Original Article

^{99m}Technetium-Labeled Methylene Diphosphonate Uptake in Maxillary Bone During and After Rapid Maxillary Expansion

Z. Mirzen Arat, DDS, PhD[a]; Hatice Gökalp, DDS, PhD[b]; Tamer Atasever, DDS, PhD[c]; Hakan Türkkahraman, DDS, PhD[d]

Abstract: The purpose of this study was to evaluate bone activity at the midpalatal suture that had been biomechanically stimulated by rapid maxillary expansion (RME). A rigid acrylic-bonded expansion device with a maxiskeleton screw was used for RME in three patients who were in three different growth periods. The screw was activated twice a day by ¼ turns. After sufficient expansion, the screw was fixed with acrylic resin, and the same appliance was used as a removable retention plate for three months. Single photone emission computed tomography (SPECT) bone scintigraphy records were obtained before (T1) and at the end of RME (T2) and three months after the retention period (T3). According to the scintigraphic records, the increase in bone activity was highest in the anterior and medial sections on both the left and right sides of the maxilla in all cases. After three months of retention, the bone activity returned to its original level. Therefore, it may be stated that the retention period of three months was sufficient for bone reorganization. (*Angle Orthod* 2003;73:545–549.)

Key Words: Bone scintigraphy; Rapid maxillary expansion; Rigid acrylic-bonded expansion device

INTRODUCTION

Maxillary constriction is a discrepancy secondary to genetic, environmental, and functional factors. Nasal airway constriction, premature contacts, and long-term retention of primary teeth are the main causes of maxillary constriction.[1–3] The most important indication of skeletal or dental upper arch narrowness is a buccal crossbite. Since 1890, various appliances have been designed to achieve minimal dentoalveolar but maximal skeletal effects on the width of the maxilla.

Many authors have investigated the effects of rapid maxillary expansion (RME) on the craniofacial structures using radiological and histological methods.[4–16] Conventional radiographs are easy to obtain; however, they are not sufficient to assess the bone activity in the midpalatal suture and its surrounding tissues. Histological findings, on the other hand, are limited to experimental studies.

Bone scintigraphy has been widely used for the detection of abnormal vascularity or osteogenesis in the skeletal system.[17,18] The sensitivity of this method is far superior to that of conventional radiology because skeletal scintigraphy identifies pathophysiological rather than morphological abnormalities.[19,20]

In this study, bone scintigraphy was used for the evaluation of biomechanically induced bone activity in the surrounding tissues of the midpalatal suture during and after rapid maxillary expansion in three patients who were in three different growth periods.

MATERIALS AND METHODS

This study includes three orthodontic patients in three different growth periods. Patient consent forms were obtained at the beginning of the study. All patients had bilateral buccal crossbites and crowding in the upper and lower dental arches.

- Case l was an 11-year-old girl in the MP3 maturation stage according to hand-wrist films.[21] She had a skeletal and dental Class I malocclusion.
- Case 2 is a 14.1-year-old boy. He was in the MP3cap maturation stage and had both skeletal and dental Class III malocclusion.
- Case 3 is a 15.8-year-old girl in the RU maturation stage.

[a] Professor, Department of Orthodontics, School of Dentistry, University of Ankara, Ankara, Turkey.

[b] Assistant Professor, Department of Orthodontics, School of Dentistry, University of Ankara, Ankara, Turkey.

[c] Associate Professor, Department of Nuclear Medicine, Gazi University, Ankara, Turkey.

[d] Research Fellow, Department of Orthodontics, School of Dentistry, University of Ankara, Ankara, Turkey.

Corresponding author: Hatice Gökalp, DDS, PhD, Ankara Üniversitesi, Diş Hekimiği Fakültesi, Ortodonti Anabilim Dalı, 06500 Beşevler, Ankara, Turkey
(e-mail: haticegokalp@yahoo.com).

