RESEARCH PAPER

A Cone-Beam Computed Tomography Evaluation of Root Resorption After Maxillary Expansion Using Hyrax and Hybrid Hyrax Appliances (Expanders)

Mohamed Taher Mohamed Abo Ghalia[1], Mostafa Mohamed Mahmoud Dawaba[2*], Saleh Anwar El-Sayed Saleh[3], Hussein Shokry Hassan Ahmed[4]

[1]Master Student, Department of Orthodontics, Faculty of Dentistry, Al-Azhar University (Assiut Branch)
[2]Asso, Professor, Department of Orthodontics, Faculty of Dental Medicine, Al-Azhar University, Assiut, Egypt
[3]Professor, Department of Orthodontics, Faculty of Dentistry, Al-Azhar University (Assiut Branch)
[4]Associate Professor, Department of Orthodontics, Faculty of Dentistry, Al-Azhar University (Assiut Branch)

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Abstract

The Objective of this study was to evaluate root resorption produced by two different types expanders (hyrax and hybrid hyrax) in patients with posterior crossbite. This study was conducted on 20 orthodontic patients with an age range from 12 to 15 year-old who were collected from the outpatient clinic at Orthodontic Department, Faculty of Dental Medicine, Al-Azhar University, Assiut, Egypt. They were randomly divided into 2 equal groups; each consisted of 10 patients, Group 1: hyrax appliance group. Group 2: hybrid hyrax group. The results showed non statistically significant differences between the two groups for all measurements..

Key words: hyrax appliances, hybrid hyrax, posterior crossbite

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Introduction

Rapid maxillary expansion (RME) is commonly used to treat transverse deficiencies of the maxilla First described in 1860, RME has been used primarily for posterior crossbite correction. More recently, RME has also been reported to facilitate the correction of Class II and Class III malocclusions and resolve arch length discrepancies. [1, 2]

Conventional (RME) in growing patients involves the use of tooth-borne appliances that apply significant forces to the maxilla. These forces are strong enough to create separation between the two halves of the maxilla, thereby promoting ‘‘skeletal expansion’’.[3-5]

RME may cause side effects such as buccal inclination of the posterior teeth, root resorption, and reduction in buccal bone thickness. [6-8]

To minimize these side effects and enhance skeletal effects in growing patients, the Hybrid Hyrax expander was introduced. This appliance distributes the expansion forces between two mini-implants placed in the anterior palate and two posterior teeth (banded molars). The device is generally well accepted by patients; the risk of infection is low and the insertion of mini-implants is minimally invasive. [9, 10]

The Root resorption may occurs because of individual biologic, genetic and mechanical factors. [11] It may manifest as localized cavities or areas of root surface loss without necessarily leading to decrease in the overall length of the root. [12, 13]

The study reported that canine root resorption did not differ significantly between labial and palatal retraction mechanics, indicating that the choice of force application method had no measurable effect on root resorption during canine retraction.[14]

There is a lack of evidence on the effects of the two appliances “Conventional (RME) and Hybrid Hyrax on the root resorption “.

This study will be carried out to evaluate the effect of two appliance on the root resorption by using Cone beam computed tomography(CBCT).

Patients and Methods

The sample

The current study was conducted on a total sample of twenty young adult orthodontic patients . All Patients presented with maxillary deficiency with an age ranged from 10-15 years. The sample was selected from patients seeking orthodontic treatment in out- patient clinic, Orthodontic Department, Faculty of Dental Medicine, Al- Azhar University, Assiut , Egypt

Study design

The study was an interventional, randomized clinical trial. A convenience sampling technique was used for patient selection., which was done on 20 orthodontic patients which was divided into two groups, group I (hyrax), group II (hybrid hyrax) .

Ethical committee was approved from Al-Azhar University, Faculty of Dentistry was taken, Number: AUAREC202300009-12 .This study was also registered in the clinical trials.gov , Number : NCT06059807.

Blinding

Blinding of both patient and clinician to the allocated intervention site was not possible due to the nature of the procedure of miniscrew placement. Blinding was done at the measurement and data analysis.

Inclusion Criteria:

The patient was included in the present study if if had one or more of the following :-

1. Skeletal maxillary transverse deficiency.
2. Unilateral or bilateral posterior crossbite.
3. Negative buccal corridor.
4. Patient with good oral hygiene and general health.
5. Patient with no previous orthodontic treatment .
6. No systematic disease that may affect bone quality or interfere with orthodontic treatment .

