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Correlation between nasolabial angle and maxillary incisors inclination using lateral cephalograms: A retrospective study

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Abstract:
The nasolabial angle (NLA) is an important soft tissue parameter used in orthodontic diagnosis to assess facial esthetics and the relationship between the upper lip and maxillary incisors. Therefore, it is of interest to evaluate the correlation between the NLA and maxillary incisor inclination using pretreatment lateral cephalometric radiographs of 100 patients aged 18–25 years. Angular (U1–NA, U1–SN, U1–Palatal Plane and interincisal angle) and linear (U1–NA, U1–Point A, U1–N Pog and U1–A Pog) cephalometric measurements were recorded and Pearson's correlation analysis was performed. The mean NLA was 94.14 ± 12.16°C. Angular measurements showed weak and statistically non-significant correlations with the NLA (P>0.05), whereas linear measurements, particularly U1–Point A, U1–N Pog and U1–A Pog, showed strong positive correlations (P<0.001). Thus, data shows that linear cephalometric parameters are more reliable than angular measurements for predicting nasolabial angle changes and may improve orthodontic diagnosis and treatment planning.

Keywords: Nasolabial angle, maxillary incisor inclination, lateral cephalogram

Background:
Facial esthetics is a primary objective of contemporary orthodontic treatment and plays a significant role in patient satisfaction. In addition to achieving functional occlusion, orthodontic therapy aims to establish a harmonious facial profile by maintaining a balanced relationship between the hard and soft tissues. Consequently, soft tissue analysis has become an essential component of orthodontic diagnosis and treatment planning because facial attractiveness is largely influenced by the morphology and position of the lips, nose and chin rather than skeletal structures alone **[1–4]**. The nasolabial angle (NLA) is a widely accepted soft tissue cephalometric parameter used to assess facial profile harmony. It is formed by the intersection of a tangent to the columella of the nose and another extending from the subnasale to the upper lip. Since its introduction by Mattos *et al.* and Fitzgerald *et al.*, the NLA has been extensively used to evaluate facial esthetics and predict soft tissue changes following orthodontic treatment **[5, 6]**. Its normal range varies among different ethnic groups, age categories and sexes, emphasizing the need for population-specific reference values during orthodontic diagnosis **[5, 7]**. The position and inclination of the maxillary incisors play an important role in determining upper lip support and facial profile. Orthodontic tooth movement, particularly incisor retraction or proclination, can alter lip posture and consequently influence the NLA. Therefore, accurate evaluation of maxillary incisor position is essential for planning extraction or non-extraction therapy and achieving favorable esthetic outcomes **[1, 2 and 8].** Angular cephalometric measurements such as U1–NA, U1–SN, U1–Palatal Plane and the interincisal angle are commonly used to assess incisor inclination, whereas linear measurements including U1–NA, U1–Point A, U1–N Pog and U1–A Pog evaluate the anteroposterior position of the incisors. Together, these measurements assist clinicians in predicting treatment-induced soft tissue changes and optimizing facial harmony **[2, 8 and 9]**. Previous studies have reported inconsistent findings regarding the relationship between the NLA and maxillary incisor inclination. Burstone suggested that the NLA reflects the position of the maxillary dentoalveolar complex, whereas Quinzi *et al.* emphasized that lip thickness, nasal morphology and skeletal pattern also influence the soft tissue profile **[10]**. Similarly, Legan and Burstone highlighted the importance of maintaining the NLA within normal limits to achieve an esthetically balanced facial profile **[11]**. Therefore, it is of interest to evaluate the correlation between the nasolabial angle and maxillary incisor inclination using angular and linear cephalometric measurements obtained from pre-treatment lateral cephalograms.

Methodology:
The present study was conducted to evaluate the association of nasolabial angle (NLA) and inclination of maxillary incisors by pretreatment lateral cephalometric radiographs. This retrospective observational study was conducted in the Department of Orthodontics and Dentofacial Orthopedics, New Horizon Dental College and Research Institute, Bilaspur, Chhattisgarh, India. The study protocol was approved by the Institutional Research Ethics Committee. The need for ethical approval and informed consent was eliminated because the study entailed retrospective assessment of stored lateral cephalograms taken before therapy. There was no direct contact with or intervention on the patients. Lateral cephalometric radiographs of 100 patients (18-25 years old) at pretreatment were obtained from the departmental archives. We included radiographs of male and female patients who fulfilled the inclusion criteria. Radiographs of appropriate diagnostic quality with complete clinical records only were included in the analysis. The study comprised patients aged 18-25 years with proclined maxillary and mandibular anterior teeth, healthy periodontal tissues, available pre-treatment lateral cephalograms and no previous orthodontic treatment. Patients with Angle's Class II Division 2 or Class III malocclusion, retroclined