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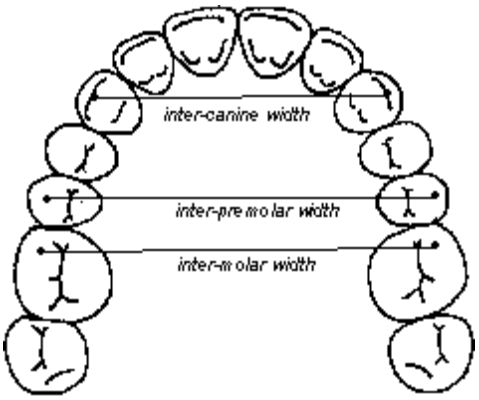


FIGURE 1. Maxillary inter-canine, inter-pre-molar and inter-molar widths were measured on dental cast.

She had a skeletal Class II and a dental Class I malocclusion.

Lateral cephalograms, hand-wrist films, dental casts, and single photon emission computed tomography (SPECT) bone scintigraphy with ^{99m}Technetium-Methylene Diphosphonate ($^{99\,m}$Tc-MDP) were obtained before treatment (T1), at the end of RME (T2), and three months after the retention period was completed (T3).

SPECT bone scintigraphy was used to assess bone activity in areas surrounding the midpalatal suture during the expansion and retention periods. Informed consent was obtained in all three cases.

For bone scintigraphy, patients were given an intravenous injection of 0.4 mCi/kg (15 MBq/kg) of ^{99m}Tc-MDP. Imaging was performed three hours after injection of the radiopharmaceutical. The effective radiation dose equivalents were 2–3 mSv for each examination. SPECT images of the skull were obtained with a dual-headed gamma camera (GE Optima, Milwaukee, Wis) using a low-energy, high-resolution collimator. Sixty-four 30-second views were acquired over 360° rotation in a 64 × 64 matrix. Two pixel–sized transaxial, coronal, and sagittal slices were generated. Coronal slices were used for quantitative evaluation. Twenty pixel–sized circular regions of interest (ROI) were defined on the anterior, medial, and posterior slices of the right and left sides of the maxilla. Background bone activity was defined from the right frontal region. Thus, the bone activity index (BAI) was defined in anterior, medial, and posterior maxillary slices by dividing maxillary activity counts by background activity counts. Maxillary intercanine, interpremolar, and intermolar widths were measured on dental cast as indicated in Figure 1.

Patients were treated with a tissue- and tooth-borne rigid RME acrylic-bonded appliance. A maxiskeleton jackscrew was embedded in acrylic between the first premolars, as close as possible to the palate, with the resin covering the occlusal and facial surfaces of the maxillary posterior permanent teeth. The occlusal resin was trimmed thin enough to preserve the freeway space while still allowing maximum bilateral occlusal contact (Figure 2). The appliance was activated by turning the screw ¼ turn twice a day. The activation continued until the buccal crossbite was eliminated. The duration of the activation period was two to three weeks, depending on the severity of the maxillary constriction. After sufficient expansion was achieved, the screw was fixed with acrylic resin. The same appliance was used as a removable retention device full-time for three months.

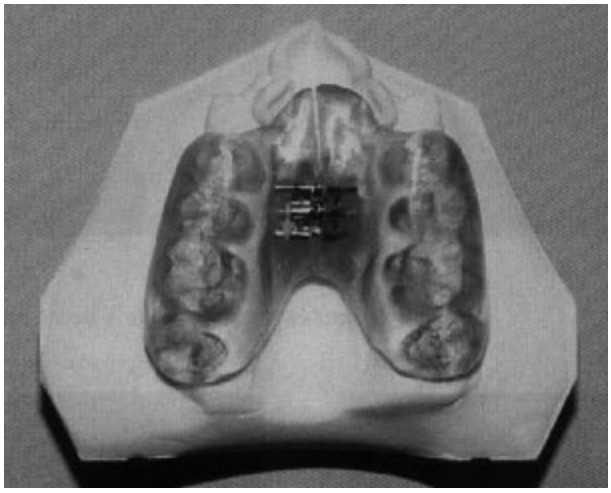


FIGURE 2. Occlusal view of the tissue and teeth-borne rigid acrylic bonded rapid maxillary expansion device with maxi-skeleton

