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## Comparison of horizontal lip position between skeletal class I and class II using five reference planes: A cephalometric study

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### Abstract

The aim of this study is to compare horizontal lip position between Class I and class II division 1 skeletal pattern using five reference planes-Ricketts' E line, Steiner's S1 line, Burstone's B line, Sushner's S2 line, and Arnett's lip measurement. Pretreatment lateral cephalograms of 80 patients (40 males and 40 females) were divided into 40 Class I (ANB  $2^{\circ}\pm 2^{\circ}$ ) and 40 Class II (ANB  $>4^{\circ}$ ) subgroups evenly distributed between males and females. The reference panes were measured. The results showed protrusive upper lip in class II subjects compared to class I subjects in both males and females. For lower lip only S2-line showed the statistically significant results. It was concluded that class II skeletal pattern showed protrusive lips in comparison to Class I skeletal pattern with no significant sexual dimorphism.

**Keywords:** Ricketts' E line, Steiner's S1 line, Burstone's B line, Sushner's S2 line, Arnett's lip measurement

### 1. Introduction

The objectives of orthodontic treatment can be summarized in the form of a triad i.e., structural balance, functional efficiency and esthetic harmony. The structural balance and functional efficiency of dentition is majorly affected by the soft tissue covering. Attractive face has a balance between hard tissue and soft tissue seen on face like lips, nose, cheeks, around eyes. Thus, the soft-tissue profile plays an important part in our orthodontic considerations. According to Holdaway<sup>[1]</sup>, 'Better treatment goals can be set if we quantitate the soft tissue features which contribute to or detract from that physical attractiveness stereotype which has been ingrained into our culture'.

For evaluation of any case, macro-, micro-, and mini-esthetics must be taken in consideration. The prominence of the lips and nose are important. Lip thickness, strain, fullness are usually determined because the decision of dental extraction will depend on these factors in addition to the facial type, skeletal and dental patterns<sup>[2]</sup>.

For a long time orthodontists have believed that horizontal lip position is the most important determinant of facial beauty. For clinical orthodontists, the Soft tissue profile has always been one of the most important aspects of diagnosis and treatment planning. As a result of its influence with regard to malocclusions, tooth stability, and facial esthetics, lip position has become one of the most important soft tissue measures relied upon by orthodontists<sup>[3]</sup>. Lip analysis in orthodontics is part of soft tissue analysis which includes lip thickness, lip seal, lip competency, lip prominence and lip length.

The horizontal lip position has been evaluated by a number of lines, planes and angles thus assessing the attractiveness of the profile. Steiner<sup>[4]</sup> evaluated the soft tissue profile by connecting a line (S line) from the middle of the S-shaped curve between the tip of the nose and sub-nasale to the soft tissue pogonion and mentioned that the lips should touch the reference line. Ricketts<sup>[5]</sup> lip analysis consists of a line, E-line (Esthetic line) which is drawn from the tip of the nose to soft tissue pogonion. Ricketts mentioned that the lips lie behind this E-line at a mean distance of 4 mm for the upper and 2mm for the lower lip respectively. Burstone's<sup>[6]</sup> B line was drawn from soft tissue sub-nasale to soft tissue Pogonion. The lips were positioned anterior to this line at a mean distance of 3.5mm for the upper and 2.2mm for

the lower lip respectively. Sushner [7] described a line (S2 line) drawn from soft tissue nasion to soft tissue pogonion. He stated that the upper and lower lips were located in front of this line in the black population. Arnett's lip measurements are done by measuring the projections of upper lip anterior and lower lip anterior to TVL (true vertical line) [8].

Cephalometric values for the soft tissue parameters are different for different ethnic and racial groups. The norms which are ideal for one group cannot be extrapolated to other ethnically and racially different groups. Various studies have been done in different populations to derive ideal values for that population. Different racial and ethnic groups should be treated according to their own characteristics and achievement of accepted norms should be the aim of orthodontic treatment. Thus the aim of this study is to evaluate comparison of horizontal lip position in adults with class I and class II division 1 skeletal malocclusions for males and females.

