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CBCT COMPARISON OF DENTAL, DENTOALVEOLAR AND SKELETAL TREATMENT RESULTS OF HYRAX EXPANDER AND MONOCORTICAL HYBRID EXPANDER IN LATE-ADOLESCENCE

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Abstract

Objective: *To compare skeletal and dentoalveolar treatment results of using a conventional Hyrax and Hybrid appliances in late-adolescent patients using CBCT scans.*

Materials and Methods: *eighteen patients with maxillary skeletal crossbites, aged between 18 and 21 were selected, divided randomly into a group treated with a conventional Hyrax, and a group with Hybrid appliance using palatal miniscrews with monocortical engagement. The Hybrid appliance was fabricated using a digital workflow; CBCT scans merged with intraoral digital scans, used to virtually position miniscews and fabricating a surgical guide through 3D printing. Both groups followed the same activation protocols. CBCT scans were taken for all patients before and after treatment. These were used for comparing dental, alveolar and skeletal treatment results. The resulting data were statistically analyzed using Shapiro Wilk Normality test and Kolmogorov test, and Paired t test between the pre and post treatment results.*

Results: *Transverse linear and angular measurements were higher in the Hyrax group due to increased buccal tipping, the dentoalveolar linear measurements showed buccal alveolar bone thinning in the Hyrax group, there was statistically significant increase in the right first premolar alveolar inclination in the Hyrax group showing more alveolar bone bending, and the skeletal linear measurements showed more parallel sutural opening with the Hybrid group .In both groups, opening happened more on the right side.*

Conclusions: *Sutural separation was possible with both appliances at the late-adolescent stage with comparable results. However, the Hybrid appliance exhibited less side effects, giving a qualitatively better expansion pattern.*

Keywords: *Maxillary Expansion; Maxillary Deficiency; Miniscrews; Skeletal crossbite*

Introduction

Maxillary transverse deficiency is a common condition in most populations. Some sources claim it to be 9.4% of the population and 30% of adult orthodontic patients(1). It is manifested in the form of crossbite malocclusion either unilateral or bilateral, crowding, V-shaped arch form and could play a role in obstructive sleep apnea due to reduced nasal airway space.

It was found that a transverse separating force applied to the maxilla was capable of separating the palatal shelves by opening the midpalatal suture; Edward Angle was the first to devise an appliance for that purpose(2). In tooth-borne and tooth-tissue-borne appliances, forces are transmitted through the teeth to the skeletal base. This had the side effects of buccal tipping, alveolar bone bending and periodontal breakdown(3).

Studies had shown that palatal expansion was more successful in younger patients where the

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palatal suture hasn't undergone extensive interdigitation as in after adolescence(4,5). Later studies found that the midpalatal suture remained in a "non-mature" state until late adulthood (6) and that other cranio-facial sutures were the source of resistance to expansion such as the piriform aperture pillars, zygomatic buttresses, pterygoid junctions(7).

Miniscrew assisted rapid palatal expansion (MARPE) has been developed to transmit forces directly to the skeletal component and avoid the dental and alvolar side effects of tooth borne devices, providing an alternative to adult patients avoiding surgical intervention(8).

Miniscrew cortical engagement in the palate has a been studied and it was found that bi-cortical engagement produced less side effects than mono-cortical ones(9).

Some studies found no significant differences in expansion produced by a tooth borne expander and a bone anchored one. (10)

In light of these previous studies, closer examination of the differences between the effects produced by the tooth anchored Hyrax appliance and the monocortically engaged bone anchored hybrid appliance seemed to be a point of worthy investigation.

Materials and Methods:

Ethical approval:

This research had been authorized by the Research Ethics Committee of Faculty of Dentistry, Minia University.

Sample Size Calculation:

Sample size calculated depending on a previous study (10.4041/kjod.2017.47.2.77) as reference. If mean ± standard deviation of control group is -1.98 ± 2.85, while mean ± standard deviation of intervention group is 2.62 ± 2.38 with 1.75 effect size, minimally the study needed 7 subjects in each group when the power was 80 % & type I error probability was 0.05. Total sample size increased to 9 subjects per group to compensate 20% drop out. Sample size was performed by using Independent t test by using G. power 3.1.9.7

Selection criteria:

Patients included in the study complied with the following:

- Being in good physical and oral health, free from any active pathology.
- No congenitally missing or extracted permanent teeth.
- No previous orthodontic treatment.
- Between the ages of 18 and 21 years old.
- Patients with maxillary constriction with posterior crossbite.

Full skull cone beam computed tomography scans were taken at the diagnostic stage and repeated after the expansion was completed (90 kvp, 10 mA, and a field of view (FOV) of 180×165 mm 0.3 mm) and on demand 3Dx software was used to manipulate the CBCT images.

The CBCT images (DICOM) were extracted using Blueskybio.

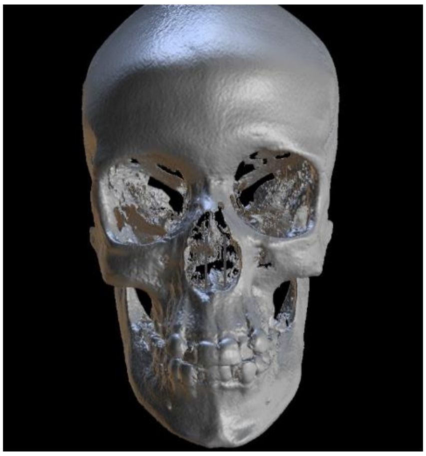

Figure 1 CBCT image

A. **Group I (Conventional Hyrax)**

1. Molar bands were fitted on the upper first permanent premolars and molars and impressions were taken with a rubber base impression material and sent to a lab for appliance fabrication.

