Perioral soft tissue evaluation of skeletal Class II division 1: A cephalometric study

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Perioral soft tissue evaluation of skeletal Class II division 1: A cephalometric study

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감사의 글

논문의 연구 계획부터 완성에 이르기까지 기틀을 잡아주시고 세심한 지도와 격려를 베풀어주신 차정열 교수님께 깊은 감사를 드립니다. 보다 좋은 논문으로 완성되는데 관심과 조언을 아끼지 않으셨던 박영철 교수님, 황충주 교수님, 그리고 바쁘신 중에도 논문의 진행과 발전에 도움을 주신 김경호 교수님, 유형석 교수님께 진심으로 감사 드립니다. 또한 교정학을 공부할 수 있도록 기회를 주시고 가르침을 주신 백형선 교수님, 이기준 교수님, 정주령 교수님께도 깊이 감사 드립니다. 더불어 항상 따뜻한 관심과 가르침을 주시며 이끌어 주신 김응수 선생님께 마음 깊이 감사 드립니다.

연구의 진행 과정 내내 많을 도움을 준 최태현 선생님과 김성진 선생님, 임선영 선생님 및 교정과 선생님들에게도 감사의 말씀을 드립니다.

항상 아낌없는 사랑과 기도로 지켜봐 주시고 응원해 주시는 양가 부모님과 가족들에게도 감사의 마음을 전합니다. 마지막으로 이 논문의 완성을 위해 가장 가까운 곳에서 끊임없이 큰 도움을 주었고, 언제나 변함없이 큰 힘이 되어주는 사랑하는 남편에게 고마운 마음을 전합니다.

2014년 2월

저자 씀

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ABSTRACT

Perioral soft tissue evaluation of skeletal Class II division 1 : A cephalometric study

The purpose of this study was to evaluate the perioral soft tissue characteristics of skeletal Class II division 1 (Group II) with low (<27°), normal (27°–36°) and high (>36°) SN–MP angle (Group IIL, IIN and IIH, respectively) compared with skeletal Class I (Group I). Lateral cephalograms of 99 individuals were divided into 4 groups according to skeletal pattern (Group I: 22 subjects, Group IIL: 14 subjects, Group IIN: 33 subjects, Group IIH: 30 subjects). For each group, the skeletal, dental and soft tissue variables were assessed by cephalometric analysis and one–way ANOVA was performed for statistical evaluation. The correlations between the skeletal, dental variables and soft tissue variables were studied and multiple linear regression tests were used to determine the variables influencing soft tissue characteristics. The results of the present study are as follows.

1. Lower lip thickness showed statistically greater value in Group II than in Group I (Group I, 15.16±1.30 mm; Group IIL, 17.24±2.56 mm, $p < 0.05$). Upper lip thickness showed no statistical difference between groups.
2. Group IIH exhibited significantly greater values than Group IIL and IIN for basic lower lip thickness and lower lip length ($p < 0.05$).
3. The measurements of perioral soft tissue thickness of Group II were correlated with inclination and anteroposterior position of upper and lower incisors along with facial depth and/or facial length.

4. Basic upper lip thickness and upper lip thickness of Group II were greatly correlated with the inclination of lower incisors ($p < 0.01$).
5. In Group II, upper lip strain was influenced by the inclination and anteroposterior position of maxillary incisors and was not influenced by any skeletal variables.

These results revealed the characteristics of perioral soft tissue thickness of skeletal Class II division 1, providing practical information and guidelines for orthodontic diagnosis and treatment.

Key words: soft tissue thickness, skeletal Class II, vertical pattern, cephalometrics

Perioral soft tissue evaluation of skeletal Class II division 1: A cephalometric study

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I. Introduction

The objectives of orthodontic treatment are 1) the best balance and harmony of facial lines that is possible 2) stability of the denture after treatment 3) healthy oral tissues, and 4) an efficient chewing mechanism (Tweed, 1953). Among these objectives, it is important to obtain the balance and harmony of the face including the morphologic relationships of the nose, lips, and chin and as well as the underlying skeletal components because nowadays successful treatment means that objective treatment goals and subjective patient desires were met. Therefore improvement in facial appearance based on soft tissue analysis should be considered importantly in the orthodontic treatment. Likewise, Bergman et al. stated that analysis of the soft tissue thickness is an important aspect in diagnosis (Bergman et al., 2013). According to Cha et al., however, the soft tissue thickness is variable because of individual factors such as age, gender, race, and nutritive conditions (Cha, 2013). Therefore, obtaining

information on the average facial soft tissue thickness would be a crucial factor for evaluating the facial soft tissue.

Many investigators have reported the interrelation between the soft tissue profile and the underlying skeletal pattern and this issue still remains controversially. Riedel represented that there were strong interconnections between the skeletal pattern and the soft tissue profile (Riedel, 1950; Riedel, 1957). On the other hand, several studies reported that the soft tissue profile was not matched to the skeletal pattern because of the variation of individual factors (Burstone, 1958; Park and Burstone, 1986; Subtelny, 1959). In this study, we assumed that the soft tissue thickness would be influenced by the horizontal and vertical position of the underlying hard tissue including skeletal and dental position.

Most of the studies which evaluated the soft tissue thickness have been carried out in normal skeletal individuals and a few studies have investigated the soft tissue thickness of patients with different skeletal classifications. Utsuno et al. have investigated the soft tissue thickness of patients with different skeletal classifications in Japanese girls (aged 6−16 years) and women (aged 17−33 years)(Utsuno et al., 2010a; Utsuno et al., 2010b). It was reported that there are differences among them in mean facial soft tissue thickness and the greatest difference was found between Classes II and III, with Class I being intermediate. Kamak et al. have made similar measurements in Turkish adults, and described that soft tissue thickness differences among skeletal classifications were observed at the labrale superius, stomion and labrale inferius sites for both men and women (Kamak and Celikoglu, 2012).

