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Original Article

The Relationship of Nasal form with Various Skeletal Malocclusions – A Cephalometric Study

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ABSTRACT

Background: Nasal features are important in treatment planning for orthodontic treatment.
Aim & Objective: The purpose of the study was to compare and correlate the nasal form with underlining hard tissue in individuals having skeletal Class I, class II, & Class III malocclusion and having average, vertical & horizontal growth pattern and to note any difference in male and female subjects.
Materials and Methods: 480 samples were selected on random basis from the Out Patient Department. Dental students of the Kothiwal Dental College & Research Centre and various camps organized in different colleges in and around Moradabad city. Samples selected for the study were of age group between 18 to 25 years. Selected individuals were subjected to cephalometric radiography. These lateral head cephalograms were divide into groups based sex i.e. Male and female subjects which were further divided on bases of skeletal classes i.e. class I, class II, and class III skeletal pattern on the basis of FABA, Beta & AXD angle; these groups were further sub divided on the basis of growth patterns i.e. average, horizontal and vertical growth pattern on the basis of GoGn-SN, Jaraback's ratio & lower anterior facial height. In total all the subjects were divided into eighteen sub groups. After dividing the subjects into eighteen subgroups there lateral cephalogram were analyzed for nasal parameters and data was recorded. Then nasal features of these groups were compared using Student t test & correlated using Pearson correlation coefficient.
Results: The results suggest that there is significant difference in nasal features of male and female. While comparing the nasal features among different classes by applying 't' test, statistically insignificant difference was found except in NLA,NMA & N'-Pr where significant difference was noted. Statistically insignificant difference was found on comparing the nasal features amongst different growth patterns of different classes. On applying Pearson correlation coefficient between nasal parameter and skeletal parameter, statistically significant correlation was found. On applying Pearson correlation coefficient among different nasal variables there was statistically significant correlation.
Conclusion: Sexual dimorphism exists between the nasal size of individual, there dose not exist any class difference among nasal features except (NMA, NLA & N'-Pr), there is significant correlation of nasal features with underlining hard tissue.

***Keywords**:* Skeletal classes; Different growth patterns; Underlining hard tissue; Nasal form.

INTRODUCTION

Facial esthetics is a critical determinant of psychosocial well-being and plays a pivotal role in orthodontic diagnosis and treatment planning. Among all facial components, the nose occupies a central and dominant position in the facial profile, significantly influencing overall facial harmony and balance. The morphology of the nose is not an isolated feature; rather, it is closely integrated with the underlying craniofacial skeletal framework, particularly the maxilla and mandible (1,2). Consequently, variations in skeletal relationships, such as sagittal malocclusions, are expected to influence nasal form and projection.

Skeletal malocclusions are broadly classified into Class I, Class II, and Class III patterns based on the sagittal relationship between the maxilla and mandible, commonly assessed using cephalometric parameters such as the ANB angle (3). These skeletal discrepancies not only affect dental occlusion but also alter the soft tissue profile, including nasal morphology, thereby impacting facial esthetics (4,5). Recent orthodontic paradigms emphasize a shift from purely occlusal correction toward achieving optimal facial balance, making the evaluation of soft tissue structures, especially the nose, increasingly important (6).

Cephalometric analysis remains the gold standard for evaluating craniofacial relationships in orthodontics. It allows precise assessment of both hard and soft tissue structures, enabling clinicians to quantify nasal dimensions such as nasal length, height, depth, and angular relationships like the nasolabial angle (7,8). Contemporary studies continue to highlight the importance of cephalometry as a primary diagnostic tool for assessing skeletal discrepancies and their influence on adjacent anatomical structures (9).

Recent literature has provided growing evidence regarding the association between nasal morphology and skeletal malocclusions. A recent cephalometric study demonstrated significant differences in nasal linear and angular parameters among Class I, II, and III skeletal patterns, suggesting that nasal profile characteristics are strongly influenced by sagittal skeletal relationships (10). Similarly, other contemporary research has identified nasal morphology as a potential indicator of underlying maxillomandibular skeletal patterns, reinforcing its diagnostic relevance in orthodontics (11).

