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Perioral soft tissue evaluation of different skeletal malocclusions

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ABSTRACT: The aim of the study was to evaluate perioral soft tissue characteristics in skeletal class I, class II division I and class III malocclusions and also to evaluate the soft tissue characteristics of class II division 1 subjects with different growth patterns **Methods:** The study comprised of 105 pre- treatment lateral cephalograms divided into 3 groups belonging to class I, II division 1 and class III as: Group I (n = 30), Group II (n = 45) and Group III (n = 30). Group II was further divided into three categories as low, normal and high angle growth patterns respectively based on the SN-MP angle (SN-MP < 27o, SN-MP 27o ≤ 36o and SN-MP > 36o). Inter class comparison of skeletal, dental and soft tissue measurements were done using 1-way ANOVA and pairwise comparison was done using the Tukey's Post Hoc test as a second step. **Results:** The class III subjects showed greater basic upper lip thickness and upper lip thickness values than did class I and class II subjects and a statistically significant difference in the basic upper lip thickness was seen between class II and III (p
= 0.002). In case of upper lip thickness, the value was significantly greater in class III compared with class I and II at p = 0.01 and p = 0.006 respectively. Group II high angle subjects showed an increased upper lip strain when compared to low and normal angle groups. Complex correlations were found among the studied variables that varied between weak to high positive or negative with varying degree of significance. **Conclusion:** Clinicians need to evaluate lip strain and lip thickness based on the skeletal pattern as well as dental inclination to obtain balance in the perioral muscle activity.

I. INTRODUCTION

The changes in approach to orthodontic diagnosis have been gradual but steady over the decades. Today's culture has an increased awareness and concern regarding facial esthetics. The shift from diagnosis based entirely on hard tissues to soft tissue based evaluations has been a result of a broadened recognition of facial appearance by our patients, and thus by the orthodontic speciality.[1]

Final facial contours are determined by the soft tissues, and these can be altered by growth and orthodontic treatment. Facial esthetics are remarkably influenced by soft-tissue characteristics.[2] Measuring the soft tissue profile establishes the ideal size and proportions of the nose and positions of the lips and chin, helping to quantify individual facial characteristics and norms. When measurements of facial features are outside the norm, there is often a decrease in facial attractiveness. The covering facial soft tissues (muscles, fat, and skin) can develop in proportion or disproportion to the corresponding skeletal structures. Variations in thickness, length, and tonicity of the soft tissues may affect the position of and the relationships among the facial structures thereby affecting facial esthetics. Such variations between skeletal and soft tissues can cause dissociation between the position of the underlying bony structures and the facial appearance.[3] Any assessment of teeth and skeletal structures should be followed by an evaluation of the configuration, relative position, and growth potential of the soft tissues of the nose, lips, and chin.[2]

Most of the studies that evaluated the soft tissue thicknesses have been carried out with subjects with normal skeletal patterns. However, because differences in the growth pattern could result in diverse demonstrations in soft tissue facial profiles, it should be considered when planning the treatment as well.[3,4] Soft tissue profiles can be influenced not only by skeletal pattern but also by dental position and degree of inclination of the teeth, and therefore dental characteristics are also taken into account in this study.[5]

The aims of this study were to determine and compare the characteristics of perioral soft tissues in adults with different skeletal malocclusions and to evaluate correlative skeletal and dental variables affecting soft tissue thickness using cephalometric analysis.

II. MATERIALS AND METHODS

In the present study, 105 pre-treatment lateral cephalograms of skeletal class I (Group I; n= 30), class II division 1 (Group II; n = 45) and class III (Group III; n = 30) patients requiring

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orthodontic treatment were selected from the archives of the Department of Orthodontics, Krishnadevaraya College of Dental Sciences and Hospital, Bangalore. The class II division 1 subjects were further sub-divided according to growth patterns based on sella-nasion to mandibular plane angle (SN-MP): A. Low angle (group II-L): SN-MP < 27° B. Normal angle (group II-N): SN-MP 27° ≤ 36° and C. High angle (group II-H): SN-MP > 36°. The average age of the subjects ranged from 16-30 years. The inclusion criteria for group I were skeletal class I (0° < ANB < 4°), natural dentition, no alteration of facial morphology, and class 1 canine and molar relationships with normal overjet and overbite with or without mild crowding. The inclusion criteria for group II were skeletal Class II Division 1 skeletal class II division 1 (ANB angle > 4°), wits appraisal > 0 mm, maxillary central incisor to SN > 95° and class II canine and molar relationship with or without mild crowding. Patients with large overjet exceeding 10mm and anterior open bite were excluded from group II. The inclusion criteria for group III were skeletal class III (ANB angle < 0°), wits appraisal < 0 mm; and class III canine and molar relationship with or without mild crowding. Patients with previous orthodontic treatment or orthognathic surgery, or craniofacial anomaly, poor quality pre-treatment radiographs and missing teeth except for the third molars were excluded from the study.

The radiographs were taken using Sirona Dental System ORTHOPHOS XG 5DS cephalometric machine (exposure time 9.4 sec, 73-84 kVp voltage, 15 mA current). All the radiographs were traced manually.

