RESEARCH PAPER

Evaluation of Dento-Skeletal Changes of Constricted Maxillary Arch after Expansion by Invisalign versus Conventional Expander

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ABSTRACT

Objective: This study aimed to compare the dento-skeletal effects of maxillary expansion achieved by a Hyrax rapid maxillary expander and clear aligner therapy using cone beam computed tomography (CBCT).

Subjects and Methods: This comparative study was conducted on 16 patients presenting with transverse maxillary deficiency. Subjects were divided into two groups: Group I treated with Hyrax rapid maxillary expander and Group II treated with clear aligner therapy designed for maxillary expansion. CBCT scans were obtained before treatment (T1) and after expansion (T2). Skeletal and dental transverse measurements were assessed three-dimensionally.

Results: Both treatment modalities resulted in a statistically significant increase in maxillary transverse dimensions. The Hyrax group demonstrated greater skeletal expansion, while the clear aligner group showed predominantly dento-alveolar changes with limited skeletal response.

Conclusions: Hyrax expansion remains more effective in producing skeletal maxillary expansion, whereas clear aligner therapy can be considered an alternative for mild transverse discrepancies where dento-alveolar expansion is sufficient.

Keywords: Maxillary expansion, Clear aligners, Hyrax, Transverse maxillary deficiency, CBCT.

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Introduction

Maxillary transverse deficiency is a prevalent orthodontic condition associated with posterior crossbite, dental crowding, and compromised airway function. Rapid maxillary expansion (RME) has long been established as an effective orthopedic procedure to correct such discrepancies by opening the midpalatal suture [(1,2)]. Rapid maxillary expansion (RME) is a frequent orthopedic procedure performed in Orthodontics. RME is indicated to treat maxillary constriction in growing patients, improving the transverse interarch relationship. It was first described by Angel in 1860 and then subjected to a lot of modifications suggested by the literatures. RME creates changes in both the dento-alveolar region and the midpalatal suture, as well as adjacent craniofacial structures. Hyrax expander is widely used due to its hygienic design and ability to deliver significant skeletal expansion. However, drawbacks such as discomfort, hygiene challenges, and aesthetic concerns have driven the demand for alternative treatment modalities.[(3,4)] Clear aligner therapy (CAT) has gained popularity due to its aesthetic appeal and patient comfort. Advances in digital orthodontics and CAD-CAM technology have enabled aligners to perform more complex tooth movements, including transverse expansion.[(5)] However, the extent to which CAT can produce true skeletal expansion remains controversial. [(6,7)] Cone-beam computed tomography (CBCT) provides accurate three-dimensional assessment of dento-skeletal structures and airway dimensions without superimposition, making it an ideal tool for evaluating treatment outcomes.[(8-10)]

From all of the previously mentioned, it was beneficial to compare the effectiveness of both RME versus CAT during maxillary expansion. Accordingly, the present study was directed to compare the dento-skeletal effect assisted by Hyrax maxillary expander versus expansion by clear aligner appliance through CBCT. Therefore, this study aimed to compare the dento-skeletal and airway changes following maxillary expansion using Hyrax expander versus clear aligners [11,12].

Subjects and methods

Institutional Review Board and Al-Azhar University's Ethical Analysis Committee reviewed and approved the study protocol. This randomized clinical trial was performed during six months on a total sample of 20 patients, 9 females and 7 males were picked from the outpatient clinic, Department of Orthodontics, Faculty of Dental Medicine, Al-Azhar University, Egypt. All patients and/or their parents who agreed to participate in this research signed an informed consent document that authorized their data to be used for research purposes. Based on the previous studies [11], a power analysis using G Power software (version 3.1.9.2; Universitat Dusseldorf, Germany) estimated that the sample size of 20 patients ensured more than 80% power to detect significant differences at a 0.05 significance level. They were randomly divided into two groups according to the intervention into Hyrax group and Clear aligner group.

All patient were selected according the inclusion criteria as the follows: Patients require mild to moderate dental maxillary expansion (constricted arch and/or mild to moderate crowding), normodivergent subjects with a skeletal Class I malocclusion, age ranged from 12 to 16 years, all permanent teeth are present, 3rd molars are excluded, good oral and general health, good compliment and motivated patients, no previous orthodontic treatment or orthognathic treatment.

