



# The Effects of Reverse Chin Cap Appliance Therapy on Dentofacial Hard and Soft Tissues

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## Abstract

**Background:** Reverse chin cap appliance consists of a removable plate that is attached to a vertical projection hooks via elastics. This appliance is preferred for treatment of combination of maxillary retrognathia and mandibular prognathism malocclusion.

**Objectives:** The aim of this study was to assess the effects of the reverse chin cap appliance to hard and soft tissues.

**Methods:** In this retrospective study 16 consecutive Class III patients (6 females, 10 males) with mean age of  $9.3 \pm 2$  (Mean  $\pm$  SD) years, who were treated with reverse chin cap appliance were selected. Pre- and post-treatment lateral cephalograms were analyzed. The overall changes were compared with growth changes in 20 control samples of Class I (10 females and 10 males) with CI occlusion and average age of  $9.9 \pm 3$  (Mean  $\pm$  SD) years. Independent Samples *t*-test was used to compare mean differences between the two of them. Differences were considered significant at  $P < 0.05$ .

**Results:** At the end of treatment in treatment group, SNB angle decreased  $3.7^\circ$  and ANB angle increased by  $2.9^\circ$  both ( $P = 0.005$ ). Mandibular length decreased 0.18 mm ( $P = 0.009$ ). Lower incisors retroclined  $10.03^\circ$  ( $P = 0.001$ ). Linear distance of the upper lip and lower lip to the E-line significantly decreased 2.3 mm ( $P = 0.04$ ) 1.1 mm ( $P = 0.05$ ) respectively. Nasolabial angle decreased significantly  $4.1^\circ$  ( $P = 0.005$ ).

**Conclusions:** Reverse chin cap appliance therapy has a skeletal and dental effects. This treatment is effective in correction of the CI III malocclusion by retroclination of the lower incisors, and retardation of mandibular growth. At the end of treatment, soft tissue profile

**Keywords:** Angle Class III, Cephalometry, Malocclusion, Prognathism, Retrognathia

## 1. Background

Skeletal Class III (CI III) malocclusions involve maxillary retrognathia, mandibular prognathism or a combination of them. The incidence of CI III malocclusion has been reported to be various among different races. The prevalence of CI III in Caucasian population is approximately 5% (1). Because the growth of the patient with CI III malocclusion is unpredictable and potentially unfavorable, treatment of this malocclusion is very difficult (2). The success of early orthopedic treatment in patients with CI III malocclusion depends on facial skeletal growth pattern and the type of treatment (3). Treatment for young patient with this malocclusion have been accomplished with growth modification. Orthopedic appliances such as removable plates, functional orthopedic appliances and face mask (often used with a maxillary expansion appliance) have been used in correction of skeletal CI III malocclu-

sions (4). Face mask appliance therapy has the following effects: forward growth and counterclockwise rotation of the maxillary bone and dentition and orthopedic effect on the mandible via reactive force exerted on the chin (5). In contrast, chin cap therapy slows growth, alters the direction of growth and leads to backward repositioning of mandible (5).

Reverse chin cap appliances (RCCAs) have been designed to treat the combination of maxillary retrognathism and mandibular prognathism. Nanda in 1980 produced a modified protraction headgear using elastics to attach the face bow to a chin cap, the inner bow of which is inserted into posterior opening of molar tubes (6). Van der Linden, recommended that "chin cup with vertical post" could be used in maxillary deficiency and mandibular excess malocclusions (7). Marcotte also indicated that the "Hickam chin cup" could be used in patient with combination of the maxillary retrusion and of the mandibular protrusion (8).

Although RCCA has been recommended by different authors as an appropriate appliance for treatment of combination of maxillary retrusion and mandibular protrusion, to the best of our knowledge there is limited study about the effects of RCCAs therapy on hard and soft tissues (9, 10).

## 2. Objectives

The purpose of present study is to evaluate the effects of RCCAs on skeletal, dental and soft tissues in Class III malocclusion patients.

