ORIGINAL ARTICLE

Effects of vertical chincap therapy on the mandibular morphology in open-bite patients

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The aim of this study was to investigate the effects of the vertical chincap on mandibular morphology and also on the dentoalveolar structures in patients with high-angle open-bite malocclusions. We examined 35 children with high-angle skeletal Class I or II open-bite malocclusions. Eighteen subjects were selected as the treatment group, and 17 were the controls. Vertical chincaps, applying 400 g on each side from beneath the anterior part of the mandibular corpus in an upward direction, were used in the treatment group for 16 hours per day over a mean period of 9 months. We studied 70 lateral cephalograms taken before and after the treatment and the control periods. The changes of 7 linear and 8 angular parameters were evaluated statistically in both groups with paired and Student *t* tests, respectively. Eruption of the mandibular incisors, decrease of the ramal inclination, decrease of the mandibular plane, and increase of the overbite in the treatment group compared with the control group were found to be statistically significant. Intrusion of the first molars, decrease of the gonial angle, and increase of the mandibular corpus inclination in the treatment group were contrary to the results observed in the control group; these comparisons were also found to be statistically significant. It appears that the vertical chincap is effective in treating skeletal open bite and in decreasing the gonial angle and ramus/corpus relationship. (Am J Orthod Dentofacial Orthop 2002;122: 506-11)

Open-bite malocclusion is influenced by many etiological factors affecting the craniofacial skeleton as well as the dentoalveolar and soft tissues. There appear to be limitations in treating skeletal open bites because of the increased vertical facial dimension. Treatment results, including functional orthopedic therapy, might be unsatisfactory because of the increased vertical facial dimensions; they have a high incidence of relapse.

Patients with skeletal open bite possess characteristics such as backward and downward rotation of the mandible,[1-10] increased vertical growth in posterior dentoalveolar structures,[3,4,8-13] short posterior facial height,[1-3,8,9,14-17] increased lower anterior facial height,[1-3,5,7-10,12,14,16-19] downward rotation of the posterior portion of the palatal plane,[5,6,8,16] and upward and forward rotation of the anterior maxilla.[5,6,8,20,21]

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The treatment objectives of patients with skeletal open bite include preventing further development of the upper and lower posterior dentoalveolar regions and the downward development of the maxilla, increasing the vertical development of the mandibular ramus and the condyle, and obtaining an anterior autorotation of the mandible.

The vertical chincap has been used as a supplementary device with intraoral appliances in early functional orthopedic treatment of skeletal open bite. Its effectiveness was first demonstrated by Tomes and Allan in Kingsley's book.[22]

The vertical chincap (vertical-pull chincap, high-pull chincap)[15,23-31] has been used to obtain the anterior rotation of the mandible, with the resultant force vector passing through the anterior part of the mandibular corpus and 3 cm from the outer canthus of the eye. Various studies have shown the effects of the supplementary usage of the vertical chincap with functional orthopedic appliances. The vertical chincap has traditionally been used with fixed orthodontic therapy,[29,32] in functional orthopedic treatment of skeletal open bite,[2,24,33,34] and with functional appliances to increase the effects of the masticatory muscles on the posterior dentoalveolar structures. The use of the vertical chincap alone[22,32,33] is also very effective in treating skeletal open bite, but studies concerning its effects, especially

Table I. Comparison of preassessed parameters

	Vertical chincap group		*Control group*		
	Mean	*SD*	*Mean*	*SD*	P
SN/GoGn	41.1	3.5	41.2	3.7	NS
ANB angle	5.4	2.2	5.7	1.7	NS
Overbite	−2.9	2.3	−2.2	2.2	NS

NS, not significant.

on the mandible, have not been published. Results indicate a decrease of the mandibular plane angle,[35] prevention of the increase of the lower anterior facial height, prevention of the eruption of the posterior teeth, and a reduction of the gonial angle.[2] Eren[36] studied the effects of the vertical chincap alone and found a decrease in the mandibular plane angle, posterior rotation of the maxilla, an increase in upper facial height, a decrease in the total anterior and lower anterior facial height, an increase in the lower posterior dentoalveolar height, and an increase in overbite. The effects of the vertical chincap alone on mandibular morphology and the direction of the changes have not yet been studied.

