Dental Arch Widths and Mandibular-Maxillary Base Width in Class III Malocclusions with Low, Average and High MP-SN Angles

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ABSTRACT

Objective: To analyze the development of the dental arches and skeletal mandibular-maxillary bases in untreated Class III malocclusions with low averages and high mandibular plane angles in subjects aged 10 to 14.

Materials and Methods: The records of 50 untreated Japanese girls with Class III malocclusions at age 10 were selected from the files of patients pending orthodontic surgery. The patients included those with low (≤27°), average (27° through 37°) and high (>37°) mandibular plane angles. The maxillary skeletal base width, biantegonial width, and maxillary and mandibular intermolar width were determined on posteroanterior cephalograms obtained at annual intervals when subjects were between 10 and 14 years of age. The difference between the maxillary and mandibular intermolar width was also calculated and reported.

Results: All skeletal and dental transverse widths in the high-angle group were significantly smaller than those in the low-angle group ($P < .05$) from ages 10 to 14. On the other hand, the maxillary to mandibular molar difference was the same for the three groups ($P > .05$) at each age. The deviations in molar differences did increase from age 10 to age 14 in all three groups.

Conclusion: Mandibular plane angles might play a stronger role in the transverse skeletal growth of the maxilla and the mandible than the transverse dental growth of the maxilla and the mandible.

KEY WORDS: Transverse development; Class III; Cephalometric analysis

INTRODUCTION

Class III malocclusion is a common clinical problem among Asians. Yang [1] discovered that 40–50% of orthodontic patients in Korea sought treatment for Class III malocclusions. Kitai et al[2] reported that about 5–20% of the Japanese population had characteristics of Class III malocclusion. Johnson et al[3] discovered that 23% of Chinese children had Class III malocclusions.

The dentofacial disharmony associated with Class III malocclusion is challenging from both the diagnostic and the treatment aspects. Treatment decisions and their success or failure rely heavily on the future growth potential of the Class III individual.[4,5] An understanding of craniofacial growth behavior in Class III patients will help in determining treatment timing and mechanics.

Most previous growth studies have used lateral cephalometric radiographs to analyze changes in the vertical and sagittal dimensions of the mandibular-maxillary base.[6–10] Evaluation of the transverse structure of the mandibular-maxillary base is needed for a comprehensive dentofacial analysis.[11–13] The inclination of the mandibular plane is a major determinant of the vertical dimension of a face (long, average, or short). A person with a larger MP-SN angle usually has a long face type, and a person with a smaller MP-SN angle usually has a short face type. Many reports have suggested a possible link between the develop-

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ments of the maxillofacial complex in the transverse dimensions and different facial types.[14–18]

Unfortunately, few studies have investigated the transverse structure of the mandibular-maxillary base in Class I malocclusion with low, average, and high MP-SN angles.[19] There is no definitive study of the dentoskeletal characteristics in the transverse plane of growing subjects with Class III malocclusion.

Hence, the aim of the present study was to use longitudinal data to analyze the mandibular-maxillary bases and dental arches in Class III cases with low, average, and high MP-SN angles from 10 to 14 years of age. The transverse development of the skeletal mandibular-maxillary bases was depicted in addition to gain insight into the underlying skeletal growth patterns.

MATERIALS AND METHODS

The longitudinal posteroanterior radiographs of 50 untreated Japanese girls with Class III malocclusions at age 10 were selected from the files of the Orthodontic Department at Niigata University Medical and Dental Hospital. All use of human subjects and information in this study has received approval from the Niigata University of Japan (permission no. NV20051120-1).

The records were recorded during the years 1985 to 1998, and all patients were pending orthodontic surgery. The patients included those with low ($\leq$27°; n = 16), average (27° through 37°; n = 15) and high (>37°; n = 19) mandibular plane angles. Only Japanese females were selected as the present subjects because there are growth differences by gender and race. The Class III subjects exhibited bilateral Class III molar and canine relationships and a skeletal Class III relationship. Serial cephalometric films were exposed annually when subjects were at ages 10, 11, 12, 13, and 14 years.

Twelve of these Class III malocclusion patients had no need for orthodontic treatment during this period, and the others did not receive orthodontic treatment for personal reasons, such as unwillingness to undergo early treatment. Exclusion criteria included systemic disease and marked mandibular asymmetry.

The mean MP-SN angles at about age 10 were 23.39 ± 2.12° for the low-angle group, 32.29 ± 2.46° for the average-angle group and 42.12 ± 2.38° for the high-angle group. The mean ANB angle was −1.22 ± 1.45° for the low-angle group, −1.37 ± 1.78° for the average-angle group and −1.25 ± 1.46° for the high-angle group.

