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Cephalometric analysis for Chinese adults with skeletal 3 craniofacial morphology

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Using Steiner analysis and Wits appraisal, we examined the facial characteristics of 21 male and 19 female Chinese adults with reverse occlusion selected from a clinic in Ningbo City in Zhejiang, China. Angular and linear measurements were determined. In comparison with pre-existing measurement values of Chinese adults with skeletal 2 malocclusion, all measurement items indicated significant differences. Compared to Japanese, the ∠SNA, ∠SNB, U1 to NA (mm), U1 to NA (angle) and the Interincisal angle were larger and ∠ANB, L1 to NB (mm), L1 to NB (angle), ∠Occl to SN and ∠GoGn to SN were smaller. These results demonstrate that although maxillary undergrowth was not observed, overgrowth was seen in the mandible. We found that, vertically, compared to Chinese adults with a skeletal 1 malocclusion, those with a skeletal 3 had a short anterior facial height and a low angle in their maxillofacial morphology. It was also found that although the lower anterior facial height was shorter than that of Japanese, it was longer than that of Caucasians. In the denture pattern, Chinese adults with a skeletal 3 malocclusion, when compared to a skeletal 1, had more pronounced labial inclination of the maxillary incisors and lingual inclination of the mandibular incisors. (J Osaka Dent Univ 2022; 56: 43-49)

Key words: Cephalometric radiography; Steiner analysis; Chinese adults; Skeletal 3 craniofacial morphology

INTRODUCTION

In cases of adult reverse occlusion, the size of the alveolar base of the mandible may be small and inconsistent with the size of the teeth, or the teeth may be too large even if the size of the mandible is not an issue. In cases in which such a dental discrepancy exists, tooth extraction is often done using the multi-bracket method in order to achieve an ideal occlusal state. If there is an abnormality in the skeletal pattern or a serious skeletal abnormality where using orthodontic treatment alone to improve occlusion would likely be difficult, these cases would be candidates for surgical orthodontic treatment. Understanding the vertical and horizontal maxillomandibular positional relationship, as well as other factors such as the position and inclination of the teeth, plays an important role when performing orthodontic treatments, regardless of whether it is combined with surgical orthodontic treatment.

Regarding the racial characteristics of malocclusion, Graber[1] reported that there was a significant racial difference and that skeletal 3 malocclusions were more likely to be found only among Danish and Chinese. In patients with abnormal vertical or horizontal occlusal relationships, answering questions related to vertical and horizontal skeletal problems such as “after what age range do skeletal abnormalities become obvious?” and “what are the contributing morphological factors?” are extremely important in clinical orthodontics. However, these questions have not yet been sufficiently answered. Currently, research on the relationship between the maxillofacial complex and dentition, especially among Chinese, has not yet been sufficiently conducted.

In this study, we determined the characteristics of the maxillofacial morphology of mandibular prognathism among Chinese adults experiencing vertical and horizontal issues with their skeletal pattern. Additionally, for the purpose of contributing to clinical orthodontics, we also compared and examined each measurement item used in Steiner analysis[2] and conducted a Wits appraisal,[3, 4] which are widely used for setting treatment goals in the field of orthodontics.

