Stability of changes associated with chin cup treatment

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During the 1960s and 1970s in Japan, most cases of skeletal Class III malocclusion in growing patients were treated with a chin cup appliance followed by full-banded orthodontics. The results of this treatment were often unsatisfactory with regard to tipping movement of anterior and buccal segments. Acceptable occlusal interdigitation of buccal segments is generally very important in maintaining good occlusion during the retention period, as Brodie[1] reported in his 1938 study of four adult Class III patients in whom excellent treatment results were obtained. Deguchi et al.[2] used cephalometric analysis to show that in skeletal Class III patients, ANB angle of the mandible in habitual occlusion and the predicted position of the mandible differed by 2°. This is enough to question the diagnosis of a horizontal skeletal discrepancy in Class III malocclusion.

Clinical orthodontists have long recognized the value of examining the familial tendency to Class III malocclusion. Recently, Nakashima et al.[3,4] found that high correlation coefficient values were seen in comparisons between parents and their offspring with Class II and Class III malocclusions. In the 1950s, applied craniofacial biology was based on genetic concepts. By the 1980s, as the understanding of the epigenetic concept of the functional matrix became clearer, almost 75% of the orthopedic problems in Class II malocclusion were managed with clinical success, although Class III malocclusion still presented significant treatment challenges.[5]

In 1981, Ohyama[6] reported that improvement in skeletal pattern was found following active treatment as a result of the anterior maxillary

Abstract

Twenty-four Japanese girls with anterior crossbite (Class III malocclusion) were selected for this study of the stability of changes associated with chin cup therapy. Pretreatment cephalometric measurements of the study sample were compared with those in a normal group. In addition, angular and linear measurements were also compared to assess the effectiveness of chin cup therapy in improving Class III skeletal components during the postretention period. The subjects showed characteristic values found in Class III malocclusion for SNB, ANB, and NPg to FH, and these values were significantly different from those in the normal group. The subjects who were past puberty showed more severe Class III skeletal patterns for ANB compared with the prepubertal subjects, and their initial Class III skeletal components showed more satisfactory improvement, including 2.0° increase of SNA and 1.8° increase of ANB during the postretention period.

Key Words

Anterior crossbite • Skeletal Class III • Nonextraction • Retention • Chin cup

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Table 1
Patient group treatment data

	Pretreatment	End of active treatment	Posttreatment	Active treatment	Retention	N
Group 1	8 y 10 m	13 y 7 m	17 y 6 m	4 y 9 m	3 y 11 m	11
Group 2	10 y 10 m	14 y 1 m	18 y 4 m	3 y 3 m	4 y 3 m	13

Group 1, prepubertal group; group 2, pubertal group

growth combined with posterior and inferior rotation of the chin point. Recently, Sugawara et al.[7] reported that, despite improvement in the skeletal profile during the initial stage of chin cup therapy, such improvements were often not maintained, especially in severe Class III cases. More recently, Lu et al.[8] reported that pretreatment craniofacial morphology was similar to posttreatment morphology in both boys and girls. They pointed out, however, that untreated skeletal Class III malocclusion progresses with age.

Materials and methods

The subjects were 24 Japanese girls with skeletal Class III malocclusion treated at the Department of Orthodontics, Matsumoto Dental Hospital, in whom chin cup therapy was begun during the period 1981 to 1983. The patients were selected for chin cup therapy at their initial examinations. The criteria for selection were overclosure on the maximum interdigitated occlusion, nonprominent skeletal Class III profile in rest position, possible taking of edge-to-edge bite on posterior guided position of the mandible, incisors normally inclined, and normal orofacial function. Although the patients were not initially selected based on cephalometric analysis, subsequent cephalometric analysis confirmed that most of the patients exhibited skeletal measurements consistent with Class III skeletal patterns. Only nonextraction cases were included in the study so that the effects of chin cup therapy could be examined. The patients were classified into prepubertal and pubertal groups, and bone age was applied because chronological age may not always be reliable in determining the stage of bone maturation. Pubertal growth condition was evaluated by assessment of the ossification of hand bones and standing height. The prepubertal group (group 1) consisted of 11 girls ranging in developmental age from 8 years 0 months to 10 years 3 months with an average age of 8 years 10 months at the initial examination. The pubertal group (group 2) consisted of 13 girls ranging in developmental age from 8 years 11 months to 11 years 11 months with an average age of 10 years 10 months at the initial examination (Table 1). The final records were obtained when each patient was 17 years old or older, when growth was thought to have ceased.[9] The average age at this time was 17 years 6 months in group 1 (range, 17 years 0 months to 19 years 1 month) and 18 years 4 months in group 2 (range, 17 years 0 months to 20 years 10 months). Data for group 1 and group 2 were compared with those for the normal means for 10 years 0 months and 11 years 0 months. Normal data were taken from the longitudinal growth study in the Department of Orthodontics, Matsumoto Dental College.[10]

