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Evaluation of Buccal Miniscrew with Transpalatal Arch versus Vertical Holding Appliance for Maxillary Molar Intrusion in Young Adults: A Randomized Controlled Trial

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ABSTRACT

Aim of the study: To evaluate the vertical dimension change through the amount of molar intrusion after using modified vertical holding appliance (VHA) versus miniscrew.

Subjects and methods: A sample of thirty six patients (32 females and 4 males) that presented with extruded upper molars and/or anterior open bite with age ranged from 17.6-26.4 years Group (1) VHA with mini screw (VHAMS) 12 patients (11 females and 1 male) , Group (2) molar intrusion with miniscrew only 12 patients (11 females and 1 male) , and Group (3) VHA without miniscrew 12 patients (10 females and 2 males), Lateral cephalometric X-ray view were taken before intrusion (T1), six months after the application of upper molar intrusive mechanics (T2) and six months after comprehensive orthodontic treatment (T3).

Results: Significant increase in SNB, overbite in groups 1and 2, while there was a significant decrease in the angle of convexity, SN-MP, FMPA, LAFH, overjet, and open bite in groups 1 and 2, indicating improvement of the open bite and facial profile.

Conclusion: Vertical Holding Appliances (VHA) and miniscrew-assisted intrusion can be effective in treating open bites or over-erupted maxillary molars. However, miniscrew-assisted intrusion often offers better control and predictability, leading to superior outcomes, particularly in cases of severe open bites.

Keywords: *Molar intrusion; vertical holding appliance; miniscrew; and openbite*

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1. INTRODUCTION

The dental open bite may be caused by mechanical interference, whereas the skeletal OB is caused by a tendency to breathe through the mouth.[4–6]

A mandible that rotates backward and downward during growth is common in patients with an increased lower anterior face height (LAFH) for several reasons, such as excessive alveolar growth, tooth extrusion, lack of ramus growth, or inadequate vertical condylar growth.[7–9]

One of the most difficult orthodontic mechanical maneuvers is tooth intrusion, which requires effective anchoring to be successful. When a tooth has extruded, this action is usually necessary, particularly if the opposing teeth are absent. Among other things, extrusion may cause occlusal interferences and ensuing functional problems.[10–12]

Molar intrusion followed by posterior vertical control can be achieved by many methods such as high-pull, facebow headgear, The amount of molar intrusion should be assessed in non-growing patient to clarify the actual effect of molar intrusive mechanics,[13–16]

In growing patients, a modified transpalatal arch (TPA) called vertical holding appliance (VHA) was used to control the vertical movement of molars.[17,18]It is possible to get effective outcomes of AOB treatment in non-growing patients and adults by intruding molar teeth with temporary anchorage devices (TADs) and producing a positive overbite on the incisors, followed by decreases in AFH. [19–22]

The possibility of molar intrusion via TADs causing a counterclockwise autorotation of the mandible was dismissed due to a lack of evidence, Post-retention relapse in both molars nearly10 to 30% of the time occur, so, the outcome of open bite treatment in adult patients using TADs may be deemed unstable. Even with various retention strategies and regimens,[20,23,24]

The effects of skeletal anchoring devices on molars to close AOB have been studied in certain reviews[19,22–24] but the comparison between the VHA and TADs has not been done, in addition the fact there is still disagreement regarding the best technique for performing molar intrusion to use during treatment of AOB.

What happens if intrusion is assisted by the myofunctional effect of tongue pressure during swallowing? Can it add another level of promising effect in molar intrusion during treatment of AOB; Hence, this study was directed to compare the amount and efficacy of molar intrusion for the closure of an anterior open bite.

2. SUBJECTS AND METHODS

Sample size calculation

Sample size calculation using G Power software was based on the observed effect sizes derived from previous articles[25,26], the calculation indicated that for a study with a power of 0.95 and an alpha of 0.05, a total of at least 36 patients (12 patients in each group) to guarantee for patients withdraw and drop out, the initial sample of forty two patients (32 females and 10 males) presented with extruded upper molars and/or anterior open bite with mean age 22.4 years (range: 17.6-26.4 years) were distributed to three equal groups, all patients had underwent in the randomization process, (Fig.1)

Group (1) VHA with mini screw (VHAMS), 14 patients (11 females and 3 males) , Group (2) maxillary molar intrusion with miniscrew and transpalatal arch (TPA), (MSTPA), 14 patients (11 females and 3 males) , and Group (3) VHA without miniscrew (VHA),14 patients (10 females and 4 males), Lateral cephalometric X-ray view were taken before intrusion (T1), six months after the application of intrusive mechanics (T2).

A final sample of thirty six patients (32 females and 4 males) after exclusion of dropout,(withdrawal or discontinued) were analysed, Group (1) VHA with mini screw (VHAMS) 12 patients (11 females and 1 male) , Group (2) miniscrew with TPA (MSTPA) only 12 patients (11 females and 1 male) , and Group (3) VHA without miniscrew (VHA) 12 patients (10 females and 2 males),

Study design

Patients were randomized equally to three groups in a single-center, double-blind, parallel-arm clinical trial; assessors and data analysts were also blinded to allocation. The study was registered on ClinicalTrials.gov with registration number:

NCT05433051

Ethical approval

This study has received approval from the Ethical Committee of Faculty of Dental Medicine (Boys), Al-Azhar University, Cairo, Egypt, with license code EC Ref. No: (807/220)

Eligibility criteria for participants

- **Inclusion criteria:-** [27]

Patients suffering from class I or II with AOB ranged between -3 up to -6 mm assessed from cephalometry, increased Maxillary Posterior dentoalveolar height, age range: 17-26 years. Patients with good oral hygiene and general health, no previous orthodontic treatment.

- **Exclusion criteria:-**

Dental open bite, FMA less than 30 degrees or SN-MP less than 40 degrees, tongue tie, extracted or short occluso-gingival height of maxillary permanent first or second molars, craniofacial syndrome, high gag reflex, temporomandibular disorder (TMD), and joint degenerative disease.

- **Patient age and treatment time:-**

The mean treatment duration was 21.8 months (range: 17–30 months), and the starting mean age was 22.4 years (range: 17.6-26.4 years).

- **Consent form**

The study's methods and results were sufficiently explained to all patients, parents, and guardians, including the potential for unsuccessful intrusion, the possibility of relapse, miniscrew failure, and root resorption. A signed study informed consent form was used.

- **Randomization (random number generation, allocation concealment, implementation)**

A random sequence table was generated using the online tool GraphPad, employing block randomization to ensure a **1:1:1 allocation ratio**. Allocation concealment was maintained through the use of opaque, tightly sealed envelopes. Due to the nature of the investigation, blinding of the operator and participants was not feasible. However, **the statistician and the outcome assessors were blinded** to group allocation to minimize assessment bias.

