ORIGINAL ARTICLE

# Treatment effects of the light-force chincup

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**Introduction:** The objective of this study was to evaluate the effectiveness of the light-force chincup appliance in correcting the skeletal and dentoalveolar components of Class III malocclusion compared with an untreated Class III control group. **Methods:** The treatment sample consisted of 26 patients (11 boys, 15 girls) treated with the light-force chincup (125-250 g). The mean age at the start of treatment in the chincup group was 8.5 years, with posttreatment cephalograms taken on average 2.6 years later. The control group consisted of 20 subjects. The mean age at the start of observation for the control group (6 boys, 14 girls) was 7.3 years, and the mean time of observation was 2.4 years. Lateral cephalograms were analyzed with a specific tracing regimen at the 2 time points for both groups. Treatment outcome were determined. The treatment group subsequently was subdivided into those treated simultaneously with a quad-helix appliance and those with the chincup only. Mann-Whitney U tests for independent samples were performed to evaluate the differences between the treated and untreated groups at both time points, the changes between the 2 time points, and the differences between the groups treated with the quad-helix and chincup, and the chincup only. **Results:** The chincup sample showed no significant skeletal changes in the mandible in either the vertical or horizontal direction, except for a slight decrease in SNB angle and an increase in ANB angle. There were significant dentoalveolar changes, particularly uprighting of the mandibular incisors. Significant positive Class III treatment outcomes were recorded in the quad-helix group, including a decrease in mandibular length of 1.9 mm compared with the chincup group. **Conclusions:** Fewer than 50% of the subjects treated with the chincup had favorable clinical outcomes. Correction of the initial Class III malocclusion occurred through significant dentoalveolar changes. The light-force chincup did not produce orthopedic changes in the mandible. Maxillary expansion with a quad-helix might aid in the correction of the Class III malocclusion in conjunction with the chincup. (Am J Orthod Dentofacial Orthop 2010;138:468-76)

The effects of the chincup on dentofacial growth have been investigated in both animal experiments and cephalometric analyses. The animal experiments on monkeys,[1,2] rabbits,[3] and rats[4-6] all demonstrated retardation of ramal growth, closure of the gonial angle, decrease in the prechondroblastic layer of the condylar cartilage, and overall growth retardation of the mandible. Cephalometric studies on humans, however, did not show such consistent results. Several studies reported decreases in mandibular length due to chincup wear.[7-12] However, most cephalometric studies showed no reduction in mandibular length but demonstrated orthopedic changes, including redirection of mandibular growth with downward and backward repositioning of the mandible and remodeling of the mandibular shape.[13-16]

In an overview of the chincup literature (Table I), we found that treatment protocols used forces between 200 and 900 g.[7-10,12-29] Graber[18] proposed that the use of force levels similar to that of the Milwaukee brace in the range of at least 2 pounds (900 g) per side would obtain orthopedic changes. No studies in the literature attempted to identify the minimum amount of force or the minimum threshold of force needed to obtain an orthopedic change. Thilander,[14] Allen et al,[13] Sugawara and Mitani,[28] and Deguchi et al[8] described contrasting results from the use of chincups that delivered 200 to 300 g of force (light-force chincup). However, these investigations (similar to most chincup studies) had some methodologic drawbacks (lack of adequate untreated Class III controls) or clinical inconsistencies (long duration of chincup wear).

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**Table I.** Chincup studies in the literature with forces measured at the center of the chincup

