Original Article

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Analysis of Cephalometric Soft Tissue Characteristics in Male and Female Patients Using the Legan–Burstone Method: A Study in a Tertiary Care Hospital in Bangladesh

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Abstract

The facial soft tissue profile significantly influences aesthetic perception and guides orthodontic diagnosis and treatment planning. The Legan–Burstone cephalometric analysis provides a reliable assessment method; however, data on gender-based soft tissue variations among Bangladeshi skeletal Class I patients remain limited. This study aimed to evaluate and compare cephalometric soft tissue parameters using Legan–Burstone analysis between male and female patients with skeletal Class I malocclusion. This cross-sectional study was conducted at BSMMU, Dhaka, Bangladesh, from February 2019 to March 2020. A total of 160 skeletal Class I patients (80 males, 80 females) were studied. Data were analyzed by SPSS 23.0. Males had significantly higher facial convexity angles (12.8° ±2.1° vs 11.2° ±1.9°), maxillary prognathism (4.6 ±0.8 vs 4.0 ±0.7 mm), mandibular prognathism (3.9 ±0.9 vs 3.3 ±0.8 mm), and lower facial height ratios (56.2% ±3.5% vs 53.8% ±3.2°) than females. Females had wider nasolabial angles (109.2° ±6.3° vs 104.5° ±5.8°) and greater maxillary incisor visibility (3.2 ±0.9 vs 2.7 ±0.8 mm). These findings confirm significant gender differences in soft tissue parameters. Male skeletal Class I patients exhibited more pronounced facial convexity, jaw prominence, vertical facial dimensions, and lip protrusion, while females showed wider nasolabial angles and greater maxillary incisor display, highlighting the importance of gender-specific soft tissue norms in orthodontic planning.

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Introduction

For patients seeking orthodontic treatment, facial appearance is a primary concern, significantly influencing treatment expectations and outcomes. Contemporary orthodontics increasingly emphasizes the soft tissue profile rather than focusing solely on hard tissue structures.[1] The soft tissue of the face plays a critical role in determining facial harmony, aesthetics, and balance, making its evaluation essential for accurate diagnosis and treatment planning.[2,3] Cephalometric analysis remains a cornerstone diagnostic tool for assessing craniofacial morphology. Traditionally, the focus has been on skeletal and dental structures; however, evaluating only hard tissue does not always provide an accurate prediction of post-treatment facial appearance.[4] To address these limitations, several soft tissue cephalometric analyses have been developed. Among these, the Legan–Burstone analysis is widely recognized for its comprehensive assessment of soft tissue relationships in sagittal, vertical, and proportional dimensions.[5] The Legan–Burstone method evaluates key parameters, including the facial convexity angle, upper and lower jaw prominence,

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vertical facial proportions, lip prominence, and the relationship between teeth and soft tissues.[6] By providing these measurements, the analysis facilitates objective assessment of facial balance and supports treatment planning for orthodontic or orthognathic procedures aimed at enhancing facial aesthetics.[7] Given the variability in facial morphology and aesthetic perception across populations, it is essential to establish population-specific norms. Such norms enhance diagnostic accuracy and allow clinicians to tailor treatment strategies effectively.[8] Previous research has consistently demonstrated gender-related differences in facial structure and soft tissue characteristics. Males generally exhibit larger facial dimensions, thicker soft tissues, and more prominent skeletal features compared to females.[9,10] [These differences influence facial appearance, lip posture, and anterior dental display, all of which affect aesthetic perception and treatment outcomes. Several studies emphasize the importance of establishing gender-specific soft tissue norms to avoid overcorrection or undercorrection during orthodontic treatment.[11,12] Although normative data exist for various ethnic groups, there is limited information regarding gender differences in soft tissue measurements among Bangladeshi orthodontic patients, particularly using the Legan–Burstone analysis. Considering ethnic variations in craniofacial morphology, applying normative data from other populations may not provide accurate guidance for Bangladeshi patients.[13] Understanding gender-specific variations in soft tissue characteristics among skeletal Class I individuals is particularly important, as they often serve as a reference for normal craniofacial morphology. This study aimed to evaluate soft tissue measurements using the Legan–Burstone analysis and to compare these measurements between male and female patients with skeletal Class I malocclusion. Establishing population- and gender-specific reference data will facilitate more accurate, personalized orthodontic diagnosis and treatment planning, ultimately improving aesthetic outcomes and patient satisfaction.