Posteroanterior cephalograms were taken by a standardized technique with the jaws in centric occlusion. The distance from the anode to the midtransverse plane of the patient was 150 cm, and the distance from the midtransverse plane to the film was 15 cm. All posteroanterior cephalometric radiographs were scanned (Epson 2200, Epson Inc. Tokyo, Japan) and imported to analysis software (Igensoft Company, Shanghai, China). The landmarks were digitized by the first author and then linear items were measured by computer. The landmarks used in this study are shown in Figure 1.

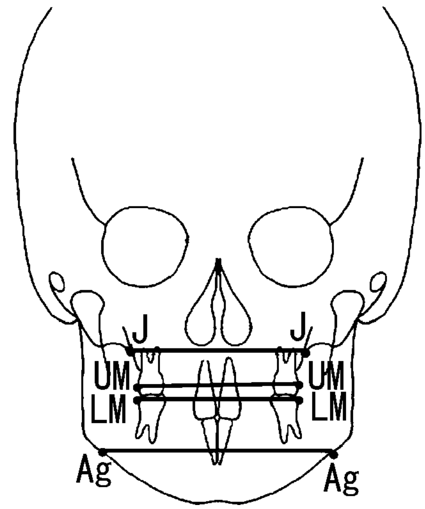

Figure 1. Posteroranterior cephalometric landmarks used in the present study. J indicates jugale, the intersection of the outline of the tuberosity of the maxilla and the zygomatic buttress; Ag, antegonion, the lateral inferior margin of the antegonial protuberances; UM, upper molar, the most prominent lateral point on the buccal surface of the upper first molar; LM, lower molar, the most prominent lateral point on the buccal surface of the lower first molar; J-J, maxillary skeletal base width, the width of the maxilla from bilateral points on the jugal process at the intersection of the outline of the tuberosity of the maxilla and the zygomatic buttress; Ag-Ag, mandibular skeletal base width, the distance between both antegonia; UM-UM, upper intermolar width, the distance between the most prominent lateral point on the buccal surface of the right and left upper first molars; and LM-LM, lower intermolar width, the distance between the most prominent lateral point on the buccal surface of the right and left lower first molars.

The following linear items were measured:

1. J-J (Maxillary skeletal base width): The width of the maxilla from bilateral points on the jugal process at the intersection of the outline of the tuberosity of the maxilla and the zygomatic buttress.
2. Ag-Ag (Mandibular skeletal base width): the distance between both antegonia (Ag).
3. UM-UM (Upper intermolar width): the distance between the most prominent lateral point on the buccal surface of the right and left upper first molar.
4. LM-LM (Lower intermolar width): the distance between the most prominent lateral point on the buccal surface of the right and left lower first molar.

The following linear item was calculated:

Table 1. Transverse Skeletal and Dental Measurements[a]

Measurement/Age, y	L	A	H	L vs A	L vs H	A vs H
J-J						
10	57.11 ± 3.18	56.05 ± 3.91	54.29 ± 3.78	NS	*	NS
11	57.23 ± 3.65	56.23 ± 4.32	54.67 ± 3.92	NS	*	NS
12	58.19 ± 3.98	56.99 ± 4.19	55.19 ± 3.98	NS	*	NS
13	58.90 ± 4.97	57.54 ± 3.28	55.60 ± 4.87	NS	*	NS
14	59.07 ± 4.27	58.04 ± 4.37	56.12 ± 3.95	NS	*	NS
Ag-Ag						
10	77.62 ± 4.34	75.35 ± 3.91	73.29 ± 3.81	*	*	*
11	78.78 ± 4.19	76.76 ± 3.97	74.69 ± 3.98	*	*	*
12	79.80 ± 4.67	77.91 ± 4.87	75.76 ± 4.19	*	*	*
13	81.98 ± 5.62	78.76 ± 3.71	76.01 ± 4.67	*	*	*
14	84.24 ± 4.19	80.39 ± 3.95	77.42 ± 4.23	*	*	*
UM-UM						
10	55.97 ± 3.47	54.76 ± 4.19	53.78 ± 4.56	NS	*	NS
11	56.37 ± 3.89	54.98 ± 5.25	54.45 ± 4.32	NS	*	NS
12	56.98 ± 3.38	55.23 ± 3.23	54.93 ± 5.34	NS	*	NS
13	57.56 ± 3.76	56.48 ± 5.72	55.12 ± 3.23	NS	*	NS
14	58.64 ± 5.25	57.28 ± 3.67	56.25 ± 4.56	NS	*	NS
LM-LM						
10	57.08 ± 5.36	56.49 ± 4.29	55.04 ± 3.29	NS	*	NS
11	57.67 ± 4.23	57.04 ± 5.23	55.93 ± 4.67	NS	*	NS
12	58.60 ± 5.18	57.62 ± 4.28	57.08 ± 4.21	NS	*	NS
13	59.58 ± 5.26	58.46 ± 3.98	57.42 ± 3.78	NS	*	NS
14	61.04 ± 4.89	60.12 ± 4.56	58.92 ± 4.56	NS	*	NS
Molar difference (UM − LM)						
10	−1.11 ± 1.12	−1.23 ± 2.23	−1.26 ± 1.87	NS	NS	NS
11	−1.30 ± 1.23	−1.46 ± 1.98	−1.48 ± 1.28	NS	NS	NS
12	−1.62 ± 1.26	−1.89 ± 1.93	−2.15 ± 1.39	NS	NS	NS
13	−2.02 ± 1.29	−1.98 ± 2.12	−2.32 ± 1.98	NS	NS	NS
14	−2.40 ± 1.22	−2.34 ± 1.34	−2.67 ± 1.97	NS	NS	NS