The following skeletal and dental measurement were identified: SNA, SNB, ANB, Wits appraisal (AO-BO), SN-MP, FMA, facial length (S-Gn), facial depth (N-Go), facial height ratio (S-Go/N-Me), U1 to SN, U1 to NA (in millimeters and degrees), L1 to NB (in millimeters and degrees), IMPA, interincisal angle, maxillary incisor exposure, overjet, and overbite. The soft tissue measurements are summarized in Figure 1.

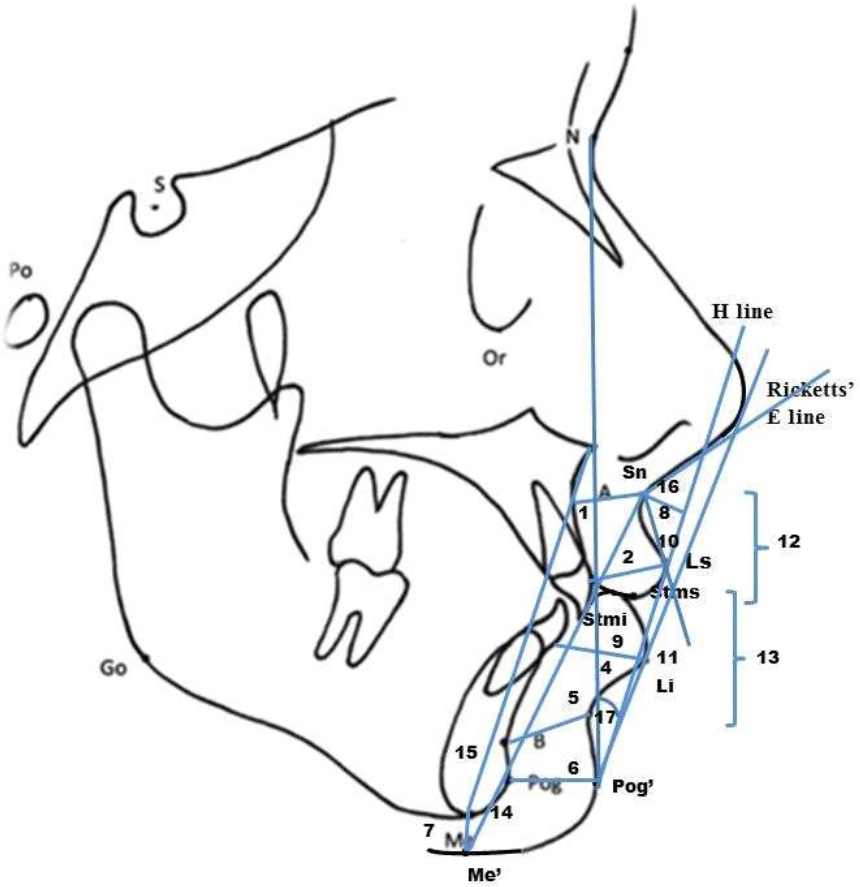

Figure 1: Soft tissue measurements

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Soft tissue landmarks and definitions of measurement for cephalometric analysis.

- Basic upper lip thickness: linear distance from 3 mm below A-point to subnasale; 2. Upper lip thickness: Linear distance from the most prominent labial point of the maxillary incisor (U1) to labrale superius (Ls); 3. Upper lip strain: The difference between basic upper lip thickness and upper lip thickness; 4. Lower lip thickness: linear distance from the most prominent labial point of the mandibular incisor (L1) to labrale inferius (Li); 5. Basic lower lip thickness: Linear distance from B-point to the deepest point of the labiomental fold; 6. Chin thickness-H: Linear distance from pogonion to its sagittal projection on the soft tissue (Pog-Pog′); 7. Chin thickness- V: Linear distance from menton to its vertical projection on the soft tissue (Me-Me′); 8. Subnasale to H-line; 9. Lower lip to H line; 10. Ricketts' E-line to upper lip; 11. Ricketts' E-line to lower lip; 12. Upper lip length, vertical distance from subnasale to the lowest point of the upper lip (Stms) perpendicular to the Frankfort horizontal plane (FH plane); 13. Lower lip length, vertical distance from the highest point of the lower lip (Stmi) to the soft tissue B-point perpendicular to the FH plane; 14. Soft tissue contour, total length of lower facial profile (subnasale-Me′); 15. Hard tissue contour, total length of hard tissue contour (anterior nasal spine- Me), and contour ratio was a percentage ratio of soft tissue contour to hard tissue contour; 16. Nasolabial angle; 17. H-angle, angle formed by H-line and soft tissue nasion-Pog' line.

Statistical analysis

The mean and the standard deviation for each cephalometric variable were determined. The comparisons among the groups (groups I, II-L, II-N, II-H and III) were performed using 1- way analysis of variance. The Tukey's post hoc test was used to analyze the differences between the groups. In addition to these tests, the Pearson correlation test was used to determine the skeletal and dental variables affecting soft tissue characteristics. In all the above tests the "p" value of less than 0.05 was accepted as indicating statistical significance. Data analysis was carried out using Statistical Package for Social Science (SPSS ver 10.5) package.