| Author | Sample size (n) | Sample ethnicity | Mean age at T1 or age range | Treatment time | Force level (g) | Untreated controls |
|---|---|---|---|---|---|---|
| Thilander (1963)[14] | 60 | White | 5-16 y | 12 mo | 200-350 | Self-control (1 y before treatment) |
| Cleall (1974)[15] | 2 | White | 9.5 y | 3 y | 900 | None |
| Irie and Nakamura (1975)[16] | 29 | Japanese | Not stated | Not stated | Not known | None |
| Vego (1976)[17] | 5 | White | 4-9 y | 2-9 mo | 300-600 | Class III (gorecast tracing) |
| Graber (1977)[18] | 30 | White | 6 y | 3 y | 900 | Class III |
| Sakamoto (1981)[19] | 26 | Japanese | 7.2 y | 2 y 9 mo | 500-600 | Class III |
| Mitani and Sakamoto (1984)[20] | 3 | Japanese | 4-8 y | 2.5-6 y | 500-600 | None |
| Wendell et al (1985)[10] | 10 | Japanese | 5-15 y | 3 y 1 mo | 500-600 | Class III |
| Ritucci and Nanda (1986)[21] | 10 | Japanese | 7.6 y | Not known | 500 | Class III |
| Mitani and Fukazawa (1986)[22] | 26 | Japanese | 6-10 y | 4-6 y | 500-600 | Class I |
| Sugawara et al (1990)[23] | 63 | Japanese | 7, 9, 11 y | 4.5 y | 500-600 | Class III |
| Allen et al (1993)[13] | 23 | White | 8.2 y | 1.4 y | 200-450 | Class I |
| Lu et al (1993)[24] | 30 | Japanese | 9 y | 5 y 1 mo | Not known | Class I |
| Uner et al (1995)[25] | 27 | Turkish | 9 y 3 mo | 12 mo | 600 | Class I treated |
| Deguchi and Kitsugi (1996)[26] | 24 | Japanese | 8-10 y | 3-5 y | 500-600 | Class I |
| Mimura and Deguchi (1996)[27] | 19 | Japanese | 10 y 2 mo | 5 mo-6 y | 500-600 | Class I |
| Basdra et al (1997)[12] | 29 | White | 8-9 y | 5 y | Not known | Class I |
| Sugawara and Mitani (1997)[28] | 63 | Japanese | 7, 9, 11 y | 4-5 y | 500-600 | Class III |
| Deguchi et al (1999)[8] | 36 | Japanese | 8 y 4 mo | 7 y | 250-300 | Class III |
| Deguchi and McNamara (1999)[9] | 22 | Japanese | 9 y 4 mo | 1 y 9 mo | 400-500 | Class III |
| Abu Alhaija and Richardson (1999)[29] | 23 | White | 8.11 y | 3 y | 200-450 | Class III |
| Deguchi et al (2002)[7] | 56 | Japanese | 8 y 4 mo | 2 y 7 mo<br>7 y 2 mo | 500<br>250-300 | Class III |

The primary purpose of this study was to investigate the short-term modifications in craniofacial structures produced by the light-force chincup appliance in a white population with Class III tendencies compared with a control group of untreated Class III subjects. The results also were analyzed in an attempt to identify factors that could allow a greater probability of success with chincup treatment, with special regard to the use of a quad-helix combined with the chincup.

## MATERIAL AND METHODS

This investigation of consecutively treated patients was designed to evaluate cephalometrically the skeletal and dentoalveolar changes produced by the light-force chincup appliance in patients with Class III malocclusion compared with Class III untreated controls. The treatment sample consisted of the cephalometric radiographs of 26 patients treated with the chincup. All subjects had occlusal signs of Class III malocclusion with a Wits appraisal of –2 mm or more. In addition, 12 of the 26 patients were treated with a quad-helix appliance for maxillary expansion. All patients were treated with the same protocol by the same group of private practitioners.

The chincups and elastic straps were obtained from Summit Orthodontics (Munroe Falls, Ohio). The traction bands were obtained from Orthoband Company (Imperial, Mo). The chincup was fitted on each patient with about 1 in of slack, which resulted in force generation of approximately 150 to 250 g, as measured by a Correx force gauge (Haag-Streit, Koeniz, Switzerland) at the center of the chincup.

The subjects in this study were instructed to wear the chincup at night only for at least 1 year. After 1 year, they were evaluated for Class III correction. If Class III correction had been achieved after a year (determined by lack of anterior crossbite and Class I molar and canine relationship), then the chincup was discontinued. If Class III correction was not achieved, chincup wear continued until Class III correction was achieved or the need for surgical intervention was determined. The mean age at the start of treatment of the chincup group was 8.5 years (T1), with the duration of treatment (T2) 2.6 years for boys and 2.4 years for girls (Table II). If a quad-helix was used, the device was placed either before or during chincup treatment and removed immediately after adequate expansion.

The Class III untreated control group consisted of 20 subjects. The cephalograms of the untreated patients were obtained from the University of Florence from clinic patients who initially refused treatment and subsequently returned seeking intervention and from the University of Michigan Growth Study. The mean age

**Table II.** Demographics of observation times

| | T1 age (y) | | T2 age (y) | | T2-T1 (y) | |
|---|---|---|---|---|---|---|
| Group | Mean | SD | Mean | SD | Mean | SD |
| Chincup (11 boys, 15 girls) | 8.5 | 1.4 | 11.1 | 1.4 | 2.6 | 1.3 |
| Control (6 boys, 14 girls) | 7.3 | 0.7 | 9.7 | 0.6 | 2.4 | 0.8 |

at the start of observation (T1) for the Class III control group was 7.3 years, and the mean time of observation (T2) was 2.4 years. Significant effort was directed to matching the control and treatment subjects as closely as possible with respect to sex distribution, age at T1, occlusal Class III characteristics, duration of observation, and prepubertal skeletal maturity as measured by the stage of cervical vertebral maturation at both time points (stage 1 or 2 at T1, and stage 2 or 3 at T2).[30]

All lateral cephalograms used in this study were hand traced on 0.003-in matte acetate paper by using a sharp 2H lead drafting pencil. Each of the 2 films for every patient was hand traced in 1 sitting and in exactly the same way by the primary investigator (A.A.F.B.), and landmark location and the accuracy of the anatomic outlines and contours were verified by a second investigator (J.A.M.). The functional occlusal plane was included on each tracing.