## 2. Materials and Methods

Pre-treatment lateral cephalograms of 80 (40 males and 40 females) patients who reported to the Department of Orthodontics MR Ambedkar Dental College and hospital for orthodontic treatment were chosen for the study. Written consent was taken from each of the patients after being informed about the nature of the study in detail. The study was approved by the local Ethical Committee. Following inclusion criteria were to be met by each subject:

- Age 18 years and above.
- No previous history of trauma to the dentofacial structures.
- No history of previous orthodontic treatment or functional jaw orthopedic treatment.
- No history of any surgery involving the jaws, cleft lip and palate and any systemic disease affecting normal growth.
- On the basis of ANB angle and gender, the subjects were divided into four groups:
- Group I included 20 males with skeletal class I malocclusion (ANB 0-4 degree)
- Group II included 20 females with skeletal class I malocclusion (ANB 0-4 degree).
- Group III included 20 males with skeletal class II malocclusion (ANB above 4 degree).
- Group IV included 20 females with skeletal class II malocclusion (ANB above 4 degree).

Lateral cephalograms were taken in standing position with the Frankfort Horizontal plane parallel to the floor. All the cephalograms were recorded with the same exposure parameters (KvP-80, mA-10, exposure time 0.5 sec) with the same magnification and the same machine (Kodak 8000C Digital and Panoramic System Cephalometer Rochester, NY, USA). All cephalograms were traced manually using lead acetate paper and 0.3mm tracings pencils by the same operator. Various landmarks were identified, and linear measurements were measured.

Various landmarks that were to be identified on the lateral cephalogram were:

1. **Glabella (G')**: The most prominent soft tissue point of the frontal bone.
2. **Nasion (N)**: The intersection of the frontal and nasal bones.
3. **Soft-tissue nasion (N')**: The point of greatest concavity in the mid-line between the forehead and the nose.
4. **Midnasale (Mn)**: The halfway point on nasal length (N'-Pr) that divides the dorsum into upper and lower dorsum.

5. **Pronasale (Pr)**: The tip of nose (nasal tip).
6. **Subnasale (Sn)**: The point at which the columella merges with the upper lip in the mid-sagittal plane.
7. **Alar curvature point (Ac)**: Is the most visible convex point on the nasal alar curvature.
8. **Labrale superior (Ls)**: Is the point on the border of the upper lip.
9. **Labrale Inferior (Li)**: The point indicating the border of the lower lip.
10. **Soft tissue pogonion (Pg')**: The most anterior point on the chin in the mid sagittal plane.
11. Point A
12. Point B
13. Sella (S)

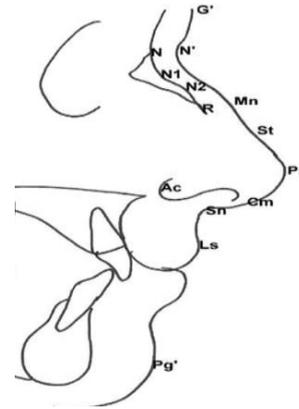


Fig 1: Various landmarks identified on lateral cephalogram.

The anteroposterior relation is assessed by measuring ANB angle.

The reference planes that are used to assess the lip position are as follows:

1. Ricketts' E-line (esthetic line): it is a line drawn from soft tissue Pogonion to the tip of the nose.
2. Steiner's S1-line: it is the line drawn from soft tissue Pogonion line to the middle of the S shaped curvature between the tip of the nose and sub-nasale.
3. Burstone's B-line: it is a line drawn from soft tissue Pogonion and soft tissue sub-nasale.
4. Sushner's S2-line: it is a line drawn from soft tissue Pogonion to soft tissue nasion.
5. Arnett's lip measurement: it is the projection of labrale superioris and labrale inferioris to TVL (line perpendicular to true horizontal through subnasale).

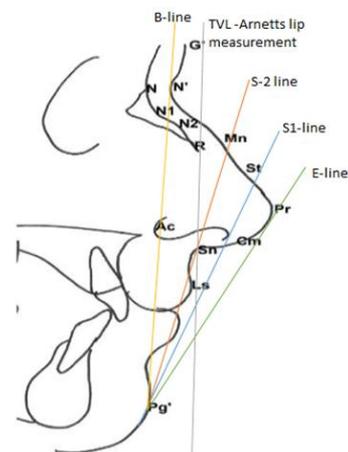


Fig 2: 5 reference lines identified on lateral cephalogram tracing (E-line, S1 line, S2 line, B-line and TVL projection for Arnett's lip measurements)

**3. Statistical analysis**

Statistical Package for Social Sciences [SPSS] for Windows Version 22.0 Released 2013. Armonk, NY: IBM Corp., was used to perform statistical analyses. The data was collected and was subjected to descriptive analysis for mean, range, standard deviation and 95% confidence interval. Based on the normality of the data, Mann Whitney test was used to compare the mean values. The level of significance will be set at  $P < 0.05$ .