However, these studies have limitations evaluated only in specific ages, gender and ethnic groups. Especially, for ethnic variations exist in the midface structure, with Asian populations having less convexity than Caucasian populations, there is an obvious need for a more objective soft tissue

cephalometric standard for each ethnic group and one that provides reference values for each gender and overlying soft tissue (Shindoi et al., 2013).

About 25% of patients have the skeletal Class II malocclusion and some distinct aspects of the soft tissues have been observed (Hoffelder et al., 2007). There were several studies that evaluated the differences of the soft tissue thickness between skeletal Class I and II group. Among them, in the study of Kim et al. soft tissue characteristics according to lateral cephalometry of skeletal Class II have been evaluated (Kim et al., 2002). However, this study has not divided skeletal Class II into division 1 (II/1) and division 2 (II/2) groups. Soft tissue profile could be influenced not only by skeletal pattern but also by dental position (Mirabella et al., 2008) and we decided to focus on the characteristics of skeletal Class II/1 in this study.

Also given the fact that differences in vertical pattern could result in diverse demonstrations in soft tissue profile, it should be considered when planning the treatment as well (Blanchette et al., 1996; Macari and Hanna, 2013). Especially, it was reported that the soft tissue profile of skeletal Class II showed greater accordance to vertical pattern than those in other skeletal groups (Kwon et al., 1997). Therefore, we evaluated the perioral soft tissue characteristics of skeletal Class II/1 with different vertical patterns.

The aim of this study was (1) to determine the characteristics of perioral soft tissue in skeletal Class II/1 (2) to evaluate correlative skeletal and dental variables affecting soft tissue thickness using cephalometric analysis.

II. Materials and Methods

The study was proven by Institution of Research review Board of the Yonsei Dental University Hospital, approval no. 2013-0070.

A. Subjects

The study sample consisted of 99 individuals including 22 of control group (11 male and 11 female)and 77 of experimental group (34 male 43 female) (Table 1). The control group (Group I) was consisted of volunteers assessed as normal occlusion who meet the following criteria by clinical exam and cephalometric analysis;

Table 1. Descriptions of subjects

	Group I	**Group II**		
		Group IIL	**Group IIN**	**Group IIH**
Age (Mean ±SD)	24.62±2.06	23.93±5.55	23.03±4.59	23.27±4.61
Male (N)	11	7	17	10
Female (N)	11	7	16	20
Total (N)	22	14	33	30

Group I: Skeletal Class I; Group II: Skeletal Class II; Group IIL; Skeletal Class II with low SN-MP (<27°) angle; Group IIN; Skeletal Class II with normal SN-MP(27°-36°) angle; Group IIH; Skeletal Class II with high SN-MP(>36°) angle.

Control group

1. Skeletal Class I (ANB: 0~4°, "Wits" Appraisal: -4.0~0 mm)
2. Have natural dentition and no missing teeth except for the third molars
3. Show no alteration of facial morphology or dental occlusion
4. Have Class I canine and molar relations with normal overjet and overbite

The experimental group (Group II) was consisted of patients who visited Yonsei University Dental Hospital. The subjects were selected based on the following criteria by clinical exam and cephalometric analysis and model analysis.

Experimental group

1. Skeletal Class II /1 (4°< ANB, 0 mm< "Wits" Appraisal)
2. Have Class II canine and molar relations

The experimental group was further divided into 3 groups according to vertical pattern based on SN-MP angle (Karlsen, 1995; Riedel, 1952):
(1) low angle (Group IIL; <27°) (2) normal angle (Group IIN; 27° to 36°) (3) high angle (Group IIH; >36°). MP was defined as a plane from constructed gonion(Go) to menton(Me). The mean SN-MP angle was 32.43° for Group I and 24.51°, 31.90°, 43.40° for Group IIL, IIN and Group IIH, respectively. Both the control and the experimental groups were assessed with initial cephalometric analysis.

B. Measurements

A standardized digital lateral cephalograms were taken by using the Cranex3+ Ceph (Soredex, Milwaukee, Wis). V-Ceph software (version 3.5; Cybermed, Seoul, Korea) was used to obtain the cephalometric measurements. The radiographic magnification of the cephalograms was standardized at 100% actual size, with a 100 mm metal ruler image captured in the digital film as the reference. Cephalometric landmarks and reference planes, skeletal and dental measurements, soft tissue measurements, and abbreviations used in this study are summarized in Fig. 1, 2 and Table 2-4 (Holdaway, 1983; Kamak and Celikoglu, 2012; Kang et al., 2000; Legan and Burstone, 1980).

Table 2. Landmarks, reference lines and their definitions (Legan and Burstone, 1980)

Landmarks	Definitions
Subnasale (Sn)	The point where the lower border of the nose meets the outer contour of upper lip
Labrale superius (Ls)	The point indicating the mucocutaneous border of the upper lip
Labrale inferior (Li)	The point indicating the mucocutaneous border of the lower lip
Stomion superior (Stms)	The lowest point of the upper lip
Stomion inferior (Stmi)	The highest point of the lower lip
Stomion (Stm)	The anteriormost point of labial contact
Pogonion' (Pog')	The most prominent point on the soft tissue contour of the chin
Menton' (Me')	The most inferior point on the soft tissue contour of the chin
Upper incisor (U1)	The incisal point of the maxillary incisor crown
Lower incisor (L1)	The incisal point of the mandibular incisor crown
Reference lines	**Definitions**
Frankfort Horizontal Plane (FHP)	Plane from anatomical porion to orbitale
Mandibular Plane (MP)	Plane from constructed gonion to menton

Table 3. Measurement variables for skeletal and dental analysis

Skeletal analysis	Dental analysis
SNA	**U1 to SN**
SNB	**U1to NA (mm, degree)**
ANB	**L1to NB (mm, degree)**
Wits	**IMPA**
SN - MP	**Interincisal Angle**
FMA	**U1 Exposure**
Facial length	**Overjet**
Facial depth	**Overbite**
Facial height ratio	

Facial length: Sella-Gnathion; Facial depth: Nasion-Gonion.

