

Ethnic variations in soft tissue lip prominence: A cephalometric evaluation of esthetic lines and incisor proclination in a Dakshina Kannada population

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Abstract

Objective: To establish normative values for lip prominence relative to the E-line, S-line, and H-line in a Dakshina Kannada skeletal Class I population and to evaluate the relationship between esthetic line measurements and incisor proclination. Interpopulation comparisons with Indian and Caucasian norms were also performed.

Materials and Methods: A cross-sectional cephalometric analysis was conducted on 100 subjects (58 females, 42 males) aged 18–25 years with skeletal Class I relationships. Upper and lower lip prominence relative to the E-line, S-line, and H-line were measured. Upper and lower incisor proclination was assessed in millimeters and degrees. Descriptive statistics were calculated, and gender differences were analyzed using independent t-tests. Pearson correlation and multiple linear regression analyses evaluated associations between incisor proclination and lip prominence. Interpopulation comparisons were performed using one-way ANOVA with Tukey post hoc tests ($\alpha = 0.05$).

Results: Mean upper and lower lip prominence relative to the E-line were 1.98 ± 2.21 mm and 3.91 ± 2.54 mm, respectively. Similar anterior positioning was observed relative to the S-line and H-line. Males demonstrated significantly greater lip prominence than females ($p < 0.05$). Strong positive correlations were identified between incisor proclination and corresponding lip prominence ($r = 0.58$ – 0.74 , $p < 0.001$). Regression analysis revealed that incisor proclination explained 52% of upper lip and 56% of lower lip projection variability. ANOVA demonstrated significant differences between Dakshina Kannada, Indian, and Caucasian populations ($p < 0.001$).

Conclusions: The Dakshina Kannada population exhibits a characteristically anterior soft tissue profile distinct from Caucasian standards. Incisor proclination significantly influences lip prominence; however, intrinsic soft tissue morphology also contributes substantially. Region-specific cephalometric norms are essential for culturally appropriate orthodontic treatment planning.

Keywords: Dakshina kannada, skeletal class i, lip prominence, E-Line, S-Line, H-Line, incisor proclination, cephalometric analysis, soft tissue profile, orthodontic treatment planning

Introduction

Facial attractiveness exerts a profound influence on personality development, psychological well-being and social interactions, and one of the most important components of orthodontic diagnosis and treatment planning is the evaluation of the patient's soft tissue profile. The face serves as a central determinant of how individuals are perceived in both personal and professional spheres, with smile playing crucial roles in defining character and beauty [1]. Consequently, orthodontic treatment planning today is not confined to achieving a functional occlusion but equally aims at enhancing soft tissue balance and overall facial esthetics.

The recognition of facial esthetics within orthodontics dates back over a century. Angle [1] emphasized that the mouth significantly contributes to facial beauty and harmony, while Wuerpel [2] later underscored that true esthetics lies in facial balance rather than mere proportionality. Simon [3] introduced measurable methods to evaluate profile changes, using "photostatics" and reference to planes such as the Frankfort horizontal in order to quantify growth-related soft tissue changes. Tweed [4], through his cephalometric analyses, stressed that understanding normal facial growth patterns was as essential as ideal occlusion, introducing key concepts such as the Frankfort–mandibular incisor angle and the diagnostic triangle for treatment planning.

Until the mid-20th century, most cephalometric studies were focused primarily on skeletal relationships, assuming a direct correlation with overlying soft tissues. However, this assumption was challenged by Subtelny [5], who demonstrated that the relationship between hard tissues and the soft tissue profile is not linear.

Burstone [6] and Bowker & Meredith [7] further advanced the field by highlighting the individuality of soft tissue thickness and variability across patients, therefore advocating for direct integration of soft tissue evaluation into orthodontic diagnosis.