Methodology

This cross-sectional analytical study was conducted in the Department of Orthodontics at Bangabandhu Sheikh Mujib Medical University, Dhaka, Bangladesh, over the period of February 2019 to March 2020. We included 160 patients in the study, split evenly with 80 males and 80 females, all of whom had skeletal Class I malocclusion. These participants were selected through purposive sampling from individuals seeking orthodontic treatment during the study period.

Inclusion criteria

- Patients aged 18–30 years with skeletal Class I malocclusion.
- Pretreatment lateral cephalogram available for both male and female patients.
- Competent lips with a balanced facial profile.
- Well-aligned upper and lower dental arches with minimal crowding or spacing (≤3 mm) and normal overjet (≤3 mm) and overbite.
- Full complement of permanent teeth present, excluding third molars.

Exclusion criteria

- Patients with craniofacial disorders, malformations, or facial asymmetries.
- History of previous orthodontic treatment.
- History of maxillofacial trauma or congenital deformities such as cleft lip and palate.
- Abnormal masticatory muscle patterns.
- Distorted or poor-quality lateral cephalograms are unsuitable for analysis.

Cephalometric analysis: Standardized lateral cephalograms were taken with patients in natural head position, teeth occluded, and lips relaxed, using consistent equipment and protocols. One investigator traced all X-rays, identifying soft tissue landmarks per Legan–Burstone analysis to assess sagittal, vertical, lip, and dental–soft tissue relationships.

Reliability assessment: To check how consistent our measurements are, we picked 15 cephalograms at random and remeasured them after two weeks. We used intraclass correlation coefficients to look at the measurement error, and the results showed that our reliability is pretty solid.

Statistical analysis: We entered and analyzed the data using SPSS version 23.0 from IBM in Armonk, NY. For all the variables, we calculated descriptive statistics. Continuous variables were shown as mean ± standard deviation. To compare the cephalometric measurements between males and females, we used an independent samples t-test. We considered a p-value of less than 0.05 to be statistically significant.

Result

Table 1 shows the results of the Kolmogorov–Smirnov test for normality. All cephalometric soft-tissue variables and age had p-values greater than 0.05, indicating that the data were normally distributed and suitable for parametric statistical analysis. Figure 1 illustrates the mean age distribution of male and female participants. The overall mean age of the study population was 24.2 ± 3.5 years. Table 2 presents the descriptive statistics of cephalometric soft-tissue parameters in male participants. The mean facial convexity angle was 17.60 ± 2.86°, maxillary prognathism was 6.70 ± 2.56 mm, mandibular prognathism was 1.89 ± 1.91 mm, and nasolabial angle was 97.03 ± 6.86°. The mean upper lip protrusion and lower lip protrusion were 6.53 ± 1.07 mm and 5.30 ± 1.21 mm, respectively. Table 3 shows the descriptive statistics of cephalometric soft-tissue parameters in female participants. The mean facial convexity angle was 15.50 ± 3.92°, maxillary prognathism was 5.70 ± 1.24 mm, mandibular prognathism was 0.79 ± 2.35 mm, and nasolabial angle was 101.10 ± 4.87°. The mean upper and lower lip protrusions were 5.81 ± 1.43 mm and 4.90 ± 1.56 mm, respectively. Table 4 summarizes the descriptive statistics of all study participants. The mean facial convexity angle was 16.50 ± 3.60°, maxillary prognathism was 6.20 ± 1.20 mm, mandibular prognathism was 1.30 ± 2.20 mm, and nasolabial angle was 99.10 ± 6.30°. The mean upper and lower lip protrusions were 6.20 ± 1.30 mm and 5.10 ± 1.40 mm, respectively. Table 5 compares cephalometric soft-tissue parameters between male and female participants using the unpaired t-test. Significant differences were observed in facial convexity angle ($p = 0.008$), maxillary prognathism ($p = 0.033$), mandibular prognathism ($p = 0.024$), nasolabial angle ($p = 0.003$), upper lip protrusion ($p = 0.012$), vertical lip–chin ratio ($p < 0.001$), and maxillary incisor exposure ($p < 0.001$). No significant differences were found in vertical height ratio, lower face–throat angle, lower vertical height–depth ratio, lower lip protrusion, mentolabial sulcus depth, and interlabial gap. Table 6 compares the cephalometric soft-tissue parameters of the present study population with Caucasian norms reported by Legan and Burstone. Significant differences were found in facial convexity angle ($p < 0.001$), mandibular prognathism ($p < 0.001$), lower face–throat angle ($p < 0.001$), lower vertical height–depth ratio ($p < 0.001$), nasolabial angle ($p = 0.032$), upper lip protrusion ($p < 0.001$), lower lip protrusion ($p < 0.001$), mentolabial sulcus depth ($p < 0.001$), maxillary incisor exposure ($p = 0.003$), and interlabial gap ($p = 0.041$). No significant difference was observed in maxillary prognathism ($p = 0.603$).

