear distance measured between Condylion (Co) to Gnathion (Gn). Mandibular inclination (ML-NSL) was the angle which is formed between mandibular base line (ML) and nasion to sella line (NSL) which indicates mandibular inclination in relation to cranial base. All nasal, maxillary, and mandibular skeletal parameters were detected on lateral cephalograms by a single investigator.

For assessment of reliability of the collected data, the lateral cephalograms of 25 patients were randomly chosen and reevaluated after 4 weeks of interval by the same researcher. Dahlberg's formula was applied to determine the method errors. These measurements were also compared by the paired t-test which depicted no significant differences ($p > 0.05$).

SPSS software for windows (IBM; SPSS, version 26.0) was utilised for the statistical analysis. The mean as well as standard deviation of nasal parameters (nasal height, nasal length, nasal depth, nasal bone length, nasal hump, nasolabial angle, nasal upward tip angle, upper lip inclination, nasal bone angle, nasal base angle, and nasal tip angle), maxillary parameters (maxillary angular position, maxillary linear position, maxillary base length, and maxillary inclination) and mandibular parameters (mandibular angular position, mandibular linear position, mandibular base length, and mandibular inclination) were calculated. Pearson correlation coefficient test was then performed to detect whether different nasal parameters had a significant correlation with maxillary and mandibular skeletal parameters. The probability level of $p \leq 0.05$ was considered to be statistically significant.

RESULTS

Table I presents the correlation of nasal linear and angular parameters with sagittal maxillary and mandibular position. Five different nasal variables exhibited a significant correlation with anteroposterior jaw position. Nasal bone length showed a statistically significant negative correlation with maxillary angular position ($p = 0.04$, $r = -0.18$), maxillary linear position ($p = 0.04$, $r = -0.18$), and mandibular angular position ($p < 0.001$, $r = -0.46$). Nasolabial angle was found to be negatively correlated with mandibular angular position ($p = 0.03$, $r = -0.19$). A significant positive correlation was observed between nasal upward tip angle and maxillary linear position ($p = 0.02$, $r = 0.20$). Nasal bone angle was found to be positively correlated with maxillary angular position ($p = 0.02$, $r = 0.20$). Nasal base angle depicted a statistically significant negative correlation with maxillary angular position ($p = 0.02$, $r = -0.20$), mandibular angular position ($p = 0.007$, $r = -0.24$) and mandibular linear position ($p = 0.001$, $r = -0.31$).

Table II depicts the Pearson correlation coefficients between nasal parameters and jaw base lengths. Nasal bone angle showed a statistically significant negative correlation with maxillary base length ($p = 0.02$, $r = -0.19$) and mandibular base length ($p = 0.03$, $r = -0.19$). A significantly negative correlation was also found when nasal tip angle was compared with maxillary base length ($p = 0.04$, $r = -0.18$).

Table III presents the correlation of linear and angular nasal parameters with jaw inclination. A significantly negative correlation was observed when nasal bone angle was compared with mandibular inclination ($p = 0.03$, $r = -0.19$). None of the remaining nasal parameters depicted any significant correlation with maxillary and mandibular inclinations.

Table I: Correlations of nasal linear and angular parameters with sagittal maxillary and mandibular position.

	Nasal height (mm)	Nasal length (mm)	Nasal depth (mm)	Nasal bone length (mm)	Nasal hump (mm)	Nasolabial angle (°)	Nasal upward tip angle (°)	Upper lip inclination (°)	Nasal bone angle (°)	Nasal base angle (°)	Nasal tip angle (°)
Maxillary angular position (°)											
r	-0.039	0.027	-0.002	-0.186*	-0.118	-0.166	0.096	-0.007	0.208*	-0.206*	0.063
p-value	0.674	0.773	0.985	0.042	0.199	0.069	0.298	0.938	0.023	0.024	0.494
Maxillary linear position (mm)											
r	0.069	0.021	0.082	-0.184	0.092	0.022	0.200*	-0.100	0.157	0.108	0.122
p-value	0.457	0.820	0.373	0.045*	0.319	0.812	0.029	0.277	0.087	0.242	0.184
Mandibular angular position (°)											
r	0.049	-0.086	0.028	0.465*	-0.028	-0.196*	-0.078	0.052	0.092	-0.246*	0.035
p-value	0.594	0.349	0.759	0.000	0.761	0.032	0.395	0.575	0.318	0.007	0.705
Mandibular linear position (mm)											
r	-0.054	0.014	-0.029	-0.016	0.091	-0.077	0.135	0.094	0.155	-0.312*	-0.069
p-value	0.556	0.876	0.753	0.860	0.321	0.402	0.142	0.306	0.090	0.001	0.453

**p ≤0.05 level, correlation is considered to be significant.*

Table II: Correlations of nasal linear and angular parameters with maxillary and mandibular base length.

