Original article

Changes in soft tissue profile during growth of Japanese female children with mild Angle Class III malocclusion

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Key words: Soft tissue analysis, Class III malocclusion, Profile change, Adolescent growth

Abstract: Lateral cephalograms of 62 female children (age: 6-14 years) with mild Angle Class III malocclusion were examined in order to identify common characteristics of soft tissue profile growth. Forty-six female children with Angle Class I malocclusion were used as a control group. Differences according to age and occlusal group were determined using an unpaired t-test. In the Class III group, the facial convexity angle tends to decrease with increasing age, and the maxillary complex shows retrusion. The thickness of the soft tissue covering the maxillary region increases, the mandible shows greater protrusion, and the lower face/throat angle decreases. The nasolabial angle remains constant. The increase in the depth of soft tissue over point A is proportionally greater than that over the pogonion with increasing age. Our findings indicate that the facial profile of subjects with mild Angle Class III malocclusion becomes more concave with age. The primary characteristics of the soft tissue in such cases could be observed in childhood.

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軽度なアングルIII級不正咬合を呈する日本人女子の軟組織側貌における成長変化

抄録：軽度なアングルIII級不正咬合を呈する日本人女子(6～14歳)62名の側面頭部X線規格写真を用いて，その軟組織側貌の成長の特徴について検討した．対照群には，アングルI級不正咬合を呈する女子46名を用いた．unpaired t-testを行い，年齢群および不正咬合群間の差異を求めた．アングルIII級不正咬合では，増齢とともにフェイシャルコンベキシティーアングルが減少し，上顎の後退を示していた．また，上顎部を被う軟組織の厚さは増加し，下顎の前突やオトガイ部の形態がより前突形態となった．鼻柱口唇角には，変化はみられなかった．硬組織A点上の軟組織の厚さは，ポゴニオン上の厚さと比較して，加齢とともに増加した．以上の結果から，軽度なアングルIII級不正咬合者の側貌は，加齢とともに陥凹形態となった．このような軟組織側貌の特徴は，小児期に観察することができよう．

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Introduction

The importance of soft tissue in the planning of orthodontic treatment is widely recognized. The soft tissue that covers the facial skeleton varies in thickness. Consequently, the outline of the soft tissue profile does not exactly correspond with the underlying skeletal framework. Thus, soft tissue can camouflage skeletal deformities.

The normal course of soft tissue development[1~5] and the typical characteristics of soft tissue in adults with normal occlusion[6~10] have been reported previously. However, the typical characteristics of soft tissue in patients who exhibit maxillofacial abnormalities have yet to be reported in detail.

The relationship between soft tissue development and hard tissue development is an important consideration for treating patients with skeletal abnormalities. Battagel (1993)[11] evaluated hard and soft tissue characteristics in Caucasian children with Class III malocclusion. However, previous studies[6,12~14] of adults have identified skeletal differences between Asians and Caucasians. Such differences in hard tissue may influence soft tissue growth. The present study was conducted in order to elucidate the typi-

Table 1 Distribution of samples according to developmental ages

Malocclusion	Class I		Class III	
Group	6-10 year	11-14 year	6-10 year	11-14 year
Number of subjects	25	21	29	33
Chronological age ($\bar{X}\pm$S.D.)	9.2±1.2	11.8±0.9	8.7±1.2	11.2±1.5
Developmental age ($\bar{X}\pm$S.D.)	9.6±0.9	11.9±0.8	9.9±0.9	12.2±1.0

cal course of development in the soft tissue profile of Japanese female children with mild Angle Class III malocclusion.

Materials and Methods

Subjects were 62 female patients ranging in age from 6 to 14 with mild Angle Class III malocclusion. Forty-six patients with Angle Class I malocclusion and well-balanced profiles with normal lip posture were used as controls. Lateral cephalograms were obtained from all patients at the Department of Orthodontics, Ohu University School of Dentistry. All cephalograms were obtained from the area of centric occlusion. The patients were instructed to keep their lips in light contact, and to tilt their heads horizontally.

Several aspects of hand-wrist roentgenograms were examined in order to determine the developmental stage of each subject. Details of the subjects are shown in Table 1.

None of the subjects had undergone orthodontic treatment. Subjects suspected to have pathosis and severe skeletal disharmony were excluded from the study.

A maxillofacial criterion of $-3<ANB<+1$ was taken to indicate Class III malocclusion. Class I malocclusion patients showed $+1<ANB<+4$.

The soft and hard tissue landmarks used in the present study are shown in Fig. 1.

