RESEARCH ARTICLE

The effect of the nose form on linear and angular lip position in Class II patients

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Abstract

Objective: To determine the effect of nose form on linear and angular lip position on pre-treatment cephalometric soft tissue analysis.

Method: The retrospective, cross-sectional, analytical study was conducted at the orthodontic department of Foundation University College of Dentistry and Hospital in Islamabad, and comprised data from October to December 2023 of patients aged 18-25 years presenting with no prior history of orthodontic treatment and craniofacial anomalies and syndromes. Pre-treatment lateral cephalograms were manually traced by a single experienced investigator. The sample was divided into two horizontal groups, using point A-nasion-point B angle. Comparisons were made based on gender and sagittal groups, and the effect of nasal profiles was assessed. Data was analysed using SPSS 23.

Results: Of the 131 patients, 96(73.2%) were females with mean age 22.70±3.97 years, and 35(26.7%) were males with mean age 20.97±3.21 years. There were 65(49.6%) subjects in sagittal Class I group, and 66(50.4%) in sagittal Class II group. A significant and inverse relationship was noted for columellar length with linear position of the upper and lower lips to E and S lines (p<0.05). Inclination of the nasal base had the most effect on the naso-labial angle (p<0.05).

Conclusion: Skeletal Class II had a prominent nose which created a relatively retrusive appearance of the upper and lower lips.

Keywords: Cephalometry, Diagnosis, Nose, Aesthetics, Rhinoplasty. (JPMA 76: 220; 2026)

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Introduction

The nose is classified into three types that vary according to facial forms and ethnicities[1,2] A study[3] found that while Class II noses have more concave nasal bones, others[4] found that they have more pronounced nasal tips and naso-facial angle (NFA) than Class I. This is in contrast to one study[5] that did not find any difference in the nose forms between Class I and Class II. With such reported variations, it becomes mandatory to provide all patients with an optimum plan suited to their aesthetic needs without disturbing the overall facial balance.

Orthodontic treatment and orthognathic surgery cause movement of the lips that also affects nose form. Extraction of teeth and the number of teeth (two upper first premolars versus all four first premolars) affect the prominence of the nose with more effect on naso-labial angle (NLA) due to two maxillary premolar extractions.[6] Single or double jaw orthognathic procedures involving maxillary advancement affect the nose tip through slight elevations, which affects the NLA angle.[7]

Adjunctive procedures, such as rhinoplasty and tip-plasty, conducted without orthodontic treatment also affect these parameters. Procedures, such as sub-nasal lip lift, can significantly decrease the NLA while increasing the vermilion show at the same time.[8] Septoplasty procedures for the correction of nasal deviations and obstructions significantly alter the NLA, NFA and nasal tip projection.[9,10] Although these procedures are done after the completion of treatment, they can be considered at pre-treatment levels in order to correct discrepancies that influence clinical diagnosis.

Skeletal Class II patients present with a convex face form that enhances the projection of the nose. Rhinoplasty procedures improve the overall facial aesthetics irrespective of lateral face profiles.[11] It is now known that for patients with concave nose contours, the maxillary incisor inclination can be increased to a maximum of five degrees for aesthetically pleasing results.[12]

Nose forms affect and are affected by treatment parameters. The aesthetic perceptions of the caregiver and receiver are also different. However, the full extent of this impact on the soft tissue (ST) is not yet fully known.

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Clinicians need to be able to differentiate whether the cause of lip retrusion or obtuse NLA is due to an upturned nose or poor lip profile. With the weightage of the relationship known, clinicians might consider the aid of orofacial therapies, such as hyaluronic acid, and adjunctive procedures, such as rhinoplasties, as part of their treatment plan.[13]

The current study was planned to determine the effect of nose form on linear and angular lip position on pre-treatment cephalometric soft tissue analysis (STA).