Table 4. Soft tissue analysis and their definitions (Holdaway, 1983; Kamak and Celikoglu, 2012; Kang et al., 2000)

Soft tissue analysis- Horizontal	Definitions
Subnasale to H line	Linear horizontal distance from Sn to H line
Basic upper lip thickness	Linear distance from 3 mm below A point to Sn
Upper lip thickness	Linear distance from labial surface of U1 to Ls
Upper lip strain	The difference between basic upper lip thickness and upper lip thickness
Lower lip thickness	Linear distance from labial surface of L1 to Li
Basic lower lip thickness	Linear distance from B point to the deepest point of labiomental fold
Lower lip to H line	Linear distance from H line to tip of lower lip
Ricketts' E line (upper)	Linear distance from Ricketts' E line to tip of upper lip
Ricketts' E line (lower)	Linear distance from Ricketts' E line to tip of lower lip
Chin thickness	Linear distance from Pog to Pog’
H angle	Angle formed by H line and Na’-Pog’ line
Soft tissue analysis- Vertical	**Definitions**
Upper lip length	Vertical distance from Sn to Stms perpendicular to FH plane
Lower lip length	Vertical distance from Stmi to B’ perpendicular to FH plane
Soft tissue contour	Distance of soft tissue contour ; Sn-Stm -Me’
Hard tissue contour	Sum of distance of hard tissue contour ; ANS-A point-U1 and L1-B point-Pog-Me
Contour ratio	Soft tissue contour/ Hard tissue contour
Chin length	Linear distance from Me to Me'
Nasolabial angle	Angle formed by the intersection of upper lip anterior and columella at Sn

H line: Harmony line drawn tangent to the soft tissue chin and upper lip

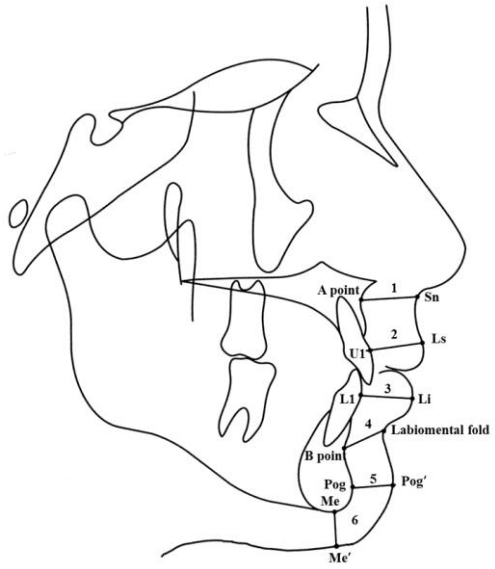

Fig. 1 Soft tissue measurements. 1. Basic upper lip thickness, 2. Upper lip thickness, 3. Lower lip thickness, 4. Basic lower lip thickness, 5. Chin thickness, 6. Chin length.

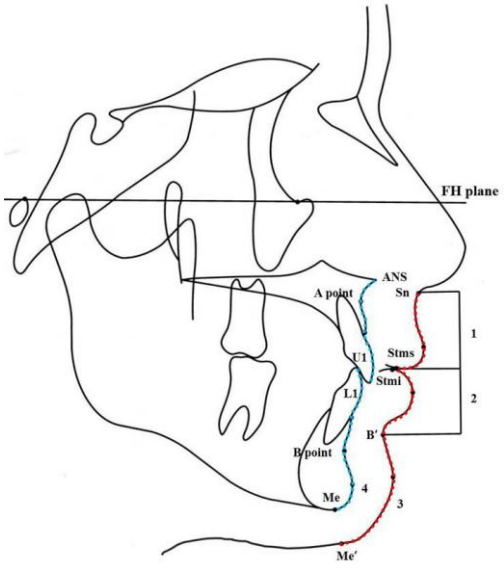

Fig. 2 Soft tissue measurements. 1. Upper lip length, 2. Lower lip length, 3. Soft tissue contour (red dot line), 4. Hard tissue contour (blue dot line).

C. Statistical analysis

All statistical analyses were performed with SPSS software (version 18.0; SPSS, Chicago, Ill). Cephalometric measurements were made with the V-Ceph software by one experienced, masked examiner (Y.J.L.). With a 2-week interval, all cephalometric digitizing and analyses were repeated by the same examiner.

The mean and the standard deviation for each cephalometric variable were determined in each group. The data were assessed for normality by using Kolmogorov-Smirov test. The comparisons among groups (i.e. Group I, IIL, IIN and IIH) were performed using one-way ANOVA test. The post-hoc Bonferroni test was used to analyze the differences between groups. In addition to these tests, independent *t* test was used to compare the mean values of the measurements between genders. Pearson's correlation analysis was carried out to evaluate the relationship between soft tissue measurements and skeletal/dental variables. Multiple linear regression was used to determine the variables affecting soft tissue characteristics. A *p*-value of <0.05 was considered statistically significant.

III. Results.

A. Intra examiner reliability and normality tests

Intra examiner reliability was assessed by paired samples *t* tests between the 2 sets of measurements, and no significant differences between them were found. There was no reason to believe that the mean scores were not normally distributed (Kolmogorov−Smirov test, $p > 0.05$), so all calculations were made assuming normality.

B. Skeletal and dental analysis

Table 5 and 6 showed the skeletal and dental measurements of all subjects in each group. For skeletal measurements, facial length (Sella−Gnathion) showed significantly greater value in Group I than in Group IIN and IIH. Facial depth (Nasion−Gonion) revealed lower value in Group IIH than in Group IIL and IIN. For dental measurements, the values for L1 to NB (degree, mm) were statistically lower in Group I than those in Group IIN and IIH. Also, the values for L1 to NB (degree, mm) represented significantly lower values in Group IIL than in Group IIN and IIH. There was a statistically significant difference in overjet between Group I and Group IIL, IIN and IIH. For overbite, Group IIL and IIN showed greater values than Group I and there were statistically significant differences in overbite among Group IIL, IIN and IIH.