III. RESULTS

When the skeletal measurements were compared between the groups, facial length (S- Gn) and facial height ratio (S-Go/N-Me) values were greater in group III than in the other two groups (Table I). The comparison of the dental measurements showed that U1-SN, U1-NA (angular and linear) and interincisal angle values were greater in group III than in groups I and II. However, L1-NB (angular and linear), IMPA, overjet and overbite showed increased values in group II when compared with the other two groups.

For the soft tissue analysis of the subjects, the results showed that basic upper lip thickness, upper lip thickness, lower lip-H line and lower lip length values were greater in group III than in groups I and II. On the other hand, subnasale-H line, Ricketts' E line-Upper lip, nasolabial angle and H-angle showed increased values in group II compared with the other two groups. However, upper lip strain value was found to be the greatest in group I (Table II).

When comparisons were done between the three subgroups of group II, basic upper lip thickness, upper lip thickness and lower lip thickness values were found to be greater in low angle group than in normal and high angle groups. On the other hand, upper lip strain, lower lip- H Line, Ricketts' E Line-Lower lip and hard tissue contour showed greater values in high angle group than in low and normal angle groups (Table IV).

Complex correlations among the studied variables were found that varied between weak to high positive or negative with varying degrees of significance. The results showed that out of the 9 skeletal variables basic upper lip thickness showed a significant positive correlation only with facial length (S-Gn) and facial depth (N-Go). In addition, chin thickness-H, upper lip length and lower lip length were also found to show a positive correlation only with facial length (S- Gn) and facial depth (N-Go). Basic lower lip thickness showed positive correlation with AO-BO also besides facial length (S-Gn) and facial depth (N-Go). In case of dental variables, basic lower lip thickness showed positive correlation only with L1-NB (linear). Nasolabial angle and contour ratio showed correlation only with dental variables. Upper lip strain showed significantly positive correlation with U1-NA (linear) and negative correlation with interincisal angle among dental variables. On the other hand, upper lip strain showed positive correlation with SN-MP and FMA while it showed negative correlation with SNB, N-Go and S-Go/N-Me among skeletal variables (Tables V, VI).

IV. DISCUSSION

For centuries, facial esthetics has been a subject of interest to people of all cultures. As far as orthodontics is concerned, harmonious facial esthetics and functional occlusion have long been recognized as the 2 most important goals of orthodontic treatment.[6] Peck et al.[7] mentioned that the soft tissues more closely determine therapeutic modifiability. 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.[8] Thus, soft tissue analysis is a critical part in orthodontic decision making, and this can be accomplished by recognizing the differences in the soft tissue thickness in each skeletal classification.

Cephalometric norms for different ethnic and racial groups have been established previously in many studies. Most investigators have concluded that there are significant differences among these groups, and many cephalometric standards have been developed for the different groups. These studies indicate that normal measurements for one group should not be considered normal for every other race or ethnic group. Therefore, it is important to develop individual standards for each population. Different racial groups must be treated according to their own characteristics.[9]

Previous studies have shown that the sagittal facial pattern is composed of vectors at the vertical and sagittal planes, and the final vector of position of the chin is a result of the competition between them; thus, clinicians often consider the relevance of the inclination of the mandibular plane. According to Schudy[10] and Isaacson et al.,[11] the degree of inclination of the mandible to the cranial base (SN-MP) has an effect on mandibular rotation. The larger the SN- MP angle, the more the mandible tends to become steeper and the more the chin moves backward, and vice versa. Therefore, we assumed that the characteristics of soft tissue measurements would be variable even in the same skeletal class if accompanied by a different vertical pattern.

In a previous study by Kamak and Celikoglu,[9] upper lip thickness was found to be greatest in skeletal Class III for both sexes of Turkish malocclusion subjects. In the present study, the upper lip thickness was found to be significantly greater in class III subjects compared with class I and II, corroborating the previous results. A previous study done by Utsuno et al.[12] in Japanese subjects revealed significant differences at two points in the upper lip region when comparison was done between the three groups. Significantly thicker soft tissue at points (Sn) and (Ls) were measured in class III because the mental region of the mandible is positioned anterior to the maxilla (overgrowth of the mandible or reduced growth of the maxilla) in this class. Pithon et al.[13] also reported that there is no difference in soft tissue thickness among the skeletal class I, II and III except between Class II and III for the anthropological points: stomion, bottom lip and Pogonion.

Previous studies[14,15] reported that skeletal Class II Division 1 and Class III subjects have shorter upper lip lengths than do skeletal Class I subjects, but we found no significant difference in upper lip length between the groups in this study. The same study also reported that Class III subjects possessed non-significant higher values of lower lip length followed by Class II then Class I. However, in the present study, the lower lip length was significantly greater in group III followed by groups I and II. This result agreed with Rakosi[16] who mentioned that the lower lip in Class III subjects is longer than that of Class I subjects. Arnett and Bergman[17] also mentioned that increased lower one–third height, and subsequently lower lip, are frequently found with vertical maxillary excess and Class III malocclusions (lack of interdigitation opens vertical height). Decreased lower one–third height is associated with vertical maxillary deficiency and mandibular retrusion with deep bites. Furthermore, anatomic short lower lip is sometimes associated with Class II malocclusion.

