Chin Cap Force to a Growing Mandible

Long-term clinical reports

Hideo Mitani
Toshihiko Sakamoto

A detailed evaluation of the changes in mandibular growth of three patients under chin cap therapy, based on extended observation with periods of treatment alternating with observation periods.

KEY WORDS: CHIN CAP THERAPY, CLASS III MALOCCLUSION, MANDIBULAR GROWTH

Chin cap therapy is an effort to retard or redirect the growth of the mandible to obtain a better anteroposterior relationship between the jaws in a growing Class III malocclusion. Recent clinical and experimental studies have demonstrated some effects of such orthopedic force to a growing mandible. However, since growth exhibits variations in several dimensions and other parameters — in amount, direction, velocity and timing — each must be considered to be an integral part of the basic question.

Regarding control over the amount of growth, **Janzen and Bluher (1965)** reported a significant decrease in the prechondroblastic layer of the condylar cartilage, which led to decreased bone formation at the condyle. Similar growth retardation has been reported in Rhesus monkeys (**Bare 1972, and Kulis 1972**), rabbits (**Matsui 1965**), rats (**Noguchi 1970, and Petrovic et al. 1975**), and guinea pigs (**Belhobek 1975**). Those findings seem to support clinical findings of retardation of vertical growth of the ramus in human patients (**Suzuki 1972, Graber 1975, and Sawa 1978**).

Author Address:

Dr. Hideo Mitani
Dept. of Orthodontics
School of Dentistry
Tohoku University
Seiryo-cho 4-1
Sendai, Miyagi
JAPAN 980

Dr. Mitani is Professor and Chairman of the Department of Orthodontics at the School of Dentistry, Tohoku University, in Sendai, Japan. He holds a D.D.S. degree from Osaka Dental University and an M.S. degree in Orthodontics from the University of Illinois in Chicago.

Dr. Sakamoto is formerly Professor and Chairman of the Department of Orthodontics at the School of Dentistry, Tohoku University, in Sendai, Japan. He is a dental graduate (D.D.S.) of Tokyo Medical and Dental University, and also holds a D.M.Sc. degree in facial growth from the same institution.

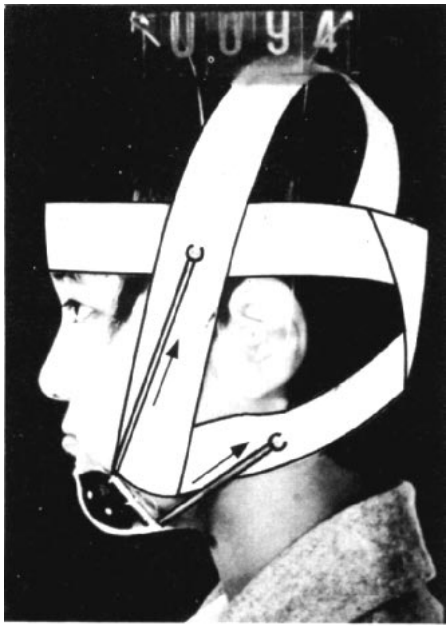

Fig. 1 The type of chin cap appliance used by the patients in this study. The cup was pulled up by one rubber elastic on each side, with ends attached on different straps. Average force level at the chin ranged from 500–600gm.

A change in the direction of mandibular growth (downward and/or backward), during the use of a chin cap has been reported (**Graber et al. 1968, Graber 1975, Armstrong 1961, Nanda 1980, Suzuki 1972, Sakamoto 1979a and 1979b, Susami 1966, Sawa 1978, Nukatsuka 1982, Yano 1971, and Cleall 1974**).

Closure of the gonial angle is also a common alteration, as reported in animal experiments (**Janzen and Bluher 1965, Matsui 1965, and Joho 1973**) and in cephalometric investgations (**Graber 1975, Suzuki 1972, Sakamoto 1979, Susami 1966, and Irie et al. 1972**).

However, Thilander (1963) reported little effect on skeletal components with chin cap force. Graber (1977) suggested that Thilander's force of 150- 200gm at the chin might have been insufficient to obtain a uniform response with the chin cap appliance.

Control of growth velocity and timing has been investigated in only a few studies. Sakamoto et al. (1979) indicated the ability of chin cap force to alter growth velocity in one longitudinal human sample. However, this is rather difficult to demonstrate reliably because one must determine whether the mandible is in an accelerative or decelerative phase, and the individual growth condition shows wide ranges of variability in velocity and timing. While the growth process in any person is continuous, its state changes continually.

The present study was undertaken to investigate whether chin cap force could control the direction, velocity and/or timing of mandibular growth, as well as the resulting form of the mandible.

Materials and Methods

The cases reported in this study were three Japanese females who had undergone several years of chin cap treatment. The sample includes different types of prognathic skeletal patterns in terms of the relative size or position of maxilla and mandible.

A chin cap was applied to the mandible with a force of 500-600gm at the chin during the treatment period. The applied force was directed toward the condylar head of the mandible within a small range of variation. The design of the chin cap is shown in Fig. 1.

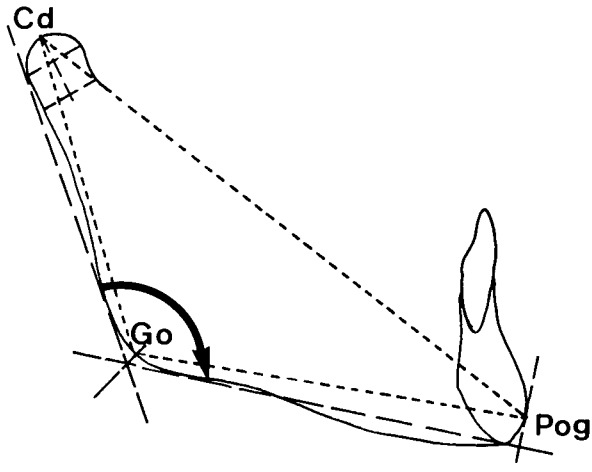

Fig. 2 Measurements used in this study. The long axis of the condyle is drawn through the midpoints of the widest and narrowest parts of the head and neck. The condyle point, Cd, is located by the intersection of the long axis with the condyle surface. Linear measurements are made between the established points. The gonial angle is centered on Go and measured to the tangent lines.

The investigation is based on serial lateral cephalometric radiographs taken at three-month intervals, along with semiannual records of standing height and wrist-hand radiographs. Each subject maintained time tables in which every hour of chin cap use was recorded.

Two of these cases were treated with a chin cap as an adjunct to an intraoral appliance for several years, and one was treated solely with a chin cap. Since two cases were treated orthodontically along with a chin cap, the changes in the face may include treatment effects other than those produced by the chin cap therapy. However, the study was based on the area where orthodontic therapy is thought to be least effective.

The cephalometric points, planes and diagram for angular and linear measurements employed in this study are shown in Fig. 2. These include overall mandibular length (Cd–Pog), mandibular body length (Go–Pog), mandibular ramus length (Cd–Go), and the gonial angle.

Measurements were made every six months. The individual growth data for each point was then combined on a graph to describe the semiannual incremental changes.

The wrist-hand radiographs and standing height data were employed to indicate the progress of each patient's growth. Ossification events seen on the wrist-hand radiographs were also indicated on the individual incremental curve of standing height. These included the hooking stages of hamate, appearance of pisiform and ulnar sesamoid at the metacarpophalangeal joint of the first finger, and epiphysis capping on its diaphysis at the middle and/or proximal phalanx of the second or

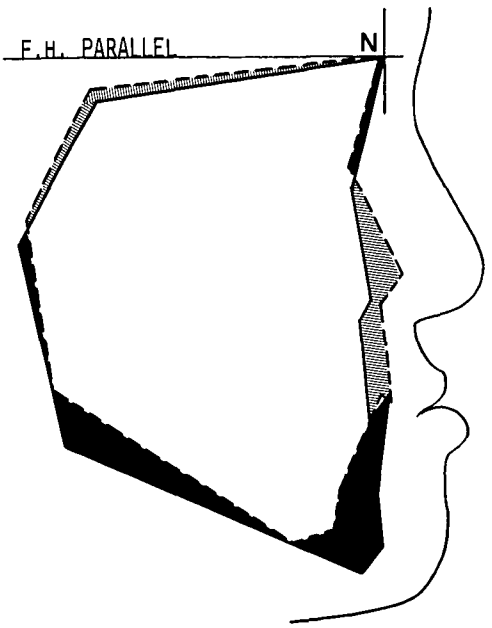

Fig. 3 **Case 1** (age 8yr 4mo), cephalometric diagram. Broken line outlines average female face at age 7yr 7mo ± 18mo. Superimposition is on Nasion, oriented on Frankfort horizontal. Black indicates patient outside the average outline, shading indicates patient inside the average outline.

third finger (**Grave and Brown, 1976**). The appearance of the first menarche was also marked on the curve of standing height.

All materials were obtained from the files of the Department of Orthodontics, Tohoku University.

Findings

Case 1 was a female, with first records taken at eight years and four months of age. The lateral cephalometric diagram shows an evident depression of the middle face as well as a remarkable protrusion of the chin when compared with the normal pattern for this age (Fig. 3). It also indicated a procumbent mandibular plane and some upward and forward rotation of the mandible.

Mandibular movements to all functional positions were felt to be smooth and normal, but a forward positioning of the mandible was noted during occlusion. From the rest to occlusal position, the central incisors showed a premature contact. The mandible then shifted forward to gain buccal occlusion. Airway was clear and showed no pathological breathing problem.

Dental occlusion shows crossbite of the incisors, deep overbite and noticeable underjet (Fig. 4).

This patient was treated with a chin cap and intraoral appliance. Fig. 5 shows the occlusion on the final record taken at the age of 17 years and 4 months. The cephalometric diagram shows the size and

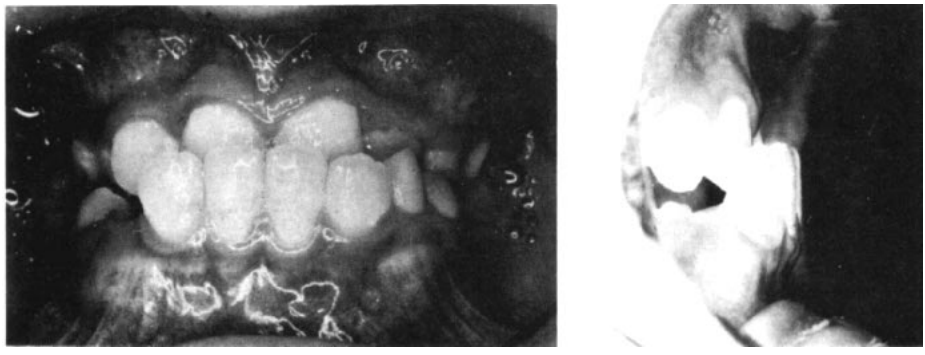

Fig. 4 **Case 1,** dental occlusion before treatment. Mandible showed some functional forward positioning.