The lips, in particular, constitute the most prominent esthetic feature of the lower third of the face. The contour, size, and curvature of the lips—especially the upper lip—have a decisive effect on facial attractiveness, with marked variations observed across individuals, genders, and ethnicities [8,9]. To evaluate lip position, several cephalometric reference lines such as Steiner's S-line [10], Ricketts' E-line [11], and Holdway's H-line [12] have historically been employed. These standards, however, were largely developed from Caucasian populations, limiting their global applicability. Cross-population studies have shown significant ethnic differences in lip morphology and projection—Caucasian samples generally exhibit thinner lips, Asians often present fuller but relatively less protrusive lips, and Africans display greater lip prominence [5, 13, 16].

Over the past two decades, increasing attention has been given to the influence of ethnicity in defining soft tissue norms, with multiple studies from different populations confirming the need for localized standards [13, 17]. Without such data, the extrapolation of Caucasian norms to non-Caucasian populations risks suboptimal esthetic outcomes and treatment dissatisfaction [18, 19]. For this reason, developing population-specific cephalometric standards has become a critical objective in orthodontic research.

The present investigation aims to address this gap by establishing normative soft tissue cephalometric data for young individuals in the Dakshina Kannada population. By providing baseline values for lip thickness and projection specific to this region, the study underscores the principle that diagnostic standards must be both region-sensitive and ethnicity-appropriate. Such data are expected to enhance diagnostic accuracy, refine orthodontic and surgical treatment planning, and ultimately improve patient satisfaction in diverse clinical settings. Further multicentric and large-scale studies across different Indian subpopulations are warranted to expand these reference data and guide evidence-based practice.

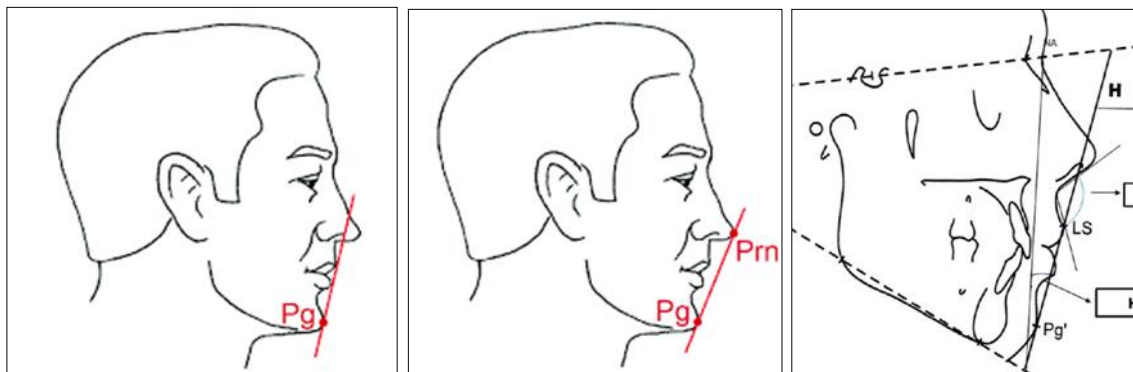
Materials and Methods

Study Design

This cross-sectional cephalometric study was conducted to evaluate lip prominence relative to established esthetic reference lines and to assess its relationship with incisor proclination in a Dakshina Kannada population with skeletal Class I relationships.

Sample Selection

A total of 100 subjects (58 females and 42 males) aged between 18 and 25 years were selected from diagnostic orthodontic records. The age range was restricted to minimize growth-related variations in soft tissue morphology and ensure skeletal maturity.



Perpendicular distances (in millimeters) from the most anterior points of the upper and lower lips to each reference line were measured.