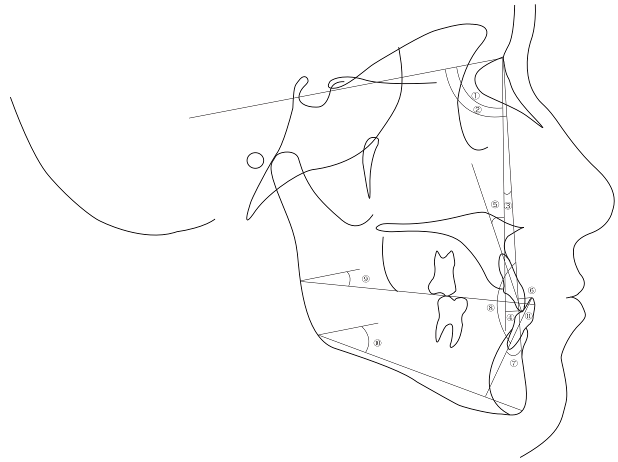

Fig. 1 Measurements on the lateral cephalogram. ① ∠SNA (angle), ② ∠SNB (angle), ③ ∠ANB (angle), ④ U1 to NA (mm) (shortest distance from edge of the maxillary central incisor to the NA line), ⑤ ∠U1 to NA (angle) (angle formed by the NA line and the axis of the maxillary central incisor), ⑥ L1 to NB (mm) (shortest distance from edge of the mandibular central incisor to the NB line), ⑦ ∠L1 to NB (angle) (angle formed by the NB line and the axis of the mandibular central incisor), ⑧ ∠Interincisal (angle), ⑨ ∠Occlusal to SN (angle), ⑩ ∠GoGn to SN (angle), ⑪ Wits appraisal (mm).

MATERIALS AND METHODS

Subjects

The subjects of this study, whose chief complaint was reverse occlusion, visited an orthodontic clinic in Ningbo City in Zhejiang, China. Among the adult patients who received orthodontic treatment alone, a total of 40 people were selected (21 males and 19 females) who had an ∠ANB of 0.5° or less, a negative overjet, no observable abnormalities in the number of teeth or teeth morphology, and no history of orthodontic treatment.

Methods

Using cephalograms of Chinese adult mandibular prognathism patients selected based on the above criteria, 11 measurement items used in Steiner analysis[2] were determined and a Wits appraisal[3, 4] was conducted (Fig. 1). Student's *t*-test was performed for each measured value and the values were then compared and evaluated against pre-existing Chinese,[5, 6] Japanese,[7] and Caucasian measurements values[8] (Table 1).

RESULTS

In this study, when comparing adult Chinese males and females with mandibular prognathism, it was found that, compared to females, males had significantly larger values for ∠SNA, ∠SNB, U1 to NA (angle), L1 to NB (mm) and L1 to NB (angle). However, the Interincisal angle, ∠Occl to SN and ∠GoGn to SN were significantly smaller for males. Next, a comparison of measured values taken from Chinese adults with mandibular prognathism and the pre-existing measurement values for Chinese adults with skeletal 2 malocclusion indicated significant differences for all measurement items. When compared to the skeletal 2 values for Chinese chil-

Table 1 Subjects in this study

Subjects	Skeletal 3 Chinese adults	Skeletal 2 Chinese adults	Skeletal 2 Chinese children	Skeletal 1 Chinese children	Skeletal 1 Japanese children
Number	40 (21 M, 19 F)	70 (35 M, 35 F)	100 (50 M, 50 F)	60 (30 M, 30 F)	90 (40 M, 50 F)
Age range	18 y 6 m-28 y 2 m	19 y 0 m-53 y 0 m	10 y 9 m-15 y 1 m	9 y 11 m-13 y 10 m	7 y 11 m-12 y 4 m
Mean age	22 y 2 m	23 y 5 m	12 y 3 m	11 y 5 m	10 y 9 m

Table 2 Comparison of skeletal 3 Chinese children with pre-existing values for Japanese and Caucasians

Parameter	Skeletal 3 Chinese adults (M) n=21	Skeletal 3 Chinese adults (S) n=19	Skeletal 3 Chinese adults (M and F) n=40	t-test (M and F)
∠SNA (angle)	83.40±4.04	80.78±4.57	82.26±4.47	*
∠SNB (angle)	84.79±3.38	82.76±4.79	83.91±4.18	*
∠ANB (angle)	−1.38±1.87	−1.98±1.75	−1.64±1.84	NS
U1 to NA (mm)	7.46±2.40	6.70±2.43	7.13±2.44	NS
U1 to NA (angle)	33.17±5.37	30.81±5.78	32.14±5.68	*
L1 to NB (mm)	5.76±2.61	4.36±2.14	5.15±2.52	*
L1 to NB (angle)	25.95±7.03	22.65±6.31	24.51±6.92	*
Po to NB (mm)	1.07±0.65	1.27±0.78	1.16±0.72	*
Interincisal (angle)	122.27±10.68	128.51±11.13	124.99±11.31	*
Occl to SN (angle)	11.44±5.59	15.15±6.29	13.06±6.19	*
GoGn to SN (angle)	26.97±6.90	31.66±6.96	29.01±7.31	*
Wits appraisal (mm)	−5.81±3.30	−7.32±3.01	−6.47±3.27	*

Mean±SD, NS: Not significant, *$p<0.05$.