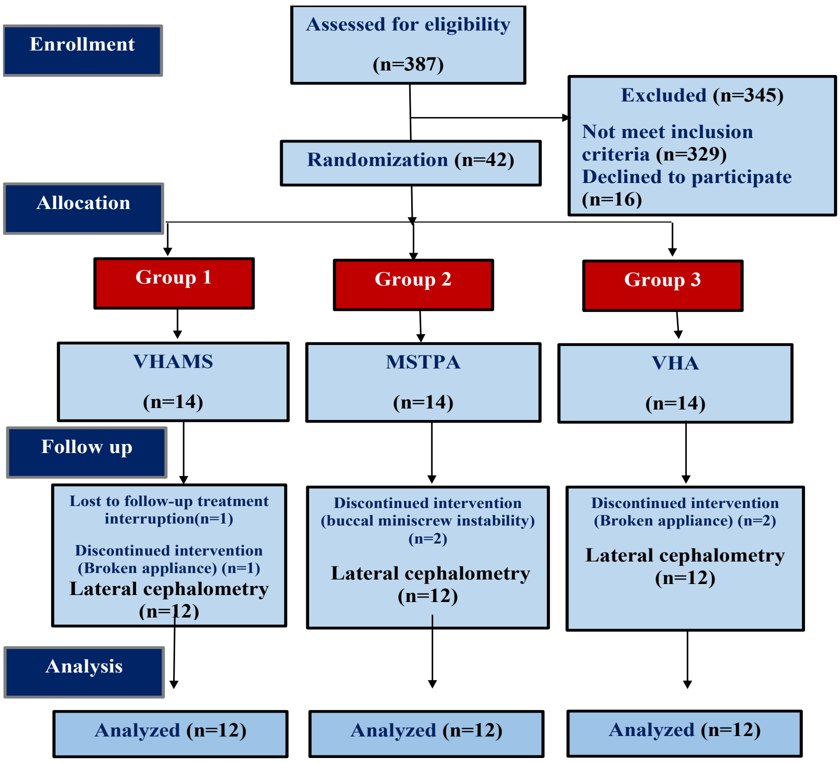

Figure (1): Consolidated Standards of Reporting Trials (CONSORT) flow chart.

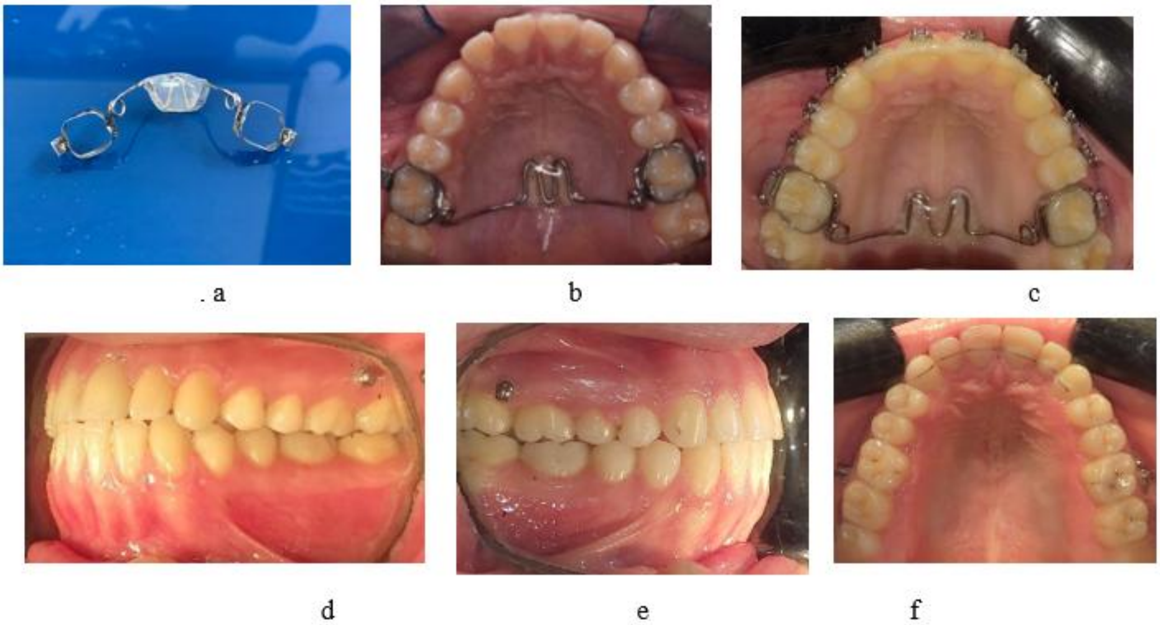

Figure (2):(a,b and c)Vertical holding appliance and (d,e and f) mini-screws supported vacuum retainer

And fixed retainer in place after 6 months of treatment .

- **Appliance fabrication**

The VHA comprised bands on the maxillary permanent first molars, joined by a 0.040-inch stainless steel wire that was laser welded for optimal strength and precision. Two helices were incorporated into the wire, enhancing its flexibility, while an acrylic button was centrally positioned, maintaining a clearance of 4–6 mm from the palatal mucosa to facilitate intrusive movements and prevent soft tissue injury, thereby minimizing the requirement for frequent adjustments or replacements. . Fabrication of all appliances was standardized by utilizing a single laboratory technician throughout the study. For both VHA and TPA, glass ionomer cement (Ketac Cem; 3M ESPE, Seefeld, Germany) was employed for luting, owing to its favorable properties, including biocompatibility and effective adhesion to maxillary posterior teeth. (Fig.2)

- **Interventions for each group**

<u>Clinical procedures and Activation protocol:</u>

Prior to initiating intrusion mechanics, the mandibular arch was leveled using until it reached a heavy holding rectangular 0.019 × 0.025-in stainless steel archwire to prevent excessive eruption of the lower molars. Bilateral miniscrews measuring 1.6 × 8 mm were inserted buccally between the maxillary first and second permanent molars, with attention to optimal angulation for increased cortical anchorage. Following administration of local anesthesia and mucosal antisepsis, miniscrews were placed using a screwdriver under continuous saline irrigation. An intrusive force was subsequently applied to the designated teeth via a power chain. (Fig.2)

The intrusive force in molars used in groups 1 and 2 was approximately 100-150 g [28]While in group 3, it was difficult to encounter. Upon completion of intrusion, upper molars were ligated using continuous MBT brackets with a 0.022-in slot, secured to the miniscrew with 0.011-in stainless steel ligature wire. [29]Except in the case of group 3, which was aided by repeated tongue tip exercise and molar posterior bite raiser to prevent extrusion.

Regular reinforcement of oral hygiene practices and professional scaling has been shown to reduce the incidence of miniscrew failure and prevent food stagnation, thereby minimizing palatal tissue irritation.

Lateral cephalometric radiographs were taken before intrusion (T1), six months after the application of upper molar intrusive mechanics (T2) and six months after comprehensive orthodontic treatment (T3).

- **Measurements and landmarks**:

1- **Cephalometric measurements**

WebCeph™ (South Korea) software was used to perform cephalometric measurements (Fig. 3), comprising 12 linear measurements (Table 1) and 8 angular measurements (Table 2).

Figure (3): Pre intrusion Lateral cephalometry

Table (1): The linear cephalometric measurements.

Overbite	Vertical overlap of maxillary incisor to lower incisor
Overjet	Horizontal distance from Labial surface of lower incisor to palatal surface of maxillary incisor
Wits appraisal	Horizontal distance between perpendicular from point A and B on functional occlusal plane that bisecting posterior occlusion
Anterior face height (AFH)	Vertical distance between Nasion and Menton
Posterior face height (PFH)	Vertical distance between Sella and Gonion
Lower anterior face height (LAFH)	Vertical distance between Anterior nasal spine and Menton
Upper anterior dental height (UADH)	Vertical perpendicular distance between incisal edge of maxillary incisor and palatal plane
Upper posterior dental height (UPDH)	Vertical perpendicular distance between mesiobuccal cusp tip of maxillary permeant first molar and palatal plane
Lower incisor- mandibular plane (L1-MP)	Vertical perpendicular distance between incisal edge of lower incisor and mandibular plane
Upper lip - E line (ULE)	Horizontal distance between upper lip and Esthetic line (soft tissue line connecting pronasale and pogonion)
Lower lip – E line (LLE)	Horizontal distance between lower lip and Esthetic line (soft tissue line connecting pronasale and pogonion)

Table (2): The angular cephalometric measurements.

