An Evaluation of The Skeletal and Dental Effects of a Modified Vertical Holding Appliance

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ABSTRACT

The purpose of the current study is to evaluate the skeletal and dental effects of a modified vertical holding appliance (MVHA) in a group of Egyptian children. The sample included fifteen females from which ten received the modified vertical holding appliance for treatment for a period of six months and five acted as controls. Measurements were taken and compared before and after treatment using Cone Beam CT (CBCT). The results revealed that the appliance was able to induce forward and upward mandibular rotation as evident from the statistically significant increase in the facial axis angle (PtGn/NBa) as well as the significant increase in the overbite.

Kew words: Modified Vertical Holding Appliance, Anterior Open Bite, Intrusion, Cone Beam CT (CBCT).

Introduction

Throughout the history of orthodontics, anterior open bite had been considered among the most difficult and challenging clinical situations facing orthodontists. This was due to the complexity of this malocclusion which was attributed to skeletal, dentoalveolar, functional and habit related factors or interaction of more than one factor (Frost DE et al., 1980; Isaacson JR et al., 1971; Schendel SA et al., 1976; Schudy FF, 1965).

Anterior open bite is a condition characteristic of and resulting from backward-rotating mandibular growth patterns. The molars overerupt, causing further rotation of the mandible away from the maxilla and swinging of the chin downward and backwards. This leaves the already erupted anterior teeth in a position of open bite.

Treatment options for open-bite malocclusions include elimination of the etiology, extrusion of the anterior teeth, surgical impaction of the maxilla, inhibition of molar eruption in growing patients, intrusion of the molars, and a combination of these (Sugawara J et al., 2002; Erverdi N et al., 2004; Pearson LE. 1973; Sherwood KH et al., 2002; Gurton AU et al., 2004).

Some of the proposed methods in growing patients are high-pull headgear for the maxilla or cervical-pull headgear for the mandible, posterior bite blocks, the vertical chin cap and occlusal splints as well as the active vertical corrector appliance (AVC) which uses repelling magnets embedded in acrylic to produce an additional posterior occlusal force and posterior bite planes. Also functional appliances which are specifically designed and fabricated with posterior bite blocks to accomplish posterior segment intrusion may be used. Unfortunately most of these systems are limited by many factors including patients’ compliance, relative number of dental anchorage units available, allergy as well as unfavorable reactionary tooth movement. A passive system achieves relative intrusion of the posterior teeth either by interfering with or reducing the potential of molar eruption during growth. While an active system, on the other hand, attempts to physically intrude the molars into their bony support (Owen AH., 1985; Pfeiffer JP and Grobety D., 1972; Pfeiffer JP and Grobety D. 1982; Teuscher U., 1978; Iscan HN et al., 2002; Woods MG and Nanda RS, 1988; Kiliaridis S et al., 1990).

Compromised esthetics and a less stable outcome than for intrusion of posterior teeth have been also considered drawbacks of incisor extrusion in these patients. So the most appropriate treatment for skeletal open bite is to intrude the molars though molar intrusion is difficult.

Deberardinis et al (2000), examined the skeletal and dental effects of a modified transpalatal bar, called the vertical holding appliance (VHA), which was used in an attempt to control the vertical dimension of high-angle patients, and found that VHA group have shown a control of the anterior vertical dimension.

The aim of the current study is to evaluate the skeletal and dental effects of a modified vertical holding appliance in a group of Egyptian children.
Materials And Methods

Sample:

This study was conducted on 15 female children. The inclusion criteria for the selected sample was that the patients age range is of 10-12 years with an anterior open bite indicated for buccal segment intrusion, fully erupted right and left maxillary first molars, fully erupted right and left maxillary first premolars, no previous orthodontic treatment as well as to agree to participate in the study after being fully informed of the procedures.

The sample was divided into 2 groups. Group 1 (treatment group) included 10 patients that were treated with the modified vertical holding appliance for 6 months while Group 2 (control group) included 5 patients that acted as controls and received no treatment for 6 months.