Figure 2 Impression with molar bands

2. Casts were poured and the jackscrew apparatus was adapted and soldered to the bands, then the appliance was finished and polished.

Figure 3 Hyrax on model

3. The premolars and molars were etched on the buccal and palatal sides, washed with water then dried.

4. Bonding agent was applied, air thinned then cured.

5. The appliance was then cemented using composite cement, excess removed, then cured.

Figure 4 Hyrax cemented

6. In some patients, bite raising was done to avoid cuspal interference.

7. The patients instructed to activate the device twice daily until a diastema appears, then once daily until adequate expansion was obtained.

8. Patients were instructed on oral hygiene measure.

9. After the expansion phase was completed, the jackscrew device was fixed using light cured flowable composite and left in place for 3 months as retention

Figure 5 Post-expansion

and bite raisers removed.

B. **Group II (Monocortical Hybrid Expander)**

Miniscrew placement:

1. **The lengths of the miniscrews were individually selected for each patient with the guide of the CBCT images. The thickness was standardized as 1.6 mm.**
2. **The CBCT images were merged with digital intraoral scans using Blueskybio software, the insertion locations and angulations of the miniscrews**

Figure 6 Miniscrew



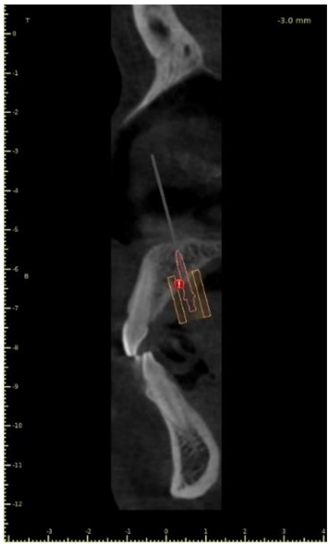

Figure 7 Digital planning

3. **were virtually selected, placed bilateral to the midpalatal suture, in the area of the third palatal rugae.**
4. **The surgical guide was designed to provide an accurate and stable fit when in use, with open channels over the planned positions of the miniscrews providing guidance for the miniscrew contra-angle driver’s tip, for controlled insertion.**
5. **The surgical guides were fabricated using a laser sintering 3D printing machine.**
6. **The palatal area was wiped with betadine.**

7. **The surgical guide was positioned and anesthesia was administered.**

Figure 8 Surgical guide & anesthesia administration

8. **The miniscrews were placed with the use of a contra-angle driver.**
9. **In patients with dense cortical bone, a pilot drill was used to overcome the cortical resistance.**

Figure 9 Miniscrew insertion

10. **After placement of the miniscrews, the guide was removed and the initial stability checked.**
11. **Prophylactic antibiotics and analgesics were prescribed and oral hygiene measures were instructed.**
12. **The miniscrews were left for 4 weeks for partial osseointegration.**

Hybrid expander fabrication:

1. **Transfer caps were placed over the miniscrews, bands fitted to the upper first molars and impressions taken using a rubber base impression material. This was sent to a lab to construct the Hybrid appliance.**

Figure 11 Transfer caps

Figure 10 Lab analog

2. **Identical miniscrews were placed into the transfer caps and the impressions poured, providing models with the miniscrews in their correct angulations.**
3. **abutment tubes were placed over the miniscrew heads. The jackscrew's anterior arms were adapted and crimped into the abutment tubes and the posterior arms were adapted soldered to the molar bands, then it was finished and polished.**

Delivery:

1. **The upper molars were etched, followed by washing with water.**
2. **After air drying, bonding agent was applied and cured.**
3. **Composite band cement was used to cement the appliance.**
4. **The same activation protocol and oral hygiene recommendations used for group I was used for this group.**
5. **After achieving the expansion, the jackscrew device was sealed with flowable resin and left in place as a retainer for three months.**

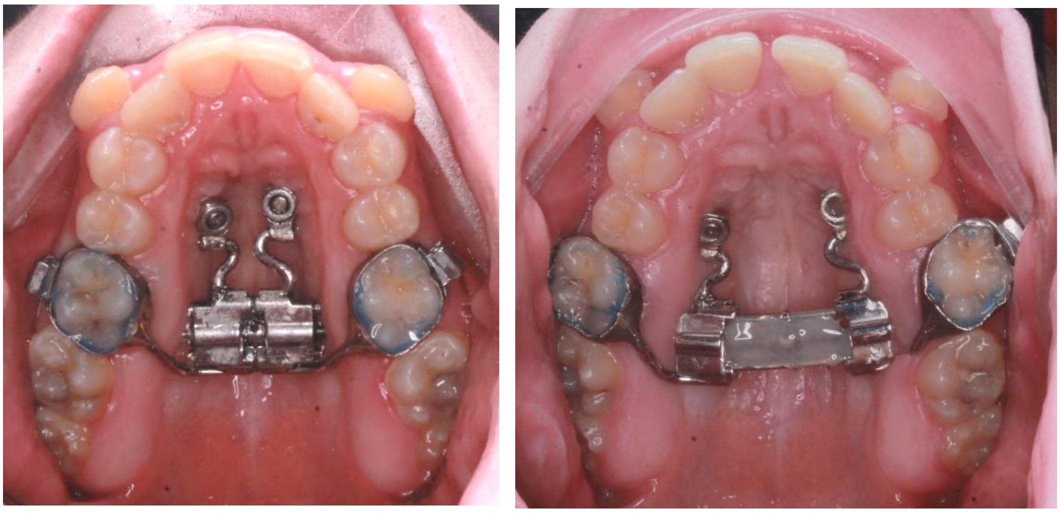

Figure 12 Hybrid Hyrax pre and post expansion

Statistical Analysis:

The data gathered were collected, tabulated and statistically analyzed using:

A. Normality exploration of data by using Shapiro Wilk Normality test and Kolmogorov test.

B. Comparison between different groups was performed by using Man Whitneys test.

RESULTS

1-Dental Linear measurements

There was a significant difference between both groups as

Group II was significantly lower in:

- **P2BW with (4.64 ± 1.69) mean difference as P=0.01.**
- **P2PW (5.07 ± 1.60) mean difference as P=0.006.**
- **P1BW with (4.05 ± 1.5) mean difference as P=0.01.**
- **P1 PW with (5.18 ± 1.19) mean difference as P=0.0001.**
- **P1AW with (2.58 ± 1.01) mean difference as P=0.02.**
- **CAW with (2.5 ± 0.99) mean difference as P=0.021.**

Table (1): Mean and standard deviation of difference between pre and post dental linear measurements of group I & II, comparison using Mann Whitney test:

Difference Dental Linear	Group I		Group II		Difference				
					Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference		P value
	Mean	Std. Deviation	Mean	Std. Deviation			Lower	Upper	
M1 BW (mm)	8.05	2.99	6.38	6.02	1.67	2.24	-3.08	6.42	0.467
M1 PW (mm)	6.72	2.82	6.05	5.69	0.67	2.12	-3.82	5.16	0.756
M1 AW (mm)	3.35	1.11	2.38	2.44	0.98	0.89	-0.92	2.87	0.291
P2 BW (mm)	7.73	2.80	3.08	4.22	4.64	1.69	1.06	8.22	0.014*
P2 PW (mm)	8.03	2.87	2.96	3.85	5.07	1.60	1.68	8.46	0.006*
P2 AW (mm)	1.12	0.98	1.44	1.81	-0.32	0.69	-1.77	1.13	0.647
P1 BW (mm)	7.18	3.11	3.13	3.23	4.05	1.50	0.88	7.22	0.015*
P1 PW (mm)	6.86	2.57	1.68	2.47	5.18	1.19	2.66	7.69	0.0001*
P1 AW (mm)	3.43	1.80	0.85	2.43	2.58	1.01	0.44	4.71	0.021*
C CW (mm)	2.73	1.27	0.66	2.70	2.07	0.99	-0.03	4.18	0.053
C AW (mm)	3.19	2.27	0.70	1.91	2.50	0.99	0.40	4.59	0.023*

M: mean SD: standard deviation MD: mean difference SED: standard error difference
CI: confidence interval L:Lower arm U: upper arm
**Significant difference as P<0.05.*
Mean with the same superscript letters were insignificantly different as P>0.05.
Mean with different superscript letters were significantly different as P<0.05.

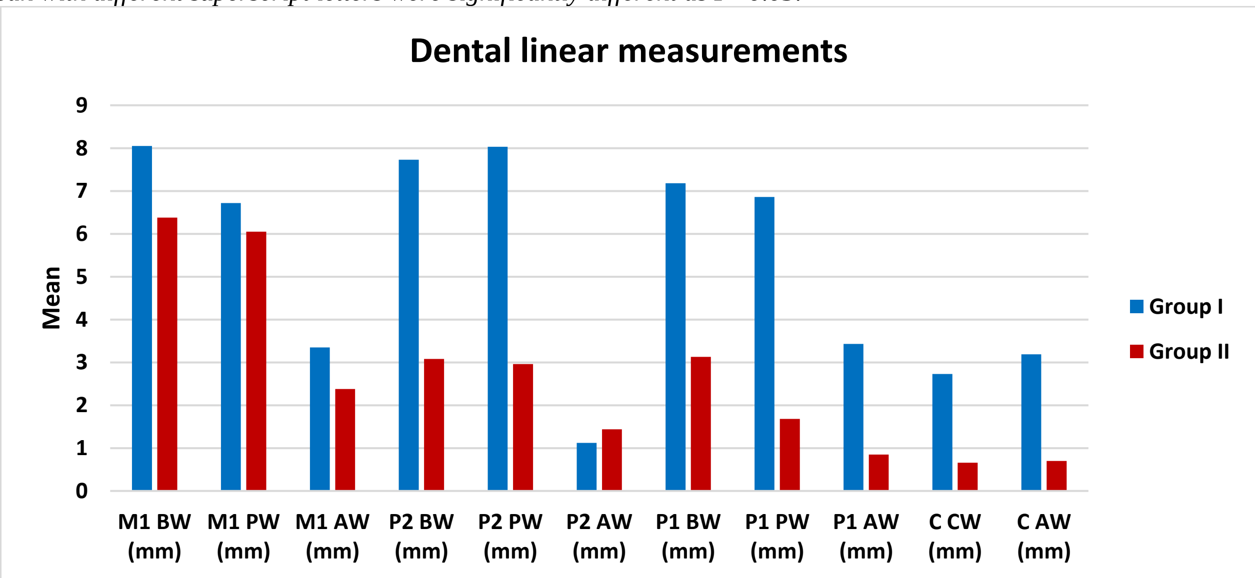

Figure 13: bar chart showing difference between pre and post dental linear measurements of group I & II.

