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Changes in digital cast measurements related with two types of rapid maxillary expanders, tooth-borne versus hybrid one: A retrospective cohort study

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Abstract---Objectives: This study compared digital study casts from tooth-borne and hybrid Rapid Maxillary Expansion (RME) using 3D virtual models scanned with a 3Shape laser scanner. Methods: A total of thirty patients with narrow maxilla were distributed into two equal groups using sequential randomization. The hybrid hyrax group (11 females and 4 males) had a mean age of 14.5 years, whereas the conventional hyrax group (10 females and 5 males) had a mean age of

13.96 years. Cone beam computed tomography and orthodontic casts were obtained before expansion and six months after the last activation. Eight parameters were measured, and the data was analyzed. Results: A paired t-test was used to evaluate the mean differences between pre-expansion and post-expansion measurements. Interdental distance (IDD) and rotations at first molar and premolars showed a statistically significant increase post-treatment compared to preoperative values, whereas arch depth and incisor inclination showed a statistically significant decrease. Furthermore, group B had statistically significant higher postoperative values and a greater IDD change ($P \leq 0.05$). Conclusion: RME with hybrid hyrax achieved skeletal effects and broaden the arch with only a slight increase in IDD compared to traditional RME. Regardless of the appliance, arch depth may be decreased following RME.

Keywords---Rapid maxillary expansion, palatal expansion, Digital cast, hyrax.

Introduction

With or without posterior crossbite, rapid palatal expansion (RPE) can widen a constricted maxilla.^{1,2} In a growing patient, RPE successfully opens the midpalatal suture using a conventional hyrax(CH).³ Because RPE is frequently coupled with high force⁴, there is a danger of root resorption⁵ and bone dehiscence of the anchored teeth.⁶ Some authors believe that with the introduction of bone-borne maxillary expansion, a few risks to anchored teeth have been avoided^{7,8}, while other studies found no change.⁹⁻¹¹

Miniscrews may be successfully inserted into the anterior palate using direct and 3D-assisted miniscrew insertion techniques. However, using insertion guides makes it easier to assure accurate miniscrew insertion, enabling doctors with less training to do so.¹² Although the relapse following RPE is predicted, the introduction of MARPE and effective retention planning made the recurrence less likely.^{13,14} Because they aid in diagnosis, case presentation, treatment planning, treatment evaluation, medicolegal documentation, evaluation of tooth size, crowding or spacing, overjet, overbite, and Bolton analysis, study casts are a crucial component of orthodontic records.^{15,16}

Previous studies have demonstrated that dental measurements produced from 3D digital models are equivalent to those obtained from conventional models in the three planes of space, require less time, and are one-to-one measurements.¹⁶⁻²⁰ There are still certain restrictions on the capacity to detect and demonstrate adequate precision when accumulating contact intensities in bite registrations, even if the new intraoral scanning approach has the potential to do away with the requirement for impressions and the time necessary to generate models.^{21,22}

Because there is no evidence concerning the differences between a hybrid hyrax (HH) and tooth borne expander²³⁻²⁵, As a result, the goal of this study was to assess changes in digital study casts between two types of RME, tooth borne

versus hybrid expander, using 3D virtual models scanned using a 3Shape laser scanner.

Materials and Methods

The Ethical Committee of Al- Azhar University, Cairo (Boys), Egypt, approved patient involvement in the research project in this retrospective investigation as a secondary outcome from a previous randomised controlled research. 2018/19). The sample was allocated into two equal groups after using sequentially numbered, opaque sealed envelopes (SNOSE)-coded vehicles. After completing this retrospective investigation, new ethics approval (code 793/220) was obtained.

Sample size calculation

Based on the dentoskeletal changes observed in the prior studies [26,27](#) and a maximum intergroup difference of 2.0 mm, the sample size calculation was performed to give 80% test power, a significance level of 0.05, a maxillary width standard deviation of 1.18 mm, a 90% confidence interval, and all other necessary parameters. A sample of fifteen patients was required for each group.