Materials and Methods

The retrospective, cross-sectional, analytical study was conducted at the orthodontic department of Foundation University College of Dentistry and Hospital, Foundation University Islamabad. It comprised data from October to December 2023. Because of the retrospective design, approval from the institutional ethics review committee was not required. All study protocols were in line with the Helsinki Declaration.[14]

The sample size was calculated with an effect size of 0.433 to detect a difference in NLA in three vertical groups using one-way analysis of variance (ANOVA) reported previously.[15] The power of the study was 83% and the significance level was set at 0.05. The final sample size was inflated by >100%. The sample size was calculated using Number Cruncher Statistical System (NCSS) Power Analysis and Sample Size (PASS) tool.[16,17] The sample was raised using non-probability purposive sampling technique.

Pre-treatment lateral cephalograms of patients aged 18-25 years presenting with no prior history of orthodontic treatment, surgery of naso-oropharynx region and without craniofacial anomalies and syndromes were included. Patients presenting with craniofacial anomalies, such as cleft lip and palate, or syndromes were excluded.

The sample was divided into two horizontal groups, using point-A Nasion-point B (ANB) angle. The ANB was taken as Class I for values in the range of 0-4º, which was the control group; and, Class II for values ≥5º.

Skeletal Class III was not considered for evaluation. It is known that all points below the Frankfort Horizontal (FH) plane are affected by growth and head position.[18] Anterior movement of the cephalometric chin points would have influenced the STA, hence overshadowing the effects of the nose form.

Good quality lateral cephalometric radiographs with head position stabilised in the cephalostats and visible radiographic markers for the head position were chosen. These markers were used as a reference for the true vertical.

Manual tracing of radiographs was done by one investigator. From the radiographs, some were randomly selected and retraced after one month for the assessment of intra-examiner reliability.

The landmarks used for nasal assessment were glabella (G), pronasale (Pn; the most prominent point at tip of the nose), columella length (CL), alar depth (AD; point of maximum convexity on the ala of the nose), subnasale (Sn), and stomion superior (Sts; at the base of the upper lip) (Figure 1). True verticals were drawn at point G (Gv) and Sn (SnV) using the cephalostat ruler as reference (Figure 2).

Assessment of nasal profile was done using various parameters,[19] includingnasal length (NL), which was the

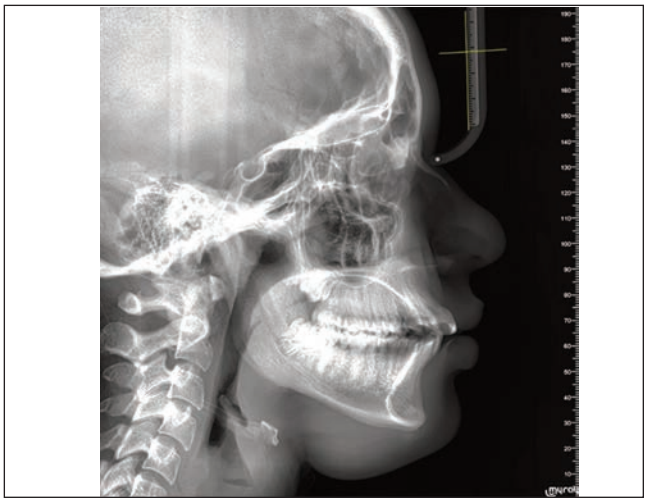

Figure-1: Lateral cephalogram showing true verticals (yellow) drawn parallel to cephalostat ruler.