Table 5. Skeletal measurements of all subjects

Skeletal measurements	Group I	Group IIL	Group IIN	Group IIH
SNA (°)	81.33±3.85	84.38±2.66	83.81±.3.01	80.44±.2.94
SNB (°)	78.81±3.74[c]	78.77±2.80[e]	77.68±2.56[f]	74.28±2.93[c,e,f]
ANB (°)	2.50±1.01[a,b,c]	5.70±1.29[a]	6.01±1.41[b]	6.16±1.46[c]
Wits (mm)	-2.43±2.15[a,b,c]	4.74±2.66[a,e]	3.50±2.43[b]	2.39±2.02[c,e]
SN to MP (°)	32.43±2.79[a,c]	24.51±2.67[a,d,e]	31.90±.2.68[d,f]	43.30±.5.11[c,e,f]
FMA (°)	24.45±3.10[a,c]	17.32±3.50[a,d,e]	25.49±3.58[d,f]	33.76±6.43[c,e,f]
Facial Length (mm)	139.14±9.09[b,c]	131.12±10.08	131.87±9.63[b]	130.57±8.28[c]
Facial Depth (mm)	134.57±5.18[c]	137.16±9.18[e]	132.13±7.95[f]	127.00±7.48[c,e,f]
Facial height ratio	67.73±2.76[a,c]	74.51±2.74[a,d,e]	68.62±2.56[d,f]	60.05±3.95[c,e,f]

All values are (mean±SD); [a] Significant different between Group I and Group IIL ($p < 0.05$); [b] Significant different between Group I and Group IIN ($p < 0.05$); [c] Significant different between Group I and Group IIH ($p < 0.05$); [d] Significant different between Group IIL and Group IIN ($p < 0.05$); [e] Significant different between Group IIL and Group IIH ($p < 0.05$); [f] Significant different between Group IIN and Group IIH ($p < 0.05$).

Table 6. Dental measurements of all subjects

Dental measurements	Group I	Group IIL	Group IIN	Group IIH
U1 to SN (°)	106.42±5.04	108.04±10.77	108.93±7.53	103.21±7.05
U1 to NA (°)	25.09±3.57	24.20±10.41	25.14±7.56	22.77±6.21
U1 to NA (mm)	6.18±2.02	5.87±2.82	6.25±3.01	5.66±2.75
L1 to NB (°)	28.15±4.47[b,c]	27.81±7.28[d,e]	33.98±4.95[b,d]	34.39±6.66[c,e]
L1 to NB (mm)	7.35±2.15[b,c]	7.16±2.59[d,e]	9.97±2.95[b,d]	10.35±3.47[c,e]
IMPA (°)	96.48±5.61[a,b]	103.59±7.52[a,e]	104.42±5.57[b,f]	96.83±7.58[e,f]
Interincisal Angle (°)	124.24±6.14[b,c]	122.13±10.55	114.88±8.13[b]	116.68±10.61[c]
U1 exposure (mm)	2.03±1.97	2.12±2.03	2.25±1.80	2.89±1.89
Overjet (mm)	2.58±0.70[a,b,c]	7.83±2.75[a,d,e]	5.88±2.67[b,d]	5.48±1.94[c,e]
Overbite (mm)	2.77±1.15[a,b]	5.90±2.34[a,d,e]	4.31±1.77[b,d,f]	3.06±1.88[e,f]

All values are (mean±SD); [a] Significant different between Group I and Group IIL ($p < 0.05$); [b] Significant different between Group I and Group IIN ($p < 0.05$); [c] Significant different between Group I and Group IIH ($p < 0.05$); [d] Significant different between Group IIL and Group IIN ($p < 0.05$); [e] Significant different between Group IIL and Group IIH ($p < 0.05$); [f] Significant different between Group IIN and Group IIH ($p < 0.05$).

C. Soft tissue analysis

Table 7 and 8 showed horizontal and vertical soft tissue measurements of all subjects. Lower lip thickness was increased in Group II compared to Group I. Especially, lower lip thickness was greater in the Group IIL than the Group I statistically. Basic lower lip thickness represented a significantly greater value in Group IIH than in Group IIL. There were no significant differences in basic upper lip thickness, upper lip thickness, upper lip strain and chin thickness among the groups of all subjects. In vertical measurements, lower lip length revealed significantly greater values for Group IIN, Group IIH compared to Group IIL. Also, there were statistical differences between Group IIL and Group IIH in soft tissue contour, hard tissue contour and contour ratio.

Table 7. Horizontal soft tissue analysis of all subjects

Horizontal measurements	**Group I**	**Group IIL**	**Group IIN**	**Group IIH**
Subnasale to H Line (mm)	12.38±3.06	11.79±2.84	14.14±3.94	14.38±2.88
Basic upper lip thickness (mm)	15.28±1.90	14.99±2.28	14.69±2.44	14.26±2.04
Upper lip thickness (mm)	13.14±1.60	13.04±2.31	12.68±2.06	12.19±2.20
Upper lip strain (mm)	2.13±1.03	1.95±1.56	2.00±1.89	2.07±1.56
Lower lip thickness (mm)	15.16±1.31[a]	17.05±2.55[a]	16.21±2.29	16.67±1.94
Basic lower lip thickness (mm)	18.03±1.72	16.49±1.85[e]	17.96±2.98	18.97±2.87[e]
Lower lip to H line (mm)	1.76±2.14	0.26±2.03[e]	1.94±1.94	2.99±2.70[e]
Ricketts' E line -upper (mm)	-0.26±2.36[b,c]	0.76±2.28	1.92±2.24[b]	2.36±2.63[c]
Ricketts' E line -lower (mm)	1.49±2.29[c]	0.45±2.31[e]	2.59±2.45	4.19±3.43[c,e]
Chin thickness (mm)	13.17±2.36	12.84±2.57	12.86±2.86	12.80±2.82
H angle (˚)	16.74±3.31	21.37±3.39	22.52±3.23	22.47±2.99

All values are (mean±SD); [a] Significant different between Group I and Group IIL ($p < 0.05$); [b] Significant different between Group I and Group IIN ($p < 0.05$); [c] Significant different between Group I and Group IIH ($p < 0.05$); [e] Significant different between Group IIL and Group IIH ($p < 0.05$).