Patient selection

A number of factors were taken into consideration, including: maxillary collapse with a skeletal foundation, unilateral or bilateral posterior crossbite, good oral and general health without any underlying conditions or medications that might affect orthodontic treatment, absence of periodontal disease in the past or present, and a history of prior orthodontic treatment.

The transverse width of the maxilla was measured both clinically and by conventional PA radiography, and only for the selected patients an orthodontic impressions and CBCT were taken.

Thirty-two patients (21 females and 11 males; mean age, 14.2 years) underwent RPE treatment in an out-patient clinic at the Orthodontic Department, Faculty of Dental Medicine, Al-Azhar University, Cairo (Boys), Egypt. The study has been followed the requirements of the Consolidated Standards of Reporting Trials (CONSORT). Using SNOSE -coded vehicles selected by the patient side directly or indirectly, the sample was then arbitrarily divided into two equal groups. The mean age of group A (hybrid hyrax) (11 females and 5 males) was 14.5 years (Y), while group B (conventional hyrax) (10 females and 6 males) had a mean age of 13.96 Y. For full therapy, another consent document was read, understood, and signed by each patient's guardian. 32 patients' CBCT and digital casts data were taken before the expansion and only 30 patients' CBCT and digital casts data were taken six months after the last activation.

Clinical procedures

The hybrid Hyrax expander (group A) was the expansion device; it had two miniscrews manually inserted in the palate behind the third raugae area and an expansion screw soldered or welded to the bands of the maxillary first molar teeth^{[28,29](#)}. In group B, conventional hyrax was used, and the expansion screw was

soldered or welded on the bands of the maxillary first premolar and molar teeth, and it was activated twice daily until the palatal cusps of the maxillary molars came into contact with the buccal cusps of the first mandibular molars, resulting in overcorrection. We obtained post-expansion orthodontic casts.

Outcomes

The primary results of the expansion from CBCT changes in dentoskeletal components were assessed. The CBCT images were examined using Invivo Anatomage version 5.2 (Anatomage, San Jose, California). The assessors were blinded during the analysis, which was conducted by the same observer twice in order to identify the measurement error.

The secondary outcome was comparing the changes between conventional hyrax (CH) and hybrid hyrax (HH) using digital models. By using a 3Shape D500 desktop scanner Red Laser (3shape, Copenhagen, Denmark) (Figure 1), the plaster models were sent to 3dVision Imaging (3dVision Imaging, Cairo, Egypt) for scanning and conversion into 3D virtual models (Figure 2). The virtual files were then exported using the non-proprietary STL open format and imported into the guide module of Ondemand3D, version 1.0 (build1.0.10.5385) Software (Cyber med Inc, Seoul, South Korea) and measurements were taken using the software. The superimposition (Figure 2) using 3rd raugae area with the best fit method^{28,29} In order to register each model, the surface 3-point approach was used. Three points were identified on each model: RP1 (Reference Point 1) close to the first or second premolars (P1&P2) first or second teeth, the posterior part of the midpalatal suture (M1 or M2), and the third raugae area, since the results are reliable, repeatable, and exact when performed on the medial region of the third raugae and a small area surrounding dorsal palate³⁰⁻³² (Figure 3). The following parameters (Angular and Linear) data were analyzed based on previous studies.^{16,33} Angular measurements: Tooth Rotation Cast (TRc), inter molar and inter premolar width (IDD) and Arch depth (AD)(Figure 2). Mesiobuccal cusp tip of maxillary first permanent molar (MB6), maxillary first molar mesiolingual cusp tip (ML6). Maxillary first premolar buccal cusp tip (B4), maxillary first premolar palatal cusp tip (P4) (Figure 2).

Arch width (AW) was measured since inter dental distance (IDD) at P1 joining the inter distance of buccal cusps B4 while joining mesiobuccal MB6 cusps at M1.¹⁶ Arch depth (AD) was calculated using the length of a perpendicular line drawn from the central incisors' mesial contact points to a line joining the second premolars and first molars (P2 & M1)¹⁶. The axial inclination of the central incisor was determined from the extracted lateral cephalometric radiograph from CBCT and was analyzed utilizing Invivo Anatomage version 5.2, because incisor inclination affects arch depth (Figure 4).