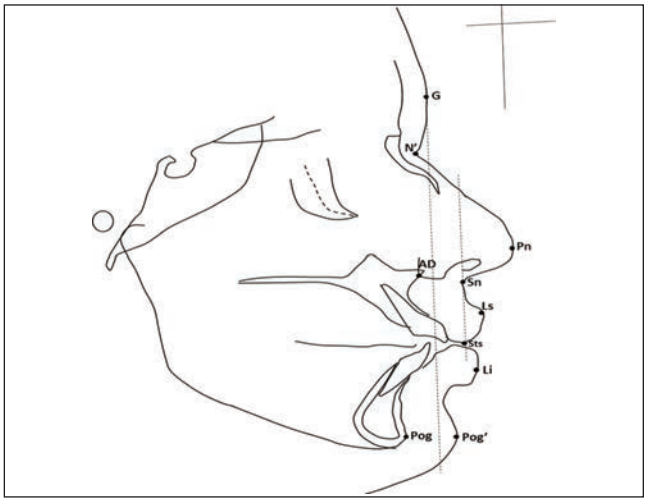

Figure-2: Cephalometric landmarks showing glabella (G), soft tissue nasion (N'), pronasale (Pn), columella length, alar depth (AD; point of maximum convexity on the ala of the nose), subnasale (Sn), labrale superioris (Ls), stomion superior (Sts), labrale inferioris (Li), pogonion (Pog), and soft tissue pogonion (Pog'). True verticals were drawn at point glabella (Gv) and subnasale (SnV) parallel to cephalostat ruler.

vertical length of nose measured from nasion to Pn; horizontal nasal prominence (HNP), which measured as a percentage of nasal height (NH; vertical distance in mm from G to Pn) to nasal depth (ND; horizontal distance in mm from G to Pn) with the ideal HNP being 33% of NH19; CL, which was the horizontal distance from SnV to Pn, taken as a percentage to upper lip height, which was the vertical distance from Sn to Sts in mm, and the ideal ratio of CL being 90% of the upper lip height;[19] ND, which was horizontal depth of the nose as measured from Pn to the point of deepest convexity of the soft tissue alar cartilage of the nose (AD); NFA, which was the angle formed between soft tissue nasion (N') and Pn and between G and pogonion (Pog'), and measures angular prominence of the nose relative to the face; inclination of the nasal base (NBI), which was the angular inclination of the base of nose with the face, and it was measured by the angle formed between SnV and a line through the long axis of the nostril;19, and the naso-mental angle (NMA), which was the angle formed between dorsum of the nose (N'-Pn) and E line (Pn-Pog') (Figure 3).

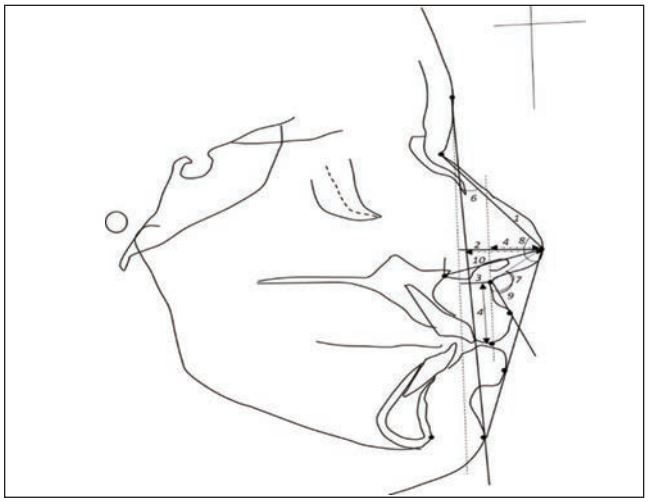

Figure-3: Nasal parameters.

G: Glabella, N': Soft tissue nasion, Pn: Pronasale, AD: Alar depth, Sn: Subnasale, Ls: Labrale superioris, Sts: Stomion superior, Li: Labrale inferioris, Pog: Pogonion, Pog': Soft tissue pogonion.

Nasal Length	1.N-Pn
Horizontal Nasal	2. G-Pn (x)
Prominence	3. G-Sn (X)
	x/X= 1/3
Columellar	4. Sn-Pn (y)
Length	5. Sn-Sts(Y)
	y/Y= 90%
Naso-Facial Angle	6. Angle formed between tangents G-Pog and N- Pn
Inclination of the Nasal Base	7. SnV- Sn-Pn
Naso-Mental Angle	8. N- Pn- Pog'
Nasolabial Angle	9. Intersection of tangent of columella and upper lip
Nasal Depth pronasale in mm	10. point of deepest convexity on soft tissue ala (AD) till the

The upper incisor inclination (UII) to maxillary plane and lower incisor mandibular plane angle (IMPA) were measured to rule out the effect of upper incisors on the position of the lip.

