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ORIGINAL RESEARCH

CEPHALOMETRIC EVALUATION OF SAGITTAL LIP POSITION ACROSS SKELETAL CLASSES USING MULTIPLE REFERENCE LINES: A RETROSPECTIVE STUDY IN YEMENI ADULT POPULATION

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Abstract

Background: Classical cephalometric reference lines such as Steiner's line (S), Burstone's line (B), Ricketts' line (E), Holdway's line (H), and Sushner's Line have been widely used to assess lip posture; however, their applicability varies across populations.

Aim: The study aimed to evaluate the sagittal position of the upper and lower lips relative to five established cephalometric reference lines in Yemeni adults with skeletal Class I, Class II, and Class III malocclusions.

Materials and Methods: A cross-sectional study was conducted on 120 lateral cephalograms (40 Class I, 40 Class II, and 40 Class III). Soft-tissue landmarks were digitized using EzDent-i software. Intra- and inter-examiner reliability was assessed using intraclass correlation coefficients (ICC). Statistical analysis included descriptive statistics, independent t-tests for gender comparison, one-way ANOVA with Tukey post-hoc tests for inter-class comparisons, and Pearson correlation analysis between lip position and ANB angle ($p < 0.05$).

Results: Class I subjects showed balanced lip posture, with the upper lip positioned slightly behind the E Line (–2.0±1.2 mm) and the lower lip near or slightly ahead (+1.0±1.4 mm). Class II subjects showed significantly more protrusive lips relative to S Line, B Line, and E Line ($p < 0.01$), while Class III subjects demonstrated retrusive lips, especially to E Line (upper lip:–2.6±1.4 mm; lower lip:–1.0±1.5 mm). Gender differences were minimal and non-significant across most measurements, except for a slightly more retrusive upper lip to E Line in males ($p < 0.05$). Correlation analysis revealed strong associations between ANB angle and lip protrusion to S, B, and Sushner's Lines, but weaker correlations for H Line.

Conclusion: Yemeni adults showed slightly protrusive lips. S Line, B Line, and E Line are reliable indicators for differentiating sagittal skeletal classes, whereas H Line is less dependable for skeletal classification.

Keywords: sagittal lip position, S Line, E Line, B Line, H Line, Sushner's Line, Yemeni adults, skeletal malocclusion

1.INTRODUCTION

Facial esthetics has become a central concern in contemporary orthodontic practice. Patients pursue orthodontic treatment not only to correct malocclusion but also to enhance their facial profile, making soft-tissue evaluation an important component of diagnosis and treatment planning. Modern orthodontics emphasizes the integration of skeletal, dental, and soft-tissue assessments to achieve outcomes that are both functionally stable and esthetically acceptable. The sagittal position of the lips plays a particularly critical role in determining facial harmony and profile attractiveness. Lip posture directly influences clinical decisions related to extraction therapy, camouflage approaches, and growth modification, and it has a strong impact on patients' perception of treatment success. Accurate evaluation of lip position is therefore essential

for predicting esthetic outcomes and ensuring patient satisfaction [1].

To facilitate objective assessment of sagittal lip position, several cephalometric reference lines have been proposed and widely adopted in orthodontic analysis. These include the Steiner's S Line, Burstone's B Line, Ricketts' E Line, Holdaway's H Line, and Sushner's Line, each of which evaluates lip prominence relative to different facial landmarks. While these reference lines provide valuable information, their interpretation is influenced by craniofacial morphology, particularly nasal projection, chin prominence, and skeletal jaw relationships [2]. As a result, reliance on a single reference line may lead to inconsistent or misleading conclusions.

Previous studies have demonstrated that sagittal skeletal relationships significantly affect soft-tissue profile characteristics. Distinct patterns of lip protrusion or retrusion have been reported among skeletal Class I, Class II, and Class III malocclusions, reflecting differences in maxillary and mandibular positioning and overall facial convexity or concavity [3]. Several studies have confirmed that Class II malocclusion is commonly associated with increased lip protrusion, whereas Class III malocclusion often presents with retrusive lips due to maxillary deficiency or mandibular prognathism [4,5]. These findings highlight the importance of evaluating lip position within the context of skeletal classification.