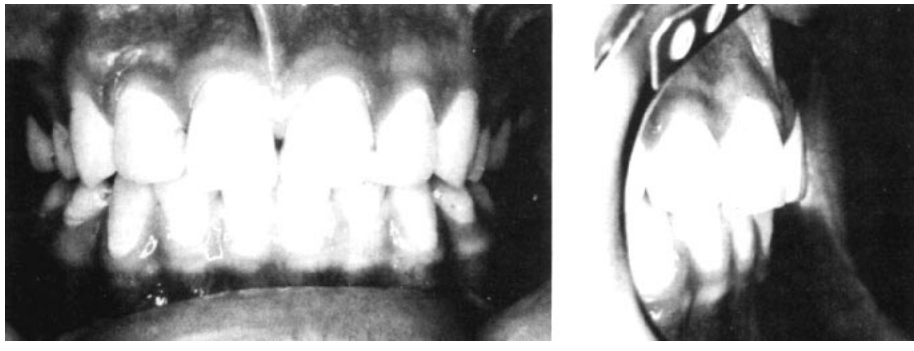

Fig. 5 **Case 1,** dental occlusion at age 17yr 4mo

position of the mandible to be fairly well balanced, yet the middle face is still retarded in relation to the normal pattern (Fig.6).

Superimposition of the radiographs on the anterior cranial base structures during wear of a chin cap shows a dramatic change in mandibular position (Fig.7). This change occurred through correction of the functional forward positioning of the mandible. After the change of the position, forward growth of the chin was more inhibited, and the chin was displaced downward. Superimposition after discontinuation of the chin cap shows almost no skeletal change (Fig. 8). The changes accomplished during chin cap wear seemed to be retained well.

Superimposition of the mandible on the mandibular plane at menton shows a peculiar change during the active chin cap period (Fig. 9), with growth at the condyle as well as the posterior border of the ramus, and a decrease in the gonial angle.

Fig. 10 shows the changes in mandibular measurements as they relate to semiannual changes in height. On the curve of the standing height, ossification events taken from the hand x-rays are also indi-

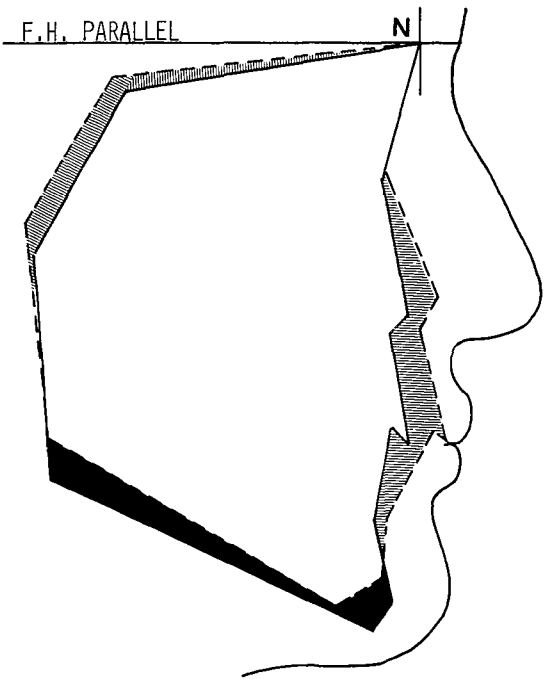

Fig. 6 **Case 1,** final cephalometric diagram superimposed on mean normal. Superimposition is on Nasion, oriented on Frankfort horizontal. Black indicates patient outside the average outline, shading indicates patient inside the average outline.

cated. This curve shows the maximum peak of height growth at the age of 11 years and 7 months. The sesamoid bone appeared at the age of 10 years and 10 months, and first menstruation at 11 years and 1 month. This is about 6 months ahead of the height peak, which is unusual.

The pubertal growth period of this patient was taken to be from a few months after age 10 to approximately the middle of age 12.

On the curve of the mandibular measurements, a solid line indicates the period that the patient wore a chin cap, from 8 years and 4 months to 14 years and 5 months. The number of hours varied.

Incremental growth changes in the mandibular measurements and standing height did not necessarily coincide during the period that a chin cap was worn, although the growth of both seemed to terminate at almost the same age. Even among the measurements of the mandible, the details of each curve show a different pattern of increase.

On the growth curve of ramal length (A), there were two periods of growth acceleration.

The first one took place from the last 6 months of 9 years, through a few months after 10 years of age. This was immediately before the pubertal growth spurt in body height, while the patient was wearing a chin cap 13.9 hours per day.

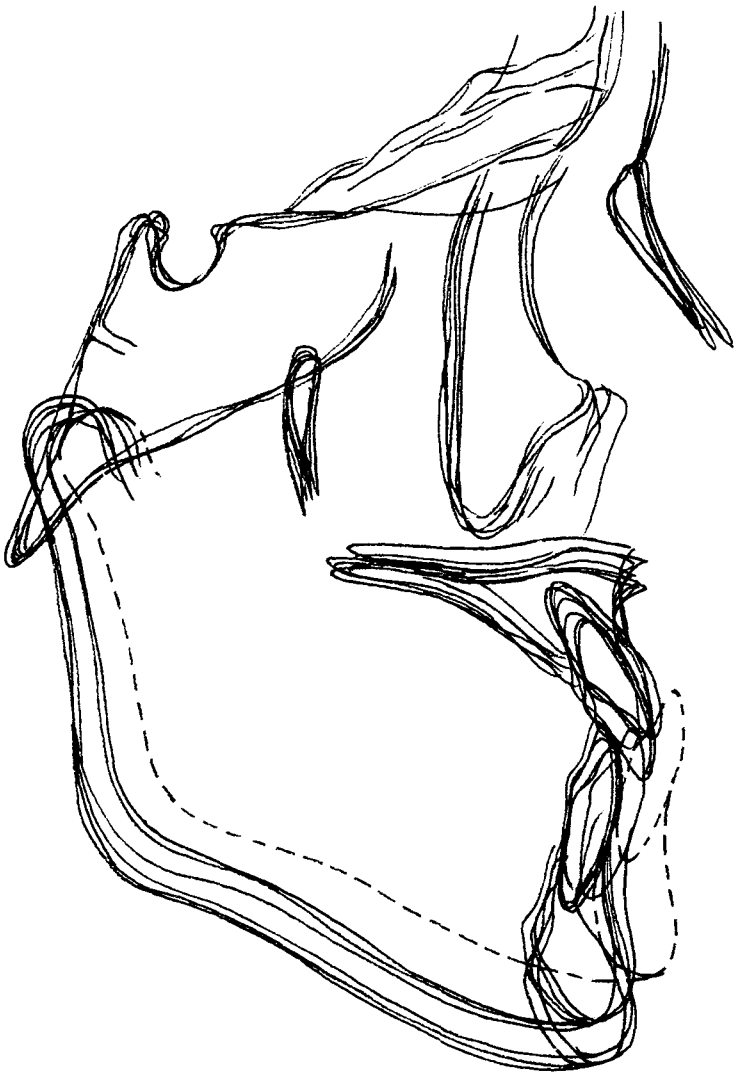

Fig. 7 **Case 1,** 8yr 4mo – 14yr 5mo, during chin cap wear. Superimposition on anterior cranial base. After correction of the forward positioning, the mandible grew downward at the chin.

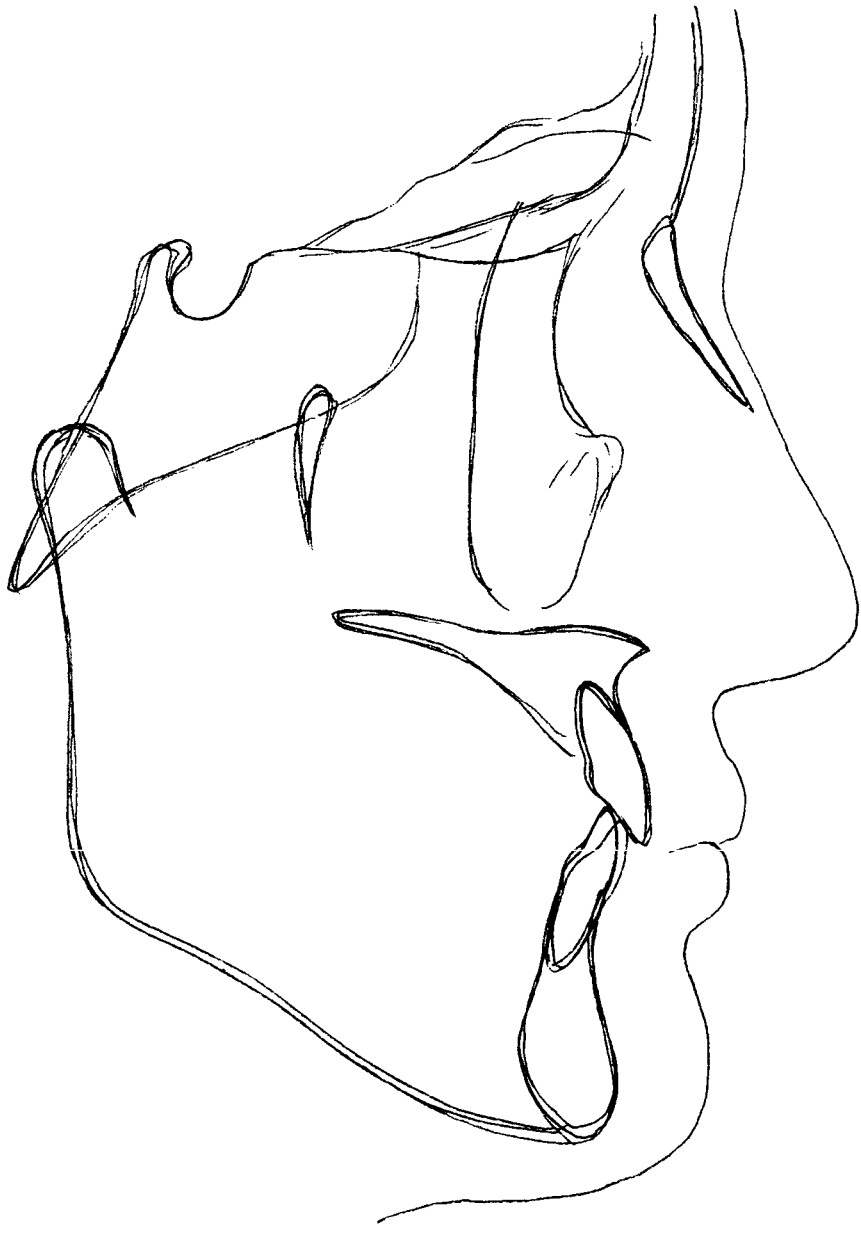

Fig. 8 **Case 1,** 14yr 5mo – 17yr 4mo, superimposition on anterior cranial base after chin cap use.