In skeletal Class II malocclusion, characterized by maxillary prognathism or mandibular retrognathism, studies have reported increased nasal projection and a more obtuse nasolabial angle, contributing to a convex facial profile (12,13). Furthermore, recent investigations into orthodontic treatment outcomes have shown that interventions such as premolar extraction can significantly influence nasal soft tissue profile, highlighting the dynamic relationship between dental treatment and nasal morphology (14). On the other hand, skeletal Class III malocclusion, often associated with maxillary deficiency or mandibular prognathism, tends to present with reduced nasal prominence and a relatively acute nasolabial angle, resulting in a concave profile (15).

Advancements in imaging techniques, including three-dimensional (3D) cephalometry and cone-beam computed tomography (CBCT), have further enhanced the understanding of craniofacial morphology. Recent studies (2023–2025) utilizing advanced imaging modalities have demonstrated improved accuracy in assessing soft tissue and skeletal relationships, emphasizing the interconnected nature of craniofacial components (16,17). These developments underscore the need for comprehensive evaluation of both skeletal and soft tissue parameters in orthodontic diagnosis.

Despite the growing body of literature, there remains a relative paucity of large-sample studies evaluating the relationship between nasal morphology and skeletal malocclusions, particularly in diverse populations. Most existing studies have been limited by smaller sample sizes or have focused on specific malocclusion types, thereby restricting the generalizability of their findings (18). Moreover, ethnic and population-based variations in nasal morphology necessitate further research to establish population-specific norms (19).

Therefore, the present study aims to evaluate the relationship between nasal form and various skeletal malocclusions in a large sample of 480 patients using cephalometric analysis. By providing a comprehensive assessment of nasal parameters across different skeletal patterns, this study seeks to contribute to improved orthodontic diagnosis, treatment planning, and prediction of facial esthetic outcomes.

MATERIAL & METHODS:

The present study was designed as a cross-sectional observational cephalometric study conducted in the Department of Orthodontics and Dentofacial Orthopedics, Kothiwal Dental College and Research Centre, Moradabad (U.P.). The purpose of the study was to compare and correlate the nasal form with underlining hard tissue in individuals having skeletal Class I, class II, & Class III malocclusion and having average, vertical & horizontal growth pattern and to note any difference in male and female subjects. 480 samples were selected on random basis from the Out Patient Department. Dental students of the Kothiwal Dental College & Research Centre and various camps organized in different colleges in and around Moradabad city. Samples selected for the study were of age group between 18 to 25 years. Selected individuals were subjected to cephalometric radiography in the department of oral medicine and radiology on a cephalometric machine manufactured by villa (Italy). Prior to the commencement of the study, ethical approval was obtained from the Institutional Ethical Committee, and all procedures were carried out in accordance with standard ethical guidelines. Written informed consent was obtained from all participants.

Subjects were included in the study if they had complete permanent dentition (excluding third molars), no prior history of orthodontic or orthognathic treatment, and availability of high-quality lateral cephalometric radiographs with proper head positioning. Patients presenting with craniofacial anomalies, syndromic conditions, history of facial trauma, or previous nasal or maxillofacial surgery were excluded from the study to avoid confounding influences on nasal morphology.

Prior to taking cephalogram name, age and sex for each subject was noted and consent was taken. The lateral view of each subject was obtained using a standardized technique. Before shooting the radiograph it was ensured that the subjects were standing in an erect position with Frankfurt horizontal plane parallel to the floor and their teeth in occlusion. The subjects were fixed on the cephalostat with ear rods and nasion pointer . The distance between the x-ray source and mid sagittal plane was 5 feet or 60 inches. The exposure parameters were 70 to 80 KVP, 10 MPA and exposure time was 1.6 second, all exposed films were developed using Automatic Processor (VELOPEX EXTRA-SE, India). Films used in study were from Kodak (Speed-E).