The landmarks used for ST assessment were Pn; ST pogonion (Pog', the most prominent point on ST chin); columellar point (Cm) formed at the middle of the base of the nose; labrale superioris (Ls), which was the most anterior point on the curvature of the upper lip.

The STA was assessed using conventional parameters, namely, E-line, S-line and NLA. The E-line was constructed from Pn, while the S-line was from the Cm at the level of the nose. Both lines had the same chin point; Pog'. The NLA was measured at the intersection of the two tangents at Sn. The first tangent was at the base of the nose, while the second was from Sn to Ls. Alo measured were the linear distance of Ls from the E-line (ELU); linear distance of the labrale inferioris (Li; the most prominent point on the curvature of lower lip) from the E-line (ELL); linear distance of Ls from the S-line (SLU); and the linear distance of the Li from the S-line (SLL).

Data was analysed using SPSS 23. Data normality was assessed using Shapiro-Wilk test, and it was found to be normally distributed for all variables except CL (p=0.001) and ND (p=0.013). Independent sample t-test was used to detect the difference in nasal profile between the genders and the sagittal groups. Spearman Correlation Coefficient test was used to establish the relationship between nasal profile and cephalometric STA, and the variables that showed the highest correlation were further analysed using linear regression analysis. The level of statistical significance was set at p<0.05. Intra-examiner reliability was assessed using the Intraclass Correlation Coefficient (ICC), and a good agreement was obtained (ICC: 0.842; p<0.001).

Results

Of the 131 patients, 96(73.2%) were females with mean age 22.70±3.97 years, and 35(26.7%) were males with mean age 20.97±3.21 years. There were 65(49.6%) subjects in sagittal Class I group, and 66(50.4%) in sagittal Class II group.

There was no significant difference in the nose form between the genders except NLA (p=0.043), ELL (p=0.024) and SLL (p=0.035). Although the values were in the normal range, males had a greater NLA, while females had a more prominent lower lip (Table 1).

The Class II group had more prominent nose forms than Class I (Table 2).

The correlation for the nasal profile with cephalometric STA showed That NFA and NBI were significantly and positively

correlated with all cephalometric ST variables (p<0.05). CL had a moderate and inverse correlation with linear distances of the upper lip (p<0.001), and NBI had a moderate correlation with NLA (p<0.001). ANB was strongly correlated with linear distances of the upper and lower lips (p<0.05), but neither of the jaws individually had a strong relationship (p>0.05). Similarly, the upper and lower lips had a weak to moderate relationship with the linear distances of the lip and NLA (Table 3).

Further, NBI positively affected NLA and for every 1° increase, the NLA increased by approximately 0.5° (p<0.05).

Table-1: Comparison of nasal and cephalometric STA between genders.

Variables	**Female** (n=96)	**Male** (n=35)	***p*-value**
Nasal Profile			
NL(mm)	45.65±6.32	47.31± 6.53	0.197
HNP (%)	39.88±9.08	38.02±10.08	0.348
CL (%)	74.45±21.08	69.24±19.60	0.192
ND (mm)	21.99±5.05	23.97±5.09	0.053
NFA (deg)	34.69±4.46	35.79±4.65	0.232
NBI (deg)	112.41±10.76	112.54±10.32	0.949
NMA(deg)	124.31±5.53	122.31±5.36	0.066
STA			
NLA(deg)	98.66±11.03	103.29±11.41	0.043*
ELU (mm)	-0.57±3.49	-2.34±3.98	0.212
ELL(mm)	-0.57±3.49	-2.34±3.98	0.024*
SLU(mm)	0.47±2.73	0.14±2.58	0.531
SLL(mm)	2.14±7.59	0.06±3.52	0.035*
Skeletal			
ANB (deg)	4.51±2.65	4.48±2.18	0.952
SNA (deg)	80.67±3.57	81±4.74	0.667
SNB (deg)	76.15±4.04	76.51±4.66	0.664
Dental			
UII (deg)	109.53±9.65	106.8±10.21	0.161
LII (deg)	98.62±8.85	98.91±9.30	0.871