Methods:

For each patient the following records were taken before and after the six months:
1) Case History and Clinical Examination: written in a diagnostic sheet.
2) Treatment consent signed by each patient.
3) Orthodontic Study Models: Upper and lower impressions were taken for each patient (before and after the 6 months treatment period) using alginate impression material as well as a wax wafer for interocclusal bite record. Impressions were poured into extra hard stone. Bases were properly formed and trimmed according to orthodontic standards.
4) Photographs: For every patient a set of extra-oral and intra-oral photographs were taken (before and after the 6 months treatment period). Extra-oral photographs which include frontal at rest, frontal on smiling photos, profile at rest and intra-oral photographs which include frontal, right, left in centric occlusion, and upper& lower occlusal photographs
5) Three-Dimensional Computed Tomography:
The images taken were imported in DICOM format (Digital imaging and communications in medicine) whereby coronal and sagittal reformatting were done and a three-dimensional image was calculated. All the CBCT cuts were then segmented to separate the soft tissue from the underlying bony structures and only bone was selected. Three-dimensional reconstructed images were finally obtained. Then, for each individual patient a series of steps were done to obtain points, lines and planes in order to calculate angular and linear measurements for proper diagnosis and the assessment of treatment changes.

Appliance Design:

The modified vertical holding appliance (fig.1) is formed of:
• Bands adapted on the maxillary right and left first molars as well as bands adapted on the right and left maxillary first premolars.
• Metal occlusal rests extending from the distal surface of the first premolar bands and mesial surface of the first molar bands to allow the intrusion of the buccal segment as a whole.
• An acrylic button of a uniform diameter (17mm) and thickness which is positioned midway between the maxillary first molars and first premolars 6mm away from the palate to allow pressure from the tongue to act as an intrusive force.
• Patients that were included in the treatment group were treated with the modified vertical holding appliance for 6 months while the control group received no treatment for 6 months.

Fig. 1: The appliance seated in the patient’s mouth.
The following measurements were measured on the CBCT before and after the six months treatment period:

I) Skeletal Measurements:

Skeletal measurements whether anteroposterior and vertical variables were measured on the cone beam CT:

- Facial axis angle (PtGn/BaN): the angle formed between the facial axis extended from Pterygoid to Gnathion (PtGn) and the Basion-Nasion (BaN) line.
- Palatal line angle (PL/ SN): the angle formed between the palatal line (ANS-PNS) and the Anterior cranial base line(S-N).
- Posterior facial height (PFH): the average measured from Sella to right and left Gonion (S-Go RL).
- The ratio between the posterior and anterior facial heights (PFH/AFH).

II) Dentoalveolar Measurements:

A number of dentoalveolar variables were measured:

- Is-PP: measured from the Incisor Superius (Is) to the palatal plane
- L6-MP: the average of the distance measured from the furcation of the right and left mandibular first molars, perpendicularly to the mandibular plane (L6-MP).
- Ii-MP: distance measured from the Incisor Inferius (Ii) to the mandibular plane
- Is-Ii: distance measured between Incisor Superius and Incisor Inferius denoting the presence of open bite (Is-Ii).
- U1/PL: angle between the long axis of the upper central incisor and the palatal line (ANS-PNS) indicating the inclination of the upper central incisors.
- L1/ML: angle between the long axis of the lower central incisor and the mandibular line indicating the inclination of the lower central incisors.

III) Soft Tissue Measurement:

- N’ Sn Pog’: the soft tissue profile angle. It is the angle formed between the soft tissue nasion, sub-nasale and the soft tissue pogonion.

The same variables for all fifteen patients were measured twice by the same observer with a one week interval between the two occasions, and also by another observer to study the intra-observer and inter-observer errors.

Statistical Analysis:

Data were presented as mean (X), standard deviation (SD) and standard error (SE) values. Paired t-test was used to study the changes after treatment within each group. Mann-Whitney U test was used to compare between percentage changes in measurements of the two groups. This test is the non-parametric alternative to Student’s t-test and it was used due to the non-parametric (non-normal) distribution of percentage change data.

The percentage change was calculated as:

\[
\text{Percentage Change} = \left( \frac{\text{Measurement (post)} - \text{Measurement (Pre)}}{\text{Measurement (Pre)}} \right) \times 100
\]

Statistical analysis was performed with SPSS 16.0 (Statistical Package for Scientific Studies) for Windows.

Results:

The clinical observations of the current study revealed that the modified vertical holding appliance was able to produce an improvement in open bite treatment over a period of 6 months. A minimal improvement in the facial profile was evident. Meanwhile, intraorally, variable amounts of open bite closure were manifested in the different subjects included in the current study (figs.2&3).
Fig. 2: Pre-treatment (A) and after 6 months treatment (B) intraoral photos of a treated case (1) in occlusion.

Fig. 3: Pre-treatment (A) and after 6 months treatment (B) intraoral photos of a treated case (2) in occlusion.

