Craniofacial adaptations induced by chincup therapy in Class III patients

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The purpose of the present study is to examine the effects of an orthopedic force produced by chincup treatment in patients with Class III malocclusion. Anteroposterior maxillary and mandibular changes were examined as were changes in the vertical dimension. Further, the possibility of posterior displacement of temporomandibular joints in treated Class III subjects was evaluated. Serial lateral headfilms of 22 young females (average age, 9 years), who had received chincup therapy were compared with those of 20 skeletal Class III subjects of similar age who received no treatment during the interval studied. A computerized x-y coordinate program was applied to analyze the cephalometric landmarks and measurements. The treated group showed improvement of the skeletal Class III pattern associated with a slight increase (0.8° per year) in SNA and a slight decrease (-0.7° per year) in SNB and also a decreased gonial angle. The distance from the condyle to the chin (Co-Gn or effective mandibular length) increased significantly less in the treated group in comparison with controls. Increases in lower anterior facial height were not different between the treated and untreated groups. In addition, the cranial base angles N-S-Ba and N-S-Ar showed no statistical difference between groups, but these angles tended to increase with time in both groups. Basion and Articulare showed almost the same amount of backward and downward movement in both groups. The results of this study indicate that the primary effect of chincup therapy was in producing a reduction in mandibular growth increments during the period studied. Maxillary growth was not affected during treatment. Further, the results of this study fail to support the hypothesis that chincup appliance significantly induces the posterior displacement of the glenoid fossa. (Am J Orthod Dentofacial Orthop 1999;115:175-82)

The treatment of Class III malocclusion remains a perplexing problem, particularly in young patients. A number of treatment protocols have been used to address this type of malocclusion, including the FR-III appliance of Fränkel, the orthopedic facial mask and the orthopedic chincup. The FR-III appliance has been recommended by Fränkel[1,2] for use in patients with maxillary skeletal retrusion as a primary component of Class III malocclusion; the orthopedic facial mask has been advocated for use in patients with a combination of problems. The facial mask has been shown to produce effective correction of an anterior crossbite by the application of protrusive force to the maxilla and maxillary dentition and retrusive forces to the mandible and mandibular dentition.[3-7]

The orthopedic chincup also is used frequently in the treatment of Class III malocclusion, especially in Asian populations. This traditional treatment approach has been recommended in those patients who have a moderately protrusive mandible and a relatively normal anteroposterior position and size of the maxilla.[3-7,8] The chincup remains popular because the direction of chincup pull produces favorable treatment effects not only in the sagittal dimension, but the vertical dimension as well.[9-12]

Several studies have indicated that the chincup not only affects the growth of the mandible, but cranial base structures as well. For example, Ritucci and Nanda[13] reported that the chincup causes a closure of the cranial flexure angle (N-S-Ba) associated with the inhibited posterior growth of the posterior cranial base at Basion and the upward movement of Sella. This positional change of the temporomandibular joint (TMJ) may affect the position of the mandible directly.[14] Thus, it may be possible that this type of orthopedic treatment may not only affect growth increments of the mandible but also may lead to a posterior displacement of the glenoid fossa. Therefore it is worthwhile to investigate cephalometrically the possibility of producing positional and morphologic[15] changes in the TMJs as the mandible is pushed poste-

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Table I. Characteristics of chincup treated and untreated skeletal III subjects

Group	*n*	*Pretreatment mean (range, y/mo)*	*Posttreatment mean (range, y/mo)*	*Period of chincup use mean (range,y/mo)*
Treated	22	9/4 (6/10-10/8)	11/3 (8/10-12/3)	1/9 (0/4 3/6)
Untreated	20	9/7 (6/9-11/7)	11/8 (9/1-13/5)	

Table II. Cephalometric comparison between chincup treated and untreated skeletal III groups

	Pretreatment				*(mm or degree)*
	Treated group (n = 22)		*Untreated group (n = 20)*		
Variable	*Mean*	*SD*	*Mean*	*SD*	*t value*
Maxilla and mandible					
SNA	79.8	3.51	80.0	3.42	0.164
SNB	80.2	3.89	78.9	3.52	1.113
ANB	–0.4	2.01	1.1	0.73	3.174**
Facial A.	87.6	2.87	85.8	2.11	2.192**
FMA	29.1	3.99	28.5	4.06	0.502
Ramus A. (FH)	81.8	4.78	84.3	2.80	1.992
Gonial A.	127.3	5.39	124.2	4.27	1.977
Nasal floor (FH)	–1.4	2.83	–0.1	2.28	1.676
Functional OP	10.9	2.80	12.4	2.88	1.703
Gn-Cd	109.3	4.16	105.4	4.43	2.871**
Denture					
U1 to FH	115.4	6.64	115.1	7.10	0.161
IMPA(L1 to Mand Pl)	89.8	5.53	92.9	5.02	1.838
Interincisal A	125.7	8.89	123.6	8.99	0.732

*$P < .05$.
**$P < .01$.
SD, Standard deviation.

riorly with the chincup, reducing the relative protrusion of the mandible.