Figure 1: Photograph of a desktop Red Laser 3Shape D500 scanner

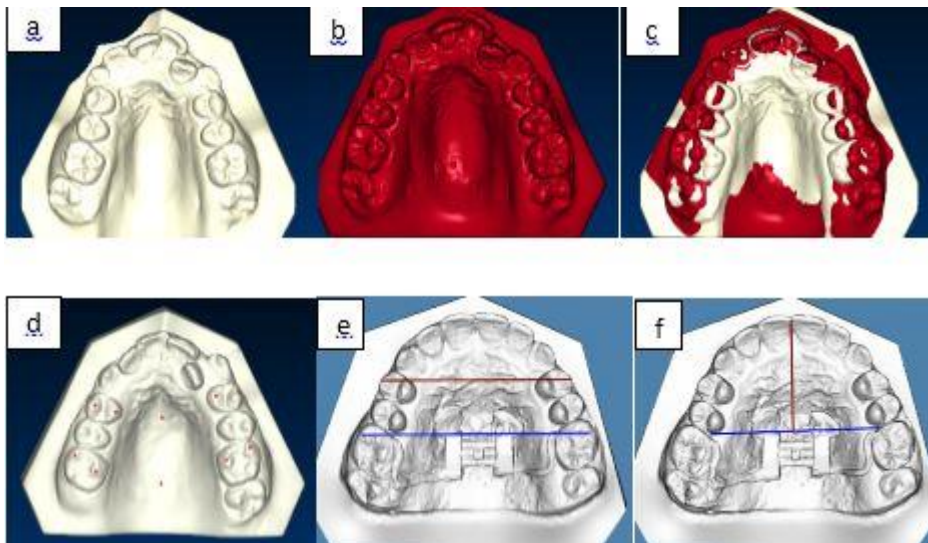


Figure 2: Photograph of scanned casts with the following categories: a-pre, b-post, c-superimposition, d-Reference points, e-IDD, and f- AD.