## 3. Methods

In this retrospective study, 16 consecutive patients (6 females, 10 males) with mean age of  $9.3 \pm 2$  years (Mean  $\pm$  SD), who were treated with RCCAs in a private office (Z.H) within the past 5 years: from 2013 to 2018 were selected. A sample size calculation was carried out on the basis of the difference in means and standard deviation of the changes in ANB from previous studies, in which changes of ANB were  $2.9^\circ \pm 3$  (Mean  $\pm$  SD). Thirteen patients in each group were needed for an alpha level of 0.05 and power of 0.95. Considering eventual drop outs, 16 patients was selected for present study. Ethical approval was obtained from the Research Ethics Committees of Shiraz University of Medical Sciences (IR.SUMS.REC1389.2017). All patients have reverse incisal overjet and Class III molar relationship, the  $ANB \geq -5^\circ$ , "Wits" value  $\geq -3$  and  $SNA \leq 80$ . The control group matched for chronological age consisted of 10 females and 10 males average age of  $10 \pm 1$  years (Mean  $\pm$  SD) with skeletal Class I (ANB angle between  $0^\circ$  and  $3^\circ$ ; Wits appraisal between 2.0 and -2.0 mm) (1) treated only with fixed appliances for dental problems at the same clinic. At the end of treatment at least a 4 mm overjet should be exist. The mean duration of treatment was  $11 \pm 5$  months (Mean  $\pm$  SD). In two group lateral cephalograms were taken at the outset and at the termination of treatment.

### 3.1. Appliance Design

The RCCA consisted of a maxillary intraoral removable plate and a chin cap with vertical wire projections. Maxillary removable appliance consisted of a palatal plate, Adams clasps at molars and/or premolars teeth and buccal hooks on the first premolars region which fabricated for each individual patient. Because maxillary deficient patient often has constricted maxilla, midpalatal screw was inserted to expand the constricted maxilla with a 1/2 turn (0.4 mm) per week (1/4 turn on Tuesday and 1/4 on Friday) with a 1/2 turn on the first day until the desired expansion was achieved (the lingual cusps of the upper

posterior teeth contact the buccal cusps of the lower posterior teeth). Protraction force provide from heavy size 3/16" elastics (American Orthodontics, Sheboygan, USA) attached to the maxillary hooks and the vertical projections on both sides directed  $20^\circ$  to  $30^\circ$  downward from the occlusal plane. They were also instructed to replace the elastics every day. The protraction force was about 200 gr and force of chin cap was about 300 gr on each side. The direction of the chin cap force was passed through condyles (Figure 1). Patients were told to use the appliance at least 16 hours per day. At the end of treatment, at least a 4-mm overjet should be achieved. Facemasks or chin caps is used for retention treatment, and some patient received fixed appliances after removal of RCCAs.