Independent sample *t*-test; $p \leq 0.05$*, $p \leq 0.001$**; NL: Nasal length, HNP: Horizontal nasal prominence, CL: Columellar length, NDL Nasal depth, NFA: Naso-facial angle, NBI: Nasal base inclination, NMA: Naso-mental angle, SNA: Angle SNA, SNB: Angle SNB, ANB: Angle ANB, UII: Upper incisor inclination, LII: Lower incisor inclination, NLA: Nasolabial angle, ELU: Upper lip to E line, ELL: Lower lip to E line, SLU: Upper lip to S line, SLL: Lower lip to S line.

Table-2: Comparison of nasal and cephalometric STA between sagittal groups.

Variables	**Class I** (n=65)	**Class II** (n=66)	***p*-value**
Nasal Profile			
NL(mm)	46.31±6.63	45.87±6.20	0.692
HNP (%)	36.59±9.09	42.13±9.73	0.001**
CL (%)	77.28±21.15	68.90±19.61	0.02*
ND (mm)	22.23±5.07	22.81±5.17	0.518
NFA (deg)	33.93±4.53	36±4.29	0.008*
NBI (deg)	110.73±9.43	114.12±11.47	0.067
NMA(deg)	125.55±5.56	122.03±4.96	<0.001***
STA			
NLA(deg)	100.06±9.82	99.72±12.61	0.866
ELU (mm)	-4.43±2.73	-1.53±2.70	<0.001***
ELL(mm)	-2.49±3.22	0.37±3.59	<0.001***
SLU(mm)	-0.89±2.26	1.63±2.48	<0.001***
SLL(mm)	-0.16±2.99	3.30±8.80	0.003*
Skeletal			
ANB (deg)	2.46±1.34	6.52±1.64	<0.001***
SNA (deg)	79.89±4	81.6±3.64	0.012*
SNB (deg)	77.43±4.29	75.08±3.79	0.001**
Dental			
UII (deg)	108.40± 9.06	109.20± 10.61	0.645
LII (deg)	96.80± 9.66	100.57±7.78	0.015*

Independent sample *t*-test; $p \leq 0.05$*, $p \leq 0.001$**, p<0.001***; NL: Nasal length, HNP: Horizontal nasal prominence, CL: Columellar length, NDL Nasal depth, NFA: Naso-facial angle, NBI: Nasal base inclination, NMA: Naso-mental angle, SNA: Angle SNA, SNB: Angle SNB, ANB: Angle ANB, UII: Upper incisor inclination, LII: Lower incisor inclination, NLA: Nasolabial angle, ELU: Upper lip to E line, ELL: Lower lip to E line, SLU: Upper lip to S line, SLL: Lower lip to S line.

Table-3: Correlation of cephalometric STA with nasal profile and skeletal and dental analyses.

Variables	**ELU**		**ELL**		**SLU**		**SLL**		**NLA**	
	***r*-value**	***p*-value**	***r*-value**	***p*-value**	***r*-value**	***p*-value**	***r*-value**	***p*-value**	***r*-value**	***p*-value**
Nasal Profile										
NL	-0.248	0.004*	-0.118	0.181	-0.142	.106	-0.085	.334	-0.008	0.931
HNP	0.087	0.325	0.176	0.044*	0.083	.347	0.157	.074	0.047	0.596
CL	-0.428	<0.001***	-0.399	<0.001***	-0.463	<0.001***	-0.418	<0.001***	0.077	0.381
ND	-0.111	0.206	-0.050	0.570	-0.093	0.293	-0.062	0.485	0.036	0.683
NFA	0.320	<0.001***	0.206	0.018*	0.293	≤0.001**	0.208	0.017*	0.124	0.159
NBI	0.343	<0.001***	0.310	<0.001***	0.273	0.002**	0.254	0.003*	0.413	<0.001***
NMA	-0.168	0.055	-0.086	0.326	-0.145	0.098	-0.070	0.427	-0.270**	0.002*
Skeletal										
ANB	0.548	<0.001***	0.446	<0.001***	0.538	<0.001***	0.422	<0.001***	-0.008	0.928
SNB	-0.199	0.022*	-0.185	0.035*	-0.217	0.013*	-0.178	0.042*	-0.057	0.520
SNA	0.136	0.120	.116	0.186	0.111	0.209	0.108	0.221	-0.029	0.746
Dental										
UII	0.230	0.008*	0.236	0.007*	0.224	0.010*	0.221	0.011*	-0.239	0.006**
LII	0.302	<0.001***	0.252	0.004*	0.293	≤0.001**	0.236	0.007*	-0.094	0.285