Table 3 Comparison of pre-existing measurement values for Chinese and Japanese

Parameter	Skeletal 3 Chinese adults n=40	Skeletal 2 Chinese adults n=70	Skeletal 2 Chinese children n=70	Skeletal 1 Chinese children n=60	t-test (Skeletal 3 Chinese adults and Skeletal 2 Chinese adults)	t-test (Skeletal 3 Chinese adults and Skeletal 2 Chinese children)	t-test (Skeletal 3 Chinese adults and Skeletal 1 Chinese children)
∠SNA (angle)	82.26±4.47	84.71±3.34	81.24±2.84	83.52±3.62	*	*	NS
∠SNB (angle)	83.91±4.18	78.28±3.70	75.46±2.84	80.38±3.39	*	*	*
∠ANB (angle)	−1.64±1.84	6.43±1.60	5.78±0.97	3.15±1.51	*	*	*
U1 to NA (mm)	7.13±2.44	5.40±2.66	7.15±3.20	6.08±1.70	*	NS	*
U1 to NA (angle)	32.14±5.68	21.21±7.93	29.98±7.15	25.22±4.59	*	*	*
L1 to NB (mm)	5.15±2.52	8.46±2.97	7.49±2.72	6.89±1.48	*	*	*
L1 to NB (angle)	24.51±6.92	32.91±6.08	30.20±6.39	29.49±4.61	*	*	*
Interincisal (angle)	124.99±11.31	120.18±12.05	114.15±8.42	122.14±6.83	*	*	*
Occl to SN (angle)	13.06±6.19	17.64±4.90	17.90±4.71	16.58±3.73	*	*	*
GoGn to SN (angle)	29.01±7.31	35.87±6.74	35.50±3.08	32.17±4.59	*	*	*

Table 4 Comparison of skeletal 3 Chinese children with pre-existing values for Japanese and Caucasians

Parameter	Skeletal 3 Chinese adults	Skeletal 1 Japanese children	Caucasians
∠SNA (angle)	82.26±4.47	81.3±3.2	82
∠SNB (angle)	83.91±4.18	76.8±3.0	80
∠ANB (angle)	−1.64±1.84	4.5±1.7	2
U1 to NA (mm)	7.13±2.44	5.9±1.8	4
U1 to NA (angle)	32.14±5.68	24.1±4.9	22
L1 to NB (mm)	5.15±2.52	7.8±2.1	4
L1 to NB (angle)	24.51±6.92	31.2±5.6	25
Po to NB (mm)	1.16±0.72	1.16±2.1	2
Interincisal (angle)	124.99±11.31	120.3±8.5	131
Occl to SN (angle)	13.06±6.19	20.0±3.7	14
GoGn to SN (angle)	29.01±7.31	36.2±4.5	22

dren during growth, a significant difference was found in all items except for U1 to NA (mm). A significant difference was found in all items except ∠SNA when compared with the measured values taken from Chinese children during growth with skeletal 1 malocclusion.[5, 6] According to Miura,[7] when compared with pre-existing measurement values collected from Japanese with skeletal 1 malocclusion still undergoing childhood development, on average, ∠SNA, ∠SNB, U1 to NA (mm), U1 to NA (angle) and the Interincisal angle were larger, and ∠ANB, L1 to NB (mm), L1 to NB (angle), ∠Occl to SN and ∠GoGn to SN were smaller. Compared with the pre-existing measurement values for Caucasians,[8] ∠SNB, U1 to NA (mm), U1 to NA (angle), L1 to NB (mm) and ∠GoGn to SN were larger, and ∠ANB, Interincisal angle and ∠Occl to SN were smaller (Tables 2-4).