The aim of this study was to assess the effect of the vertical chincap on the morphology of the mandible in treating skeletal open bite.

MATERIAL AND METHODS

Thirty-five subjects, 23 girls and 12 boys, with Angle Class I or II malocclusions and skeletal and dental open bites were evaluated. Subjects with high growth potential having mandibular plane angles (SN/GoGn) greater than 38° and ANB angles indicating a skeletal Class I or II relationship were included. No subjects needed surgery for nasal airway obstruction.

The experimental group consisted of 12 girls and 6 boys. A control group of 17 (11 girls, 6 boys) open-bite subjects, derived from the archives of our department, was matched with the experimental group according to sex, mandibular plane angle, ANB angle, and amount of open bite (Table I).

The pretreatment chronological ages were 8.08 to 11.11 years, and the skeletal ages were 7.00 to 10.00 years in the experimental group. The pretreatment chronological ages were 8.40 to 12.26 years, and the skeletal ages were 8.60 to 11.60 years in the control group. The mean chronological ages were 9.48 years (SD 0.98) in the experimental group and 10.88 years (SD 1.39) in the control group before the study. The mean skeletal ages were 8.43 years (SD 0.94) in the experimental group and 9.99 years (SD 1.53) in the control group. The skeletal ages were determined by using the method of Greulich and Pyle.[37]

Vertical chincaps (3M Unitek, Monrovia, Calif) were worn 16 hours per day by the subjects in the experimental group, with 400 g of force applied per side; the force vector passed through the anterior and inferior region of the mandibular corpus and 3 cm from outer canthus of the eye. The vertical chincap was used until overbite was obtained, except in 2 subjects, and the treatment time was 6 to 12 months.

We studied the pretreatment and posttreatment lateral cephalometric and hand-wrist radiographs of the 18 patients treated with vertical chincaps. The lateral cephalometric and hand-wrist radiographs of the 17 control subjects, who had been followed for 7 to 12 months, were also used.

Cephalometric evaluation

The local structural superimposition method of Björk and Skieller[38]and Björk[39] was used to assess changes during the study period. A horizontal line (HL; x-axis) was drawn between the inferior border of the mandibular corpus and the mandibular first molar apices on the initial lateral cephalograms. A perpendicular line passing through the mandibular symphysis (VL; y-axis) was drawn to the horizontal axis. The pretreatment and posttreatment cephalograms were superimposed on the mandible, the coordinate system constructed on the first cephalogram was transferred to the second (posttreatment) cephalogram, and measurements were made accordingly (Fig 1). ANB angle, SN/GoGn angle, SN/ANS-PNS angle, and overbite were also measured on pretreatment and posttreatment cephalograms separately. Overbite was measured as the vertical distance between the upper and lower incisal edges of the central incisors perpendicular to the occlusal plane—the line passing through the midpoint of the overlap of the mesiobuccal cusp of the maxillary and mandibular first molars and the midpoint between the incisal edges of the maxillary and mandibular central incisors.

The measurements were made up to 0.5 mm and 0.5°. The landmarks and planes we used are shown in Figure 1.

Statistical analysis

Mean changes for the measurements in each group were evaluated with paired *t* tests. Comparisons of the mean changes between the groups were made with Student *t* tests.