Incisor Proclination Assessment

Incisor proclination was evaluated using both linear and angular measurements:

- **Maxillary incisor (U1):** Linear measurement relative to NA line (mm) and angular inclination relative to NA plane (degrees)
- **Mandibular incisor (L1):** Linear measurement relative to NB line (mm) and angular inclination relative to NB plane (degrees)

Inclusion Criteria

- Skeletal Class I sagittal relationship (ANB angle between 0° and 2°)
- Complete permanent dentition (excluding third molars)
- No prior orthodontic treatment
- Absence of craniofacial anomalies or facial trauma
- Both parents native to the Dakshina Kannada region

Exclusion Criteria

- Skeletal Class II or Class III malocclusion
- History of orthognathic surgery
- Severe facial asymmetry
- Poor-quality or distorted radiographs

Radiographic Procedure

Standardized lateral cephalometric radiographs were obtained using a calibrated cephalostat. Subjects were positioned in natural head posture with teeth in centric occlusion and lips in a relaxed state. All radiographs were acquired under uniform exposure parameters to maintain consistency in image quality.

Cephalometric Measurements

Manual/Digital tracings were performed using calibrated cephalometric software (software name and version to be specified). All landmarks were identified by a single trained examiner to maintain measurement consistency.

Esthetics Reference Lines

- **E-line (Ricketts line):** Drawn from pronasale to soft tissue pogonion as described by Robert M. Ricketts.
- **S-line (Steiner line):** Drawn from the midpoint between subnasale and pronasale to soft tissue pogonion as described by Cecil C. Steiner.
- **H-line (Holdaway line):** Drawn from soft tissue pogonion to the upper lip.

Reliability Assessment

To evaluate intra-examiner reliability, 20 randomly selected radiographs were retraced after a two-week interval. Intraclass correlation coefficients (ICC) were calculated to assess reproducibility, and Dahlberg's formula was applied to estimate measurement error. ICC values greater than 0.90 indicated excellent reliability.

Statistical Analysis

Statistical analyses were performed using SPSS software (Version XX; IBM Corp., Armonk, NY, USA). Normality of distribution was assessed using the Shapiro–Wilk test.

Descriptive statistics (mean $\pm$ standard deviation) were calculated for all variables. Independent sample t-tests were used to assess gender differences. Pearson correlation analysis evaluated associations between incisor proclination and lip prominence. Multiple linear regression analysis determined the predictive contribution of incisor variables to soft tissue projection.

Interpopulation comparisons with published Indian and Caucasian normative data were conducted using one-way analysis of variance (ANOVA), followed by Tukey's post hoc test. Statistical significance was set at $p < 0.05$.

Results

The study sample comprised 100 subjects (58 females, 42 males) aged 18–25 years. All participants exhibited a skeletal Class I sagittal relationship with a mean ANB angle of $1.08^\circ \pm 0.91$.

Descriptive statistics demonstrated an anterior soft tissue profile across all esthetic reference systems. Mean upper and lower lip prominence relative to the E-line were 1.98 ± 2.21 mm and 3.91 ± 2.54 mm, respectively (Table 1). For the S-line, mean values were 2.76 ± 2.09 mm (upper) and 4.68 ± 2.37 mm (lower), while H-line measurements were 0.42 ± 1.36 mm (upper) and 1.84 ± 1.92 mm (lower) (Table 1). In all reference systems, lower lip prominence was significantly greater than upper lip prominence ($p < 0.05$).

Table 1: Descriptive Statistics of Esthetic Line Measurements

Parameter	Mean (mm)	SD	Minimum	Maximum
Upper Lip to E-line	1.98	2.21	-5.0	8.0
Lower Lip to E-line	3.91	2.54	-4.0	9.0
Upper Lip to S-line	2.76	2.09	-4.0	7.5
Lower Lip to S-line	4.68	2.37	-3.5	9.5
Upper Lip to H-line	0.42	1.36	-3.0	4.0
Lower Lip to H-line	1.84	1.92	-2.5	6.0

Independent t-test analysis revealed statistically significant gender differences, with males demonstrating greater lip prominence relative to E-line, S-line, and H-line ($p < 0.05$). The mean difference ranged from 0.8 to 1.2 mm (Table 2).

