Original Article

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Comparison of skeletal and dentoalveolar effects of tooth-and-bone-borne and bone-borne miniscrew-assisted rapid palatal expansion in young adults

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Objective: To investigate the frequency of midpalatal suture separation with tooth-and-bone-borne (TBB) and bone-borne (BB) miniscrew-assisted rapid palatal expansion and to compare their skeletal and dentoalveolar effects in young adults. **Methods:** This retrospective study included 34 patients (14 male and 20 female) who underwent palatal expansion divided into two groups: TBB group (n = 15; mean age, 22.3 years) and BB group (n = 19; mean age, 21.7 years). Cone-beam computed tomography images were acquired before treatment (T0) and after a 3-month consolidation period (T1). The primary outcomes were the frequency of midpalatal suture separation (%) and skeletal and dentoalveolar changes after expansion. The secondary outcome was the dental expansion ratio (%). **Results:** Midpalatal suture separation was observed in 73.3% (11/15) and 73.7% (14/19) of patients in the TBB and BB groups, respectively. Both groups showed comparable increases in skeletal measurements. However, the TBB group demonstrated greater dentoalveolar expansion than the BB group. In addition, the TBB group exhibited greater dental inclination and a greater reduction in the buccal alveolar bone thickness than the BB group. Furthermore, the dental expansion ratio was significantly higher in the TBB group (65.0%) than in the BB group (35.7%, $P < 0.001$). **Conclusions:** Both TBB and BB achieved successful midpalatal suture separation in young adults, with success rates of 73.3% and 73.7%, respectively. Moreover, skeletal expansion outcomes were comparable between the groups. However, dental expansion was greater in the TBB group than in the BB group, with a greater increase in dental inclination.

Keywords: Orthodontic mini-implant, Palatal expansion

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INTRODUCTION

Miniscrew-assisted rapid palatal expansion (MARPE), first introduced in 2010,[1] has been widely used in clinical practice because of its ability to achieve significant skeletal and dentoalveolar expansion. Moreover, a high success rate for midpalatal suture separation has been reported in young adults.[2,3] The stability of skeletal and dental expansion achieved with MARPE in young adults is acceptable, with a success rate of 86.96%.[4-6] In contrast with conventional rapid palatal expansion, MARPE involves the use of a tooth-and-bone-borne (TBB) appliance; therefore, forces are distributed to both the supporting teeth and maxillary bone through skeletal anchorage.[4,7,8] Although MARPE exhibits notable efficacy and stability, complications such as alveolar bone bending and tipping of the anchor teeth have been reported.[5] Therefore, careful monitoring is recommended if the buccal bone of the supporting teeth is thin or if alveolar-bone dehiscence is suspected.

The skeletal and dental effects of bone-borne (BB) MARPE, which does not apply direct force to the teeth,[9-13] have been reported. A finite-element study indicated that nonsurgical maxillary expansion using BB MARPE in young adults is associated with a risk of suture opening. This may lead to high-stress distribution around the miniscrews and could be mechanically disadvantageous for suture opening.[14] However, in patients in their growth phase, BB expanders produce greater orthopedic effects and fewer dentoalveolar side effects than conventional rapid palatal expansion.[10,15] Nevertheless, no study has established the differences in the skeletal and dental effects or the frequency of midpalatal suture separation between TBB and BB MARPE in adults aged > 18 years.

This study aimed to investigate the frequency of midpalatal suture separation with TBB MARPE and BB MARPE and to compare their short-term skeletal and dentoalveolar effects in young adults using low-dose cone-beam computed tomography (CBCT).

MATERIALS AND METHODS

Study design and participants

This study included adults aged > 18 years who were diagnosed with a transverse discrepancy and underwent palatal expansion using TBB or BB at the Department of Orthodontics at the Yonsei University Dental Hospital between June 2022 and September 2023. The study adhered to the tenets of the Declaration of Helsinki and was approved by the Institutional Review Board of Yonsei Dental Hospital (IRB No. 2-2024-0054). The requirement to obtain informed consent was waived.