Case selection, diagnosis and treatment planning, most of the active treatment, and retention observation were performed by one of the authors (T. Deguchi). All patients were instructed to wear a chin cup appliance a minimum of 10 hours per day, until the anterior crossbite was corrected. Chin cup therapy was continued for another 6 months after correction of the anterior crossbite with acceptable posterior occlusion.

The appliance was loaded to a force of 500 to 600 grams per side, directed at the condylar head (Figure 1). Patients were instructed to telephone the clinic if they noticed any temporomandibular joint (TMJ) pain or unusual movement of the mandible.

In this study, the initial cephalometric recording demonstrating skeletal Class III malocclusion in subjects with overclosure was obtained in CR using a wax bite method, and the predicted position of the mandible was obtained on tracing paper for final cephalometric analysis of the mandibular position, applying the method of Deguchi et al.[2] Assuming that unsatisfactory interdigitation of posterior segments could be a cause of relapse, good active treatment results were assessed together with the effect of chin cup use. All patients were instructed to wear the appliance for 6 to 12 months during the first phase

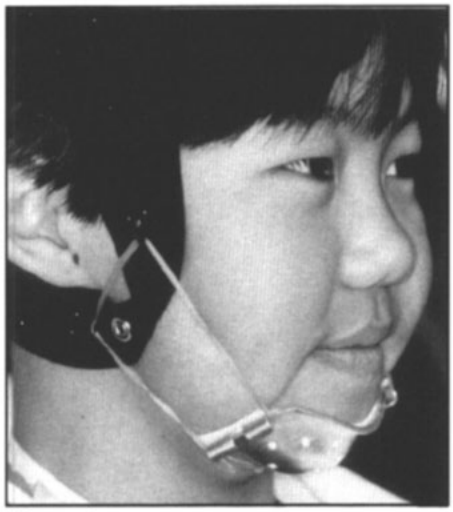

Figure 1

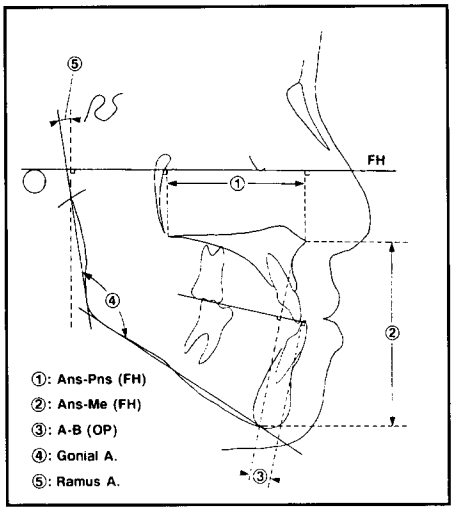

Figure 2

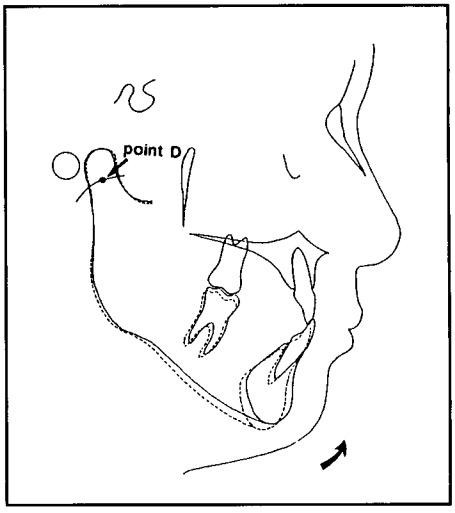

Figure 3

of treatment. This first phase treatment was with chin cup therapy and a Mershon lingual arch appliance. The second phase for detailed dental alignment consisted of .018' slot bracket edgewise appliances, if necessary.

Cephalometric analysis

Cephalometric measurements were performed on lateral headfilms obtained at the pretreatment, end of active treatment, and posttreatment examinations. Measurements that are not commonly encountered in routine clinical practice are shown in Figure 2. The Wits[11] reading was measured from AO to BO, with greater negative(-) value of the measurement indicating greater severity of skeletal Class III pattern. In subjects with Class III occlusion with overclosure, a headfilm was taken in CR using the wax bite method. As CR is also the opening position of the mandible, the mandible was then rotated forward until an overbite of 2.0 mm was obtained, as measured using tracing paper (Figure 3).