Ethnic background has also been shown to influence soft-tissue norms. Studies conducted in Middle Eastern, African, and Asian populations consistently report fuller lips and more protrusive soft-tissue profiles compared with Caucasian standards [6-9]. Specifically, Yemeni adults have demonstrated distinct soft-tissue characteristics that differ from Western reference values, stress the limitations of applying universal cephalometric norms across diverse populations. However, many of these studies focused on general soft-tissue standards without comprehensive stratification by skeletal malocclusion, gender, or lack skeletal vertical classification [2,7].

Additionally, the diagnostic reliability of these reference lines in distinguishing skeletal malocclusion patterns remains insufficiently explored, particularly in Yemeni adults. The lack of population-specific normative values stratified by skeletal pattern and gender represents a significant gap in the orthodontic literature and limits the precision of esthetic diagnosis and treatment planning [6,7].

Therefore, the present study was designed to comprehensively evaluate the sagittal position of the upper and lower lips in relation to five commonly used cephalometric reference lines (S Line, B Line, E Line, H Line, and Sushner's Line) on lateral cephalograms. By comparing lip position among skeletal Class I, Class II, and Class III Yemeni adults, analyzing gender differences, and assessing correlations with skeletal parameters, this study aims to establish population-specific normative values and to identify the most reliable reference lines for clinical application.

2. MATERIALS AND METHODS

This retrospective cross-sectional cephalometric study evaluated the sagittal position of the upper and lower lips in Yemeni adults with different skeletal malocclusion patterns.

Sample size was calculated using G*Power software (version 3.1.9) following the methodology described by Joshi et al. [10]. Based on a power of 95%, significance level of 5%, and an effect size of 0.88, a minimum sample size of 111 lateral cephalograms was required. To compensate for potential exclusions, the sample was rounded to 120 radiographs, with 40 subjects allocated to each skeletal class.

Digital lateral cephalometric radiographs (LCRs) of 120 subjects (40 per skeletal class) which collected from a private radiology centre in Sana'a city were analyzed. The study was conducted at the Postgraduate Orthodontic Clinics, Faculty of Dentistry, Sana'a University, between October 2024 and October 2025. Ethical approval was obtained from faculty of dentistry Sana'a University (Ref.No. : 959 ;Date : 10/10/2024).

LCRs of subjects aged 18–35 years were included if they had high-quality digital radiographs, no history of orthodontic or orthognathic treatment, fully erupted permanent dentition (excluding third molars), and no craniofacial anomalies. Skeletal classification was based on the ANB angle and confirmed using Wits appraisal. Subjects were categorized as Class I (ANB 1°–4°), Class II (ANB > 4°), or Class III (ANB < 1°). Wits appraisal values between −1 mm and +1 mm were considered Class I, values greater than +1 mm indicated Class II, and values less than −1 mm indicated Class III. Final classification was accepted only when both methods were concordant. To control for the effect of vertical growth pattern, only normodivergent subjects were included. Vertical skeletal pattern was assessed using the SN–GoGn angle, with values between 27° and 36° considered Normodivergent (Figure 1).

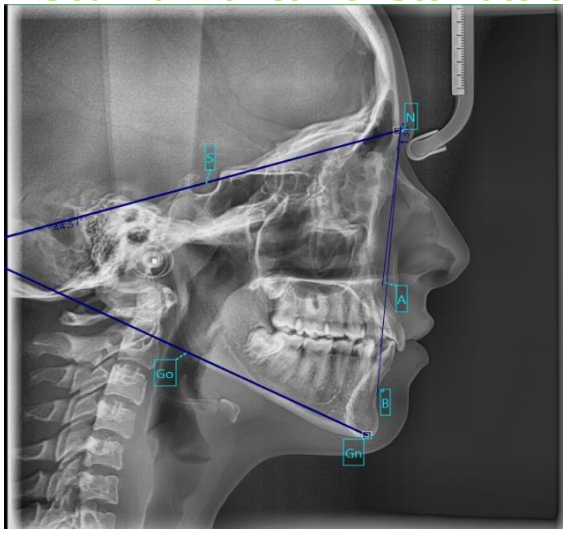

Figure 1. Measurements of ANB and SN-GOGN angles on the lateral cephalometric

All radiographs were obtained under standardized conditions, including natural head position, centric occlusion, and relaxed lips. Cephalometric analysis was performed using EzDent-i software (version 3.5.0). Hard- and soft-tissue landmarks were identified according to standardized definitions, and five sagittal reference lines, Steiner's S Line, Burstone's B Line, Ricketts' E Line, Holdaway's H Line, and Sushner's Line were digitally constructed.