The comparison of the pretreatment and post treatment three dimensional reconstructed computed tomographic (CT) images showed an obvious counterclockwise rotation of the mandible. Statistical analysis of the collected data is represented as follows:

Table (1) shows the comparison between the pre-treatment and post-treatment linear and angular skeletal measurements in the treatment group. Regarding the linear skeletal measurements in the treatment group, a statistically increase in S-Go/N-Me mean at $P \leq 0.030$, while there was no statistically significant change in S-Go post-treatment.

The angular skeletal measurements in the treatment group showed a statistically significant increase in Pt Gn/N-Ba mean at $P \leq 0.001$ post-treatment, while there was no statistically significant change in PP/SN mean post-treatment. The comparison between the pre-treatment and post-treatment linear and angular dental measurements as well as the soft tissue profile measurement in the treatment group is reported in table (1).

Regarding the linear dental measurements in the treatment group there was a statistically significant decrease in Is – Li mean at $P \leq 0.008$ post-treatment as well as a statistically significant increase in L6 – MP mean at $P \leq 0.041$ and Li - MP mean at $P \leq 0.003$ post-treatment. While there was no statistically significant change in the means of Is – PP post-treatment.

In the angular dental measurements of the treatment group, there was a statistically significant increase in Li/MP mean at $P \leq 0.003$ post-treatment, while there was no statistically significant change in Ui/PP mean post-treatment nor in the soft tissue profile (fig. 4).
Table 1: Comparison between the pretreatment and post treatment measurements within the treatment group using the paired t-test.

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Pre-treatment</th>
<th>Post-treatment</th>
<th>Mean change</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre-treatment</td>
<td>Post-treatment</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>$\bar{x}_1$</td>
<td>$\bar{x}_2$</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>SE</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>SE</td>
<td>P-value</td>
<td></td>
<td></td>
</tr>
<tr>
<td>S-Go</td>
<td>72.8</td>
<td>73.8</td>
<td>1</td>
<td>0.289</td>
</tr>
<tr>
<td>S-Go/N-Me</td>
<td>0.60</td>
<td>0.62</td>
<td>0.02</td>
<td>0.289</td>
</tr>
<tr>
<td>Pt Gn/N-Ba</td>
<td>84.8</td>
<td>86.6</td>
<td>1.4</td>
<td>0.01</td>
</tr>
<tr>
<td>PP/SN</td>
<td>6.3</td>
<td>6.3</td>
<td>1.2</td>
<td>0.096</td>
</tr>
<tr>
<td>Is – Li</td>
<td>6.3</td>
<td>4.7</td>
<td>-1.6</td>
<td>0.008</td>
</tr>
<tr>
<td>Is – PP</td>
<td>27.2</td>
<td>27.7</td>
<td>1.3</td>
<td>0.062</td>
</tr>
<tr>
<td>L6 – MP</td>
<td>17</td>
<td>17.4</td>
<td>1.7</td>
<td>0.064</td>
</tr>
<tr>
<td>Li – MP</td>
<td>37.9</td>
<td>38.5</td>
<td>1.2</td>
<td>0.064</td>
</tr>
<tr>
<td>Is – PP</td>
<td>116.4</td>
<td>117.5</td>
<td>1.1</td>
<td>0.064</td>
</tr>
<tr>
<td>Li/MP</td>
<td>88.6</td>
<td>89.6</td>
<td>1.0</td>
<td>0.064</td>
</tr>
<tr>
<td>N’ Sn Pog’</td>
<td>161.1</td>
<td>161.8</td>
<td>1.0</td>
<td>0.064</td>
</tr>
</tbody>
</table>

$\bar{x}_1$ =The mean of pre-treatment measurements

$\bar{x}_2$ = The mean of post-treatment measurements

SE=Standard Error

P-value=Probability Level

*: Significant at $P \leq 0.05$

Fig. 4: Representing the pretreatment and post-treatment changes in the treatment group.

In the control group, there was no statistically significant change in the means of ANS-Me, S-Go, S-Go/N-Me, Pt Gn/N-Ba, and PP/SN after 6 months treatment. The linear dental measurements in the control group showed no statistically significant change in all measurements after 6 months of observation while there was a statistically significant increase in means U1/PP at $P \leq 0.003$ and Li/MP at $P \leq 0.007$ after 6 months treatment (table 2 & figure 5).

Table 2: Comparison between the measurements by time within control group using paired t-test.