Table 8. Vertical soft tissue analysis of all subjects

Vertical measurements	Group I	Group IIL	Group IIN	Group IIH
Upper lip length (mm)	27.45±2.95	25.68±3.12	26.07±4.14	26.89±3.52
Lower lip length (mm)	18.60±1.89	16.49±2.11[d,e]	18.75±2.55[d]	19.13±2.42[e]
Soft tissue contour (mm)	97.65±7.89	88.35±8.02[e]	93.78±11.19	97.41±9.73[e]
Hard tissue contour (mm)	95.37±6.08	88.26±7.6[e]	95.34±10.29[f]	101.87±9.74[e,f]
Contour ratio	1.02±0.37[b,c]	1.00±0.53[e]	0.98±0.06[b]	0.96±0.45[c,e]
Chin length (mm)	9.04±2.08	7.89±1.72	8.37±1.86	7.68±2.10
Nasolabial angle (˚)	96.88±9.44	98.62±10.30	96.62±9.61	101.36±8.61

All values are (mean±SD); a Significant different between Group I and Group IIL ($p < 0.05$); b Significant different between Group I and Group IIN ($p < 0.05$); c Significant different between Group I and Group IIH ($p < 0.05$); d Significant different between Group IIL and Group IIN ($p < 0.05$); e Significant different between Group IIL and Group IIH ($p < 0.05$); f Significant different between Group IIN and Group IIH ($p < 0.05$).

Table 9 and 10 showed a comparison of horizontal and vertical soft tissue measurements between genders for each experimental group. All measurements of horizontal and vertical soft tissue thickness were greater in male than in female in all groups. The values for basic upper lip thickness and upper lip thickness were significantly greater in male than female in all groups.

Table 9. Horizontal soft tissue analysis between genders for each experimental group

Horizontal measurements	Group IIL		Group IIN		Group IIH	
	male	female	male	female	male	female
Subnasale to H Line (mm)	11.30±2.78	12.29±3.02	15.79±4.29†	12.39±2.68†	14.66±3.53	14.24±2.58
Basic upper lip thickness (mm)	16.60±1.32†	13.58±1.87†	15.79±2.49†	13.52±1.80†	16.20±1.79†	13.28±1.37†
Upper lip thickness (mm)	14.51±1.99†	11.27±1.61†	13.42±1.63†	11.90±2.22†	13.79±2.53†	11.38±1.53†
Upper lip strain (mm)	2.09±1.93	2.31±1.20	2.37±2.03	1.61±1.70	2.42±1.81	1.90±1.43
Lower lip thickness (mm)	18.96±1.32†	15.15±1.97†	17.03±1.93†	15.35±2.38†	17.58±2.61	16.21±1.37
Basic lower lip thickness (mm)	16.65±1.81	16.32±2.01	19.42±2.99†	16.42±2.11†	19.98±2.48	18.46±2.98
Lower lip to H line (mm)	-0.83±1.83†	1.35±1.67†	1.95±2.06	1.93±1.88	3.01±2.58	2.98±2.82
Ricketts' E line -upper (mm)	0.08±1.73	1.44±2.67	2.74±2.26†	1.04±1.91†	2.49±2.45	2.30±2.78
Ricketts' E line -lower (mm)	-0.64±1.79	1.54±2.37	3.11±2.46	2.05±2.39	4.48±3.49	4.04±3.48
Chin thickness (mm)	14.71±2.17†	10.96±1.18†	13.09±3.04	12.62±2.73	12.88±2.36†	12.76±3.08†
H angle (°)	21.61±3.12	21.12±3.87	23.89±2.90†	21.06±2.99†	21.84±3.26	22.78±2.88

All values are (mean±SD); † Significant different between genders in each group by t-test ($p < 0.05$).

Table 10. Vertical soft tissue analysis between genders for each experimental group

Vertical measurements	Group IIL		Group IIN		Group IIH	
	male	female	male	female	male	female
Upper lip length (mm)	26.60±3.14	24.46±2.64	28.08±4.17†	23.93±2.92†	27.21±4.15	26.73±3.26
Lower lip length (mm)	16.61±2.42	15.96±1.94	20.01±2.63†	17.41±1.65†	20.43±2.02†	18.48±2.37†
Soft tissue contour (mm)	90.15±8.11	84.10±8.73	99.81±11.60†	87.38±6.23†	101.62±8.71	95.30±9.72
Hard tissue contour (mm)	89.27±6.59	85.03±9.81	100.68±9.70†	89.66±7.65†	106.36±9.43	99.63±9.32
Contour ratio	1.01±0.05	0.99±0.59	0.99±0.07	0.98±0.05	0.96±0.05	0.96±0.44
Chin length (mm)	9.42±2.08†	6.90±1.34†	8.63±1.92	8.09±1.82	8.79±1.99†	7.13±1.97†
Nasolabial angle (°)	99.59±8.29	95.38±13.15	96.71±9.74	96.54±9.79	101.14±8.06	101.47±9.08

All values are (mean±SD); † Significant different between genders in each group by t-test ($p < 0.05$).

D. Correlations and multiple linear regression analysis between soft tissue measurements and skeletal/dental variables

Further analysis of the measurements of perioral soft tissue thickness for Group II was done in order to evaluate the relationship between the measurements and skeletal/dental variables. Table 11 and 12 demonstrated that horizontal and vertical thickness of the perioral soft tissue was correlated with facial depth and/or facial length except for upper lip length. Also, basic lower lip thickness and lower lip length were correlated with SN−MP and FMA.