DISCUSSION

Growth and development of skeletal 3 malocclusion

Maxilla

Because the Chinese adult mandibular prognathism (skeletal 3) data used in this study is not longitudinal, it is not possible to compare the growth and development of individual participants. Accordingly, the growth and development of skeletal 3 malocclusion was evaluated using previously obtained skeletal 1 and 2 malocclusion measurements. Regarding the maxilla of skeletal 3 malocclusion, Susami[9] found that the maxilla was retracted in young people and this tendency continued until adulthood. Sawa[10] studied the growth of the maxillofacial skeleton in cases of reverse occlusion and, by the age of 6 or 7, the maxilla tended to be small, with slightly slower growth being reported thereafter. Mitani *et al*.[11] also showed that patients with mandibular prognathism often had the maxilla in the posterior position at 6 years of age and that tendency continued with age. In a Steiner analysis, the measurement item used to evaluate the maxilla is ∠SNA.

In this study, the measured values taken from Chinese adults with skeletal 3 malocclusion were smaller than those taken from Chinese adults with skeletal 1 malocclusion. Because of this, similar to previous reports on Japanese, the maxilla of Chinese adults with skeletal 3 malocclusion showed poor growth from early childhood. After that, it was found that the amount of growth of the maxilla was small. ∠SNA depends on the amount of growth of the anterior cranial base. Susami,[9] Hopkin *et al.,*[12] and Sawa[10] reported that the growth of the anterior cranial base is smaller in a skeletal 3 malocclusion compared to a skeletal 1. If the amount of growth of the anterior cranial base is small, then the ∠SNA will be large. The measurements collected from Chinese adults with a skeletal 3 malocclusion showed a larger ∠SNA compared with those from other groups, such as Chinese children going through development with a skeletal 2 malocclusion and Japanese children going through development with a skeletal 1 malocclusion. It is thought that the cause of this may be the amount of growth in the anterior cranial base. Additionally, another contributing factor may be that the amount of change of the ∠SNA may also be influenced by the amount of growth of the anterior cranial base. In addition, the ∠SNA showed a small value in comparison with the measured values taken from Chinese adults with a skeletal 2 malocclusion, suggesting that the amount of maxillary growth of patients with mandibular prognathism is small compared to the skeletal pattern of patients with maxillary protrusion.

Mandible

Mitani *et al.*[11] Sawa,[10] and Takeuchi *et al.*[13] reported that there was no significant difference in regards to the amount of skeletal 3 malocclusion mandibular growth that occurs after the onset of puberty or up until the pubertal growth peak. On the other hand, Susami[9] reported that there was overgrowth, indicating a disagreement in the literature. In a Steiner analysis, ∠SNB is the measurement item used to evaluate the mandible. The measured ∠SNB of Chinese adults with skeletal 3 malocclusion were larger than those previously collected from Chinese children during growth with skeletal 1 and 2 malocclusion. Sugawara *et al.*[14] and Sato *et al.*[15] compared changes in growth of the skeletal 3 group and the skeletal 1 group in late puberty, and reported no significant difference between the two groups.

If the changes in mandibular growth in a person with a skeletal 3 malocclusion is the same as someone with a skeletal 1 malocclusion, then excessive mandibular growth in a person with a skeletal 3 malocclusion could not have occurred during late puberty. Since the measured values collected in this study of the mandibles of Chinese adults with a skeletal 3 malocclusion were also excessively large, based on previous reports, it was hypothesized that the sizes of the mandibles measured before puberty would be larger compared to patients with a skeletal 1 malocclusion.