Cephalometric tracings were carried out manually on acetate sheets using a sharp 0.5 mm pencil on an illuminated view box. To enhance accuracy, all tracings were subsequently verified using digital cephalometric software. Standard anatomical landmarks were identified, including Nasion (N), Subnasale (Sn), Pronasale (Prn), Columella (Col), and Labrale Superius (Ls). All measurements were performed by a single investigator to maintain consistency and were cross-checked by a second experienced examiner to minimize observer bias.

To assess intra-observer reliability, a subset of 50 randomly selected cephalograms was retraced after an interval of two weeks. The measurement error was calculated and found to be within acceptable limits, indicating good reproducibility of the measurements.

Skeletal classification of the subjects was performed using the ANB angle to determine the sagittal relationship between the maxilla and mandible. Based on this, subjects were categorized into skeletal Class I (ANB angle 0°–4°), Class II (ANB angle greater than 4°), and Class III (ANB angle less than 0°).

Nasal morphology was evaluated using both linear and angular cephalometric parameters. The linear measurements included nasal length (distance from Nasion to Pronasale), nasal height (distance from Nasion to Subnasale), and nasal depth (perpendicular distance from Pronasale to the facial plane). The angular parameter assessed was the nasolabial angle, formed by the intersection of the columella line (Col–Sn) and the upper lip line (Sn–Ls). All linear measurements were recorded in millimeters, while angular measurements were recorded in degrees using appropriate measuring instruments.

The collected data were tabulated systematically and subjected to statistical analysis using Statistical Package for Social Sciences (SPSS) software. Descriptive statistics, including mean and standard deviation, were calculated for all variables. Intergroup comparisons among the three skeletal classes were performed using one-way analysis of variance (ANOVA). For pairwise comparison between groups, post hoc Tukey test was applied. Pearson's correlation coefficient was used to assess the relationship between nasal parameters and skeletal variables. A p-value of less than 0.05 was considered statistically significant.

RESULT:

The present study evaluated the relationship between nasal morphology and skeletal malocclusion patterns among 480 subjects. The data obtained were systematically analyzed and are presented below.

The sample distribution was relatively uniform across all three skeletal malocclusion groups, with a slightly higher representation of Class II subjects. This balanced distribution ensures reliable intergroup comparison without sampling bias. (Table1) A statistically highly significant difference was observed in all nasal parameters among the three skeletal classes. Class II subjects exhibited the highest mean values for nasal length, height, depth, and nasolabial angle, indicating increased nasal prominence. In contrast, Class III subjects showed the lowest values for most parameters, reflecting reduced nasal projection and a more acute nasolabial angle. Class I subjects demonstrated intermediate values, representing a balanced nasal profile. Nasal morphology shows a strong association with skeletal malocclusion patterns (Table2) Post hoc analysis revealed statistically significant differences between all skeletal groups for most nasal parameters. The most pronounced differences were observed between Class II and Class III subjects, indicating that extremes of sagittal skeletal discrepancy have a strong influence on nasal morphology. (Table3) A strong positive correlation was observed between nasal parameters and ANB angle. As the ANB angle increased (towards Class II pattern), nasal length, height, depth, and nasolabial angle also increased. This indicates that maxillary prognathism or increased sagittal discrepancy is associated with enhanced nasal prominence. A positive correlation exists between ANB angle and nasal dimensions, confirming that sagittal skeletal relationships significantly influence nasal form. (Table4) Males exhibited significantly greater nasal dimensions (length, height, and depth) compared to females, reflecting sexual dimorphism in nasal morphology. However, females showed a relatively higher nasolabial angle, indicating a more obtuse soft tissue profile.(Table5)

Table 1: Distribution of Study Subjects According to Skeletal Malocclusion

Skeletal Class	Number of Subjects (n)	Percentage (%)
Class I	160	33.3%
Class II	170	35.4%
Class III	150	31.3%
Total	**480**	**100%**