Each patient underwent thorough scaling and polishing to ensure optimal oral hygiene prior to the commencement of the study, an intraoral scan of the maxillary arch and occlusion was performed using Intraoral Scanner. The resulting images were saved in STL file format for further digital workup. A full-arch impression was taken using Alginate impression material and was immediately poured with dental hard stone to create study models. The resulting dental casts were carefully trimmed and labeled with the patient's name and identification number. A digital scan of each cast was subsequently performed using a state-of-the-art digital scanner to obtain an STL digital model, ensuring high accuracy and reproducibility for subsequent analysis (Fig.1).

For group I

Appliance design; a 7 mm Hyrax expander screw was utilized in the construction of the appliance. The wire framework was fabricated from 0.040-inch (18-gauge) stainless steel, extending around the buccal and palatal surfaces of the posterior teeth and canines. The midline of the Hyrax screw was precisely aligned with the median palatine raphe to ensure optimal placement. Additionally, the wire extensions of the screw were carefully adjusted to maintain contact with the palatal surface of the framework, providing stability and effective force distribution during expansion. Appliance delivery; the appliance was fully seated and cemented with glass ionomer-cement (GI). Excess cement was removed and the patient was instructed to bite on a cotton roll for isolation for 10 minutes. The bite raising using GI on opposing arch on posterior teeth to avoid locking inter-cuspation (Fig.2).

Expansion protocol; On the day of the appliance cementation activation began by turning the screw of the expander twice daily for a total of 0.5 of expansion day after day.

Patients' instruction after delivery; Parents were thoroughly instructed regarding the frequency and direction of screw activations to ensure proper appliance adjustment at home. Comprehensive oral hygiene guidelines were provided, emphasizing the importance of maintaining excellent oral care to minimize the risk of oral tissue inflammation. Additionally, parents and patients were advised to immediately contact the supervising clinician if the appliance became loose or dislodged between scheduled visits.

Retention protocol; after achieving the desired maxillary expansion, the screw of the appliance was stabilized using composite resin. The appliance was then maintained in place as a passive retainer for a period of six months to ensure stabilization of the expanded arch.

For group II

A software (Maestro 3D) was used in designing and planning the clear aligner trays and positioning of the attachments. The process begins with automatic correction of 3D scan imperfections, reconstruction of missing parts, and edge refinement to ensure high-quality input files (Fig.3). Virtual study models are then generated, allowing for precise occlusal analysis and measurements. AI-driven automatic tooth segmentation identifies and numbers teeth, eliminating the need for manual input. The software further enhances accuracy by integrating digitized crowns with CBCT-acquired roots, and it facilitates

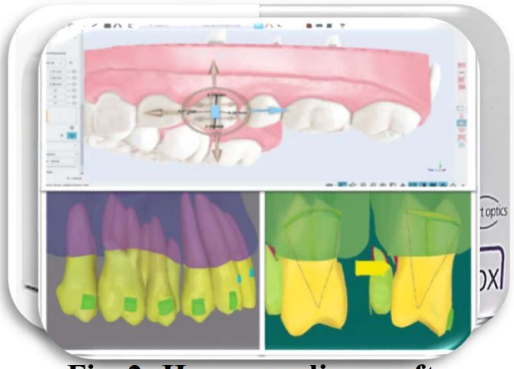

Fig. 2: Hyrax appliance after cemented in the mouth.

Fig. 3: Intraoral scan of maxillary arch.

comprehensive treatment planning by importing CBCT images of the jaws. The virtual setup phase is crucial, enabling clinicians to plan final tooth positions with advanced tools to monitor movements and attachment placement.

The software supports automatic attachment placement based on user-defined treatment protocols, making dental movements highly predictable and personalized by augmentation with CBCT for every patient to adjust torque and tipping (Fig.4).

Attachments were added on the buccal surface of posterior teeth that were aimed at moving buccally, the attachments were occlusally-beveled rectangular horizontal of dimensions 3×2×1 mm [11]. The digital design and treatment plans for each case involved intended teeth movements according to the stage of treatment with number of aligners not exceed 12.

Primary outcome: Skeletal changes in transverse width of maxilla (inter jugale distance).

Secondary outcome: Inter maxillary molar width, Inter maxillary canine width, Alveolar bone tipping, Maxillary 1st molar tipping, Buccal and palatal maxillary width.

The outcomes were measured by evaluating the amount of change on the CBCT between the pretreatment (T0) and the measurements (T1) after 6 months.

The pre and post expansion CBCT superimposition was done based on the three reference planes and anatomical reference landmarks including the ANS,PNS, right and left vomer. Superimposition was

done to ensure that accuracy of post expansion measurements to evaluate the treatment outcomes.