The purpose of this study is to determine the precise nature of the craniofacial adaptations produced by the orthopedic chincup. In particular, this investigation examines whether a retrusive orthopedic force to the mandibular condyle causes the posterior displacement of the structures comprising TMJs (eg, mandibular condyle and glenoid fossa) in treated skeletal Class III subjects. In the present study, an untreated Class III sample is used as a comparison group.

MATERIAL AND METHODS

Sample

Serial lateral cephalograms of 42 females of Japanese ancestry with skeletal Class III malocclusion were studied. Twenty-two were treated with a chincup, and an additional 20 subjects did not receive any orthodontic or orthopedic treatment during the period studied. The records of the treated skeletal Class III subjects were obtained from the Department of Orthodontics, Matsumoto Dental Hospital, whereas the records of the untreated subjects were obtained from the files of a private clinic.

The developmental age (determined from the date of menarche, hand-wrist x-ray, and increments of the height) and sex as well as the number and time between head films were matched in both groups (Table I). The initial cephalometric analyses were compared to study the difference in severity of skeletal Class III morphology in both groups (Table II).

All subjects were treated with an occipital-pull chincup (Fig 1*A*). In addition, during the initial stage of correction of anterior crossbite, an auxiliary 0.016 inch wire soldered to an 0.036 inch lingual arch appliance (Fig 1*B*) was activated to flare the maxillary incisors for several months and retained until the posterior occlusion was stabilized. The patients were instructed to wear the chincup while sleeping (7 to 9 hours per day). The total force applied was approximately 400 to 500 g in total, and the force direction was through the condyle. The period of active chincup use ranged from 4 months to 3 years 6 months, depending on the skele-

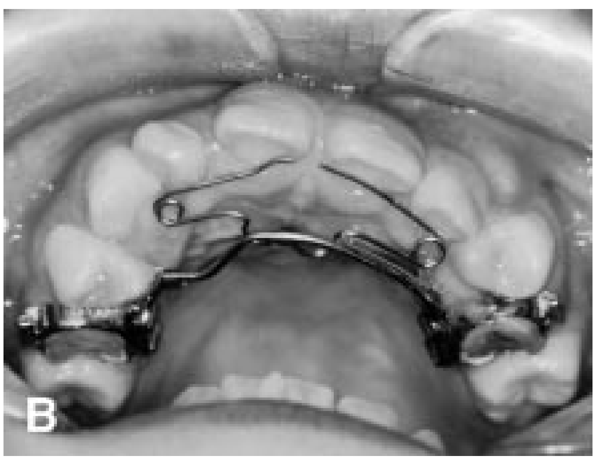

Fig 1. A, Patient wearing chin-cup appliance. **B,** Lingual arch appliance to flare the upper incisors; upper deciduous second molars are banded.

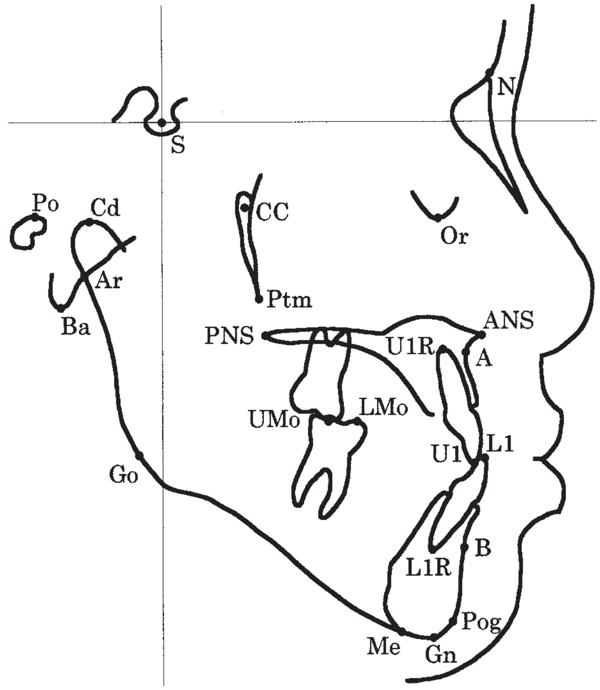

Fig 2. Location of cephalometric landmarks taken on computerized x-y coordinate.