Exclusion criteria:

The patient was excluded from this study according to the following criteria :

1. Craniofacial congenital anomalies, such as cleft lip and palate.
2. A history of periodontal disease.
3. Incomplete treatment records, or metallic restorations in the maxillary first molars.

Discontinuation criteria:

The patient was excluded from this study if :

1. Uncooperative patient by ignoring the giving instructions .
2. Frequent missing appointment .
3. Improper oral hygiene measures .
4. Improper appliance activation protocol.

Ethical consideration

An informed consent form that explains every step in the research was given and discussed carefully with the patients and patient guardians before participation in the study and start our treatment steps.

Diagnostic Records:

Extra-oral and five intra-oral photographs. Panoramic radiograph, standardized lateral cephalometric radiograph, Posteroanterior cephalometric x.ray (P.A)"only before starting of treatment" , cone-beam computed tomography(CBCT) and orthodontic study cast model.

For each patient, two CBCT were obtained; one pre-installation of the appliance and another immediately after the removal of the appliance.

Operative procedures

The selected patients were divided randomly into equal groups each group contains 10 patients :

Group I : The patients were treated using hyrax .

Group II : The patients were treated hybrid hyrax.

The initial CBCT records had been taken immediately before expansion (T0)

A. Preparation of the subject:-

After obtaining the pretreatment records , prophylactic procedures were performed for each patient including scaling, polishing, and gingival treatment.

A written homecare instructions were provided to all patients and then all patients enrolled in the study participated in a special oral hygiene home-care program for one month to standardize as much as possible, the pre-treatment oral hygiene measures before expansion.

B. Fabrication of the expansion appliance

Appliance positioning: The size of the expander was selected based on the maximum size that could fit within the palatal vault.

For group II , the hybrid appliance consisted of a central body containing an expansion screw with two welded tubes. Each tube was 1.8 mm in diameter and 2 mm in length and served as an insertion slot for two mini-implants. Each mini-implant was 1.6 mm in diameter and 10 mm in length. Two molar bands attached to maxillary first molars.

The appliance was tried in and then cemented. Subseqently, the two mini-implants were inserted into the expander body using low-speed contra-angle handpiece with a driver.

Assessment of the mini-implants: The mini-implants were checked for mobility and inflammation of the gingiva around the neck of the screw before loading of force and at every clinical appointment.

C. Expansion protocol:

The initial expansion rate was two turns per day (twice/ daily), each activation quarter was equivalent to 0.2 mm (according to the screw manufacturer). In both groups, the first activation was a complete turn of the expander screw (0.8 mm), the activation was continued with two-quarter turns per day until the correction of the posterior crossbite was achieved with overcorrection (occlusion of the palatal cusp of the maxillary first molars with the corresponding buccal cusp of the mandibular first molars).[15]

D. Cone beam computerized tomographic (CBCT)

To minimize radiation exposure, CBCT scans were obtained only in the maxillary area. The participants were oriented with the Frankfurt horizontal plane parallel to the floor and the midsagittal plane perpendicular to the Frankfurt plane to standardize the head position during CBCT acquisition.

Scans were obtained before treatment (T0) and 6 months after the activation phase (T1), based on a previously defined methodology

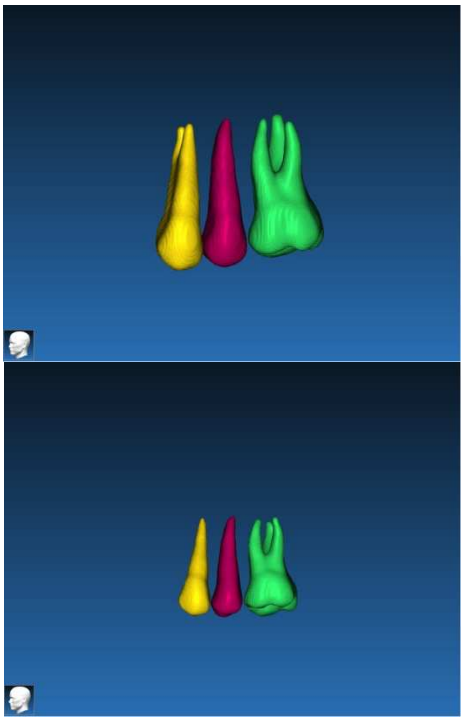


Fig (1) Color-coded labeling of T0 and T1 tooth models: maxillary first premolar (P1), maxillary second premolar (P2), and maxillary first molar (M1)