TABLE 1. Intercanine, Interpremolar, and Intermolar Width of Case 1[a]

Case 1	Intercanine Width (mm)	Interpremolar Width (mm)	Intermolar Width (mm)
T1	29.92	29.13	36.04
T2	39.55	39.20	47.68
T3	39.46	39.87	48.05

[a] T1 indicates before rapid maxillary expansion (RME); T2, end of RME; T3, after three months of retention.

TABLE 2. Intercanine, Interpremolar, and Intermolar Width of Case 2[a]

Case 2	Intercanine Width (mm)	Interpremolar Width (mm)	Intermolar Width (mm)
T1	23.28	28.24	30.74
T2	35.07	39.38	41.92
T3	32.53	37.72	41.42

[a] T1 indicates before rapid maxillary expansion (RME); T2, end of RME; T3, after three months of retention.

RESULTS

Dental cast measurements

Sufficient expansion was attained in the upper dental arch and the buccal crossbite was eliminated in all three cases. Changes of maxillary intercanine, interpremolar, and intermolar widths (mm) are presented in Tables 1 through 3.

TABLE 3. Intercanine, Interpremolar, and Intermolar Width of Case 3[a]

Case 3	Intercanine Width (mm)	Interpremolar Width (mm)	Intermolar Width (mm)
T1	27.50	32.45	38.18
T2	31.79	39.00	42.90
T3	32.34	39.36	42.91

[a] T1 indicates before rapid maxillary expansion (RME); T2, end of RME; T3, after three months of retention.

TABLE 4. Bone Activity Index of the Right and Left Maxillary Region in Case 1 Before and After Rapid Maxillary Expansion (RME) and After the Retention Period of Three Months

	Right Side of the Maxilla			Left Side of the Maxilla		
	Before RME	After RME	After Retention	Before RME	After RME	After Retention
Anterior slice	2.58	4.41	3.08	2.95	5.07	3.10
Medial slice	2.66	4.38	2.73	2.93	4.83	2.76
Posterior slice	2.56	3.82	2.56	2.67	4.03	2.55

TABLE 5. Bone Activity Index of the Right and Left Maxillary Region in Case 2 Before and After Rapid Maxillary Expansion (RME) and After the Retention Period of Three Months

	Right Side of the Maxilla			Left Side of the Maxillar		
	Before RME	After RME	After Retention	Before RME	After RME	After Retention
Anterior slice	2.41	3.46	2.85	2.48	3.69	3.16
Medial slice	2.31	3.40	2.72	2.38	3.29	2.73
Posterior slice	1.97	3.04	2.86	2.01	2.88	2.64

In the first and second cases (patients who were in MP3 and in MP3 cap maturation periods, respectively), the intermolar width was increased 11.64 and 11.18 mm, respectively. In the third case (RU maturation stage), the interpremolar width was increased 6.55 mm and the intermolar width was increased 4.72 mm.