Perpendicular distances from the upper lip (Ls) and lower lip (Li) to each reference line were measured in millimeters. Examiner calibration was performed prior to data collection, and inter- and intra-examiner reliability were assessed using intraclass correlation coefficients (ICC).

2.1. Landmark Identification

Hard- and soft-tissue landmarks were identified according to standardized definitions reported in previous cephalometric studies [10,12,13]. All landmarks were initially detected by the software and subsequently verified manually to ensure accuracy.

2.2. Construction of Reference Lines

Five sagittal soft-tissue reference lines were digitally constructed according to Pandey et al. [12] as the following

1. Steiner's (S) Line: the line was constructed from Columella (Cm) point to Pogonion (Pog′) point (Figure 2).
2. Ricketts' (E) Line: the line was constructed from Pronasal (Prn) point to Pog′ point (Figure 3).
3. Holdaway's (H) Line: the line was constructed from Labrale Superius (Ls) to Pog′ point (Figure 4).
4. Sushner's Line: the line was constructed from soft tissue Nasion (N′) point to Pog′ point (Figure 5).
5. Burstone's (B) Line: the line was constructed from Subnasal (Sn) point to Pog′ point (Figure 6).

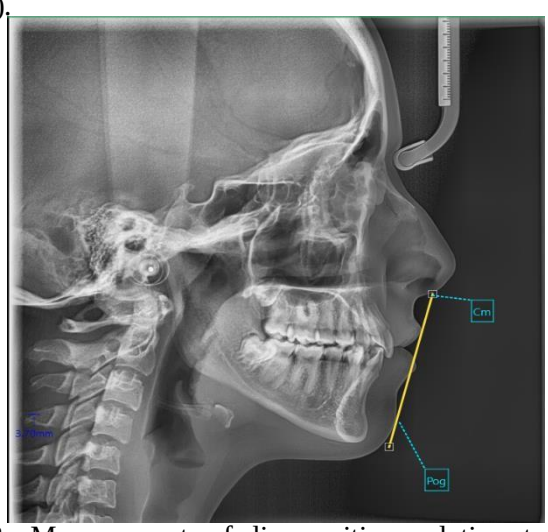

Figure 2. Measurement of lip position relative to Steiner's S Line using EzDent-i software. The S Line is drawn from the midpoint of the columella (subnasale region) to the soft tissue pogonion. The perpendicular distances of the upper and lower lips to this line were measured digitally.

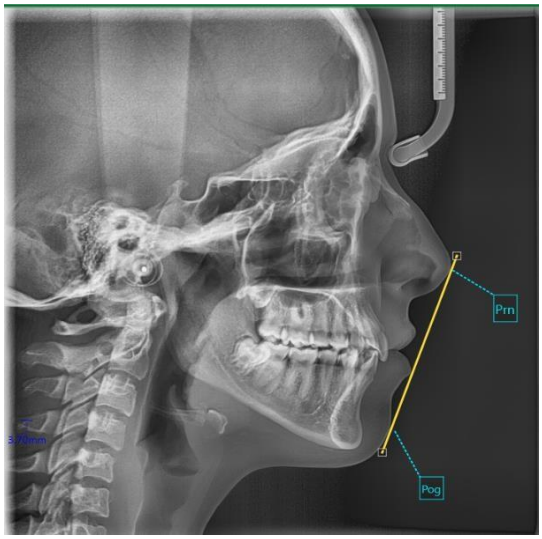

Figure 3. Measurement of lip position relative to Ricketts' E Line (esthetic plane) using EzDent-i software. The E Line extends from pronasale (tip of the nose) to soft tissue pogonion. The upper and lower lip positions were recorded as their horizontal distances to this plane.