Regional superimpositions were done by hand, as described by Ricketts[31] and McNamara.[32] Cranial base superimpositions showed changes in maxillary and mandibular skeletal positions. Films were oriented along the basion-nasion line and registered at the most posterosuperior aspect of the pterygomaxillary fissure, with the contour of the skull immediately posterior to the foramen magnum used to verify the accuracy of the superimposition.

Maxillary regional superimpositions identified movements of the maxillary dentition relative to the maxillary basal bone. The maxilla was superimposed along the palatal plane by registering on bony internal details of the maxilla superior to the incisors and the superior and inferior surfaces of the hard palate. Mandibular regional superimpositions characterized movements of the mandibular dentition relative to the mandibular basal bone. Mandibular superimpositions were performed posteriorly on the outline of the inferior alveolar nerve canal and any tooth germs (before root formation) and anteriorly on the anterior contour of the bony chin and the internal structures of the mandibular symphysis.

Lateral cephalograms for each patient at T1 and T2 were digitized by using a customized digitization regimen (version 2.5, Dentofacial Planner, Toronto, Ontario, Canada) that included 78 landmarks and 4 fiducial markers. Any magnification differences were adjusted before digitization by using the magnification factor in the software. This program analyzed the cephalometric data and superimpositions of the serial cephalograms to meet the needs of this study.

After digitization, a custom cephalometric analysis was performed. Thirty-three variables were generated for each tracing. Then all linear measurements were standardized to an enlargement of 8%.

The overall treatment outcomes in the chincup patients were assessed from the T2 films. Treatment outcomes were divided into 3 categories: positive, negative, or neutral. The criteria for a positive outcome were positive overjet, Class I (or super Class I) molar relationship, and improvement in the facial profile. An outcome was considered neutral when there was no noticeable improvement in these characteristics, and the patient appeared similar to the T1 film. A negative outcome was noted when overjet and all other Class III features were worse in the T2 film than in the T1 film.

After treatment outcome assessment, it became evident that many subjects with positive treatment outcomes were those who had received a quad-helix in addition to chincup treatment. Because of this finding, the treated sample subsequently was subdivided into 2 groups: those treated with the quad-helix and the chincup (n = 12), and those treated with the chincup only (n = 14). The cephalometric outcomes of these 2 subgroups after treatment were compared to evaluate the possible effectiveness of the quad-helix.

### Statistical analysis

Means and standard deviations were calculated for age, duration of treatment, and changes between T1 and T2 of all cephalometric measurements for the treatment and control groups. The data were analyzed with a Windows-based statistical software package (version 16.0, SPSS, Chicago, Ill). Statistical significance was tested at $P < 0.05$, $P < 0.01$, and $P < 0.001$.

Lack of normal distribution for the examined variables was shown by the Shapiro-Wilks test. Mann-Whitney U tests for independent samples were performed to evaluate the differences between the treated and untreated groups at both time points and the changes between time points. Because of the number of subjects examined and the standard deviations of the variables investigated, the power of the study exceeded 0.85 at $\alpha = 0.05$. Mann-Whitney U tests for independent samples were used to compare the changes in the quad-helix and chincup group vs the chincup-only group. The same nonparametric test didd not find a significant difference between the 2 subgroups at T1.

On the basis of repeated cephalometric measurements, errors were smaller than 1° and 1 mm for all