tal severity and the level of cooperation of the individual patient. The average time interval between films was 28.0 months (standard deviation (SD) = ± 7.9 months) for the treated group and 30.0 months (SD = ± 12.0 months) for the control (Table I).

Cephalometric Analysis

A computerized x-y coordinate program (Hoya Medical Co., Tokyo, Japan) was used to analyze the cephalograms representing the growth of an individual subject. The position of each landmark was double checked by superimposing two head films on tracing paper to determine the accuracy of landmark identification. For the purpose of orientation, the Frankfort plane was designated as the x axis, and a line perpendicular to Frankfort passing through the Sella was designated as the y axis, according to the method of Sakamoto.[16] The landmarks used in the cephalometric analysis then were identified and digitized (Fig 2).

Conventional cephalometric analysis was used to identify differences for maxillary, mandibular, dentoalveolar and cranial base structures between the untreated and the treated groups pretreatment (T1) and posttreatment (T2) (Tables II-V). Horizontal and vertical changes in the cephalometric landmarks also were measured and calculated (Table VI). The difference between the pretreatment and the posttreatment measures (T2-T1) was divided by the treatment time, and T2-T1 differences per year were calculated to obtain statistical significance of the cephalometric measurements between groups, using a two-tailed independent two-group *t* test after comparison by an F-test (Tables II-VI).

Profilograms

Using average values of the pretreatment and posttreatment headfilms extrapolated to 2 years between films, profilograms were constructed to illustrate graphically the amount and direction of craniofacial growth in the treated and untreated Class III samples (Figs 3 and 4).

Table III. Cephalometric comparison of cranial base structures between chincup treated and untreated skeletal III groups

	Pretreatment				
	Treated group (n = 22)		*Untreated group (n = 20)*		*(mm or degree)*
Variable	*Mean*	*SD*	*Mean*	*SD*	*t value*
Cranial base					
S-N	65.4	2.76	64.9	2.41	0.644
SN to FH	8.5	2.29	8.0	2.29	0.690
N-Ba	100.8	3.77	99.6	3.63	1.015
N-CC	53.6	2.95	54.4	2.43	0.908
CC-Ba	47.2	2.43	45.2	2.27	2.615*
NSBa	133.5	4.07	133.3	5.26	0.088
NSAr	125.2	4.47	125.4	5.50	0.158

*$P < .05$.
SD, Standard deviation.

Table IV. Cephalometric comparison between chincup treated and untreated skeletal III groups

	Posttreatment				
	Treated group (n = 22)		*Untreated group (n = 20)*		*(mm or degree)*
Variable	*Mean*	*SD*	*Mean*	*SD*	*t value*
Maxilla and mandible					
SNA	80.7	3.49	81.2	3.21	0.508
SNB	79.5	4.15	79.9	3.61	0.340
ANB	1.2	1.91	1.3	1.08	0.230
Facial A	87.4	2.81	87.3	2.05	0.153
FMA	29.7	4.03	27.2	4.23	1.967
Ramus A (FH)	83.1	4.76	83.9	3.01	0.641
Gonial A	126.6	5.49	123.2	4.59	2.089*
Nasal floor (FH)	–1.5	2.61	-0.9	2.53	0.737
Functional OP	9.3	3.12	9.3	2.95	0.104
Gn-Cd	115.4	6.50	115.5	5.24	0.059
Denture					
U1 to FH	123.6	7.40	118.7	3.09	2.790**
IMPA(L1 to Mand Pl)	86.5	5.77	92.7	4.65	3.700**
Interincisal A	121.5	7.19	121.4	6.60	0.023

*$P < .05$.
**$P < .01$.
SD, Standard deviation.

RESULTS

Conventional Cephalometric Analysis

Maxilla and mandible (Tables II and IV). The two groups of Class III subjects were well matched at the beginning of the study except for a few variables (Table II). The maxillomandibular relationship, as indicated by the ANB angle, was greater in the untreated group (1.1°) than in the treated group (-0.4°), as was the facial angle (the angle between the FH plane and the N-Pg line). Effective mandibular length (Gn-Cd) also was greater in the treated group (109.3 mm) than in the controls (105.4 mm) before treatment.