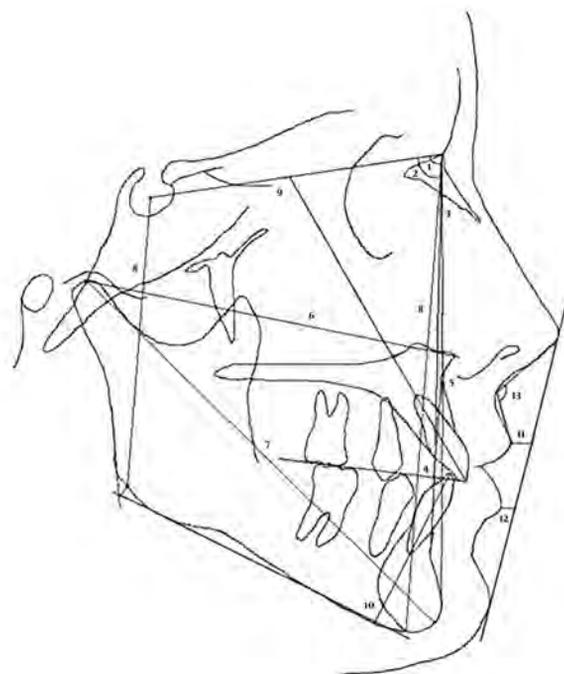


Figure 1. Frontal and lateral view of reverse chin cap appliance

### 3.2. Cephalometric Analysis

Cephalometric analysis consisted of 9 angular and 4 linear measurements (Figure 2). Definition of the measurements used to evaluate differences between groups are presented in Table 1. The difference between pre and post in treated and control samples was available (Table 2). All lateral cephalograms were hand-traced on orthodontic tracing paper on a conventional light box by using a 0.5-mm lead pencil and measured by the same investigator (S.S.) under optimal conditions.



**Figure 2.** Schematic image of angles and distances definite in table I from well-balanced face. 1: SNA; 2: SNB; 3: ANB (not shown); 4: wits value; 5: angle of convexity; 6: maxillary length; 7: mandibular length; 8: PFH:AFH; 9: U1-SN; 10: Lito Mn plane; 11: upper lip to E-Line; 12: lower lip to E-Line; and 13: nasolabial angle.

**Table 1.** Illustration of Angles and Distances Measured in Cephalogram

Measurements	Definition
SNA	Angle formed by the Nasion-A point plane and anterior cranial base (S-N)
SNB	Angle formed by the Nasion-B point plane and anterior cranial base (S-N)
ANB	Angle between Nasion-A point plane and the Nasion-B point plane
Wits appraisal	A line perpendicular from points A and B onto the occlusal plane through the overlapping cusps of Molars and Premolars
Angle of Convexity	Angle between Nasion-A point plane and A point-Pogonion Line
Maxillary length	The distance in millimeters between the condilion point to the anterior nasal spine point
Mandibular length	distance that exists between the condilion and pogonion points (Co-Gn)
PFH: AFH	Percentage ratio between posterior facial height (N-ME) and anterior facial height (S-Go)
U1-SN	Angle formed by the axial inclination of the maxillary incisor and SN plane
Lito Mn plane	Angle between lower incisor inclination and mandibular plane
U lip to E plane	The distance of the upper lip to E plane (The Ricketts' esthetic plane, a line drawn from Pn to Pog') measured at the right angle from labrale superius to E plane
L lip to E plane	The distance of the lower lip to E plane measured at the right angles from labrale inferius to E plane
Nasolabial angle	Angle between Columella, subnasale plane and labrale superius plane

### 3.3. Statistical Analysis

Statistical analysis was performed using SPSS20 (Illinois, Chicago). To compare mean differences between the

two groups the independent samples *t*-test test was used. Differences were considered significant at  $P < 0.05$ . To evaluate intraobserver reproducibility, 40 lateral cephalograms were randomly selected and analyzed again at least one month later. The method error was calculated by Dahlberg's formula (11).

## 4. Results

The error of the method was 0.5 linear mm for measurements and was  $0.6^\circ$  for angular measurements.

Pre- and post-treatment changes of measurements in both groups was describe in Table 2. Comparison of the changes in treatment and control groups during active treatment are presented in the table III. At the end of active orthodontic treatment, no significant change was observed in the SNA angle in treated group compared to control group. Evaluation of the SNB changes in both groups revealed significant difference ( $P = 0.005$ ). ANB angle showed significant increment in treated group compared to control ( $P = 0.005$ ). Comparison of the "Wits" appraisal changes in both groups revealed no significant change. Evaluation of the angle of convexity in both groups did not show significant difference. Maxillary length showed no statistically significant change. Statistically significant changes were observed in the total mandibular length ( $P = 0.009$ ). At the end of treatment, no significant changes in the posterior facial height to anterior facial height ratio were observed. Dentally, the angulation of upper incisors relative to S-N plane did not change statistically significant. Angulation of lower incisors relative to mandibular plane show statistically significant decrease ( $P = 0.001$ ). Evaluation of the position of the upper lip and lower lip relative to the E-line showed significant decrement ( $P = 0.042$  and  $P = 0.056$  respectively). Nasolabial angle show significant decrement in treatment group ( $P = 0.005$ ).