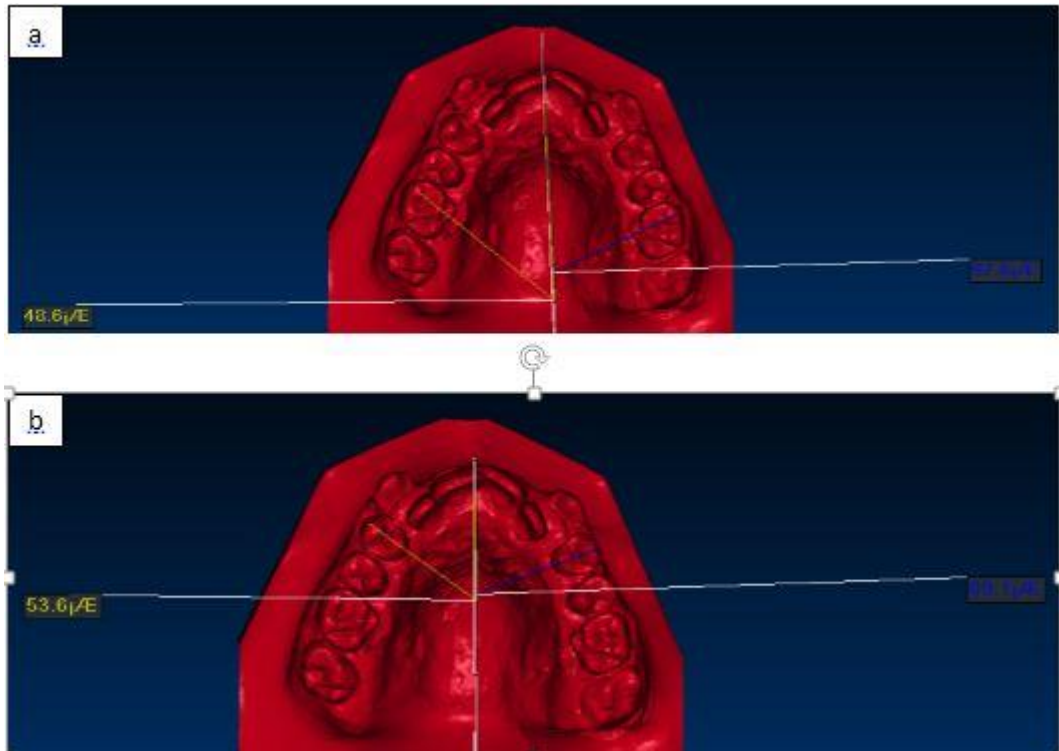


Figure 3: Photograph of TR using the Ondemand3D application

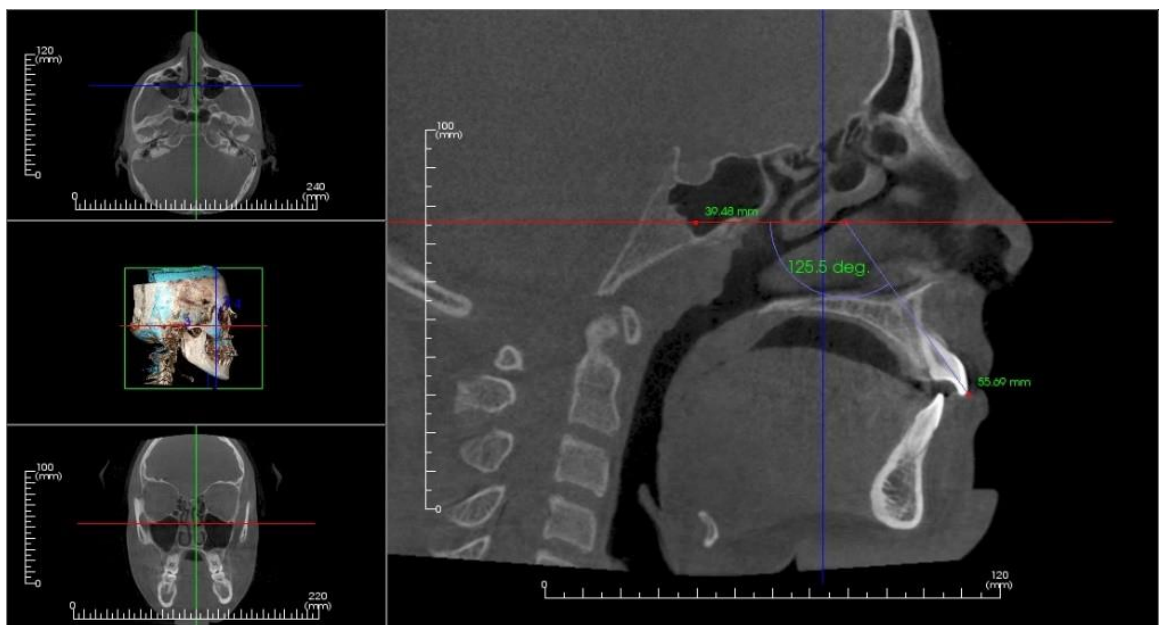


Figure 4: Photograph of an IC using an Invivo 5.

Statistical analysis

The Statistical Package for Social Sciences (SPSS) version 18 was used for data management and statistical analysis. By examining the data distribution and performing the Kolmogorov-Smirnov and Shapiro-Wilk tests, data were examined for normality. Comparisons of normally distributed numeric variables between groups or between unilateral or bilateral crossbite cases was performed by independent t test, whereas pre and post values was compared by paired t test. The mean difference was calculated by the formula: (Value after-value before) Difference data were non-parametric and were compared between groups using Wilcoxon signed rank test. P-values are always two-sided. P-values less than 0.05 were regarded as significant.

