EGYPTIAN
DENTAL JOURNAL
www.eda-egypt.org

Vol. 68, 1999:2007, July, 2022

Print ISSN 0070-9484 • Online ISSN 2090-2360

Orthodontics, Pediatric and Preventive Dentistry

Submit Date : 12-12-2022 • Accept Date : 24-04-2022 • Available online: 30-06-2022 • DOI : 10.21608/edj.2022.110796.1905

MAXILLARY MOLAR INTRUSION USING MODIFIED VERTICAL HOLDING APPLIANCE VERSUS MINISCREW-SUPPORTED APPLIANCE IN GROWING CHILDREN WITH SKELETAL OPEN BITE: A RETROSPECTIVE STUDY

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ABSTRACT

Introduction: Skeletal open bite is a condition characteristic of and resulting from backward-rotating mandibular growth patterns. The molars over erupt, causing further rotation of the mandible away from the maxilla and swinging of the chin downward and backwards. Many appliances for molar intrusion have been proposed in the literature including vertical holding appliances and miniscrew- supported intrusion appliances.

Aim: To compare the amount of maxillary molar intrusion and mandibular plane autorotation induced after using a modified vertical holding appliance (MVHA) versus a miniscrew-supported appliance in a group of children with skeletal open bite.

Materials and Methods: The CBCTs of 20 growing female patients with skeletal open bites were collected and analyzed. Half of the patients were treated with modified vertical holding appliance and the other half received a miniscrew-supported appliance (MSA) for maxillary molar intrusion.

Results: Significant maxillary molar intrusion was achieved in the MVHA group (1.2mm) as well as in the MSA group (1.8mm). Areduction in the mandibular plane inclination was acheived in both groups.(MVHA 2.5 degrees - MSA 2.8 degrees).

Conclusion: Both groups were equally effeective in inducing skeletal open bite closure through comparable amounts of maxillary molar intrusion.

KEYWORDS: Intrusion, skeletal open bite, miniscrew

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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.[1]

Skeletal open bite is a condition characteristic of and resulting from backward-rotating mandibular growth patterns. The molars over erupt, 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.[2]

Open-bite malocclusions with skeletal components were also difficult to treat because of their high relapse tendencies. Patients with skeletal open bites often exhibit vertical skeletal-growth discrepancies, abnormal muscular and soft-tissue development, or habits that cause unfavorable tongue and orofacial muscle activity. [3]

Treatment options for skeletal 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. Compromised stability and esthetics are considered the main drawbacks of incisor extrusion in these patients. So, the most appropriate treatment for skeletal open bite is to intrude the molars.

Some of the proposed methods for molar intrusion in growing patients are high-pull headgear[4] 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)[5] which uses repelling magnets embedded in acrylic to produce an additional posterior occlusal force and posterior bite planes. Moreover, functional appliances which are specifically designed and fabricated with posterior bite blocks to accomplish posterior segment intrusion may be used.[6] 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.[7] Hence, this study was designed to compare the significance of change after using one of these passive appliances which was the modified vertical holding appliance and one of the active systems which was the miniscrew supported appliance.

SUBJECTS AND METHODS

SUBJECTS

The sample for this retrospective study comprised 20 females equally divided into two groups; the first group was treated with vertical holding appliance and the other group was treated with miniscrew-supported appliance for a period of 9 months. The cases were selected from the records of the Orthodontic Department at Cairo University.

All subjects were growing patients (CVMI stage 2-3) with age range of 8-12 years. Only those subjects manifesting the following criteria were included in the study: A skeletal open bite indicated for buccal segment intrusion, fully erupted right, and left maxillary first molars, and no previous orthodontic treatment.

Patients having a history of any systemic disease, craniofacial syndrome or congenital abnormalities, any habits that would antagonize or hinder closure of the open bite such as thumb sucking and those who had active periodontal diseases were excluded from the study.

METHODS

Appliance design

The modified vertical holding appliance was 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 extended 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. An acrylic button of a uniform diameter (17mm) and thickness was 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 (fig. 1).

Fig. (1) The MVH appliance in the patient mouth.

The miniscrew supported appliance consisted of 4 miniscrews which were immediately loaded with an intrusive force of 75g on each side (buccal and palatal) through closed NiTi coil springs. The buccal screw of the appropriate size (absoanchor SH 1615-07) was self-drilled into the cortical bone of the right and left infra-zygomatic crests, while the palatal screw of the appropriate size (absoanchor LH 13-07) self-drilled midway between the cervical margin and median palatine raphae corono- apically as shown in fig. (2).