At the end of the second observation period, the initial value (1.\1°; Table II) of the ANB angle in the untreated group remained relatively unchanged (1.3°; Table IV). In the chincup treated subjects, however, the initial -0.4° ANB angle improved to 1.2°, a change that was associated with a slight increase (0.9°) of SNA and slight decrease (-0.7°) in the SNB angle. At the end of treatment, the facial angle remained unchanged in the treated group, but increased 1.5° in the untreated group (Table IV).

There was no difference between groups in the gonial angle at pretreatment (Table II); however, in the treated group, the gonial angle decreased significantly in comparison to the controls. Effective mandibular length (Gn-Cd) at posttreatment showed

Table V. Cephalometric comparison of cranial base structures between chincup treated and untreated skeletal III groups

	Posttreatment				
	Treated group (n = 22)		*Untreated group (n = 20)*		*(mm or degree)*
Variable	*Mean*	*SD*	*Mean*	*SD*	*t value*
Cranial base					
S-N	66.9	2.88	67.6	2.68	0.737
SN to FH	8.6	2.29	7.8	2.51	1.054
N-Ba	104.6	4.33	106.0	3.97	1.024
N-CC	55.0	3.18	56.7	2.78	1.761
CC-Ba	49.6	2.99	49.3	2.72	0.342
NSBa	133.7	3.98	133.4	5.73	0.213
NSAr	125.6	4.53	126.5	5.57	0.569

SD, Standard deviation.

Table VI. Cephalometric comparison between chincup treated and untreated skeletal III groups in horizontal (x) and vertical (y) landmarks changes (mm/year)

		Treated group (n = 22)		*Untreated group (n = 20)*		
Variable		*Mean*	*SD*	*Mean*	*SD*	*t value*
N	x	0.76	0.36	0.80	0.32	0.330
	y	0.12	0.46	0.01	0.31	0.836
Or	x	0.68	1.17	0.85	0.40	0.599
	y	–0.46	0.58	–0.53	0.57	0.366
ANS	x	1.13	0.58	0.96	0.37	1.012
	y	–1.18	0.53	–1.40	0.53	1.325
A	x	1.09	0.46	1.07	0.38	0.262
	y	–1.50	0.87	–1.47	0.41	0.187
U1	x	2.66	1.91	1.98	0.76	1.472
	y	–1.37	1.49	–1.84	0.38	1.31 7
L1	x	–0.32	1.21	1.35	0.85	4.988**
	y	–1.27	1.23	–1.42	0.54	0.528
B	x	–0.20	1.50	1.14	0.80	3.359**
	y	–2.12	1.27	–2.25	0.77	0.394
Pog	x	0.10	1.56	1.55	0.94	3.501.*
	y	–2.92	1.30	–2.41	0.71	1.507
Me	x	–0.06	1.74	1.42	1.04	3.203**
	y	–3.10	1.13	–2.65	0.72	1.487
Go	x	–1.23	1.05	–0.48	0.71	2.602*
	y	–1.89	0.92	–2.20	0.68	1.223
Ar	x	–0.67	0.36	–0.75	0.38	0.655
	y	–1.09	0.61	–0.93	0.38	0.998
CC	x	0.11	0.58	0.24	0.25	0.945
	y	–0.39	0.51	–0.38	0.27	0.209
Ba	x	–0.91	0.46	–0.84	0.40	0.549
	y	–1.25	0.82	–1.02	0.32	1.120
Cd	x;	–0.82	1.14	–0.65	0.54	0.550
	y	–0.10	0.83	–0.46	0.50	1.688

*$P < .05$.
**$P < .01$.
SD, Standard deviation.

no statistical difference between the two groups, although average mandibular length was statistically different between groups before treatment (Tables II and IV).