**Table III.** Comparison of starting forms between the treated and untreated groups

| Cephalometric measurement | Chincup group n = 26 | | Control group (CG) n = 20 | | Chincup vs CG | | |
|---|---|---|---|---|---|---|---|
| | Mean | SD | Mean | SD | Mean difference | P value* | |
| Cranial base | | | | | | | |
| Ba-S-N (°) | 126.6 | 4.2 | 128.7 | 5.5 | −2.1 | 0.150 | NS |
| Maxillary A-P skeletal | | | | | | | |
| SNA (°) | 79.4 | 4.2 | 79.9 | 4.7 | −0.6 | 0.666 | NS |
| Pt A-Na perp (mm) | −2.2 | 3.2 | −1.0 | 3.3 | −1.2 | 0.210 | NS |
| Co-Pt A (mm) | 81.5 | 5.1 | 79.3 | 4.4 | 2.2 | 0.136 | NS |
| Mandibular A-P skeletal | | | | | | | |
| SNB (°) | 80.0 | 3.7 | 79.4 | 4.4 | 0.6 | 0.598 | NS |
| Pg-Na perp (mm) | −2.6 | 5.2 | −2.7 | 7.5 | 0.3 | 0.875 | NS |
| Co-Gn (mm) | 107.4 | 6.0 | 104.7 | 5.3 | 2.7 | 0.113 | NS |
| Co-Go (mm) | 49.6 | 2.9 | 48.9 | 3.6 | 0.6 | 0.509 | NS |
| Intermaxillary | | | | | | | |
| ANB (°) | −0.7 | 2.3 | 0.5 | 3.1 | −1.2 | 0.142 | NS |
| Wits (mm) | −5.4 | 1.7 | −6.8 | 4.0 | 1.4 | 0.119 | NS |
| Mx/mn diff (mm) | 25.9 | 2.6 | 25.3 | 4.3 | 0.6 | 0.575 | NS |
| Vertical skeletal | | | | | | | |
| FH-FOP (°) | 9.8 | 3.5 | 11.9 | 4.3 | −2.0 | 0.080 | NS |
| FH-PP (°) | 1.1 | 2.4 | −0.4 | 3.2 | 1.5 | 0.071 | NS |
| FMA (°) | 25.1 | 5.6 | 27.7 | 6.6 | −2.5 | 0.171 | NS |
| Gonial angle (°) | 126.7 | 8.0 | 130.8 | 6.3 | −4.1 | 0.063 | NS |
| UFH (mm) | 46.9 | 3.4 | 46.6 | 2.8 | 0.3 | 0.755 | NS |
| LAFH (mm) | 60.1 | 5.2 | 59.6 | 4.2 | 0.5 | 0.738 | NS |
| Interdental | | | | | | | |
| OJ (mm) | −0.9 | 1.3 | −1.7 | 3.3 | 0.8 | 0.270 | NS |
| OB (mm) | 0.7 | 1.7 | 0.5 | 2.2 | 0.2 | 0.736 | NS |
| I/I (°) | 134.3 | 14.1 | 137.3 | 11.4 | −3.0 | 0.449 | NS |
| 6/6 (mm) | 3.6 | 1.9 | 4.3 | 2.1 | −0.8 | 0.207 | NS |
| Maxillary dentoalveolar | | | | | | | |
| U1-FH (°) | 110.5 | 6.2 | 106.9 | 5.8 | 3.6 | 0.107 | NS |
| U1-Pt A vert (mm) | 2.7 | 1.4 | 2.1 | 1.9 | 0.6 | 0.210 | NS |
| Mandibular dentoalveolar | | | | | | | |
| IMPA (°) | 90.1 | 5.6 | 88.3 | 4.7 | 1.8 | 0.458 | NS |
| L1-APg (mm) | 3.8 | 2.6 | 3.9 | 2.1 | −0.1 | 0.896 | NS |
| Soft tissue | | | | | | | |
| UL to E plane (mm) | −4.4 | 2.5 | −4.7 | 3.4 | 0.3 | 0.722 | NS |
| LL to E plane (mm) | −0.8 | 2.7 | −0.2 | 3.1 | −0.6 | 0.492 | NS |
| Nasolabial angle (°) | 108.0 | 14.3 | 108.3 | 11.6 | −0.3 | 0.944 | NS |

*NS*, Not significant.
*Independent sample Student *t* test.

angular and linear measurements, thus confirming previous reports on the error of a comparable cephalometric analysis.[33]

## RESULTS

Descriptive data and statistical comparisons for starting forms and cephalometric changes in both groups from T1 to T2 are given in Tables III and IV, respectively.

There were no significant differences in the starting forms between the chincup and the control groups.

From T1 to T2, the chincup group had a significant reduction in the SNB angle of 1.5° compared with the control group. In addition, there was a significant decrease of 1.7 mm in chin projection (pogonion to nasion perpendicular) in the treated group. The ANB angle increased significantly by 1.1° in the chincup group. There was a small decrease in the length of the mandible, measured from condylion to gnathion in the chincup group compared with the controls, but this decrease was not significant. There was no significant change in ramus length as calculated from condylion to gonion when comparing the treated sample with the untreated controls.

There were no significant changes in the maxillary anteroposterior or vertical skeletal measurements, except for a decrease in the palatal plane angle of 1.6° in

