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SCIENTIFIC SECTION

The effects of facemask and reverse chin cup on maxillary deficient patients

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Introduction: The aim of this randomized clinical trial was to assess differences in the effects of face mask and reverse chin cup therapy on maxillary deficient growing patients.

Methods: The sample consisted of 42 class III patients with maxillary deficiency randomly divided into two equal groups. Twenty-one patients (10 males and 11 females) with a mean age of 8.9 (SD: 1.4) years were treated with a face mask for 18 (SD: 2) months. Twenty-one patients (9 males and 12 females) with the mean age of 9.2 (SD: 1.1) years were treated with a reverse chin cup for 19 (SD: 4) months. Cephalometric radiographs were taken at the beginning and end of treatment and the cephalometric measurements were analysed. Paired *t*-tests and a Wilcoxon test were used for intra-group evaluations. Mann–Whitney test was used for inter-group evaluations.

Results: Sella–Nasion–A point (SNA) was increased by 1° (SD: 1.7°) ($P<0.003$) and 1.8° (SD: 1.7°) ($P<0.001$) in the face mask and reverse chin cup groups, respectively. The IMPA decreased by 4.1° (SD: 6.5°) in face mask group ($P<0.009$) and 3.1° (SD: 4.7°) in the reverse chin cup group ($P<0.008$). However, no statistically significant differences were seen in changes between the two groups.

Conclusion: Both face mask and reverse chin cup appliances are successful at moving the maxilla forward.

Key words: Cl III malocclusion, facemask, maxillary deficiency, orthopaedic traction, reverse chin cup

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Introduction

Skeletal class III malocclusion can be defined as a skeletal facial deformity characterized by maxillary skeletal retrusion, mandibular skeletal protrusion or a combination of both. The realization that maxillary deficiency is frequently a component of skeletal class III, and new possibilities for correcting it, have led recently to a great increase in treatment aimed at promoting maxillary growth.[1] The prevalence of class III malocclusion ranges between 1 and 4% in North American[2] and 1.5 and 5.3% in Europeans.[3] In Asian populations, the frequency of class III malocclusion is reported to be higher and in Chinese populations, the prevalence can be as high as 12%.[4] It is noteworthy that all these variations depend on the ethnic group, method of classifying the malocclusion and the age group evaluated.

A series of approaches can be found in the literature regarding orthopaedic treatment in class III malocclusion, if the mandible is not markedly affected. Orthopaedic correction of class III malocclusion and maxillary deficiency has been described utilizing face mask,[5–7] Frankel FR-III[8] and reverse headgear appliances.[9,10] Shapiro and Kokich deliberately ankylosed primary canines in order to protract the maxilla,[11] while numerous other appliance designs such as endosseous implants,[12] surgically-assisted orthopaedic protraction,[13] distraction osteogenesis,[14] tongue appliances,[15–17] tongue plates,[18] suborbital protraction appliances[19–21] and Nanda's modified protraction headgear[22] have been introduced in attempts to protract the maxilla. Recently, miniplates,[6,23,24] mini-implants[25,26] and reverse chin cup[27] have also been used for the treatment of this malocclusion.

The aim of this investigation was to test effectiveness of the face mask and a newly designed appliance called the reverse chin cup[27] in the treatment of growing patients affected by maxillary deficiency.

Materials and methods

Ethical approval was obtained from the IAU Local Research Ethics Committees (19014, October 2009).

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Figure 1 Lateral intra-oral view of upper removable appliance which connects to facemask

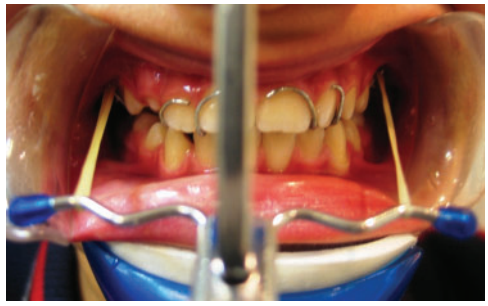

Figure 2 Frontal intra-oral view of upper removable appliance which connects to facemask

Informed written consent was obtained from each patient and a parent or guardian. A sample size calculation was carried out on the basis of the difference in means and standard deviation of the changes in SNA from previous studies, similar in nature to the current one,[28–30] in which changes of SNA were 0.7° (SD: 0.6). For an alpha level of 0.05, a sample size of 20 per group was necessary to achieve a power of 0.90. Considering these studies, following published guidelines[31] and considering probable drop outs, an optimal sample size of 42 patients was chosen for this study.