	Nasal height (mm)	Nasal length (mm)	Nasal depth (mm)	Nasal bone length (mm)	Nasal hump (mm)	Nasolabial angle (°)	Nasal upward tip angle (°)	Upper lip inclination (°)	Nasal bone angle (°)	Nasal base angle (°)	Nasal tip angle (°)
Maxillary base length (mm)											
r	0.059	0.102	-0.091	-0.050	-0.099	0.029	-0.120	0.169	-0.199*	0.042	-0.183*
p-value	0.521	0.265	0.324	0.587	0.281	0.757	0.192	0.065	0.029	0.652	0.045
Mandibular base length (mm)											
r	0.168	-0.013	0.081	-0.118	-0.010	-0.115	-0.150	0.076	-0.194*	0.051	-0.002
p-value	0.066	0.888	0.379	0.198	0.915	0.210	0.103	0.410	0.034	0.578	0.987

**p ≤0.05 level, correlation is considered to be significant.*

Table III: Correlations of nasal linear and angular parameters with maxillary and mandibular inclination.

	Nasal height (mm)	Nasal length (mm)	Nasal depth (mm)	Nasal bone length (mm)	Nasal hump (mm)	Nasolabial angle (°)	Nasal upward tip angle (°)	Upper lip inclination (°)	Nasal bone angle (°)	Nasal base angle (°)	Nasal tip angle (°)
Maxillary inclination (°)											
r	-0.078	0.052	-0.160	-0.094	0.041	0.086	-0.078	-0.106	0.033	0.000	0.042
p-value	0.395	0.571	0.081	0.306	0.657	0.352	0.395	0.250	0.717	0.998	0.646
Mandibular inclination (°)											
r	0.069	-0.027	-0.017	0.136	0.063	-0.066	0.060	-0.029	-0.196*	0.025	-0.100
p-value	0.452	0.767	0.851	0.139	0.496	0.472	0.513	0.753	0.032	0.790	0.275

**p ≤0.05 level, correlation is considered to be significant.*

DISCUSSION

The present study exhibited a significant negative correlation of nasal bone length with maxillary and mandibular sagittal position (Table I) which is in accordance with the findings by Jankowska *et al*.[13] It suggests that the individual with increased nasal bone length is more likely to have a retrusive maxilla and mandible. However, in a study conducted by Chen *et al*.,[15] nasal bone length was found to be positively correlated with maxillary length (palatal length) exhibiting that when the maxilla is prognathic, it results in excessive forward growth of the nose which is contradicted by the present study. Moreover, in this study, nasolabial angle depicted a significant negative correlation with mandibular angular position (Table I) which is supported by Jankowska *et al.*[13] However, Gulsen *et al.* found a significant negative correlation of nasolabial angle with mandibular linear position.[16] These findings reveal that the nasolabial angle is highly influenced by the anteroposterior position of mandible and high nasolabial angle indicates a mandibular retrusion. Nasal upward tip angle depicted a significant positive correlation with maxillary sagittal position (Table I). Analogous conclusions were reported by Gulsen and Krishnaveni *et al.* who found a positive correlation with all of the sagittal maxillary parameters.[16] This depicted that an increased nasal upward tip angle indicates the presence of a protrusive maxilla.

Nasal bone angle showed a statistically significant positive association with maxillary angular position, maxillary and mandibular base lengths, and negative association with mandibular inclination (Table I-III). This result showed that

as the maxillary angular position and jaw lengths increase, nasal bone angle also increases but as the mandibular inclination increases, nasal bone angle decreases. In this study, nasal base angle revealed a significant negative correlation with maxillary angular position, mandibular angular position, and mandibular linear position (Table I). Thakur *et al.* also showed a negative correlation of nasal base angle with sagittal position of both the jaws which was in accordance with this study's results.[17] This suggested that an individual with retrusive jaw bases has the tendency to have an increased nasal base inclination. Nasal tip angle depicted a significant negative correlation with maxillary base length (Table II) which revealed that the individuals with reduced maxillary base length are more likely to have an increased nasal tip angle. This finding of the present study is supported by Prasad *et al.*[9]

The findings of this study confirmed that some of the linear as well as angular nasal parameters depicted a significant correlation with sagittal jaw pattern, and the understanding of this relationship might help to determine the treatment goals and to attain the desired treatment outcomes in patients undergoing orthognathic or other craniofacial surgical procedures. However, any errors in lateral cephalogram's tracing and landmark's detection can be considered as the limitation of the study. In the future studies, larger sample size and more cephalometric variables should be considered.

CONCLUSION

None of the nasal parameters showed any significant correlation with maxillary inclination but a significant correlation between nasal bone angle and mandibular inclination was observed. This revealed that the inclination of maxilla has no major effect on nasal morphology. Maxillary and mandibular sagittal position and lengths can depict a greater impact on nasal morphology than the jaw inclinations. An association seems to exist between nasal integument and sagittal jaw configuration, however, the effectiveness and outcome of orthodontic treatment, orthopedic intervention, orthognathic, profiloplastic, rhinoplastic and genioplastic procedures will be deteriorated if this relationship is not understood.

ETHICAL APPROVAL:

An approval of this study was obtained from Institutional Review Board of Liaquat College of Medicine and Dentistry (Ref. no. IRB/D-000020/21) prior to initiation of the research work.

PATIENTS' CONSENT:

Informed consents were taken from patients to publish the data concerning this study.

COMPETING INTEREST:

The authors declared no competing interest.

AUTHORS' CONTRIBUTION:

ASF: Conception, design, data collection and interpretation, statistical analysis, writing of the original draft and validation.

AS: Supervision, writing of the review, editing, validation and project administration.

All authors approved the final version of the manuscript to be published.

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