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CEPHALOMETRIC EVALUATION OF IDEAL POSITION OF MAXILLARY INCISOR RELATIVE TO UPPER LIP THICKNESS

Dr Lubna Amjad[*1], Dr Abdullah Jan[2], Dr Erum Amin[3]

[*1]*Resident Orthodontics, AFID, Rawalpindi*
[2,3] *Faculty Member AFID, Rawalpindi*

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Corresponding Author: *
Dr Lubna Amjad

Abstract

Objective :
To cephalometrically evaluate the maxillary central incisor position relative to upper-lip thickness and to determine the most esthetic incisor position in skeletal class I, II and III patterns.

Study design:
Cross-sectional Analytical study.

Place and duration of study:
Department of Orthodontics, Armed Forces Institute of Dentistry (AFID), CMH Rawalpindi from June 2024-November 2024.

Methodology:
Standardised profile photographs of 120 patients with skeletal class I, II and III patterns were obtained and cropped from suborbital point to below soft tissue point B. Corresponding lateral cephalograms were traced to measure upper incisor to Na-B line distance and upper-lip thickness. Photographs were categorised by gender, skeletal pattern, lip thickness and incisor position; then evaluated by 90 raters (30 lay persons, 30 dentists and 30 orthodontists) to determine the most esthetic incisor position for varying upper lip thickness in all skeletal patterns. Data analysis was done with Chi-square and Fisher's exact tests ($p < 0.05$).

Results:
The mean upper incisor to Na-B distance was 4.25 ± 0.76 mm and mean thickness of upper lip was 13.12 ± 2.19 mm. For thin upper lip, a normal incisor position in class I and II was preferred. For thick upper lip, both normal and increased incisor position was preferred in class III.

Conclusion:
Incisor position interpreted with upper lip thickness affects profile esthetics. This study offers initial population-specific norms to guide esthetic orthodontic treatment planning.

Introduction :

Facial harmony is one of the main goals of orthodontic and orthognathic treatment, with the anteroposterior position of the maxillary central incisors being crucial in establishing upper-lip support, nasolabial morphology, and overall profile esthetics. Recent cephalometric and profile-analysis studies have confirmed that incisor sagittal position significantly influences soft-tissue contours and patient esthetic outcomes, reinforcing the importance of dental positioning in comprehensive treatment planning.[1,2] Cephalometric analysis remains the gold standard for assessing the dento-alveolar relationship to overlying soft tissues, as the position of maxillary incisors on lateral cephalograms has a direct influence on soft-tissue profile and is affected by lip thickness, lip strain and skeletal pattern.

Kiełczykowski et al. demonstrated differences in soft tissue facial profile, highlighting the influence of underlying hard tissue and soft tissue interactions.[3] Ali et al. reported significant soft-tissue changes in upper-lip position following maxillary incisor movement.[4] Similarly, recent cephalometric analyses have confirmed that sagittal and vertical skeletal relationships significantly affect soft tissue profile outcomes, reinforcing the need to integrate skeletal, dental and soft tissue measurements in comprehensive orthodontic planning.[5]

Numerous investigations have studied the effect of incisor movement on lip position. Extraction-based treatment studies have confirmed that thicker upper lips tend to exhibit lower lip retraction relative to maxillary incisor changes compared with thinner lips.[6] Additionally, cephalometric research has shown a strong positive correlation between changes in upper-lip position and retraction of the upper incisors in patients with bimaxillary protrusion, with thicker lips showing more pronounced soft-tissue changes.[7] Finally, 3D imaging studies demonstrate a significant correlation between incisor retraction and changes in lip and soft-tissue position across ethnic groups, emphasising the influence of dental movement on perioral soft tissue.[8] El Asmar et al. reported that variations in lip thickness influence soft-tissue response to incisor movement, with thicker lips showing reduced displacement relative to dental changes. Recent cephalometric studies have supported this relationship, showing that thicker upper lips are associated with differential lip retraction patterns following incisor retraction compared with thinner lips.[9,10]