maxillary incisors, short upper lip, tilted nose, poor periodontal state, severe dental caries, evident attrition, craniofacial deformities or a history of facial cosmetic or orthognathic surgery were excluded. Pre-treatment lateral cephalograms were manually traced on 0.003-in matte acetate tracing paper under regulated settings. The nasolabial angle was measured as the angle between a tangent from the subnasale (Sn) to the most anterior point of the columella (Cm) and a second tangent from the subnasale to the labrale superius (LS). Angular measures were Nasolabial angle (NLA), U1-NA, U1-SN, U1-Palatal plane and interincisal angle. The linear measurements were U1-NA, U1-Point A, U1-N Pog and U1-A Pog. All measurements are given in degrees or millimeters when appropriate. The obtained data were entered into Microsoft Excel and analyzed using the Statistical Package for the Social Sciences version 23.0 (SPSS Inc., Chicago, IL, USA). Continuous variables were presented as mean ± standard deviation (SD). The Pearson's correlation coefficient (r) was utilized to determine the connection of nasolabial angle with the angular and linear cephalometric measurements. Statistical significance was defined as a two-tailed p-value <0.05.

Results:

The study included 100 pre-treatment lateral cephalometric radiographs to study the connection of nasolabial angle (NLA) to inclination of maxillary incisor. Descriptive statistical analysis was performed for all angular and linear cephalometric variables. Pearson's correlation analysis was subsequently performed to determine the link with NLA. The mean NLA of the study population was 94.14±12.16°C and ranged from 70°C to 120°C. The mean values for the angular measurements were : 33.15 ± 11.32°C for U1–NA, 114.60 ± 30.60°C for U1–SN , 74.76 ± 9.28°C for U1–Palatal Plane and 103.02 ± 12.16°C for Interincisal angle . Mean linear measurements were U1-NA, U1-Point A, U1-N Pog and U1-A Pog values 9.28 ± 2.61 mm, 10.03 ± 2.26 mm, 14.68 ± 3.03 mm and 10.31 ± 1.92 mm, respectively **(Table 1).** Association with Pearson's test showed that there was no statistically significant association between any of the angular cephalometric parameters and nasolabial angle. U1–NA showed a small negative correlation (r = –0.119, P = 0.240). U1–SN (r = 0.145, P = 0.150), U1–Palatal Plane (r = 0.051, P = 0.616) and Interincisal angle (r = 0.182, P = 0.069) had mild positive correlations that were not statistically significant **(Table 2).** The results of this study suggest that differences in angular measurements had no impact on the NLA in the study population. The pattern of the linear cephalometric parameters, however, was considerably different. U1–Point A (r = 0.999), U1–N Pog (r = 1.000) and U1–A Pog (r = 0.999) were strongly correlated with nasolabial angle and all of them were highly statistically significant (P < 0.001). The linear U1–NA measurement, however, did not show any significant negative connection (r = −0.097, P = 0.335). These data imply that the linear measures of the anteroposterior location of the maxillary incisors are more related to the nasolabial angle than to angular measurements **(Table 3).**

Table 1: Descriptive statistics of cephalometric measurements

Parameter	Mean ± SD	Minimum	Maximum
Nasolabial angle (°C)	94.14 ± 12.16	70	120
U1–NA (°C)	33.15 ± 11.32	20	49
U1–SN (°C)	114.60 ± 30.60	65	134
U1–Palatal Plane (°C)	74.76 ± 9.28	40	133
Interincisal angle (°C)	103.02 ± 12.16	80	132
U1–NA (mm)	9.28 ± 2.61	5	18
U1–Point A (mm)	10.03 ± 2.26	4	19
U1–N Pog (mm)	14.68 ± 3.03	9	23
U1–A Pog (mm)	10.31 ± 1.92	7	20

Table 2: Correlation between angular cephalometric measurements and the nasolabial angle

Parameter	Pearson's correlation coefficient (*r*)	*P* value
U1–NA (°C)	–0.119	0.240
U1–SN (°C)	0.145	0.150
U1–Palatal Plane (°C)	0.051	0.616
Interincisal angle (°C)	0.182	0.069

Table 3: Correlation between linear cephalometric measurements and the nasolabial angle

Parameter	Pearson's correlation coefficient (*r*)	*P* value
U1–NA (mm)	–0.097	0.335
U1–Point A (mm)	0.999	<0.001*
U1–N Pog (mm)	1.000	<0.001*
U1–A Pog (mm)	0.999	<0.001*

**Statistically significant.*

Discussion:

The present retrospective study evaluated the correlation between the nasolabial angle (NLA) and maxillary incisor inclination using angular and linear cephalometric measurements. The findings showed that angular measurements exhibited negligible correlations with the NLA, whereas linear measurements showed a strong positive correlation. These observations suggest that the anteroposterior position of the

maxillary incisors has a greater influence on the nasolabial soft tissue profile than incisor angulation alone, supporting the concept that soft tissue morphology is influenced by multiple dentoskeletal and soft tissue factors rather than by dental inclination alone. Recent evidence emphasizes the importance of integrating soft tissue analysis into orthodontic diagnosis and treatment planning **[12].** Zhou *et al.* developed individualized prediction models based on dentoskeletal and soft tissue characteristics and reported that customized positioning of the maxillary incisors achieved superior facial esthetic outcomes compared with conventional cephalometric norms **[13]**. Likewise, He *et al.* showed that post-treatment facial attractiveness depends on both soft tissue characteristics and maxillary incisor position, indicating that objective linear measurements provide a better representation of clinically relevant facial profile changes than angular measurements alone **[14]**. The absence of a significant correlation between angular parameters and the NLA in the present study may be attributed to the influence of additional anatomical factors, including upper lip thickness, nasal projection and skeletal growth pattern. Orthodontic tooth movement alters incisor inclination; however, the resulting soft tissue response varies considerably among individuals because of differences in lip morphology, tissue elasticity and facial proportions. Therefore, angular measurements alone may not reliably predict soft tissue profile changes following orthodontic treatment **[15]**. Previous studies have also demonstrated that changes in maxillary incisor inclination differ according to facial growth patterns. Bou Assi *et al.* reported that orthodontic treatment produced varying changes in incisor inclination depending on vertical skeletal morphology, highlighting the importance of considering skeletal divergence when predicting soft tissue response **[1]**. Similarly, Mattos *et al.* observed that changes in the nasolabial angle following premolar extraction were influenced not only by maxillary incisor retraction but also by pre-treatment soft tissue characteristics and upper lip morphology, emphasizing the need for individualized treatment planning **[5]**. These findings support the present results, where linear measurements demonstrated stronger correlations with the NLA than angular measurements. Recent advances in orthodontics have further reinforced the importance of comprehensive facial analysis. Chan *et al.* showed that dentoskeletal changes following orthodontic treatment were significantly associated with alterations in the soft tissue facial profile, particularly in patients with high-angle skeletal Class II malocclusion. Their findings suggested that soft tissue adaptation cannot be predicted solely by changes in incisor inclination because skeletal morphology and facial growth patterns substantially influence treatment outcomes **[16]**. Similarly, Singh *et al.* reported that changes in maxillary and mandibular incisor position resulted in measurable improvements in facial profile and esthetics, although the extent of these improvements depended on the patient's pretreatment soft tissue characteristics **[17]**. These observations are consistent with the present findings, highlighting the greater clinical relevance of linear cephalometric parameters for evaluating facial profile changes. Facial attractiveness is determined by the harmonious relationship between skeletal structures, dentition and surrounding soft tissues. Ghorbanyjavadpour and Rakhshan demonstrated that upper lip position, nasal morphology, chin prominence and overall facial balance significantly influence the perception of facial beauty, suggesting that orthodontic treatment should focus on achieving facial harmony rather than relying solely on cephalometric norms **[18]**. Likewise, Pop *et al.* reported that combining cephalometric and photographic analyses provides a more comprehensive assessment of the nasolabial angle and treatment-induced facial profile changes than cephalometric evaluation alone **[19]**. These findings further support the integration of multiple diagnostic methods during orthodontic treatment planning. The strengths of the present study include the use of a standardized cephalometric protocol and simultaneous evaluation of both angular and linear parameters in a homogeneous sample of young adults. However, the retrospective design, single-center setting and use of two-dimensional lateral cephalograms may limit the generalizability of the findings. Future multicenter prospective studies incorporating three-dimensional imaging and larger, ethnically diverse populations are warranted to improve the prediction of soft tissue changes following orthodontic treatment.

Conclusion:

Linear cephalometric measurements showed a stronger association with the nasolabial angle than angular parameters, highlighting the significant influence of maxillary incisor anteroposterior position on the soft tissue facial profile. These findings emphasize the importance of integrating linear measurements with conventional angular assessments for a comprehensive evaluation of dentofacial relationships and facial esthetics. Incorporating linear parameters into routine cephalometric analysis may improve the prediction of soft tissue changes and facilitate more precise, individualized orthodontic treatment planning to achieve optimal facial esthetic outcomes.

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