**4. Results**

On comparison of upper lips between class I and class II males there was a statistically significant higher value observed in UL of class II males compared to class I males among E line ( $P = 0.039$ ), S1 Line ( $P = 0.008$ ) and S2 Line ( $P = 0.003$ ). (Table 1). On comparison of lower lips between class I and class II males there was statistically significant higher value detected in LL of class II males compared to class I males among S2 Line ( $P = 0.048$ ). (Table 2). In females, statistically significant higher values were observed in UL of class II compared to class I among E line ( $P = 0.002$ ), S1 Line ( $P = 0.007$ ), B Line ( $P = 0.004$ ) and S2 Line ( $P = 0.001$ ). (Table 3). Statistically significant higher values were observed in LL of class II females compared to class I females among Sushner's S2 line ( $P = 0.036$ ). (Table 4)

On comparison of upper and lower lips in males and females in class I and class II patterns separately no statistically significant difference was observed.

**4.1 Tables**

**Table 1:** Comparison of UL of class 1 males with class 2 males among different soft tissue parameters

	Mean Rank	Asymp. Sig. (2-tailed)
E Line	16.7	0.039*
	24.3	
S1 Line	15.6	0.008*
	25.4	
B Line	17.53	0.104
	23.48	
S2 Line	15.08	0.003*
	25.93	
Arnett's Lip Measurement	19.6	0.623
	21.4	

\*Statistical significance set at 0.05

**Table 2:** Comparison of LL of class 1 males with class 2 males among different soft tissue parameters

	Mean Rank	Asymp. Sig. (2-tailed)
E Line	17.45	0.097
	23.55	
S1 Line	17.93	0.161
	23.08	
B Line	18.63	0.307
	22.38	
S2 Line	16.85	0.048*
	24.15	
Arnett's Lip Measurement	23.93	0.063
	17.08	

\*Statistical significance set at 0.05

**Table 3:** Comparison of UL of class 1 females with class 2 females among different soft tissue parameters

	Mean Rank	Asymp. Sig. (2-tailed)
E Line	14.9	0.002*
	26.1	
S1 Line	15.55	0.007*
	25.45	
B Line	15.18	0.004*
	25.83	
S2 Line	13.4	0.001*
	27.6	
Arnett's Lip Measurement	17.78	0.137
	23.23	

\*Statistical significance set at 0.05

**Table 4:** Comparison of LL of class 1 females with class 2 females among different soft tissue parameters

	Mean Rank	Asymp. Sig. (2-tailed)
E Line	17.7	0.128
	23.3	
S1 Line	17.93	0.161
	23.08	
B Line	18.45	0.265
	22.55	
S2 Line	24.38	0.036*
	16.63	
Arnett's Lip Measurement	17.33	0.084
	23.68	

\*Statistical significance set at 0.05

**Table 5:** Descriptive Statistics among UL and LL of class 1 and Class 2 in males and females among different soft tissue parameters

Variable	Class I				Class II			
	Males		Females		Males		Females	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
<b>Ricketts' E line:</b>								
UL	-0.57	2.85	-1.7	1.43	1.37	2.22	0.5	2.7
LL	1.67	2.44	1.47	2.22	2.75	3.13	2.45	3.56
<b>Steiner's S1 line:</b>								
UL	2.275	2.17	1.75	1.23	4.1	1.52	3.35	2.24
LL	3.25	2.26	3.2	2.02	4.15	2.88	4	2.85
<b>Burstone's B line:</b>								
UL	5.65	2.26	5.1	1.07	6.725	1.80	6.45	1.73
LL	5.27	2.08	5.15	2.10	5.85	2.57	5.6	2.74
<b>Sushner's S2 line:</b>								
UL	12.05	3.18	10.62	1.79	15.12	3.75	13.8	2.65
LL	9	2.94	8.72	2.20	10.75	3.15	9.72	2.92
<b>Arnett's lip measurement:</b>								
UL	2.95	2.48	5.25	0.91	3.12	2.17	4.025	1.83
LL	0.2	2.41	1.67	1.97	1.55	3.96	0.52	3.42

## 5. Discussion

One of the most important opportunities of orthodontic treatment is to improve the esthetic and morphological harmony as well as the function of the oral and maxillofacial region<sup>[9]</sup>. In today's multicultural society, racial and ethnic differences are assuming an increasing level of importance. In the past, the majority of patients in a given practice usually were from one or two racial or ethnic groups. Currently, metropolitan areas of the world have a much more diverse patient population, bringing with it a need to recognize that a single standard of facial esthetics may not be appropriate when making diagnostic and treatment planning decisions for patients from diverse racial and ethnic backgrounds<sup>[10]</sup>.

