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Cone beam computed tomography study on changes of monocortical versus bicortical miniscrews assisted palatal expansion

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Abstract

Objective: *To compare dental treatment results of using Mono and Bicortical Hybrid Hyrax appliances in late-adolescent patients using CBCT scans.*

Materials and Methods: *A total of 16 patients, ages 18 to 21, who had maxillary skeletal crossbite, were chosen. They were then randomly assigned to have treatment with a monocortical hybrid hyrax or a bicortical hybrid hyrax appliance that used palatal miniscrews with either a monocortical or bicortical engagement. The digital method used to create the hybrid appliances combined CBCT and intraoral digital images, which were then used to position miniscrews virtually and create a surgical guide utilizing 3D printing. The activation techniques were the same for both groups. Every patient had CBCT scans both before and after therapy. These were employed to contrast dental outcomes. The Shapiro-Wilk Normality Test, Kolmogorov Test, and Paired T Test between the pre- and post-treatment outcomes were used to statistically assess the resultant data.*

Results: *Transverse dental linear measurements was successful in both groups as there was no statical significance except, in M1 AW (mm) as Group I (3.16 ± 0.72) was significantly lower than Group II (5.48 ± 1.78) with (2.32 ± 0.68) difference as P=0.0001.*

Conclusions: *Transverse interdental expansion was possible at the late-adolescent stage with Hybrid Hyrax appliances either mono or bicortical group. Expansion results were comparable in both groups.*

Keywords: *Palatal Expansion; Miniscrews; crossbite.*

Introduction

In the majority of populations, maxillary transverse deficiency is a prevalent problem. According to certain sources, it represents 30% of adult orthodontic patients and 9.4% of the population (11). It presents as crowding, a V-shaped arch, unilateral or bilateral crossbite malocclusion, and it may contribute to breathing and air way problems.

Research has indicated that palatal expansion is more effective in younger patients because the palatal suture has not experienced as much interdigitation as it does during adolescence (15). Subsequent research revealed that the pterygoids, zygomatic buttresses, and piriform aperture were the sources of resistance to expansion (2), whereas the midpalatal suture remained in a "non-mature" state until late adolescence (9).

As an alternative for adult patients who prefer not to have surgery, miniscrew assisted rapid palatal expansion (MARPE) has been created to transfer stresses directly to the skeletal component while avoiding the dental and alveolar adverse effects of tooth-borne devices (17).

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Studies have shown no discernible variations between the expansion generated by a bone-anchored expander and one that is carried by teeth anchored expanders only (3). Also, bi-cortical engagement in the palate was reported to have fewer adverse effects than mono-cortical engagement in a study on miniscrew cortical engagement (12).

Given the results of this earlier research, it appeared worthwhile to look more closely at the distinctions between the effects of the monocortical hybrid Hyrax appliance and the bicortically engaged bone-anchored hybrid appliance.

Materials and Methods:

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

Sample size was determined using the reference value of a prior study (16). The study required a minimum of 7 individuals in each group at 80% power and a type I error probability of 0.05. To account for, the total sample size was increased to 8 patients each group and the total sample size was 16 patients for the sum of group I and group II. G. power 3.1.9.7 was used to perform the independent t test for sample size.

The study's participants were compliant with the following: being in good physical and dental health. No permanent teeth that were extracted or missing. No prior orthodontic treatment. Patients with posterior crossbite and maxillary constriction between the ages of 18 and 21.

Pre-expansion stage (T0) full skull cone beam computed tomography scans were obtained using Scanora® 3D (*Scanora, Soredex, Palodex Group Oy, Nahkelantie 16, Finland*) with 90 kvp, 10mA, and a field of view (FOV) of 180 x 165 mm with 0.3 mm voxel size resolution. The first scan was taken to ensure skeletal transverse discrepancy and was repeated after the expansion was finished (T1). Digital Imaging and Communications in Medicine (DICOM) format was exported and then images were applied to (*Blue Sky Bio, LLC's Blue Sky Plan software version 4.9.4.).* Then patients were prepared for appliance customisation, and the following actions were to be conducted based on whatever monocortical or bicortical hybrid hyrax group they had been assigned to.