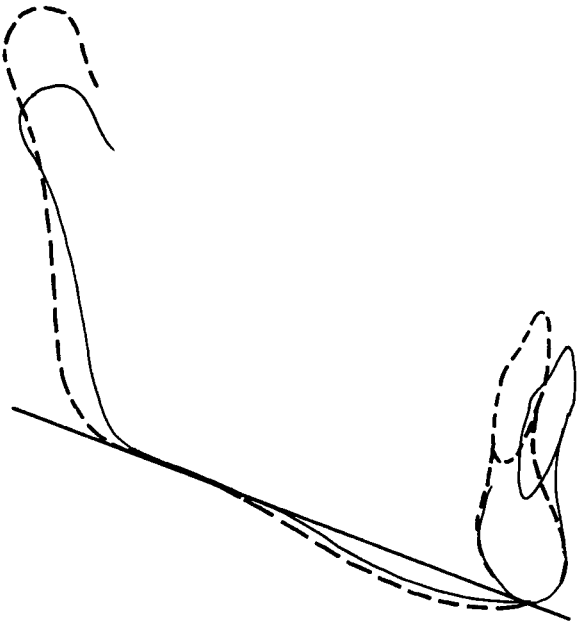

Fig. 9 **Case 1**, superimposition of the mandible on the mandibular plane at menton before and after chin cap use. Growth is seen at the condyle and posterior border of the ramus.

The second acceleration of ramal growth took place during the last 6 months of 11 years, through the first 6 months of 12 years of age. This period was partially in the pubertal growth peak of standing height, but coincided most closely with the period that growth in height was decelerating remarkably. During this period, the patient wore a chin cap for 9.2 hours per day.

Between those two periods of growth acceleration, a chin cap was worn for 12.0 hours per day. There was little growth in ramal length, in spite of the fact that growth in height was entering into the pubertal spurt during this time.

On the growth curve of mandibular body length (B), there was one period of growth acceleration. It took place during the last 6 months of 10 years of age. This period was in the pubertal growth spurt just preceding the maximum peak, while the patient was wearing a chin cap for 12 hours per day. After this period, the patient decreased the daily hours of chin cap wear to 9.2, but the incremental velocity showed no more acceleration even though the growth in height was undergoing a remarkable increase.

On the growth curve of total length of the mandible (C), there was one period of marked acceleration, from the late 11-year age to the middle 12- year age. This period coincided with a marked deceleration in growth in height. The patient wore a chin cap for 9.2 hours daily during this period.

On the curve of the gonial angle change, there were two stages of decrease.

The first took place right after the start of chin cap use. It continued for a year, until the age of 9 years and 4 months,

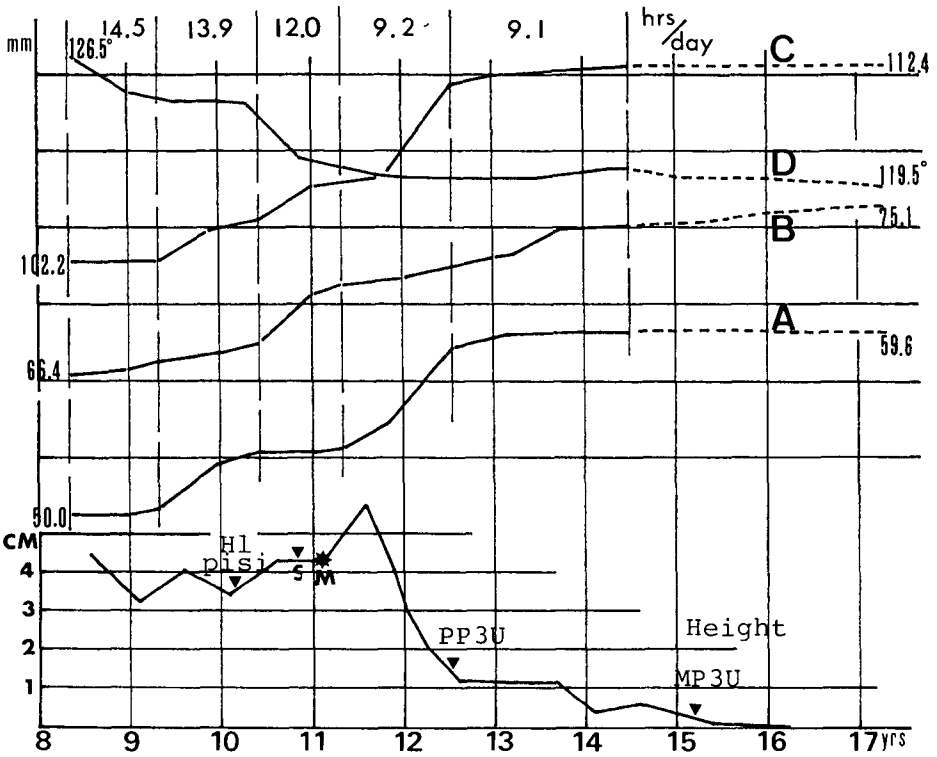

Fig. 10 **Case 1**, incremental curves of mandibular measurements and standing height
A: Cd – Go
B: Go – Pog
C: Cd – Pog
D: Gonial angle

Solid line — period of chin cap use
Broken line — no chin cap
Top numbers — hours of daily chin cap wear
H1 — Stage 1 hooking of hamate
pisi — Appearance of pisiform
S — Appearance of ulnar sesamoid at metacarpophalangeal joint of first finger
M — First menstruation
PP 3U — Complete epiphyseal union of proximal phalanx of third finger
MP 3U — Complete epiphyseal union of middle phalanx of third finger

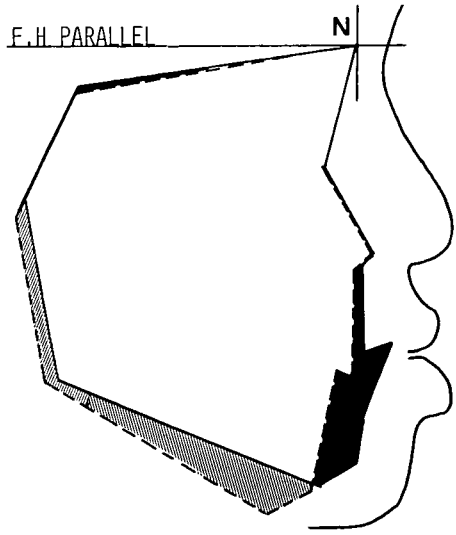

Fig. 11 **Case 2** (age 4yr 9mo), cephalometric diagram. Broken line outlines average female face at age 5yr 2mo ± 8mo. Superimposition is on Nasion, oriented on Frankfort horizontal. Black indicates patient outside the average outline, shading indicates patient inside the average outline.

while the patient was wearing a chin cap for 14.5 hours per day. The growth of the mandible was not active in all dimensions during this period, which might indicate that the change of the gonial angle could occur with a small growth of the mandible or as an immediate reaction against a heavy applied force.

The second decrease appeared during the last 6 months of 10 years of age. This was just before the maximum peak in the pubertal growth spurt in standing height, while the patient wore a chin cap for 12 hours each day. There was a noticeable growth acceleration in mandibular body length (B) during this period.

There was almost no change in the gonial angle during the year between these two periods of decrease, even though the patient wore a chin cap for an average of 13.9 hours per day.

The gonial angle has been fairly stable after the second decrease, and shows no tendency to open toward its original angulation.

Case 2 was a female first evaluated at 4 years and 9 months of age. The lateral cephalometric diagram shows her maxilla relatively well balanced in the face (Fig. 11). It also shows that the chin is protruded, with some forward and upward rotation of the mandible. The mandibular movements to all functional positions were felt to be smooth and normal, with no functional positioning during occlusion.

The airway was fairly clear, and no pathological breathing was noted, although her adenoid tissue was slightly enlarged.

Dental occlusion showed a crossbite of deciduous incisors (Fig. 12).

The patient was under observation until 6 years of age. A chin cap was used from the age of 6 until 7 years, when it was discontinued until 9 years and 2 months of age.

The permanent incisors developed a crossbite during the period of discontinuation, so the chin cap was replaced and

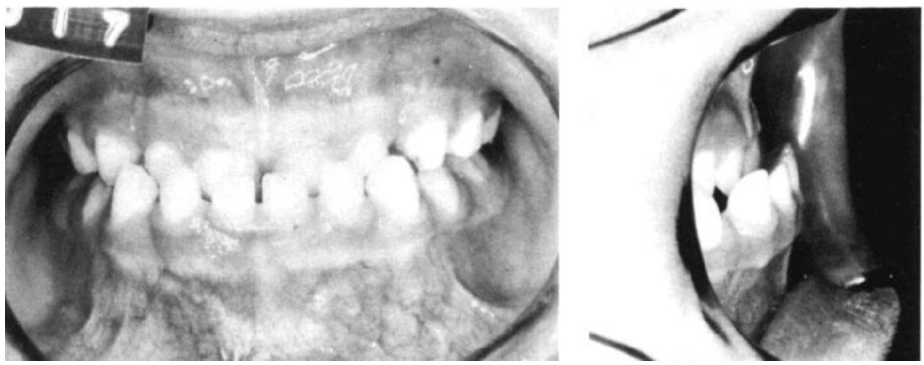

Fig. 12 **Case 2,** dental occlusion before treatment. Mandible showed no functional forward positioning in closure.