**Table IV.** Comparison of changes during time of observation

| *Cephalometric measurement* | *Chincup group n = 26* | | *Control group (CG) n = 20* | | *Chincup vs CG* | | |
|---|---|---|---|---|---|---|---|
| | *Mean* | *SD* | *Mean* | *SD* | *Mean difference* | *P value*[§] | |
| Cranial base | | | | | | | |
| Ba-S-N (°) | 0.2 | 1.5 | −0.2 | 1.8 | 0.4 | 0.371 | NS |
| Maxillary A-P skeletal | | | | | | | |
| SNA (°) | −0.9 | 2.1 | −0.6 | 1.5 | −0.4 | 0.486 | NS |
| Pt A-Na perp (mm) | −1.1 | 1.7 | −0.9 | 1.2 | −0.1 | 0.780 | NS |
| Co-Pt A (mm) | 2.8 | 3.1 | 2.5 | 1.0 | 0.3 | 0.684 | NS |
| Mandibular A-P skeletal | | | | | | | |
| SNB (°) | −1.3 | 2.2 | 0.2 | 1.3 | −1.5 | 0.010 | * |
| Pg-Na perp (mm) | −1.6 | 3.1 | 0.1 | 2.4 | −1.7 | 0.045 | * |
| Co-Gn (mm) | 4.7 | 4.4 | 5.8 | 2.0 | −0.9 | 0.391 | NS |
| Co-Go (mm) | 2.4 | 2.9 | 2.8 | 1.9 | −0.4 | 0.614 | NS |
| Intermaxillary | | | | | | | |
| ANB (°) | 0.3 | 1.7 | −0.7 | 1.1 | 1.1 | 0.016 | * |
| Wits (mm) | 1.5 | 2.5 | −0.1 | 4.3 | 1.7 | 0.102 | NS |
| Mx/mn diff (mm) | 2.1 | 2.7 | 3.3 | 1.6 | −1.2 | 0.079 | NS |
| Vertical skeletal | | | | | | | |
| FH-FOP (°) | −1.2 | 2.8 | −1.5 | 2.1 | 0.4 | 0.638 | NS |
| FH-PP (°) | −1.0 | 2.3 | 0.6 | 1.8 | −1.6 | 0.014 | * |
| FMA (°) | 0.2 | 2.1 | 0.4 | 2.1 | −0.2 | 0.698 | NS |
| Gonial angle (°) | −2.3 | 2.7 | −1.2 | 2.8 | −1.1 | 0.191 | NS |
| UFH (mm) | 3.6 | 3.0 | 3.5 | 1.4 | 0.2 | 0.822 | NS |
| LAFH (mm) | 3.1 | 3.0 | 2.8 | 2.4 | 0.3 | 0.741 | NS |
| Interdental | | | | | | | |
| OJ (mm) | 3.2 | 1.7 | 0.6 | 1.3 | 2.6 | 0.000 | ‡ |
| OB (mm) | 1.0 | 1.7 | 1.2 | 1.9 | −0.2 | 0.678 | NS |
| I/I (°) | −1.3 | 11.1 | −7.1 | 7.8 | 5.8 | 0.053 | NS |
| 6/6 (mm) | −0.4 | 1.5 | 0.4 | 1.4 | −0.8 | 0.080 | NS |
| Maxillary dentoalveolar | | | | | | | |
| U1-FH (°) | 6.2 | 2.7 | 6.8 | 2.5 | −0.6 | 0.754 | NS |
| U1-Pt A vert (mm) | 1.8 | 1.4 | 1.8 | 1.4 | 0.1 | 0.869 | NS |
| U1H (mm) | 1.9 | 1.6 | 2.3 | 1.4 | −0.5 | 0.301 | NS |
| U1V (mm) | 1.0 | 1.8 | 1.3 | 1.4 | −0.3 | 0.587 | NS |
| U6H (mm) | 1.3 | 1.5 | 1.4 | 1.0 | −0.1 | 0.794 | NS |
| U6V (mm) | 0.7 | 1.7 | 1.6 | 7.0 | −0.8 | 0.555 | NS |
| Mandibular dentoalveolar | | | | | | | |
| IMPA (°) | −4.5 | 3.4 | −0.3 | 3.5 | −4.2 | 0.001 | † |
| L1-APg (mm) | −1.0 | 1.4 | 0.8 | 1.1 | −1.8 | 0.000 | ‡ |
| L1H (mm) | −0.8 | 1.1 | 0.2 | 1.1 | −1.0 | 0.004 | † |
| L1V (mm) | 2.3 | 1.9 | 2.2 | 1.2 | 0.2 | 0.724 | NS |
| L6H (mm) | 1.3 | 1.6 | 0.4 | 0.7 | 0.9 | 0.062 | NS |
| L6V (mm) | 2.2 | 2.2 | 1.6 | 1.5 | 0.6 | 0.265 | NS |
| Soft tissue | | | | | | | |
| UL to E plane (mm) | −0.2 | 1.9 | −0.2 | 2.4 | −0.1 | 0.910 | NS |
| LL to E plane (mm) | −1.5 | 1.6 | 0.0 | 1.6 | −1.5 | 0.003 | † |
| Nasolabial angle (°) | 0.7 | 9.2 | −4.9 | 11.6 | 5.6 | 0.049 | * |

*$P$ <0.05; †$P$ <0.01; ‡$P$ <0.001; *NS*, not significant.
§Independent sample Student *t* test.

the chincup group relative to the controls. The gonial angle tended to decrease in the treated sample, but this difference was not significant compared with control values.