Statistical analysis

Student's t-test was used to compare the initial headplate radiographic cephalometric measurements in the normal group with those in groups 1 and 2. The mean and standard deviation of angular measurements of cephalometric analysis obtained at pretreatment, end of active treatment, and posttreatment were compared to examine the degree of skeletal improvement in the active treatment and postretention periods.

Error analysis

With the aid of a table of random numbers, 10 three-film sets (five from group 1 and five from group 2) were selected and reanalyzed. Dahlberg's formula, $SD_E=\sqrt{\Sigma D^2/2N}$, where D is the difference between a double determination, was then used to calculate the error standard deviation for each of the variables in the analysis.[12,13] The various angular measurements have error standard deviation less than 2° and linear measurements less than 1 mm. The results of this error study compare favorably with other estimates of technical error[14] and argue that the present analysis is reliable.

Results

Treatment results

Good treatment results with acceptable occlusion and profile were obtained. The anterior crossbite was corrected in all the patients, with good occlusal interdigitation of the posterior teeth, within 6 to 12 months after the patients began wearing the chin cup. The degree of improvement paralleled the severity of the initial skeletal discrepancies and the patient's cooperation.

Statistical analysis of cephalometric measurements

Group 1 vs. normal group at pretreatment (Table 2)

The measured values of SNB, ANB, and A-B(OP) in group 1 were significantly different from those in the normal group ($P<0.05$, $P<0.05$, and $P<0.01$, respectively). The lower value of IMPA in group 1 may have contributed to the dental compensation for the skeletal Class III pattern, but the difference from the normal value was not significant.

Group 2 vs. normal group at pretreatment (Table 3)

The measured values of SNB, ANB, and A-B (OP) were significantly different in the two groups (all, $P<0.01$), and the value of IMPA was also significantly decreased in group 2 ($P<0.05$).

Figure 1
A patient wearing a chin cup appliance.

Figure 2
Cephalometric measurements not commonly encountered in clinical practice.

Figure 3
Prediction of the correct position of the mandible from centric relation using Thorne's point D. The dotted line indicates the position of the mandible in CR with a wax bite method, which is the opening position of the mandible. The solid line indicates the predicted correct position of the mandible.

Table 2
Comparison of normal and group 1 pretreatment cephalometric values

Values	Group 1 (n = 11) Mean age 8 y 10 m Mean	SD	Normal (n = 16) Mean age 10 y 0 m Mean	SD
SNA	81.6	3.3	80.1	3.7
SNB	80.6	3.0	77.4	3.3*
ANB	1.0	2.0	2.7	1.8*
IMPA	86.3	8.3	91.6	6.0
FMA	31.1	5.6	29.9	3.8
Gonial angle	127.6	8.9	128.6	3.1
Ramus angle	6.8	6.1	9.3	3.3
Interincisal angle	128.5	8.4	127.8	6.7
A-B (OP)	-6.4	1.9	2.2	1.6**
ANS-Me (mm)	61.4	4.5	59.2	4.0
S-N (mm)	64.1	1.7	65.7	2.7
PNS-ANS (mm)	46.1	1.9	46.9	2.2

*P<0.05; **P<0.01

Table 3
Comparison of normal and group 2 pretreatment cephalometric values

Values	Group 2 (n = 13) Mean age 10 y 10 m Mean	SD	Normal (n = 16) Mean age 11 y 0 m Mean	SD
SNA	81.5	3.3	80.5	3.5
SNB	82.9	3.7	77.7	3.1**
ANB	-1.3	2.6	2.8	2.0**
IMPA	85.7	6.9	91.5	6.0*
FMA	28.2	4.2	29.2	4.1
Gonial angle	127.3	5.2	127.6	3.8
Ramus angle	8.0	3.2	8.9	3.4
Interincisal angle	131.7	5.7	128.5	7.3
A-B (OP)	-7.4	2.8	2.3	1.5**
ANS-Me (mm)	62.7	3.8	60.4	4.4
S-N (mm)	66.4	3.2	66.7	2.9
PNS-ANS (mm)	49.0	1.8	48.5	2.1

*P<0.05; **P<0.01

Pretreatment vs. end of active treatment for group 1 (Table 4)

The distance from U1 to NA (mm) showed a significant increase at the end of active treatment (P<0.01), indicating greater flare of the upper incisors than at the initial examination. The lengths of ANS-Me(FH), S-N and PNS-ANS(FH) increased as the patient grew.