Results

Results of Baseline data

Only 30 patients' CBCT and digital casts data were collected six months after the previous activation, compared to 32 patients' data collected before to the expansion due to drop out or discontinuation of two male patients. The mean age for group A "Hybrid hyrax" was 14.5 ± 1.04 , while for Group B "Conventional hyrax", the mean age was 13.96 ± 1.21 , with no significant difference in age ($P=0.121$). For group A, 4 (26.7%) cases were unilateral and 11 cases (73.3%) bilateral. For group B, 5 cases (33.3%) were unilateral and 10 cases (66.7%) bilateral. There was no significant difference in the gender distribution between groups A and B ($p=0.69$), with group A having 11 females (73.3%) and 4 males (26.7%), and group B having 10 females (66.7%) and 5 males (33.3%).

Comparison between Hybrid and conventional hyrax groups

Before treatment and after treatment, there was no significant difference between Groups regarding values for the interdental distance (IDD) in the first molar (M1) and first premolar (P1), arch depth (AD), Rotation (ROT) and incisor inclination (IC) ($P \geq 0.05$, Figure 5).

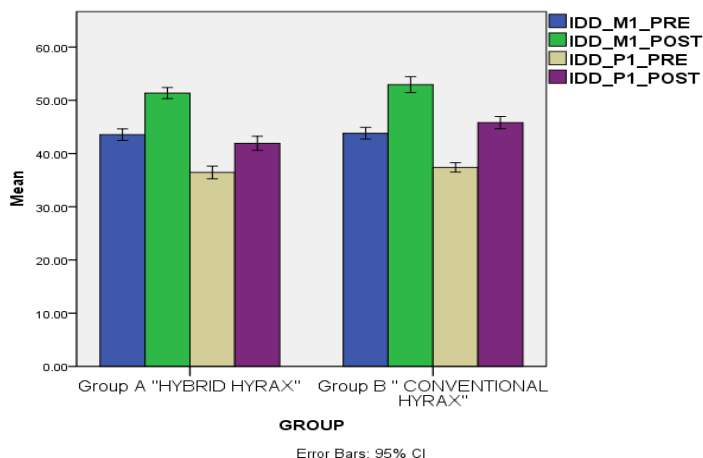


Figure 5: Bar chart illustrating mean Interdental distance (IDD) (first premolar and first molar) in group A and group B

When compared to pre-treatment values, the interdental distance IDD (the first molar M1 and first premolar PI), Rotation ROT (M1 and PI) right and left showed a statistically significant increase, while in arch depth AD and Incisor inclination IC showed a statistically significant decrease (Figure 6).

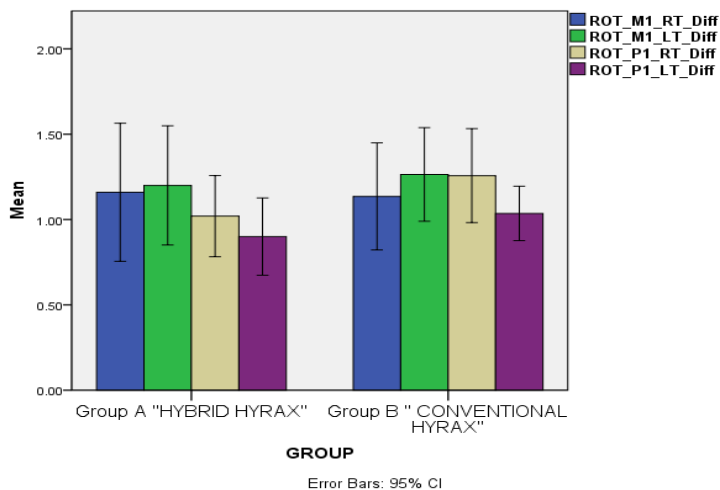


Figure 6: A bar graph, shows the mean difference between group A and group b's first premolars (P1) and first molars (M1) after treatment for right (RT) and left (LT) rotation, respectively

Discussion

The differences in digital study casts between tooth-borne and hybrid Rapid Maxillary Expansion (RME) were examined in this study using 3D virtual models that were scanned using a 3Shape laser scanner. Since the mid palatal suture is frequently matured and difficult to open, the use of RME operations in young adults and adults is controversial. So, despite its high costs and increased post-

surgical morbidity, surgically aided rapid palatal expansion (SARPE) is an orthodontic approach that seeks to correct the maxillary transversal discrepancy by opening circummaxillary sutures in postpubertal patients.⁷