The most significant dentoalveolar change in the chincup group vs the untreated controls was uprighting of the mandibular incisors in the chincup group, with the IMPA decreasing by 4.2°, the L1 to Point A-pogonion line decreasing by 1.8 mm, and the L1 horizontal movement decreasing by 1 mm. As a result, there also was a significant increase in overjet in the treated subjects of 2.6 mm. There were no significant maxillary dentoalveolar changes between the chincup and the untreated control groups. Flaring of the maxillary incisors appeared to decrease, and the maxillary vertical molar movement had a tendency to decrease with chincup treatment, but this difference was not significant.

With respect to soft-tissue changes, the lower lip to E plane decreased significantly by 1.5 mm. The lower lip change resulted in improvement in the soft-tissue profile, bringing it closer to normal values. The nasolabial angle also increased significantly, with a 5.6° change between the chincup and untreated groups.

Treatment outcome was assessed in all 26 treated subjects. Twelve of them (46%) had in a positive treatment outcome. Nine (35%) had a neutral outcome, and 5 (19%) had a negative outcome. Of the 12 patients treated with the quad-helix, all had either a positive or a neutral outcome.

Compared with the chincup-only group, the patients treated simultaneously with the quad-helix had more significant mandibular skeletal changes (Table V). SNB significantly decreased by 1.6° more than with the chincup only. Pogonion to nasion perpendicular also decreased significantly by 1.5 mm. There was a significant change in mandibular length with the addition of the quad-helix, with a decrease of 1.9 mm compared with those treated with the chincup only. There was no significant difference in ramus length between the 2 treatments.

There were no significant maxillary skeletal differences between the 2 protocols. The only significant vertical skeletal difference between the quad-helix and the chincup-only treatment was the decrease in the gonial angle of 1.6° in the quad-helix group.

There were several significant differences in the dentoalveolar changes between the 2 groups. Overjet and overbite both increased significantly in the quad-helix group by 1.1 and 1.2 mm, respectively. IMPA increased significantly in the quad-helix group compared with the chincup-only group by 2.3°, a decrease in the amount of uprighting of the mandibular incisors in the quad-helix group. There also were significant maxillary dentoalveolar changes. The relationship of the maxillary incisor to the cranial base (U1 to sella nasion) increased significantly in the quad-helix group by 1.9°, and U1 to Point A vertical increased as well by 1.8 mm.

There were no significant soft-tissue changes between the groups treated with the quad-helix and the chincup, and the chincup only.

## DISCUSSION

In this study, we compared the treatment effects of the light-force chincup appliance with an untreated Class III group. The chincup group was treated by using chincup forces of 150 to 250 g for an average treatment duration of 2.6 years. The significant treatment effects of the light-force chincup will be discussed in greater detail.

There were no significant changes in the maxillary anteroposterior skeletal measurements. This observation is consistent with the findings of Ritucci and Nanda,[21] who looked exclusively at the maxillary and cranial base effects of the chincup. Their study had only a small group of patients, but most chincup studies in the literature report little to no effect on the maxilla.

A few studies in the chincup literature have found small increases in SNA and maxillary length, but they are in the minority.[12,25,26] It appears that, overall, the chincup appliance does not affect maxillary skeletal structures and is not indicated for patients with maxillary deficiencies who make up almost half of Class III patients, as reported by Guyer et al.[34]

In our study, there was no significant reduction in mandibular length; this is supported by most published clinical studies including those of Graber,[18] Sugawara et al,[23] Allen et al,[13] and Lu et al.[24] The only significant mandibular skeletal effects of the chincup in this study include reduction in the SNB angle and decrease of pogonion to nasion perpendicular of 1.5° and 1.7 mm, respectively. These findings most likely are the result of positional changes in the mandible and uprighting of the mandibular incisors, whereas no modification in mandibular length was found. Generally, little mandibular orthopedic change occurred. No reduction in the gonial angle was noted in this study, the most common significant clinical finding in the chincup literature.[17,18,25,27,28] The lack of mandibular change even compared with the findings of previous studies appears to indicate that the light forces used in our study might not have been sufficient to elicit an orthopedic response. Also, light compressive forces on the mandibular condyle have been shown to modify phosphatase activity and increase the growth rate of the condylar cartilage of the rat in vitro.[35]

The only significant intermaxillary change from chincup treatment analyzed in this study was an increase in the ANB angle, but with no concurrent change in the Wits appraisal. Because there was no significant change in the position of Point A, the significant ANB change was due mainly to the change in the position of Point B from the uprighting of the mandibular incisors and possibly the slight amount of backward rotation of the mandible.