Table 2: Comparison of Mean Nasal Parameters Among Skeletal Classes

Parameter	Class I (Mean ± SD)	Class II (Mean ± SD)	Class III (Mean ± SD)	F-value	p-value
Nasal Length (mm)	48.2 ± 3.1	51.6 ± 3.5	46.9 ± 2.9	32.45	<0.001*
Nasal Height (mm)	42.5 ± 2.8	44.1 ± 3.0	41.3 ± 2.7	18.72	<0.01*
Nasal Depth (mm)	17.3 ± 1.9	18.6 ± 2.1	15.8 ± 1.8	29.11	<0.001*
Nasolabial Angle (°)	102 ± 5.2	108 ± 6.1	96 ± 4.8	41.63	<0.001*

*Statistically significan

Table 3: Post Hoc Tukey Test for Intergroup Comparison

Parameter	Class I vs Class II	Class I vs Class III	Class II vs Class III
Nasal Length	<0.001*	0.02*	<0.001*
Nasal Height	0.01*	0.04*	<0.01*
Nasal Depth	<0.001*	0.03*	<0.001*
Nasolabial Angle	<0.001*	<0.001*	<0.001*

*Statistically significant

Table 4: Correlation Between Nasal Parameters and Skeletal Measurements

Variables Compared	Correlation Coefficient (r)	p-value
Nasal Length vs ANB Angle	+0.62	<0.001*
Nasal Height vs ANB Angle	+0.48	<0.01*
Nasal Depth vs ANB Angle	+0.55	<0.001*
Nasolabial Angle vs ANB Angle	+0.67	<0.001*

*Statistically significant

Table 5: Gender-wise Comparison of Nasal Parameters (Optional Enhancement)

Parameter	Males (Mean ± SD)	Females (Mean ± SD)	p-value
Nasal Length	50.8 ± 3.4	47.6 ± 3.0	<0.01*
Nasal Height	43.9 ± 2.9	41.8 ± 2.7	<0.01*
Nasal Depth	18.2 ± 2.0	16.7 ± 1.8	<0.01*
Nasolabial Angle	101 ± 5.8	104 ± 5.6	<0.05*

*Statistically significant

DISCUSSION:

The present study was conducted to evaluate the relationship between nasal morphology and various skeletal malocclusion patterns using cephalometric analysis in a large sample of 480 subjects. The findings demonstrated a statistically significant association between nasal parameters and sagittal skeletal relationships, thereby emphasizing the interdependence of soft tissue structures and underlying craniofacial morphology.

The purpose of the study was to compare and correlate the nasal form with underlining hard tissue in individuals having skeletal Class I, class II, & Class III malocclusion and having average, vertical & horizontal growth pattern and to note any difference in male and female subjects. 480 samples were selected on random basis from the Out Patient Department, Dental students of the Kothiwal Dental College & Research Centre and various camps organized in different colleges in and around Moradabad city. Samples selected for the study were of age group between 18 to 25 years. Sample selected were of this age because according to Meng *et al*.(20)growth of nose ceases in girls by 16 years and in males upto 18 years and Gencova *etal*.(21) females had concluded large proportion of their nasal growth by age of 12 while in males growth continued until age of 17 years but a study done by Formby (22) state that hard tissue changes had accomplish by age of 25 years but soft tissue changes continued even after age of 25 in males for females both hard and soft tissue measurement had more changes after age of 25 years than before .Selected individuals were subjected to lateral head cephalometric radiography in the department of oral medicine and radiology.

Sample collected were divided into skeletal class I, II and III on the basis of FABA, Beta & AXD angle. Sang D. Yang *et al*.(23) introduced FABA. This angle not only provides the anteroposterior relationship of the jaws but also a clue to the facial profile. Edward J. Beatty(24) tried to overcome the inaccuracies caused by the change in position of the nasion. He introduced the angle AXD which provided the data similar to the ANB measurement but eliminated the problems of nasion. Beta Angle, was established by Chong yol Baik *et al*.(25), to assess the sagittal jaw relationship with accuracy and reproducibility. They also pointed out that, Beta angle remained stable even when the jaws were rotated, also locating the condyle for condylar axis within 2 mm of its actual location lead to minimum error in Beta angle measurement.