Table 2: Gender Comparison of Lip Prominence (Independent t-test)

Parameter	Male (Mean $\pm$ SD)	Female (Mean $\pm$ SD)	t-value	p-value
Upper Lip to E-line	2.54 ± 2.18	1.57 ± 2.03	2.41	0.018*
Lower Lip to E-line	4.56 ± 2.49	3.41 ± 2.38	2.63	0.010*
Upper Lip to S-line	3.32 ± 2.12	2.31 ± 1.97	2.52	0.014*
Lower Lip to S-line	5.21 ± 2.44	4.29 ± 2.19	2.18	0.032*

Mean upper incisor proclination measured 8.4 ± 2.1 mm and $34.8 \pm 6.2^\circ$, while lower incisor proclination measured 6.7 ± 2.0 mm and $34.2 \pm 6.8^\circ$ (Table 3).

Table 3: Incisor Proclination Measurements

Parameter	Mean $\pm$ SD	Range
Upper Incisor (mm)	8.4 ± 2.1	4–13
Upper Incisor ($^\circ$)	34.8 ± 6.2	21–45
Lower Incisor (mm)	6.7 ± 2.0	2–11.5
Lower Incisor ($^\circ$)	34.2 ± 6.8	12–45

Pearson correlation analysis demonstrated significant positive associations between incisor proclination and lip

prominence (Table 4). Upper incisor linear proclination correlated with upper lip prominence relative to E-line ($r = 0.71$), S-line ($r = 0.69$), and H-line ($r = 0.58$) ($p < 0.001$). Lower incisor linear proclination showed stronger correlations with lower lip prominence relative to E-line ($r = 0.74$), S-line ($r = 0.72$), and H-line ($r = 0.61$) ($p < 0.001$). Angular proclination demonstrated comparatively weaker associations.

Table 4: Pearson Correlation Between Incisor Proclination and Lip Prominence

Variables	r	p-value
U1 (mm) vs Upper Lip to E-line	0.71	<0.001*
U1 (mm) vs Upper Lip to S-line	0.69	<0.001*
U1 (mm) vs Upper Lip to H-line	0.58	<0.001*
L1 (mm) vs Lower Lip to E-line	0.74	<0.001*
L1 (mm) vs Lower Lip to S-line	0.72	<0.001*
L1 (mm) vs Lower Lip to H-line	0.61	<0.001*

*Statistically significant

Multiple linear regression analysis indicated that upper incisor proclination explained 52% of the variability in upper lip prominence ($R^2 = 0.52$, $p < 0.001$), and lower incisor proclination accounted for 56% of variability in lower lip projection ($R^2 = 0.56$, $p < 0.001$) (Table 5). Linear proclination (mm) showed stronger predictive influence than angular inclination.

Upper Lip to E-line (Dependent Variable) Lower Lip to E-line (Dependent Variable)

Table 5: Multiple Linear Regression Analysis

Predictor	β	SE	p-value	Predictor	β	SE	p-value
Upper Incisor (mm)	0.62	0.08	<0.001*	Lower Incisor (mm)	0.68	0.07	<0.001*
Upper Incisor ($^\circ$)	0.41	0.05	0.003*	Lower Incisor ($^\circ$)	0.39	0.06	0.005*

$R^2 = 0.52$

One-way ANOVA demonstrated statistically significant differences among Dakshina Kannada, general Indian, and Caucasian populations across all esthetic line parameters ($p < 0.001$) (Table 6). Post hoc Tukey analysis showed significantly greater lip prominence in the Dakshina Kannada cohort compared to Caucasian norms across all measurements, with mean differences approaching 6 mm for E-line values. Significant differences were also observed between Dakshina Kannada and general Indian cohorts ($p < 0.05$) (Table 7). The greatest intergroup difference was noted in lower lip prominence relative to the E-line.