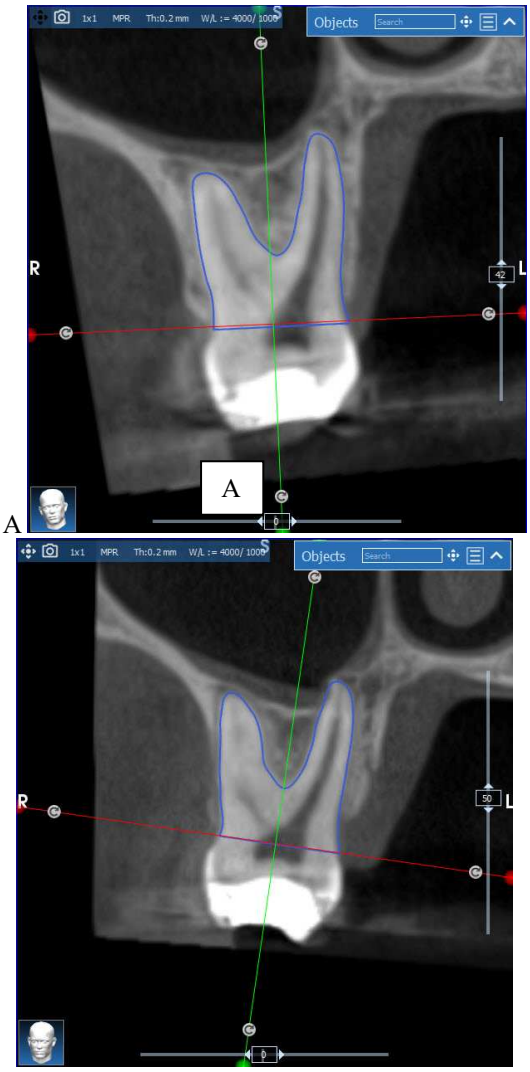


Fig (2) Group I HG (A): pre-operative CBCT radiograph, (B): Post-operative CBCT radiograph

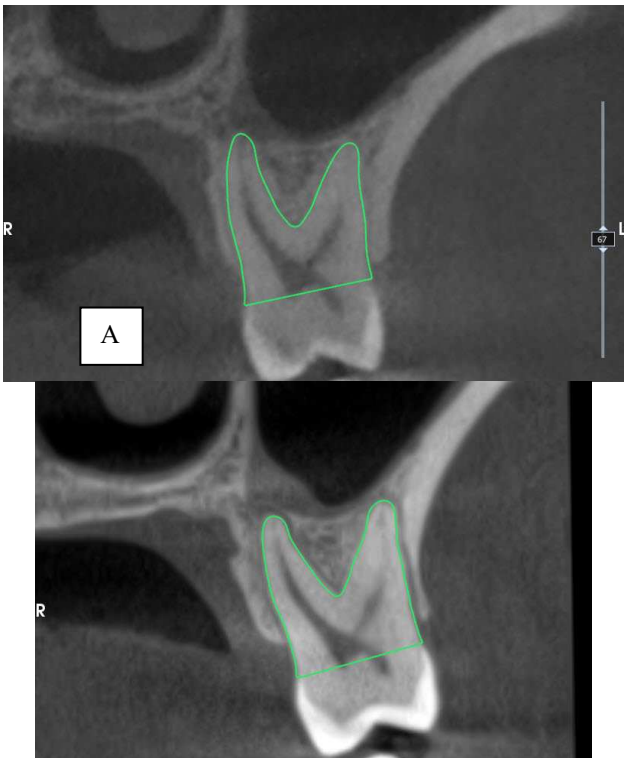


Fig (3) Group II HHG: (A): pre-operative CBCT radiograph, (B): Post-operative CBCT radiograph

Statistical analysis

Intergroup comparison:

Analysis of root volume changes between the two groups:

- Independent sample t-test has been performed to compare the mean changes for root volume (before and after expansion) of posterior teeth between the two groups tables (1), figures (4). The result showed non-statistically significant differences between the two groups for all measurements.
- When we compared the mean change of root volume of Rt 1st premolar of the two groups, we found that there was statistically significant difference between the two groups as reported by unpaired T test (p =.002).
- When we compared the mean change of root volume of Rt 2nd premolar of the two groups, we found that there was statistically significant difference between the two groups as reported by unpaired T test (p = .859).
- When we compared the mean change of root volume of Rt 1st molar of the two groups, we found that there was statistically significant difference between the two groups as reported by unpaired T test (p <.000).
- When we compared the mean change of root volume of Lt 1st premolar of the two groups, we found that there was statistically significant difference between the two groups as reported by unpaired T test (p <.000).
- When we compared the mean change of root volume of Lt 2nd premolar of the two groups, we found that there was statistically significant difference between the two groups as reported by unpaired T test (p <.000).
- When we compared the mean change of root volume of Lt 1st molar of the two groups, we found that there was statistically significant difference between the two groups as reported by unpaired T test (p =.022).