The following inclusion criteria were used:

- Sella–Nasion–A point (SNA) $\leqslant 80°$; Sella–Nasion–B point (SNB) $\leqslant 80°$; A point–Nasion–B point (ANB) $\leqslant 0°$;
- class III molar relationship;
- no mandibular shift;
- negative overjet;
- no congenital disease or endocrine disorders;
- no previous orthodontic treatment and surgical intervention.

An unstratified subject allocation sequence was generated by computer program (Etcetra Version 2.59); random numbers were generated and assignment was carried out by one of the investigators, thus concealing allocation from the clinician until the time of the appointment at which the appliance was to be placed. The treating clinician was blinded from the randomization procedure, but because of clear differences in appliance design, blinding was not possible during the treatment period.

Participants were allocated to one of two groups:

- Group I: received a Multi-Adjustable face mask® (Ortho Technology Inc., Tampa, FL, USA) and a fully anchoraged removable appliance in the upper jaw. The upper removable appliance had two Adams clasps on the permanent first molars, two C clasps on the primary canines, and two C clasps on the permanent central incisors. If necessary, the number of C clasps and Adams clasps could be increased for anchorage reinforcement. Two hooks were mounted on the right and left buccal segments. Two orthodontic latex elastics (5/16″, medium size) connected the hooks of the upper removable appliance to the horizontal crossbar of the face mask in order to deliver approximately 500 g of force (Figures 1 and 2). The patients were instructed to wear the appliance full-time except for eating, contact sports and tooth brushing.
- Group II: received the reverse chin cup.[27] This upper removable appliance had two Adams clasps on the permanent first molars, two C clasps on the primary canines and two other C clasps on the permanent central incisors. If necessary, the number of C clasps and Adams clasps could be increased for anchorage reinforcement. A porous acrylic chin cup with two vertical arms (1 mm stainless steel) was fabricated for each individual patient. The end of each arm was bent to form a hook. Two orthodontic latex elastics (5/16″, heavy size) connected the hooks of the palatal canine area of the upper removable appliance to the hooks of reverse chin cup in order to deliver approximately 500 g of force on each side. A high pull head cap was used to hold the reverse chin cup (Figures 3–5). The patients were instructed to wear the appliance full-time except for eating, contact sports and tooth brushing.

Lateral cephalograms, panoramic radiographs, photographs and study casts of the patients in both groups were taken before (T1) and after (T2) treatment. SNA, SNB, ANB, Upper I to SN, ANS–PNS, to SN, Go–Gn, Jarabak ratio, Upper I to ANS–PNS, Go–Gn to Sn and IMPA were measured. The radiographs of each patient were measured before and after treatment by one trained clinician. The reliability of the measurements was determined by randomly selecting 10 cephalograms at the beginning and end of treatment from each group.

Figure 3 Lateral extra-oral view of reverse chin cup

Figure 5 Frontal intra-oral view of upper removable appliance which connects to reverse chin cup

They were traced twice by the same trained clinician on two separate occasions after a 1-month interval. Paired *t*-test showed no statistically significant differences between the two measurements.

An intra-class correlation coefficient was also calculated to assess test/re-test reliability, the results of which revealed a kappa value of 0.84, which is considered excellent. The level of statistical significance was set at $P<0.05$.

Data were tested for normality and appropriate statistical tests were applied (Table 1). Paired *t*-tests were used for intra group evaluation if the distribution was normal; otherwise, a Wilcoxon test was used. *t*-test was used to compare the data between the two groups if the distribution was normal; otherwise, a Mann–Whitney test was used.