The soft tissue of each patient was analyzed according to the methods described by Legan and Burstone (1980)[15] (Figs. 2 and 3), and by Subtelny (1959)[16] (Fig. 4). The data were cross-sectional.

Statistical analysis

Data were evaluated using the StatView statistical analysis software package (Abacus Concepts Inc.). Means and standard deviations were calculated for each group, and differences according to age and occlusal groups were evaluated using an unpaired t-test.

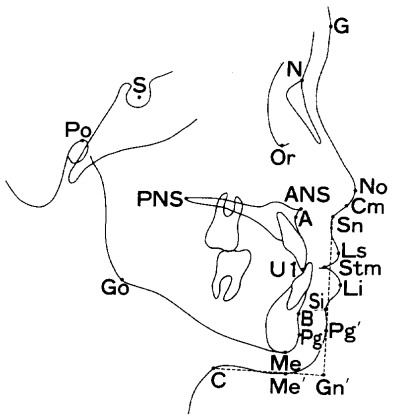

Fig. 1 Soft and hard tissue landmarks

Hard tissue : A, point A ; ANS, anterior nasal spine ; B, point B ; Go, gonion ; Me, menton ; N, nasion ; Or, orbitale ; Pg, pogonion ; PNS, posterior nasal spine ; Po, porion ; S, sella ; U1, Upper incisor

Soft tissue : C, cervical point, (innermost point between submental area and neck located at intersection of lines drawn tangent to neck and submental area) ; Cm, columella point, (most anterior point on columella of nose) ; G, glabella, (most prominent point in midsagittal plane of forehead) ; Gn', soft tissue gnathion, (mid-point between soft tissue pogonion and soft tissue menton, located at intersection of subnasale to soft tissue pogonion line and line from C to Me') ; Li, labrale inferious, (point indicating mucocutaneous border of lower lip) ; Ls, labrale superius, (point indicating mucocutaneous border of upper lip) ; Me', soft tissue menton, (lowest point on contour of soft tissue chin, perpendicular to horizontal plane through menton) ; No, nose, (tip of the nose) ; Pg', soft tissue pogonion, (most anterior point on soft tissue chin) ; Si, mentolabial sulcus, (point of greatest concavity in midline between lower lip (Li) and chin (Pg')) ; Sn, subnasale, (point at which nasal septum merges with upper cutaneous lip in midsagittal plane) ; Stm, stomion, (intersection of upper and lower lips)

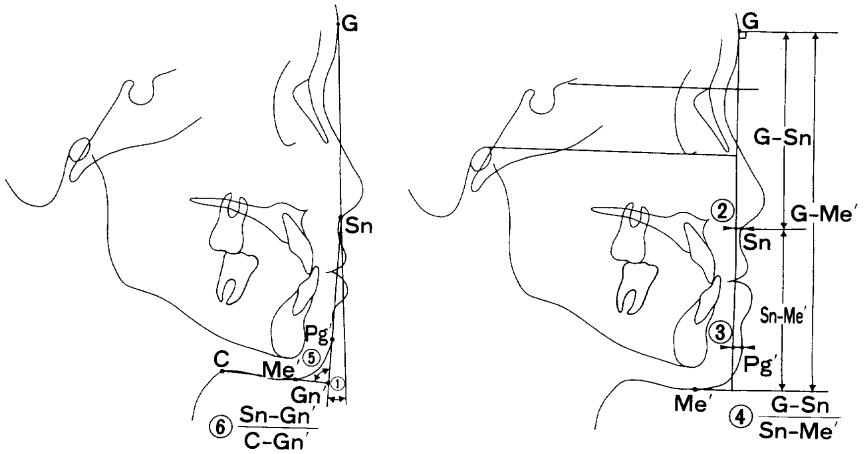

Fig. 2 Legan and Burstone soft tissue analysis of facial form

1. Facial convexity angle (G-Sn-Pg') ; 2. Maxillary prognathism (G-Sn (HP) *) ; 3. Mandibular prognathism (G-Pg'(HP)) ; 4. Vertical height ratio (G-Sn/Sn-Me'(HP)†) ; 5. Lower face-throat angle (Sn-Gn'-C) ; 6. Lower vertical height-depth ratio (Sn-Gn'/C-Gn')