Three-Dimensional Computed Tomography analysis

Cone beam computed tomographic scans were taken before start of the treatment and after 9 months of treatment. The images taken were imported in DICOM format (Digital imaging and communications in medicine) and processed into volumetric images using Anatomage image processing software version 5.2, multiplanar sagittal, coronal and axial projections were generated. Craniofacial selected points were identified three dimensionally, Lines and planes were constructed, and selected linear and angular measurements were computed and recorded.

The planes and line used in these measurements

- **SN plane:** plane formed between S point and point N.

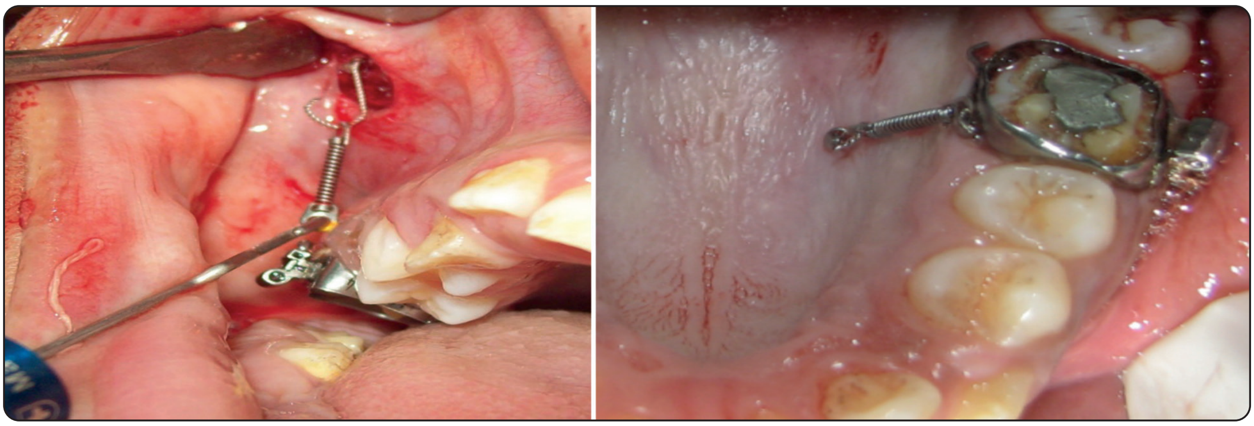

Fig. (2): The loaded buccal and palatal miniscrews.

- **Maxillary plane (PP):** plane formed between anterior nasal spine, right posterior nasal spine, and left posterior nasal spine.
- **Mandibular Plane (MP):** plane formed between right Gonion (Go R), left Gonion (Go L) and Menton (Me).

Definitions of the included measurements in the study are presented in (table 1) and figure (3).

Statistical Analysis

Data were presented as mean, and standard error values. Paired t-test was used to study the changes after treatment within each group. Chi square test was used for comparing between percentage changes in measurements of the two groups. The method error was assessed by randomly selecting ten patients' Dicom files from the two study groups; these were digitized by the same examiner a second time 1 week after the first evaluation. The same variables were measured by a different researcher.

RESULTS

Method error coefficients for all measurements were calculated (kappa test) and were within acceptable limits (ranged between 0.672 – 0.916 for inter-observer and 0.894 - 0.986 for intra-observer measurements).

Regarding the modified vertical holding appliance (MVHA); there were statistical significant increase in ANS-Me at P≤ 0.030, N-Me at P ≤ 0.018, and L6-MP at P≤ 0.001, while there were statistical significant decrease in SN/MP at P≤ 0.032, U6-PP at P≤ 0.001, and Is-Li at P≤ 0.007. No statistical significant change was found regarding, N-ANS/ANS-Me, S-Go, S-Go/N-Me, PP/MP, SN/PP, and N' Sn Pog' at P ≥0.1; as shown in table 2, fig.4.

Regarding the miniscrew supported appliance (MSA); there were statistical significant increase in N-ANS/ANS-Me at P≤ 0.002, S-Go/N-Me at P≤ 0.030, and L6-MP at P≤ 0.041, while there

TABLE (1): Measurements used in the study.