3D digital model measurement:
Intercanine cusp width: measured as the linear distance in millimeters between the cusps of maxillary canines on opposite sides, first molar mesiobuccal cusp width: the linear distance in millimeter between the mesiobuccal cusps of 1st permanent molar on opposite sides.

Statistical Analysis
All data were statistically analyzed using the SPSS (Statistical Package for Social Sciences (SPSS, version 23) program.

Results

A comparison between the two studied groups (table 1) during maxillary expansion distance (mm); Group I showed that a statistically significant increase in most transverse and dental measurements, with several parameters being highly significant, indicating effective skeletal and dental expansion, on the other hand, group II demonstrated limited changes with non-significant improvement of most variables.

Table (1): Descriptive statistics of CBCT measurements of distance (mm) changes of maxillary expansion, amount of inter maxillary molars and canines widths between experimental sides in both group's pre and post (6 months) period of study.

	(N=16)									
	Group I (N=8)					Group II (N=8)				
	Pre. (T0)		Post.(T1)			Pre.(T0)		Post.(T1)		
	Mean	SD	Mean	SD	Sig.	Mean	SD	Mean	SD	Sig.
Inter jugale width	53.93	2.46	56.7	1.74	HS*	54.1	2.5	54.2	3.05	NS
BMW	50.85	2.8	54.18	2.45	S*	51.1	2.75	51.9	1.3	NS
PMW	25	2.02	27.58	1.87	S*	25..2	2.1	26.0	0.8	NS
Alveolar tipping	21.08	4.77	23.17	4.9	S*	21.3	4.8	21.7	2.3	NS
Maxillary 1st molar tipping	23.78	4.87	26.7	5.12	HS*	24.0	4.9	25.1	2.6	NS
Inter canine width	25.2	1.4	29.1	1.6	S	25.2	1.4	29.1	1.6	S
Inter molar width	49.1	1.8	55.4	1.2	HS	49.1	1.8	55.4	1.2	S

Group I= Hyrax, Group II= CAT, SD=Standard deviation, SE= Standard errors, Sig= Significance, NS= Non-significant, HS=Highly significant.

A comparison between the two studied groups (table 2) during maxillary expansion differences amounts of change (T1-T0) after the six months period of study between both groups, alveolar tipping and maxillary first molar tipping

Table (2): Descriptive statistics and comparison between the differences in the amount of change after 6 months an between experimental sides in both groups.

	Group I Difference T1-T0		Group II Difference T1-T0		Difference T1-T0		P-value	Sig*
	Mean	SD	Mean	SD	MD	SD		

Inter jugale width	**2.77**	**1.18**	**0.1**	**1.55**	**2.67**	**1.95**	**0.004**	**HS**
BMW	**3.33**	**2.44**	**0.9**	**0.09**	**2.34**	**2.44**	**0.01**	**S***
PMW	**2.58**	**1.67**	**0.8**	**0.07**	**1.78**	**1.67**	**0.02**	**S***
Alveolar tipping	**2.08**	**1.16**	**0.4**	**0.08**	**1.68**	**1.16**	**0.07**	**NS**
Maxillary 1st molar tipping	**2.92**	**1.79**	**1.1**	**0.4**	**1.82**	**1.83**	**0.09**	**NS**
Inter canine width	**3.9**	**0.8**	**2.3**	**0.6**	**1.6**	**1**	**0.01**	**S***
Inter molar width	**6.3**	**1.2**	**2.0**	**0.9**	**4.30**	**1.50**	**0.001**	**HS***

Group I= Hyrax, Group II= CAT, SD=Standard deviation, SE= Standard errors, Sig= Significance, NS= Non-significant, HS=Highly significant.

Discussion

The present study demonstrated that Hyrax expander produces superior skeletal expansion compared to clear aligners. This is attributed to the orthopedic forces applied directly to the midpalatal suture.

In contrast, clear aligners primarily induce dentoalveolar expansion through buccal tipping, which aligns with previous studies reporting approximately 70% accuracy in predicted expansion.

The aesthetic and comfort advantages of clear aligners make them a viable option for mild to moderate cases, but their limitations in skeletal expansion must be considered.[11,14]

Conclusion

Group I (Hyrax) demonstrated greater overall expansion compared to group II (CAT), particularly in skeletal measurements such as inter-jugale width. Alveolar changes including buccal and palatal maxillary width, were significantly higher in group I, while group II showed mostly non-significant changes. Dental tipping increased in both groups without statistically significant difference between them. Additionally, 3D cast measurements revealed significantly greater increase in intercanine and inter molar widths in group I compared to group II.

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