Maxillary assisted rapid maxillary expansion (MARPE) allowed for less buccal tilting, less loss of alveolar height on anchoring teeth, and more predictable and considerable skeletal extension. Therefore, for patients who have skeletal maxillary deficiency after the pubertal development phase, MARPE is a better treatment option.³⁴⁻³⁶

Before treatment, there were no detectable variations in age, sex distribution, periodontal health, skeletal condition, or the majority of dentoalveolar characteristics between the hyrax and hybrid hyrax groups, indicating that the two groups were comparable. The activation period for both groups lasted approximately 16-20 days. Additionally, Before treatment and after treatment, there was no significant difference between Groups regarding values for the interdental distance (IDD) in the first molar (M1) and first premolar (P1), arch depth (AD), Rotation (ROT) and Incisor inclination (IC) ($P \geq 0.05$).

According to Kartalian et al.³⁷, there was no statistically significant dental tilting following RME. As a result of the preceding findings, it is possible to conclude that RME causes tilting of the maxillary posterior teeth to varying degrees depending on the patient's age, type of expander, activation technique, and time of evaluation at T2 from the baseline.

According to this study's findings, an increase in IDDM1 in CH as compared to HH due to increase the tipping effect in CH, this was in agreement with Gunyuz et al³, Bazzani et al²⁴ and Martina et al²⁷. On the other side this was in disagreement with Pasqua et al³⁸ since maxillary width showed significant difference between groups, increasing more in HHG than conventional one, this might attributed to different design of the appliance with different age group.

According to Braun et al³⁹, this non-significant rise was caused by the hyrax's stiffness, which restricted rotation using the biomechanical notion. The current study's findings regarding tooth rotation differed with those of Corbridge et al⁴⁰ who claimed that there had been a considerable increase in molar rotation; this was because they employed a different technique (SME), a different device (a quad helix), and a different age group (9.2 Y). In contrast to Chung et al³³, the degree of rotation was 2.32 degrees for the first premolars and 3.09 degrees for the first molars, with no statistically significant difference because they used SARPE.

Additionally, this study's degree of rotation differed from Ciambotti et al.⁴¹ sample, which included bonded and banded rapid palatal expansion appliances of a different design. Contrasting Montaroli et al.⁴² With a NiTi palatal expander, the molar rotation was 26.61° as opposed to 1.58° with an RPE, and the intermolar width was 4.76 mm as opposed to 6.26 mm. In line with other investigations, palatal inclination of the maxillary incisors was seen in both groups in the current study, this as in accordance with previous studies.^{43,44} From the opposite view this was in contrast to the study by Sandikcioglu et al⁴⁵ who found incisor proclination high might due to backward and downward rotation of mandible.

Additionally, Doruk et al.⁴⁶ noted some incisor proclination in group I (fan type), whereas group II (hyrax type) was consistent with the present findings. Because the anterior teeth were shifted laterally and anteriorly with the fan-type RME, the angular opening of the midpalatal suture is more rotational than it was with the hyrax-based RME, which may account for the difference with his group I.

Since the angular opening of the midpalatal suture is what causes labial tipping, they were corrected with the RME in the current investigation. The incisors may not have tipped toward the labial because of the perioral musculature or other physiological influences. The molars' rigid connection to the appliance, as demonstrated by Braun et al³⁹, may have contributed to the incisors' lack of buccal tilting while the molars did, as this prevented forces from the perioral musculature and other physiological factors from acting on them.

Limitations

The study's limitation was the lack of a control group, firstly for ethical issue and finally the quantitative findings in both treated groups may have been influenced by normal growth expansion. Given that the data were obtained following a quick (6-month) review, this limitation may be overlooked. The use of intraoral scanner was not available because the study was finished.

Conclusions

In compared to a traditional one, RME using hybrid hyrax can achieve skeletal effects and widen the arch with only a slight increase in interpremolar distance in comparison to conventional one. Arch depth might be decreased after RME regardless the type of appliance.

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