Using an intraoral scanner Medit i700 (*MEDIT CORP, Seoul, Republic of Korea*), digital study models of the upper arch were obtained in (STL) format, including the palate. This allowed for the digital design and fabrication of the surgical guide, which was necessary for the precise placement of the miniscrews in both expander groups (figure1).

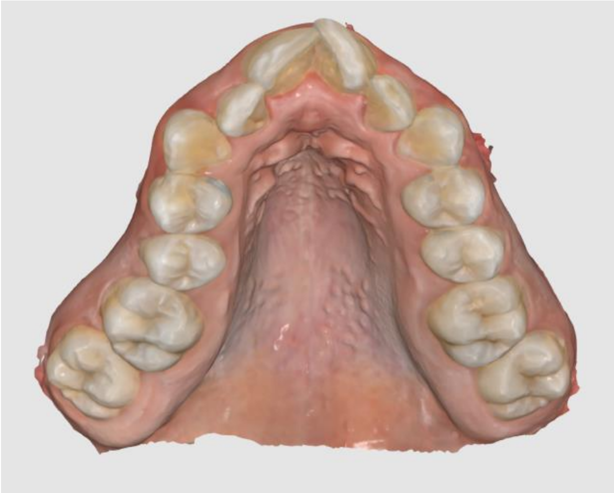


Figure 1 Intraoral scan

1- Surgical guide plan:

Using Blue Sky Bio, the intraoral scan (STL file) and CBCT (DICOM files) of the upper jaw were superimposed to provide an exact representation of the soft tissue at the palatal insertion location as well as the teeth's occlusal surface for a true guide seated on it. The surgical guidance module's software automatically aligned the files (figure2).

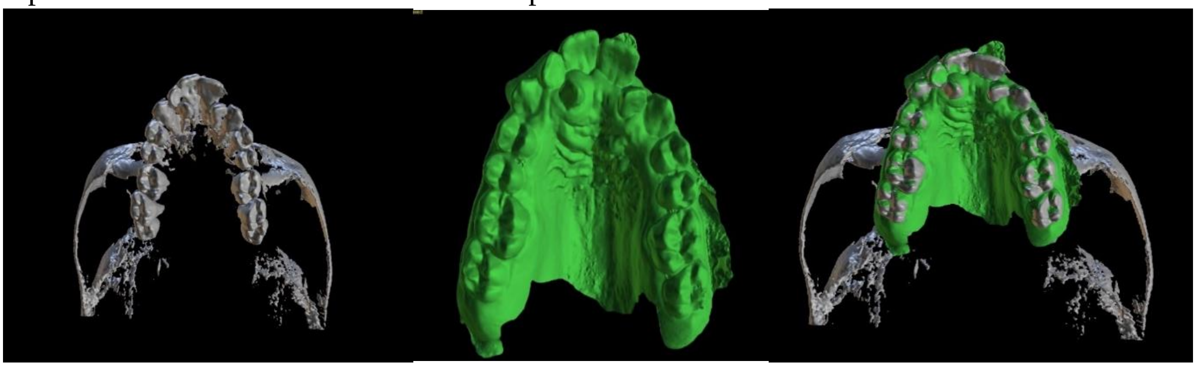


Figure 2 superimposition of DICOM and STL

Subsequently, the positions and angles of the two miniscrews were virtually chosen, usually in regions with sufficient bone density that will optimally support and hold the miniscrews while adhering to the intended design. In addition, to achieve the appropriate cortical penetration miniscrew position (figure3).

Figure 3 Miniscrews positioning and planning

The diameter of the miniscrews utilized in this investigation (*Tomas® temporary anchorage system, DENTAURUM Gmbh&Co, Germany*) was 1.6 mm for all patients, whereas the length of the screws ranged between 8 and 10 mm. The screws were intended to be positioned lateral to the midpalatal sutures in the premolar region (figure 4).