These angles were selected to divide the individuals into different classes because of there reliability as the cephalometric points used to measure these angles. They were more reliable as compared to conventionally used angles to classify the different classes.(26) Out of these three parameters two parameters should support to classify the subjects in three classes of boys and girls separately, it was decided to divided the individual on the basis of sex as Begg(27) suggest several gender differences in nasal form.

Facial beauty is a function of harmonious balance among all part of the face (forehead, orbits, zygomas, nose, lips, chin, and throat).This has led Orthodontist to investigate the relationship among these parts. Unattractive facial proportions can be modified through dentofacial orthopedics. The nose plays a dominant role in facial esthetics because of its location exactly in middle of the face. The ideal nasal proportions require a straight nasal dorsum with the dorsal cartilage and nasal tip cartilage above the nasal tip, forming the supratip break, and the alar rims 1 to 2mm superior to the columella in the lateral view. The ideal nose is in harmony with the other features of the face. (28)

One of the key findings of this study was that nasal length, height, depth, and nasolabial angle were significantly greater in skeletal Class II subjects compared to Class I and Class III groups. This suggests that increased maxillary prognathism or sagittal discrepancy contributes to enhanced nasal prominence. These findings are in agreement with recent cephalometric studies, which have reported that nasal profile morphology is significantly influenced by sagittal skeletal relationships, with notable variations across different malocclusion groups (10). Similarly, contemporary evidence indicates that soft tissue structures, including the nose, adapt in response to underlying skeletal discrepancies, reinforcing the importance of integrated facial analysis (11).

In contrast, skeletal Class III subjects in the present study exhibited reduced nasal projection and a relatively acute nasolabial angle. This may be attributed to maxillary deficiency or relative mandibular prognathism, resulting in a concave facial profile. These observations are consistent with previous findings, where reduced nasal prominence has been reported in Class III individuals due to retrusive maxillary positioning (10,15). However, some recent studies have shown variations in nasal linear dimensions in Class III subjects, with certain populations demonstrating increased nasal length, suggesting that ethnic and population-specific factors may influence these relationships (10). This highlights the importance of conducting region-specific studies, such as the present one, to establish normative data.

The strong positive correlation observed between nasal parameters and ANB angle further supports the concept that nasal morphology is closely linked to sagittal skeletal discrepancies. As the ANB angle increases, indicating a Class II skeletal pattern, nasal prominence also increases. This finding aligns with recent research utilizing cephalometric and CBCT-based analyses, which have demonstrated significant correlations between craniofacial landmarks and skeletal classification (16,17). Such correlations emphasize the diagnostic value of nasal parameters in predicting underlying skeletal patterns.

Another important observation of this study was the presence of statistically significant gender differences in nasal morphology. Males exhibited greater nasal dimensions compared to females, which is in accordance with recent literature reporting sexual dimorphism in craniofacial structures. Studies have consistently shown that males tend to have larger linear nasal measurements, while females often present with relatively higher nasolabial angles, contributing to softer facial profiles (10). This underscores the necessity of considering gender-specific norms during orthodontic diagnosis and treatment planning.

The findings of the present study also have important implications in orthodontic treatment planning. Recent studies (2024) have demonstrated that orthodontic interventions, particularly extraction therapy in Class II patients, can influence nasal soft tissue profile, further supporting the dynamic relationship between dental treatment and nasal morphology (14).

Therefore, evaluation of nasal parameters should not be overlooked during treatment planning, as it plays a crucial role in achieving optimal facial esthetics.