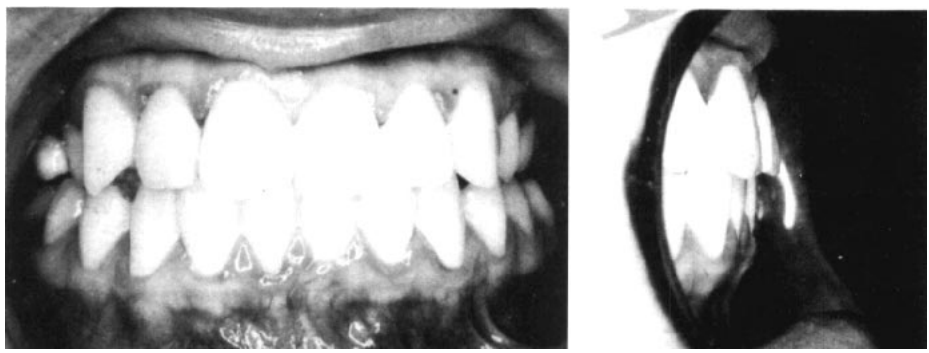

Fig. 13 **Case 2,** dental occlusion at age 15yr 0mo

continued until 11 years of age. At the age of 13, the upper first bicuspids were removed, and an intraoral appliance was placed for about ten months. The last records were taken at the age of 15 years (Fig. 13).

The cephalometric diagram of the final record shows that the face was relatively well balanced in every dimension (Fig. 14).

Superimposition of the radiographs covering the initial observation period (from 4 years and 9 months to 6 years) shows a typical growth pattern of the mandible (Fig. 15), which grew downward and forward at the chin. Mandibular superimposition reveals good growth at the condyle head as well as the posterior border of the ramus.

However, the mandible shifted slightly backward with chin cap use (Fig. 16). Mandibular superimposition shows a decrease in the gonial angle, with forward uprighting of the condylar process (Fig. 16). During the intermission period from 7 years 0 months to 9 years 2 months, the

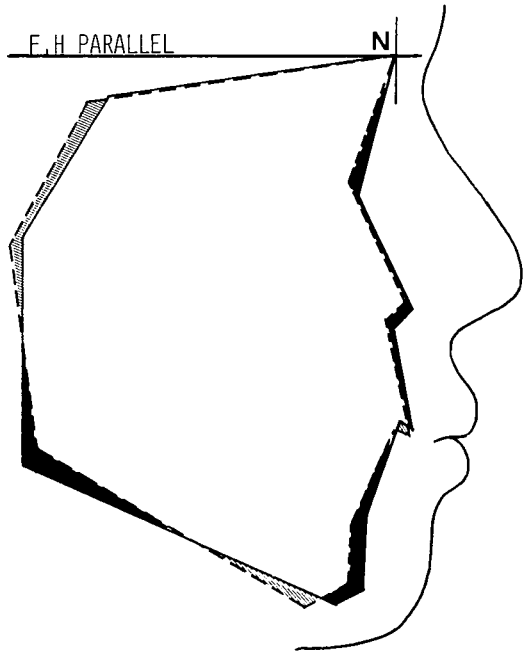

Fig. 14 **Case 2,** final cephalometric diagram superimposed on mean normal. Superimposition is on Nasion, oriented on Frankfort horizontal. Black indicates patient outside the average outline, shading indicates patient inside the average outline.

growth pattern returned to that seen before the chin cap use, with retention of the decreased angle (Fig. 17). Mandibular superimposition also shows that growth took place at the condylar head and the posterior border of the ramus (Fig. 17).

During the second period of chin cap use, the mandible was displaced downward and backward at the chin (Fig. 18). Mandibular superimposition shows that growth took place at the head of the condyle as well as at the lower portion of the posterior border of the ramus, resulting in a further decrease in the gonial angle (Fig. 18).

After discontinuation of a chin cap, the growth pattern of the mandible returned again to that seen during previous periods without a chin cap (Fig. 19). These changes in the growth pattern seem to demonstrate an actual effect of the chin cap force to a growing mandible.

Fig. 20 shows the curves of mandibular measurements and standing height. Ossification events are indicated in the curve of standing height. The pubertal growth period of this patient was taken from the ages of 9 years and 4 months to approximately 13 years. During this period, the patient showed two peaks of maximum growth (spurt) in standing height. Since the ulnar sesamoid bone appeared after the first peak but before the second, and the epiphysis capping on its diaphysis at the middle phalanx of the third finger appeared close to the second peak, it was determined that the second peak should be regarded as the maximum pubertal growth peak.

The curve for each mandibular mea-

Fig. 15 **Case 2,** observation period from 4yr 9mo to 6yr 0mo. No chin cap.

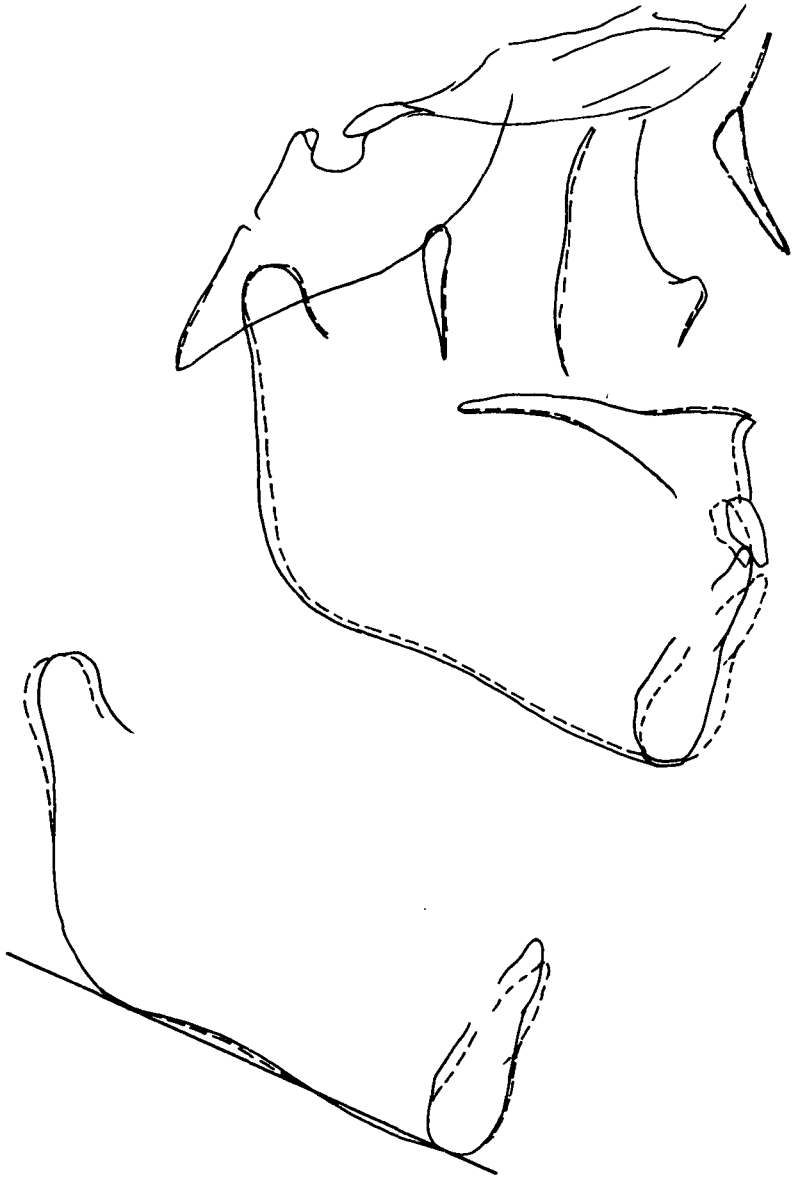

Fig. 16 **Case 2,** first stage of chin cap wear, from 6yr 0mo (broken line) to 7yr 0mo (solid line).

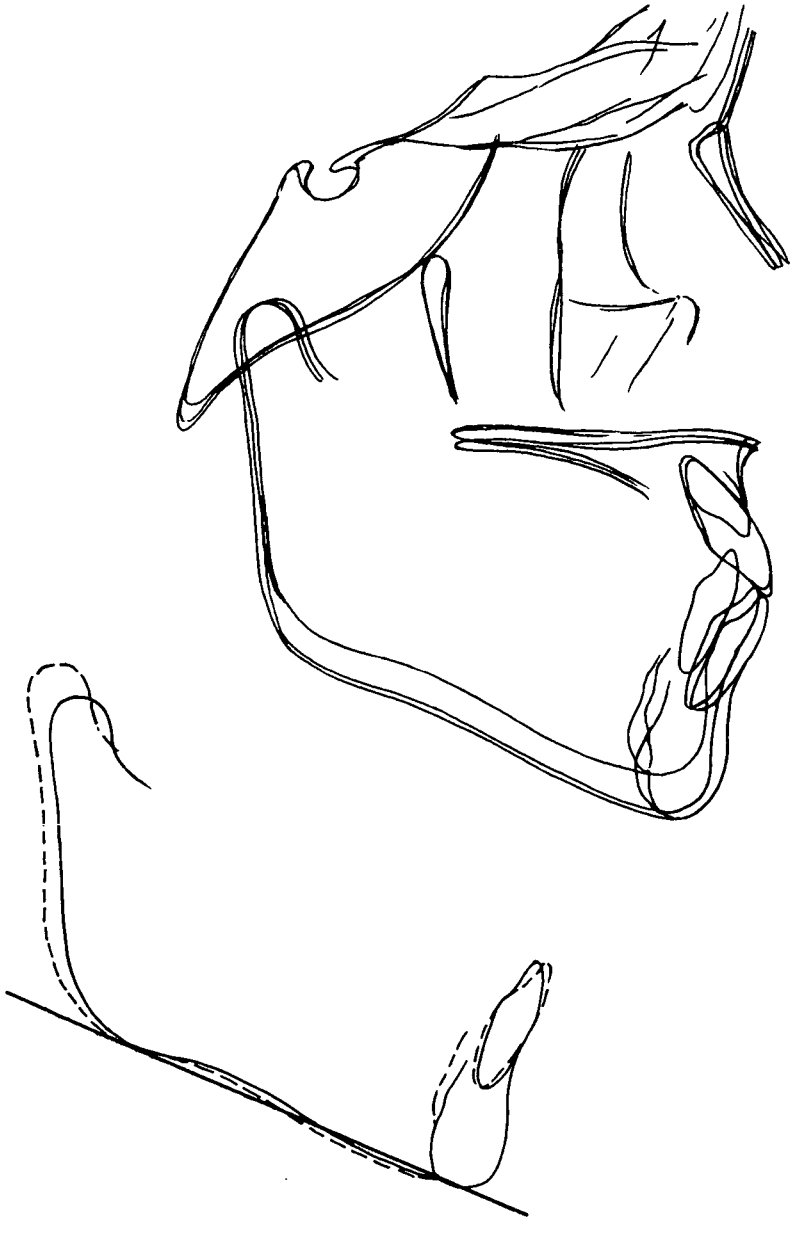

Fig. 17 **Case 2,** intermission period without chin cap wear, from 7yr 0mo (broken line) to 9yr 2mo (solid line). Note that the direction of mandibular growth at the chin reverted to the original pattern (Fig. 15).