In our study, subnasale-H Line, Ricketts' E Line-Upper lip and H angle were found to be increased in class II compared with the other two groups. This may be due to the presence of retrognathic mandible in class II subjects as evident from the statistically significant lower value of SNB when compared to the other groups. The results of our study confirm Holdaway's statement that the ANB angle is the main guiding variable in an evaluation of the magnitude of the H angle.[18] He also added that in cases with high convexity and severely retrognathic pattern, success in uprighting lower incisor depended upon the ability to retract point A, which will bring about a balanced profile of the subject. Among the class II subgroups, the value was found to be highest in the high angle group which agrees with the above finding.

In high angle cases with backward rotation of the mandible, it might be speculated that the lips become vertically less compressed during bite opening and stretch to compensate for the vertical changes. This is an important finding for clinicians treating patients with deep bite, where significant bite opening is expected. In

the present study, class II high angle subgroup had an increased upper lip strain than did normal and low angle groups which coincided with the above findings.

Previous study by Blanchette et al.[19] reported that the growth curves for the upper lip to the esthetic plane revealed that the boys and girls with long vertical patterns exhibited more protrusive lips at all age intervals. The results of our study showed that lower lip-H line and Ricketts' E line-Lower lip values were the greatest in the high angle group and this coincided with the above finding. According to Blanchette et al., this may have been a natural effort to compensate for the shorter mandibular corpus length to mask the condition and to provide a more normal facial appearance.

In the present study, upper lip thickness and lower lip thickness were found to be significantly greater in the low angle group when compared with high angle group. According to Macari and Hanna,[20] the thickness values at the gnathion and menton were thinner in the high-angle group when both genders were combined. Celikoglu et al.,[21] reported that the soft tissue thickness values were thinnest in the high angle group for both women and men.

Jakobsone et al.[22] reported different correlation coefficients between soft and hard tissue landmarks and suggested that these differences may be due to different characteristics of the soft tissue. The correlation analysis in the present study was carried out among all the variables for all the subjects in Class II division 1. Some of them showed a positive correlation, while others show a negative one. The "r" value was described as significant at $P < 0.05$. Complex correlations were found among the studied variables that varied between weak to high positive or negative with varying degrees of significance. Among the skeletal variables, soft tissue measurements showed high correlation with facial length (S-Gn) and facial depth (N-Go). Basic lower lip thickness showed positive correlation only with L1-NB (linear) and upper lip strain showed significantly positive correlation with U1-NA (linear) and negative correlation with interincisal angle among dental variables. It could be suggested that the measurements of perioral soft tissue thickness of skeletal Class II Division 1 patients are affected generally by the various dental variables in this study as forementioned. Among the skeletal variables, facial depth and facial length were correlated with the sagittal and vertical measurements of the perioral soft tissues. Facial depth and facial length behave similarly in terms of longitudinal development of the face and dentition. Since the vertical measurements would be directly proportional to the development of the face i.e., face length and depth, it could be suggested that not only the vertical measurements, but also the sagittal measurements of perioral soft tissue thicknesses werepositively correlated.[23]

In this study, the sample size was too small. Therefore, further comparative studies with larger samples and additional skeletal classifications such as Class II Division 2 could be conducted to increase the scientific and statistical power. A further analysis on the changes of perioral soft tissue measurements after orthodontic treatment should be considered as well. Soft tissue thickness has also been studied in different races. For example, the soft tissue thickness of African Americans has been reported to be quite different from that of white Americans.[24,25] Another study suggested that the soft-tissue thickness in Saudi Arabians also differs from that of white people.[26] Therefore, the thickness characteristic of this study is limited to Indians, and future research should consider racial differences when validating our results. Further comparisons could be done separately for women and men to eliminate the effect of gender on findings.

V. CONCLUSION:

- The class III subjects showed greater basic upper lip thickness and upper lip thickness values than did class I and class II subjects. There was a statistically significant difference in the basic upper lip thickness between class II and III ($p = 0.002$). In case of upper lip thickness, the value was found to be significantly greater in class III compared with class I and II at $p = 0.01$ and $p = 0.006$ respectively.
- The lower lip length was significantly greater in class III followed by class I and II ($p = 0.01$ and $p < 0.001$ respectively).
- In class II subjects, basic upper lip thickness, upper lip thickness and lower lip thickness values were found to be greater in low angle group than in normal and high angle groups.
- Class II high angle subjects showed an increased upper lip strain when compared to low and normal angle groups. However, a statistically significant difference was seen between high angle and normal angle groups only.
- Complex correlations were found among the studied variables that varied between weak to high positive or negative with varying degree of significance. Among the skeletal variables,

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soft tissue measurements showed high correlation with facial length (S-Gn) and facial depth (N-Go).

Table I. Skeletal and dental measurements (means and standard deviations) for all subjects.