Spearman Correlation; $p \leq 0.05$*,$p \leq 0.001$**, p<0.001***; NL: Nasal length, HNP: Horizontal nasal prominence, CL: Columellar length, NDL Nasal depth, NFA: Naso-facial angle, NBI: Nasal base inclination, NMA: Naso-mental angle, SNA: Angle SNA, SNB: Angle SNB, ANB: Angle ANB, UII: Upper incisor inclination, LII: Lower incisor inclination, NLA: Nasolabial angle, ELU: Upper lip to E line, ELL: Lower lip to E line, SLU: Upper lip to S line, SLL: Lower lip to S line.

CL had an inverse effect on the linear distance of upper and lower lips, and with 1mm decrease in CL, the upper and lower lip prominence increased in the range of 0.23-0.32mm. The sagittal jaw position positively affected the prominence of the upper and lower lips, and with 1° increase in ANB, the lip prominence increased in the range of 0.25-0.35mm. UII also positively increased the upper and lower lip prominence, and with each degree, the prominence increased in the range 0.32-0.36mm (p<0.001). Between the NBI and UII, the odds of NBI affecting the NLA were higher than the UII (Table 4).

Table-4: The effect of nasal profile on cephalometric STA.

	ELU			ELL			SLU			SLL			NLA		
	β	*p*-value	95% CI	*β*	*p*-value	95% CI	*β*	*p*-value	95% CI	*β*	*p*-value	95% CI	*β*	*p*-value	95% CI
CL	-0.268	<0.001***	-0.059, -0.021	-0.231	0.002*	-0.067, -0.015	-0.324	<0.001***	-0.059, -0.025	-0.271	0.001**	-0.068,-0.019	0.145	0.056	-0.002,0.160
NFA	0.079	0.244	-0.037, 0.144	0.043	0.574	-0.088, 0.158	0.099	0.150	-0.022, 0.140	0.059	0.451	-0.071,0.158	0.120	0.125	-0.084,0.681
NBI	0.219	0.001	0.025, 0.102	0.217	0.005*	0.023, 0.128	0.128	0.064	-0.002, 0.067	0.150	0.056	-0.001,0.096	0.496	<0.001***	0.364,0.690
ANB	0.355	<0.001***	0.251, 0.614	0.285	0.001**	0.171, 0.664	0.338	<0.001***	0.198, 0.521	0.258	0.004*	0.113,0.569	-0.084	0.332	-1.141,0.389
SNB	-0.203	0.010**	-0.260, -0.037	-0.202	0.022*	-0.329, -0.026	-0.214	0.008*	-0.236, -0.037	-0.198	0.028*	-0.298,-0.017	-0.112	0.208	-0.773,0.170
UII	0.362	<0.001***	0.070, 0.156	0.336	<0.001***	0.068, 0.184	0.350	<0.001***	0.058, 0.134	0.326	<0.001***	0.057,0.165	-0.307	<0.001***	-0.532,-0.171
LII	-0.001	0.982	-0.005, 0.005	-0.028	0.706	-0.008, 0.005	-0.018	0.788	-0.005, 0.004	-0.040	0.596	-0.008,0.004	-0.144	0.054	-0.041,0.004

Linear Regression; p≤0.05*, p≤0.001**, p<0.001***; CL: Columellar length, NFA: Naso-facial angle, NBI: Nasal base inclination, SNB: Angle SNB, ANB: Angle ANB, UII: Upper incisor inclination, LII: Lower incisor inclination, NLA: Nasolabial angle, ELU: Upper lip to E line, ELL: Lower lip to E line, SLU: Upper lip to S line, SLL: Lower lip to S line.