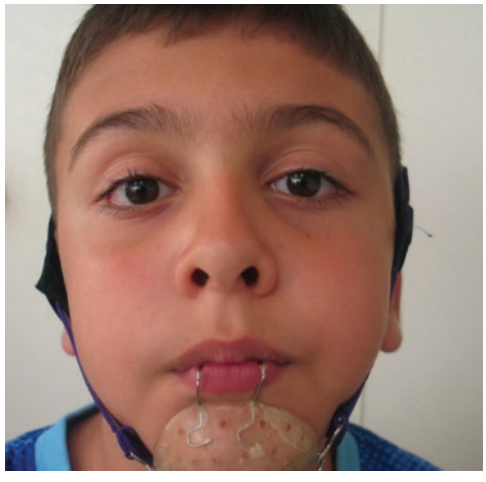

Figure 4 Frontal extra-oral view of reverse chin cup

Results

A total of 42 patients (19 males and 23 females) were recruited to the study. A CONSORT diagram showing the flow of patients through the trial is provided in Figure 6. There were 21 patients (10 males and 11 females), with a mean age of 8.9 (SD: 1.4) years treated using the face mask. The active treatment time was 18 (SD: 2) months. There were 21 patients (nine males and 12 females), with a mean age of 9.2 (SD: 1.1) years treated using the reverse chin cup. The active treatment time was 19 (SD: 4) months.

The results of the cephalometric analysis are shown in Tables 2 and 3. Analysis using paired *t*-test and Wilcoxon test showed that the SNA in the face mask group increased by 1° (SD: 1.7) from 76.6° (SD: 2.8) to 77.6° (SD: 3.2) ($P<0.003$) and ANB increased from −1.1° (SD: 1.5) to 0.5° (SD: 2.4) ($P<0.001$). The changes in SNB were not significant. IMPA showed a decrease of 4.1° (SD: 6.5) from 91.1° (SD: 6.4) to 87° (SD: 5.6) ($P<0.009$) (Table 2). In the reverse chin cup group, SNA increased by 1.8° (SD: 1.7) from 75.8° (SD: 2.6) to 77.6° (SD: 2.9) ($P<0.001$), and ANB increased by 1.4° (SD: 1.5) from −1.4° (SD: 1.9) to 0° (SD: 2.2) ($P<0.001$). SNB showed a non-significant change. IMPA was decreased by 3.1° (SD: 4.7) from 89.7° (SD: 6.2) to 86.6° (SD: 6.4) ($P<0.008$) (Table 2).

In the inter-group evaluation, *t*-test and Mann–Whitney test showed no statistically significant differences between the cephalometric measurements of the two groups (Table 3).