The inclusion criteria were individuals aged ≥ 18 years with maxillary constriction presenting as a unilateral or bilateral posterior crossbite, and who had not undergone prior orthodontic treatment. Exclusion criteria included age > 30 years, congenitally missing teeth (except third molars), moderate-to-severe periodontal disease, and congenital craniofacial deformities such as cleft lip and palate or hemifacial microsomia.

The TBB MARPE device (Figure 1A and 1B) consisted of four rigid stainless steel wire connectors with helical hooks soldered onto the base of Hyrax screws (semi-rigid Hyrax II; Dentaurum, Ispringen, Germany). The center of the device was positioned between the maxillary first premolar and first molar.[16] Following MARPE cementation, four miniscrews (diameter, 1.5 mm; length, 13 mm anteriorly and 11 mm posteriorly; BMK, BioMaterials Korea, Seoul, Korea) were implanted perpendicular to the central axis of the helical hooks. The miniscrews were connected to the helical hooks using light-cured composite resin (Light-Core; BISCO Dental, Schaumburg, IL, USA).

Based on a previous finite-element analysis study,[16] the center of the BB MARPE appliance (Figure 1D and 1E) was positioned to align with the midpalatal suture between the maxillary second premolar and first molar. In this study, BB MARPE appliances from two manufacturers were used: Osteonic (Seoul, Korea) and BioMaterials Korea. Four miniscrews (diameter, 1.8 mm; length, 13 mm anteriorly and 11 mm posteriorly; BMK, BioMaterials Korea) were placed under local anesthesia. The four arms of the BB MARPE appliance were designed to make contact with the teeth and serve as guides for maintaining the position of the expander on the palate prior to miniscrew insertion. Following placement of the miniscrews, all four arms were removed from the main body of the expander.

The TBB MARPE was activated 0.2 mm with a quarter turn every other day. BB MARPE devices also were activated every other day. The device from Osteonic was activated by one-quarter turn (0.2 mm), and the device from BioMaterials Korea was activated by one-third of a turn (0.27 mm). Activation was halted upon the alignment of the palatal cusps of the maxillary first molars with the buccal cusp tips of the mandibular first molars. After maxillary expansion was completed, the appliance was maintained for 3 months (consolidation period) to allow bone formation before removal. In the BB group, a passive transpalatal arch fabricated using a 0.032 × 0.032-inch stainless steel wire was used to maintain the transverse dimensions of the maxillary first molar during the consolidation period. Subsequently, all patients underwent orthodontic treatment using a straight-wire appliance.

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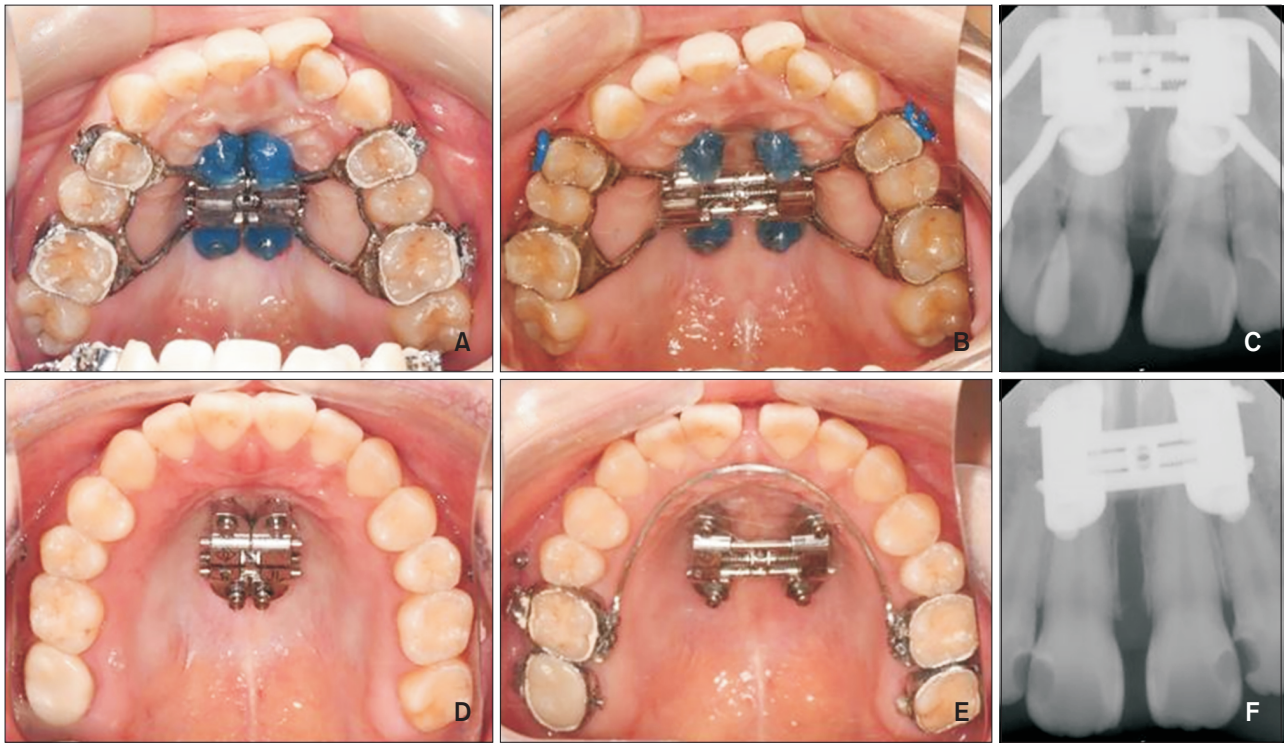