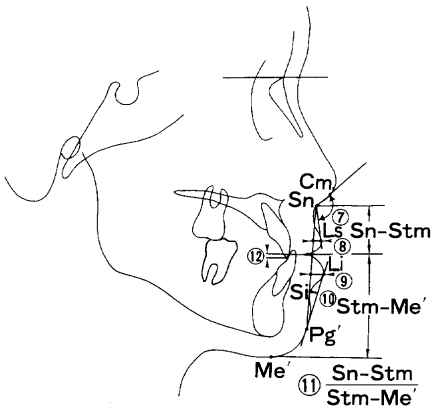

Fig. 3 Legan and Burstone soft tissue analysis of lip position

7. Nasolabial angle (Cm-Sn-Ls) ; 8. Upper lip protrusion (Ls to (Sn-Pg')) ; 9. Lower lip protrusion (Li to (Sn-Pg')) ; 10. Mentolabial sulcus (Si to (Li-Pg')) ; 11. Vertical lip-chin ratio (Sn-Stm/Stm-Me'(HP)) ; 12. Maxillary incisor exposure (Stm-U1)

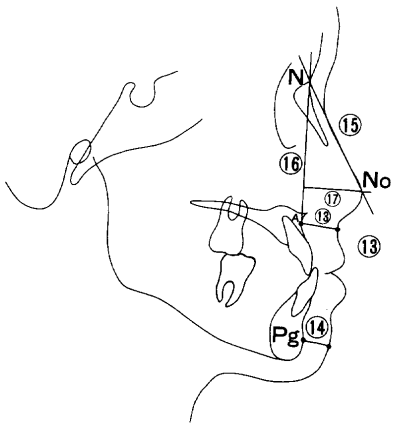

Fig. 4 Subtelny's soft tissue analysis of nose and thickness of soft tissue profile

13. Upper lip thickness overlying point A ; 14. Chin thickness overlying pogonion ; 15. Nose length ; 16. Vertical height of Nose ; 17. Anterior-posterior length of nose

Results

The means and standard deviations of each hard tissue measurement during pubertal growth in the Class I and Class III malocclusion groups are shown in Table 2. The statistical significance of these values is shown in Table 3.

The disproportionate growth of the mandible in Class III malocclusion groups is reflected by the significantly greater SNB angle observed in adolescence (mean : 82.0±3.2) compared with that observed during childhood (79.3±4.0).

The SNA angle, however, shows no significant difference between childhood (79.3±3.6) and adolescence in Class III malocclusion patients (80.6±

Table 2 Hard tissue measurements

Malocclusion	Class I				Class III			
Age	6-10 year		11-14 year		6-10 year		11-14 year	
Variables	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
SNA	80.8	2.6	82.3	2.6	79.3	3.6	80.6	2.7
SNB	77.9	2.4	79.7	2.8	79.3	4.0	82.0	3.2
ANB	3.1	1.1	2.7	0.9	0.0	1.3	−1.4	1.5
Facial Angle	85.4	1.2	87.5	2.0	88.7	3.1	89.6	3.0
Mand P Angle	29.2	3.0	28.7	3.6	28.6	4.4	28.2	5.1
Ramus Angle	81.8	3.7	82.0	3.1	80.6	4.5	80.9	4.3
U1 to FH	114.6	4.6	114.9	3.8	113.0	6.7	116.1	6.4
L1 to Mand P	92.0	5.2	90.1	6.7	88.5	5.5	86.2	6.0
Overbite(mm)	1.5	0.7	1.9	1.0	2.6	1.3	2.1	1.6
Overjet(mm)	2.2	0.8	3.0	1.1	−2.1	1.0	−1.8	0.8
FH to SN	8.0	2.6	8.1	1.6	8.8	3.1	8.1	3.1

Table 3 Statistical significance of hard tissue variables

	C I (6-10)/C I (11-14)	CIII(6-10)/CIII(11-14)	C I (6-10)/CIII(6-10)	C I (11-14)/CIII(11-14)
SNA	*	NS	*	*
SNB	*	**	NS	**
ANB	NS	***	***	***
Facial Angle	***	NS	***	**
Mand P Angle	NS	NS	NS	NS
Ramus Angle	NS	NS	NS	NS
U1 to FH	NS	*	NS	NS
L1 to Mand P	NS	NS	*	*
Overbite(mm)	NS	NS	***	NS
Overjet(mm)	**	NS	***	***
FH to SN	NS	NS	NS	NS

NS : Not Significant, *p : <0.05, **p : <0.01, ***p : <0.001

2.7).

The most significant difference between the Class III and Class I malocclusion groups was observed in the ANB angle ($P<0.001$). This significant difference reflects protrusion of the Class III mandible relative to the anterior cranial base in the 11-14 year-old group, and retrusion of the maxilla in the 6-10 year-old group. The facial angle showed no significant difference between childhood and adolescence in the Class III malocclusion group (Table 3).