Discussion

Various studies have focused on aesthetic perceptions and nasal profiles, aiming to investigate whether the orthodontists and laypersons had similar aesthetic perceptions regarding NLA.[20,21] The current study, to our knowledge, is the first to focus on the objective assessment of nasal profile and cephalometric STA.

Although facial aesthetics and balance are subjective phenomena, orthodontists prefer a more objective approach for the prediction of treatment effects in the initial stage.[22] Thus, each patient receives a specific, customised treatment plan.

Skeletal Class II patients clinically present with prominent upturned noses along with increased overjets that add to profile convexity. Extractions followed by retractions is the preferred plan for them, but the fear of profile flattening can be challenging.[23] The present study found that incisor inclination and CL had an almost equal effect on the linear position of the upper and lower lips.

The association between the lip and orthodontic tooth movement is known.[24] The NLA became more acute with increasing UII, but the odds of NBI affecting the NLA were higher. With increasing NBI, the NLA increases, becoming more obtuse. Nandini et al.[25] also found a better correlation of NBI with NLA ($p \leq 0.001$). Hence, the effect of an upturned nose on NLA is more relevant than the UII.

Cephalometric planes are constructed lines between two points.[18] Points below the FH plane are affected by growth, development and maturation, and by racial and ethnic parameters.[18] A projected nose with increased CL will place the Pn point in a more anterior position. This creates the illusion of retrusive appearance of the upper lip. A study[26] found that noses with increased projections were not favoured aesthetically (nose prominence $p=0.044$). However, 'protruded lips (ELU $p=0.001$) with less prominent noses (NFA $p=0.028$) were considered attractive. The current results concur with these findings, but NFA did not have any effect on the linear position of the lips.

The Class II group had slightly more prognathic maxilla (SNA: 81.61±3.64, $-p=0.012$) and presented with more prominent nose forms (Table 2). Although NFA was significantly and positively correlated with ELU and SLU, it did not have an overall effect on any of the variables.

The NMA did not affect the linear position of the lips (NLA $p=0.008$). There was no difference between the genders on this count ($p=0.066$), while a significant difference was noted between the sagittal groups ($p<0.001$). The values of NMA and NFA vary with populations, and a study[27] in Iraq did not find any difference between these two angle for Class I and II.

The current study also assessed skeletal and dental effects in order to rule out their possible effects on the cephalometric STA. There was no correlation of SNA, SNB and ANB with any of the STA variables. UII was significantly but weakly associated with linear position of the upper and lower lips, and with increasing inclination, the prominence of the lips increased and the NLA reduced ($p=0.006$). Although the odds of the UII affecting the linear and angular position of the lips were higher on further analysis, they were still comparable with CL and NBI.

Class II profiles are associated with prominent and upturned noses. However, these patients present with increased overjets that often require extractions for correction. This creates the fear of worsening the profile due to the NLA becoming more obtuse. Addition of procedures for correction of the nasal septum can be considered as part of the treatment plan in the early stages to cater to the potential detrimental effects that may occur due to incisor retraction. Hence, timely correction of ST to create a balanced profile should be considered before finalising the treatment plan.

The limitations of the current study include the fact that all radiographs were manually traced. However, earlier research has shown that there is no difference in the tracings conducted manually by experienced investigators versus digital tracings.[28]

Conclusion

Skeletal Class II had a prominent nose which created a relatively retrusive appearance of the upper and lower lips. Nose forms and their impact on ST profile should be strongly taken into consideration at pre-treatment levels, and procedures, such as medical rhinoplasty, should precede orthodontic treatment.

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Conflict of Interest: None.

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Author Contribution:

TAS: Concept, methodology, software, validation, formal analysis, investigation, original draft preparation and supervision.

RHS: Software, formal analysis, data curation, original draft preparation and project administration.

AH: Resources and visualisation.

RA: Validation, writing, review and editing.

HAM & SM: Writing, review, editing and visualisation.