The only vertical skeletal effect of the light-force chincup of any significance was the decrease (tipping up) in the palatal plane angle. This finding also was shown by Schulz et al[36] on the effects of the vertical-pull chincup. Graber[18] and Ritucci and Nanda[21] found the opposite in their investigations. They reported

**Table V.** Quad-helix (QHX) and chincup (CC) vs chincup only: comparisons of change during time of observation

| | *QHX + CC n = 12* | | *CC only n = 14* | | *QHX + CC vs CC only* | | |
|---|---|---|---|---|---|---|---|
| *Cephalometric measurement* | *Mean* | *SD* | *Mean* | *SD* | *Mean difference* | P *value*‡ | |
| Cranial base | | | | | | | |
| Ba-S-N (°) | 0.1 | 1.6 | 0.6 | 1.9 | −0.5 | 0.451 | NS |
| Maxillary A-P skeletal | | | | | | | |
| SNA (°) | −0.7 | 2.3 | −0.6 | 1.6 | −0.1 | 0.876 | NS |
| Pt A-Na perp (mm) | −0.5 | 1.9 | −0.6 | 1.4 | 0.1 | 0.780 | NS |
| Co-Pt A (mm) | 2.6 | 3.2 | 3.0 | 3.1 | −0.4 | 0.676 | NS |
| Mandibular A-P skeletal | | | | | | | |
| SNB (°) | −2.2 | 2.4 | −0.6 | 1.9 | −1.6 | 0.032 | * |
| Pg-Na perp (mm) | −2.3 | 3.2 | −0.8 | 2.9 | −1.5 | 0.048 | * |
| Co-Gn (mm) | 3.6 | 4.5 | 5.5 | 3.9 | −1.9 | 0.027 | * |
| Co-Go (mm) | 2.4 | 2.9 | 2.5 | 2.9 | −0.1 | 0.896 | NS |
| Intermaxillary | | | | | | | |
| ANB (°) | 0.5 | 1.8 | 0.3 | 1.9 | 0.2 | 0.567 | NS |
| Wits (mm) | 1.5 | 2.7 | 1.7 | 3.0 | −0.2 | 0.402 | NS |
| Mx/mn diff (mm) | 1.4 | 2.8 | 2.4 | 2.7 | −1.0 | 0.134 | NS |
| Vertical skeletal | | | | | | | |
| FH-FOP (°) | −0.9 | 2.9 | −1.5 | 2.8 | 0.6 | 0.438 | NS |
| FH-PP (°) | −1.2 | 2.4 | −0.7 | 2.8 | −0.5 | 0.354 | NS |
| FMA (°) | −0.2 | 2.4 | −0.4 | 2.6 | 0.2 | 0.665 | NS |
| Gonial angle (°) | −3.1 | 2.8 | −1.4 | 2.8 | −1.6 | 0.024 | * |
| UFH (mm) | 3.7 | 3.3 | 3.5 | 3.4 | 0.2 | 0.856 | NS |
| LAFH (mm) | 3.0 | 3.1 | 2.9 | 3.1 | 0.1 | 0.798 | NS |
| Interdental | | | | | | | |
| OJ (mm) | 3.8 | 1.9 | 2.7 | 1.7 | 1.1 | 0.021 | * |
| OB (mm) | 1.6 | 1.8 | 0.4 | 1.9 | 1.2 | 0.010 | * |
| I/I (°) | −4.1 | 11.4 | −2.1 | 8.8 | −2.0 | 0.256 | NS |
| 6/6 (mm) | −1.0 | 1.9 | −0.4 | 2.14 | −0.6 | 0.178 | NS |
| Maxillary dentoalveolar | | | | | | | |
| U1-FH (°) | 7.8 | 2.9 | 5.9 | 2.9 | 1.9 | 0.035 | * |
| U1-Pt A vert (mm) | 2.7 | 1.6 | 0.9 | 1.8 | 1.8 | 0.007 | † |
| U1H (mm) | 2.1 | 1.9 | 2.0 | 1.7 | 0.1 | 0.845 | NS |
| U1V (mm) | 1.3 | 1.9 | 1.1 | 2.0 | 0.2 | 0.587 | NS |
| U6H (mm) | 1.3 | 1.5 | 1.4 | 1.6 | −0.1 | 0.744 | NS |
| U6V (mm) | 0.7 | 1.8 | 0.6 | 1.7 | 0.1 | 0.675 | NS |
| Mandibular dentoalveolar | | | | | | | |
| IMPA (°) | −3.3 | 4.2 | −5.6 | 3.7 | 2.3 | 0.013 | * |
| L1-APg (mm) | −0.4 | 1.7 | −0.9 | 1.8 | 0.5 | 0.345 | NS |
| L1H (mm) | −0.9 | 1.2 | −0.8 | 1.2 | −0.1 | 0.785 | NS |
| L1V (mm) | 2.3 | 1.9 | 2.4 | 1.9 | 0.1 | 0.796 | NS |
| L6H (mm) | 1.3 | 1.6 | 1.4 | 1.9 | −0.1 | 0.874 | NS |
| L6V (mm) | 1.5 | 2.4 | 2.3 | 2.5 | −0.8 | 0.234 | NS |
| Soft tissue | | | | | | | |
| UL to E plane (mm) | −0.4 | 1.9 | −0.3 | 2.4 | −0.1 | 0.841 | NS |
| LL to E plane (mm) | −1.5 | 1.6 | −1.3 | 1.6 | −0.2 | 0.725 | NS |
| Nasolabial angle (°) | 2.8 | 9.2 | 0.6 | 11.6 | 2.2 | 0.123 | NS |

**P* <0.05; †*P* <0.01; *NS,* not significant.
‡Mann-Whitney U test.

increases in the palatal plane angle, resulting in clockwise rotation of the maxilla due to the increased vertical growth restriction of the posterior maxilla as opposed to the anterior maxilla.