Figure 4 Miniscrews planning in premolar area

2-Guide 3D printing:

Using a laser sintering 3D printer (*Phrozen Sonic Mighty 4k resin 3D printer*) and serentek 3D resin printer (*SENERTEK ENERJİ OTOMASYON LTD. TÜRKİYE*) for the production of the surgical guide, each patient received a customized guide that would help with the precise insertion of the miniscrews. Then 3D printed guide was checked for fitting.

3-Miniscrew placement:

The surgical guide was positioned and anaesthesia was administered. A pilot drill was used to overcome the cortical resistance. Using contra angle driver, the miniscrews were placed (figure5).

Figure 5 miniscrew insertion through the 3D printed guide

4-Hybrid expander fabrication:

Rubber base impression material was used to take impressions of the palate and upper jaw utilizing transfer caps over the miniscrew heads. The dental laboratory technician received the impression in order to build the hybrid device (figure 6).

Figure 6 (rubber base impression by the use of transfer caps)

To create models with the miniscrews in the proper angulations, identical miniscrews were inserted into the transfer caps and the impressions were poured. The miniscrew heads were covered with abutment tubes. The jackscrew was finished and polished after its anterior arms were crimped into the abutment tubes and its posterior arms were soldered to the molar band (figure7).

Figure 7 final hybrid expander ready

5-Hybrid Hyrax delivery and opening:

The upper molars were etched, then flush etch with copious water. After air drying, resin band cement was used to cement the appliance. Activation protocol was same for both groups either mono or bicortical twice turns daily until opened diastema appears then down to one turn daily. After achieving the expansion, the jackscrew device was sealed with flowable resin and left in place as a retainer for three months (Figure 8).

Figure 8 pre and post expansion

Post-expansion CBCT were taken of the patients after the expansion (at least 3 months from the first one) and dental changes on both pre and post scans were compared.

Parameters

An independent radiologist measured both group 1 and group 2 pre- and post-CBCT scans. Dental linear and angular values were measured and measurements were repeated after 2 weeks.

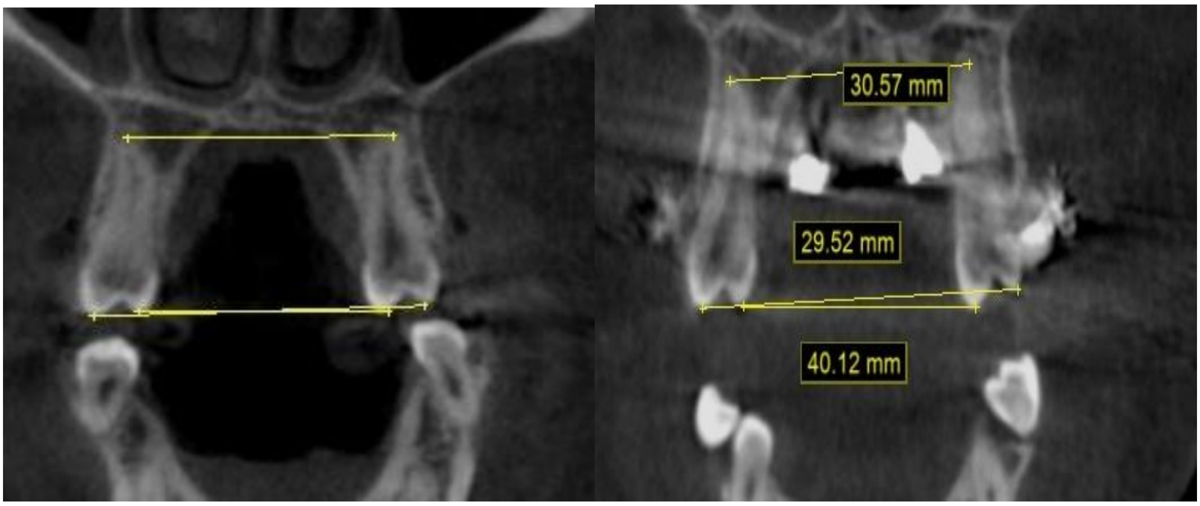
1. Dental linear measurements:

Table (1): Dental linear measurements:

M1 BW (Intermolar buccal cuspal width)	The linear distance measured from the mesiobuccal cusp tips of the right to the left first molars
M1 PW (Intermolar palatal cuspal width)	The linear distance measured from the mesiopalatal cusp tips of the right to the left first molars
M1 AW (Intermolar apical width)	The linear distance measured from the palatal root apex of the right molar to the palatal apex left first molar
P2 BW (Inter second premolar buccal cuspal width)	The linear distance measured from the buccal cusp tip of the right second premolar to the left second premolar
P2 PW (Inter second premolar palatal cuspal width)	The linear distance measured from the palatal cusp tips of the right second premolar to the left second premolar
P2 AW (Intersecond premolar apical width)	The linear distance measured from the root apex of the right second premolar to the left second premolar
P1 BW (Inter first premolar buccal cuspal width)	The linear distance measured from the buccal cusp tip of the right first premolar to the left first premolar
P1 PW (Inter first premolar palatal cuspal width)	The linear distance measured from the palatal cusp tips of the right first premolar to the left first premolar
P1 AW (Inter first premolar apical width)	The linear distance measured from the root apex of the right first premolar to the left first premolar
C CW (Inter canine cuspal width)	The linear distance measured from the cusp tip of the right canine to the cusp tip of the left canine
C AW (Inter canine apical width)	The linear distance measured from the root apex of the right canine to the root apex of the left canine

(A) **(B)**

Figure 9 Coronal cone-beam computed tomographic curs acquired (a) before and (b) after expansion during 1st molar buccal cusp expansion, 1st molar palatal cusp expansion, 1st molar palatal roots expansion, and buccal maxillary width measurement.



(A) **(B)**

Figure 10 A coronal cut during the 1st premolar buccal cusp expansion, 1st premolar palatal cusp expansion, and 1st premolar palatal root apical expansion measurement: A) before expansion, B) after expansion

Statistical Analysis:

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

- Normality exploration of data by using Shapiro Wilk Normality test and Kolmogorov test.
- Comparison between different groups was performed by using Man Whitneys test.
- Comparison between pre and post was performed by using Paired t test.

RESULTS

I-Dental linear measurements:

1-Group I:

Table (3): Mean and standard deviation of before and after dental linear measurements in group I:

Dental Linear measurements	Before		After		Difference					
	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation	Std. Error Mean	95% Confidence Interval of the Difference: Lower	95% Confidence Interval of the Difference: Upper	P value
M1 BW (mm)	44.52	4.35	51.12	3.69	6.60	1.17	0.41	5.62	7.58	0.0001*
M1 PW (mm)	32.68	2.68	39.26	2.32	6.59	1.34	0.47	5.47	7.70	0.0001*
M1 AW (mm)	26.23	3.14	29.39	2.96	3.16	0.72	0.25	2.56	3.76	0.0001*
P2 BW (mm)	40.67	2.30	44.67	3.27	4.00	1.28	0.45	2.93	5.07	0.0001*
P2 PW (mm)	31.03	3.52	34.90	3.70	3.87	0.81	0.29	3.19	4.55	0.0001*
P2 AW (mm)	32.44	2.94	34.55	3.29	2.11	1.43	0.51	0.92	3.31	0.004*
P1 BW (mm)	34.64	3.24	38.15	3.05	3.51	1.12	0.39	2.57	4.44	0.0001*
P1 PW (mm)	24.85	2.85	28.12	3.15	3.28	0.90	0.32	2.52	4.03	0.0001*
P1 AW (mm)	27.04	3.69	29.19	3.83	2.15	0.99	0.35	1.33	2.98	0.0005*
C CW (mm)	29.54	6.02	31.07	5.67	1.53	0.65	0.23	0.98	2.07	0.0003*
C AW (mm)	22.71	2.89	24.42	3.34	1.72	1.35	0.48	0.59	2.84	0.0088*