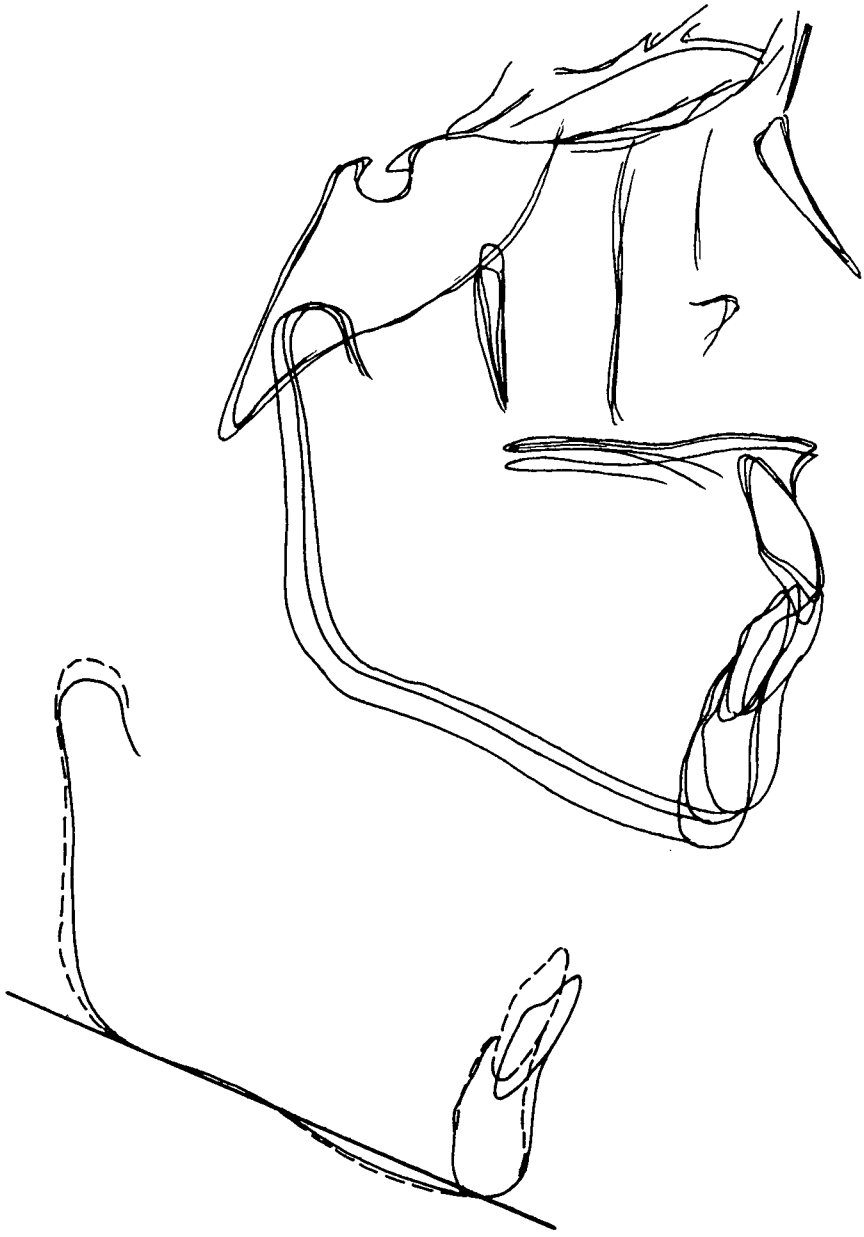

Fig. 18 **Case 2,** second stage of chin cap use, from 9yr 2mo (broken line) to 11yr 2mo (solid line). Note that the direction of mandibular growth is now downward and backward. Mandibular superimposition shows the growth at the condyle and lower border.

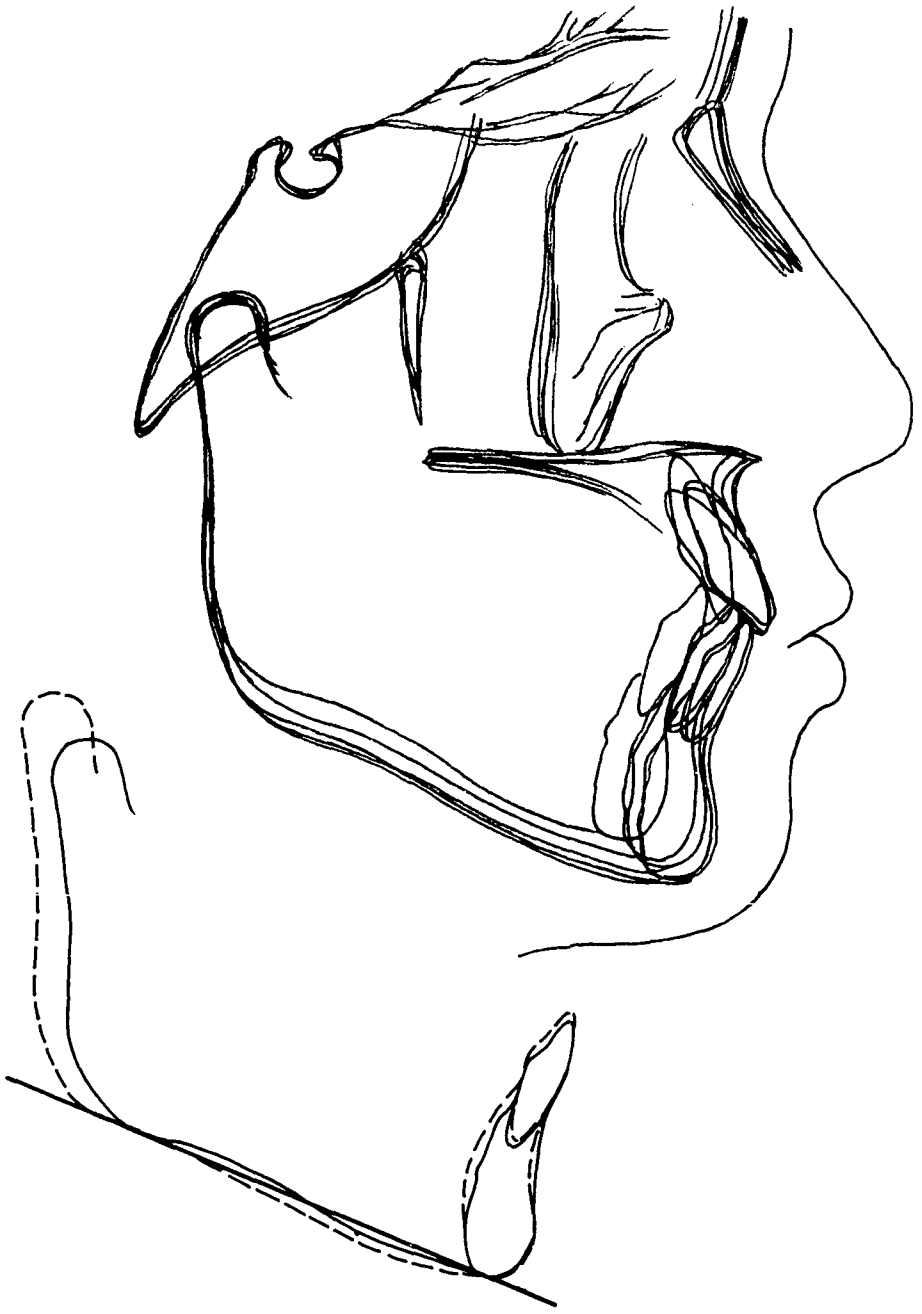

Fig. 19 **Case 2,** after discontinuation of chin cap use, from 11yr 0mo (broken line) to 15yr 0mo (solid line). The direction of mandibular growth is once again downward and forward.

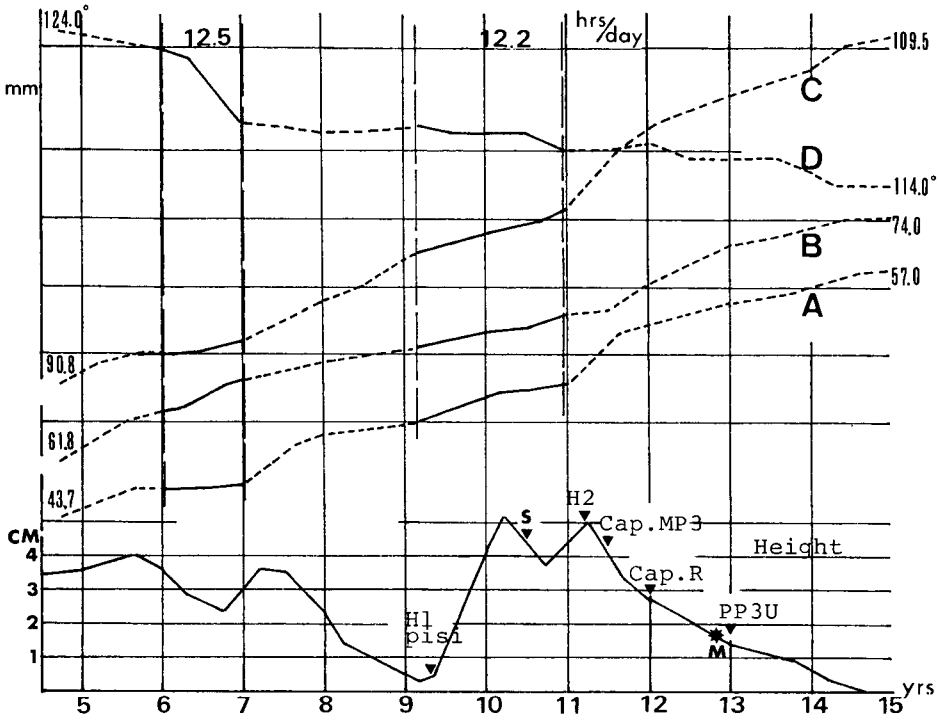

Fig. 20 **Case 2**, incremental curves of mandibular measurements and standing height
A: Cd – Go
B: Go – Pog
C: Cd – Pog
D: Gonial angle

Solid line — period of chin cap use
Broken line — no chin cap
Top numbers — hours of daily chin cap wear
H2 — Stage 2 hooking of hamate
Cap.MP3 — Epiphysis capping on diaphysis at middle phalanx of third finger
Cap.R — Epiphysis capping at radius
(See Fig. 10 for other abbreviations)

surement shows a different manner of increase. The total length (C) and the ramal length (A) shows acceleration of increase during the 11-year age period, which coincided with the maximum peak of height growth. Ramal length also shows acceleration during the age of 7 years, when the growth in height showed a prepubertal peak. The length of the mandibular body (B) generally showed a smooth increase, except for minor accelerations at 6 and 12 years of age.