The result showed non-statistically significant differences between the two groups for all measurements.

Results

Table (1): comparison of different variables, means values between groups

ROOT VOLUME	groups	N	Mean	SD	SE	Mean Diff	independent sample t test		
							t	df	sig
Root volume change of RT 1st premolar	Hyrax	10	-30.26	13.16	4.16	-19.7	-3.67	18	.002*
	Hybrid hyrax	10	-10.51	10.71	3.38				
Root volume change of RT 2nd premolar	Hyrax	10	-12.39	5.02	1.58	.909	.180	18	.859 NS
	Hybrid hyrax	10	-13.30	15.17	4.79				
Root volume change of RT 1st molar	Hyrax	10	-6.08	2.56	.810	16.4	5.64	18	<.000*
	Hybrid hyrax	10	-22.54	8.84	2.79				
Root volume change of LT 1st premolar	Hyrax	10	-34.61	3.26	1.03	-20.7	-4.83	18	<.000*
	Hybrid hyrax	10	-13.86	13.17	4.16				

Root volume change of LT 2nd premolar	Hyrax	10	-26.31	8.47	2.67	-21.8	-7.73	18	<.000*
	Hybrid hyrax	10	-4.43	2.87	.908				
Root volume change of LT 1st molar	Hyrax	10	-45.42	21.96	6.94	-26.7	-2.50	18	<.022*
	Hybrid hyrax	10	-18.63	25.76	8.14				

N= number, SD= standard deviation, SE= standard error df= degree of freedom, NS= non-significant P > 0.05, * Significant at P < 0.05.

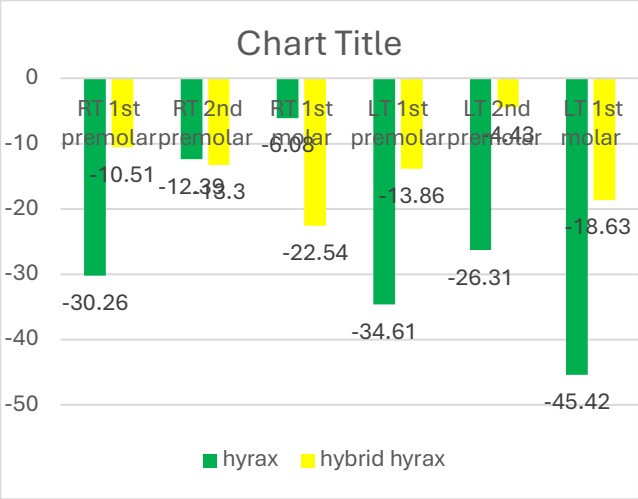


Fig (4): A bar chart showing comparison of root volume changes between the two groups.