**Significant difference as P<0.05.*

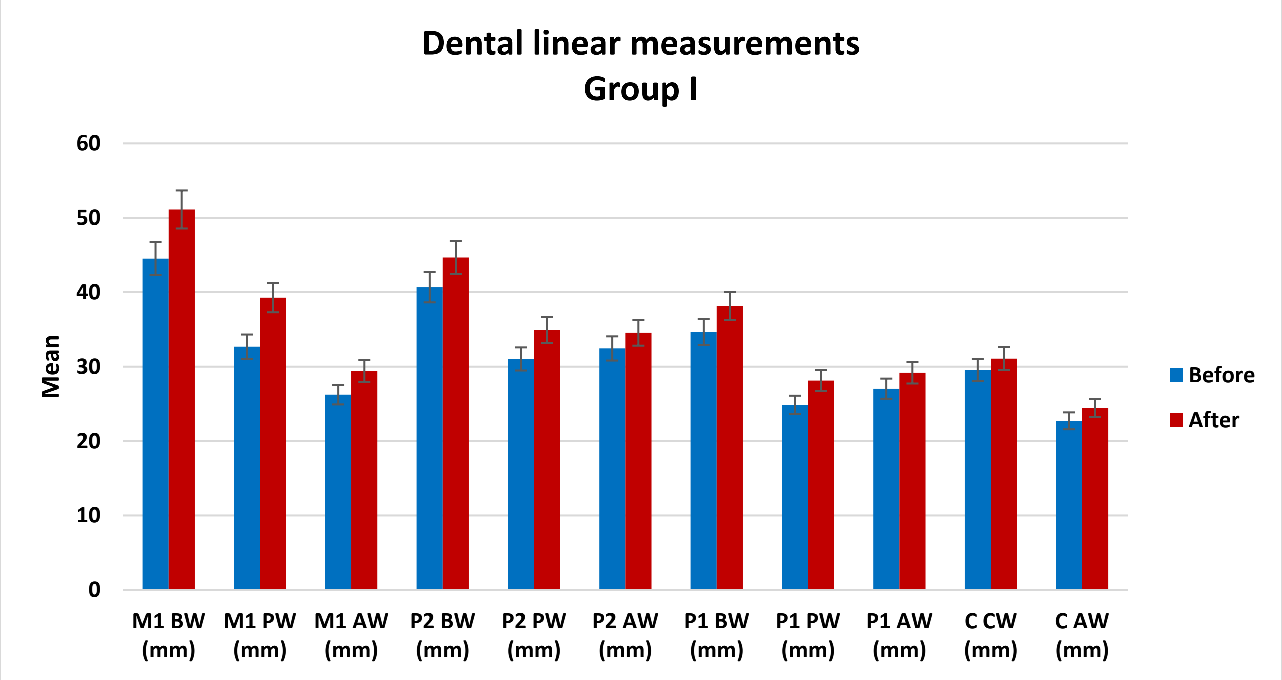


Figure (12): bar chart showing before and after dental linear measurements in group I.

2-Group II:

Table (4): Mean and standard deviation of before and after dental linear measurements in group II:

Dental Linear measurements	Before		After		Difference					
					Mean	Standard Deviation	Std. Error Mean	95% Confidence Interval of the Difference		P value
	Mean	Standard Deviation	Mean	Standard Deviation				Lower	Upper	
M1 BW (mm)	42.74	1.19	51.18	4.67	8.44	3.51	1.24	5.51	11.37	0.0001*
M1 PW (mm)	30.71	2.21	38.89	4.80	8.18	2.63	0.93	5.98	10.38	0.0001*
M1 AW (mm)	26.06	1.12	31.54	2.90	5.48	1.78	0.63	4.00	6.97	0.0001*
P2 BW (mm)	38.68	3.85	45.20	6.29	6.52	2.44	0.86	4.48	8.56	0.0001*
P2 PW (mm)	28.50	3.44	34.52	5.95	6.01	2.52	0.89	3.91	8.12	0.0001*
P2 AW (mm)	32.40	1.95	34.45	1.76	2.06	0.98	0.35	1.23	2.88	0.001*
P1 BW (mm)	35.41	2.26	38.95	4.39	3.54	2.56	0.91	1.39	5.68	0.006*
P1 PW (mm)	24.17	2.72	27.25	3.63	3.08	1.05	0.37	2.20	3.96	0.0001*
P1 AW (mm)	25.73	3.74	27.59	2.79	1.86	1.17	0.42	0.88	2.84	0.003*
C CW (mm)	28.39	1.77	30.34	2.25	1.96	0.70	0.25	1.38	2.54	0.0001*
C AW (mm)	18.90	1.44	20.32	1.31	1.42	0.74	0.26	0.80	2.04	0.001*