This patient wore a chin cap for two different periods, with relatively even hours of use. Individual mandibular measurements did not show rapid increase

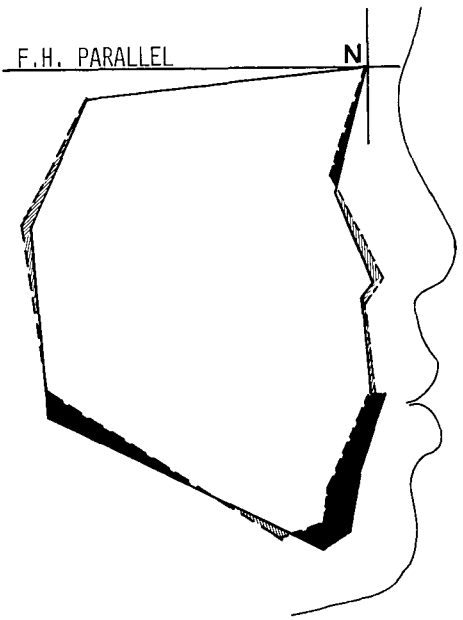

Fig. 21 **Case 3** (age 6yr 5mo), cephalometric diagram. Broken line outlines average female face at age 7yr 7mo ±18mo. Superimposition is on Nasion, oriented on Frankfort horizontal. Black indicates patient outside the average outline, shading indicates patient inside the average outline.

during wear of a chin cap, with the exception of body length (B) during the first period.

Ramal length and total length of the mandible showed peculiar accelerations immediately after the release from chin cap use. However, their timing also coincided with the growth peak of standing height, which might indicate that growth had become more active in the mandible as well.

Growth in each mandibular measurement seemed to have terminated after the age of 14 years, coinciding with the termination of growth in standing height.

The graph for the gonial angle shows a distinctive decrease during the first period of chin cap use. During this period, only the body length (B) shows a minor acceleration of growth. A sudden decrease in the gonial angle took place with wear of 12.5 hours per day. After the first period, the gonial angle showed a relatively smooth and gradual decrease. This trend was continued through the second period of chin cap use. The decreased gonial angle was retained, and it shows no tendency toward relapse up to the termination of growth.

Case 3 was first evaluated at 6 years and 5 months of age. The cephalometric diagram shows that the maxilla was balanced, but the mandible was protruded downward and forward compared with a normal pattern at this age (Fig. 21). No functional forward positioning of the mandible was noted.

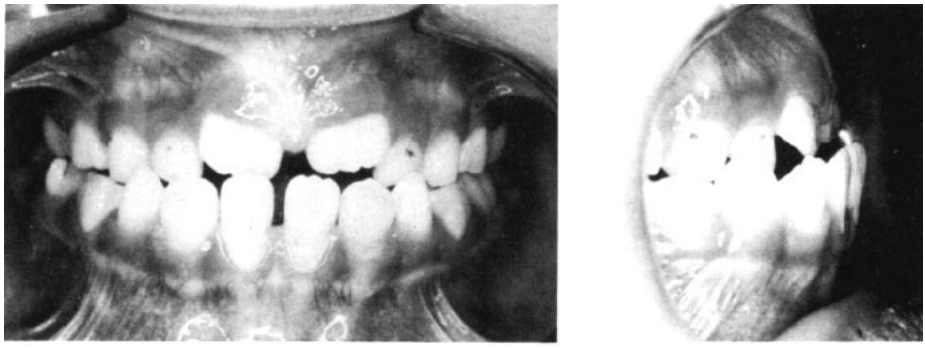

Fig. 22 **Case 2**, dental occlusion before treatment. Mandible showed no functional forward positioning in closure.

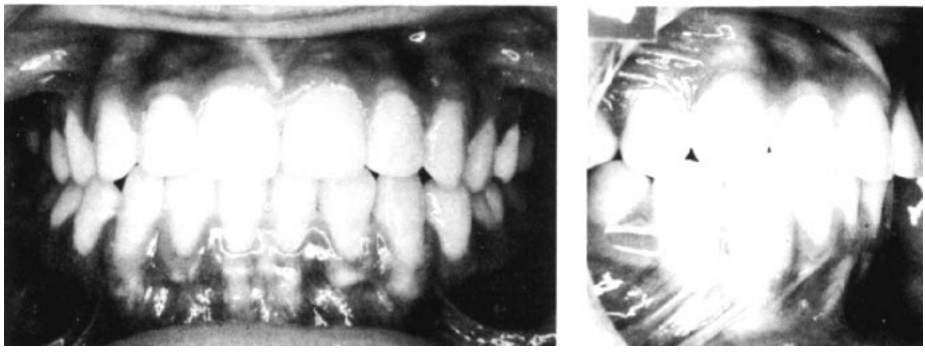

Fig. 23 **Case 3**, dental occlusion at age 13yr 6mo

Airway showed no pathological breathing problem.

Dental occlusion showed a crossbite of the anterior teeth (Fig. 22).

The patient was treated solely with a chin cap; no intraoral appliance was used. The chin cap was applied in the same manner as in the other cases. The final occlusion is shown in Fig. 23. The cephalometric diagram of the final record shows a tendency toward bimaxillary protrusion with an acute gonial angle (Fig. 24).

This patient was placed under observation for one year, until 7 years and 5 months of age. Superimposition of headfilms during this period shows a typical pattern of growth of the mandible (Fig. 25), which grew downward and forward at the chin.

Chin cap therapy was begun at the age of 7 years and 5 months, and continued until 10 years and 6 months of age. Superimposition of the tracings covering the chincap period shows that the mandible grew downward, with a slight backward tendency at the chin (Fig. 26). Mandibular superimposition also shows unique changes in both size and form of the mandible. The condyle shows notice-

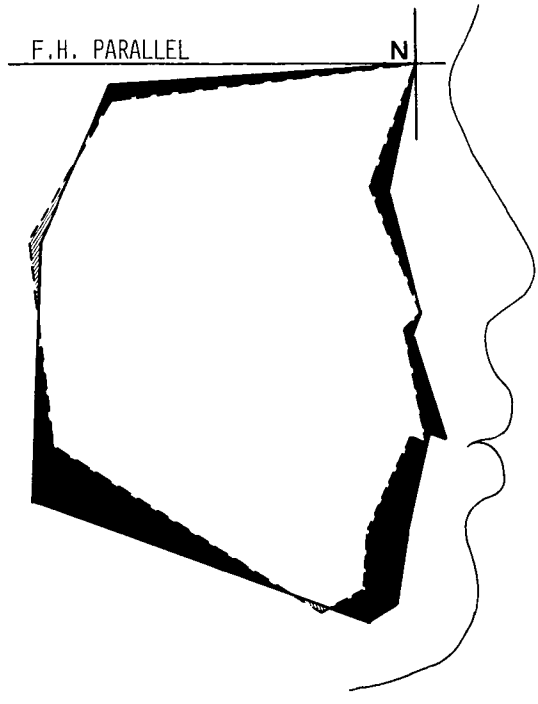

Fig. 24 **Case 3,** final cephalometric diagram superimposed on mean normal. Superimposition is on Nasion, oriented on Frankfort horizontal. Black indicates patient outside the average outline, shading indicates patient inside the average outline.

able growth forward and upward. The gonial area shows a change of outline and a deepened antegonial notch.

After discontinuation of the chin cap, the growth pattern of the mandible returned to that seen prior to chin cap use (Fig. 27).

Mandibular superimposition shows a unique change at the posterior border of the ramus (Fig. 27), with remarkable growth at the head of the condyle and the lower portion of the posterior border of the ramus. This had the effect of uprighting the ramal plane, with a resultant decrease in the gonial angle.

Fig. 28 shows the curves of the mandibular measurements and standing height, with ossification events shown on the height curve.

This patient shows a clear spurt of pubertal growth in height. However, the ossification events occurred slightly later in relation to the change in height when compared to a typical pattern. A pisiform and the first stage of hamate hooking appeared at the middle of the 9th year of age, on the maximum peak of growth in height. Ulnar sesamoid bone also appeared at about this age. Epiphysis capping of the middle phalanx of the third finger appeared at the age of 10, and the complete union of the proximal phalanx of the third finger appeared around the age of 13 years. The first menstruation occurred around the middle of 11 years of age.