SKELETAL MEASUREMENTS	GROUP I	GROUP II	GROUP III	SIGNIFICANCE I/II	II/III	I/III
SN-MP	29.73±5.74	30.42±8.21	25.60±6.52	NS	*	NS
SNA	81.07±3.08	83.27±4.86	82.03±5.12	NS	NS	NS
SNB	79.30±3.15	76.91±4.46	85.67±4.46	*	*	*
ANB	1.80±1.00	6.36±2.13	-3.63±2.77	*	*	*
FMA	27.63±5.79	28.09±7.46	22.77±6.57	NS	*	*
AO-BO	-1.02±1.45	3.38±1.81	-7.73±4.11	*	*	*
S-Gn	122.47±8.35	118.51±9.30	129.50±11.79	NS	*	*
N-Go	113.90±9.36	115.07±8.82	114.10±10.16	NS	NS	NS
S-Go/N-Me	65.61±4.49	65.97±6.05	68.91±5.00	NS	NS	*
DENTAL MEASUREMENTS						
U1-SN	118.40±7.49	114.58±9.28	123.03±8.26	NS	*	NS
U1-NA(angular)	35.80±7.41	29.87±8.39	39.57±7.84	*	*	NS
L1-NB (angular)	30.93±6.00	34.47±8.14	26.77±7.53	NS	*	NS
Interincisal angle	110.33±8.93	108.69±13.48	116.30±11.19	NS	*	NS
IMPA	97.67±8.08	103.16±7.85	92.20±8.85	*	*	*
U1-NA (linear)	9.20±2.48	6.29±2.95	9.67±3.72	*	*	NS
L1-NB (linear)	6.60±2.16	8.20±3.58	5.10±3.06	NS	*	NS
U1 Exposure	5.07±1.89	4.93±2.44	2.83±2.49	NS	*	*
Overjet	3.63±1.97	5.58±2.32	-0.03±2.28	*	*	*
Overbite	2.23±1.96	3.13±2.05	1.27±1.95	NS	*	NS

*p<0.05 statistically significant, p>0.05 Non Significant, NS

Table II. Soft tissue measurements (means and standard deviations) for all subjects.

SOFT TISSUE MEASUREMENTS	GROUP I	GROUP II	GROUP III	SIGNIFICANCE I/II	II/III	I/III
Basic upper lip thickness	15.90±2.23	14.29±1.98	16.20±2.67	*	*	NS
Upper lip thickness	12.03±2.08	12.11±2.17	13.90±3.03	NS	*	*
Upper lip strain	3.87±1.74	2.18±1.40	2.30±1.75	*	NS	*
Lower lip thickness	14.80±1.96	15.00±2.21	14.40±1.99	NS	NS	NS
Basic lower lip thickness	11.00±1.66	11.16±2.22	11.90±2.60	NS	NS	NS
Chin thickness-H	11.50±1.82	11.42±2.45	12.10±2.51	NS	NS	NS
Chin thickness-V	6.43±1.57	6.76±2.22	7.23±1.78	NS	NS	NS
Subnasale-H Line	7.70±2.40	8.44±2.04	5.60±2.70	NS	*	*

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Lower lip-H Line	2.93±2.08	1.87±2.60	3.20±2.38	NS	NS	NS
Ricketts' E Line-Upper lip	-1.57±2.25	0.04±2.54	-4.63±2.53	*	*	*
Ricketts' E Line-Lower lip	2.07±2.60	1.58±3.35	0.70±3.09	NS	NS	NS
Upper lip length	20.17±2.56	19.53±2.06	19.60±3.48	NS	NS	NS
Lower lip length	16.10±2.77	14.76±2.01	18.57±4.83	NS	*	*
Soft tissue contour	73.50±6.76	71.16±5.89	70.70±7.46	NS	NS	NS
Hard tissue contour	67.80±6.52	65.82±6.35	66.50±7.79	NS	NS	NS
Contour ratio	108.48±3.37	108.32±4.44	106.52±3.92	NS	NS	NS
Nasolabial angle	89.53±13.85	95.91±9.88	85.03±16.04	NS	*	NS
H-angle	17.30±3.62	21.69±4.49	11.23±3.66	*	*	*

*p<0.05 statistically significant, p>0.05 Non Significant, NS

Table III. Skeletal and dental measurements (means and standard deviations) for Group IIsubjects.

SKELETAL MEASUREMENTS	**GROUP II-L**	**GROUP II-N**	**GROUP II-H**	**SIGNIFICANCE**		
				L/N	**L/H**	**N/H**
SN-MP	20.87±4.16	31.07±2.25	39.33±2.47	*	*	*
SNA	85.53±4.16	83.33±5.37	80.93±4.11	NS	*	NS
SNB	80.13±3.98	76.87±3.48	73.73±3.54	*	*	NS
ANB	5.40±1.30	6.47±2.53	7.20±2.11	NS	NS	NS
FMA	21.20±4.36	27.53±3.91	35.53±5.48	*	*	*
AO-BO	3.53±2.07	3.13±1.55	3.47±1.88	NS	NS	NS
S-Gn	121.53±9.78	118.20±9.14	115.80±8.65	NS	NS	NS
N-Go	119.93±7.90	114.07±6.93	111.20±9.56	NS	*	NS
S-Go/N-Me	72.61±4.08	65.28±2.97	60.03±1.98	*	*	*
DENTAL MEASUREMENTS						
U1-SN	121.40±10.32	111.53±8.14	110.80±4.77	*	*	NS
U1-NA(angular)	33.40±10.44	27.33±8.27	28.87±4.76	NS	NS	NS
L1-NB (angular)	32.00±8.91	33.60±9.23	37.80±4.95	NS	NS	NS
Interincisal angle	108.47±18.01	112.27±13.71	105.33±5.73	NS	NS	NS
IMPA	106.60±8.70	102.07±8.29	100.80±5.43	NS	NS	NS
U1-NA (linear)	7.20±3.28	5.20±3.45	6.47±1.60	NS	NS	NS
L1-NB (linear)	6.47±3.42	8.27±4.33	9.87±1.89	NS	*	NS
U1 Exposure	3.13±2.30	6.07±2.28	5.60±1.68	*	*	NS
Overjet	6.67±2.09	4.73±1.71	5.33±2.74	NS	NS	NS
Overbite	4.20±1.90	3.40±1.64	1.80±1.94	NS	*	NS