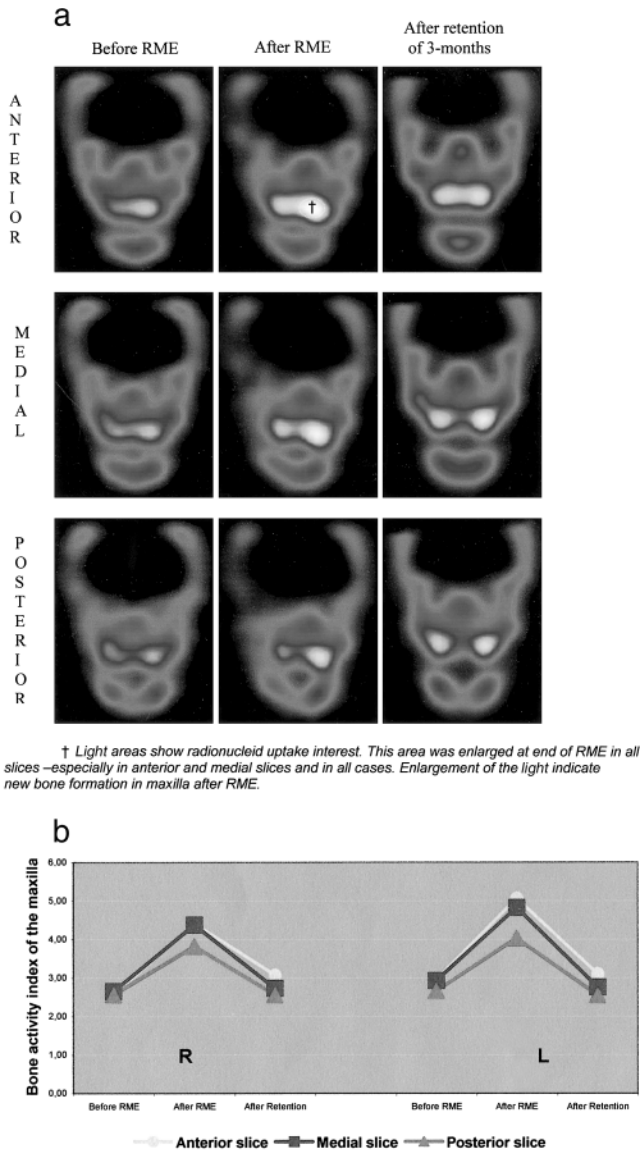
The amount of expansion was stable in all the cases during the retention period (T3), but the intercanine and interpremolar width tended to decrease in the second case. However, the amount of expansion in all three regions (anterior, medial, and posterior) of the first and second cases was much higher than in the third case. In other words, considering interpremolar and intermolar width, the amount of expansion in the first and second cases was almost twice as much as the expansion achieved in the third case.

Bone scintigraphy

Scintigraphic records revealed an increase in the BAI during expansion in all slices and all three cases (Tables 4 through 6; Figures 3a,b; 4a,b; and 5a,b). The increased BAI

TABLE 6. Bone Activity Index of the Right and Left Maxillary Region in Case 3 Before and After Rapid Maxillary Expansion (RME) and After the Retention Period of Three Months

	Right Side of the Maxilla			Left Side of the Maxilla		
	Before RME	After RME	After Retention	Before RME	After RME	After Retention
Anterior slice	2.46	3.80	2.89	2.37	3.71	2.94
Medial slice	2.20	3.86	2.47	2.29	3.99	2.66
Posterior slice	2.26	3.32	2.07	2.73	3.70	2.33



† *Light areas show radionucleid uptake interest. This area was enlarged at end of RME in all slices –especially in anterior and medial slices and in all cases. Enlargement of the light indicate new bone formation in maxilla after RME.*

R: Right maxillary region

L: Left maxillary region

FIGURE 3. (a) Anterior, medial and posterior SPECT views of case I. (b) Bone activity index of the right and left maxilla in all slices of case I.

showed new bone formation during RME in the midpalatal suture on both the right and left sides of the maxillary bone. After a retention period of three months, the BAI of the first and the third case returned almost to the initial status in both the right and left maxillary region (Figures 3b and 5b; Tables 4 and 6). The BAI of the second case did not return to the initial status during this period in either the right or left maxillary regions (Figure 4b; Table 5).

DISCUSSION

RME has been widely used for the treatment of maxillary constriction. The expansion of the upper jaw without expanding the teeth is the main objective of this method. Thus, RME is considered as an orthopedic approach.