## 5. Discussion

At the end of treatment, all patients had positive overjet indicated that RCCA was an effective option for treatment of maxillary deficient and mandibular excess patient. Because of the low prevalence of CI III patients to match for skeletal age and the ethical principles did not allow to defer of treatment in Class III patients for accomplishment of research, the control group consist of dentally and skeletally Class I samples. According to Kim et al. the normal CI I and skeletal CI III patients aged from 7 to 10 years have similar growth rate and pattern (2).

Because palatal expansion opens sutural articulation of the maxillary to other bones, protraction force with

**Table 2.** Description of Pre- and Post-treatment Changes of Measurements in Control and Treatment Groups<sup>a</sup>

Cephalometric Measurement	Control		Treatment	
	Before	After	Before	After
SNA, °	80.25 ± 3.14	79.68 ± 2.72	78.63 ± 3.01	79.25 ± 2.61
SNB, °	77.53 ± 2.90	77.75 ± 2.59	80.75 ± 2.70	77.03 ± 1.79
ANB, °	2.55 ± 1.32	2.20 ± 0.85	1.44 ± 2.86	-1.50 ± 2.22
“Wits” appraisal, mm	0.67 ± 1.28	-0.06 ± 1.04	-3.66 ± 2.58	-4.47 ± 2.38
Angle of convexity, °	4.73 ± 2.42	2.68 ± 1.40	1.50 ± 6.29	-1.81 ± 2.50
Maxillary length, mm	100.63 ± 5.63	103.55 ± 3.77	101.56 ± 4.97	103.09 ± 5.68
Mandibular length, mm	80.00 ± 8.41	81.91 ± 5.29	83.94 ± 3.54	83.76 ± 7.08
PFH: AFH, %	59.30 ± 2.91	61.90 ± 2.76	58.87 ± 3.99	61.03 ± 2.13
U1 to S-N, °	100.33 ± 2.14	102.48 ± 4.60	100.68 ± 4.30	102.24 ± 2.85
I1 to mandibular plane, °	94.40 ± 3.09	92.65 ± 2.23	93.03 ± 7.47	82.87 ± 3.39
UL to E-Line, mm	-1.08 ± 1.69	-1.35 ± 1.51	-3.09 ± 1.95	-0.75 ± 3.38
LL to E-Line, mm	0.18 ± 1.21	-0.61 ± 1.81	-0.47 ± 2.12	0.34 ± 2.87
Nasolabial angle, °	100.71 ± 3.70	103.90 ± 6.36	107.59 ± 10.35	103.41 ± 5.57

<sup>a</sup>Values are expressed as mean ± SD.

maxillary expansion could be effective. Kim et al. showed that there is very little difference between the results of face mask therapy with and without the expansion except the upper incisors inclination. Non-expansion group revealed greater upper incisor proclination and deduced with the expansion appliance, skeletal change is more than dental change, while more dental change is obtained with non-expansion appliance (2).

SNB angle show significant increase in treated group (Table 3), indicating this appliance could control forward direction of the mandibular growth. Showkatbakhsh et al found similar results after treatment of CI III patients with reverse chin cap appliances (9).

ANB value decrease was statistically significant, indicating this appliance could be used for correction of maxillomandibular discrepancies. Comparison of the SNA and SNB showed that the major influencing factor in the correction of Class III disorders was the mandibular position change. Sagittal changes of B point toward posterior were approximately threefold the anterior changes of A point (Table 2).

There was a significant decrease in the total mandibular length, which could be interpreted as retardation in the mandibular growth. Janzen and Bluher (12) and Asano (13) stated that chin cap could retard the growth of the mandible. Kim et al found that the effects of the chin cap therapy on mandible included growth retardation and change in the direction of the growth (2). Alarcon et al. in their study concluded that the treatment with chin cap

appliance led to retroclination of the lower incisors and mandibular length decrement due to the condylar growth reorientation, compression of the gonial area, and symphysis narrowing (14).