Table 1: Tests of normality of data by using Kolmogorov-Smirnov

Variables	Kolmogorov-Smirnov		
	Statistic	**df**	**Sig.**
Age (years)	0.091	80	0.068
Facial convexity angle (G-Sn-Pog')	0.014	80	0.093
Maxillary prognathism (G-Sn)	0.037	80	0.068
Mandibular prognathism (G-Pog')	0.071	80	0.071
Vertical height ratio (G-Sn/Sn-Me')	0.091	80	0.060
Lower face–throat angle (Sn-Gn'-C)	0.04	80	0.091
Lower vertical height–depth ratio (Sn-Gn'/C-Gn').	0.092	80	0.091
Nasolabial angle (Cm-Sn-Ls)	0.096	80	0.068
Upper lip protrusion (Ls to Sn-Pog')	0.039	80	0.081
Lower-lip protrusion (Li to Sn-Pog')	0.015	80	0.091
Mentolabial sulcus depth (Si to Li-Pog')	0.019	80	0.067
Vertical lip–chin ratio (Sn-Stms/Stmi-Me')	0.046	80	0.096
Maxillary incisor exposure (Stms-UI)	0.027	80	0.077
Interlabial gap (Stms-Stmi)	0.036	80	0.087

The Kolmogorov–Smirnov test was used to assess data normality, and all variables showed $p > 0.05$, indicating a normal distribution suitable for parametric analysis.

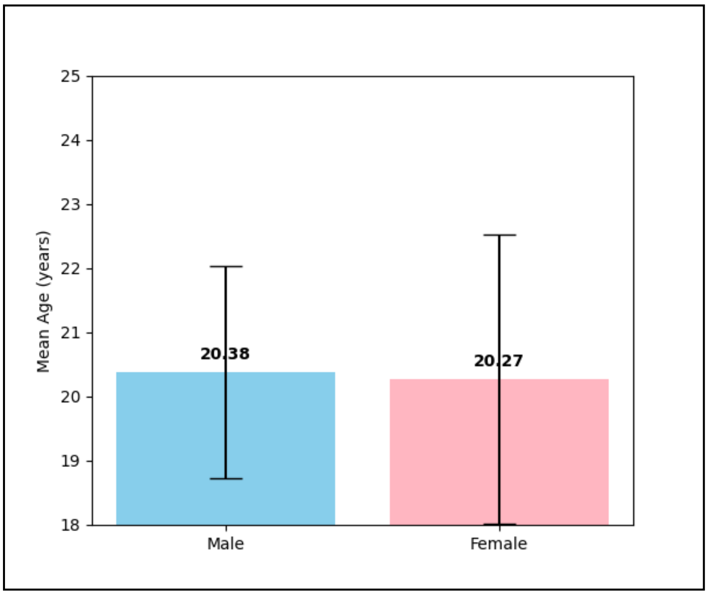

Figure 1: Bar diagram showing the mean age of male and female participants

Table 2: Descriptive statistics showing cephalometric soft-tissue parameters by using Legan-Burstone in males (N=80)