[a] L indicates low angle; A, average angle; H, high angle; NS, not significant.
* $P < .05$.

1. Molar difference: the difference between the maxillary and mandibular intermolar width.

Because measurement by radiography was 1.1 times the actual distance, all measurements were divided by 1.1 to correct for magnification.

In order to determine measurement errors, 20 cephalograms were digitized and measured again 10 days later. The differences between the measurements were evaluated by Student's *t*-test with a paired design.

Statistical Analysis

Data were analyzed using the statistical package program SPSS Version 10.0 (SPSS Inc, Chicago, Ill). Descriptive statistics including the means and standard deviations were calculated for each group. Bonferroni multiple comparison tests were used to compare the differences between the three groups. A value of $P < .05$ was considered statistically significant.

Measurement errors. The size of the combined method error (ME) was calculated by $ME = \sqrt{\Sigma d^2/2n}$, where d was the difference between two registrations of a pair and n was the number of samples. No significant differences were found between the measurements on different occasions ($P > .05$). The standard deviations ranged from 0.20 to 0.32 mm for the distances and 0.15° to 0.25° for the angles.

RESULTS

Descriptive statistics including means and standard deviation were determined for each group from ages 10 to 14. *P*-values of the group comparison are shown in Table 1.

In the skeletal maxillary and mandibular widths (Table 1), a significant difference in maxillary width was shown between only the low- and high-angle groups, whereas a significant group difference in mandibular width was shown among all three groups. A width increase was seen in each group from ages 10 to 14. The total growth of the maxillary width was almost the same in the three groups (1.96 mm. 1.99 mm, and 1.83 mm for the low-, average-, and high-angle groups respectively). In contrast, the total growth of the mandibular width differed among the three groups (6.62 mm, 5.04 mm and 4.13 mm for the low-, average-, and high-angle groups respectively).

Regarding the transverse development of the dental arches (Table 1), the low-angle group exhibited the largest intermolar widths among the three groups. Statistically significant differences appeared between only the low-angle and high-angle groups. The growth of the maxillary and mandible intermolar widths from 10 to 14 years of age was almost the same in the three groups (2.67 mm, 2.52 mm, and 2.47 mm for the maxillary intermolar width in the low-, average-, and high-angle groups respectively; the same data for the mandibular width were 3.96 mm, 3.63 mm, and 3.88 mm). The molar differences improved from ages 10 to 14 in each group, especially from ages 13 to 14, but there was no significant difference among the three groups at any point.

DISCUSSION

The period between 10 and 14 years of age is a stage at which corrective orthodontic treatment is most frequently applied. Therefore, an evaluation of the growth changes normally occurring during this period could provide valuable information for treatment planning.[20] To our knowledge, the current study is the first to analyze specifically the growth changes of the transverse dentofacial structures in children with Class III malocclusion.

The importance of the transverse dimension in Class III malocclusion is indicated indirectly by the clinical protocols of therapy, which include a preliminary phase of maxillary expansion prior to maxillary protraction.[21,22] Baik[23] observed significantly more favorable results for maxillary protraction in a group of Class III subjects treated with rapid maxillary expansion prior to facemask wear compared with the results in a group of Class III subjects treated with only a facemask.