Basic upper lip thickness and upper lip thickness showed inverse correlations with L1 to NB (degree) with the highest coefficients. Upper lip strain showed correlations only with dental values, such as U1 to NA (degree, mm), U1 to SN (degree) and overjet. Basic upper lip thickness and basic lower lip thickness were correlated positively with most of the dental variables including L1 to NB (degree, mm) and U1 to NA (degree, mm).

The perioral soft tissue thickness values used in the correlation test were all acceptable for the regression model (Table 13). The adjusted R^2 values were observed between 0.077 and 0.523. Horizontal soft tissue thickness (i.e. basic upper lip thickness, upper lip thickness, lower lip thickness and basic lower lip thickness) was generally influenced by L1 to NB (degree, mm) and overjet. Upper lip strain was associated with U1 to NA (mm) and overjet. Also, upper lip length and lower lip length were influenced by U1 exposure and L1 to NB (mm), respectively. Basic upper lip thickness, basic lower lip thickness and lower lip length were influenced by facial length (Table 14).

Table 11. Pearson correlation coefficients of Group II between soft tissue thickness and skeletal variables

Soft tissue thickness	Skeletal variables			
Basic upper lip thickness (mm)	Facial length(mm)	Facial depth(mm)	Wits(mm)	
	0.342**	0.321**	0.252*	
Upper lip thickness (mm)	Facial depth(mm)			
	0.278*			
Lower lip thickness (mm)	Facial depth(mm)	Facial length(mm)		
	0.278*	0.238*		
Basic lower lip thickness (mm)	Facial length(mm)	FMA(˚)	SN-MP(˚)	Facial height ratio
	0.408**	0.341**	0.329**	-0.270*
Lower lip length (mm)	Facial length(mm)	SN-MP(˚)	FMA(˚)	
	0.411**	0.311**	0.269**	

* indicates significance (*$p < 0.05$; ** $p < 0.01$).

Table 12. Pearson correlation coefficients of Group II between soft tissue thickness and dental variables

Soft tissue thickness	**Dental variables**						
Basic upper lip thickness (mm)	L1 to NB(˚)	Overjet(mm)	Overbite(mm)	IMPA(˚)	L1 to NB(mm)	U1 exposure(mm)	
	-0.415**	0.392*	0.377**	-0.282**	-0.247*	-0.244*	
Upper lip thickness (mm)	L1 to NB(˚)	Interincisal angle(˚)	L1 to NB(mm)	Overbite(mm)	U1 to NA(mm)		
	-0.397**	0.377**	-0.297**	0.286*	-0.245*		
Upper lip strain	U1 to NA(mm)	Overjet(mm)	U1 to NA(˚)	U1 to SN(˚)	Interincisal angle(˚)		
	.483**	0.461**	0.427**	0.389**	-0.281*		
Lower lip thickness (mm)	L1 to NB(˚)	Overjet(mm)	IMPA(˚)	Overbite(mm)	L1 to NB(mm)	Interincisal angle(˚)	
	-0.387**	0.351**	-0.316**	0.312**	-0.294**	0.224*	
Basic lower lip thickness (mm)	L1 to NB(mm)	Interincisal angle(˚)	Overbite(mm)	L1 to NB(˚)	U1 to NA(mm)	U1 to SN(˚)	U1 to NA(˚)
	0.650**	-0.435**	-0.371**	0.352**	0.327**	0.232*	0.226*
Upper lip length (mm)	U1 exposure(mm)						
	-0.298**						
Lower lip length (mm)	L1 to NB(mm)						
	0.487**						

* indicates significance (*$p < 0.05$; ** $p < 0.01$).

Table 13. Regression model fit test of Group II

Dependent variables	F value	Sig.	R^2	Adjusted R^2
Basic upper lip thickness (mm)	10.278	***	0.297	0.268
Upper lip thickness (mm)	9.519	***	0.205	0.183
Upper lip strain	16.081	***	0.303	0.284
Lower lip thickness (mm)	8.959	***	0.195	0.173
Basic lower lip thickness (mm)	42.599	***	0.535	0.523
Upper lip length (mm)	7.308	**	0.089	0.077
Lower lip length (mm)	21.269	***	0.365	0.348

* indicates significance (**$p < 0.01$; ***$p < 0.001$).

Table 14. Results for multiple linear regression of Group II

Dependent variables		B	S. E.	Beta	t	Sig.
Basic upper lip thickness (mm)	Constant	7.282	3.952		1.843	
	L1 to NB (˚)	-0.082	0.038	-0.237	-2.142	**
	Facial length (mm)	0.065	0.025	0.263	2.59	**
	Overjet (mm)	0.246	0.096	0.277	2.573	*
Upper lip thickness (mm)	Constant	17.622	1.212		14.544	
	L1 to NB (˚)	-0.126	0.034	-0.381	-3.668	***
	U1 to NA (mm)	-0.164	0.078	-0.218	-2.094	*
Upper lip strain	Constant	-0.314	0.462		-0.68	
	U1 to NA (mm)	0.203	0.065	0.342	3.104	**
	Overjet (mm)	0.200	0.073	0.299	2.720	**
Lower lip thickness (mm)	Constant	18.588	1.636		11.363	
	L1 to NB (˚)	-0.099	0.039	-0.293	-2.563	*
	Overjet (mm)	0.202	0.099	0.232	2.032	*
Basic lower lip thickness (mm)	Constant	-1.045	3.303		-0.316	
	L1 to NB (mm)	0.535	0.070	0.611	7.663	***
	Facial length (mm)	0.107	0.025	0.338	4.233	***
Upper lip length (mm)	Constant	27.773	0.675		41.139	
	U1 exposure (mm)	-0.588	0.217	-0.298	-2.703	**
Lower lip length (mm)	Constant	1.758	3.463		0.508	
	L1 to NB (mm)	0.350	0.073	0.446	4.781	***
	Facial length (mm)	0.102	0.026	0.360	3.859	***

* indicates significance (*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$); B: Unstandardized coefficients; S.E.: Standard error; Beta: Standardized coefficients.