Pretreatment vs. posttreatment for group 1 (Table 4)

The FMA and gonial angle were decreased, but the posttreatment value was not significantly different from the pretreatment one. The distance from U1 to NA (mm) showed significant increase.

Pretreatment vs. end of active treatment for group 2 (Table 5)

Compared with pretreatment values, the values of ANB, A-B(OP), interincisal angle, and U1 to NA (°, mm) were all significantly different at the end of active treatment (P<0.05 or 0.01). The significant improvement of the ANB angle was associated with 1.8° increase of SNA and 3.4 mm increase of A-B(OP), resulting in favorable anterior advancement of the maxilla and improved horizontal jaw relationship.

End of active treatment vs. posttreatment (Tables 4 and 5)

In both groups, all values showed no significant difference between end of active treatment and posttreatment, indicating that the changes remained stable during posttreatment period.

Discussion

In this study, a headfilm was taken in CR, and the predicted position of the mandible was found on a paper tracing by applying point D of Thorne's method as a reference.[15] Improvements in cephalometric diagnostic techniques have recently enabled us to identify, with considerable accuracy, the components of the Class III malocclusion. The common morphological characteristics in juveniles and adolescents are: retrusive maxilla, protrusive mandible, anteriorly positioned mandible, obtuse gonial angle, increased mandibular plane angle, increased vertical lower facial height, flared maxillary incisors, and retroclined mandibular incisors.[16-20] The skeletal features of a Class III malocclusion become worse with age,[6,17,18] indicating that anterior crossbite may inhibit anterior growth of the maxilla and may also accelerate mandibular growth with the tendency to posture the jaw forward. In regard to patient selection, we excluded patients with severe mandibular protrusion, who usually have greater vertical lower facial height and a prominent Class III profile, based on chairside observation.

In order to study the morphological differences between skeletal Class III subjects and normal subjects, we compared the initial records of Class III subjects with those of normal subjects. Group 2 showed a more characteristic skeletal Class III pattern than did group 1, and the measurements of SNB, ANB, IMPA, and ramus angle in group

Table 4
Comparison of pretreatment, end of active treatment, and posttreatment cephalometric values in group 1

Values	Pretreatment Mean	SD	End of active treatment Mean	SD	Posttreatment Mean	SD
SNA	81.6	3.3	82.8	3.5	83.0	3.5
SNB	80.6	3.0	81.6	4.2	81.8	4.5
ANB	1.0	2.0	1.2	2.1	1.2	3.0
SN-MP	38.2	6.1	36.5	7.5	36.0	7.9
NPg-FH	86.4	3.5	88.1	4.6	88.2	4.8
IMPA	86.3	8.3	88.3	8.7	87.7	6.5
FMA	31.1	5.6	29.5	7.1	29.0	7.6
Gonial angle	127.6	8.9	124.9	8.3	123.7	8.5
Ramus angle	6.8	6.1	5.4	4.3	4.6	4.4
A-B (OP)	-6.4	1.9	-4.9	1.9	-4.7	2.0
U1 to NA	25.2	9.6	29.2	6.3	28.5	6.8
U1 to NA (mm)	3.2	2.7	6.5	2.3**	6.0	2.8
L1 to NB	25.8	7.9	26.6	8.3	26.0	6.5
L1 to NB (mm)	5.4	2.0	5.8	2.9	5.5	2.6
Interincisal angle	128.5	8.4	123.1	11.9	124.4	8.3
ANS-Me (mm)	61.4	4.5	69.0	5.7**	70.6	5.7**
S-N (mm)	64.1	1.7	67.9	2.0**	69.0	2.2
PNS-ANS (mm)	46.1	1.9	49.5	3.0**	51.0	2.5**

*P<0.05; **P<0.01

Table 5
Comparison of pretreatment, end of active treatment, and posttreatment cephalometric values in group 2