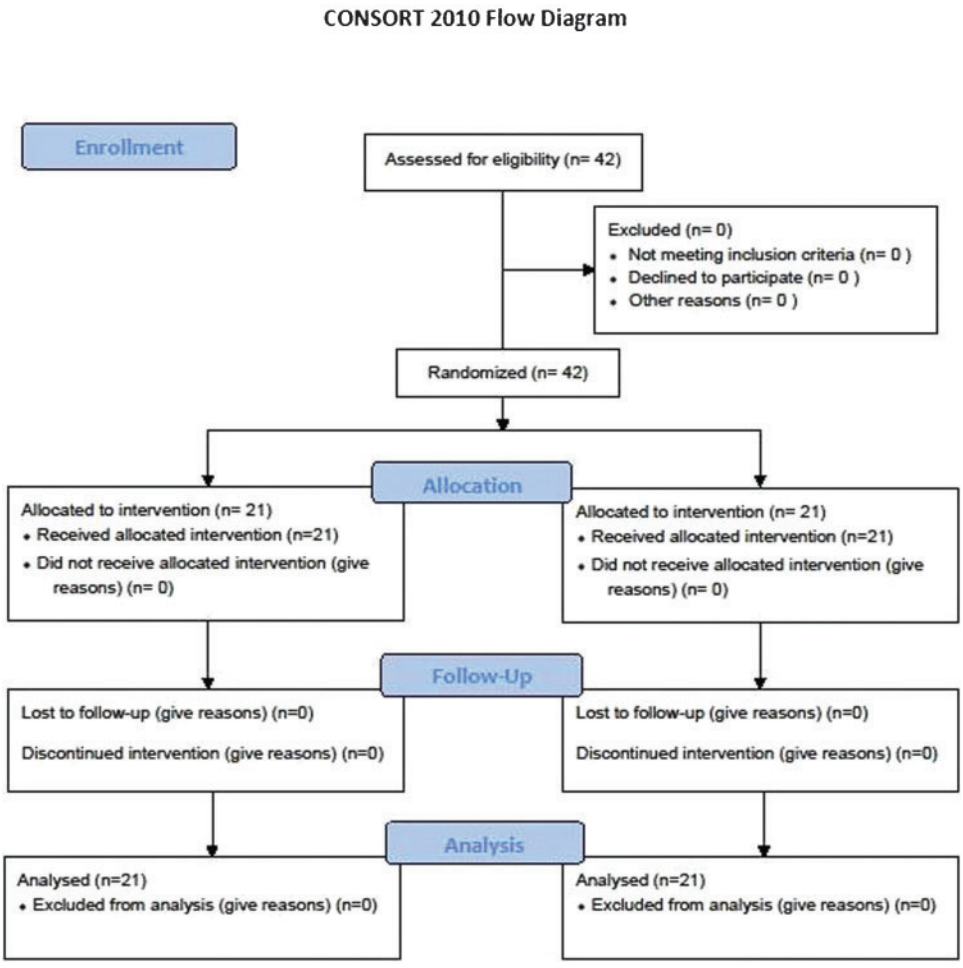

Figure 6 CONSORT flow diagram of subjects through each stage of the study

Table 1 Definition of the cephalometric variables.

Cephalometric variables	Definition
SNA (°)	The angle between the anterior cranial base (sella to nasion) and NA (nasion to point A) line
SNB (°)	The angle between the anterior cranial base (sella to nasion) and NB (nasion to point B) line
ANB (°)	The angle between the NA and NB lines
U1 to SN (°)	The angle between long axis upper central incisor and anterior cranial base
ANS–PNS (mm)	Anterior nasal spine-posterior nasal spine
Palatal–SN (°)	The angle between palatal plane and SN
GoGn (mm)	The distance between gonion and gnathion
Jarabak ratio (%)	The ratio between posterior and anterior face heights; S–Go/N–Me
U1 to palatal (°)	The angle between long axis upper central incisors and palatal plane
Inclination angle	The angle formed between a perpendicular line to soft tissue nasion and palatal plane
GoGn–SN (°)	Mandibular plane angle
IMPA (°)	The angle between the long axis of the lower central incisor and mandibular plane

Table 2 Pre- and post-treatment measurements of the Face mask and Reverse Chin Cup groups.

Cephalometric measurement	Groups	Pre-treatment mean	SD	Post-treatment mean	SD	*P* value
SNA (°)	Face Mask	76.6	2.8	77.6	3.2	0.003
	R. Chin Cup	75.8	2.6	77.6	2.9	0.001
SNB (°)	Face Mask	77.8	2.2	77.3	2.6	0.100
	R. Chin Cup	77.2	2.3	77.5	2.5	0.300
ANB (°)	Face Mask	−1.1	1.5	0.5	2.4	0.001
	R. Chin Cup	−1.4	1.9	0	2.2	0.001
U1 to SN (°)	Face Mask	98.1	9.2	104.3	5.2	0.001
	R. Chin Cup	101	10.4	105.1	6.9	0.050
ANS–PNS (mm)	Face Mask	44.3	3	46.3	3.7	0.020
	R. Chin Cup	45.9	3.6	46.9	2.9	0.100
Palatal–SN°	Face Mask	9.8	2.8	10	3.8	0.800
	R. Chin Cup	10.3	4.4	10	3.3	0.600
GoGn (mm)	Face Mask	62.9	3.9	64.4	3.5	0.090
	R. Chin Cup	67.5	5.9	69.1	4.5	0.100
Jarabak ratio (%)	Face Mask	62.8	5.3	63.6	5.6	0.070
	R. Chin Cup	62.7	5.2	63.7	3.7	0.030
U1 to palatal (°)	Face Mask	107.7	10.1	114.7	5.9	0.003
	R. Chin Cup	111	11.1	115	7.1	0.050
Inclination angle	Face Mask	83.1	2.8	82.9	3.6	0.700
	R. Chin Cup	82.4	4.2	83.1	3.1	0.200
GoGn–SN (°)	Face Mask	33.6	5.5	33.3	5.8	0.400
	R. Chin Cup	35.5	5.5	34.2	5.2	0.009
IMPA (°)	Face Mask	91.1	6.4	87	5.6	0.009
	R. Chin Cup	89.7	6.2	86.6	6.4	0.008

Discussion

The present study has indicated that treatment with a face mask or reverse chin cup appliance might have the following effects: (1) forward movement of the maxilla; and (2) forward movement of the maxillary dentition and lingual movement of the mandibular incisors.

In view of the high frequency of maxillary retrusion, maxillary advancement by reverse headgear has been considered a major treatment option in young patients.[10] The aim of these orthopaedic approaches is to provide a more favourable environment for normal growth, as well as an improvement in the occlusal relationship.[21] Face mask therapy has become a common technique used to

Table 3 Comparison of cephalometric changes between Facemask and Reverse Chin Cup groups.