Figure 1. MARPE with two types of devices. **A**, Preoperative photograph showing a TBB MARPE appliance, **B**, intraoral photograph after expansion using TBB MARPE, **C**, periapical radiograph 2 weeks after expansion using TBB MARPE shows a diastema caused by splitting of the midpalatal suture. **D**, Preoperative photograph showing a BB MARPE appliance, **E**, intraoral photograph after expansion using BB MARPE, and **F**, periapical radiograph 2 weeks after expansion using BB MARPE.
MARPE, miniscrew-assisted rapid palatal expansion; TBB, tooth-and-bone-borne; BB, bone-borne.

Measurement time points

A periapical radiograph was obtained 2 weeks after expansion, and evidence of midpalatal suture separation on this radiograph was defined as successful suture opening (Figure 1C and 1F).

CBCT images were acquired before treatment (T0), and immediately after a 3-month consolidation period (T1). The CBCT device (Alphard VEGA; ASAHI Roentgen Ind., Kyoto, Japan) was used with low-dose exposure with the following settings: voltage, 80 kV; current, 5.0 mA; scanning time, 17 seconds; field of view, 154 × 154-mm; and voxel size, 0.3 mm. The total amount of radiation received during all CBCT scans did not exceed the prescribed annual limit of 1 mSv.

Cone-beam computed tomography imaging and three-dimensional reconstruction

Digital Imaging and Communications in Medicine data obtained via CBCT were reconstructed in three dimensions using OnDemand software (Cybermed, Seoul, Korea) and analyzed by superimposing the images based on the anterior cranial base.

Based on previous studies,[17,18] 20 landmarks were analyzed, and each landmark on the left and right sides was measured at both T0 and T1 (Table 1, Figures 2, 3A, and 3B).

Buccal bone plate thickness was measured as the shortest distance from the buccal boundary of the maxillary first premolar and first molar on both sides to the cortical bone boundary in the axial section passing through the root furcation of the maxillary first molars (Figure 3C and Table 2).[7,19]

Outcomes

The primary outcomes were the frequency of midpalatal suture separation (%) and skeletal and dentoalveolar changes after expansion, including those in six linear measurements, four angular measurements, and the buccal bone plate thickness at six points. For bilateral measurements, the mean of the left and right sides was calculated and used for the analysis.

The secondary outcome was the dental expansion ratio (%), defined as the interfurcation width (mm) divided by the jackscrew expansion (mm).