2-Dental Angular measurements

There was a significant difference between both groups as

Group I was significantly higher in:

- **Right P2DI with (10.08 ± 2.36) mean difference as P=0.001.**
- **Right CDI with (3.79 ± 1.73) mean difference as P=0.04.**

Group II was significantly lower in:

- **Left P2DI (12.26 ± 1.79) mean difference as P=0.0001.**
- **Left P1DI with (4.58 ± 1.13) mean difference as P=0.001.**

Table (2): Mean and standard deviation of difference between pre and post dental angular measurements of group I & II, comparison using Independent t test:

Difference Angular Dental		Group I		Group II		Difference				
						Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference		P value
		Mean	Std. Deviation	Mean	Std. Deviation			Lower	Upper	
Right	M1 DI (°)	7.35	5.21	3.64	4.94	3.71	2.39	-1.36	8.78	0.141
	P2 DI (°)	13.75	5.42	3.67	4.55	10.08	2.36	5.09	15.08	0.001*
	P1 DI (°)	8.13	2.94	2.93	7.10	5.19	2.56	-0.24	10.62	0.060
	C DI (°)	2.83	3.82	-0.97	3.52	3.79	1.73	0.12	7.46	0.044*
Left	M1 DI (°)2	7.43	3.56	3.80	4.42	3.63	1.89	-0.39	7.64	0.074
	P2 DI (°)3	12.63	4.49	0.37	2.97	12.26	1.79	8.46	16.06	0.000*
	P1 DI (°)4	7.18	1.69	2.60	2.93	4.58	1.13	2.18	6.97	0.001*
	C DI (°)5	1.70	3.71	-0.30	4.84	2.00	2.03	-2.31	6.31	0.339

M: mean SD: standard deviation MD: mean difference SED: standard error difference
CI: confidence interval L:Lower arm U: upper arm
**Significant difference as P<0.05.*
Mean with the same superscript letters were insignificantly different as P>0.05.
Mean with different superscript letters were significantly different as P<0.05.

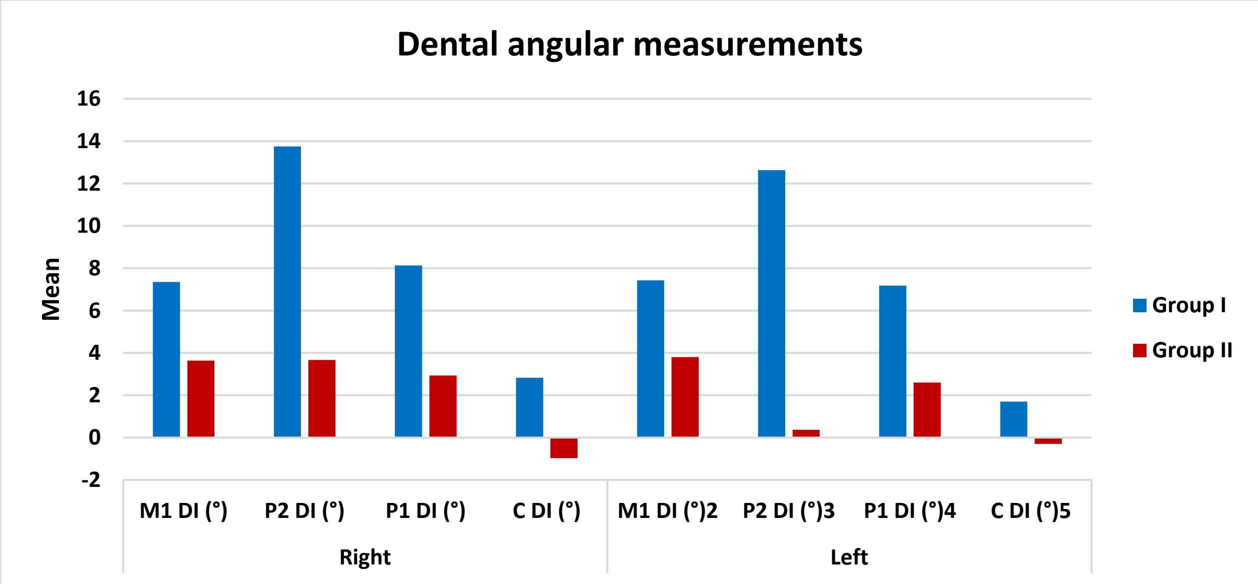

Figure 14: bar chart showing difference between pre and post dental angular measurements of group I & II.