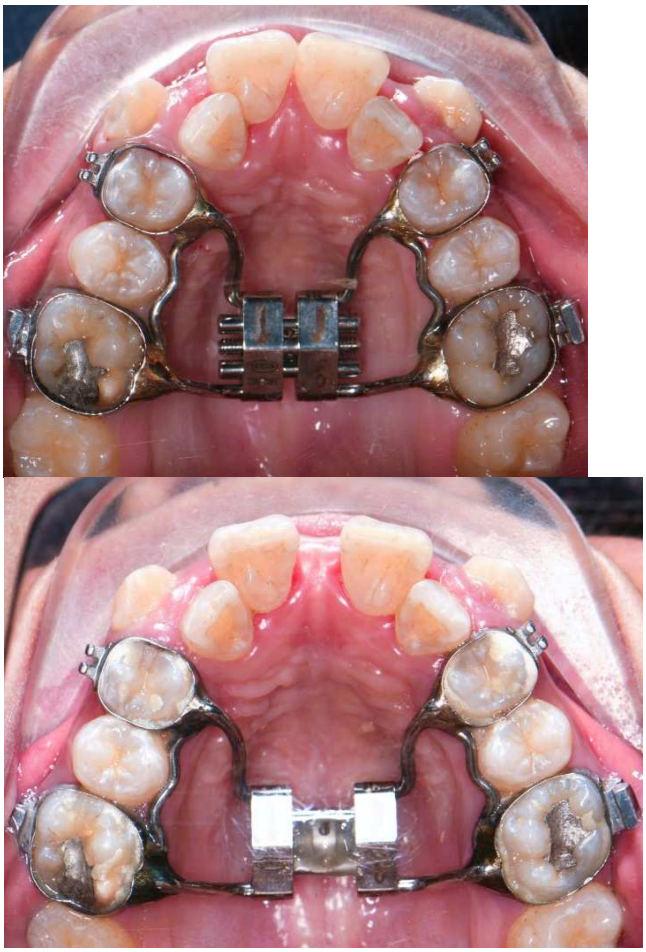
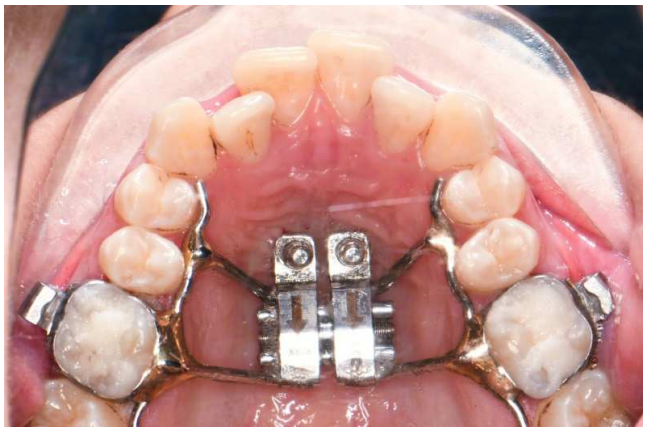


Fig (5): HYRAX inserted before and after activation



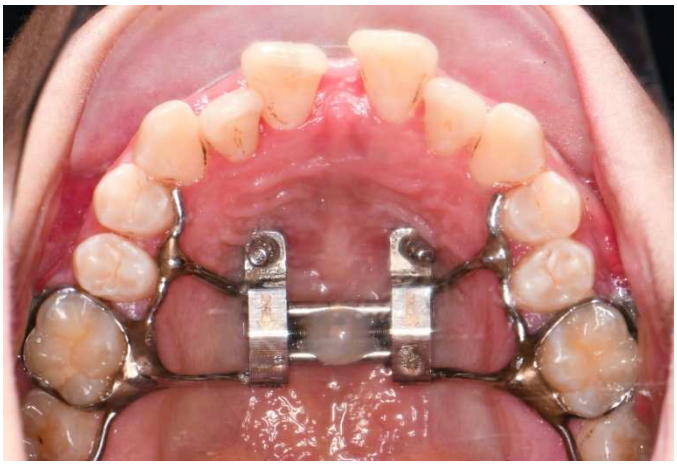


Fig (6): Hybrid HYRAX inserted before and after activation

Discussion

Maxillary expansion is considered an integral component of contemporary orthodontic treatment by increasing the transverse dimension of the maxillary arch and improving arch perimeter. In patients with maxillary transverse deficiency, expansion can alleviate dental crowding, correct posterior crossbite, and create sufficient space for proper alignment of the teeth. Consequently, it may reduce or even eliminate the need for premolar extractions in selected cases, particularly in growing patients. By addressing the underlying skeletal discrepancy rather than relying solely on dental compensation, maxillary expansion facilitates a more conservative treatment approach, improves occlusal relationships, and enhances long-term stability. Therefore, rapid maxillary expansion (RME) has become an essential component of orthodontic treatment planning when transverse maxillary deficiency contributes to space deficiency and malocclusion.[16, 17]

The conventional Hyrax and Hybrid Hyrax appliances were selected for the present study because they represent two well-established rapid maxillary expansion (RME) protocols with fundamentally different anchorage designs. The conventional Hyrax appliance is a tooth-borne expander that has long been regarded as the standard approach for the correction of transverse maxillary deficiency in growing patients. In contrast, the Hybrid Hyrax appliance incorporates both dental and skeletal anchorage through the use of palatal mini-implants, allowing expansion forces to be distributed between the dentition and the maxillary basal bone. This biomechanical modification has been proposed to enhance the skeletal effects of expansion while reducing undesirable dentoalveolar side effects associated with conventional tooth-borne expansion, particularly external root resorption. [18, 19]

Accordingly, the present study was designed to evaluate and compare the amount of external root resorption associated with these two expansion protocols using cone-beam computed tomography (CBCT). By comparing the biological response of the dentoalveolar tissues following treatment with the conventional Hyrax and Hybrid Hyrax appliances, the study aimed to determine whether the incorporation of skeletal anchorage provides measurable biological advantages over conventional tooth-borne rapid maxillary expansion.