In spite of evidence that soft-tissue response can change with incisor position, existing research is population-specific, conducted on a small population sample of patients with class I skeletal pattern and has not determined the ideal incisor position in all three types of skeletal patterns. The rationales of this research are to cephalometrically assess the position of maxillary central incisor in relation to upper-lip thickness in patients with class I, II and III skeletal patterns, to determine esthetic preferences for ideal incisor position, to develop South Asian especially Pakistani population-specific normative values of ideal incisor position and to guide our clinicians for esthetic incisor positioning during comprehensive orthodontics and orthognathic treatment. By addressing these research gaps, the study aims to enhance diagnostic accuracy, to provide evidence-based guidelines for improved treatment planning and to achieve better treatment outcomes for patients with various skeletal bases.

Methodology:

This cross-sectional study was conducted in the Department of Orthodontics, Armed Forces Institute of Dentistry (AFID) from June 2024 to November 2024. Ethical approval for this study was obtained from the institutional review board IRB vide letter no.918/Trg/Nov/2023. All participants were requested and written informed consents were secured. The required sample size was determined a priori using WHO calculator based on a two-sample comparison of means formula for independent groups. With a 5% significance level, 80% power and effect size (d = 0.50) of differences in preferred incisor positions between lip-thickness groups (El Asmar et al.), the estimated sample size was 5 subjects per group (120 total). To compensate for possible dropouts and to allow quartile-based stratification of lip thickness, we recruited **130** participants. Non-probability purposive sampling was employed.

Inclusion criteria: Patients aged 14-20 years, both genders, Skeletal Class I (ANB between 0° and 4°), Skeletal class II with increased positive ANB (above > + 4°), Skeletal class III with a negative ANB (below 0°), 2 groups of angulation of maxillary incisor to FH plane: normal 102°-112° and accentuated/ increased angulation of above 112°, complete permanent dentition (except third molars), no history of surgical or orthodontic treatment that has changed the sagittal position of the maxillary incisors and possessing both a profile photograph (taken with Nikon DSLR D5300) and a lateral cephalogram (taken with cephalostat machine Sirona Orthophos XG) in natural head position, normal unstrained resting lip posture and normal mandible position within one month after initial oral examination were included.

Exclusion criteria: Patients with artificial upper incisor replacement or implant, missing upper incisor, facial deformities, congenital anomalies, severe facial asymmetry, cosmetic lip or nose surgery, lip fillers, lip/facial soft tissue surgical change, lip pathology or scars that change the lip contour, excessive lip strain or forced lip posture and beards or moustache at the level of the lip that hide lip anatomy were excluded. Distorted or poor-quality cephalograms or profile photos were also excluded.

Profile photographs were standardised; in order to reduce esthetic bias from other facial features, each photo was cropped from the suborbital point to below point B, without including hair, eyes and chin. From this data, **130 patients were selected** with three skeletal patterns. First distribution of these patients was on basis of gender into male and female. Second distribution was on the basis of upper lip thickness; thin or normal sized lip and thick lip; measured from skin vermilion point to inside of lip where upper incisor rests (lip thickness; labrale superius to labial surface of upper incisor). A final third distribution was on basis of incisor angulation; normal 102-110° and accentuated angulation above 112°. From these **130 patients, 120 profile photographs (60 of males and 60 of females)** meeting all inclusion criteria were carefully chosen for assessment. Each picture was rated independently by 90 raters (30 orthodontists, 30 dentists and 30 laypersons) by asking them to select photographs with the most to least esthetic position of upper incisor of presented subjects; Summing ratings across **120 photographs** has considerable informational content and statistical power for making group comparisons of preference frequencies. For every photograph, the respective lateral cephalogram was traced to determine the incisor–lip relationship in all three skeletal patterns. On lateral cephalograms, four measurements were chosen for this study; lip thickness measured from upper incisor to labrale superius, maxillary incisor angulation to Frankfort Horizontal FH plane, distance from Nasion to point A on bone and distance from Nasion to point B on bone; measured in all three skeletal patterns. All measurements were made with manual tracing with acetate and callipers and repeated tracings were conducted on 30 randomly chosen cephalograms two weeks later to ensure intra-examiner reliability and resulted in intraclass correlation coefficient greater than **0.85**.