SNA	The maxillary base anteroposterior position to the anterior cranial base
SNB	The angle between the points S, N, and B
ANB	The angle between the points A, N, and B
Angle of convexity	The angle between line Nasion-A and Pogonion- A
Mandibular plane (MP)- SN	The angle between the line S-N and the mandibular plane
Mandibular plane - Frankfurt plane (FMPA)	The angle between the Frankfurt horizontal plane and the mandibular plane
Mandibular plane (MP)- palatal plane (PP)	The angle between the palatal plane and the mandibular plane
Upper incisor with palatal plane (UI-PP)	The angle between the maxillary incisor and the palatal plane
N' Sn Pog'	The angle between soft tissue nasion, sub-nasale point , and soft tissue pogonion

The method error:

After three weeks, all cephalometric measurements were performed again by the same examiner, and the technique error was determined using Concordance Correlation Coefficients. (table 6 and 7).

Statistical analysis:

To ascertain whether the data was normal, the Kolmogorov-Smirnov test was used. For data with a normal distribution, parametric statistics (analysis of variance, Student-Newman-Keuls post hoc test for independent samples, comparing the mean , and t-test for pairs) were used; if the distribution was non-normal, non-parametric tests (Kruskal-Wallis with Mann-Whitney post hoc test with, Bonferroni correction for independent samples, and Wilcoxon test for paired samples) were used, comparing the distribution. The relationship between pre and post measures (ΔT2-T1) was investigated using Spearman correlation. Changes in dentoskeletal parameters that set the groups apart were found using discriminant analysis.

Pearson chi-square test was conducted in order to verify the gender distribution. Because there were few samples, the genders were compared with Mann Whitney U regarding changes. The data was merged because no gender variation was noticed ($p > 0.05$).

3. RESULTS

I-Demographic data

Age and treatment time: The starting mean age was 22.4 years (range: 17.6-26.4 years),(Table 3 - Fig.4) and the mean treatment duration (Table 4 - Fig.5)was 21.8 months (range: 17–30 months), There was no significant difference in age between groups (p=0.23),

Table (3) Descriptive statistics and comparison of age among groups (ANOVA test)

Age	Mean	SD	Min	Max	P value
VHAMS	22.4	1.03	17.60	26.40	0.230 ns
MSTPA	22.8	1.44	18.70	25.40	
VHA	21.9	.95	18.10	26.10	

Significance level p≤0.05, ns=non-significant

(VHA) vertical holding appliance,(VHAMS) VHA with mini screw , (MSTPA) miniscrew with trans palatal arch , (SD) standard deviation,(Min) minimum, (Max)maximum, and (P) probability.

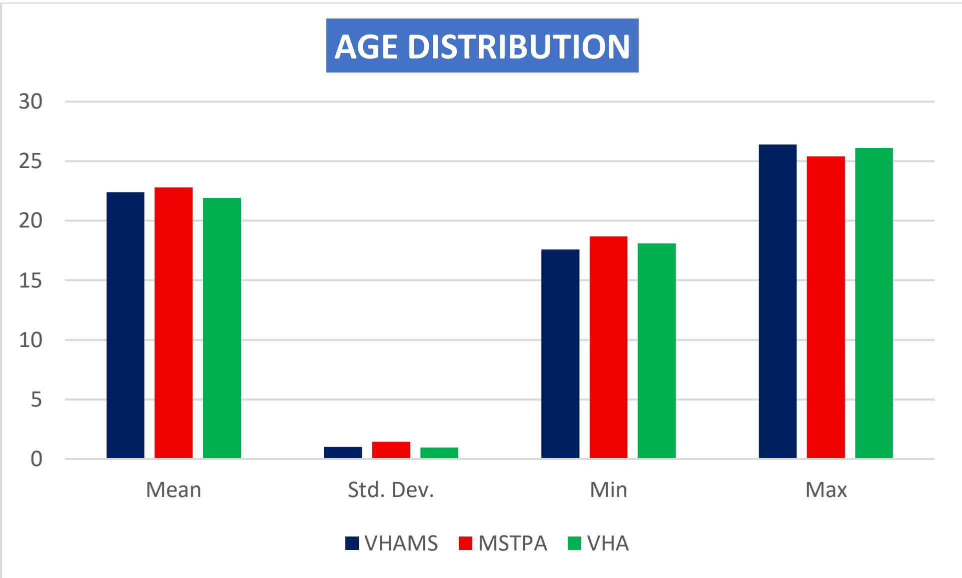

Figure (4): Bar chart for age distribution

Table (4) Descriptive statistics and comparison of the treatment duration among groups (ANOVA test)

Treatment duration	Mean	SD	Min	Max	P value
VHAMS	21.8	3.2	17	30	0.312 ns
MSTPA	21.2	2.9	17.3	29.3	
VHA	22.3	3.9	18.1	30	

Significance level p≤0.05, ns=non-significant

(VHA) vertical holding appliance,(VHAMS) VHA with mini screw , (MSTPA) miniscrew with trans palatal arch , (SD) standard deviation,(Min) minimum, (Max)maximum, and (P) probability.

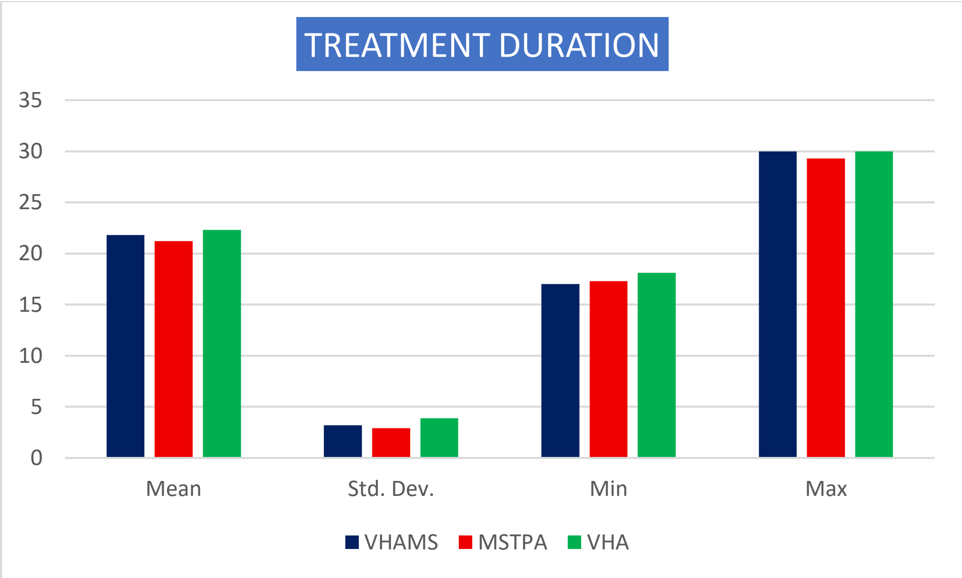

Figure (5): Bar chart for treatment duration

Malocclusion: In group 1,2 and 3, 75% of cases were class 1, in comparison to 25% class 2 cases ; with no significant difference between groups (p=0.842), (Table 2, Fig.6)

Table (5) Distribution of cases according to type of malocclusion

MALOCCLUSION	Groups			
	VHAMS	MSTPA	VHA	P value
Class 1	9 (75%)	8(66.6%)	10 (83.3%)	0.842 ns
Class 2	3 (25%)	4 (33.3%)	2 (16.6%)	
Total	12	12	12	

Significance level p≤0.05, ns=non-significant

(VHA) vertical holding appliance,(VHAMS) VHA with mini screw (MSTPA) miniscrew with trans palatal arch, and (P) probability.