Variable	Definition
N-ANS (mm)	The linear distance between point N and point ANS, measuring the upper anterior facial height.
ANS-Me(mm)	The linear distance between point ANS and point Me, measuring the lower anterior facial height.
N-ANS/ANS-Me	The ratio between the upper anterior facial height and the lower anterior facial height.
AFH (mm)	The linear distance between point N and point Me, measuring the anterior facial height.
PFH (mm)	The linear distance between point S and point InGo, measuring the posterior facial height.
Jarabak ratio (S-Go/ N-Me)	The ratio between the posterior facial height and the anterior facial height.
PP/SN°	The angle between the line S-N and palatal lines, measuring the palatal plane tipping relative to the cranium.
MP/SN°	The angle between the line S-N and the mandibular plane, measuring the mandibular base tipping relative to the cranium.
PP/MP°	The angle between the line Palatal line and mandibular plane, measuring the palatal plane tipping relative to the mandibular plan.
U6-PL(mm)	The linear distance between U6 furcation and palatal line(measurement was taken average between right and left).
L6-MP(mm)	The linear distance between L6 furcation and mandibular plane. (Measurement was taken average between right and left).
Is-Ii(mm)	Linear distance between incisor superius and incisor inferius denoting the presence of open bite.
N' Sn Pog'°	The angle between soft tissue nasion, sub-nasale point , and soft tissue pogonion.

were statistical significant decrease in ANS-Me at P≤ 0.002, N-Me at P≤ 0.001, SN/MP at P≤ 0.006, PP/MP at P≤ 0.019, U6-PP at P≤0.001, and Is-Li at P≤0.008. No statistical significant change was found regarding, S-Go, SN/PP, and N' Sn Pog' at P ≥0.02; as shown in table (2), figure (4) .

Performing Chi square test for testing the significance between the two groups, it was revealed that there was no significant difference between both groups as P-value > 0.05 for all measurements, as listed in table (2), figure (4).

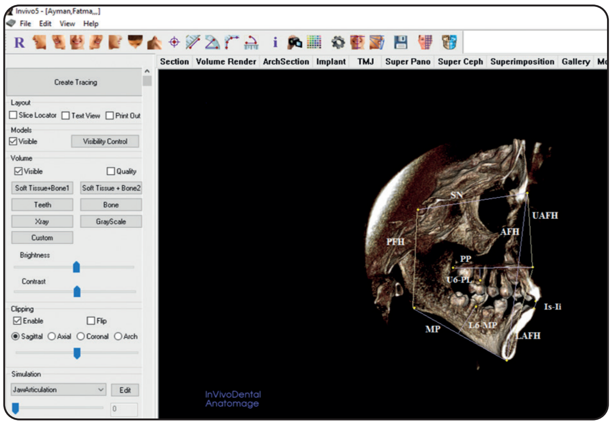

fig. (3): Measurements used in the study presented on 3D volume of the skull.

TABLE (2): Comparison of skeletal, dental and soft tissue measurements (Mean±SE) in vertical holding device (MVHA) group and miniscrew supported appliance (MSA) group.

Variable	MVHA Group						MSA Group						*P*-value
	Pre-treatment		Post-Treatment		M change %	*P*-value	Pre-treatment		Post-Treatment		M change %	*P*-value	
	M	SE	M	SE			M	SE	M	SE			
N-ANS	51	1.2	52.1	1.4	**2.16 %**	0.027*	48.1	2.8	49	3	**1.87 %**	0.024*	**0.9661 (ns)**
ANS-Me	71.8	1.7	72.9	1.5	**1.53 %**	0.030*	69.8	2.3	67.6	2.2	**-3.15 %**	0.002*	**0.8214 (ns)**
N-ANS/ ANS-Me	0.7	0.03	0.7	0.02	**0.00 %**	0.300	0.69	0.02	0.71	0.02	**2.90 %**	0.002*	**0.8252 (ns)**
S-Go	70.2	1.2	71.4	1.4	**1.71 %**	0.111	72.8	2.6	73.8	2.2	**1.37 %**	0.289	**0.9546 (ns)**
N-Me	123.7	2.3	126.0	2.1	**1.86 %**	0.018*	121.4	2.9	118.8	2.9	**-2.14 %**	<0.001*	**0.9671 (ns)**
S-Go/N-Me	0.6	0.008	0.6	0.008	**0.00 %**	0.922	0.60	0.02	0.62	0.01	**3.33 %**	0.030*	**0.1113 (ns)**
SN/MP	47.8	1.5	45.3	1.1	**-3.41 %**	0.032*	49.4	2.8	46.7	3	**-5.27 %**	0.006*	**0.5916 (ns)**
PP/MP	40.0	1.7	37.9	1.0	**-5.25 %**	0.061	38.2	2.4	35.3	2.3	**-7.59 %**	0.019*	**0.8440 (ns)**
SN/PP	8.0	1.0	8.0	1.0	**0.00 %**	1.000	6.3	1.1	6.3	1.2	**0.00 %**	0.963	**Absolut insignificance**
U6 - PP	12.5	0.7	11.3	0.6	**-9.60 %**	0.001***	11.7	1.4	9.9	1.2	**-15.38 %**	0.001*	**0.7185 (ns)**
L6 - MP	18.8	0.8	20	0.8	**6.38 %**	0.001***	17	0.6	17.4	0.6	**2.35 %**	0.041*	**0.6843 (ns)**
Ls-li	6	0.9	3.5	0.8	**-30 %**	0.007**	7.4	0.7	4.7	2.6	**% -25.39**	0.008*	**0.8318 (ns)**
N' Sn Pog'	164.4	0.6	164.5	0.6	**-0.0 %**	0.872	161.1	0.8	161.8	0.7	**0.43 %**	0.140	**0.8482 (ns)**