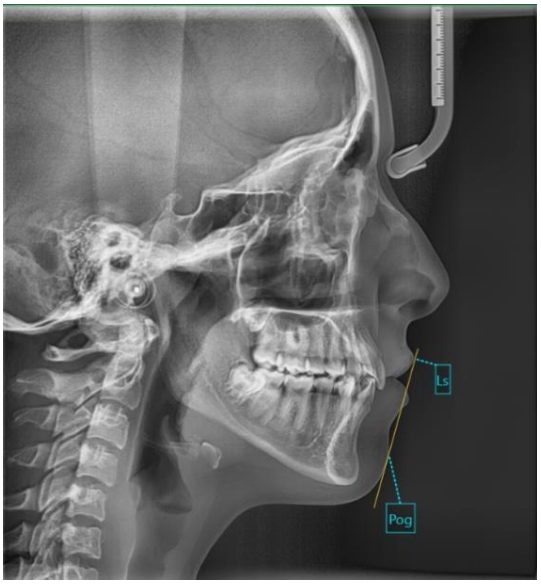

Figure 4. Measurement of lip position relative to Holdaway's H Line using EzDent-i software. The H Line is tangent to the upper lip and soft tissue pogonion. Lip protrusion and retrusion relative to this line were measured digitally.

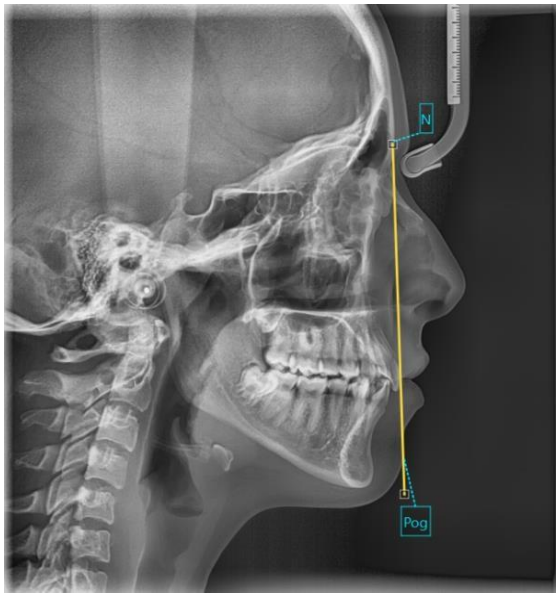

Figure 5. Measurement of lip position relative to Sushner's Line using EzDent-i software. This line is drawn from soft tissue nasion to soft tissue pogonion. The sagittal position of the lips was determined by measuring their distances perpendicular to this line

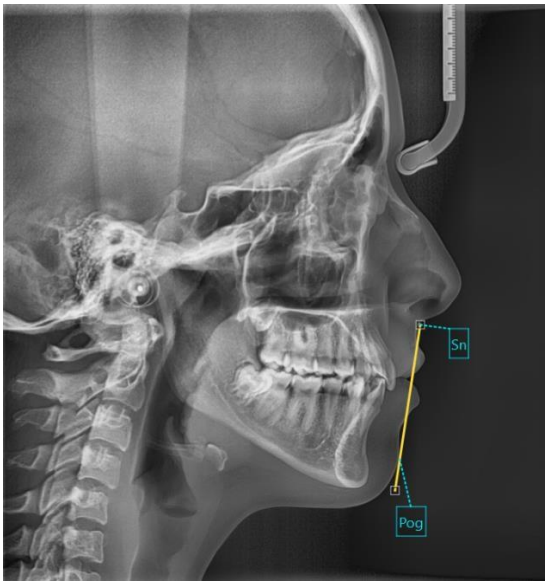

Figure 6. Measurement of lip position relative to Burstone's B Line using EzDent-i software. The B Line is defined from subnasale to soft tissue pogonion. Lip position was assessed as the linear distance of the upper and lower lips perpendicular to this line.