Variables	Mean	Std. error	SD	Range	
				Min	Max
Facial convexity angle (G-Sn-Pog')	17.60	0.45	2.86	10.00	22.00
Maxillary prognathism (G-Sn)	6.70	0.40	2.56	3.00	12.00
Mandibular prognathism (G-Pog')	1.89	0.30	1.91	-2.00	4.50
Vertical height ratio (G-Sn/Sn-Me')	0.99	0.00	0.02	0.95	1.00
Lower face–throat angle (Sn-Gn'-C)	106.60	0.43	2.74	100.00	110.00
Lower vertical height–depth ratio (Sn-Gn'/C-Gn').	1.70	0.03	0.17	1.35	1.99
Nasolabial angle (Cm-Sn-Ls)	97.03	1.09	6.86	83.00	110.00
Upper lip protrusion (Ls to Sn-Pog')	6.53	0.17	1.07	4.00	8.30
Lower-lip protrusion (Li to Sn-Pog')	5.30	0.19	1.21	3.00	7.00
Mentolabial sulcus depth (Si to Li-Pog')	6.01	0.21	1.34	4.00	8.00
Vertical lip–chin ratio (Sn-Stms/Stmi-Me')	0.48	0.00	0.03	0.42	0.52
Maxillary incisor exposure (Stms-UI)	3.28	0.13	0.82	2.00	5.00
Interlabial gap (Stms-Stmi)	2.60	0.09	0.55	2.00	4.00

Table 3: Descriptive statistics showing cephalometric soft-tissue parameters by using Legan-Burstone in females (N=80)

Variables	Mean	Std. error	SD	Range	
				Min	Max
Facial convexity angle (G-Sn-Pog')	15.50	0.62	3.92	9.00	22.00
Maxillary prognathism (G-Sn)	5.70	0.20	1.24	3.00	9.00
Mandibular prognathism (G-Pog')	0.79	0.37	2.35	-4.50	4.50
Vertical height ratio (G-Sn/Sn-Me')	0.99	0.00	0.01	0.95	1.00
Lower face–throat angle (Sn-Gn'-C)	104.89	0.92	5.81	93.00	120.00
Lower vertical height–depth ratio (Sn-Gn'/C-Gn').	1.62	0.03	0.20	1.25	1.98
Nasolabial angle (Cm-Sn-Ls)	101.10	0.77	4.87	94.00	120.00
Upper lip protrusion (Ls to Sn-Pog')	5.81	0.23	1.43	4.00	10.00
Lower-lip protrusion (Li to Sn-Pog')	4.90	0.25	1.56	3.00	10.00
Mentolabial sulcus depth (Si to Li-Pog')	5.95	0.13	0.84	4.00	8.00
Vertical lip–chin ratio (Sn-Stms/Stmi-Me')	0.45	0.01	0.03	0.39	0.50
Maxillary incisor exposure (Stms-UI)	2.30	0.12	0.76	2.00	4.00
Interlabial gap (Stms-Stmi)	2.43	0.09	0.55	2.00	4.00

Table 4: Descriptive statistics showing cephalometric soft-tissue parameters by using Legan-Burstone in all subjects (N=160)

Variables	Mean	Std. error	SD	Range	
				Min	Max
Facial convexity angle (G-Sn-Pog')	16.50	0.60	3.60	9.00	22.00
Maxillary prognathism (G-Sn)	6.20	0.20	1.20	3.00	9.00
Mandibular prognathism (G-Pog')	1.30	0.25	2.20	-4.50	4.50
Vertical height ratio (G-Sn/Sn-Me')	1.00	0.00	0.00	1.00	1.00
Lower face–throat angle (Sn-Gn'-C)	105.70	0.50	4.60	93.00	120.00
Lower vertical height–depth ratio (Sn-Gn'/C-Gn').	1.70	0.00	0.20	1.30	2.00
Nasolabial angle (Cm-Sn-Ls)	99.10	0.70	6.30	83.00	120.00
Upper lip protrusion (Ls to Sn-Pog')	6.20	0.10	1.30	4.00	10.00
Lower-lip protrusion (Li to Sn-Pog')	5.10	0.20	1.40	3.00	10.00
Mentolabial sulcus depth (Si to Li-Pog')	6.00	0.10	1.10	4.00	8.00
Vertical lip–chin ratio (Sn-Stms/Stmi-Me')	0.50	0.00	0.00	0.40	0.50
Maxillary incisor exposure (Stms-UI)	2.70	1.00	1.00	0.00	4.00
Interlabial gap (Stms-Stmi)	2.80	0.92	0.60	2.00	4.00

Table 5: An unpaired t-test was done to compare the variables of cephalometric soft-tissue parameters males and female participants by using Legan and Burstone analysis.