Skeletal 3 malocclusion craniofacial morphology

Chan[16] measured the maxillofacial morphology of Chinese with a skeletal 1 malocclusion aged 18-33 years using each item in Taylor's Alabama analysis.[17] Table 5 shows the measurement items that are related to items in the Steiner analysis. For Chinese adults with a skeletal 3 malocclusion skeletal type, the ∠SNA and ∠ANB were small, and the ∠SNB was large horizontally. The measured ∠SNA of Chinese adults with a skeletal 3 malocclusion were smaller than those with a skeletal 1. However, since there was no difference between the skeletal 3 in this study and the skeletal 1 in reports published by Iizuka *et al.*[18] and Nagaoka *et al.,*[19] as well as between the values from previously conducted studies with Caucasian participants,[8] it cannot be said that there was undergrowth of the maxilla in the Chinese adults with a skeletal 3 malocclusion. At the same time, it was found that Chinese adults with a skeletal 1 malocclusion had overgrowth, which resulted in the ∠SNA of skeletal 3 being smaller. Overgrowth was observed in the mandible.

Table 5 Comparison of Wang's results with Chan's results

Parameter	Skeletal 3 Chinese adults	Skeletal 1 Chinese adults
∠SNA (angle)	82.26±4.47	83.78±3.49
∠SNB (angle)	83.91±4.18	79.88±3.84
∠ANB (angle)	−1.64±1.84	3.90±1.96
U1 to NA (angle)	32.14±5.68	24.1±4.9
Interincisal (angle)	124.99±11.31	120.3±8.5

Vertically, the ∠GoGn to SN of the Chinese adults with a skeletal 3 malocclusion was significantly smaller than the ∠SN-MP value reported by Chan.[16] Based on this, it was found that the lower anterior facial height was shorter and there was a low angle in the maxillofacial morphology compared to a skeletal 1 malocclusion. Moreover, the values were smaller than the measured values of Japanese adults with a skeletal 1 malocclusion, but larger than the previously collected measured values for Caucasians. Because of this, it can be said that Chinese adults with a skeletal 3 malocclusion had a shorter, lower anterior facial height compared to Japanese with a skeletal 1 malocclusion, but a longer, lower anterior facial height compared to Caucasians. The dental impressions of Chinese adults with a skeletal 3 malocclusion showed that they had larger U1 to NA (angle) and Interincisal angle compared with skeletal 1 malocclusion, and labial inclination of maxillary incisors and lingual inclination of mandibular incisors. In addition, the ∠Occl to SN also had a small value. In the maxillofacial skeleton, there was a correlation between the occlusal plane angle and the mandibular plane angle. If the ∠GoGn to SN is small, then the ∠Occl to SN will also become smaller, which was observed in this study.

Orthodontic and surgical orthodontic treatment

While measurements such as ∠ANB, Facial plane angle, Gonial angle, Y-axis (angle), Go-Me (mm), Wits appraisal (mm), and anterior facial height are listed as criteria for determining whether surgical orthodontic treatment is appropriate, of these, ∠ANB, which was created by Riedel,[20] is often used. Valko[21] stated that a ∠ANB value of less than −2° is an indication for surgical orthodontic treatment. However, Niwa *et al.*[22] who surveyed Japanese, stated that the indication was 0.5° or less, while Matsuura *et al.*[23] stated that it was less than 0°. However, as reported by Freeman,[24] Deguchi,[25] and Matsuda *et al.*,[26] the ∠ANB is not always reliable when the anteroposterior positional relationship between points N and A is not within the normal range. As a solution to these problems, Bishara *et al.*[27] proposed that it is necessary to utilize both the ∠ANB and Wits appraisal when evaluating the anteroposterior positional relationship of the maxilla and mandible with normal occlusion. Wits appraisal is based on the occlusal plane and since the anteroposterior positional relationship of the maxillary and mandibular apical bases can be evaluated, it is reported to be an analytical method that represents the limits of orthodontic treatment relatively well.[28-31]