**Significant difference as P<0.05.*

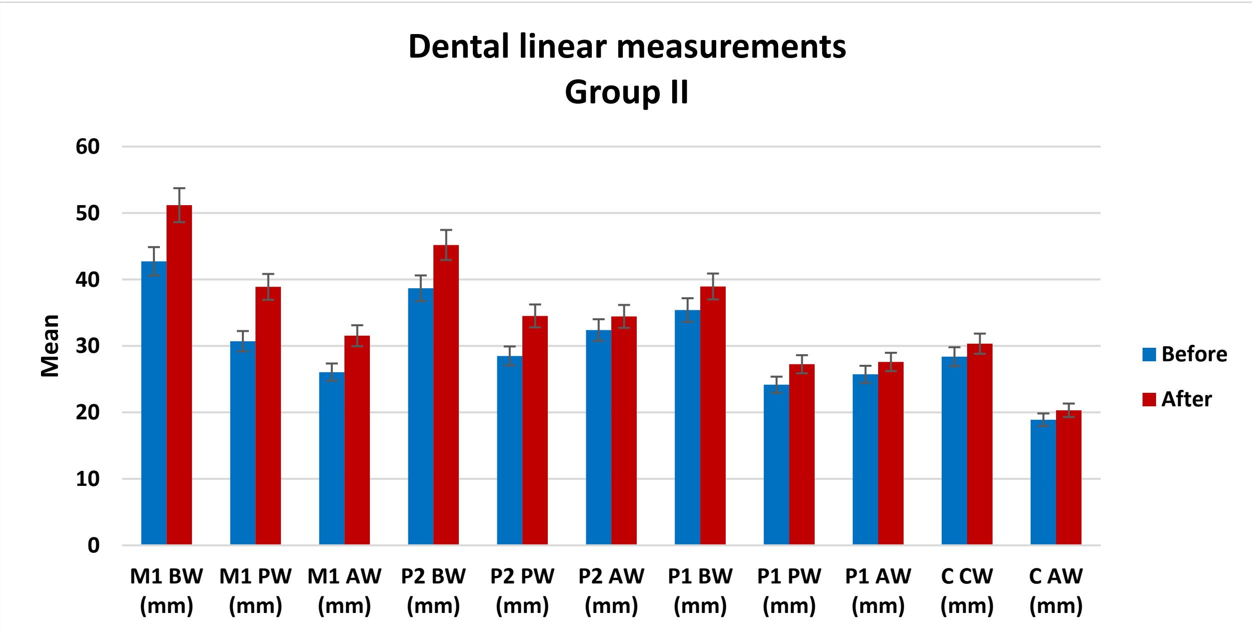


Figure (13): bar chart showing before and after dental linear measurements in group II.

3-Comparison between groups:

Mean difference and standard deviation of difference between pre and post dental linear measurements in group I & II were presented in table (3) and figure (3) Comparison between Group I & II measurements was performed by using Mann Whiteny`s test which revealed that there was insignificant difference between groups in all measurements (P>0.05) except in M1 AW (mm) as Group I (3.16 ± 0.72) was significantly lower than Group II (5.48 ± 1.78) with (2.32 ± 0.68) difference as P=0.0001.