IV. Discussion

It was reported that soft tissues more closely determine therapeutic modifiability (Peck et al., 1992). Thus analysis of the soft tissues is a critical part in orthodontic decision making and this can be accomplished by acknowledging differences of the soft tissue thickness in each skeletal Class. In Korea, about 25% patients have the skeletal Class II malocclusion and the percentage of Class II/1 is more than 10 times greater than Class II/2 (Hwang et al., 2001). Therefore, in this study, we decided to evaluate the characteristics of perioral soft tissue measurements of skeletal Class II/1, data that could be useful in diagnosis and treatment planning.

Various landmarks and reference lines were used to analyze the soft tissue measurements different from each other and difficult to construct in previous studies. And comparing the results of them has been challenging tasks. Hence, in this study, the chosen landmarks and reference lines were simple and straight forward to analyze the soft tissue measurements

Previous studies have shown that sagittal facial pattern is composed of vertical and horizontal vector and the final vector of position of the chin is a result of the competition between them (Creekmore, 1967; Isaacson et al., 1971; Schudy, 1964), thus clinicians often considered the relevance of inclination of mandible plane. According to Schudy and Isaacson et al., the degree of inclination of the mandible to the cranial base (SN-MP) has an effect upon the degree of mandibular rotation (Isaacson et al., 1971; Schudy, 1964). The larger the SN-MP angle, the more the mandible tends to become steeper, the more the chin moves backward and vice versa. Since it was suggested that the soft tissue measurements reflect the underlying skeletal pattern, we assumed that the characteristics of soft tissue measurements would be variable even in the same skeletal class if accompanied by different vertical pattern.

In the present study, the measurements of perioral soft tissue thickness all sites were greater in male than in female. Especially, the values for basic upper lip thickness and upper lip thickness were significantly greater in male than female in all groups. Several studies evaluating the soft tissue measurements for male and female found that the values for male are greater than those for female (Kim et al., 2002; Sung et al., 1989).

There was a statistical difference in lower lip thickness between the Group II and I. In previous study, lower lip thickness was the greatest in skeletal Class II for both male and female (Kamak and Celikoglu, 2012). The values for lower lip thickness found in this study were greater in Group IIL, IIN and IIH than in Group I in all subjects with a statistical difference between Group I and IIL, corroborating the results abovementioned. The greater value of the lower lip thickness could be interpreted as the soft tissue characteristic of skeletal Class II/1 even in diverse ethnic groups. In analyzing the result of Table 8, we found that Group I possesses higher values of upper lip length followed by Group IIH, IIN and IIL in all subjects, but showed no statistical significance. This result agreed with Al-Hamdany who mentioned that skeletal Class II/1 had shorter upper lip length than that of skeletal Class I (Al-Hamdany, 2007). Kim et al. in their comparative study of soft tissue measurements between skeletal Class I and II found that Class I male revealed statistically higher value for upper lip length (Kim et al., 2002).

The characteristics of soft tissue measurements according to the vertical pattern (SN-MP) were distinct, revealing statistical differences in basic lower lip thickness, lower lip length, soft and hard tissue contour and contour ratio. Group IIH exhibited a statistically greater value in basic lower lip thickness than Group IIL (18.97±2.87 mm, 16.49±1.85 mm for Group IIH and IIN, respectively). This can be explained as an attempt of soft tissue to compensate for the high SN-MP skeletal pattern. According to Blanchette et al., this may have been a natural effort to compensate for the shorter mandibular corpus length in order to mask the

condition and to provide a more normal facial appearance (Blanchette et al., 1996). Also, it could be speculated that the converse was true for the short vertical pattern that showed a lower basic lower lip thickness simply just as a result of deficiency of vertical skeletal growth. Lower lip length was statistically greater in Group IIH than in Group IIL (19.13±2.42 mm, 16.49±2.11 mm for Group IIH and IIL, respectively). It could be argued that smaller lip length in the low SN-MP skeletal pattern was due to lip closure, leading to a greater curling of lip tissue and enhanced lower lip thickness (17.05±2.55 mm, 16.67±1.94 mm for Group IIL and IIH, respectively). Contour ratio was statistically lower in Group IIH than in Group IIL.

According to Holdaway, upper lip strain, a difference between basic upper lip thickness and upper lip thickness was useful when determining the amount of lip strain or incompetency present (Holdaway, 1983). Holdaway suggested that within 1 mm of upper lip strain would be acceptable and excessive amount would be indicative of the thinning of the upper lip thickness as it is stretched over protrusive teeth. Therefore, acceptable upper lip strain could be established by control of incisors eliminating lip strain. From the correlation results of Group II, upper lip strain was correlated with U1 to NA (degree, mm), U1 to SN (degree) and overjet positively (Table 12). Therefore, it could be mentioned that upper lip strain, observed in a relatively consistent range (2.13±1.03 mm, 1.95±1.56 mm, 2.00±1.89 mm, 2.07±1.56 mm for Group I, IIL, IIN and IIH, respectively), was influenced by the inclination and anteroposterior position of U1 rather than by the horizontal and vertical skeletal pattern.

Basic upper lip thickness and upper lip thickness showed the highest correlation coefficients with L1 to NB (degree). Basic upper lip thickness and basic lower lip thickness were correlated with most of the dental variables including L1 to NB (degree, mm) and U1 to NA (degree, mm). And the possibility of its being influenced by the position and angulation of the maxillary incisors was reported by Angle and explained by Subtelny, because lower lip usually covers the incisal third

of the maxillary incisors (Angle, 1899; Subtelny, 1961). It could be suggested that the measurements of perioral soft tissue thickness of skeletal Class II/1 were affected generally by various dental variables in this study as abovementioned. Among skeletal variables, facial depth and/or facial length were correlated with horizontal and vertical measurements of the perioral soft tissue. Facial depth and facial length behave similarly with each other in terms of longitudinal development of face and dentition (Hahn von Dorsche et al., 1999). Given the fact that vertical measurements would be directly proportional with the development of face, as to say face length and depth, it could be suggested that not only the vertical measurements but also the horizontal measurements of perioral soft tissue thickness were positively correlated.