*p<0.05 statistically significant, p>0.05 Non Significant, NS

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Table IV. Soft tissue measurements (means and standard deviations) for Group II subjects.

SOFT TISSUE MEASUREMENTS	GROUP II-L	GROUP II-N	GROUP II-H	SIGNIFICANCE L/N	L/H	N/H
Basic upper lip thickness	15.33±2.13	13.67±1.80	13.87±1.69	NS	NS	NS
Upper lip thickness	13.47±2.45	11.93±1.71	10.93±1.53	NS	*	NS
Upper lip strain	1.87±1.19	1.73±1.62	2.93±1.10	NS	NS	*
Lower lip thickness	16.47±2.23	14.27±1.58	14.27±2.09	*	*	NS
Basic lower lip thickness	10.80±1.94	11.67±2.50	11.00±2.24	NS	NS	NS
Chin thickness-H	11.80±2.27	10.53±2.20	11.93±2.74	NS	NS	NS
Chin thickness-V	7.67±2.44	6.13±2.00	6.47±2.03	NS	NS	NS
Subnasale-H Line	8.33±2.23	8.07±2.40	8.93±1.39	NS	NS	NS
Lower lip-H Line	0.27±2.40	2.00±2.54	3.33±1.99	NS	*	NS
Ricketts' E Line-Upper lip	-0.27±2.28	-0.33±3.20	0.73±2.02	NS	NS	NS
Ricketts' E Line-Lower lip	0.00±3.19	1.33±3.66	3.40±2.32	NS	*	NS
Upper lip length	19.60±2.29	19.07±1.87	19.93±2.05	NS	NS	NS
Lower lip length	14.33±1.99	14.87±1.46	15.07±2.52	NS	NS	NS
Soft tissue contour	69.00±6.39	70.60±6.00	73.87±4.37	NS	NS	NS
Hard tissue contour	63.00±7.11	65.60±5.97	68.87±4.70	NS	*	NS
Contour ratio	109.85±4.85	107.75±4.46	107.38±3.83	NS	NS	NS
Nasolabial angle	97.20±11.00	93.73±9.49	96.80±9.38	NS	NS	NS
H-angle	21.67±3.70	21.13±5.98	22.27±3.63	NS	NS	NS

*p<0.05 statistically significant, p>0.05 Non Significant, NS

Table V. Correlation between soft tissue and skeletal variables

		SN-MP	SNA	SNB	ANB	FMA	AO-BO	S-Gn	N-Go	S-Go/N-Me
Basic upper lip thickness	r	-0.28	-0.17	-0.05	-0.29	-0.11	0.20	0.33	0.45	0.26
	p-value	0.06(NS)	0.26(NS)	0.74(NS)	0.06(NS)	0.49(NS)	0.18(NS)	0.03*	0.002*	0.09(NS)
Upper lip thickness	r	-0.52	-0.02	0.16	-0.37	-0.32	0.22	0.47	0.65	0.48
	p-value	<0.001*	0.90(NS)	0.31(NS)	0.01*	0.03*	0.15(NS)	0.001*	<0.001*	0.001*
Upper lip strain	r	0.41	-0.21	-0.31	0.17	0.34	-0.05	-0.26	-0.36	-0.38
	p-value	0.006*	0.16(NS)	0.04*	0.27(NS)	0.02*	0.73(NS)	0.09(NS)	0.02*	0.01*
Lower lip thickness	r	-0.40	0.08	0.16	-0.16	-0.31	0.26	0.47	0.55	0.40
	p-value	0.007*	0.61(NS)	0.28(NS)	0.28(NS)	0.04*	0.09(NS)	0.001*	<0.001*	0.007*
Basic	r	0.02	0.12	0.16	-0.07	0.08	0.33	0.57	0.36	0.02