3-Dentoalveolar Linear measurements

There was a significant difference between both groups as

Group II was significantly lower in:

- **Right M1 MBBT with (0.3 ± 0.14) mean difference as P=0.04.**
- **Right M1 PBT with (0.69 ± 0.12) mean difference as P=0.0001.**
- **left P2 PBT with (0.46± 0.22) mean difference as P=0.05.**
- **left P1 BBT with (0.31 ± 0.14) mean difference as P=0.04.**
- **Left P1 PBT with (0.59 ± 0.15) mean difference as P=0.001.**

Group II was significantly higher in:

- **right P2 PBT with (0.77 ± 0.16) mean difference as P=0.0001.**
- **Left P2 BBT with (0.62 ± 0.16) mean difference as P=0.001**
- **Left C PBT with (0.71 ± 0.24) mean difference as P=0.01**

Table (3): Mean and standard deviation of difference between pre and post dentoalveolar linear measurements of group I & II, comparison using Mann Whiteny`s test:

Difference linear	Dentoalveolar	Group I		Group II		Difference				
						Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference		P value
		Mean	Std. Deviation	Mean	Std. Deviation			Lower	Upper	
Right	M1 MBBT (mm)	0.06	0.38	-0.24	0.18	0.30	0.14	0.00	0.59	0.048
	M1 DBBT (mm)	-0.09	0.32	0.02	0.13	-0.12	0.12	-0.36	0.13	0.329
	M1 PBT (mm)	0.68	0.36	-0.01	0.05	0.69	0.12	0.43	0.94	0.000
	P2 BBT (mm)	-0.03	0.53	0.09	0.38	-0.12	0.22	-0.59	0.34	0.589
	P2 PBT (mm)	0.54	0.29	-0.23	0.39	0.77	0.16	0.43	1.12	0.000
	P1 BBT (mm)	-0.34	0.23	0.13	0.07	-0.47	0.08	-0.63	-0.30	0.000
	P1 PBT (mm)	0.21	0.18	-0.48	0.82	0.69	0.28	0.10	1.29	0.025
	C BBT (mm)	-0.10	0.17	0.23	0.41	0.33	0.14	0.01	0.64	0.041
	C PBT (mm)	0.08	0.14	-0.54	1.26	0.63	0.42	-0.27	1.52	0.157
Left	M1 MBBT (mm)	-0.52	0.59	0.10	0.26	-0.62	0.22	-1.08	-0.17	0.010
	M1 DBBT (mm)	-0.41	0.56	0.46	0.38	-0.88	0.22	-1.35	-0.40	0.001
	M1 PBT (mm)	0.60	0.35	0.65	0.38	-0.05	0.17	-0.41	0.31	0.770
	P2 BBT (mm)	-0.39	0.44	0.24	0.20	-0.62	0.16	-0.97	-0.28	0.001
	P2 PBT (mm)	0.52	0.17	0.06	0.64	0.46	0.22	0.00	0.93	0.051
	P1 BBT (mm)	-0.30	0.18	0.00	0.38	-0.31	0.14	-0.60	-0.01	0.043
	P1 PBT (mm)	0.20	0.24	-0.39	0.37	0.59	0.15	0.28	0.90	0.001
	C BBT (mm)	0.05	0.12	0.09	0.64	-0.05	0.22	-0.51	0.41	0.825
	C PBT (mm)	-0.11	0.44	-0.81	0.58	0.71	0.24	0.19	1.23	0.010

M: mean SD: standard deviation MD: mean difference SED: standard error difference
*CI: confidence interval L:Lower arm U: upper arm *Significant difference as P<0.05.4*
Mean with the same superscript letters were insignificantly different as P>0.05.
Mean with different superscript letters were significantly different as P<0.05.

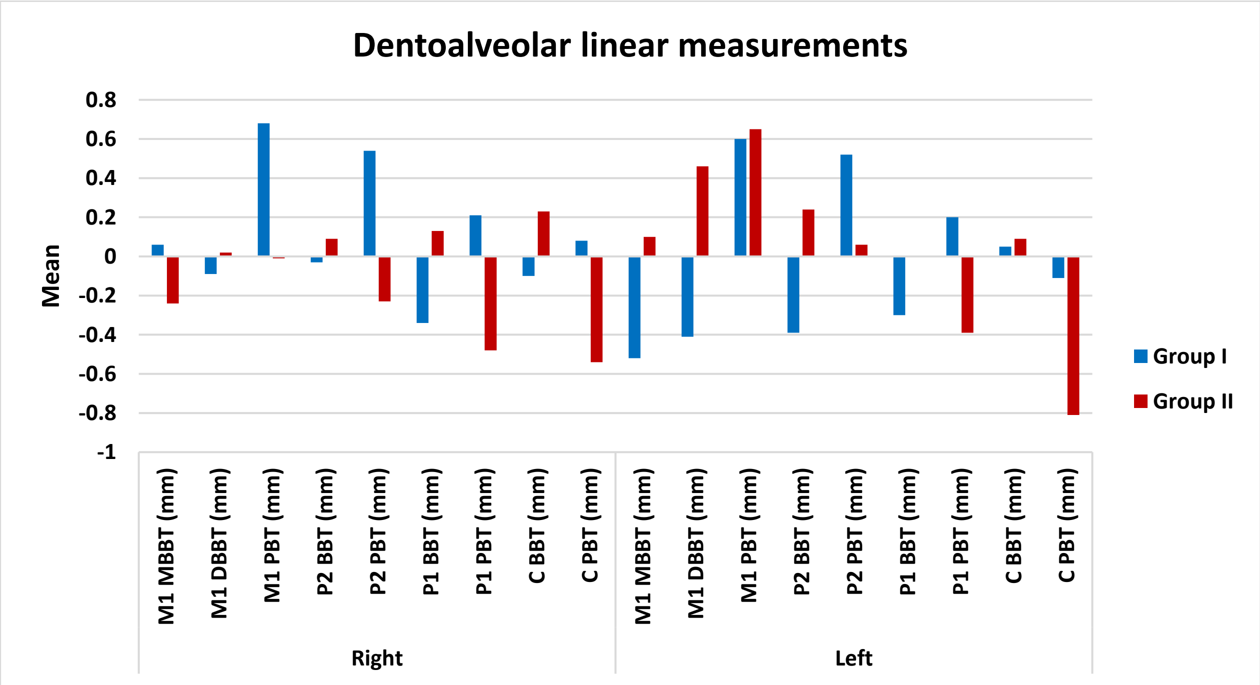

Figure 15: bar chart showing difference between pre and post dentoalveolar linear measurements of group I & II.