Table 1. Landmarks used in this study

Landmark	Description
Nasal alare (1–2)*	The most inferolateral point of the nasal aperture in a transverse plane
Processus zygomaticus (3–4)*	The most inferolateral point of the processus zygomaticus
Ectocanine (5–6)*	The most inferolateral point on the alveolar ridge opposite the center of the maxillary canine
Ectomolare (7–8)*	The most inferolateral point on the alveolar ridge opposite the center of the maxillary first molar
Furcation of maxillary first molar (9–10)*	Furcation of maxillary first molar's root
Central fossa of maxillary first molar (11–12)*	Central fossa of maxillary first molar's crown
RP cusp (13)†	Cusp tip of the right first premolar's palatal cusp
RP apex (14)†	Apical third of the right first premolar' palatal root
LP cusp (15)†	Cusp tip of the left first premolar's palatal cusp
LP apex (16)†	Apical third of the left first molar's palatal root
RM cusp (17)†	Cusp tip of the right first molar's palatal cusp
RM apex (18)†	Apical third of the right first molar's palatal root
LM cusp (19)†	Cusp tip of the left first molar's palatal cusp
LM apex (20)†	Apical third of the left first molar's palatal root

RP, right premolar; LP, left premolar; RM, right molar; LM, left molar.
*The number in the description indicates the number of the landmarks presented in Figure 2.
†The number in the description indicates the number of the landmarks presented in Figure 3.

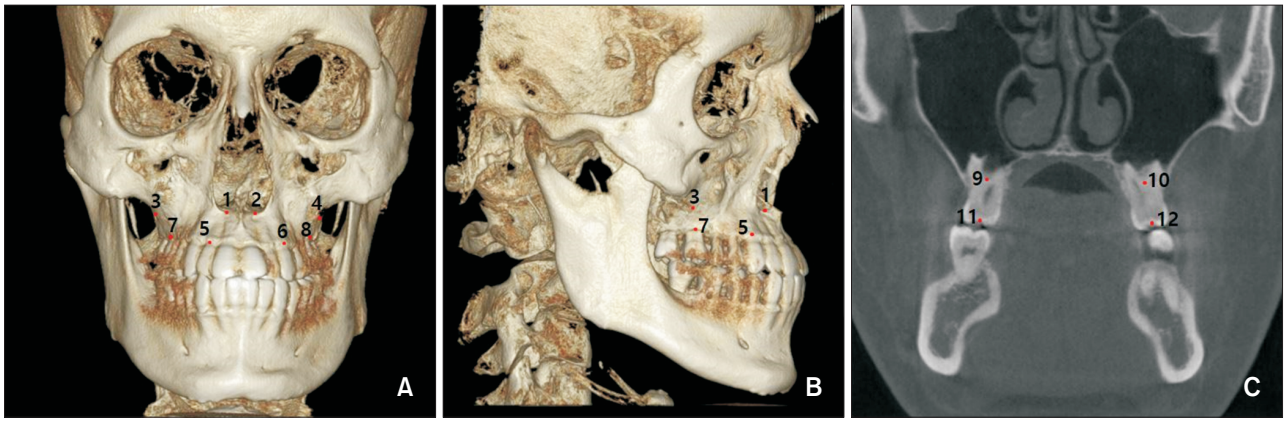

Figure 2. Skeletal and dentoalveolar landmarks and coordinate system for linear measurements. **A**, Landmarks in frontal view. **B**, Landmarks in lateral view. **C**, Landmarks in coronal view.
See Tables 1, 2 for definitions of each landmark or measurement.

Statistical analysis

Statistical analyses were performed using Statistical Package for the Social Sciences (version 27.0; IBM, Armonk, NY, USA). Repeated-measures analysis of variance was performed to identify skeletal and dental changes after expansion. In accordance with the findings of a previous study,[18] a large effect size (Cohen's f = 0.40) was adopted for the power analysis. Post hoc analysis using G*Power 3 (Düsseldorf, Germany) for detecting longitudinal changes in skeletal and dentoalveolar parameters within each group, was performed using data from 25 cases with successful expansion. The results indicated a statistical power > 0.90, at a significance level of 0.05 and a large effect size (Cohen's f = 0.40).