Niwa *et al.*[22] described the need for comprehensive analysis that takes into account angle and distance measurements when determining the indication criteria for cases with many craniofacial morphological abnormalities that require surgical correction. They also reported that the Wits appraisal indication value for surgical orthodontic treatment should be −6.5 mm or less. In the cases evaluated in this study, the ∠ANB averaged −1.64°, and ranged from −7° to −0.4°, while the Wits appraisal averaged −6.47 mmand ranged from −10.8 mm to −1.4 mm. Based on the measured values, it is possible that the cases in this study also included subjects who barely qualified for surgical orthodontic treatment. At the same time, Chinese adults with a skeletal 3 malocclusion had a short anterior facial height and a low angle maxillofacial morphology. Moreover, since there were clear signs of a labial inclination of the maxillary incisors and a lingual inclination of the mandibular incisors, it is suggested that the criteria for determining whether surgical orthodontic treatment is appropriate may be different for Chinese than for Japanese.

CONCLUSION

In this study, we focused on the maxillofacial characteristics of Chinese adults with skeletal 3 craniofacial morphology. The skeletal and denture patterns were examined by analyzing values obtained from a Steiner analysis and a Wits appraisal. Although maxillary undergrowth was not observed in Chinese adults with a skeletal 3 malocclusion, overgrowth was observed in the mandible. It was found that, vertically, compared to Chinese adults with a skeletal 1 malocclusion, those with a skeletal 3 had a short anterior facial height and a craniofacial morphology with a low angle. It was also found that although the lower anterior facial height was shorter than that of Japanese with a skeletal 1 malocclusion, it was longer than that of Caucasians. The dental impressions of Chinese adults with skeletal 3 malocclusion, when compared to those with skeletal 1, had more pronounced labial inclination of the maxillary incisors and lingual inclination of the mandibular incisors.

This study was conducted with the approval of the Ethics Committee of Osaka Dental University (Approval No. 111186-0).

REFERENCES

1. Graber TM. Orthodontics. Philadelphia: Saunders, 1972: 204-210.
2. Steiner CC. Cephalometrics for you and me. *Am J Orthod* 1953; **39**: 729-755.
3. Jacobson A. The Wits appraisal of jaw disharmony. *Am J Orthod* 1975; **67**: 125-138.
4. Jacobson A. Application of the Wits appraisal. *Am J Orthod* 1976; **70**: 179-189.
5. Gon G, Zhao J, Matsumoto N. A study of Steiner analysis for Chinese children with maxillary protrusion. *J Osaka Dent Univ* 2021; **55**: 65-72.
6. Chen YW, Inami K, Matsumoto N. A study of Steiner cephalometric norms for Chinese children. *J Osaka Dent Univ* 2015; **49**: 237-244.
7. Miura F, Inoue N, Suzuki K. Cephalometric standards for Japanese according to the Steiner analysis. *Am J Orthod* 1965; **51**: 288-295.
8. Steiner CC. Cephalometrics in clinical practice. *Angle Orthod* 1959; **29**: 8-29.
9. Susami R. A cephalometric study of dentofacial growth in mandibular prognathism. *J Jpn Orthod Soc* 1967; **26**: 1-34. (Japanese)
10. Sawa S. Roentogeno-cephalometric study on the dentocraniofacial growth on the individuals with reversed occlusion. *J Jpn Orthod Soc* 1978; **37**: 237-268. (Japanese)
11. Mitani H, Sakamoto T, Kuwahara M. A longitudinal cephalometric study of the mandibular prognathism of Japanese girls. *The Nippon Dental Review* 1979; **442**: 123-127. (Japanese)
12. Hopkin GB, Houston WJB, James GA. The cranial base as an etiological factor in malocclusion. *Angle Orthod* 1968; **38**: 250-255.