Table (5): Mean difference and standard deviation of difference between before and after dental linear measurements in group I &II:

Dental Linear measurements	Group I		Group II		Difference				
	Mean	Standard Deviation	Mean	Standard Deviation	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference		P value
							Lower	Upper	
M1 BW (mm)	6.60	1.17	8.44	3.51	1.84	1.31	-4.64	0.97	0.32
M1 PW (mm)	6.59	1.34	8.18	2.63	1.59	1.04	-3.83	0.64	0.70
M1 AW (mm)	3.16	0.72	5.48	1.78	2.32	0.68	-3.77	-0.87	0.0001*
P2 BW (mm)	4.00	1.28	6.52	2.44	2.52	0.97	-4.61	-0.43	0.08
P2 PW (mm)	3.87	0.81	6.01	2.52	2.14	0.94	-4.15	-0.13	0.44
P2 AW (mm)	2.11	1.43	2.06	0.98	0.06	0.61	-1.26	1.37	1.00
P1 BW (mm)	3.51	1.12	3.54	2.56	0.03	0.99	-2.15	2.09	0.95
P1 PW (mm)	3.28	0.90	3.08	1.05	0.19	0.49	-0.86	1.25	0.87
P1 AW (mm)	2.15	0.99	1.86	1.17	0.29	0.54	-0.87	1.45	0.57
C CW (mm)	1.53	0.65	1.96	0.70	0.43	0.34	-1.15	0.29	0.16
C AW (mm)	1.72	1.35	1.42	0.74	0.29	0.54	-0.87	1.46	0.99

**Significant difference as P<0.05.*

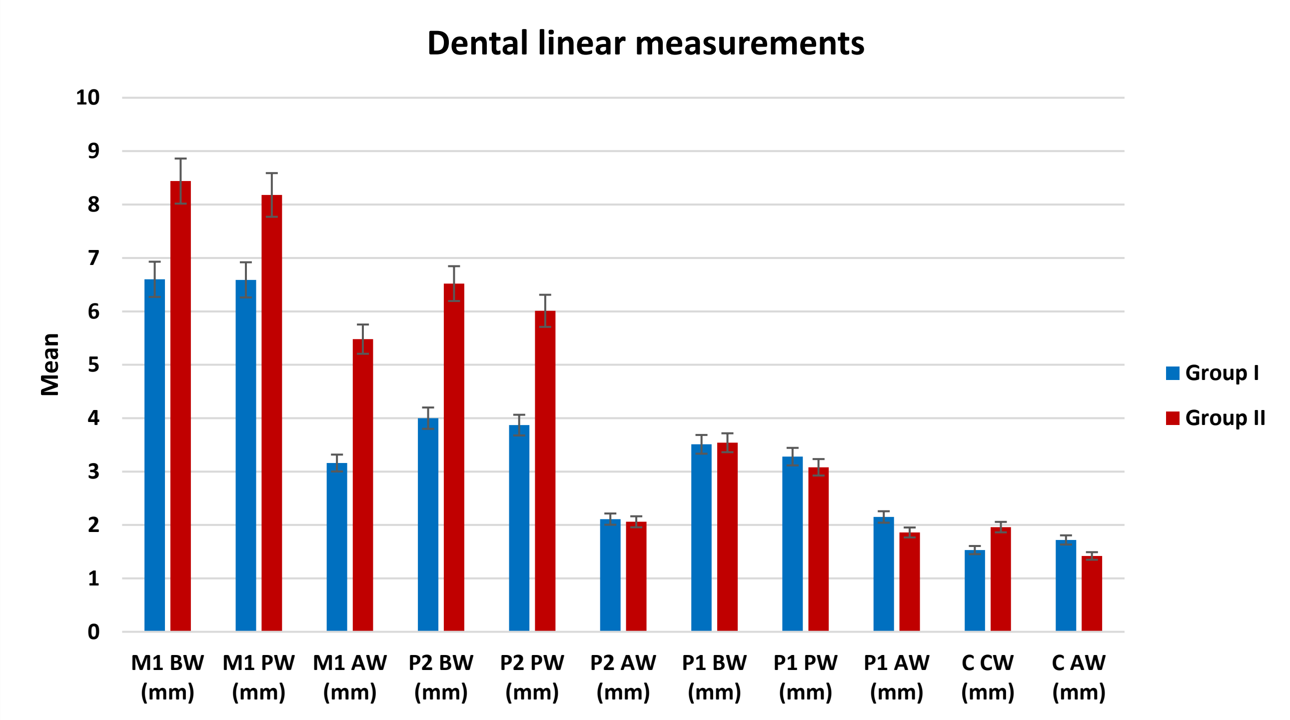


Figure (14): bar chart showing before and after dental linear measurements in group I & II