Present study evaluated sagittal lip position using Ricketts' E line (esthetic line), Steiner's S1 line, Burstone's B line, Sushner's S2 line, and Arnett's lip measurement. Significant difference was seen in the upper and lower lips when the comparison was made between class I and class II malocclusion in males and females separately. The lips are significantly retro positioned in class I malocclusion than in class II malocclusion both in males and females. Retrusive positioning of upper and lower lip in class I malocclusion can be explained by the fact that position of lips depends upon underlying hard tissues. In class I malocclusion maxilla is normal but in class II malocclusion maxilla is protrusive or mandible is retrusive. So in class II malocclusion lips are forwardly placed as compared to those in class I malocclusion. In the present study Ricketts' E line, Steiner's S1 line, Sushner's S2 line showed statistically significant results between class I and class II males and females. It implies upper and lower lips are more retrusive in class I pattern as compared to class II.

The only variation was that Arnett's lip measurement showed a statistically significant result in females in class I compared to class II females with respect to lower lip. The other variables showed no statistical significance. This might be due to poor soft tissue compensation in retruded mandibles in females.

McNamara *et al.*<sup>[11]</sup> evaluated the position of the lips with the soft tissue analysis of Steiner, Holdaway's and Ricketts' on Caucasians having Class I occlusion and acceptable facial aesthetics. They reported that the position of the lower lip in females was significantly more protruded than it was in males. Similarly, Erbay *et al.*<sup>[12]</sup> concluded that the upper and lower lips were retruded according to the norms of Steiner and Ricketts. Both the upper and lower lip values were within the normal range according to Burstone's B line. However, in the present study Ricketts' E line, Steiner's S1 line, Burstone B line, Sushner's S2 line and Arnett lip measurements did not show any statistically significant difference. But the measured values were greater in males when compared to females in class I individuals. Hence males show protrusive lips when compared to females in skeletally normal individuals.

In class I individuals the Ricketts' E line values were much more than norm (as calculated by Ricketts) showing that horizontal lip position is more protrusive in south Indian population, which comprised the study subjects. Similarly, the values evaluated for Steiner's S1 line Sushner's S2 line, Burstone's B line and Arnett's lip measurements were more when compared to the norms given by these authors implying that lips were protrusive in South Indian population irrespective of skeletal pattern. The reason for this variation might be smaller nasal prominence and less prominent chin.

Many authors have reported that the normative values for a certain population differ from another<sup>[13, 14, 15]</sup>. Ethnic and

racial differences have been reported in evaluating the horizontal position of the lips in relation to the chin and the nose. Thus, nasal prominence, chin prominence along with rotation of the chin may affect horizontal lip position and should be considered during orthodontic treatment planning. Many photographic, photogrammetric and CBCT studies<sup>[17, 18, 19]</sup> have also been done to get better insight into the variations in soft tissue covering orofacial region in general and lip position in particular.

## 6. Conclusion

1. The horizontal lip position in class II males and females is protrusive when compared to class I subjects. Since soft tissue contour follows the underlying skeletal tissues, protrusive maxilla in class II might be the contributing factor to such horizontal lip position.
2. The sex differences were not statistically significant between female and male subjects' horizontal lip position.
3. Even though the differences were not statistically significant, the upper and lower lip in skeletal class I subjects was noticeably more protrusive than it was in the normal subjects (Caucasian norms) in relation to the Steiner's S1 line, Ricketts' E line, Burstone's B line, Sushner's S2 line, and Arnett's lip measurement.

Since each population has specific nose and chin characteristics according to their race and ethnicity, it would be useful to evaluate nose, chin and lip characteristics separately and establish a relationship between them. Orthodontist should establish norms according to patient population and plan the treatment accordingly. This will help achieve the best esthetic soft tissue profile of the patient.

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