With regard to the facial convexity angle, both the maxillary and mandibular prognathisms tended to increase with age in the Class I malocclusion group. However, in the Class III malocclusion group, the prognathisms tended to remain constant (Tables 4 and 5). In addition, the facial convexity angle was significantly smaller ($P<0.001$) and the mandibular prognathism was significantly larger in the Class III occlusion group ($P<0.05$).

The lower face/throat angle was significantly smaller in the Class III malocclusion groups than in the Class I malocclusion groups ($p<0.05$).

During childhood and adolescence, a significantly greater increase was observed in the thickness of the soft tissue covering the maxillary region ($p<0.001$) than in that of the soft tissue covering pogonion area. All nasal measurements varied significantly with age ($p<0.001$), although no significant difference in these measurements was observed between the Class I and Class III malocclusion groups (Tables 4 and 5).

Table 4 Soft tissue measurements

Malocclusion	Class I				Class III			
Age	6-10 year		11-14 year		6-10 year		11-14 year	
Variables	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
Facial convexity angle	10.0	3.9	11.8	2.6	4.6	4.0	3.5	5.8
Maxillary prognathism (mm)	2.6	3.4	4.9	2.1	2.3	2.9	2.8	4.0
Mandibular prognathism (mm)	−3.9	4.1	−1.0	4.5	1.2	6.3	2.4	6.1
Vertical height ratio	1.0	0.1	1.0	0.1	0.8	0.3	0.9	0.1
Lower face-throat angle	102.1	7.7	101.1	6.5	96.5	9.4	95.9	8.6
Lower vertical height-depth ratio	1.3	0.1	1.3	0.1	1.3	0.2	1.3	0.2
Nasolabial angle	92.7	10.0	92.0	8.0	89.1	12.5	90.8	12.0
Upper lip protrusion (mm)	7.3	1.6	7.2	2.3	7.1	1.7	6.5	2.5
Lower lip protrusion (mm)	6.3	2.2	9.1	14.0	8.3	2.0	7.6	2.9
Mentolabial sulcus (mm)	4.2	1.1	4.3	0.9	3.7	1.1	4.3	2.3
Vertical lip-chin ratio	0.5	0.0	0.5	0.1	0.5	0.1	0.5	0.1
Maxillary incisor exposure (mm)	1.1	1.5	1.5	1.2	1.8	1.3	1.6	2.2
Upper lip thickness (mm)	12.2	1.6	14.4	1.2	12.6	1.7	14.2	1.9
Chin thickness (mm)	11.7	1.6	12.6	2.0	12.3	2.1	13.1	2.1
Nose length (mm)	48.7	2.2	52.7	3.0	48.6	2.5	52.4	4.1
Vertical height of nose (mm)	41.5	1.8	45.1	3.1	42.6	2.8	45.9	3.9
Ant-post length of nose (mm)	23.7	1.6	26.3	2.6	23.4	1.4	26.3	2.7

Table 5 Statistical significance of soft tissue variables

	C I (6-10)/C I (11-14)	CIII (6-10)/CIII (11-14)	C I (6-10)/CIII (6-10)	C I (11-14)/CIII (11-14)
Facial convexity angle	*	NS	***	***
Maxillary prognathism (mm)	**	NS	NS	*
Mandibular prognathism (mm)	*	NS	***	*
Vertical height ratio	NS	*	*	NS
Lower face-throat angle	NS	NS	*	*
Lower vertical height-depth ratio	NS	*	NS	NS
Nasolabial angle	NS	NS	NS	NS
Upper lip protrusion (mm)	NS	NS	NS	NS
Lower lip protrusion (mm)	NS	***	***	NS
Mentolabial sulcus (mm)	NS	NS	*	NS
Vertical lip-chin ratio	NS	NS	*	*
Maxillary incisor exposure (mm)	NS	NS	*	NS
Upper lip thickness (mm)	***	***	NS	NS
Chin thickness (mm)	NS	NS	NS	NS
Nose length (mm)	***	***	NS	NS
Vertical height of nose (mm)	***	***	NS	NS
Ant-post length of nose (mm)	***	***	NS	NS

NS : Not Significant, *p : <0.05, **p : <0.01, ***p : <0.001

Discussion

Horizontal growth

In the Class III malocclusion group, the maxilla showed significant retrusion during childhood in comparison with the control group. This finding agrees with the reports of Susami (1967)[17] and Mitani, *et al.* (1993)[18] on Japanese subjects, and of Battagel[11] on Caucasian subjects. Nonetheless, Jacobson, *et al.* (1974)[19] reported that the maxillary complex shows little growth in patients with Class

III malocclusion. Some degree of maxillary deficiency has been reported to persist through adolescence[20] and adulthood[19] in these patients. However, Mitani, *et al.*[18] reported that the proportions of the maxillofacial structure in cases of Class III malocclusion are fairly similar to those of normal subjects after pubertal growth peak.