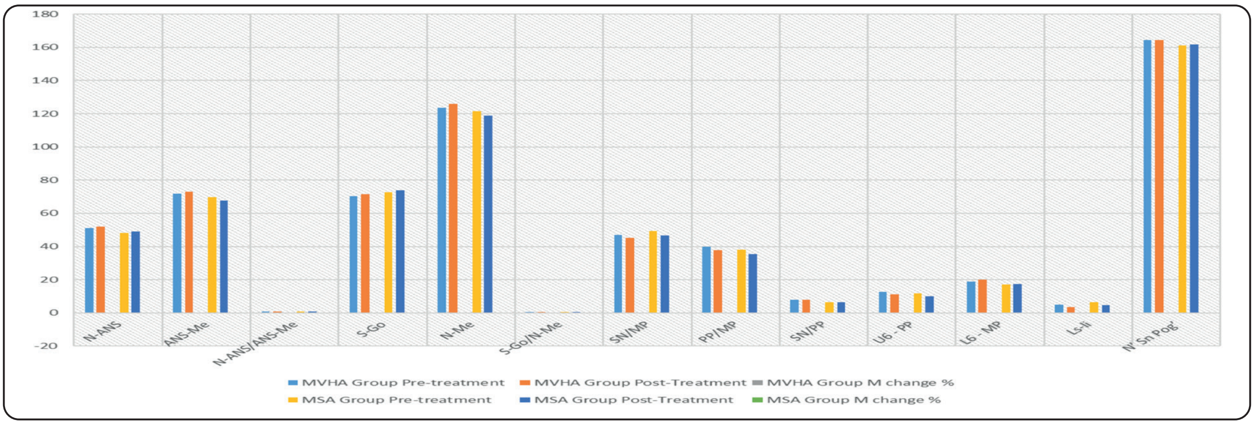

Fig. (4): Bar Chart revealing comparison of skeletal, dental and soft tissue measurements in vertical holding device (MVHA) group and miniscrew supported appliance (MSA) group

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.[1,2,3]

Despite that, such vertical skeletal dysplasias have not been frequently tackled among the wide diversity of the orthodontic literature. Although, it's well proven that vertical discrepancies must be solved before anteroposterior ones, the treatment of the skeletal anteroposterior dysplasias continued to gain more rapport over their vertical counterparts. Hence, was our trigger to explore into the already available treatment options, and to attempt to test the efficiency of more recent alternatives.[3,4]

Reviewing the literature, many treatment modalities were reported by Firouz et al. (1992)[4] , Dellinger (1986)[5] , Defraia et al. (2007)[6] , Baccetti et al. (2008)[7], Barbre et al. (1991)[8] , Deberardinis et al. (2000)[9] , Barbosa et al. (2005)[10], Cozza et al.(2007)[11], and Guitini et al.(2008)[12] whereby successful molar intrusion was achieved in an attempt to correct the skeletal open bite. The maximum amount of true molar intrusion achieved was found to be 0.96±0.54mm through wearing the high pull head gear appliance as reported in a systematic review by **Ng et al. (2006)**[13], and approximately 2-4 mm using skeletal anchorage with better results in the maxilla than mandible.[14-17] Moreover, the Mandibular counterclockwise rotation was found to be between 2.3° and 3.9° as reported in a systematic review of **Alsafadi et al. (2016).**[18]

Regarding the optimum force for intrusion, **Burstone (1977)**[2]**,** suggested 20g of force for intruding anterior teeth. While, for molar intrusion, **Mikako et al. (1999)**[19]**,** recommended an initial force of 50g. **Karla et al (1989),**[20] suggested about 90g per tooth for molar intrusion in growing children, and **Melsen and Fiorelli (1996)**[21]**,** used about 50g buccolingually to intrude maxillary molars in adult patients. **Park et al (2003)**[22]**,** advocated the application of 200-300g of intrusive force on maxillary posterior teeth with 3 roots.