2.3. Examiner Training and Calibration

Prior to data collection, the examiner underwent standardized training under the supervision of an experienced technician. A pilot set of radiographs was jointly analyzed to ensure consistency. Inter-examiner reliability was assessed by independently re-measuring 20 radiographs, and intraclass correlation coefficients were calculated.

2.4. Measurement of Lip Position

Perpendicular distances from the upper lip (Ls) and lower lip (Li) to each reference line were measured in millimeters. Positive values indicated lip protrusion relative to the reference line, while negative values indicated retrusion.

2.5. Reliability Test

For intra-examiner reliability, 20 randomly selected radiographs were re-traced and re-measured by the same examiner after a three-week interval under identical conditions. The examiner was blinded to the initial measurements to minimize recall bias.

2.6 Statistical Analysis

All data were recorded in Microsoft Excel 2019 and analyzed using IBM SPSS Statistics version 26.0 (IBM Corp., Armonk, NY, USA). Descriptive statistics, including means, standard deviations, and ranges, were calculated for lip position measurements across skeletal classes and genders. One-way analysis of variance (ANOVA) was used to compare differences among skeletal classes, followed by post-hoc tests for pairwise comparisons. Gender differences within each skeletal class were assessed using independent-samples t-tests. Pearson's correlation coefficient was used to evaluate the relationship between ANB angle and lip position measurements. Statistical significance was set at $p < 0.05$.

3. RESULTS

3.1. Reliability of Measurements

ICC values were 0.90 for intra-examiner and 0.85 for inter-examiner measurements indicate high intra- and inter-examiner reliability, validating the consistency of landmark identification and linear measurements in this study.

Table 1. Intra- and inter-examiner reliability for cephalometric measurements

Measurement	Intra-Examiner ICC	Inter-Examiner ICC	Interpretation
S Line – Upper Lip	0.92	0.89	Excellent
S Line – Lower Lip	0.94	0.91	Excellent
E Line – Upper Lip	0.91	0.88	Excellent
H Line	0.88	0.85	Good
Sushner Line – Upper Lip	0.90	0.87	Excellent

Interpretation: ICC > 0.80 = high reliability.

3.2. Sample Characteristics

The study included 120 lateral cephalograms (60 males and 60 females; mean age = 24.3 ± 3.2 years) divided equally into skeletal Classes I, II, and III (n = 40 each) according to ANB and Wits appraisal. All participants exhibited normodivergent growth patterns (SN–GoGn = 32° ± 5°).

Table 2. Sample distribution by skeletal class and gender

Skeletal Class	Male (n)	Female (n)	Total (n)	Mean Age (years ± SD)
Class I	20	20	40	24.1 ± 3.0
Class II	20	20	40	24.6 ± 3.5
Class III	20	20	40	24.2 ± 3.2
Total	60	60	120	24.3 ± 3.2

3.3. Descriptive Statistics by Skeletal Class

Descriptive analysis of upper and lower lip positions across five reference lines revealed clear trends corresponding to skeletal patterns. Class II subjects showed the most protrusive lips, while Class III exhibited retrusive lips relative to most reference lines.

Table 3. Descriptive statistics of sagittal lip position (mm) across skeletal classes

Reference Line	Class I (Mean ± SD)	Class II (Mean ± SD)	Class III (Mean ± SD)
S Line – Upper Lip	0.5 ± 1.1	1.4 ± 1.3	–0.8 ± 1.2
S Line – Lower Lip	1.1 ± 1.3	2.2 ± 1.3	0.0 ± 1.3
B Line – Upper Lip	0.7 ± 1.1	1.3 ± 1.2	–0.4 ± 1.1
B Line – Lower Lip	1.3 ± 1.2	2.4 ± 1.1	0.6 ± 1.2
E Line – Upper Lip	–2.8 ± 1.0	–0.1 ± 0.9	–5.8 ± 0.9
E Line – Lower Lip	2.3 ± 0.9	4.2 ± 1.0	–2.2 ± 1.0
H Line – Lower Lip	2.0 ± 1.0	2.3 ± 0.9	0.8 ± 1.0
Sushner's Line – UL	1.8 ± 1.1	2.6 ± 1.2	1.2 ± 1.2
Sushner's Line – LL	1.6 ± 1.2	2.1 ± 1.1	1.1 ± 1.1

Negative values indicate retrusion behind the line.