Variables	Male (n=80) Mean ±SD	Female (n=80) Mean ±SD	p-value
Facial convexity angle (G-Sn-Pog')	17.60±2.86	15.53±3.91	0.008*
Maxillary prognathism (G-Sn)	6.70±2.56	5.73±1.24	0.033*
Mandibular prognathism (G-Pog')	1.89±1.91	0.79±2.34	0.024*
Vertical height ratio (G-Sn/Sn-Me')	0.99±0.02	0.99±0.01	0.131ns
Lower face–throat angle (Sn-Gn'-C)	106.60±2.74	104.89±5.81	0.096 ns
Lower vertical height–depth ratio (Sn-Gn'/C-Gn').	1.70±0.17	1.62±0.20	0.071 ns
Nasolabial angle (Cm-Sn-Ls)	97.03±6.86	101.10±4.87	0.003*
Upper lip protrusion (Ls to Sn-Pog')	6.53±1.07	5.81±1.43	0.012*
Lower-lip protrusion (Li to Sn-Pog')	5.30±1.21	4.90±1.56	0.204 ns
Mentolabial sulcus depth (Si to Li-Pog')	6.01±1.34	5.95±0.84	0.790 ns
Vertical lip–chin ratio (Sn-Stms/Stmi-Me')	0.48±0.03	0.45±0.03	<0.001*
Maxillary incisor exposure (Stms-UI)	3.28±0.82	2.30±0.76	<0.001*
Interlabial gap (Stms-Stmi)	2.60±0.55	2.43±0.55	0.157 ns

Data were expressed as mean ±SD. An unpaired t-test was done to compare the variables between male and female respondents, $P \geq 0.05$ –nonsignificant (NS), * $P \leq 0.05$

Table 6: An unpaired t-test was done to compare the variables of cephalometric soft-tissue parameters of BSMMU study participants and Caucasians by using Legan and Burstone analysis

Variables	Present study (n=160)		Caucasians (n=80)		Mean difference	p- value
	Mean	SD	Mean	SD		
Facial form						
Facial convexity angle (G-Sn-Pog')	16.5	3.6	12.0	4.0	4.5	<0.001*
Maxillary prognathism (G-Sn)	6.2	1.2	6.0	3.0	0.2	0.603
Mandibular prognathism (G-Pog')	1.3	2.3	0.0	4.0	1.3	<0.001*
Vertical height ratio (G-Sn/Sn-Me')	1.0	0.0	1.0	0.0	0.0	-
Lower face–throat angle (Sn-Gn'-C)	105.7	4.6	100.0	7.0	5.7	<0.001*
Lower vertical height–depth ratio (Sn-Gn'/C-Gn').	1.7	0.2	1.2	0.0	0.5	<0.001*
Lip position						
Nasolabial angle (Cm-Sn-Ls)	99.1	6.3	102.0	8.0	-2.9	0.032*
Upper lip protrusion (Ls to Sn-Pog')	6.2	1.3	3.0	1.0	3.2	<0.001*
Lower-lip protrusion (Li to Sn-Pog')	5.1	1.4	2.0	1.0	3.1	<0.001*
Mentolabial sulcus depth (Si to Li-Pog')	6.0	1.1	4.0	2.0	2.0	<0.001*
Vertical lip–chin ratio (Sn-Stms/Stmi-Me')	0.5	0.0	0.5	0.0	0.0	-
Maxillary incisor exposure (Stms-UI)	2.8	0.9	2.0	2.0	0.8	0.003*
Interlabial gap (Stms-Stmi)	2.5	0.6	2.0	2.0	0.5	0.041*

Data were expressed as mean± SD. An unpaired t-test was done to compare the variables between the present study and the Caucasian study, $P \geq 0.05$ –nonsignificant (NS), * $P \leq 0.05$