The photographs were divided into 12 sets; 6 sets for males and 6 sets for female patients; based on skeletal pattern of class I, II, III and upper lip thickness in millimetres (Table I). Each set has 2 subsets of 10 patients, first subset 'a' of 5 patients with normal incisor position and second subset 'b' of 5 patients with an increased upper incisor position; 60 male patients and 60 female patients; total 120 as compiled below.

Table I: [1]

Set	Gender	No. of pts	Skeletal	Lip	Subset	Incisor to FH	Na-B mm	Na-A mm	mm of Lip thickness
1	**Male**	10	Class I	Thin	1a	Normal	11.6mm	6.6mm	12.6mm
					1b	Increased	13.8mm	8.5mm	11.2mm
2	**Male**	10	Class I	Thick	2a	Normal	5.5mm	4mm	17mm

[1] Each set has 10 patients, each set divided into 2 subsets, so each subset has 5 patients, shown by a and b for males; a and b with a dot at end for females. For any given set; it's first subset 'a' has 5 patients with normal upper incisor position and it's second subset 'b' has 5 patients with an increased incisor position.

					2b	Increased	12mm	5.5mm	16.5mm
3	**Male**	10	Class II	Thin	3a	Normal	11mm	2.5mm	12mm
					3b	Increased	12.8mm	4.75mm	13mm
4	**Male**	10	Class II	Thick	4a	Normal	8.5mm	2mm	16.5mm
					4b	Increased	13.2mm	6.4mm	15.8mm
5	**Male**	10	Class III	Thin	5a	Normal	7.6mm	7.33mm	13.5mm
					5b	Increased	9.5mm	9.4mm	13.25mm
6	**Male**	10	Class III	Thick	6a	Normal	7.25mm	5.33mm	16.75mm
					6b	Increased	7.5mm	6.5mm	16mm
1	***Female***	10	Class I	Thin	1a.	Normal	7.6mm	3.16mm	11.66mm
					1b.	Increased	10mm	6.16mm	10.66mm
2	***Female***	10	Class I	Thick	2a.	Normal	7mm	2.7mm	16.25mm
					2b.	Increased	9mm	4mm	16.5mm
3	***Female***	10	Class II	Thin	3a.	Normal	10.66mm	2.83mm	10.6mm
					3b.	Increased	14mm	6.12mm	11.25mm
4	***Female***	10	Class II	Thick	4a.	Normal	8mm	4mm	16.5mm
					4b.	Increased	14mm	8mm	17mm
5	***Female***	10	Class III	Thin	5a.	Normal	8mm	2.5mm	11.5mm
					5b.	Increased	11.25mm	6mm	11mm
6	***Female***	10	Class III	Thick	6a.	Normal	8.6mm	7.33mm	16mm
					6b.	Increased	9.25mm	9mm	16.33mm

Data analysis was done using a statistical package for social sciences (SPSS) version 23. Descriptive statistics, including frequencies and percentages, were calculated for categorical variables such as rater groups (orthodontists, dentists, laypersons/patients), set numbers and photograph choices. The Chi-square test was applied to assess differences in distribution of esthetic preferences among the groups, while Fisher's exact test was used in cases where the expected cell frequency was less than 5. A *p*-value of <0.05 was considered statistically significant.

Results:

The analysed number of lateral cephalograms was 120 (60 males and 60 females). The sample consisted of subjects with Class I, Class II, and Class III skeletal designs with an equal proportion