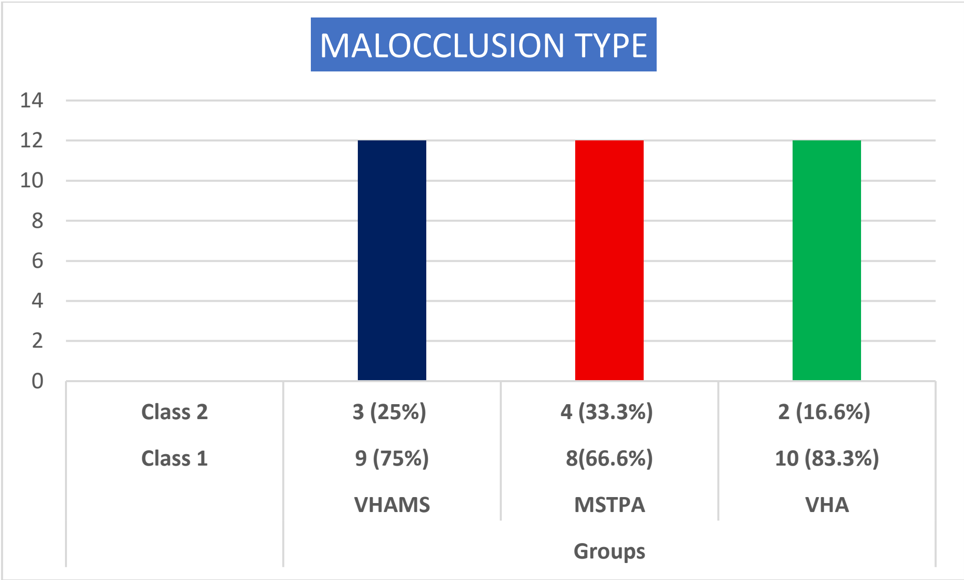

Figure (6): Bar chart for malocclusion type

Table (6) Concordance Correlation Coefficients (CCCs) for the Intraobserver and Interobserver Reliability of the Linear Measurements Used in the

Measurements	**Interobserver Reliability Scores**			**Intraobserver Reliability Scores**		
	CCC		**95% Confidence Limits**	**CCC**		**95% Confidence Limits**
Wits appraisal	0.981		0.975-0.988	0.987		0.965-0.991
Overbite	0.953		0.932-0.970	0.962		0.951-0.973
Overjet	0.942		0.923-0.963	0.972		0.941-0.991
UAFH	0.971		0.934-0.992	0.972		0.925-0.987
LAFH	0.976		0.926-0.989	0.983		0.924-0.989
TAFH	0.925		0.913-0.944	0.932		0.926-0.963
PFH	0.959		0.916-0.975	0.945		0.932-0.974
UADH	0.940		0.942-0.976	0.853		0.817-0.911
UPDH	0.974		0.902-0.981	0.948		0.915-0.981
LI-MP	0.903		0.896-0.924	0.912		0.899-0.931
ULE	0.952		0.914-0.974	0.966		0.947-0.982
LLE	0.964		0.927-0.985	0.973		0.958-0.991

Table (7) Concordance Correlation Coefficients (CCCs) for the Intraobserver and Interobserver Reliability of the Angular Measurements Used in the

Measurements	Interobserver Reliability Scores			Intraobserver Reliability Scores		
	CCC		95% Confidence Limits	CCC		95% Confidence Limits
SNA	0.885		0.831-0.915	0.794		0.752-0.821
SNB	0.986		0.913-0.991	0.867		0.821-0.923
ANB	0.996		0.986-0.998	0.997		0.992-0.999
Angle of convexity	0.768		0.742-0.858	0.963		0.914-0.984
FMPA	0.925		0.914-0.963	0.913		0.892-0.941
SN-MP	0.987		0.952-0.989	0.952		0.912-0.983
PP-MP	0.913		0.899-0.932	0.963		0.921-0.984
N’ Sn Pog’	0.925		0.913-0.936	0.945		0.927-0.978

Table (8) Descriptive statistics and test of significance (ANOVA) for the pre-treatment Linear measurements in all groups

Measurement	**Mean**	**SD**	**Minimum**	**Maximum**	**F**	***P Value***
Wits appraisal						
VHAMS	2.5	1.5	0.3	4.5	6.27	.379
MSTPA	2.3	1.3	0.6	4.3		
VHA	2.1	1.2	0.5	3.9		
Overjet						
VHAMS	5.5	1.4	2.5	7.1	2.46	.516
MSTPA	5.8	1.1	2.3	7.7		
VHA	5.2	1.3	2.2	7.2		
Overbite						
VHAMS	-4.6	1.2	-2.5	6.1	3.14	.412
MSTPA	-4.1	1.3	-2.7	6.3		
VHA	-4.3	1.4	-2.2	5.9		
UAFH						
VHAMS	55.3	4.1	48.1	68.7	2.72	.271
MSTPA	54.1	4.8	47.3	67.4		
VHA	56.7	5.5	45.4	69.5		
LAFH						
VHAMS	80.32	19.5	60.82	99.82	1.89	.19
MSTPA	79.4	18.35	61.05	97.75		

VHA	81.45	20.25	61.21	101.7		
TAFH						
VHAMS	135.3	7.2	125.3	155.2	3.25	.351
MSTPA	133.2	8.5	123.6	153.8		
VHA	136.5	6.9	121.4	159.3		
PFH						
VHAMS	75.4	15.6	59.8	91.2	0.021	.891
MSTPA	74.26	14.57	59.69	88.83		
VHA	77.61	17.2	60.41	94.81		
UADH						
VHAMS	25.342	2.9	21.942	28.742	0.18	.836
MSTPA	26.326	2.8	22.5	29.3		
VHA	27.124	3.2	23.4	30.5		
UPDH						
VHAMS	30.46	3.2	27.26	33.66	0.926	.782
MSTPA	29.34	4.15	25.19	33.49		
VHA	28.2	3.56	24.64	31.76		
LI-MP						
VHAMS	42.1	2.6	33.2	47.5	1.8	.312
MSTPA	43.3	2.7	32.7	48.2		
VHA	41.5	2.3	31.6	46.8		
ULE						
VHAMS	3.1	1	1.8	6.2	0.843	.423
MSTPA	3.2	0.9	1.9	6.4		
VHA	3.5	0.6	1.7	5.8		
LLE						
VHAMS	3.2	1.1	0.8	6.8	0.743	.536
MSTPA	3.1	1	0.9	6.5		
VHA	3.4	1.2	0.9	5.8		