According to the timing of these events, the pubertal growth period of this patient

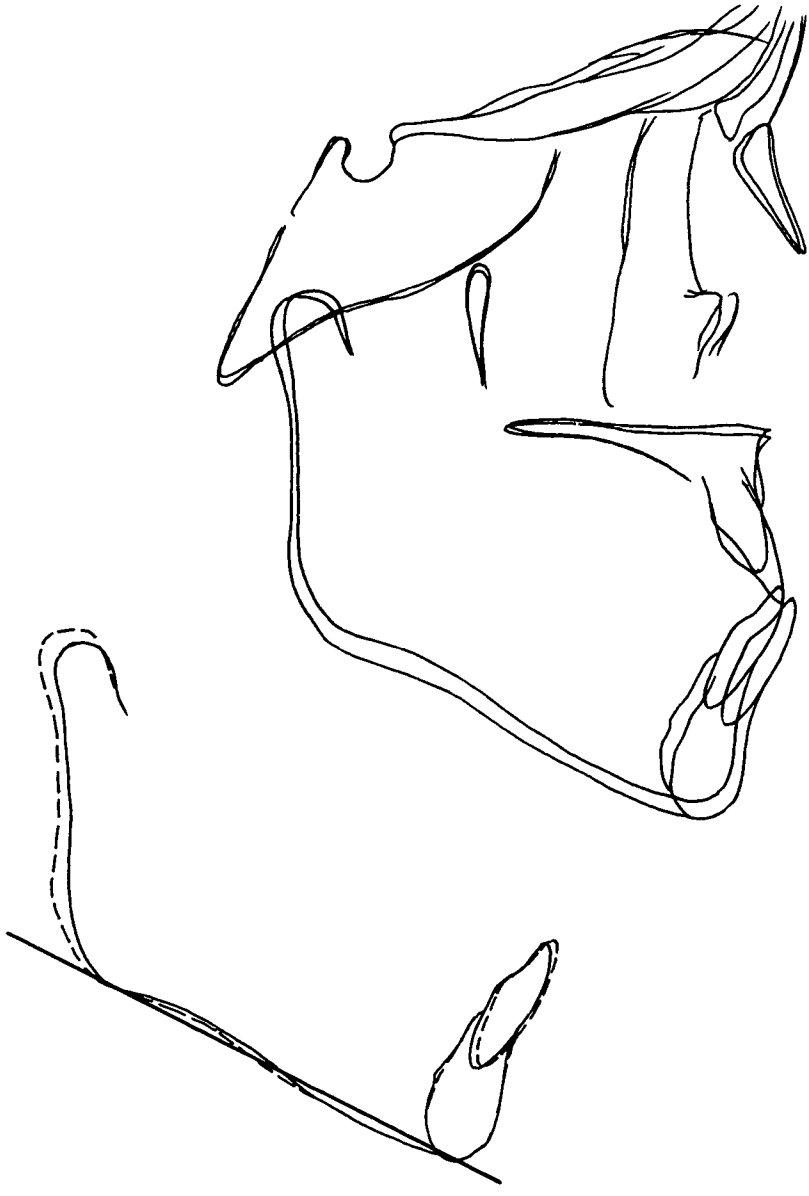

Fig. 25 **Case 3,** observation period from 6yr 5mo to 7yr 5mo. No chin cap.

Fig. 26 **Case 3,** headfilm superimposition during period of chin cap use, from 7yr 5mo to 10yr 6mo. Note that growth direction of the chin has changed to downward and backward. Mandibular change shows an unusual change at the condylar process and deepening of the antegonial notch.

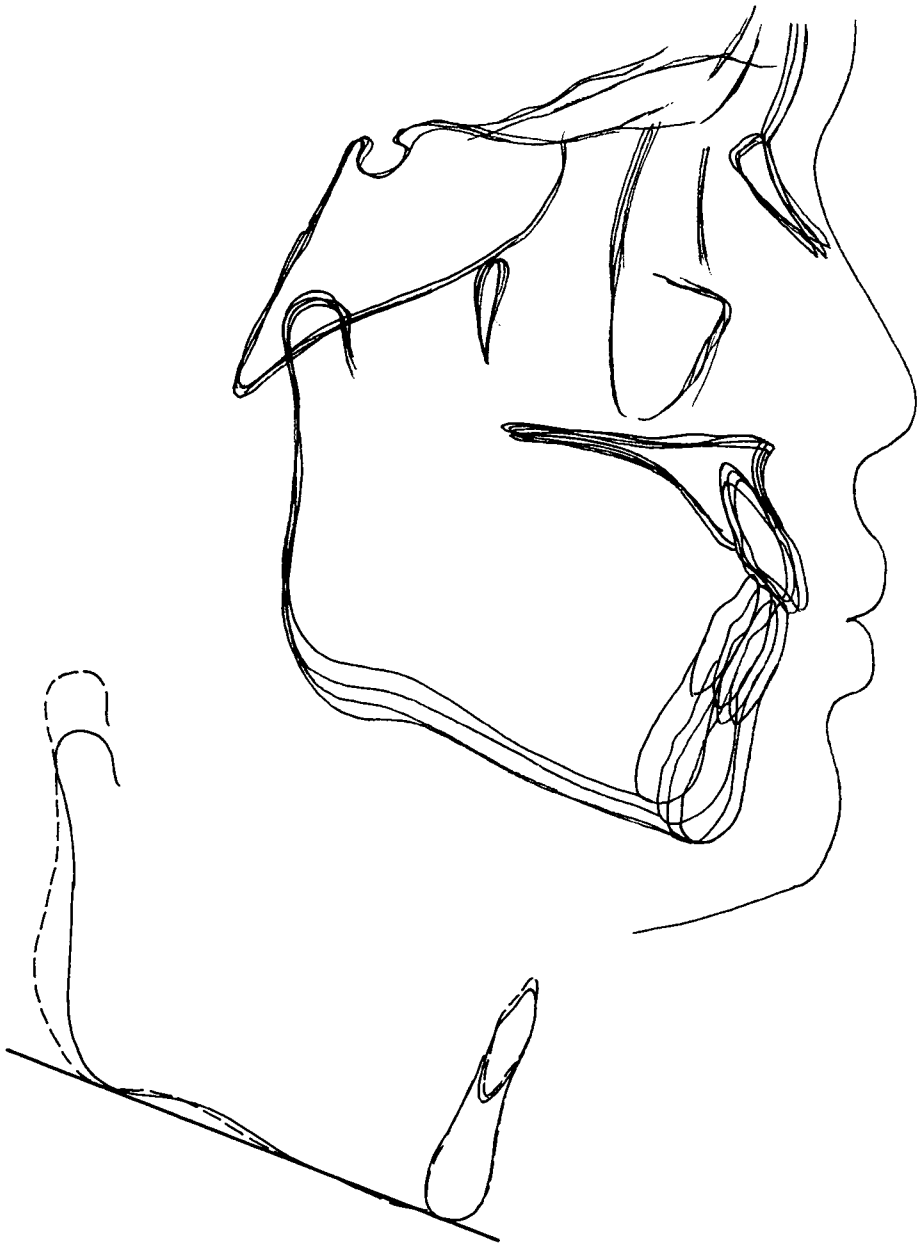

Fig. 27 **Case 3,** headfilm superimposition during period after discontinuation of chin cap use, from 10yr 6mo to 13yr 6mo. Note the change in growth direction at the chin.

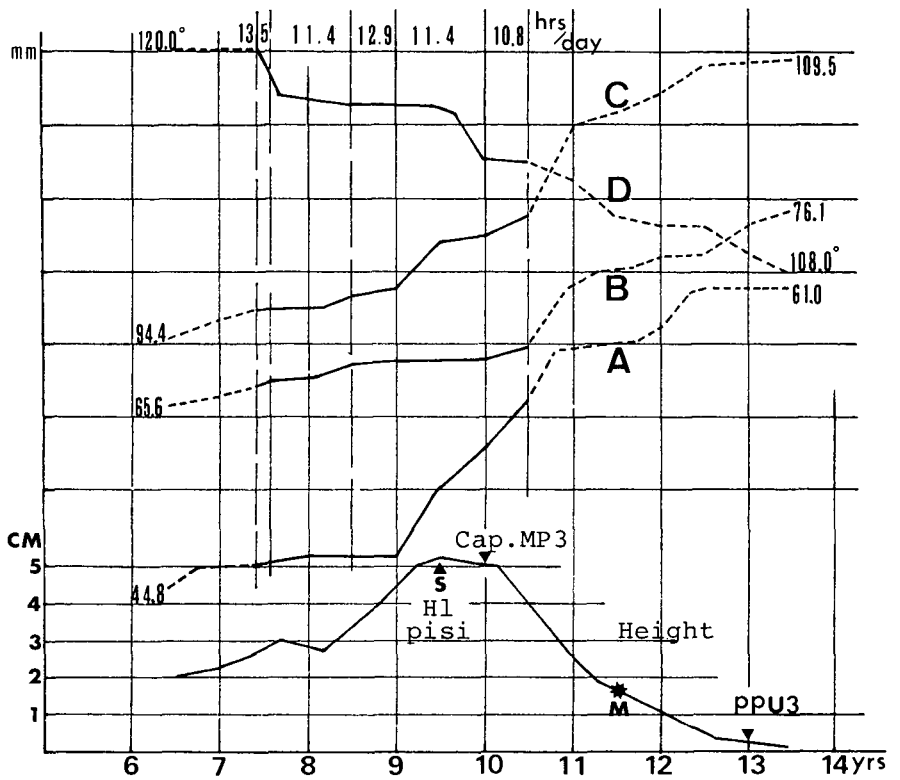

Fig. 28 **Case 3**, incremental curves of mandibular measurements and standing height
A: Cd – Go
B: Go – Pog
C: Cd – Pog
D: Gonial angle

Solid line — period of chin cap use
Broken line — no chin cap
(See Figs. 10 and 20 for other abbreviations)

was taken from the middle of 9 years to the end of 12 years of age. The maximum peak of growth was around the beginning of 10 years.

On the curve of ramal length (A), remarkable acceleration is seen to occur suddenly at the beginning of 9 years, continuing until the end of 10 years of age. This appeared during the use of a chin cap when wearing hours were decreased from 12.9 to 11.4 hours a day. However, this acceleration also coincided with the maximum peak of growth in height. This curve also shows a minor acceleration around the age of 12.0 years.

On the curve of the mandibular body length (B), remarkable acceleration is seen during the last 6 months of 10 years,

immediately after release from the chin cap. Little growth was seen during wear of a chin cap, with the hours of daily wear varying from 12.9 down to 10.8 hours. Growth of the mandibular body length appeared to be well inhibited with wear of a chin cap, even when physical growth activity entered the pubertal period.

On the curve of total length of the mandible (C), distinctive acceleration also occurred during the last 6 months of 10 years, immediately after the release from a chin cap. This curve also showed a small acceleration of growth during the first six months of 9 years, while a chin cap was being worn for 11.4 hours per day. This was probably an effect of the remarkable acceleration in growth of ramal length.