Conventional radiography is not capable of detecting the structural changes of the bone during RME. Bone scintigraphy, however, is an appropriate method for the early diagnosis of the lesions and activation regions in the bone.[18,20] Bone scintigraphy has been used rather scarcely in orthodontics.[22–25] It has been used for the examination of asymmetric condylar activity in unilateral condylar hyperplasia.[26,27] Paulsen[24] reported a differential condylar adaptive response attained with the Herbst appliance in a retrognathic case having asymmetric face and occlusion (a girl in the period of MP3cap-DP3u) with planar bone scintigraphy. In a recent study, Arat et al[25] have also investigated the effects of functional appliance on the temporomandibular joint in Class II malocclusion using planar bone scintigraphy.

In this study, the bone activation in midpalatal suture during RME was examined with SPECT bone scintigraphy. To have some idea of the role of age in bone activation and reorganization, three individuals in three different growth phases were included. The cast measurements and scintigraphic records were evaluated in the anterior, medial, and posterior regions of the maxilla. The largest expansions were measured in the first and second cases as 11.18 and 11.64 mm, respectively, in the posterior region. In the third case, the largest expansion was observed in the medial region and measured 6.6 mm. This shows that the reaction to maxillary expansion decreases by half in cases where the patients have completed their active growth. This result is also supported by the results of a recent study.[28]

According to scintigraphic records, the increase in bone activation is highest in the anterior and medial sections but least in the posterior region in all cases. Consequently, we might presume that the amount of expansion and the amount of bone activation are not parallel. An evaluation of the BAI with regard to growth periods revealed that the first case (a girl in MP3 maturation period) had the highest BAI. Contradictory to the expectations, the BAI in the third case was higher than in the second case.

CONCLUSIONS

- According to scintigraphic records, the increase in bone activation is highest in the anterior and medial region, but least in the posterior region in all cases.