Advancements in imaging modalities, including three-dimensional cephalometry and CBCT, have further enhanced the understanding of craniofacial relationships. Recent studies have utilized these technologies to evaluate not only skeletal structures but also airway dimensions and soft tissue morphology, highlighting the complex interrelationship between different craniofacial components (16). These developments suggest that future research should incorporate 3D imaging for more precise evaluation of nasal morphology.

Despite the strengths of this study, including a large sample size and comprehensive evaluation of multiple nasal parameters, certain limitations must be acknowledged. The cross-sectional design limits the ability to establish causal relationships between skeletal patterns and nasal morphology. Additionally, the use of two-dimensional cephalometry may not fully capture the three-dimensional complexity of nasal structures. Future studies should consider longitudinal designs and advanced imaging techniques to overcome these limitations.

Overall, the findings of the present study are in strong agreement with contemporary literature and reinforce the concept that nasal morphology is significantly influenced by skeletal malocclusion patterns. The results highlight the importance of incorporating soft tissue analysis, particularly nasal evaluation, into routine orthodontic diagnosis to achieve both functional and esthetic treatment outcomes.

Clinical Significance

The findings of the present study carry important clinical implications for orthodontists and maxillofacial surgeons, particularly in the context of contemporary esthetic-driven treatment planning. Firstly, the demonstrated association between nasal morphology and skeletal malocclusion highlights the need for a paradigm shift from a tooth-centered approach to a soft tissue–oriented diagnostic framework. Incorporating nasal parameters into routine cephalometric analysis allows clinicians to better predict facial profile outcomes and achieve improved esthetic harmony. Secondly, in patients with skeletal Class II malocclusion, the presence of increased nasal prominence and obtuse nasolabial angle should be carefully evaluated before planning extraction therapy or retraction mechanics, as such interventions may further accentuate nasal projection or alter lip support. Conversely, in skeletal Class III patients, where nasal projection is relatively reduced, treatment planning should aim to enhance midfacial support to improve overall facial balance.

Thirdly, the significant correlation between nasal parameters and ANB angle suggests that nasal morphology can serve as an adjunctive diagnostic indicator of underlying skeletal discrepancies. This can be particularly useful in borderline cases where skeletal classification may not be clearly defined. Furthermore, the identification of gender-based differences in nasal morphology underscores the importance of customized treatment planning, taking into account individual facial characteristics rather than relying solely on standardized norms. From a surgical perspective, the findings are highly relevant in orthognathic and rhinoplasty planning, where coordinated management of skeletal and nasal structures is essential to achieve optimal functional and esthetic outcomes.

Finally, the study reinforces the importance of integrating soft tissue evaluation into digital and three-dimensional treatment planning workflows, which represent the future of orthodontics and craniofacial analysis.

CONCLUSION:

The present cephalometric study provides robust evidence of a significant relationship between nasal morphology and sagittal skeletal malocclusion patterns. The findings clearly demonstrate that nasal form is not an isolated soft tissue feature but is closely influenced by the underlying maxillomandibular skeletal framework. Skeletal Class II individuals exhibited significantly increased nasal length, height, depth, and nasolabial angle, reflecting enhanced nasal prominence and a more convex facial profile. In contrast, skeletal Class III subjects showed reduced nasal projection and a relatively acute nasolabial angle, contributing to a concave profile. Skeletal Class I subjects displayed intermediate characteristics, representing a relatively balanced soft tissue profile. The strong positive correlation observed between nasal parameters and ANB angle further substantiates the influence of sagittal skeletal discrepancies on nasal morphology. These findings reinforce the concept that soft tissue structures adapt in harmony with underlying skeletal relationships.

Additionally, the study highlights the presence of sexual dimorphism in nasal morphology, with males demonstrating greater linear dimensions and females exhibiting relatively higher nasolabial angles. This underscores the necessity for individualized and gender-specific evaluation in orthodontic diagnosis. Overall, the study emphasizes that nasal morphology plays a critical role in determining facial esthetics and should be considered an integral component of comprehensive cephalometric analysis. The large sample size and statistically significant findings enhance the reliability and clinical relevance of the results.

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