Dentoalveolar adaptation (Tables II and IV). There was no significant difference in dentoalveolar measures between the two groups before treatment. The angle of the upper incisor relative to the Frankfort hor-

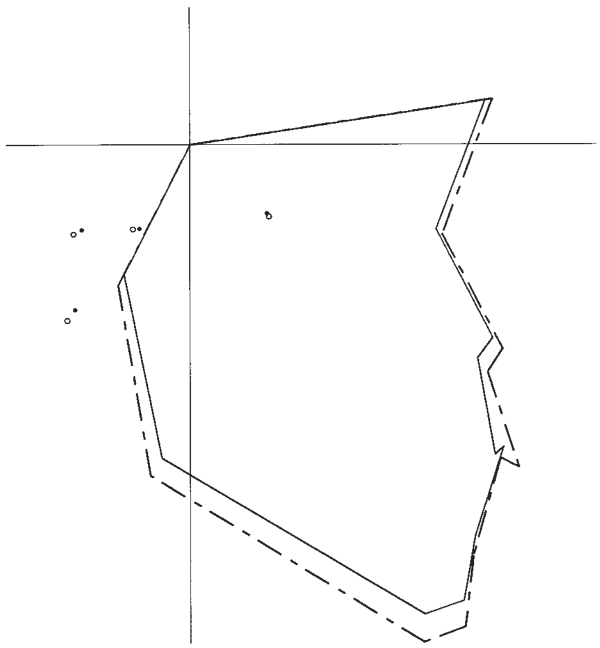

Fig 3. Superimposed profilogram of treated group at 2-year intervals.

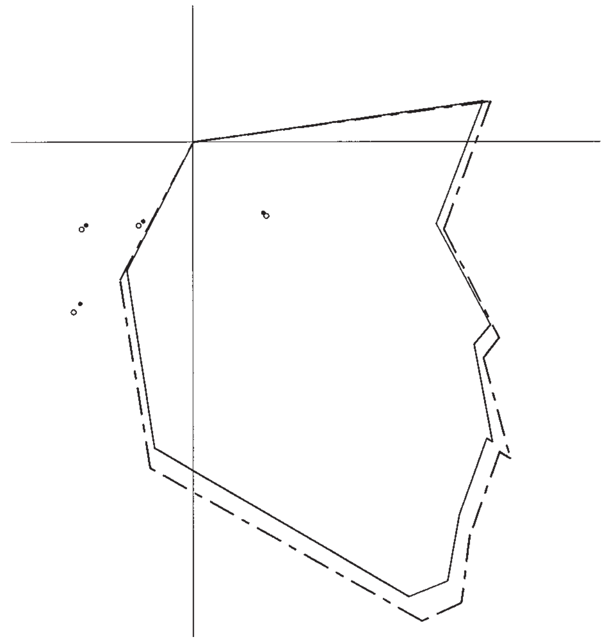

Fig 4. Superimposed profilogram of untreated group at 2-year intervals.

izontal increased by 8.2° during treatment, and the angle of the lower incisor relative to the mandibular plane decreased by 3° in the treated group. The angle of the occlusal plane decreased slightly in both groups between Time 1 and Time 2.

Cranial base (Tables III and V). At Time 1, the two groups showed no significant difference in the variables associated with cranial base structures, except for the center of the pterygomaxillary fissure (CC) and Basion (Ba). The cranial base angles N-S-Ba and N-S-Ar showed no statistical significance between two groups at pretreatment and posttreatment (Tables III and V).

Horizontal and Vertical Changes in Landmark Position (Table VI). In order to evaluate the movement of individual landmarks over time, the landmarks in the Time 1 and Time 2 films were measured relative to the x and y axes. Values were analyzed for comparison between groups.

Maxilla and mandible. No differences were noted in the horizontal movement of maxillary landmarks between groups. Both groups moved about the same amount anteriorly, about 1.1 mm per year. No difference was seen in the vertical movement of Point A, but ANS descended less vertically in the treatment group in comparison to controls, a 0.2 mm difference (Table VI).

In the mandible, significant differences were noted in the movement of Point B and Pogonion. Point B moved forward 1.1 mm per year in the controls, but moved posteriorly 0.2 mm per year in the chincup group. Similarly, Pogonion moved anteriorly 1.6 mm per year in the controls, but only 0.1 mm in the treated group. These differences were statistically significant (Table VI). In addition, Menton moved vertically more in the treated group (–3.1 mm per year) than in the controls (–2.7 mm per year) (Table VI).

Cranial base. No differences were observed between groups in the horizontal and vertical movement of any of the landmarks associated with the cranial base (ie, N, Ar, CC, Ba). In addition, no difference was observed in the horizontal movement of the condyle. Condylion moved less vertically in the treatment group (-0.1 mm per year) in comparison to controls (-0.5 mm per year) (Table VI).