The graph of the gonial angle shows two stages of decrease during chin cap wear. The first took place immediately after the initiation of the chin cap, when it was being worn for 13.5 hours each day. This decrease occurred over a short period, when there was almost no growth of the mandible. The change was retained until the second stage of decrease, which took place during the last six months of 9 years while a chin cap was being worn for 11.4 hours a day.

The second period of gonial angle decrease was immediately before the maximum peak of height growth, when the ramus was growing well in length. Although a chin cap was worn for relatively even hours each day through the period, the gonial angle did not show a smooth and gradual change. Rather, the change seemed to occur independently, unrelated to the period of daily wear. Furthermore, the gonial angle of this patient continued to decrease *after* release from a chin cap, as long as the mandible was growing.

Discussion

The question of the ability to alter the mandibular growth pattern with a chin cap should be regarded in the light of all of the variables that may influence growth. Although experimental animal studies examining the effect of such orthopedic force against the temporomandibular joint have shown relatively consistent results, previous studies on growing humans have reported various results.

Such inconsistency of findings in human samples is due to the many differences between individuals. It seems logical to assume that certain effects should occur on growing bony structures when an orthopedic force is applied to it; however, the difficulty and uncertainty of precise control in the practical application of this appliance has caused less attention to the use of a chin cap in the treatment of growing Class III malocclusions.

Even though only three cases were studied here, the results raise several points for discussion. It seems that a complete inhibition of mandibular growth is difficult to achieve with a chin cap appliance in human subjects. There was always some increment of growth in each mandibular measurement during use of a chin cap. Growth always continued when a chin cap was worn for 12-14 hours per day, which seems to be the most practical time length to expect most patients to wear this appliance.

This leaves the question whether a chin cap could abate all growth unanswered. GRABER (1977) has reported statistically significant *retardation* of vertical ramal height, but the small sample in this study makes such a statistical evaluation impossible.

Growth velocity and timing in the mandible did not indicate a consistent pattern

of change when a chin cap was used. There was no clear correlation between the length of time of chin cap use and the change in growth velocity in these three cases; a longer application of the force each day was not always associated with a greater deceleration of velocity than a shorter application might achieve. The change of growth velocity and timing seem to be controlled fundamentally by the individual inherited growth potential, and a foreign mechanical intervention may play little on it.

This conclusion was reached by examining the correlation of timing of growth in standing height with ossification events in hand bones and with each mandibular measurement. However, correlation of growth timing between the mandible and standing height and/or hand bones is still controversial (**Nanda 1955, Bhamba 1961, Hunter 1966, Fukuhara and Matsumoto 1968, Bergersen 1972**). This is a critical point in the assessment of the timing of facial growth in relation to the effect of chin cap force to a growing mandible.

Growth direction seemed to be altered downward or downward and backward by the chin cap force, as reported by previous studies. This was indicated by the specific change of the growth direction at the chin that occurred when a chin cap was used. Alteration of the direction was limited to the period that the force was applied. Inherited growth direction seems to be maintained, and to recover when the mechanical intervention is removed.

The change of growth direction at the chin should be somewhat related to the length of daily chin cap wearing time (**Jo et al. 1980**). It has been indicated that wearing a chin cap for more than 9 hours and less than 15 hours per day could produce various effects on the direction of chin displacement. Thus, growth direction and growth velocity seem to react differently to the time length of the force application.

Mandibular form could be alterable with the chin cap force, as shown in the previous studies. However, there seemed to be two types of alteration in response to the force.

FIRST, the mandible seemed to show a certain change at the condyle area immediately after the application of the force. This reduces the gonial angle. This alteration might take place regardless growth when the force is applied for more than 12 hours per day.

SECOND, the angle of the mandible seemed to show a remodeling, with deepening of the antegonial notch during the period of force application. This also reduces the gonial angle.

Those changes seem to be retained, and show no tendency toward relapse or rebound after release from the force. However, the change of the gonial angle during the use of a chin cap was neither smooth and steady in degree nor consistent in the structural changes underlying it. Although it commonly showed a decrease soon after the start of chin cap wear in these cases, it seemed to be unpredictable in terms of when and to what degree the following changes might occur.

Conclusion

There are different types of Class III malocclusions in growing patients. Even with a similar skeletal problem, variations exist not only in the form and/or constitution of skeletal parts of the face, but also in the direction, velocity and timing of growth changes. Individual reactions to the chin cap force are different in the effects on those variables, but the difficulty of controlling each variable is not necessarily the same.

For instance, redirection of mandibular

growth at the chin seems to be favorably controlled by the chin cap, but control over growth velocity seems to be slight. Since it is essential for diagnosis and treatment to determine exact variations in growth when this appliance is used, it is recommended that growth-related records be made as early as possible. Although the precise mechanism of control of mandibular growth by a chin cap may still be open to debate, chin cap therapy can be effective within certain limits in certain aspects of growth if it is used properly.

It is clear that further investigation is needed to gain more practical direction for chin cap use on growing Class III malocclusions.

References

Armstrong, C. J. 1961. A clinical evaluation of the chincup. *Aust. Dent. J.* 6:338-346.

Bambha, J. K. 1961. Longitudinal cephalometric roetgenographic study of face and cranium in relation to body height. *J.A.D.A.* 63:776- 799.

Bare, M. R. 1972. Influence of orthopedic forces on the vector and pattern of mandibular growth in Macaca mulatta monkeys: A histologic and gross anatomic study. Master's thesis. Northwestern University

Belhobek, J. H. 1975. The alterability of mandibular growth. Quoted by Graber, L. W. in *Determinants of Mandibular Form and Growth,* J. A. McNamara, Jr., ed. pp. 229-241. Craniofacial growth series. Ann Arbor: Center for Human Growth and Development.

Bergersen, E. O. 1972. The male adolescent facial growth spurt: Its prediction and relation to skeletal maturation. *Angle Orthod.* 42:319- 338.

Cleall, J. F. 1974. Dentofacial orthopedics. *Am. J. Orthod.* 66:237-250

Fukuhara, T., and Matsumoto, M. 1968. A longitudinal study of facial growth in relation to general body height during adolescence. *Bull. Tokyo Med. and Dent. Univ.* 15:161-170.

Graber, L. W.

1975 The alterability of mandibular growth. In *Determinants of Mandibular Form and Growth,* J. A. McNamara, Jr. ed. pp. 229-241. Craniofacial growth series. Ann Arbor: Center for Human Growth and Development.

1977 Chin cup therapy for mandibular prognathism. *Am. J. Orthod.* 72:23-41

Graber, T. M.; Chung, B.; and Aoba, T. J. 1968. Dentofacial orthopedics. *Aust. Orthodont. J.* 1:84-125

Grave, K. C., and Brown, T. 1976. Skeletal ossification and the adolescent growth spurt. *Am. J. Orthod.* 69:611-619.

Hunter, C. J. 1966. The correlation of facial growth with body height and skeletal maturation at adolescence. *Angle Orthod.* 36:44-54.

Irie, M., and Nakamura S. 1972. Cephalometric changes in treatment of anterior cross-bite cases with the chin caps. *J. Jap. Orthod. Soc.* 31:75-86.

Janzen, E. K., and Bluher, J. A. 1965. The cephalometric, anatomic, and histologic changes in Macaca mulatta after application of a continuous- acting retraction force on the mandible. *Am. J. Orthod.* 51:823-855.

Jo, K.; Mitani, H.; and Kawarada, T. 1980. Displacement of chin in relation to daily hours of chin cap use. *J. Michinoku Dent Soc.* 11:80- 81.

Joho, J. P. 1973. The effects of extraoral low pull traction to the mandibular dentition of Macaca mulatta. *Am. J. Orthod.* 64:555-577.

Kulis, R. W. 1972. A gross anatomic, cephalometric, and radiographic study of the influence of orthopedic forces on the vector of mandibular growth in Macaca mulatta. Master's thesis. Northwestern University.

Matsui, Y. 1965. Effect of chin cap on the growing mandible. *J. Jap. Orthod. Soc.* 24:165-181.

Nanda, R. S. 1955. The rate of growth of several facial components measured from serial cephalometric roentgenograms. *Am. J. Orthod.* 41:658-673.

Nanda, R. 1980. Biomechanical and clinical considerations of a modified protraction headgear. *Am. J. Orthod.* 78:125-139.

Noguchi, K. 1970. Effects of extrinsic forces on the mandibular condyle of the young rat: Observations using ^{3}H-thymidine autoradiography. *J. Jap. Stomatological Soc.* 37:222-241.

Nukatsuka, S. 1982. The longitudinal study of orthopedic effect caused by chin cap treatment. *Tohoku Univ. Dent. J.* 1:1-17.

Petrovic, A. G.; Stutzmann, J. J.; and Oudet, C. L. 1975. Control processes in the postnatal growth of the condylar cartilage of the mandible - Effect of orthopedic therapy on condylar growth. In *Determinants of mandibular form and growth,* J. A. McNamara, Jr. ed. pp. 106-113. Craniofacial growth

series. Ann Arbor: Center for Human Growth and Development.

Sakamoto, T.; Kawarada, T.; and Asano, T. 1979. A long term observation of a skeletal Class III case treated with the chin cap. *Nippon Dental Review.* 446:99-106.

Sakamoto, T.; Kawarada, T.; and Ohtani, N. 1979. An improvement of the skeletal reverse occlusion. *Nippon Dental Review.* 441:133-140.

Sawa, S. 1978. Roentgenocephalometric study on the dentocraniofacial growth in Japanese children. *J. Jap. Orthod. Soc.* 37:237-268.

Susami, R.; Akiyama, K.; Ohnishi, K.; Yamano, C.; and Deguchi, T. 1966. Cephalometric survey of reaction to orthodontic treatment in anterior cross-bite cases: Part III. Cases treated with chin cap. *J. Jap. Orthod. Soc.* 25:75-82.

Suzuki, N. 1972. A cephalometric observation on the effects of the chin cap. *J. Jap. Orthod. Soc.* 31:64-74.

Thilander, B. 1963. Treatment of Angle Class III malocclusion with chin cup. *Trans. Eur. Orthod. Soc.* 39:384-398.

Yano, Y. 1971. The prognosis of the Class III case. *J. Jap. Orthod. Soc.* 30:96-108.