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Pre-treatment</th>
<th>After 6 months</th>
<th>Mean change</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$\bar{x}_1$</td>
<td>$\bar{x}_2$</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>SE</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>SE</td>
<td>P-value</td>
<td></td>
<td></td>
</tr>
<tr>
<td>S-Go</td>
<td>63.6</td>
<td>63.6</td>
<td>0</td>
<td>Not computed **</td>
</tr>
<tr>
<td>S-Go/N-Me</td>
<td>0.52</td>
<td>0.52</td>
<td>0.01</td>
<td>0.152</td>
</tr>
<tr>
<td>Pt Gn/N-Ba</td>
<td>85.7</td>
<td>85.6</td>
<td>1.1</td>
<td>0.704</td>
</tr>
<tr>
<td>PP/SN</td>
<td>6.6</td>
<td>6.7</td>
<td>0.6</td>
<td>0.374</td>
</tr>
<tr>
<td>Is – Li</td>
<td>6</td>
<td>5.9</td>
<td>0.6</td>
<td>0.402</td>
</tr>
</tbody>
</table>

$\bar{x}_1$ =The mean of the measurements at the start of the observation

$\bar{x}_2$ = The mean of the measurements after 6 months observation

SE=Standard Error

P-value=Probability Level

*: Significant at $P \leq 0.05$
Discussion:

Skeletal open bite had always been one of the most challenging malocclusions, not only to treat, but also to retain. The complexity of this malocclusion was usually attributed to its multifactorial nature, where combinations of skeletal, dental and sometimes functional factors interact. It is often the outcome of a vertical growth pattern, where the downward descend of the posterior maxillary segment results in clockwise rotation of the mandible and swinging of the chin downward and backward. Reviewing the literature, many treatment modalities were reported by Dellinger (1986), Barbre et al (1991), Firouz et al (1992), Deberardinis et al (2000), Barbosa et al (2005), Cozza et al (2007), Defraia et al (2007), Giuntini et al (2008) and Baccetti et al (2008), whereby successful molar intrusion was achieved in an attempt to correct the skeletal open bite. However, the maximum amount of true molar intrusion achieved was only 0.96 mm, through wearing the high pull head gear appliance, as reported in a recent systematic review by Ng et al (2006), and yet the clinical significance of such amount in the correction of open bite is still questionable. The vertical holding appliance was introduced by Deberardinis et al (2000) who modified the transpalatal arch in an attempt to control the vertical dimension of high-angle patients. This appliance was modified and used in the treatment group for 6 months in which metal occlusal rests were extended from the mesial surface of the maxillary first molar and distal surface of the maxillary first premolar to allow the intrusion of the buccal segment as a whole. The acrylic button of the modified vertical holding appliance was of a uniform diameter (17 mm) and thickness which was positioned midway between the maxillary first molars and first premolars 6 mm away from the palate to allow pressure from the tongue to act as an intrusive force as described by Chiba et al (2003), who found that the maximum tongue pressure was obtained at a distance of 6 mm from the palatal mucosa. An acrylic button of uniform diameter (17 mm) and thickness positioned midway between the maxillary first molars and maxillary first premolars was used instead of the normal loop form of the transpalatal arch to prevent the loop imprint and discomfort to the tongue as well as standardization and delivering uniform pressure during swallowing. Upon placing the appliance, the patients felt discomfort as well as difficulty in swallowing and talking at first and others experienced a sore tongue. But within a couple of days they got adapted and were able to swallow and talk normally.

According to Winders (1958) tongue pressure during deglutition ranges from 41 to 709 gms/cm² (0.40-6.95 N/cm²); Kydd and Toda (1962) reported that tongue pressure has a range of 37 to 240 gms/cm² (0.36-2.35N/cm²) and 112 gms/cm² (1.10 N/cm²) on average. Kincaid (1951) reported that the average frequency of deglutition was 1600 times a day, and Staub (1961) stated that it was about 2400 times a day. Therefore, one could conclude that the tongue can deliver orthodontic forces with considerable frequency.