Most Class III correction from the light-force chincup came from the significant uprighting of the mandibular incisors. IMPA decreased on average by 4.2°. This is another common finding in the chincup literature.[9,12,14,29] Graber[18] was the only author to report a small increase in the IMPA compared with Class III controls. The light-force chincup here might not have had enough force to produce an orthopedic effect on the mandible, but the forces were adequate to produce orthodontic movement of the mandibular dentition.

There were no significant maxillary dentoalveolar changes between the chincup and untreated control groups. There was a slight tendency for a decrease in maxillary flaring compared with the controls, but this difference was not significant. This finding again supports the concept that the light-force chincup does not affect the maxilla or the maxillary dentition. These results contrast with several studies that reported flaring of the maxillary incisors.[7-9,13,17,21,29]

The only interdental effect of any significance found in this study was an increase in overjet of the treated subjects by 2.6 mm. This increase was due mainly to the dentoalveolar effect of retroclining the mandibular incisors.

Expansion of the maxillary arch with a quad-helix in conjunction with chincup treatment appeared to have significantly positive effects on overall treatment outcomes. Again, there were no significant maxillary anteroposterior skeletal effects from using the quad-helix, but reports in the literature, particularly by Baik,[37] found a small amount of forward positioning of Point A as a result of expansion. This observation was not supported here and could perhaps be affected by the type of dentoalveolar expansion produced by the quad-helix used in this study.

The addition of a quad-helix appeared to produce significant positive skeletal changes in the mandible. There were overall decreases in SNB and the distance from pogonion to the nasion perpendicular. More importantly, there was a decrease in mandibular length compared with those treated with the chincup only; it did not prove to be significant overall with chincup therapy. Haas[38] suggested that expansion could result in overall improvement of Class III malocclusions. The quad-helix used here might have helped disclude the interdigitation of the posterior teeth.

Furthermore, there was a significant decrease in the gonial angle of subjects treated with the quad-helix. This finding indicated a positive effect in the vertical dimension of Class III subjects, who have a tendency toward increased facial height, as reported Guyer et al,[34] Battagel,[39] and Baccetti et al.[40] As stated before, a decrease in the gonial angle with chincup therapy is commonly reported in the literature.[17,18,25,27,28]

In the quad-helix group, there was a significant increase in the flaring of the maxillary incisors. This effect could be the result of the expansion itself, since there was no effect on maxillary skeletal structures with the chincup alone. Lastly, the quad-helix group demonstrated a significant decrease in the amount of uprighting of the mandibular incisors compared with the group treated with the chincup only. This observation appears to be mostly the result of increases in the amount of flaring of the maxillary incisors and the amount of mandibular skeletal changes that allowed for overjet to be established without as much retroclination of the mandibular incisors. Following the same line of reasoning, overjet and overbite both increased in the group treated with the quad-helix. Overall, this study suggests that Class III correction was significantly improved in all dimensions with the addition of the quad-helix.

This study showed that treatment with the light-force chincup produced limited correction of Class III malocclusion; most of this correction was obtained through dentoalveolar changes and compensations. Less than 50% of the patients had favorable clinical outcomes after treatment with the chincup. It appears that the light-force chincup cannot produce enough force to cause orthopedic skeletal changes in the mandible in the short term.

Furthermore, long-term observations on chincup treatment showed that therapeutical effects achieved before puberty might be challenged significantly by the recurrence of the Class III growth pattern at puberty and after puberty.[28] Therefore, patients who do not have a favorable outcome before puberty (as in this study) will have even more unfavorable growth changes during the next developmental phases.

The ideal force level for chincup therapy is still unknown, but a significant increase with respect to the level of force examined here would be needed to potentially achieve the skeletal changes reported in the literature. Among the factors associated with positive chincup results, the use of an expansion appliance such as the quad-helix can contribute significantly to the overall treatment success for Class III malocclusion.

## CONCLUSIONS

This study showed that (1) the light-force chincup achieves Class III correction in less than 50% of the patients in the short term, and (2) the light-force chincup produces most of its Class III correction through the dentoalveolar change of uprighting the mandibular incisors, but it does not produce enough force for a significant orthopedic change in the mandible.

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