3.4. Gender Comparison

Table 4. Comparison of lip position measurements between genders across skeletal classes

Reference Line	Skeletal Class	Male (n=20)	Female (n=20)	p-value
S Line – UL	Class I	0.4 ± 1.2	0.6 ± 1.2	0.412
	Class II	1.3 ± 1.2	1.5 ± 1.3	0.368
	Class III	–0.9 ± 1.3	–0.7 ± 1.1	0.458
S Line – LL	Class I	1.0 ± 1.3	1.2 ± 1.3	0.475
	Class II	2.0 ± 1.4	2.3 ± 1.3	0.363
	Class III	–0.1 ± 1.2	0.1 ± 1.3	0.389
B Line – UL	Class I	0.6 ± 1.2	0.8 ± 1.1	0.386
	Class II	1.2 ± 1.2	1.4 ± 1.1	0.402
	Class III	–0.5 ± 1.2	–0.3 ± 1.0	0.352
B Line – LL	Class I	1.2 ± 1.3	1.4 ± 1.1	0.378

	Class II	2.3 ± 1.2	2.5 ± 1.1	0.363
	Class III	0.4 ± 1.1	0.7 ± 1.3	0.291
E Line – UL	Class I	–3.0 ± 1.1	–2.6 ± 1.0	0.041*
	Class II	–0.2 ± 1.0	0.0 ± 0.9	0.276
	Class III	–5.8 ± 0.9	–5.6 ± 1.0	0.230
E Line – LL	Class I	2.3 ± 0.8	2.5 ± 0.9	0.037*
	Class II	4.0 ± 1.0	4.4 ± 1.0	0.272
	Class III	–2.5 ± 1.0	–1.9 ± 1.1	0.183
H Line – LL	Class I	2.0 ± 1.0	2.1 ± 0.9	0.624
	Class II	2.2 ± 1.0	2.4 ± 0.9	0.421
	Class III	0.7 ± 1.1	0.8 ± 1.0	0.536
Sushner Line – UL	Class I	1.7 ± 1.2	1.9 ± 1.1	0.392
	Class II	2.5 ± 1.2	2.7 ± 1.1	0.334
	Class III	1.0 ± 1.2	1.3 ± 1.1	0.444
Sushner Line – LL	Class I	1.5 ± 1.2	1.7 ± 1.1	0.375
	Class II	2.0 ± 1.1	2.2 ± 1.2	0.372
	Class III	1.0 ± 1.2	1.2 ± 1.0	0.472

No statistically significant gender differences were found across the majority of reference lines in any skeletal class ($p > 0.05$), except for the E Line measurements in Class I, which revealed significantly greater lip retrusion in males compared to females ($p < 0.05$).

3.5. ANOVA Analysis of Inter-Class Comparisons

3.5.1 ANOVA Results

ANOVA demonstrated statistically significant differences among skeletal classes for the S Line, B Line, and E Line ($p < 0.05$), while H Line and Sushner's Line did not show significance.

Table 5. One-way ANOVA comparing upper and lower lip position across skeletal classes

Reference Line	F-value	p-value	Significance
S Line – Upper	6.15	0.003*	Significant
B Line – Upper	7.20	0.001*	Significant

E Line – Upper	8.80	0.000*	Highly Significant
Sushner's Line– Upper	2.90	0.063	NS
S Line – Lower	7.55	0.001*	Significant
B Line – Lower	8.25	0.001*	Significant
E Line – Lower	9.20	0.000*	Highly Significant
H Line – Lower	2.00	0.130	NS
Sushner's Line – Lower	2.50	0.081	NS

Significance level = $p < 0.05$.

3.6. Correlations Between Reference Lines and ANB Angle

Pearson's correlation analysis revealed strong positive correlations between ANB and the S, B, and E Lines (r = 0.62–0.71, p < 0.01), confirming that increasing skeletal convexity is associated with lip protrusion. H Line and Sushner's Line showed weaker, nonsignificant correlations.