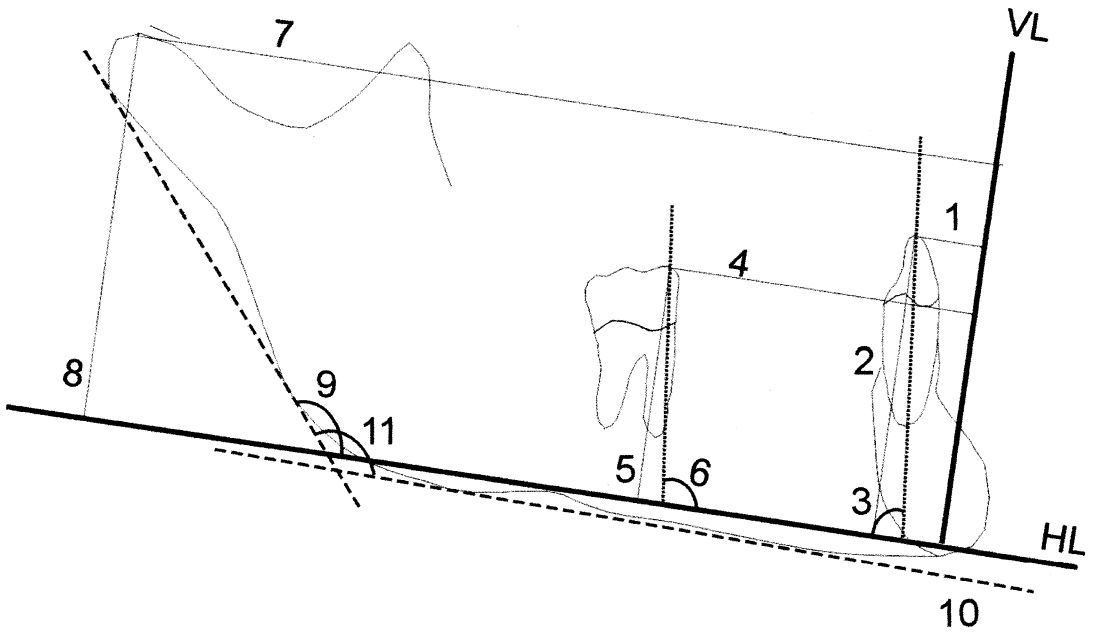

Fig 1. Measurements made: 1, perpendicular distance between mandibular incisor and vertical line (VL); 2, perpendicular distance between mandibular incisor and horizontal line (HL); 3, inclination of incisor; 4, perpendicular distance between mandibular first molar and VL; 5, perpendicular distance between mandibular first molar and HL; 6, inclination of first molar; 7, perpendicular distance between condylion and VL; 8, perpendicular distance between condylion and HL; 9, ramal inclination; 10, corpus inclination; 11, gonial angle.

RESULTS

Superimpositions of the mean changes selected as samples are shown in Figure 2. The changes during the study in each group and the comparison of these changes between the groups are shown in Table II.

Overbite was achieved clinically in all but 2 subjects treated with the vertical chincap, although apparent correction of open bite could be observed. Overbite increased significantly in both groups, and the increase in the vertical chincap group was found to be significantly ($P < .01$) more than the increase in the control group.

The mandibular plane angle showed a statistically significant decrease of 1.42° in the vertical chincap group, and a significant difference was found compared with the control group ($P < .05$) (Table II).

The ramal inclination angle decreased significantly (mean, 1.03°) in the vertical chincap group, and a statistically significant difference was found compared with the control group ($P < .05$).

The gonial angle decreased significantly in the vertical chincap group (−1.92°; $P < .01$), whereas it increased significantly in the control group (0.44°; $P < .05$), and a significant difference was found between the groups ($P < .01$).

The corpus inclination angle increased significantly in the vertical chincap group (0.58°; $P < .01$) and decreased significantly in the control group (−0.21°; $P < .05$), and a significant difference was observed between the groups ($P < .01$).

Eruption of the mandibular incisors was found to be significantly more in the vertical chincap group ($P < .05$). Significant intrusion of the mandibular molars was observed in the vertical chincap group (−0.97 mm; $P < .01$), whereas an eruption of the mandibular molar was observed in the control group (1.53 mm; $P < .01$), and a significant difference was found between the groups.