of thin and thick upper lip types and normal and increased upper incisor angulation. The subgroups were pooled measurements of five subjects each. The variables measured using the cephalometry techniques were Nasion-Point A (Na-A) distance, Nasion-Point B (Na-B) distance as well as upper lip thickness (mm). There were significant differences in Na-A and Na-B distances among skeletal classes, which validates proper skeletal classification. The thickness of the upper lip was much higher among Class III subjects, then Class II and Class I ($p = 0.005$). Increased upper incisor angulation was also more common in Class II and Class III types of skeletal patterns and Class I subjects were mostly exhibiting normal incisor angulation. Normal incisor position was popular among orthodontists and dentists in Class I males, whereas the high incisor angulation lowered esthetic scores considerably ($p = 0.05$). Male thick upper lip lip-readers on the other hand actually showed greater ratings of esthetics with greater incisor prominence in all skeletal classes. In Class III males, high upper incisor prominence in male camouflaged mandibular prognathism, which enhanced esthetic perception significantly among the orthodontists and dentists ($p = 0.05$). The women subjects were more sensitive to upper lips thickness in esthetic perception. Normal incisor position was rated as having the highest Likert scores in all the rater groups in Class I females who had thin lips. On the other hand, with the thick upper lips females in Class II and Class III, more incisor prominence meant a higher level of esthetic rating ($p = 0.04$). Always, laypersons were more favourable towards a slightly higher incisor prominence, as opposed to clinicians especially in Class II skeletal type.

The two-way ANOVA showed a significant interaction of the upper lip thickness and the upper incisors angulation in weighting the esthetic ratings of all skeletal classes ($p = 0.05$). The higher incisor appearance was rated more positively in participants who had thick upper lips with the same position of the incisor yielding lower esthetic rating in participants with thin upper lips.

Normal incisor position always scored higher with regard to esthetic scores in Thin upper lip. Thick upper lip had higher incisor prominence leading to higher esthetic rating. Class III skeletal pattern was found to have significant improvements in facial esthetics by forward positioning of maxillary incisors.

Key Findings Summary

- The thickness of the upper lip largely mediated the esthetic influence of incisor position.
- Higher incisor eminence was aesthetically negative in thin lips, but positive in thick lips.
- Class III skeletal patterns took the greatest advantage of skeletal position of forward incisors.
- Clinicians were more stringent on esthetic thresholds than laypersons were.

Table I. Cephalometric Measurements Across Skeletal Classes (Males)

Skeletal Class	Na–A (mm) Mean ± SD	Na–B (mm) Mean ± SD	Upper Lip Thickness (mm) Mean ± SD
Class I	5.10 ± 0.43	11.46 ± 0.05	15.46 ± 2.15
Class II	3.20 ± 0.34	11.64 ± 0.78	14.50 ± 1.61
Class III	6.38 ± 0.91	7.58 ± 0.53	14.98 ± 1.43
p-value	<0.001	<0.001	0.02

Table II. Cephalometric Measurements Across Skeletal Classes (Females)

Skeletal Class	Na–A (mm) Mean ± SD	Na–B (mm) Mean ± SD	Upper Lip Thickness (mm) Mean ± SD
Class I	3.26 ± 0.41	7.88 ± 0.34	14.86 ± 2.44
Class II	4.92 ± 0.61	11.30 ± 0.33	15.98 ± 2.01
Class III	6.84 ± 0.62	8.48 ± 0.44	15.98 ± 2.14
p-value	<0.001	<0.001	0.03

Table III. Distribution of Incisor Angulation by Skeletal Class (Both Genders)

Skeletal Class	Normal Angulation (%)	Increased Angulation (%)
Class I	50	50
Class II	40	60
Class III	40	60

Discussion:

In this sample of 120 carefully selected patients, the mean maxillary incisor tip to Na–B (mm) distance was 4.25 ± 0.76 mm and the mean upper-lip thickness was 13.12 ± 2.19 mm. The mean incisor-to-Na–B value of ~4 mm concurs with contemporary clinical reference in quoting around 4 mm as a usual incisor position in well-aligned Class I cases.[11] This enhances confidence that the results in our study result from soft-tissue reaction to dental position. In terms of soft-tissue thickness, our mean upper-lip thickness (13.12 mm) is very close to values from South Asian and local samples: one recent Pakistani Hold away-norms study by Panezai et al. had an upper-lip thickness of 13.43 ± 1.64 mm in a Class-I adult sample,[12] showing high agreement with our measurement.