In the present study, the patients were randomly allocated into two equal groups. Group I was treated using the conventional tooth-borne Hyrax appliance, whereas Group II received treatment with the Hybrid Hyrax appliance. The findings demonstrated that both expansion appliances resulted in a reduction in root volume following expansion, indicating the occurrence of external root resorption in all treated patients. In the Hyrax group, the greatest root volume loss was observed in the left first molar (45.42 mm^3), whereas the smallest reduction occurred in the right first molar (6.08 mm^3). In contrast, the Hybrid Hyrax group exhibited the greatest root volume loss in the right first molar (22.54 mm^3) and the least loss in the left second premolar (4.43 mm^3). These findings are consistent with those reported by Baysal et al., who demonstrated that rapid maxillary expansion produces detectable external root resorption when evaluated using CBCT. The root resorption observed following expansion is attributed to the high orthopedic forces generated during treatment, which create compressive stresses within the periodontal ligament and adjacent alveolar bone, leading to cementum and dentin resorption, particularly in the apical region of the roots.[6, 13, 20]

The use of CBCT in the present study provided accurate three-dimensional assessment of root volume changes before and after expansion. Compared with conventional two-dimensional radiographs, CBCT offers superior diagnostic capability for detecting small resorptive defects without superimposition or distortion. Therefore, CBCT has become an important diagnostic tool in evaluating orthodontically induced root resorption. However, despite its diagnostic advantages, radiation exposure should always be considered, especially in growing patients. For this reason, the field of view in the present study was limited only to the maxillary region to minimize radiation dose. [19, 21, 22]

The present study had several strengths, including the prospective study design, standardized expansion protocol, and the use of CBCT for three-dimensional volumetric analysis. In addition, all patients were treated within a relatively narrow age range, which helped reduce variability related to growth and maturation.

Within the limitations of the present study, both the conventional Hyrax and Hybrid Hyrax appliances were found to be effective treatment modalities for rapid maxillary expansion and were associated with only a limited degree of external root resorption. Although the Hybrid Hyrax appliance demonstrated a tendency toward lower root volume loss in several teeth, no statistically significant differences were identified between the two treatment modalities. Consequently, both appliances exhibited comparable biological effects on the dentoalveolar structures and may be considered reliable and clinically acceptable options for the correction of transverse maxillary deficiency.

Conclusions

1) Both hyrax and hybrid hyrax appliance were effective in correcting maxillary transverse deficiency.
2) Both appliances caused significant reduction in root volume of posterior teeth. However, the hybrid hyrax appliances demonstrate a lower degree of root resorption compared to the conventional hyrax, suggesting it may be a more favorable option for minimizing adverse effects on dental structure during maxillary expansion.
3) Resorptive changes were observed not only in anchorage teeth but also in adjacent non-anchorage teeth(upper second premolar), indicating that rapid maxillary expansion produces a broader distribution of stresses throughout the maxillary dentition.
4) CBCT is a reliable 3D tool for evaluating orthodontically induced root conventional radiograph.resorption and detecting root volume changes that may not be visible on
5) overall, root resorption in both groups was limited and of minor clinical significance in healthy growing patients. However, minimizing root resorption remains important, especially in patients with risk factors.

Recommendations

Based on the findings in this study, the following recommendations for future studies are suggested :

1. Further long-term studies are recommended to evaluate the dental and skeletal effects of miniscrew-assisted rapid palatal expansion appliances, especially during the retention period.
2. Additional investigations should be conducted to compare different types of miniscrew-assisted rapid palatal expansion appliances in the management of skeletal posterior crossbite.
3. Further research is needed to minimize undesirable dental side effects associated with posterior skeletal crossbite treatment.
4. Future studies should evaluate nasal airway changes, patient discomfort, facial skeletal changes, and the relationship between maxillary posterior roots and the maxillary sinus following posterior crossbite management.

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