Discussion

Because the orthodontic literature contains little information on the effects of tooth-bone-borne RME, the goal of this study was to assess the dental responses of hybrid hyrax expanders by using monocortical or bicortical miniscrews hybrid hyrax (14,18)

In recent previous studies that used Computed Tomography or CBCT to work on effects of RME either tooth or tooth-bone anchored instead of conventional measuring methods that had a lot of limitations, as superimposition limitation, landmarks identification could be a challenge, 2D representation of 3D structure and capture the same of head position in reproducible manner (1,6,7).

The choice of when to conduct RPE is becoming more and more significant because it is based on the developmental stage of the subject. The palatine and circum-maxillary sutures in developing subjects offer the least resistance to expansion forces, hence decreasing the reaction force directed toward the anchor units and increasing the correction of skeletal discrepancies (11).

Furthermore, it is generally accepted that addressing restricted maxilla in people under the age of 15 is best handled with standard RPE (5,15). The purpose of the current study was to determine whether placing miniscrews as anchor units in the monocortical (palatal cortex) or bicortical (involving both the nasal and palatal cortex) would be advantageous for subjects older than 15, as well as to compare the effects of the two penetration types.

A maxillary palatal expander's design includes miniscrews to enhance the device's ability to transfer and redirect the majority of the separation forces to the bone. As a result, the detrimental effects on the oral and alveolar tissues are significantly reduced (11). Specifically at this age range, to have a deeper comprehension of the effects of hybrid Hyrax expanders. This study examined the dental responses of tooth-bone borne expanders (Hybrid Hyrax) with monocortical and bicortical anchorage in late adolescence because there are insufficient studies on the mono or bicortical effect of minis-crews on the expansion results.

With the aid of a 3D printed surgical guide that we planned and created using CAD/CAM technology, we were able to accurately position the miniscrews. The computerized plan for every patient was tailored according to their individual anatomical variations, soft tissue thickness, and bone quality. The accuracy of this procedure was confirmed by **Casseta et al** (4). By employing digital workflow, the ideal place for the mini-screw insertion may be virtually allocated, allowing for the alignment and depth of the screws to be parallel to one another. The 3D printed guide was then used to guide the clinical insertion of the miniscrews (13).

Comparison between pre and post dental linear measurements revealed a significant increase in both Monocortical and Bicicortical Hybrid Hyrax groups. Comparison between the two groups revealed that There was insignificant difference between both groups regarding all measurements as P>0.05, except in M1 AW (mm) as Group I (3.16 ± 0.72) was significantly lower than Group II (5.48 ± 1.78) with (2.32 ± 0.68) difference as P=0. 0001.This means that the expansion was successful in both groups. All interdental measurements rose considerably after enlargement in both groups.

According to **gunyuz et al** (8) results in hybrid hyrax, the expansion of the dental arch with a reverse "V" pattern was seen in the two groups of hybrid hyrax, where the rise in inter-first premolar distances was nearly twice as great as the increase in intermolar distances in monocortical group and a bit more in the bicortical group. **Wilmes et al**. (18) reported a V-shaped expansion that decreased from anterior to posterior, which is in contradiction to our findings. The variations seen between the trials could potentially be attributed to the younger patients' (mean age, 11 years) greater skeletal reaction to the expansion forces generated by the hybrid hyrax in the premolar region.

Lagravère et al (10) used CBCT to evaluate the bone-supported expander to the conventional tooth-supported expander (hyrax). The skeletal, alveolar, and dental effects of the two expanders were found to be equivalent in the transverse plane; however, because the first premolars are banded, the expansion between them was more pronounced in the tooth-supported expansion group as compared to the bone-supported expansion group. So that’s in agreement with our results in the hybrid hyrax.

Conclusion

1. Transverse interdental expansion was possible at the post-adolescent stage with Hybrid Hyrax appliances either mono or bicortical group.

2. Expansion results were comparable in both groups, but The Bicortical Hybrid appliance was better in inter apical width in first molars that's means less tilt in first molar anchor teeth.

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