lower lip thickness	p-value	0.92(NS)	0.45(NS)	0.30(NS)	0.67(NS)	0.61(NS)	0.03*	<0.001*	0.02*	0.91(NS)
Chin thickness-H	r	-0.01	-0.02	-0.03	0.02	0.13	0.26	0.39	0.37	0.05
	p-value	0.95(NS)	0.89(NS)	0.82(NS)	0.88(NS)	0.40(NS)	0.08(NS)	0.008*	0.01*	0.77(NS)
Chin thickness-V	r	-0.29	-0.07	0.04	-0.24	-0.23	-0.01	0.26	0.38	0.29
	p-value	0.06(NS)	0.63(NS)	0.82(NS)	0.11(NS)	0.12(NS)	0.95(NS)	0.09(NS)	0.009*	0.05(NS)
Subnasale-H Liine	r	0.18	0.21	0.02	0.44	0.26	0.39	0.26	0.14	-0.19
	p-value	0.25(NS)	0.16(NS)	0.89(NS)	0.003*	0.08(NS)	0.008*	0.08(NS)	0.38(NS)	0.22(NS)
Lower lip-H Line	r	0.58	0.10	-0.14	0.52	0.51	0.11	-0.09	-0.37	-0.57
	p-value	<0.001*	0.51(NS)	0.37(NS)	<0.001*	<0.001*	0.46(NS)	0.57(NS)	0.01*	<0.001*
Ricketts' E Line-Upperlip	r	0.27	0.25	-0.03	0.63	0.30	0.28	-0.07	-0.23	-0.31
	p-value	0.08(NS)	0.10(NS)	0.83(NS)	<0.001*	0.04*	0.07(NS)	0.66(NS)	0.13(NS)	0.04*
Ricketts' E Line-Lowerlip	r	0.51	0.14	-0.13	0.59	0.46	0.16	-0.12	-0.35	-0.53
	p-value	<0.001*	0.36(NS)	0.39(NS)	<0.001*	0.001*	0.29(NS)	0.45(NS)	0.02*	<0.001*
Upper lip length	r	0.14	0.03	-0.03	0.13	0.18	0.20	0.43	0.30	-0.09
	p-value	0.37(NS)	0.86(NS)	0.84(NS)	0.41(NS)	0.25(NS)	0.19(NS)	0.004*	0.04*	0.54(NS)
Lower lip length	r	0.13	-0.06	0.00	-0.13	0.07	0.24	0.52	0.36	-0.08
	p-value	0.39(NS)	0.69(NS)	0.99(NS)	0.39(NS)	0.64(NS)	0.11(NS)	<0.001*	0.02*	0.61(NS)
Soft tissue contour	r	0.36	-0.06	-0.16	0.21	0.42	0.41	0.60	0.42	-0.29
	p-value	0.02*	0.72(NS)	0.30(NS)	0.18(NS)	0.005*	0.006*	<0.001*	0.004*	0.05(NS)
Hard tissue contour	r	0.41	-0.05	-0.15	0.20	0.46	0.40	0.59	0.39	-0.33
	p-value	0.005*	0.75(NS)	0.32(NS)	0.18(NS)	0.002*	0.007*	<0.001*	0.008*	0.03*
Contour ratio	r	-0.27	0.02	0.06	-0.08	-0.27	-0.12	-0.20	-0.08	0.21
	p-value	0.07(NS)	0.90(NS)	0.70(NS)	0.61(NS)	0.08(NS)	0.44(NS)	0.18(NS)	0.60(NS)	0.17(NS)
Nasolabial angle	r	0.02	-0.02	-0.11	0.17	0.06	-0.03	-0.26	-0.25	-0.06
	p-value	0.92(NS)	0.89(NS)	0.49(NS)	0.27(NS)	0.69(NS)	0.83(NS)	0.09(NS)	0.10(NS)	0.69(NS)
H-angle	r	0.15	0.28	-0.02	0.68	0.18	0.29	-0.15	-0.22	-0.20
	p-value	0.34(NS)	0.06(NS)	0.92(NS)	<0.001*	0.24(NS)	0.05(NS)	0.33(NS)	0.15(NS)	0.19(NS)

Pearsons correlation test
*p<0.05 statistically significant, p>0.05 Non Significant, NS

Table VI. Correlation between soft tissue and dental variables

		U1-SN	U1-NA (angular)	L1-NB (angular)	Interincisal angle	IMPA	U1-NA (linear)	L1-NB (linear)	U1 Exposure	Overjet	Overbite
Basic upper lip thickness	r	0.09	0.13	-0.31	0.15	-0.17	0.13	-0.28	-0.33	0.26	0.24
	p-value	0.58(NS)	0.40(NS)	0.04*	0.33(NS)	0.27(NS)	0.38(NS)	0.07(NS)	0.03*	0.08(NS)	0.11(NS)
Upper lip	r	0.07	-0.02	-0.47	0.36	-0.14	-0.07	-0.42	-0.23	0.16	0.39