Multiple linear regression analysis revealed results in accordance with those of correlation analysis. Basic upper lip thickness, upper lip thickness, lower lip thickness and basic lower lip thickness were influenced by L1 to NB (degree, mm) and overjet. Upper lip strain was associated with U1 to NA (mm) and overjet. The skeletal independent variable influencing the measurements of perioral soft tissue thickness was facial length. The adjusted R^2 value, observed between 0.077 and 0.523, represents that much is unexplained about perioral soft tissue measurements, which also could be influenced by features unlikely to be related with orthodontic diagnosis and treatment.

There are a few limitations in the present study. Because of various individual factors, perioral soft tissue analysis is intricate to evaluate. The sample size is quite small to show the statistical power. Further comparative studies with larger sample size and additional skeletal classifications (i.e. Class II/2 or Class III) could be conducted so as to increase the scientific and statistical power.

Within limitations of this study, it can be concluded that perioral soft tissue characteristics of skeletal Class II/1 revealed significant difference according to horizontal and vertical skeletal pattern and were influenced by anteroposterior position and inclination of incisors along with facial depth and facial length.

V. Conclusions

To evaluate the perioral soft tissue characteristics in skeletal Class II division 1 (Group II) with low (<27°), normal (27° −36°) and high (>36°) SN−MP angle (Group IIL, IIN and IIH, respectively) compared to skeletal Class I (Group I), cephalometric analysis was conducted to total 99 individuals divided into 4 groups according to skeletal pattern (Group I: 22 subjects, Group IIL: 14 subjects, Group IIN: 33 subjects, Group IIH: 30 subjects). For each group, skeletal, dental and soft tissue variables were assessed for statistical evaluation. And the correlations between the skeletal, dental variables and soft tissue variables were studied and multiple linear regression was used to determine the variables affecting soft tissue characteristics. The results of the present study were as follows.

1. Lower lip thickness showed statistically greater value in Group II than in Group I (Group I, 15.16±1.30 mm; Group IIL, 17.24±2.56 mm, $p < 0.05$). Upper lip thickness showed no statistical difference between groups.
2. Group IIH exhibited significantly greater values than Group IIL and IIN for basic lower lip thickness and lower lip length ($p < 0.05$).
3. The measurements of perioral soft tissue thickness were correlated with inclination and anteroposterior position of upper and lower incisors along with facial depth and/or facial length in Group II.
4. Basic upper lip thickness and upper lip thickness of Group II were strongly correlated with the inclination of lower incisors ($p < 0.01$).
5. In Group II, upper lip strain was influenced by the inclination and anteroposterior position of maxillary incisors and was not influenced by any skeletal variables.

These results revealed the characteristics of perioral soft tissue thickness of skeletal Class II division 1, providing practical information and guidelines for orthodontic diagnosis and treatment.

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국 문 요 약

골격성 II급 1류 부정교합 환자의 입술주변 연조직 특성 분석

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악안면 연조직은 기능과 심미성 그리고 치료 후의 안정성에 큰 영향을 미치는 요소이기 때문에 부정교합 환자의 진단과 치료계획 수립 시 중요한 고려사항으로 평가되고 있다. 하지만, 그간 국내외에서의 연조직의 특성에 대한 연구는 정상교합자 에 국한되었거나 치료 전후의 변화를 보여주는 연구가 많았고, 골격적 차이에 따른 연조직의 특성과 그에 영향을 주는 요인에 대한 연구는 미비하였다. 이에 본 연구의 목적은 성인 골격성 II 급 1 류 (Group II) 부정교합자 중 수직적 양상에 따라 세개의 그룹으로 나누어 (Group IIL: SN−MP<27° , Group IIN: 27° <SN−MP<36° , Group IIH: 36° <SN−MP), 연조직의 특성과 영향을 미치는 요소들을 평가하고 성인 골격성 I 급 (Group I) 정상교합자와 비교하는 것이다. 총 99 명의 대상 중 Group I 22 명, Group IIL 14 명, Group IIN 33 명, Group IIH 30 명 이었고, 측모두부방사선 계측을 통해 골격성, 치성, 연조직의 변수를 계측하고, 통계처리하여 다음과 같은 결과를 얻었다.

1. 하순의 두께가 Group II에서 Group I에 비해 통계적으로 큰 수치를 보였다 (Group I, 15.16±1.30 mm; Group IIL, 17.24±2.56 mm, $p < 0.05$). 반면, 상순의 두께는 group 간의 유의한 차이를 보이지 않았다.
2. Group IIH에서 Group IIL에 비해 기저부에서의 하순 두께와 하순 길이의 계측치가 더 커지는 양상을 보였다 ($p < 0.05$).

3. Group II의 입술 주변의 연조직 계측치는 상하악 전치의 전후방적 위치 및 경사도, 안면고경, 안면심도와 상관관계를 보였다.
4. Group II의 기저부 및 치관부에서의 상순 두께는 하악 전치의 경사도와 가장 큰 상관성을 보였다 ($p < 0.01$).
5. 상순의 기저부와 치관부의 두께차이 (Upper lip strain)는 Group II에서 상악 중절치의 각도와 전후방적 위치에 영향을 받으며, 골격적 특성에 영향을 받지 않았다.

이번 연구는 골격성 II 급 1 류 부정교합자의 입술 주변 연조직 두께의 특성을 제시함으로써, 골격성 II 급 부정교합자의 교정진단 및 치료, 그 예후에 있어서 유용한 기준 정보로 활용될 수 있을 것이다.

핵심되는 말: 연조직, 골격성 II 급 1 류 부정교합, 측모두부규격 방사선 계측