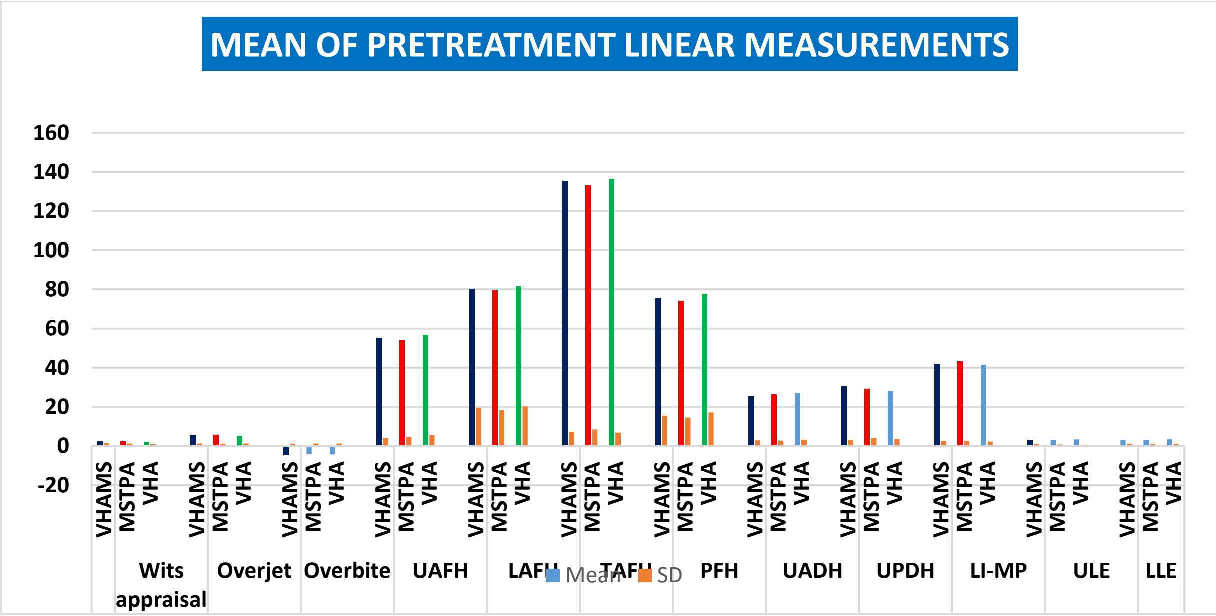

Figure (7): Bar chart for the mean of pretreatment linear measurements

Table (9) Descriptive statistics and test of significance (ANOVA) for the pre-treatment Angular measurements in all groups

Measurement	**Mean**	**SD**	**Minimum**	**Maximum**	**F**	***P Value***
SNA						
VHAMS	82.3	2.7	78.3	86.2	4.26	.356
MSTPA	82.5	2.8	78.1	87.1		
VHA	82.1	2.4	77.8	86.3		
SNB						
VHAMS	78.2	2.1	75.1	82.3	3.19	.537
MSTPA	78.5	2.4	75.5	82.8		
VHA	77.9	2.5	74.8	81.5		
ANB						
VHAMS	5.3	2.2	2.1	7.8	4.85	.638
MSTPA	4.9	2.5	2.2	8.1		
VHA	5.4	2.1	2.5	8.2		
Angle of convexity						
VHAMS	2.5	2.4	0.8	7.3	5.27	.247
MSTPA	3.1	2.6	0.3	7.7		
VHA	2.9	2.3	0.5	7.9		
FMPA						
VHAMS	36.5	4.2	33.1	40.1	2.56	.247
MSTPA	35.7	3.5	32.9	39.63		

VHA	37.26	5.2	34.4	41.21		
SN-MP						
VHAMS	41.2	5.21	35.9	46.41	3.42	.146
MSTPA	42.3	6.5	35.8	48.8		
VHA	40.2	3.71	36.49	43.9		
PP-MP						
VHAMS	23.5	5.4	15.7	37.6	5.23	.268
MSTPA	22.5	5.7	14.8	36.2		
VHA	24.3	5.1	16.7	35.3		
N' Sn Pog'						
VHAMS	163.8	0.7	155.6	167.2	832	.426
MSTPA	165.6	0.8	153.5	166.3		
VHA	164.1	0.8	156.7	167.8		

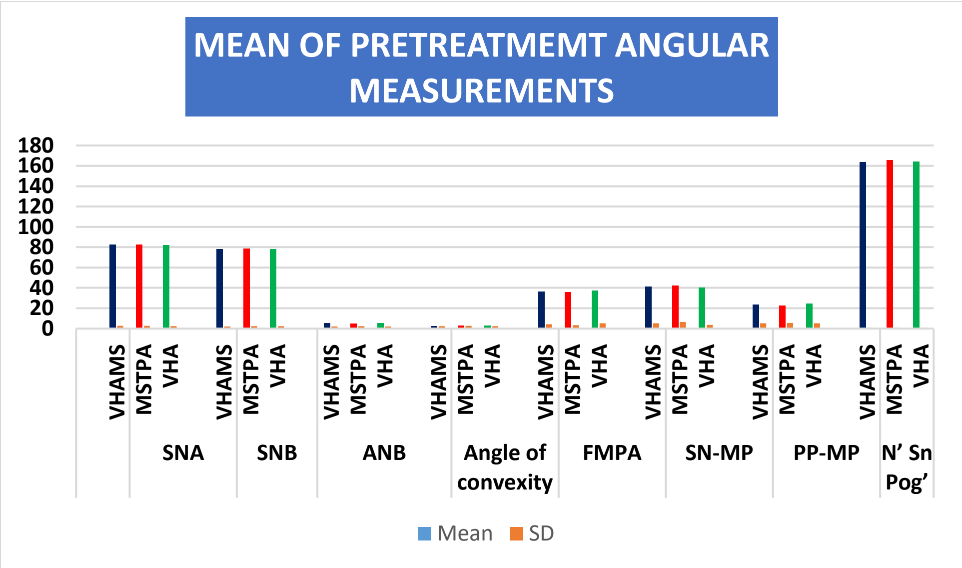

Figure (8): Bar chart for the mean of pretreatment angular measurements

Skeletal, dental, and soft tissue changes:

Significant increase in SNB, overbite in groups 1and 2, while there was a significant decrease in the angle of convexity, SN-MP, FMPA, LAFH, overjet, and open bite in groups 1 and 2, indicating improvement of the open bite and facial profile.

Table (10) Cephalometric linear variables Pre-treatment (T1), Post-intrusion (T2) and 6 Months Post-treatment (T3).

Measurement	T1		T2		T3	
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**
Wits appraisal						
VHAMS	2.5	1.5	1.1	1.4	1.3	0.9
MSTPA	2.3	1.3	1.2	1.3	1.1	1.1

VHA	2.1	1.2	1.9	0.9	1.8	0.8
Overjet						
VHAMS	5.5	1.4	2.8	0.76	3.3	1.4
MSTPA	5.8	1.1	2.9	0.83	3.5	1.2
VHA	5.2	1.3	2.9	0.67	3.1	1.3
Overbite						
VHAMS	-4.6	1.2	1.2	0.8	2.1	1.8
MSTPA	-4.1	1.3	1.5	0.7	2.5	1.3
VHA	-4.3	1.4	-1.9	1.2	1.1	0.9
UAFH						
VHAMS	55.3	4.1	55.4	3.9	55.2	3.8
MSTPA	54.1	4.8	54.3	4.2	54.2	4.4
VHA	56.7	5.5	56.5	5.3	56.4	5.4
LAFH						
VHAMS	80.32	19.5	77.2	16.6	77.8	15.9
MSTPA	79.4	18.35	76.5	17.8	77.2	17.2
VHA	81.45	20.25	80.2	19.3	79.4	18.6
TAFH						
VHAMS	135.3	7.2	132.1	6.9	132.6	6.3
MSTPA	133.2	8.5	130.1	7.4	131.4	7.7
VHA	136.5	6.9	135.4	6.3	134.1	6.1
PFH						
VHAMS	75.4	15.6	77.2	13.2	77.1	12.5
MSTPA	74.26	14.57	76.1	12.4	75.8	13.2
VHA	77.61	17.2	77.9	16.8	78.3	16.5
UADH						
VHAMS	25.142	2.9	26.7	2.6	26.3	2.5
MSTPA	26.126	2.8	27.4	2.5	26.9	2.3
VHA	27.124	3.2	28.1	2.8	28.3	2.5
UPDH						
VHAMS	30.46	3.2	27.1	2.9	27.3	2.8
MSTPA	29.34	4.15	26.5	3.5	26.9	3.1
VHA	28.2	3.56	27.8	2.1	27.5	2.2
LI-MP						
VHAMS	42.1	2.6	44.7	2.4	44.5	2.3
MSTPA	43.3	2.7	45.6	2.6	45.2	2.4