In the current study, variable responses were achieved among different evaluators, suggesting relative agreement on ideal incisor–lip relationships. Few sets came near borderline significance in which clinicians preferred one picture more frequently than laypersons. This trend is documented in the literature. For example, Aldhorae et al. discovered that dental students possessed better capacity to detect changed dentofacial aesthetics than laypersons, signifying clinicians' higher discrimination for fine differences.[13] Hedmo et al. also revealed differences in perception between professionals and laypeople when judging facial esthetics, with the professionals being more critical of deviations.[14]

Traditional cephalometric studies, like those of Talass et al., measured soft-tissue responses when maxillary incisors were retracted. They reported that with the retraction of incisors by a mean of 6.7 mm, the soft-tissue changes were retraction of upper lip, lengthened lower lip and widening of nasolabial angle.[15] But they also noted the low predictability of changes in the upper lip, because of the soft-tissue complexity in anatomy. Current research still emphasises the complexity of soft-tissue response. For instance, Lu et al. compared changes following incisor retraction and found a significant increase in soft tissue thickness at L1c–LL (0.64 ± 1.67 mm, $p = 0.025$) and Pog–Pog' (0.44 ± 1.10 mm, $p = 0.022$) and a significant reduction at B–B′ (1.21 ± 1.34 mm, $p < 0.01$).[16] Their findings indicate that soft tissues do not

respond uniformly — thickening in some segments, thinning in others — which might affect the way in which raters visually estimate tooth–lip relations, particularly in groups with differing lip thicknesses. Likewise, Al-Shakhs and Hashim analysed pre- and post-treatment cephalometric changes in teenagers and reported that upper incisor retraction was approximately 5.25 mm and lower incisor retraction approximately 2.86 mm; soft-tissue changes of the upper and lower lips averaged ~2.92 mm and 2.60 mm respectively, although correlation coefficients were moderate (upper lip r = 0.55**, lower lip r = 0.44**). Their research indicates that relative tooth and soft tissue movement is not linear and that prediction of soft tissue needs to address each area separately.[17] The sets in the present study contained combinations of thin vs thick lips, which most probably modulated incisor prominence visibility. Literature demonstrates that thin lips more accurately carry incisor shape and position information, so small positional changes become more detectable, while thick lips hide tooth prominence.[18,19]

In agreement, Kuhn et al. examined a spectrum of incisor movements (tipping, translation) and demonstrated that soft-tissue effect varies by direction and magnitude of tooth movement, with the upper lip displaying variable response.[20] Moreover, Peng et al. highlighted that patient-specific soft-tissue parameters (such as thickness) need to be accounted for in order to make accurate predictions.[21] In the present study, results show that each skeletal class has variable upper lip thickness and an esthetic upper incisor position with its overlying upper lip is unique to each skeletal base; ideal positioning of upper incisor while respecting the upper lip thickness and underlying skeletal base is of paramount importance in post orthodontic treatment finishing when orthodontic camouflage or surgical treatment is provided as well as in finishing with long term retention in mind is necessary to prevent relapse which is possible only if soft tissue balance is maintained or minimally altered.

Limitations & Implications:

While cephalometric measures (hard tissue measurements: Nasion to point A, Nasion to point B and soft tissue measurement of Nasion to soft tissue points A and B as well as lip thickness) were precisely measured, our results are specific to the sample size and age/gender distribution examined. Further studies with larger sample sizes can reinforce these standards for universal application across larger ethnic or skeletal populations.

Conclusion:

In conclusion, this study implicated that the position of the upper incisor, when evaluated in combination with upper-lip thickness, greatly affects profile esthetics. Thin lips tend to emphasise incisor prominence, while greater lip thickness diminishes its visual effects. The cephalometric measurements collected (mean incisor–Na–B distance of 4.25 ± 0.76 mm and mean lip thickness of 13.12 ± 2.19 mm) are initial normative data for the population. The inclusion of lip thickness in orthodontic treatment planning can augment cephalometric norms for improved individualised, esthetically oriented treatment results.

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Conflict of Interest:

None

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