Subtelny[16] stated that the alveolar processes at point B exhibit anteroposterior stability after 9 years of age, while the supporting skeletal bases continue to grow and change with regard to their anteroposterior relationship. Our findings indicate similar growth rates in relation to the SNB and facial angles.

However, considerable potential for mandibular growth was observed in the 6-10 year-old group. Corresponding to an acceleration in mandibular growth, point B moved forward, and the lower face became more prognathic in this age group. As in previous studies[11,17,19], the Class III malocclusion group showed a smaller ANB angle.

In agreement with the majority of previous studies[11,17,19] the mandibular prognathism was observed to progressively increase until the end of growth. Thus, Class III malocclusion differs from Class I malocclusion not only with regard to mandibular protrusion, but also in its distally-positioned maxilla, which accentuates the typical skeletal profile of Class III malocclusion subjects[17].

Subtelny[1,16], Wisth[2], and Chaconas and Bartroff (1975)[21] affirm that the soft tissue profile, excluding the nose, tends to maintain its degree of convexity over time.

The present study reveals that in Class I malocclusion group, facial convexity significantly increases with age, but that in Class III malocclusion group, convexity of the soft tissue profile tends to remain stable. However, as expected, the convexity of the soft tissue is smaller in the Class III malocclusion group. This finding indicates that the facial profile of patients with mild Angle Class III malocclusion becomes more concave with age.

The skeletal structure in cases of Class III malocclusion is reflected by the facial soft tissue profile[22]. In the present study, the Class III malocclusion group showed an acute face/throat angle. This observation probably reflects protrusion of the mandible relative to the maxilla.

In both malocclusion groups, the thickness of the soft tissue overlying point A in the middle third of the face was found to increase at a greater rate with increasing age than that of the soft tissue overlying the pogonion in the lower third of the face. These findings are in agreement with those of Wisth[2] and Subtelny[16]. Based on these results, it appears that soft tissue could be used to camouflage maxillo-mandibular disharmony, thus, reducing the apparent prognathism of the mandible.

Nose

In both malocclusion groups, incremental growth of the nose was observed with increasing age[23~25]. In contrast to the findings of Chaconas (1969)[24], who reported that Class III malocclusion patients tend to have longer noses with greater anterior-posterior depth, the results of the present study indicate that the nose shows normal development in Class III malocclusion patients.

However, a small number of Class III subjects in Chaconas's study[24] could not be evaluated. Aigase, *et al.*[26] reported that the anterior-posterior nose length was similar between Class III subjects and normal subjects.

Lips and dentition

The Class III malocclusion subjects in Kajikawa's study (1979)[22] showed a smaller nasolabial angle after anterior crossbite treatment, whereas Nakashima, *et al.*(1980)[27] reported no change in this angle. In accordance with the Nakashima report, the present study revealed no significant difference in the nasolabial angle between patients who had undergone surgery and patients who had not undergone surgery. These conflicting results can be explained by differences in the subjects observed. In Kajikawa's study[22], the subjects required surgical correction, and dental compensation was clearly observed. In Nakashima's study, as well as in the present study, the subjects only showed mild anterior crossbite malocclusion.

As is typical in cases of Class III malocclusion[11,19], the lower incisors were found to be more retroinclined than those in the control subjects. However, the upper incisors did not show consistent proclination. This disparity can be attributed to the fact that in the present study, several of the Class III malocclusion cases were not severe, sharing a number of physical characteristics with the Class I malocclusion group.

Most authors concur that the soft tissue overlying the dentition tends to maintain a close positional relationship with the dentoalveolar complex[1,11,28]. In

the present study, the angularity of the upper and lower incisors did not appear to influence the morphology of the overlying soft tissue.

As stated above, the soft tissue profile of patients with mild Angle Class III malocclusion has been characterized by maxillary retrusion, mandibular protrusion, and an acute chin angle, which conceal the maxillo-mandibular disharmony due to increased upper lip thickness with age. The primary features of the soft tissue profile in such cases can be clearly observed during childhood. Because anterior growth of the maxilla affects the formation of the skeletal Class III structure, efforts should be made to ensure anterior development of the maxilla.

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