VHA	41.5	2.3	42.2	2.1	41.9	1.9
ULE						
VHAMS	3.1	1	3.2	0.9	4.3	1.3
MSTPA	3.2	0.9	3.3	0.8	5.2	1.5
VHA	3.5	0.6	3.6	0.7	3.7	0.8
LLE						
VHAMS	3.2	1.1	2.5	1.2	2.2	0.7
MSTPA	3.1	1	2.3	1.1	1.9	0.6
VHA	3.4	1.2	3.1	1.3	2.7	0.8

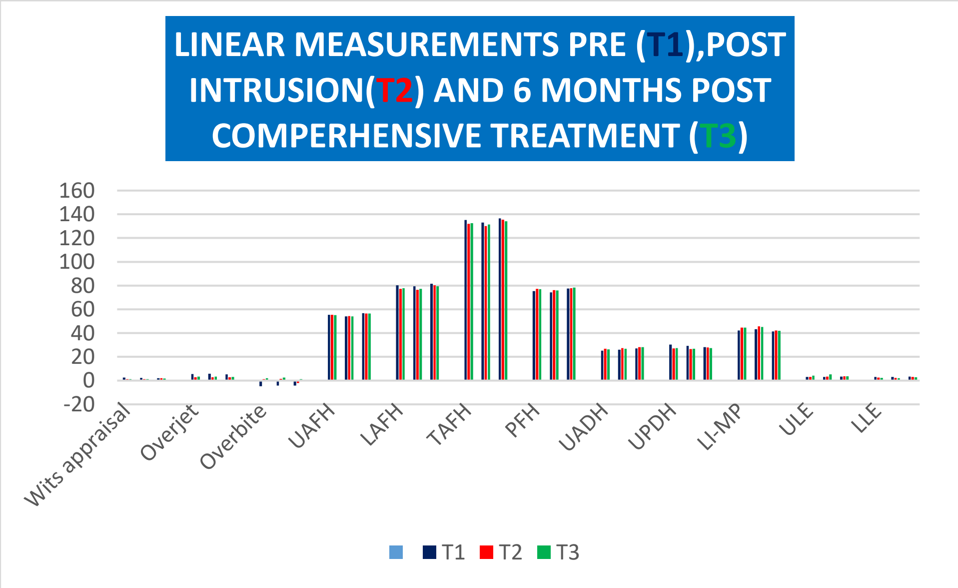

Figure (9): Bar chart for the mean linear measurements comparison of pretreatment (T1), post intrusion (T2), and post-comprehensive orthodontic treatment (T3).

Table (11) Cephalometric angular variables Pre-treatment (T1), Post-intrusion (T2) and 6 Months Post-treatment (T3).

Measurement	**T1**		**T2**		**T3**	
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**
SNA						
VHAMS	82.3	2.7	82.4	2.5	82.3	2.4
MSTPA	82.5	2.8	82.2	2.6	82.1	2.5
VHA	82.1	2.4	82	2.2	82.2	2.3
SNB						
VHAMS	78.2	2.1	80	1.9	79.8	1.8
MSTPA	78.5	2.4	80.5	2.2	80.2	1.9
VHA	77.9	2.5	78.6	2.3	78.3	2.1
ANB						

VHAMS	5.3	2.2	3.8	2.1	3.6	2.2
MSTPA	4.9	2.5	3.5	1.9	3.4	2.1
VHA	5.4	2.1	5.1	2.2	4.5	1.8
Angle of convexity						
VHAMS	2.5	2.4	1.4	0.9	1.5	0.8
MSTPA	3.1	2.6	1.5	0.8	1.6	0.7
VHA	2.9	2.3	2.5	1.9	1.9	0.6
FMPA						
VHAMS	36.5	4.2	33.6	3.8	34.1	3.7
MSTPA	35.7	3.5	33.9	2.9	34.2	3.1
VHA	37.26	5.2	36.1	4.2	35.6	3.9
SN-MP						
VHAMS	41.2	5.21	39.1	4.3	39.6	4.1
MSTPA	42.3	6.5	39.7	4.2	40.4	4.2
VHA	40.2	3.71	39.3	4.1	39.1	3.9
PP-MP						
VHAMS	23.5	5.4	21.3	4.6	21.4	5.1
MSTPA	22.5	5.7	20.4	4.3	20.3	4.6
VHA	24.3	5.1	23.4	4.9	23.6	4.7
N' Sn Pog'						
VHAMS	163.8	0.7	164.9	0.8	164.7	0.7
MSTPA	165.6	0.8	166.9	0.9	166.7	0.6
VHA	164.1	0.8	164.4	0.6	164.3	0.8

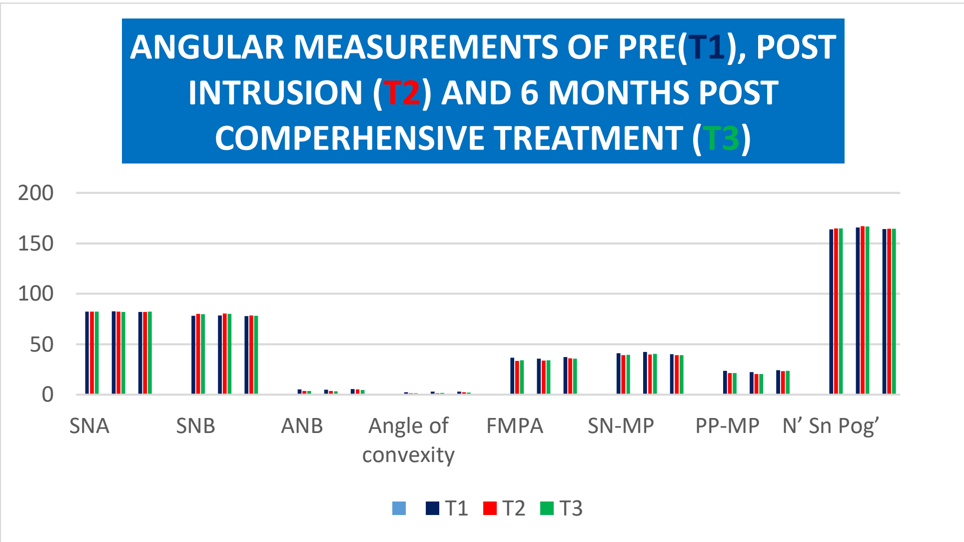

Figure (10): Bar chart for the mean angular measurements comparison of pretreatment (T1), post intrusion (T2), and post-comprehensive orthodontic treatment (T3).

Table (12) Pearson correlation coefficients between cephalometric variables (T2-T1) in all groups.