Table 6. Correlation between sagittal reference lines and ANB angle

Reference Line	Lip Position	Correlation with ANB (r)	p-value	Significance
S Line	Upper Lip	+0.42	0.001	Significant
	Lower Lip	+0.47	<0.001	Significant
B Line	Upper Lip	+0.51	<0.001	Significant
	Lower Lip	+0.55	<0.001	Significant
E Line	Upper Lip	–0.46	0.002	Significant
	Lower Lip	–0.39	0.005	Significant
H Line	Lower Lip	+0.22	0.071	NS
Sushner's Line	Upper Lip	+0.28	0.043*	Significant
	Lower Lip	+0.31	0.038*	Significant

NS = Not significant ($p > 0.05$).

Positive correlations were found with S Line, B Line, and Sushner's Line, indicating that as the ANB angle increased (toward skeletal Class II), the lips tended to be more protrusive relative to these lines. In contrast, E Line showed a significant negative correlation, confirming that larger ANB values were associated with less retrusive lips relative to the aesthetic plane. H Line demonstrated only a weak, non-significant correlation with ANB, suggesting limited reliability in reflecting skeletal discrepancyes.

4. DISCUSSION

Accurate evaluation of sagittal lip position is a fundamental component of contemporary orthodontic diagnosis, as facial esthetics has become a key determinant of treatment success alongside functional correction. Lip posture plays a decisive role in shaping the facial profile and directly influences clinical decisions such as extraction planning, camouflage strategies, and growth modification. However, soft-tissue assessment remains challenging because lip position is affected by skeletal pattern, soft-tissue thickness, and ethnic characteristics. Consequently, reliance on a single cephalometric reference line may lead to incomplete or misleading interpretations [14,15]. The present study addressed this limitation by evaluating upper and lower lip position using five commonly applied reference lines, providing a comprehensive and clinically relevant assessment of sagittal soft-tissue relationships.

A major methodological strength of this study was the inclusion of only normodivergent subjects, which allowed the sagittal influence of skeletal malocclusion on lip position to be examined without the confounding effects of vertical facial pattern [2,7,16]. Previous investigations often combined sagittal and vertical discrepancies, despite evidence that vertical divergence significantly affects lip posture and facial proportions [17]. By controlling vertical skeletal pattern, the present findings more accurately reflect sagittal soft-tissue behavior and offer population-specific norms that are directly applicable to clinical practice [1,17].

Standardized radiographic conditions, including natural head position, centric occlusion, and relaxed lips, were used to ensure reliable soft-tissue measurements. Digital tracing with manual verification minimized landmark identification errors, and the high intra- and inter-examiner reliability values confirmed that the observed differences among skeletal classes reflected true biological variation rather than methodological inconsistencies. These findings are consistent with recent digital cephalometric studies that have reported high reproducibility when standardized protocols are applied [8,11].

The reference lines selected in this study represent different analytical philosophies. Steiner's S Line provides a rapid clinical estimate of lip prominence with minimal nasal influence, while Burstone's B Line emphasizes the relationship between the lips and skeletal base, making it sensitive to sagittal discrepancies. Ricketts' E Line remains widely used due to its simplicity, although its dependence on nasal and chin projection is well recognized. Holdaway's H Line primarily reflects lower-lip balance relative to the soft-tissue chin, whereas Sushner's Line was developed to better accommodate ethnic variations in lip fullness [18,19,20]. Consistent with previous reports, the present findings confirmed that no single reference line adequately captures sagittal soft-tissue morphology, supporting the use of a multi-line approach for comprehensive evaluation [7,9,11,20].

In skeletal Class I subjects, lip position was relatively balanced across all reference lines, with mild protrusion particularly evident when assessed using S and B Lines. This pattern is consistent with previous studies in Yemeni and Middle Eastern populations, which reported fuller lip profiles compared with Western norms [2,7,11]. The agreement is largely attributable to ethnic differences in soft-tissue thickness and lip morphology, as populations from the Middle East and Africa tend to exhibit greater lip volume even in skeletally balanced individuals [2,3,4,5,6]. Similar findings reported in Saudi, Nigerian, and Sudanese samples further support the influence of ethnicity on soft-tissue norms [5,19,2]. Minor inter-study variations may be related to differences in sample characteristics, age range, and analytical techniques.