DISCUSSION

The vertical chincap has traditionally been used to treat skeletal open bite supplementary to intraoral orthodontic appliances. This study was planned to evaluate the sole effects of vertical chincap therapy on the morphology of the mandible.

Overbite was obtained in all subjects as observed

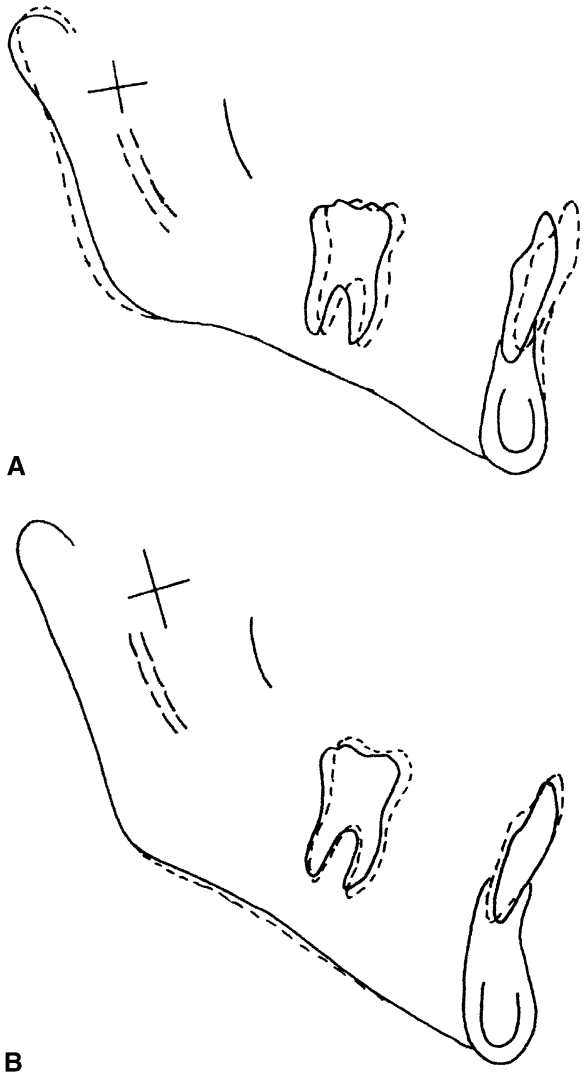

Fig 2. Superimposition of sample showing mean changes in **A**, experimental group, and **B**, control group.

clinically, and the mandibular plane angle decreased significantly in all but 2 patients. Both of those patients had excessive amounts of open bite before treatment, and an apparent decrease was observed in the severity of their malocclusions.

The effects of the vertical chincap have been evaluated when used with functional orthopedic appliances[2,24,33-35] and with fixed appliances to compensate for the extrusive effects of fixed mechanics.[29,30,32]

Spyropoulos[33] investigated the vertical changes of using the vertical chincap and found a decrease in the mandibular plane angle.

The anterior rotation effect of the vertical chincap on the mandible was observed as a result of the mandibular first molar intrusion and the inhibition of vertical growth of the mandibular dentoalveolar region in the current study.

Changes in the mandibular ramus and corpus of the dentoalveolar region were examined by structural mandibular superimposition. The decrease in gonial angle is another finding that supports the decrease in the mandibular plane angle.

Björk and Skieller[38] have declared that the gonial angle had a tendency to decrease when the mandible rotates anteriorly. The decrease in the ramal inclination angle observed in this study with the effect of the vertical chincap indicates anterior rotation of the mandible. The change in the corpus inclination angle shows the inferior positional change of the gonial angle as well as the superior positional change of the bony chin. However, increases in the ramal inclination angle and the gonial angle have been shown with posterior bite block therapy of skeletal open bite cases, even though a decrease in the mandibular plane angle was obtained.[34,40]

Schudy[41] pointed out that the vertical growth of the mandibular condyle, the mandibular and maxillary posterior dentoalveolar regions, and the maxillary corpus, the vertical positional change of the glenoid fossa, and the growth of nasion play important roles in the forward or downward positional change of pogonion. The anterior rotation of the mandible was seen together with a decrease of the gonial angle and the ramal inclination in this study; this indicates the benefit of vertical chincap therapy.