thickness	p-value	0.67(NS)	0.89(NS)	0.001*	0.02*	0.37(NS)	0.64(NS)	0.004*	0.13(NS)	0.28(NS)	0.008*
Upper lip strain	r	0.02	0.21	0.29	-0.34	-0.03	0.30	0.26	-0.11	0.12	-0.26
	p-value	0.90(NS)	0.16(NS)	0.05(NS)	0.02*	0.87(NS)	0.04*	0.09(NS)	0.47(NS)	0.43(NS)	0.08(NS)
Lower lip thickness	r	0.13	0.03	-0.15	0.10	0.08	0.09	-0.15	-0.28	0.23	0.39
	p-value	0.41(NS)	0.85(NS)	0.33(NS)	0.54(NS)	0.60(NS)	0.57(NS)	0.32(NS)	0.06(NS)	0.13(NS)	0.008*
Basic lower lip thickness	r	0.09	0.06	0.04	-0.05	-0.09	0.17	0.30	0.27	-0.14	-0.17
	p-value	0.54(NS)	0.71(NS)	0.81(NS)	0.76(NS)	0.56(NS)	0.26(NS)	0.04*	0.07(NS)	0.37(NS)	0.28(NS)
Chin thickness-H	r	-0.05	-0.06	-0.02	0.06	-0.07	0.04	0.04	-0.06	0.18	0.01
	p-value	0.76(NS)	0.72(NS)	0.88(NS)	0.72(NS)	0.67(NS)	0.81(NS)	0.78(NS)	0.70(NS)	0.25(NS)	0.94(NS)
Chin thickness-V	r	-0.09	-0.08	-0.21	0.22	0.02	-0.10	-0.33	-0.39	0.12	0.18
	p-value	0.57(NS)	0.61(NS)	0.16(NS)	0.14(NS)	0.91(NS)	0.51(NS)	0.03*	0.008*	0.45(NS)	0.23(NS)
Subnasale-H Liine	r	0.06	0.00	0.57	-0.45	0.39	0.24	0.61	0.29	0.19	-0.06
	p-value	0.69(NS)	0.98(NS)	<0.001*	0.002*	0.007*	0.12(NS)	<0.001*	0.05*	0.23(NS)	0.71(NS)
Lower lip-H Line	r	-0.11	-0.09	0.65	-0.44	0.19	0.12	0.75	0.40	-0.25	-0.39
	p-value	0.47(NS)	0.58(NS)	<0.001*	0.003*	0.22(NS)	0.44(NS)	<0.001*	0.006*	0.09(NS)	0.008*
Ricketts' E Line-Upper lip	r	0.05	0.01	0.69	-0.54	0.48	0.19	0.66	0.22	0.19	-0.06
	p-value	0.77(NS)	0.95(NS)	<0.001*	<0.001*	0.001*	0.22(NS)	<0.001*	0.15(NS)	0.22(NS)	0.69(NS)
Ricketts' E Line-Lower lip	r	-0.05	-0.03	0.71	-0.53	0.31	0.18	0.76	0.37	-0.10	-0.34
	p-value	0.76(NS)	0.84(NS)	<0.001*	<0.001*	0.04(NS)	0.24(NS)	<0.001*	0.01*	0.53(NS)	0.02*
Upper lip length	r	0.01	0.02	0.32	-0.25	0.13	0.24	0.35	-0.10	0.04	-0.09
	p-value	0.94(NS)	0.89(NS)	0.03*	0.10(NS)	0.40(NS)	0.11(NS)	0.02*	0.53(NS)	0.80(NS)	0.57(NS)
Lower lip length	r	0.05	0.02	-0.07	0.05	-0.21	0.20	0.17	0.03	-0.13	-0.10
	p-value	0.76(NS)	0.89(NS)	0.65(NS)	0.75(NS)	0.17(NS)	0.18(NS)	0.26(NS)	0.85(NS)	0.41(NS)	0.51(NS)
Soft tissue contour	r	-0.12	-0.07	0.21	-0.13	-0.08	0.18	0.42	0.44	0.01	-0.23
	p-value	0.45(NS)	0.64(NS)	0.16(NS)	0.38(NS)	0.61(NS)	0.25(NS)	0.004*	0.002*	0.96(NS)	0.13(NS)
Hard tissue contour	r	-0.17	-0.17	0.19	-0.05	-0.14	0.10	0.46	0.53	-0.13	-0.21
	p-value	0.25(NS)	0.25(NS)	0.21(NS)	0.72(NS)	0.35(NS)	0.53(NS)	0.001*	<0.001*	0.40(NS)	0.18(NS)
Contour ratio	r	0.20	0.28	-0.02	-0.14	0.18	0.13	-0.26	-0.38	0.34	0.04
	p-	0.19(NS	0.06(NS	0.90(NS	0.35(NS)	0.23(NS	0.42(NS	0.09(NS	0.01*	0.02*	0.82(NS

	value	)	)	)		)	)	)			)
Nasolabial angle	r	-0.14	-0.05	0.12	-0.06	0.10	-0.15	0.00	-0.37	-0.05	0.12
	p-value	0.36(NS)	0.74(NS)	0.43(NS)	0.70(NS)	0.52(NS)	0.34(NS)	0.98(NS)	0.01*	0.75(NS)	0.43(NS)
H-angle	r	0.00	-0.10	0.59	-0.41	0.45	0.02	0.46	0.07	0.24	0.03
	p-value	0.99(NS)	0.50(NS)	<0.001*	0.005*	0.002*	0.92(NS)	0.002*	0.64(NS)	0.11(NS)	0.85(NS)

Pearsons correlation test
*p<0.05 statistically significant, p>0.05 Non Significant, NS

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