4-Dentoalveolar Angular measurements

There was a significant difference between both groups in left P1 AI: Group I with (5.06 ± 1.67) mean difference as P=0.008.

Table (4): Mean and standard deviation of difference between pre and post dentoalveolar angular measurements of group I & II, comparison using Mann Whiteny`s test:

Difference Dentoalveolar angular		Group I		Group II		Difference				
						Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference		P value
		Mean	Std. Deviation	Mean	Std. Deviation			Lower	Upper	
Right	M1 AI (°)	5.38	6.39	4.48	4.11	0.89	2.53	-4.48	6.26	0.729
	P1 AI (°)	5.83	3.77	0.77	3.31	5.06	1.67	1.52	8.60	0.008*
left	M1 AI (°)6	6.98	6.30	4.14	3.04	2.84	2.33	-2.10	7.78	0.241
	P1 AI (°)7	7.35	5.11	2.65	6.41	4.70	2.73	-1.09	10.49	0.105

M: mean SD: standard deviation MD: mean difference SED: standard error difference
CI: confidence interval L:Lower arm U: upper arm
**Significant difference as P<0.05.*
Mean with the same superscript letters were insignificantly different as P>0.05.
Mean with different superscript letters were significantly different as P<0.05.

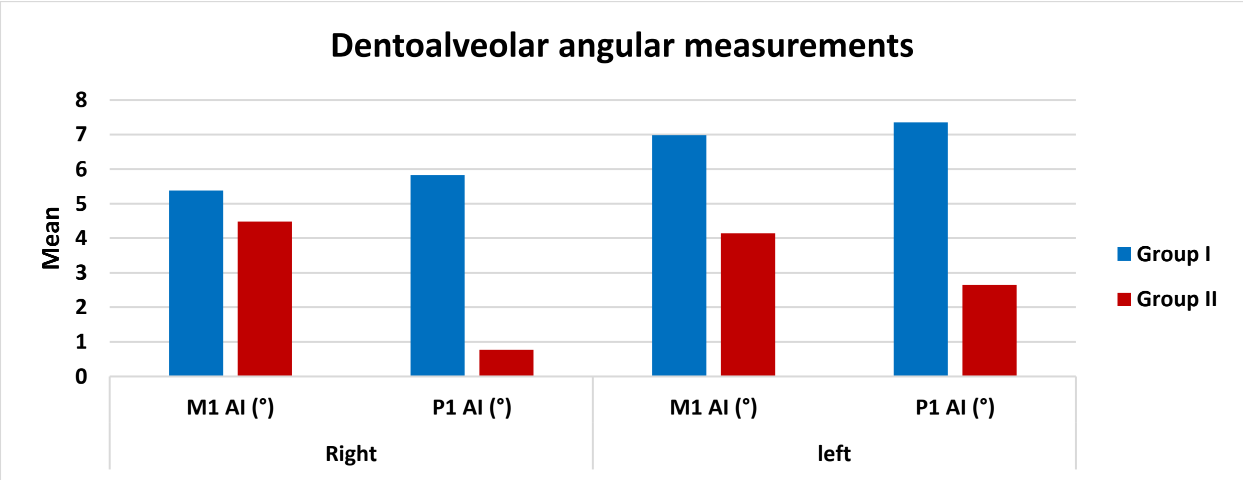

Figure 16: bar chart showing difference between pre and post dentoalveolar angular measurements of group I & II.

5-Skeletal linear measurements
There was a significant difference in:

Group II was significantly lower in:

- **Med: with (1.73 ± 0.79) mean difference as P=0.04.**
- **Lt PNS to max. sag. Plane with (0.36 ± 0.05) mean difference as P=0.0001.**

Table (5): Mean and standard deviation of difference between pre and post skeletal linear measurements of group I & II, comparison using Mann Whitney's test:

difference Skeletal Linear	Group I		Group II		Comparison				
					Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference		P value
	MD	SD	MD	SD			Lower	Upper	
dist. Rt. & Lt. Prosthion	2.52	0.55	2.56	0.95	-0.04	0.37	-0.81	0.74	0.920
ANT	2.11	0.68	2.41	1.18	-0.30	0.45	-1.26	0.67	0.525
MED	3.20	2.27	1.48	0.66	1.73	0.79	0.05	3.40	0.044*
POST	1.20	1.13	0.68	0.65	0.53	0.44	-0.40	1.45	0.245
AP	2.60	0.98	1.85	0.94	0.75	0.45	-0.21	1.71	0.119
PP	2.30	0.54	3.95	4.39	-1.65	1.47	-4.77	1.48	0.280
Rt ANS to max. sag. plane	1.00	0.65	1.30	1.02	-0.30	0.40	-1.15	0.55	0.468
Lt ANS to max. sag.plane	1.10	0.40	1.10	0.21	0.00	0.15	-0.32	0.32	1.000
Rt PNS to max. sag. Plane	0.80	1.20	0.64	0.67	0.16	0.46	-0.81	1.14	0.728
Lt PNS to max. dag. Plane	0.40	0.15	0.04	0.06	0.36	0.05	0.25	0.48	0.0001*
NF	0.20	2.27	0.90	0.52	-0.70	0.78	-2.35	0.95	0.381
MW (mm)	3.79	1.73	2.80	2.92	0.98	1.13	-1.42	3.38	0.397
PMW (mm)	3.01	1.31	1.81	2.39	1.20	0.91	-0.73	3.13	0.205
IPD (mm)	0.20	0.29	0.28	0.44	-0.08	0.18	-0.45	0.30	0.666

M: mean SD: standard deviation MD: mean difference SED: standard error difference
CI: confidence interval L:Lower arm U: upper arm
*Significant difference as P<0.05.
Mean with the same superscript letters were insignificantly different as P>0.05.
Mean with different superscript letters were significantly different as P<0.05.

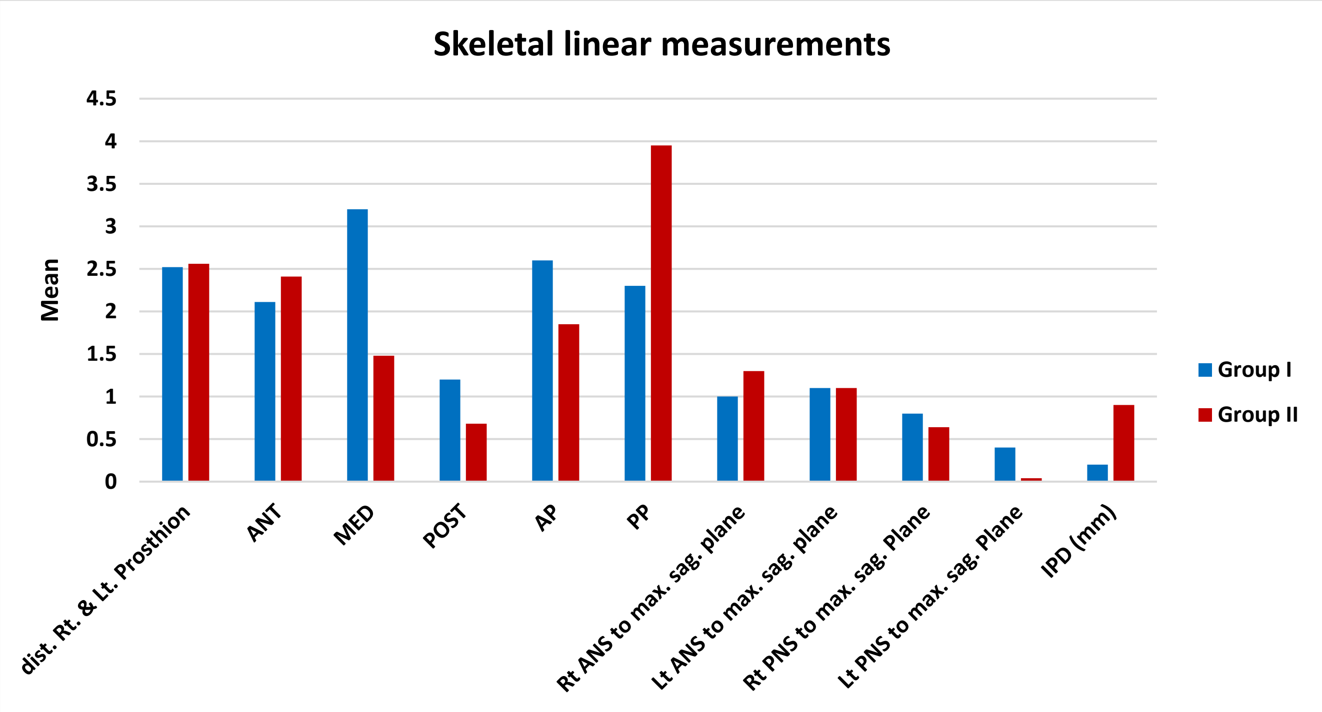

Figure 17: bar chart showing difference between pre and post skeletal linear measurements of group I & II.

Discussion

Dental linear results show greater increase in transverse widths in Group I in most points. On the level of the first permanent molars, the increase was comparable being higher in Group I showing more dental tipping but the differences were insignificant.

Significant differences were seen at the second premolar buccal and palatal widths, being higher in Group I; probably due to the buccal forces exerted on the second premolar by the palatally connecting bar between the molar and first premolar bands.

The first premolar buccal, palatal and apical widths was significantly different between both groups. This can be explained by the rigid connection of the jackscrew device with the first premolars in Group I, as opposed to Group II where there is no force applied on them.

In both groups, the canine apical width had increased more than the canine cusp width with a more palatal tipping pattern in Group I while Group II showed more bodily movement. The difference between both groups was statistically significant.