Posterior bite blocks also provide intrusive forces on the buccal segments in treating skeletal open bites and alter the craniofacial and dentoalveolar structures.[42-44] The effects of the spring-loaded posterior bite blocks on the posterior inclination of the mandibular ramus were significantly different from those of the passive posterior bite blocks used with vertical chincaps.[34] Some studies have shown that the use of spring-loaded and magnetic bite blocks increases the ramal inclination and the gonial angle.[44,45] The effects of a vertical chincap alone to treat skeletal open bite appear to be different from the effects of passive and spring-loaded bite blocks. The force mechanism involved in these treatment results is rather complicated. The effect of the vertical chincap might be due to the differential remodeling in the ramus-corpus region as a result of a fulcrum-type effect in the mandibular first permanent molar region.

Mandibular incisor eruption was observed in the vertical chincap group; this also played a significant role in correcting the open bites in our study. Similar eruption was also seen in the control group, and this can be interpreted as a compensation mechanism for cor-

Table II. Mean changes and significance based on paired t test

	Vertical chincap group		*Control group*	
Measurements	*D*	*SD*	*D*	P
Mand 1 to VL (mm)	−0.17	1.31	−0.24	NS
Mand 1 to HL (mm)	1.56**	0.95	0.91**	*
Mand 1/HL (°)	1.06	2.51	1.35*	NS
Mand 6 to VL (mm)	−0.58*	0.93	−0.50*	NS
Mand 6 to HL (mm)	−0.97**	0.53	1.53**	**
Mand 6/HL (°)	1.31*	2.20	0.00	NS
Co to VL (mm)	0.33	0.73	0.27	NS
Co to HL (mm)	−0.06	1.09	0.24	NS
Ramal inc (°)	−1.03**	0.90	−0.29	*
Corpus inc (°)	0.58**	0.58	−0.21*	**
Gonial angle (°)	−1.92**	1.63	0.44*	**
ANB (°)	−0.11	0.65	−0.32*	NS
SN/ANS-PNS (°)	0.67	1.81	0.27	NS
SN/GoGn (°)	−1.42*	1.68	−0.15	*
Overbite (mm)	3.92**	1.49	0.47*	**

Mand, mandibular; *1*, central incisor; *6*, first molar; *VL*, vertical line; *HL*, horizontal line; *inc*, inclination; *NS*, not significant; *D*, mean difference. *$P < .05$; ** $P < .01$.

recting the open bite. Eruption of the mandibular incisors was observed significantly more in the vertical chincap group. This eruption cannot be interpreted as a consequence of the retrusion of the mandibular incisors with the effect of the vertical chincap because nearly the same amount of retrusion was observed in the control group. Thus, this eruption effect seemed to coincide with the anterior rotation of the mandible in the vertical chincap group, but the mechanisms involved in the anterior rotation of the mandible should be further investigated.

We studied the effects of vertical chincap therapy in open-bite patients in a short experimental period. Posttreatment changes are being assessed to learn more about stability in open-bite patients with backward rotations.

CONCLUSIONS

Skeletal and dental open bites were successfully corrected by using vertical chincaps. The mandibular plane angle decreased significantly. The gonial angle closed, the ramal inclination angle decreased, and the corpus inclination increased, all indicating anterior rotation of the mandible. Anterior rotation of the mandible occurred as a result of inhibiting the vertical growth in the mandibular posterior dentoalveolar region. The eruption of the mandibular incisors played an important role in correcting the open bites in the vertical chincap group.

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