Variable 1	Variable 2	R	P	Significance
UPDH	MP-SN			
VHAMS		0.46	0.041	s
MSTPA		0.52	0.032	s
VHA		0.97	0.120	ns
UPDH	FMA			
VHAMS		0.53	0.000	s
MSTPA		0.46	0.046	s
VHA		0.89	2.35	ns
UPDH	OJ			
VHAMS		0.33	0.011	s
MSTPA		0.34	0.046	s
VHA		0.68	3.57	ns
UPDH	OB			
VHAMS		-0.021	0.003	s
MSTPA		-0.034	0.002	s
VHA		-0.83	0.67	ns
UPDH	Angle of convexity			
VHAMS		0.52	0.006	s
MSTPA		0.62	0.002	s
VHA		0.134	0.68	ns
OB	SN-MP			
VHAMS		-0.70	0.004	s
MSTPA		-0.68	0.032	s
VHA		-0.13	0.38	ns
OB	SNB			
VHAMS		0.97	0.036	s
MSTPA		0.71	0.043	s
VHA		0.19	2.70	ns
SNB	SN-MP			
VHAMS		-0.84	0.005	s
MSTPA		-0.74	0.022	s
VHA		-0.11	1.46	ns

T1, pretreatment; T2, post treatment; R, Pearson correlation coefficient; S, significance; NS, not significant P ≤0.05;

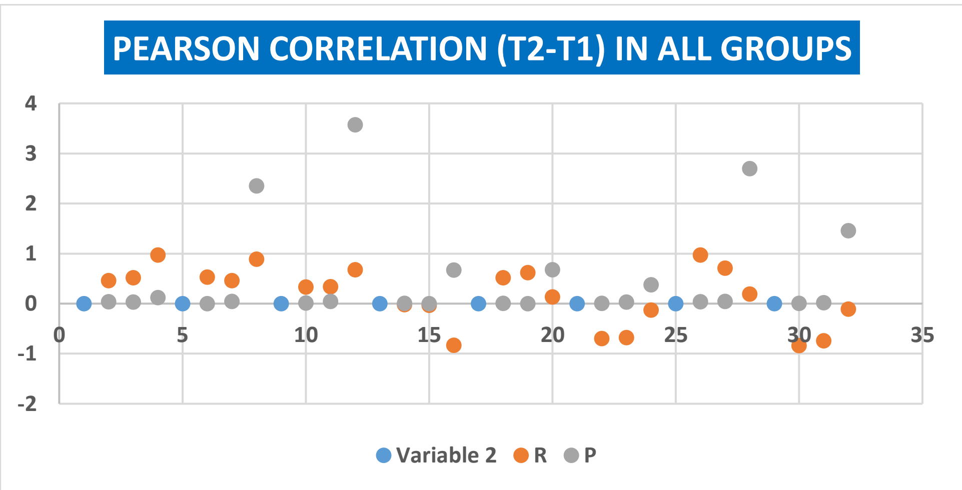

Figure (11): The Pearson correlation in all groups (T2-T1).

Table (13) Pearson correlation coefficients between pretreatment measurements (T1) and changes in overbite OB (T3-T2) in all groups.

Variable 1 T1	Variable 2 T3-T2	R	P	Significance
FMPA	**OB**			
VHAMS		-0.325	0.637	ns
MSTPA		-0.287	0.432	ns
VHA		-0.72	0.336	ns
SN-MP	**OB**			
VHAMS		-0.263	0.573	ns
MSTPA		-0.278	0.472	ns
VHA		-0.12	0.841	ns
LAFH	**OB**			
VHAMS		-0.085	0.743	ns
MSTPA		-0.096	0.826	ns
VHA		-0.83	0.945	ns

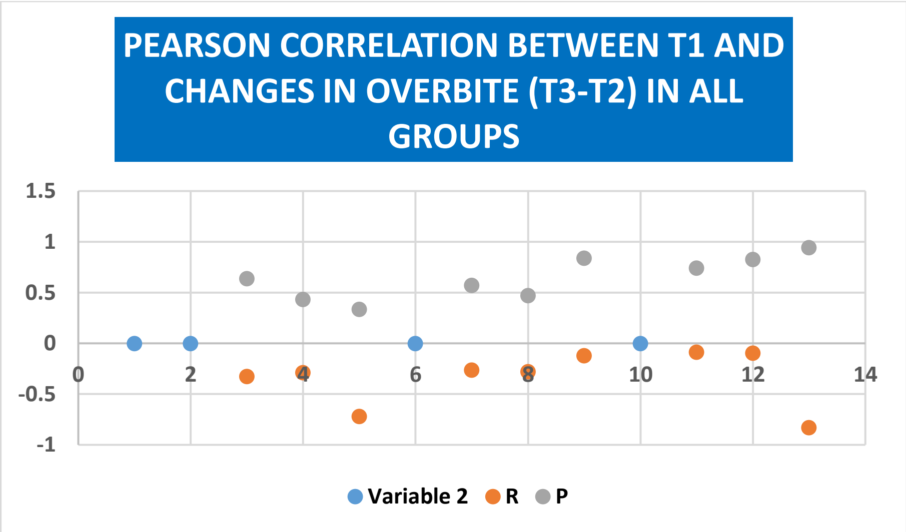

Figure (12): The Pearson correlation between (T1) and the changes in overbite (T3-T2) in all groups.

Table (14) Rate of relapse % (T3-T2) / (T2-T1).

Variable	Rate of relapse% (T3-T2) / (T2-T1)		
	VHAMS	**MSTPA**	**VHA**
Overbite	17.3	15.4	32.7
Overjet	16.6	14.7	26.8
UPDH	21.35	18.9	35.6

UPDH, upper posterior dental height

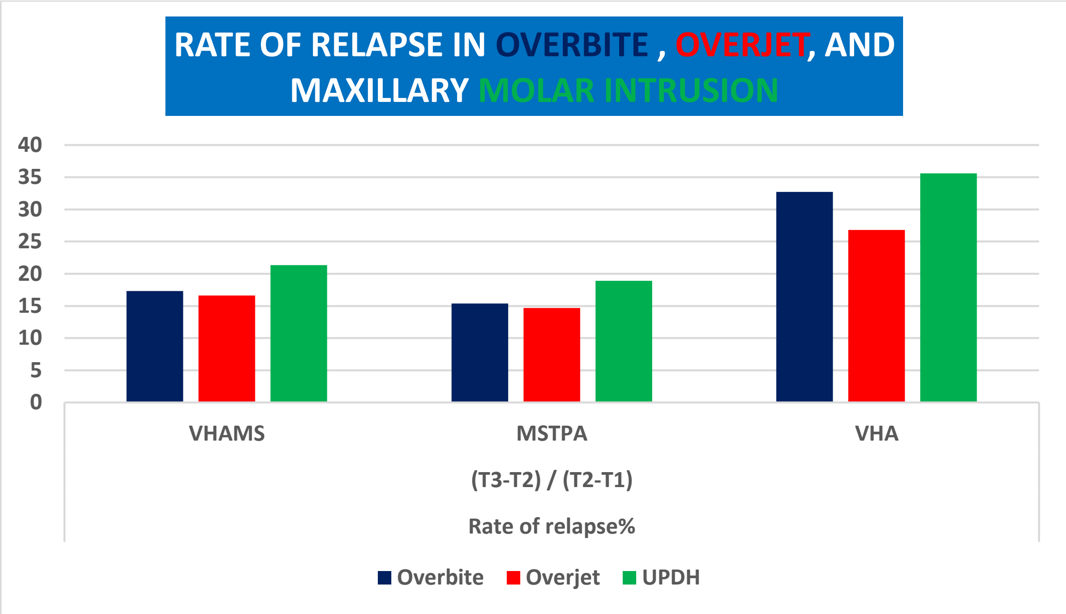

Figure (13): Bar chart for the rate of relapse in overbite, overjet, and maxillary molar intrusion in all groups.