Upper Lip to E-line Lower Lip to E-line

Table 6: One-Way ANOVA Comparing Populations

Source	df	F-value	p-value	Source	df	F-value	p-value
Between Groups	2	36.84	<0.001*	Between Groups	2	48.17	<0.001*

Table 7: Tukey Post Hoc Comparison (Mean Difference in mm)

Comparison	Upper Lip (E-line)	Lower Lip (E-line)	p-value
Dakshina Kannada vs Caucasian	+5.96	+5.88	<0.001*
Dakshina Kannada vs Indian	+1.76	+1.78	<0.05*

Discussion

The present study establishes region-specific soft tissue norms for lip prominence in a Dakshina Kannada skeletal Class I population and demonstrates significant ethnic and dental and soft tissue associations. The findings confirm that this population exhibits a consistently anterior lip profile relative to classical esthetic reference lines and differs significantly from both Caucasian and previously reported Indian cohorts.

The anterior positioning of both upper and lower lips relative to the E-line observed in this study contrasts with the retrieve lip position typically reported in Caucasian samples described by Ricketts^[11] and subsequent European-American cohorts^[20]. In Caucasian populations, the upper and lower lips frequently lie posterior to or close to the E-line, whereas in the present sample both lips were positioned anteriorly, with mean interpopulation differences approaching 6 mm. Such magnitude exceeds what would be considered minor morphological variation and instead reflects true ethnic profile differentiation.

Comparable findings have been reported in African and African-American populations, where increased lip prominence has been documented as a normative characteristic rather than a malocclusion trait^[21, 22]. Similarly, Korean and Chinese cephalometric investigations have demonstrated population-specific soft tissue convexity patterns distinct from Caucasian norms^[13, 23]. The present data align with these cross-ethnic findings and reinforce that soft tissue morphology is strongly influenced by genetic and ethnic background.

Importantly, significant differences were also observed between Dakshina Kannada subjects and previously published general Indian norms^[16]. This intra-national variability supports the concept that “Indian norms” cannot be generalized across all regional subgroups. Craniofacial diversity within the Indian population has been previously emphasized in regional cephalometric studies^[24, 25], and the present findings provide further evidence of this heterogeneity.

Lower lip prominence consistently exceeded upper lip prominence across all reference lines. Similar lower lip dominance has been observed in African^[21] and certain Asian populations^[23], suggesting that mandibular soft tissue projection may play a dominant role in ethnic facial convexity. In contrast, Caucasian samples often demonstrate a more balanced upper–lower lip relationship^[20]. This mandibular soft tissue influence may partially explain the greater interpopulation differences observed for lower lip measurements in the present study.

Strong correlations between incisor proclination and lip prominence ($r = 0.58\text{--}0.74$) are consistent with the findings of Subtelny^[5] and later investigations by Roos^[26] and Hodges *et al*^[27], who demonstrated significant soft tissue response to incisor retraction. The present regression analysis indicates that incisor proclination accounts for more than 50% of lip projection variability, underscoring the clinical relevance of dentoalveolar positioning in profile management.

However, the incomplete variance explanation confirms that intrinsic soft tissue thickness and morphology contribute substantially to lip projection. This observation aligns with Burstone’s soft tissue paradigm^[6] and the contemporary esthetic model proposed by Sarver and Ackerman¹⁹, which

emphasizes the primacy of soft tissue evaluation over skeletal-only analysis.

The findings strongly suggest that application of Caucasian-based E-line and S-line norms to South Indian patients may result in over-retraction of incisors and profile flattening. Ethnic facial harmony must be preserved rather than altered to conform to inappropriate reference standards. Population-specific norms are therefore essential for individualized orthodontic and orthognathic treatment planning.

The use of multiple esthetic reference lines strengthens the robustness of the findings, and restriction to skeletal Class I subjects minimized skeletal confounding. Nevertheless, the cross-sectional design limits evaluation of dynamic soft tissue response. Future longitudinal studies assessing treatment-related profile changes across diverse Indian subpopulations would further refine normative standards.

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