The findings of this study indicate that skeletal transverse widths demonstrated a progressive increase between 10 and 14 years of age in the three groups. The growth of the mandibular width during this period was greater than the maxillary growth. These results are consistent with the findings of previous studies.[12,13]

On comparing the three groups, the largest incremental growth was found in the mandibular width of the-low angle group, whereas the lowest growth increment was observed in the maxillary growth of the high-angle group. From the view of functional anatomy, the skeletal mandibular width is influenced by masticatory function. This is not unexpected because the Ag point is closer to the ramus and the area of attachment of the masticatory muscles. Jaw-closing muscle activity is said to be greatest in subjects with lower MP-SN angles.[18] Christie[14] evaluated the orthodontic records of 82 white adults (43 women and 39 men) with normal untreated occlusions and found that short-faced (low-angle) men had greater maxillary and mandibular widths than normal. Ricketts et al[24] described the long-face pattern as being narrow and transverse in width and having weak musculature. In contrast, the short-face pattern is short and wide, with a strong and square mandible. Our results are in agreement with theirs.

The dental arch width demonstrated incremental growth changes during the period from ages 10 to 14. The total increment was almost the same for the three groups during this period. On comparing the three groups, the dental arch width in the low-angle group was significantly larger than that in the high-angle group. Sillman[25] and Moyers[26] found an increase in the maxillary and mandibular intermolar widths with age. The results of the present study confirmed their findings. However, Athanasiou et al[11] and Snodell et al[12] found a decrease in the mandibular intermolar width with age in contrast to the findings of the present study. Ricketts et al[24] also described the long-face pattern as being narrow with dental arches and the short face as being a wide one and this is in agreement with our results.

The mean change in the skeletal maxillary width was about 2 mm among the three groups. The mean changes in mandibular width for the low-, average-, and high-angle groups were 6.62 mm, 5.04 mm, and 4.13 mm, respectively. The increments in the mandibular width were almost three times as great as the increments in the maxillary width for the low-angle group and twice as great as these increments for the high-angle group. It is interesting to note that the molar difference among the three groups had no significance at the same age. This indicates a weak relationship between molar difference and skeletal difference induced by different face types.

Allen et al[27] compared skeletal and dental arch morphologies of children with posterior crossbites (33 boys and 60 girls) and children without posterior crossbites (50 boys and 47 girls) and found that J-J/Ag-Ag alone accounted for only 4% of the variation in UM-UM/LM-LM. Tsunori et al[18] studied the computer tomographs of 39 dry skulls of male Asiatic Indians and found mandibular molars inclined more lingually in the short faced group than they did in average-face and long-face group. Cortella et al[13] reported that the greater growth observed in mandibular width relative to the maxilla in normal occlusions suggests the presence of a compensatory mechanism that allows the preservation of normal occlusion (no crossbite) between the posterior teeth. Our result suggests that this compensation mechanism remains inadequate in Class III malocclusions and posterior crossbite formation is inevitable.

The findings obtained in the current study have obvious clinical implications. They indicate that the difference between skeletal maxillary width and mandibular width in Class III malocclusion is already established before 10 years of age and, without intervention, is not self-correcting and increases with time. Therefore, in patients presenting with Class III occlusal signs in the mixed dentition, it is possible to start treatment at that stage of dental development.

Because Class III subjects in the mixed dentition almost always present with a deficiency in maxillary arch width, an initial goal of treatment might be the early correction of the interarch transverse discrepancy by means of rapid maxillary expansion (RME).[28] In patients with mild to moderate Class III problems, the use of RME in the early mixed dentition may lead to a spontaneous correction of the Class III occlusal relationship. The amount of possible posttreatment relapse in the transverse dimension suggests the overcorrection of the maxillary transverse deficiency as part of the treatment strategy in growing Class III subjects.

Finally, the limitations of this study must be acknowledged. Because of the large individual variation encountered, all findings present tendencies rather than general growth laws. Nevertheless, the clinician should be aware of the changes in intermaxillary relationship with age and, as a consequence, pay attention to interarch discrepancies in the process of diagnosing of different malocclusions. In addition, the morphological characteristics depicted in the various types of malocclusions may serve as additional determinants when choosing suitable treatment strategies in borderline cases between extraction and nonextraction treatment.

CONCLUSIONS

- Mandibular plane angles might play a stronger role in the transverse skeletal growth of the maxilla and the mandible than the transverse dental growth of the maxilla and the mandible.
- In patients presenting with Class III occlusal signs in the mixed dentition, it is possible to start treatment at that stage of dental development.

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