Cephalometric measurements	Facemask mean	SD	Reverse Chin Cup mean	SD	Confidence interval	*P* value
SNA (°)	1	1.7	1.8	1.7	…	0.07
SNB (°)	−0.5	1.2	0.3	1.6	…	0.07
ANB (°)	1.6	1.5	1.4	1.5	…	0.30
U1 to SN (°)	6.2	7.1	4.1	8.8	−7.2–2.8	0.10
ANS–PNS (mm)	2	3.5	1	2.5	…	0.40
Palatal–SN (°)	0.2	2.9	−0.3	2.7	…	0.90
GoGn (mm)	1.5	2.1	1.6	4.5	−2.6)–(2.9	0.90
Jarabak ratio (%)	0.8	2.1	1	1.8	…	0.60
U1 to palatal (°)	7	9.4	4	8.7	−8.6–2.6	0.10
Inclination angle	−0.2	2.7	0.7	2.7	…	0.40
GoGn–SN (°)	−0.3	1.6	−1.3	2.1	…	0.20
IMPA (°)	−4.1	6.5	−3.1	4.7	…	0.90

correct the developing class III malocclusion.[32,33] An electronic search in the literature reveals copious investigations relating to face masks and their effects on the nasomaxillary complex. In addition, experimental studies constantly demonstrate pronounced forward movement of the maxilla due to heavy and continuous protraction forces of via a face mask.[34–36] Face mask therapy is recommended to begin before the age of 8 years for maximal effect.[37] However, one of the problems with the face mask is the bulky size and shape, which make it a discouraging choice for children, which can be associated with discomfort. This discomfort, along with the embarrassment caused by the large size, especially at school in front of other peers, potentially reduces compliance. For most young children, protraction headgear is a more acceptable method for the treatment of maxillary deficiency.[37] The protraction headgear used in this study was a reverse chin cup,[19] which is similar to a chin support with cranial straps.[38] A porous acrylic chin pad was used in order to allow better ventilation to reduce skin irritation. The reverse chin cup is not a small appliance by itself; however, it is smaller than the face mask. Moreover, it lacks the forehead rest of the face mask.

The major goal of both treatment modalities was to correct the jaw discrepancy; however, tooth movement is inevitable when force is applied via the dentition. In addition, in both groups, the pressure of the chin cup caused a decrease in the IMPA. These findings are similar to other studies, which indicate that the usual effects of conventional face mask therapy on the dentition include proclination of the maxillary incisors, and retroclination of the mandibular incisors.[10,33,39–42] However, mini-plates and mini-implants combined with class III elastics do not cause retroclination of the lower incisors.[6,26] The reason for this difference is that mini-plates and mini-implants combined with class III elastics utilise bone anchorage; thus, they do not exert any pressure on the lower incisors. The force applied on the face mask is not completely transferred to the chin, part of it being counteracted by forehead anchorage and resulting in less backward rotation of the maxilla. However, the force associated with the reverse chin cup is transferred completely to the chin and causes more backward rotation of the mandible. Although the origin of force application varies between the face mask and reverse chin cup, they are very similar because in both of them orthopaedic force is directed 30° downward and forward from the occlusal plane.

The treatment methods used in this study were for the correction of skeletal problems. Therefore, when the active treatment was finished, patients were instructed to wear the appliances only at nights to act as a retainer. The process will continue until the permanent dentition. Once in the permanent dentition, further treatment will be continued with the use of fixed appliances.

Conclusions

- Facemask and reverse chin cup therapy is able to produce forward movement of the maxilla in the growing child.
- Both appliances were also associated with lingual tipping of the lower incisors and labial tipping of the uppers.

Contributors

Rahman Showkatbakhsh was responsible for study design, administration and writing the manuscript. Abdolreza Jamilian was responsible for the study concept, treatment, data interpretation and writing the manuscript. Mehrangiz Ghassemi was responsible for statistical analysis, data interpretation, critical revision and final approval of the article. Alireza Ghassemi was responsible for sample randomization, statistical analysis, data interpretation, critical revision and final approval of the article. Tannaz Taban was responsible for recruitment of participants and data collection; analysis; and drafting. Zahra Imani was responsible for recruitment, obtaining ethical approval, and drafting. Abdolreza Jamilian is the guarantor.

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