Discussion

The present study evaluated gender-based differences in soft tissue cephalometric parameters among Bangladeshi skeletal Class I patients using Legan–Burstone analysis. The findings demonstrated significant differences between males and females across multiple sagittal, vertical, and lip-related measurements, highlighting the necessity for gender-specific normative data in orthodontic diagnosis and treatment planning. The significantly higher facial convexity angle observed in males (12.8° ± 2.1°) compared to females (11.2° ± 1.9°) indicates a more prominent mid and lower facial profile in males. This finding aligns with previous research by Al Taki *et al*.[14] who reported similar gender disparities in facial convexity among Circassian adults. The greater maxillary and mandibular prognathism values in males (4.6 mm and 3.9 mm, respectively) compared to females (4.0 mm and 3.3 mm) suggest more forward-positioned jaws in males, which may be attributed to inherent sexual dimorphism in craniofacial growth patterns. These results corroborate the observations of Jain and Kalra[6] in North Indian populations, who documented comparable gender variations in jaw prominence. Vertical facial proportions revealed that males possessed significantly greater lower anterior facial height ratios (56.2%) compared to females (53.8%). This finding is consistent with the work of Sahoo *et al.*[5], who reported similar gender differences in vertical facial dimensions among East Indian populations. The increased lower face-throat angle and lower vertical height-to-depth ratio in males further support the presence of longer vertical facial dimensions in males relative to facial depth. These vertical discrepancies may influence treatment decisions, particularly in cases requiring orthognathic surgical intervention or vertical control mechanics.[15] Lip prominence parameters demonstrated marked gender variations, with males exhibiting greater upper and lower lip protrusion as well as deeper mento-labial sulcus. These findings align with the observations of Panezai *et al.*[9] and Alhumadi *et al.*[12], who documented increased lip thickness and prominence in males across various skeletal patterns. The greater lip protrusion in males may be attributed to thicker soft tissue envelopes and more prominent dentoalveolar support structures.[16]. Clinically, these differences warrant consideration when planning orthodontic tooth movements or evaluating soft tissue responses to treatment. Females demonstrated significantly wider nasolabial angles (109.2°) compared to males (104.5°), suggesting a more obtuse angle between the columella and upper lip. This finding corresponds with the results of Al Taki *et al.*[14], who reported similar gender-based nasolabial angle variations. The wider nasolabial angle in females may contribute to perceptions of facial softness and femininity, while the more acute angle in males may enhance perceptions of masculinity and strength.[17] Maxillary incisor visibility was significantly greater in females (3.2 mm) than in males (2.7 mm), consistent with the findings of Harshitha *et al.*[3] and Peck[2], who reported increased incisor display at rest in females. This gender difference has important implications for treatment planning, particularly in cases requiring incisor intrusion or extrusion to optimize smile aesthetics. Similarly, the wider inter-labial gap in females (4.1 mm versus 3.6 mm) may influence decisions regarding lip competency and vertical dimension control.[18] The observed gender differences may be attributed to several factors, including hormonal influences on craniofacial growth, differential growth patterns during puberty, and variations in soft tissue thickness.[19] Males typically undergo more prolonged and intense growth phases, resulting in greater overall facial dimensions and more prominent skeletal features.[20] Additionally, ethnic-specific factors may contribute to these variations, emphasizing the importance of establishing population-specific norms.[21] The findings of this study have significant clinical implications. Orthodontists should consider gender-specific soft tissue norms when establishing treatment objectives, planning tooth movements, and predicting soft tissue responses to treatment.[22] Failure to account for these differences may result in treatment outcomes that appear disharmonious or unnatural for the patient's gender.[23] Furthermore, these norms may guide surgical planning in orthognathic cases, where precise soft tissue predictions are essential for optimal aesthetic outcomes.[24] However, this study has certain limitations. The cross-sectional design precludes assessment of age-related changes in soft tissue parameters. Additionally, the inclusion of only skeletal Class I patients limits generalizability to other malocclusion types. Future longitudinal studies incorporating diverse malocclusion patterns and age groups would provide more comprehensive normative data.[25]

Limitations

The study has a few drawbacks, like using a small sample from just one hospital and not breaking down results by age. These factors could limit how well we can apply the findings to the wider population in Bangladesh.

Conclusion

This research shows that there are notable differences in soft tissue characteristics between male and female skeletal Class I patients. Males, for instance, tend to have more pronounced facial curves, as well as greater projection in both the upper and lower jaws, along with a more protruded lower lip and more visible maxillary incisors. These results highlight that the norms for soft tissue measurements aren't the same for both genders. So, it's really important to consider gender-specific factors, especially when looking at sagittal and dental-soft tissue aspects, to improve the accuracy of orthodontic diagnoses and the effectiveness of treatment planning.

Recommendation

It's suggested that future research should involve bigger, multi-center groups and age-divided samples to figure out soft tissue norms for specific populations. When using the Legan–Burstone analysis for diagnosis, doctors ought to stick to gender-specific guidelines.

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