Values	Pretreatment Mean	SD	End of active treatment Mean	SD	Posttreatment Mean	SD
SNA	81.5	3.3	83.3	4.0	83.5	3.6
SNB	82.9	3.7	82.8	3.9	83.0	3.5
ANB	-1.3	2.6	0.5	1.9*	0.5	1.9*
SN-MP	34.7	4.8	35.3	5.0	34.5	5.6
NPg-FH	88.7	3.0	89.2	3.2	89.7	3.0
IMPA	85.7	6.9	85.0	6.6	85.4	9.6
FMA	28.2	4.2	28.9	4.7	28.1	5.3
Gonial angle	127.3	5.2	126.0	5.0	126.0	5.6
Ramus angle	8.0	3.2	7.1	3.7	7.6	3.8
A-B (OP)	-7.4	2.8	-4.0	2.6**	-4.2	2.2**
U1 to NA	25.9	3.7	32.1	4.9**	31.8	4.8**
U1 to NA (mm)	4.1	2.1	7.1	2.6**	7.0	2.6**
L1 to NB	23.9	5.8	23.2	5.8	23.8	7.0
L1 to NB (mm)	4.6	1.7	5.1	2.4	5.2	2.6
Interincisal angle	131.7	5.7	124.5	7.6*	123.8	9.1*
ANS-Me (mm)	62.7	3.8	68.8	4.5**	70.5	3.9**
S-N (mm)	66.4	3.2	68.3	3.0	69.0	3.0*
PNS-ANS (mm)	49.0	1.8	51.3	2.1**	52.0	2.1**

*P<0.05; **P<0.01

2 were significantly different from those in the normal group. The present findings suggest that the prepubertal group showed less improvement of skeletal Class III discrepancies than did the pubertal group, in opposition to Sakamoto's findings.[21] In group 1, a significant difference between the pretreatment and the end of active treatment values was observed only for the distance U1 to NA. This indicates flaring of the maxillary incisors, which are definitely affected by the modified Mershon lingual arch. The lengths ANS-Me(FH) and PNS-ANS (mm) increased with aging. The significant posttreatment changes of the ANB, A-B(OP) and U1 to NA values in group 2 indicated that chin cup therapy was effective in improving the horizontal jaw relationship. With regard to midface advance, chin cup therapy resulted in about 2° of change in the mean SNA angle, but this change was not significant.

Valco et al.[22] reported that orthodontic treatment without surgery in adults should be considered under the following conditions: less than -2° ANB angle, maxillary and mandibular incisor inclination within normal range, and facial profile and mandibular plane angle within normal range. Sperry et al.[23] also indicated that orthodontic treatment of adults was appropriate when the ANB angle was less than -1.8°, U1 to SN was equal to 107.4°, or L1 to MP was equal to 85.7°. Of the young Class III subjects in the current study, the patient with the most severe skeletal Class III malocclusion had an ANB of -3° and A-B (OP) of -10 mm. This individual was treated successfully, both dentally and skeletally.

Mitani and Fukazawa[24] reported that chin cup force application of 6 to 15 hours per day had no significant effect on the change in amount or timing of growth. Cureton et al.[25] reported the role of a headgear calendar and use of a timer. They found that there was poor correlation between the number of hours of wear the patient reported and the actual number of hours worn. Experienced orthodontists can estimate the number of hours per day the patient has worn the appliance by examining the signs of wear on the strap or the head portion on the appliance. In the present clinical study, the use of a commercially available timer was initially incorporated into the schedule, but it was found that the timer was not reliable. The authors estimate that most of the 24 patients in this study wore the chin cup appliance for 5 to 8 hours per day until the anterior crossbite was successfully corrected. Once the anterior crossbite is corrected, the normal incisor relationship may induce functional and skeletal adaptation to the occlusion and morphology of the skeletal components in the pubertal and adolescent periods. Wearing a chin cup appliance for 12 months may be sufficient to improve a skeletal Class III discrepancy.

Five of 40 patients (unpublished data for the present 24 nonextraction and 16 other extraction patients) who underwent chin cup treatment complained of temporary soreness of the TMJ during the retention period, at age 17 to 19 years. This discomfort disappeared within several months. Two patients, however, continued to have TMJ pain and some degree of difficulty in opening the mouth after the end of active treatment. Mukaiyama and Fukazawa et al.[26] studied palpation of the muscles in the TMJ area and suggested that orthopedic force on the mandible should be applied carefully. Motegi and Miyazaki et al.[27] also studied 7337 Japanese children, 6 to 18 years old, and found that the overall prevalence of TMD was 12% and that joint sound was the most common symptom (89%). In addition, 5.6% of the subjects with TMD also showed anterior crossbite.

The etiology of mandibular pain and dysfunction remains obscure and complicated. Given that the chin cup force is distributed to the dentition, TMJ, midface, and cranial base,[28] the orthopedic force on the TMJ area may not be as great as might be expected.[29] If chin cup therapy does cause an idiopathic TMJ disorder, the patient should be carefully evaluated with TMJ radiography and MR imaging and alternative treatment modalities should be considered.

In conclusion, chin cup therapy is very effective in improving occlusion in skeletal Class III malocclusion, and its orthopedic advantages seem to outweigh its disadvantage of occasionally inducing TMJ disorder.

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