13. Takeuchi Y, Genba Y, Suzuki S, Nakamura S. Longitudinal growth study on untreated cases with reversed occlusion. *J Jpn Orthod Soc* 1979; **38**: 14-29. (Japanese)
14. Sugawara J, Tsuchikawa T, Soya T, Mitani H. Late adolescent growth of skeletal Class Ⅲ craniofaces in Japanese girls －average growth from 14 to 17 years of age based on longitudinal data－. *J Jpn Orthod Soc* 1979; **42**: 399-408. (Japanese)
15. Sato K, Sugawara J, Mitani H. Longitudinal study on average craniofacial growth of skeletal Class Ⅲ girls in late adolescent period －possibility of early orthognathic surgery－. *J Jpn Orthod Soc* 1979; **48**: 21-28. (Japanese)
16. Chan GKH. A cephalometric appraisal of the Chinese (Cantonese). *Am J Orthod* 1972; **61**: 279-285.
17. Taylor WH, Hitch HP. The Alabama analysis. *Am J Orthod* 1966; **52**: 245-265.
18. Iizuka T, Ishikawa F. Points and landmarks on head plates. *J Jpn Orthod Soc* 1957; **16**: 60-75. (Japanese)
19. Nagaoka K, Kuwabara Y. Normal standards for various Roentgen cephalometric and cast model analyses in present day Japanese adults: part 1. *J Jpn Orthod Soc* 1993; **52**: 467-480. (Japanese)
20. Ridel RA. The relation of maxillary structures to cranium in malocclusion and in normal occlusion. *Angle Orthod* 1952; **22**: 142-145.
21. Valko RM, Sather AH, Turlingion RG. Indication for selecting surgical or orthodontic correction of mandibular protrusion. *J Oral Surg* 1968; **26**: 230-238.
22. Niwa T, Ozawa M, Teramachi K, Deguchi T. Evaluation of ANB angle to diagnostic criterion in orthognathic surgery for skeletal mandibular prognathism. *J Jpn Stomatol Soc* 1984; **33**: 486-490. (Japanese)
23. Matsuura C, Miyazono H, Morishita T, Nakata S, Nakashima A. Comparison of maxillofacial morphology in patients with mandibular prognathism treated with orthognathic surgery or orthodontics. *J Nishi-Nippon Orthod Soc* 2001; **45**: 143-149. (Japanese)
24. Freeman RS. Adjusting A-N-B angles to reflect the effect of maxillary position. *Angle Orthod* 1981; **51**: 162-171.
25. Deguchi T. Adjustment of FH-SN angle and ANB angle to cephalometric analysis of horizontal jaw relation. *J Jpn Orthod Soc* 1982; **41**: 757-764. (Japanese)
26. Matsuda Y, Deguchi T. Diagnosis for orthognathic surgery －calibration method of ANB angle－. *J Jpn Stomatol Soc* 1983; **32**: 291-298. (Japanese)
27. Bishara SE, Fahl JA, Peterson LC. Longitudinal changes in the ANB angle and Wits appraisal: clinical implications. *Am J Orthod* 1983; **84**: 133-189.
28. Nishiyama K, Imai T, Ueno T, Ando Y, Okamoto T, Sato Y, Yamamoto T, Nakamura S. Dentofacial morphological differences between surgically treated patients and orthodontically treated patients with skeletal Class Ⅲ malocclusion who exhibited similar antero-posterior jaw relationship. *J Jpn Orthod Soc* 1998; **57**: 247-257. (Japanese)
29. Henmi M, Takeshita H, Nakamura Y, kuwahara Y. A-B plane to mandibular plane angle: an adjunct to differential diagnosis of mandibular prognathism. *Bull Jpn Soc Jaw Deform* 1990; **9**: 121-123. (Japanese)
30. Muramatsu H, Noma H, Uchida S, Yamamura S, Manabe O, Maezawa S, Namura S. Morphological studies of skeletal mandibular prognathism －morphological difference of dentofacial complex between orthodontic cases and orthognathic surgical cases and a discussion of orthognathic surgery－. *J Jpn Orthod Soc* 1986; **45**: 646-657. (Japanese)
31. Watanabe M, Sugawara J, Endo N, Mitani H. Variation of skeletal facial pattern in acceptable occlusion －treatment goals of orthognathic surgery－. *J Jpn Orthod Soc* 1995; **54**: 170-176. (Japanese)