Gender differences within Class I subjects were minimal, in agreement with previous studies reporting limited sexual dimorphism in sagittal lip position when skeletal relationships are balanced [2,9,21,23]. This finding suggests that, in the absence of marked skeletal discrepancies, gender-related soft-tissue variation is insufficient to produce clinically meaningful differences in lip posture.

Class II subjects demonstrated more anteriorly positioned upper and lower lips across most reference lines, reflecting the increased facial convexity associated with maxillary prognathism and mandibular retrusion. This pattern has been consistently documented across diverse populations and can be directly explained by the underlying skeletal imbalance characteristic of Class II malocclusion. The reduced lip retrusion observed relative to the E Line in Class II subjects is attributable to posterior positioning of the chin rather than true lip protrusion, a phenomenon previously described in convex profiles. This explains the close agreement between the present findings and those reported in Sudanese and Pakistani populations, emphasizing that sagittal skeletal pattern exerts a stronger influence on lip position than ethnicity alone [6,9,15,22].

No significant gender differences were observed within Class II subjects, further supporting the concept that skeletal morphology predominates over gender-related

soft-tissue variation in malocclusions with pronounced sagittal discrepancies.

Skeletal Class III subjects exhibited retrusive upper and lower lips relative to all reference lines, consistent with the concave facial profile produced by mandibular prognathism and/or maxillary deficiency. The marked retrusion of the upper lip reflects reduced maxillary support, a finding consistently reported across ethnic groups [7,12,21,24]. In this group, H Line measurements showed limited discriminatory ability, likely due to their strong dependence on soft-tissue chin morphology rather than true sagittal lip position.

Statistical analysis revealed significant inter-class differences in lip position when assessed using S, B, and E Lines, confirming their reliability in distinguishing sagittal skeletal patterns [8,10,11,15]. In contrast, H Line and Sushner's Line demonstrated greater variability, particularly in Class III subjects, reflecting the influence of ethnic lip thickness and chin prominence. Positive correlations between ANB angle and lip protrusion measured using S, B, and Sushner's Lines confirmed that increased skeletal convexity is associated with more anterior lip posture, while negative correlations with the E Line reflected its dependence on nasal and chin projection rather than lip position alone [17,26,27].

Overall, the present findings align with classical soft-tissue concepts while reinforcing contemporary evidence that emphasizes ethnic variability in lip position [19,21,26]. Yemeni adults demonstrated slightly more protrusive lips compared with Caucasian norms, a pattern also reported in Middle Eastern and African populations. By controlling vertical skeletal pattern, this study provided clearer insight into sagittal soft-tissue relationships and demonstrated the clinical value of combining multiple reference lines for accurate esthetic assessment and orthodontic decision-making.

5. CONCLUSION

This study demonstrated that sagittal lip position varies significantly according to skeletal malocclusion and the reference line used for assessment. Distinct differences were observed among skeletal Classes I, II, and III, with balanced lip posture in Class I, increased lip protrusion in Class II, and lip retrusion in Class III subjects, confirming the strong influence of sagittal skeletal relationships on soft-tissue profile. No significant gender differences were detected, indicating that skeletal pattern predominates over sexual dimorphism when vertical pattern is controlled. Among the reference lines evaluated, Steiner's S Line, Burstone's B Line, and Ricketts' E Line showed the greatest reliability for distinguishing sagittal lip position, whereas Holdaway's H Line demonstrated limited sensitivity. Population-specific normative values for Yemeni adults were established and differed from Western standards, highlighting the necessity of ethnic-specific references in orthodontic diagnosis. A significant correlation between lip position and ANB angle further confirmed the close relationship between skeletal convexity and sagittal soft-tissue profile.

DECLARATION

Declaration of Interest

The authors of this article declared no conflict of interest.

Ethical Considerations

All ethical principles were adheried in conducting and writing this article.

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