4. DISCUSSION

Even when anterior open bite (AOB) is treated in growing patients, there remains a substantial risk of relapse due to factors such as unfavorable tongue posture, thrusting habits, and altered tongue kinetics compared with individuals who swallow normally. Long-term stability of the neutral zone or functional area relies on correcting these habits and maintaining proper tongue posture. The current study highlights the use of the vertical holding appliance (VHA) as a myofunctional therapy modality and addresses habit modification to counter relapse risk in AOB cases.[30]

Based on prior research by Akbaydogan et al,[31] which demonstrated no significant differences in cephalometric measurements that could affect study outcomes, the male-to-female ratio was not considered in this study.

It is recommended to prevent overeruption of the lower molars to maximize the effectiveness of maxillary molar intrusion.[32] This recommendation contrasts with the findings of DeBerardinis et al.,[33] who reported an average lower molar extrusion of 2.91 mm due to the lack of control over lower molar overeruption during treatment.

Miniplates provide more reliable anchorage than miniscrews but require invasive surgery, making them less practical for this study. Miniscrews offer simpler, less invasive placement without surgical complexity.

Miniscrew placement was meticulously planned to avoid removal and reinstallation due to narrow interdental spaces, which can mechanically hinder adjacent tooth movement and increase the risk of root resorption. Additionally, palatal control was incorporated during intrusion to reduce buccal tipping, consistent with established recommendations.[34,35] Helices were incorporated into the VHA to regulate force magnitude and range of action, reducing the need for multiple appliance remakes for the same patient.

The intrusive force in molars used in groups 1 and 2 was approximately 100-150 g [28]While in group 3, it was difficult to encounter.

In the current study, the PDH was decreased which is in accordance with previous studies of Akan et al[36] and Scheffler et al[40]

In the current study for every 1 mm of posterior teeth intrusion, a 3 mm closure of the bite was observed, as similarly reported in previous studies. Additionally, myofunctional therapy, particularly tongue exercises, played an important role in the treatment of AOB.[38,39]

In the study by Scheffler et al[40], the molar intrusion was 2.3 mm using a maxillary occlusal splint and nickel-titanium coil springs to TAD, Akan et al[36] used a force of 400 g to achieve a maxillary molar intrusion of 3.37 ± 1.21 mm with an average period of 6.84 ± 1.64 months.

Molar intrusion in the current study was 2.2± 0.4 , 1.8± 0.3and 0.9±0.5 in group 1,2 and 3 respectively, This was concomitant with previous studies of Mai H. Aboulfotouh, et al,[41] , Xun et al ,[42] and Erverdi et al.[43]

The lower amount of molar intrusion relapse observed in the current study compared to Scheffler et al [32] and Marzouk et al [26] is likely due to the shorter post-treatment observation period of 6 months, whereas the others had follow-up durations of 2 and 3 years, respectively.

Mandibular counterclockwise rotation measured 4 ± 0.5°, 2.9 ± 0.6°, and 1.5 ± 0.4° in groups 1, 2, and 3, respectively, consistent with previous studies. [43–45] This rotation contributed to improvement in Class II malocclusion by reducing the ANB angle and angle of convexity, thereby enhancing the soft tissue profile.

Lower anterior face height decreased after treatment due to counterclockwise mandibular rotation, consistent with the findings of Sugawar et al, [16]Baek et al,[2] Scheffler et al,[32] Marzouk et al[44]. However, this result contrasts with Deguchi et al[46] who did not observe a similar change.

Post-treatment stability at 1 year was favorable, with groups 1 and 2 exhibiting minimal relapse, whereas group 3 demonstrated a higher degree of relapse. These findings align with Sugawara et al.,[16] and Scheffler et al., [32] but contrast with Deguchi et al[46] likely due to differences in appliance design.

The initial treatment outcomes for groups 1 and 2 were promising, demonstrating a relatively low relapse rate after one year. In contrast, group 3 exhibited a greater tendency for relapse, indicating potential limitations in the treatment approach or the appliance utilized in this group.

All patients in groups 1 and 2 exhibited a positive overbite of at least 1 mm from T1 to T2, whereas only 2 out of 12 patients in group 3 achieved this overlap. The degree of overbite correction depends on factors such as persistent oral habits, the severity of the initial open bite, and the extent of lower molar extrusion, particularly when extrusion is not controlled.

Incisor extrusion has been noticed in the current study, specially in group1 and 2 which was in agreement with Scheffler et al[40] and Kuroda et al,[46] due to the faster rate of anterior extrusion in comparison to posterior intrusion, the postpone of bonding upper anterior bracket was recommended after finishing of posterior intrusion this was in accordance to Marzouk et al[44] and Choi et al.[29]

Due to differing intrusive mechanical designs, the regression analysis revealed that a bite closure of 1.9 mm occurs for every 1 mm of maxillary molar intrusion. This agreed with Marzouk et al[44] and disagreed with Kuroda et al[46].

The amount of lower molar intrusion in the present study was not considered since it was controlled by the use of heavy st st wire this was in disagreement with Gaafar et al [47] who found 1.6 mm and 1.8 mm of lower molar intrusion, this might be due to the use of two appliances that has a direct intrusive effect on mandibular first molars.

The buccal tipping in the present study was prevented by using TPA this was in disagreement with Maha et al [48], who did not use TPA in their study.

he amount of lower incisors extrusion was controlled but in the finishing stages it might have contributed to the maintenance of a positive overbite. Post treatment relapse of maxillary anterior teeth was noticed in 4 cases that was related to group 3, this was in accordance to Scheffler et al[40] et al, and was in disagreement with Sugawara et al [16] and Baek et al [2] who found extrusion rather than intrusion, this might be related to different intrusion Mechanics and different way for comprehensive orthodontic treatment with different retention protocol.

The angle of convexity decreased by 2.6°, 1.8°, and 1.1° in groups 1, 2, and 3, respectively, consistent with Marzouk et al,.[26] However, this finding contrasts with Erverdi et al,[43] who reported greater changes, possibly due to differing intrusion mechanics involving zygomatic anchorage.

The degree of relapse of overbite was noticed in all groups but with different ratio, this was in accordance with Scheffier etal [32] and Marzouk et al[26]

The greater degree of overbite relapse in group 3 indicates that the vertical holding appliance (VHA) alone is insufficient for molar intrusion in adults. Post-treatment relapse is influenced by retainer type, patient compliance, and habit persistence, aligning with the findings of Scheffier et al [32] and Marzouk et al.[26]

5. CONCLUSION

1- Both appliances effectively treat open bite or overerupted maxillary molars, with superior results for the vertical holding appliance (VHA) assisted by miniscrews.

2- Maxillary molar intrusion using miniscrews can preserve overerupted lower molars, avoiding aggressive crown reduction or root canal therapy when creating space for prosthetics.

3- Miniscrews alone are preferred for unilateral intrusion or in patients who are non-compliant or have a high gag reflex, due to reduced discomfort compared to VHA.

4- VHA alone is suitable for growing patients to control vertical dimension but is not recommended for adults without miniscrew support.

5- Orthodontic miniscrews provide absolute anchorage crucial for molar intrusion in anterior open bite treatment and require both buccal and palatal application for effectiveness.

6. LIMITATIONS

Limitations include frequent appliance breakage and difficulty in separately evaluating right and left molar intrusion due to reliance on two-dimensional imaging without postero-anterior X-rays. Additionally, the study lacks long-term follow-up evaluation.

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