The preliminary results of this study showed that the modified vertical holding appliance could be successfully used to treat open bite malocclusion in growing subjects. Statistical evaluations of the treatment changes revealed a mandibular counterclockwise autorotation. No statistically significant change was observed for the ratio of the anterior cranial base to the palatal plane (SN/PP) that reflected that the change occurred in the mandibular plane angle. These results were in accordance with Deberardinis et al (2000) who found that there was a decrease in the angle between the mandibular plane and the SN plane 0.58˚ when the VHA was used, with putting into consideration that in the present study the mandibular plane is the right Gonion and left Gonion to the Menton while they measured the Gonion Gnathion. A significant increase was also noted for the facial axis angle (1.8˚). There was also a significant decrease in N-Me (2.6mm) post-treatment which disagreed with the results recorded by Deberardinis et al (2000) in which the lower anterior facial height increased with mean 1.53mm in the VHA group. The present study also recorded statistically significant increase in means S-Go/N-Me describing a decrease in the anterior facial height in relation to the posterior facial height. Regarding the dental changes, a mean of 1.6mm with a maximum of 3mm open bite reduction in a period of 6 months was accomplished. It was difficult to compare the changes in overbite between the two studies since lack of overbite was only one of the possible criteria for patient selection in the VHA study while it was essential to be included in the present study. There was also a minimal extrusion of the lower first molar (0.4mm) and the lower first incisor (0.6mm) in relation to the mandibular plane as well as 1˚ increase in the inclination of the lower central incisor.

Difference between the outcome of this study and that of Deberardinis et al (2000) might be due to the difference in the criteria of patient selection whether in relation to the age factor or the presence of lack of overbite, though the VHA study concluded the possibility of the VHA to control the anterior vertical dimensions. Considering the soft tissue changes, minimal improvement in the facial profile was achieved utilizing the chosen treatment mechanics as evident from the clinical findings, as well as the statistically insignificant change of the facial profile angle.

Conclusions:

The following conclusions were drawn:
1. The appliance was able to induce forward and upward mandibular rotation as evident from the statistically significant the increase in the facial axis angle (PtGn/NBa).
2. The appliance was able to induce bite closure, as confirmed by the significant increase in the overbite.
3. Extrusion of the lower first molar occurred, as revealed from the significant increase in the L6- mandibular plane reading.
4. The soft tissue profile was improved clinically, despite that no statistically significant improvement was achieved in the soft tissue profile angle (N’Sn Pog˚).

References


Appendix:

Case history chart

<table>
<thead>
<tr>
<th>Name: ___________________________</th>
<th>Age: ……y…..m</th>
<th>Sex: ______________</th>
<th>Date of birth: ……/…../……..</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phone number: ___________________</td>
<td>Date: ……/…../……..</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Chief complaint: __________________________________________________________

Are you in a good health? ........................................
Do you receive any regular medications? .......... If so, for what condition? ........
Do you bleed excessively if cut? ........................................................................
Are you sensitive to Penicillin, Sulpha, aspirin, or any other drug? ............
Have you ever been hospitalized? If so, for what condition? ..........................
Have you had any of the following?

- Asthma ................................................................
- Abnormal blood pressure ................................
- Anaemia ......................................................
- Arthritis ......................................................
- Diabetes Mellitus ........................................

Asthma…………………………………        Heart problem……………………
Abnormal blood pressure………………        Hepatitis…………………………
Anaemia.……………………………….        Thyroid problems………………
Arthritis.……………………………….        Epilepsy…………………………
Diabetes Mellitus.………………………….        Rheumatic fever………………

Any other health condition? ................................

Have you ever received any orthodontic treatment before? .........................

Have you had any dental treatment before……with/without local anaesthesia? ....

Have you had any facial trauma? ......................................................................

Have you ever had any oral habits e.g. thumb sucking, nail biting, clenching, mouth breathing? ..........................................................

How often do you brush your teeth? ..............................................................

Clinical examination chart

Frontal facial analysis:

- Facial type: Mesocephalic Dolicocephalic Brachycephalic
- Lower facial height: Normal Increased Decreased
- Reflex of nares: Normal No reflex
- Lips: Competent Incompetent
- Mentalis muscle: Normal Hyperactive Hypoactive
- Teeth show: …mm at rest …mm at smile
- Smile arch: Normal Reversed Accentuated

Facial profile analysis:

- Profile: Straight Convex Concave
- Nasolabial angle: Normal Acute Obtuse
- Upper lip: Normal Protruded Retruded
- Lower lip: Normal Protruded Retruded
- Mentolabial sulcus: Acute Observe(flat) Acute(deepend)
- Chin button: Orthognathic Prognathic Retrognathic
- Mandibular plane inclination: Normal Steep (high angle) Flat (low angle)
- Antgonial notch: Normal Accentuated Flat

Intraoral examination:

- Oral hygiene: Good Fair Poor
- Tongue: Normal Large(scalloped border)
- Dentition: Deciduous Mixed Permanent
- Teeth present in oral cavity: ___________________________
- Molar relation: Class I Class II Class III
- Canine relation: Class I Class II Class III
- Anterior overbite: Normal Deep….mm Open ….mm