The modified vertical holding appliance used in this retrospective study was a modification of the vertical holding appliance introduced by **Deberardinis et al (2000)**[9] who modified the transpalatal arch in an attempt to control the vertical dimension of high-angle patients. The acrylic button of the modified vertical holding appliance was placed 6mm away from the palate to allow pressure from the tongue to act as an intrusive force as **Chiba et al. (2003)**[3] found that the maximum tongue pressure was obtained at a distance of 6 mm from the palatal mucosa. The acrylic button 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 delivering uniform pressure.

The results of this study revealed that both the modified vertical holding appliance and the miniscrews supported appliance could be successfully used in growing subjects to treat open bite malocclusion. Statistical evaluation of the treatment changes revealed a significant amount of maxillary first molar intrusion (≈ 1.2mm) was accomplished in the MVHA group, and (≈ 1.8mm) was obtained in MSA.

An open bite reduction was obtained by average 2.5 mm in MVHA group and 2.7 mm in the MSA group a period of 9 months. Mandibular counterclockwise autorotation was also clearly demonstrated through the significant decrease in the inclination of mandibular plane to anterior cranial base angle (SN/MP) in the MVHA group and MSA group with an average 2.5˚ and 2.8˚ respectively which was in accordance with other studies presented in a review of **Alsafadi et al.(2016)**

Although a statistically significant increase in N-ANS/ANS-Me, S-Go/N-Me, and decrease in the ANS-Me, N-Me, and PP/MP was revealed in the miniscrews supported appliance group only, there was insignificant difference between both groups as P-value > 0.05 for all measurements.

Greater amounts of open bite closure and molar intrusion were reported in other studies. The wide diversity in the applied treatment mechanics and the degree of the pretreatment vertical skeletal discrepancy could be accused for the yielded variability between the results of the present study and that of other studies. A rate of 0.5-1 mm molar intrusion per month was reported by **Park et al. (2003)**[22]. **Kuroda et al. (2004)**[23], reported maxillary first molar intrusion of 3mm and bite closure of 9 mm. This discrepancy in amount of molar intrusion achieved could be related to the application of intrusive mechanics for both upper and lower molars (3mm each) in the previous study in contrast to the current study where intrusive forces where restricted to the maxillary molars only.

Analyzing the findings reported by **Park et al. (2004)**[24]**,** more than 3 mm open bite reduction, could be mainly attributed not only to maxillary posterior teeth intrusion, but to the forward movement of the mandibular posterior teeth as well, which resulted in the movement of the fulcrum forward and consequently allowed a better chance for manbibular autorotation and hence closure of the bite. In addition, **Erverdi et al. (2006)**[25]**,** presented a case where maxillary molars were impacted 3.6mm using zygomatic anchorage in a period of 5-6 months. However, the appliance design used in such former study consisted of two acrylic bite blocks for controlling the whole posterior segment and to which an intrusive force of 400g is applied via two 9-mm NiTi coil springs attached to the zygomatic miniscrews. Such mechanics created doubt about the achieved treatment results, whether being due to the intrusive effect of the miniscrews or that of the bite blocks.

Another study by **Park et al. (2006)**[26]**,** reported a 3mm closure of anterior open bite in a period of 11 months. However, the application of upper and lower posterior segment intrusive forces as well as the distal movement of the mandibular anterior teeth are suggested responsible for the difference in the treatment outcome between this study and the present one.

Other recent studies by **Akan et al. (2013)** [15] who achieved a maxillary molar intrusion of 3.37 ± 1.21 mm was obtained with a force of 400 g in an average period of 6.84 ± 1.64 months through using zygomatic anchorage for molar intrusion, and in the study of **Scheffler et al. (2014)**[16], the molar intrusion obtained was 2.3 mm through using a maxillary occlusal splint and nickel-titanium coil springs to temporary anchorage devices in the zygomatic buttress area, buccal and apical to the maxillary molars.

In a most recent study, **Cerruto et al. (2018)**[27] and **Greco et al. (2021)**[28] used the modified VHA to treat the skeletal open bite, they found after superimposing the final x-rays on the initial x ray a very good vertical control of the maxilla associated with autorotation of the mandible that was revealed in the decrease of FMA by 3°. They proved that the VHA was effective for controlling the vertical growth of the maxilla. During the treatment some extrusion of the lower molars still occurred, but it was compensated by the remarkable growth of the mandibular ramus, which was in agreement to our study.

The following conclusions were drawn:

1. Both appliances were able to induce open bite closure, as confirmed by the significant molar intrusion.
2. Both modified vertical holding appliance and the miniscrew supported appliance were able to induce forward and upward mandibular rotation.

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