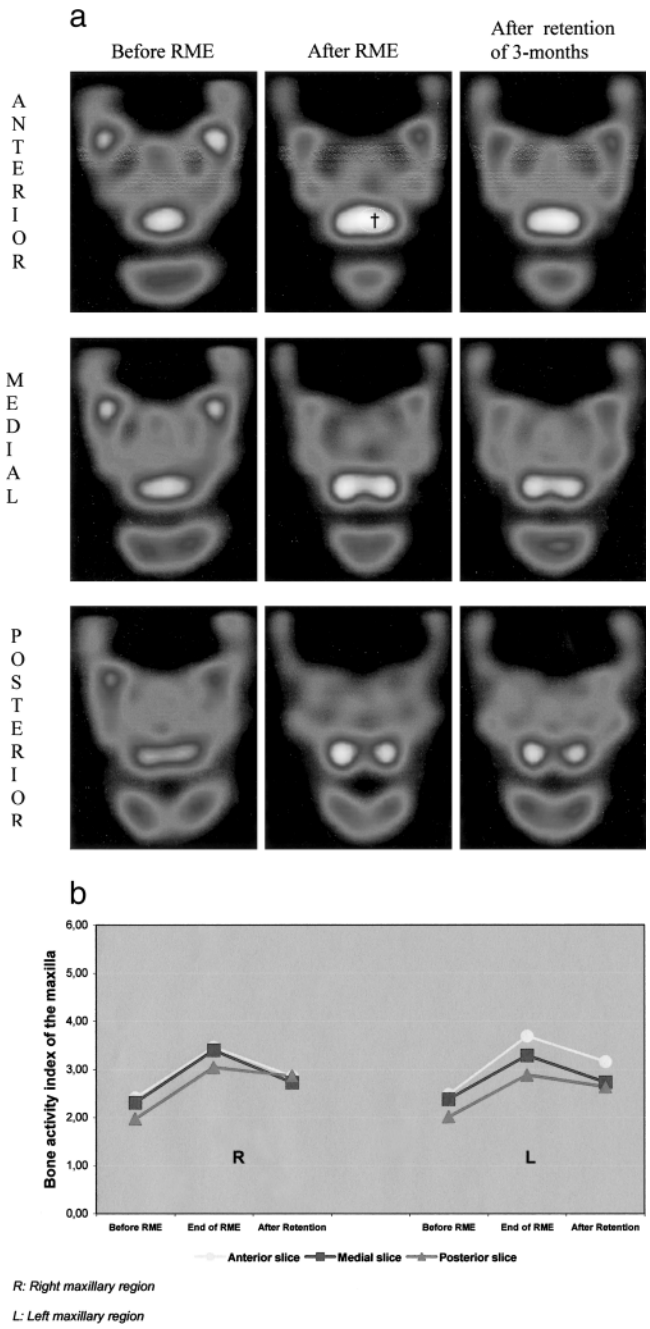
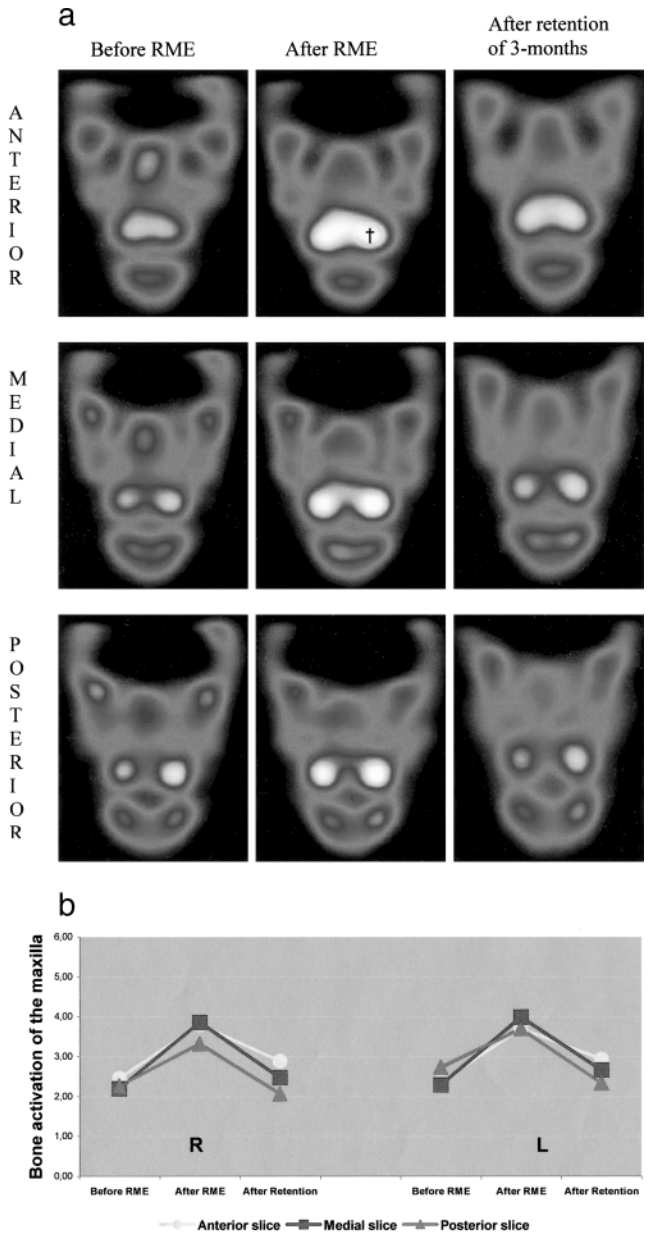


FIGURE 4. (a) Anterior, medial, and posterior SPECT views of case II. (b) Bone activity index of the right and left maxilla in all slices of case II.

- The reaction to maxillary expansion decreases by half in cases where patients have completed their active growth.
- In the retention period (T2-T3), the BAI was very close to the initial value in all sections. This may imply that retention of three months is sufficient for bone reorganization. However, it would be too optimistic to state that the reorganization in the bone is insurance against relapse. It should always be kept in mind, however, that the muscular environment plays an important role in relapse.



R: Right maxillary region

L: Left maxillary region

FIGURE 5. (a) Anterior, medial, and posterior SPECT views of case III. (b) Bone activity index of the right and left maxilla in all slices of case III.

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