The increase in width from the molar area posteriorly to the canine area anteriorly in both groups indicates a more parallel dental expansion in Group I and a reverse ‘v’ pattern in Group II, coinciding with the findings of **Rungcharassaeng et al (2007)**(11) **Gunyuz et al (2015)** (12) but in contrast to **Ngan et al (2011)**(13) where a ‘V’ shaped expansion pattern was seen.

Dental angular measurements reveal increased tipping of the first molars, second and first premolars and canines in Group I; a predictable result for the tooth-borne appliance. In Group II, the posterior teeth have increased slightly in their buccal angulation, but decreased in the case of the canines. These were explained by **Gunyuz et al (2015)**(12) to be the result of the buccal musculature resisting the buccal movement.

The increase in dental angulation of the left molar and first premolar was more than the right side in Group II. This is in contrast to the findings of **Carlson et al (2016)** (14) whose results showed higher increase in inclination of these teeth on the right side.

Statistically significant differences were found with the right second premolar and canine and the left first and second premolar inclinations.

In Group I, the dentoalveolar linear measurements show a general decrease in buccal bone thickness of the posterior teeth and the right canine, with the exception of the mesiobuccal bone thickness of the upper right first molar and the buccal bone thickness of the upper left canine.

With statistically significant decreases of the buccal bone thickness of the right and left first premolars, the upper left second premolar and first molar. And significant increases in the palatal thickness of the upper posterior teeth; indicating tooth movement through the alveolar bone in a buccal direction.

In Group II, an increase in the buccal bone thickness and a decrease in the palatal bone thickness is seen, with the exception of the palatal bone thickness of the upper left second premolar and the mesiobuccal bone thickness of the upper right first molar.

Statistically significant increases were found in the palatal bone thickness of the upper left molar and the buccal bone thickness of the upper right premolar, upper left second premolar and the distobuccal area of the upper first molar; suggesting movement of the teeth in the palatal direction through the alveolar bone, thus, implying that the separation forces were mostly transmitted to the skeletal element, evident in the achievement of the crossbite correction with apparent inward movement of the posterior teeth.

Buccal inclination of the dentoalveolar structure of the first premolar and the first molar in Group I was higher, and statistically significant, which is a reflection of the increased buccal tipping.

The increases in Group II were found to be insignificant. A significant difference was seen in the right premolar alveolar inclination between the two groups, supporting the bodily pattern of tooth movement produced by the Hybrid device.

In both groups, separation at the right and left Prosthion points -clinically seen as a midline diastema- in relation to the separation between the right and left anterior nasal spine points was in a reverse ‘V’ pattern; with more separation occurring at the Prosthion points. This was more pronounced in Group I implying more expansion on the dental level with increased tipping of the dental and alveolar structures. Group II showed more maxillary skeletal separation had occurred with a more parallel pattern, conforming with the findings of **Gunyuz et al (2015)**(12) and **Ludwig et al (2013)**(15).

There were insignificant differences between the separation at ANT and the POST points, but there was a significant statistical difference at the MED point, giving a Diamond shaped separation pattern in Group I with the widest diameter being at the MED area were the premolar bands are located. Group II showed a more uniform albeit slightly ‘V’ shaped progressing from the Anterior to the Posterior area. This pattern difference is explained by **Guerrero-Vargas et al (2019)**(16) who concluded that sutural interdigitation did not have an effect on the displacement but its geometry was affected by the areas at which the forces were applied, this explains and coincides with the findings of this study, but the pattern of expansion in Group II was in contradiction to their findings. This may be due to the design of their study model and their use of four miniscrews with a bilateral anterior and posterior configuration.

The separation at AP (anterior palate) measured between the external walls of the incisive foramen show higher values in Group I. This can be explained by the distance between the points of force application from the centers of resistance of the right and left maxillary halves; as it is a tooth-borne device, producing a rotational effect, adding to the linear distance of those points.

Lower values are seen at the AP points in Group II, this can be explained also by the forces applied in the anterior portion of the palate are transmitted through mini-screws which are closer to the center of resistance of the maxillary complex, reducing their rotation.

The separation that occurred at PP (posterior palate) measured between the external walls of the palatal foramina, was higher in Group II, producing more posterior separation. However, these differences between the two groups were statistically insignificant.

The amount of separation between the right and left ANS and PNS to the Maxillary Sagittal plane as defined by **Cantarella et al (2017)**(17) shows asymmetrical expansion happening more on the right side, which is in accordance with the previously mentioned author's findings. The reason for this asymmetry was said to be unknown but could be the result of factors such as the presence of a unilateral cross bite that might pose a hinderance to the movement of the palatal bone, the circummaxillary sutures that might not respond in the same proportions on both sides, and this might also be as a result of differences in the morphology and density of the zygomatic buttress.

The IPD (Interpterygoid Distance) increase was similar in both groups, only slightly more in Group II as was the findings of **Gunyuz et al (2015)**(12).

The maxillary width measurements at the NF points were found to be higher in Group II, whereas the Maxillary width (MW) was found to be increased in Group I this was explained to be due to the lateral rotation of the maxillary halves with the fulcrum being closer to the NF area at the frontomaxillary suture. These difference between the two groups were insignificant. These findings were in accordance with the findings of **Garib et al (2005)**(18).

Conclusions

1. **Sutural separation was possible at the post-adolescent stage with the Hyrax and Hybrid appliances.**
2. **Expansion results were comparable in both groups, but The Hybrid appliance had qualitatively better expansion pattern with less unwanted dental and alveolar effects.**

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