Profilograms

Figs 3 and 4 show the differences of the landmark changes originated from the Sella for the 2-year interval of both the treated and untreated groups. The treated subjects show a significant backward rotation of the mandible.

DISCUSSION

There is no agreement in the orthodontic literature as to whether chincup therapy may[17,18] or may not[19] inhibit the growth of mandible. Further, the stability of a therapeutically induced reduction in the length of the mandible remains unclear, particularly for boys with a longer growth period. In female Class III subjects, however, horizontal maxillary and mandibular changes associated with chincup treatment have been shown to remain stable[20] after 17 years or more.[8] In addition, chincup therapy has been shown to produce a change in the mandible associated with a downward and backward rotation and decreased angle of the mandible.[8,21,22]

In the present Class III subjects, the significant treatment effects produced by chincup therapy were a decrease in the gonial angle, less incremental increase in mandibular length (Gn-Cd) and posterior movement of Point B and Pogonion. The vertical movement of Menton was well controlled, so that no increase in lower anterior facial height occurred relative to the untreated group. Vertical control is extremely important for Class III treatment in the Japanese because this ethnic group typically has a larger anterior facial height than that observed in Caucasians.[23,24] A decrease of the gonial angle in the treated group contributes to the control of anterior facial height, whereas a chincup induces a backward rotation of the mandible. Ohyama,[20] however, found a significant opening of the gonial angle in 5-year records after correction of anterior crossbite was achieved in chincup treated female subjects. He suggested that the severe skeletal Class III subjects in Japan continue to grow intrinsically to the direction of the original skeletal characteristics (hyperdivergent pattern), even if an anterior crossbite was corrected. The occipital-pull chincup may produce the force closing the gonial angle biomechanically but the growth trends of the severe skeletal Class III overcome it.

Class III treatment has been shown to have several effects on condylar morphology. Previous studies have demonstrated that functional appliance therapy may result in a significant upward and forward direction of condylar growth.[25] Chincup treatment also can induce a forward bending of the condylar neck.[15] This therapeutically induced change in growth direction of the mandibular condyle has been considered a skeletal sign of a mechanism compensating for excessive mandibular growth.[25-27]

Theoretically, positional and morphologic changes in the glenoid fossa also may be important factors related to understanding the therapeutic effects of chincup therapy. When evaluating the morphology of the TMJ in Class III subjects, Ricketts[28] noted a shallower articular fossa and flatter articular eminence in comparison to normals. Seren et al[29] found that the mediolateral dimensions of the condyles of the Class III group were statistically higher in the glenoid fossa, and the anteroposterior fossa dimensions were smaller in Class III patients. Those findings correlate with the anterior mandibular displacement in skeletal Class III malocclusions.[30] Our previous study, however, found that chincup therapy could widen and deepen the glenoid cavity and induce the normalization of the morphology of the Class III TMJ.[15] In addition, a study of force distribution produced by the chincup appliance on a young dry skull indicates widespread localization and distribution of forces throughout the craniofacial complex.[31] Further, Kerr and TenHave[32] found that FR-III appliances produced a small but significant increase in cranial base flexure (N-S-Ba), an observation that was not substantiated by the results of Ritucci and Nanda.[11] Sawa[33] reported that skeletal Class III subjects with anterior crossbite showed a significant decrease of N-S-Ar angle for a 2.5 year interval during prepubertal growth, and chincup treatment significantly increased N-S-Ar angle.

In the current study, there was no statistical differences in the morphologic changes noted in the TMJs and the cranial base structures between the untreated and the treated groups at posttreatment. The chincup-treated Class III subjects showed improvement of skeletal Class III jaw relationships and a reduction in mandibular growth increments during the treatment period. The movement of Point A and anterior nasal spine was not different statistically between groups, which means that the chincup does not inhibit the anterior growth of the maxilla.

A sample that has narrow parameters may add strength to those findings obtained in this type of research, although it is very difficult to obtain a larger sample size.

SUMMARY AND CONCLUSION

The present cephalometric study compared serial lateral cephalograms of Japanese children who were on average 9 years of age at the time the initial cephalogram was taken. A comparison of the two groups revealed that the primary effect of chincup therapy was a reduction in mandibular growth increments during the period studied. Horizontal maxillary movement and lower anterior facial height were not affected during treatment. Further, the results of this study fail to support the hypothesis that the chincup appliance significantly induces the posterior displacement of the glenoid fossa.

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