The linear distance of the lower lip relative to E-line decreased significantly, which indicates lower lip retrusion. On the contrary, Kilic et al in their study has shown that after treatment with facial mask there was no significant change in the distance of lower lip to E-line (15).

Although axial inclination of upper incisor was not significantly changed, the linear distance of upper lip relative to E-line and Nasolabial angle change significantly. According to Lai et al, due to the large variability of soft tissues among individuals, prediction the response of soft tissues to the incisors movement was not successful (16).

In present study the concave skeletal profiles were corrected mainly by changes in the mandibular dental and skeletal components in sagittal direction and, to some extent, by maxillary dental and skeletal changes.

Concerning the post treatment stability, some investigations reported that in some cases maxilla moves downward and slightly backward, with clockwise rotation of the palate. Hence, the use of orthopedic appliances should be continued until cessation of growth (5). Some authors stated that positive results of the treatment with chin cap could disappear until the growth was continued (5, 17) therefore retention until growth stop is necessary. The main drawbacks of this study are small sample size and limited duration of study; therefore, a study with large

**Table 3.** Comparisons of Changes in the Class III Group vs. Changes in the Control Group<sup>a</sup>

Cephalometric Measurement	Pre- and Post-treatment Mean Differences		P Value	Significant
	Control Group (N = 20)	Treatment Group (N = 16)		
<b>Skeletal</b>				
SNA, °	-0.57 ± 5.03	0.62 ± 3.74	0.43	NS
SNB, °	-0.22 ± 4.58	3.71 ± 2.81	0.005	S
ANB, °	-0.35 ± 1.24	-2.93 ± 3.07	0.005	S
"Wits" appraisal, mm	-0.72 ± 1.68	-0.81 ± 2.05	0.89	NS
Angle of convexity, °	-2.05 ± 2.17	-3.31 ± 5.94	0.43	NS
Maxillary length, mm	2.92 ± 6.36	1.53 ± 6.34	0.51	NS
Mandibular length, mm	1.91 ± 0.77	-0.18 ± 2.75	0.009	S
PFH: AFH, %	-0.3 ± 1.20	-0.43 ± 2.39	0.9	NS
<b>Dental</b>				
UI to S-N, °	2.15 ± 5.89	1.98 ± 4.91	0.93	NS
LI to mandibular plane, °	-1.75 ± 3.96	-10.03 ± 5.80	0.0001	S
<b>Soft tissue</b>				
UL to E-Line, mm	-0.27 ± 1.89	2.34 ± 4.49	0.04	S
LL to E-Line, mm	-0.79 ± 2.36	1.13 ± 3.38	0.05	S
Nasolabial angle, °	3.19 ± 6.98	-4.18 ± 7.79	0.005	S

Abbreviations: NS, not significant; S, significant

<sup>a</sup>Values are expressed as mean ± SD.

number of samples over long period of time until the mandibular growth is completed is required to validate our findings.

### 5.1. Conclusions

The main contributing factor in the success of RCCA treatment was mandibular skeletal and dental retrusion than maxillary skeletal and dental change.

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### Footnotes

**Authors' Contribution:** The study was planned by Samaneh Sadeghi and Zohreh Hedayati. Data collection was carried out by Samaneh Sadeghi and Zohreh Hedayati. Statistical analyses and interpretation of data were carried out by Samaneh Sadeghi. The manuscript was prepared by Samaneh Sadeghi. All the authors critically revised the manuscript for intellectual content. All the authors have read and approved the final manuscript for submission.

**Conflict of Interests:** There is no conflict of interest.

**Ethical Approval:** The study has been approved by Research Ethics Committees of University of Medical Sciences (IR.SUMS.REC1389.2017).

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