Normality of variable distribution was assessed using the Shapiro–Wilk test. Descriptive statistical measures such as means and standard deviations were used to depict the distribution of each variable. The success rate of suture opening was evaluated using Fisher's exact test. Repeated-measures analysis of variance was performed

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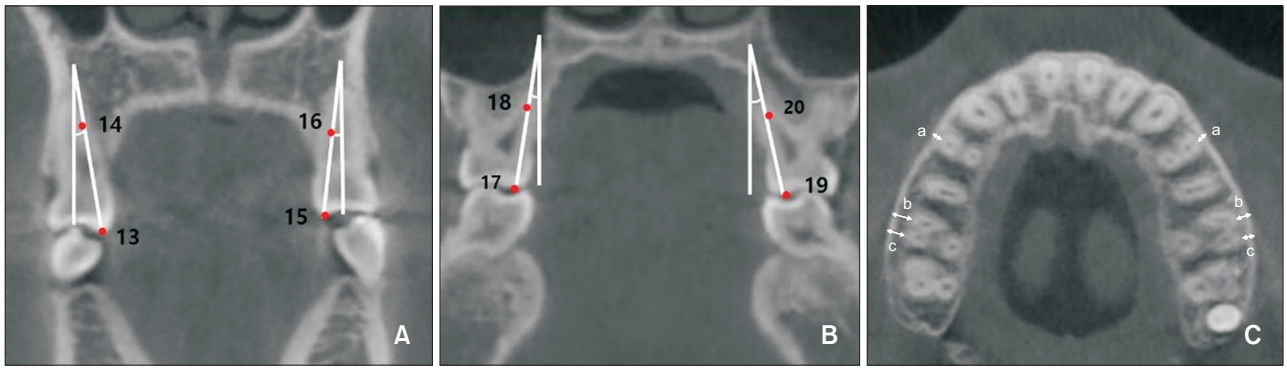

Figure 3. Dentoalveolar landmarks and coordinate system for angular measurement and buccal bone plate thickness. **A**, Maxillary first premolar inclination. **B**, Maxillary first molar inclination. **C**, Cone-beam computed tomography image illustrating the periodontal variables.
a, PM-BBPT; b, M-BBPT (mesial root); c, M-BBPT (distal root).
See Tables 1, 2 for definitions of each landmark or measurement.

Table 2. Parameters measured in this study

Parameter	Description
Skeletal linear measurements	
Interalare width	Linear distance (mm) between the left and right alare (1–2)*
Interprocesus zygomaticus width	Linear distance (mm) between the left and right processus zygomaticus (3–4)*
Dentoalveolar linear measurements	
Interectocanine width	Linear distance (mm) between the left and right ectocanine (5–6)*
Interectomolare width	Linear distance (mm) between the left and right ectomolare (7–8)*
Interfurcation width	Linear distance (mm) between the left and right furcation of maxillary first molar (9–10)*
Intercentral fossa width	Linear distance (mm) between the left and right central fossa of maxillary first molar (11–12)*
Dental angular measurements	
Inclination of maxillary first premolar	Mean of inclination (°) of both maxillary first premolar (13–14, 15–16)†
Inclination of maxillary first molar	Mean of inclination (°) of both maxillary first molar (17–18, 19–20)†
BBPT	
First premolar (PM-BBPT)	The shortest distance between the buccal cortical plate and the buccal root surface of maxillary first premolar
First molar (M-BBPT [mesial root])	The shortest distance between the buccal cortical plate and the buccal root surface of maxillary first molar mesial root
First molar (M-BBPT [distal root])	The shortest distance between the buccal cortical plate and the buccal root surface of maxillary first molar distal root

PM-BBPT, premolar buccal bone plate thickness; M-BBPT, molar buccal bone plate thickness.
*The number in the description indicates the number of the landmarks presented in Figure 2.
†The number in the description indicates the number of the landmarks presented in Figure 3.

to test the significance of the changes after expansion within the groups and to compare the changes between the two groups. The intraclass correlation coefficient (ICC) and Dahlberg error were used to assess intra-examiner errors. The dental expansion ratio was compared between the groups using an independent *t* test.

Reliability

Reproducibility was determined by comparing the measurements obtained from the initial assessment with

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those obtained from repeated assessments. A single examiner (SR) performed all linear and angular measurements and repeated them on 30% of the samples 2 weeks later. ICCs ranging from 0.961 to 0.998 for linear measurements and from 0.920 to 0.993 for angular measurements, indicated good reproducibility. Corresponding Dahlberg errors ranged from 0.05 to 0.47 mm and from 0.59° to 1.81°, respectively, indicating a high level of measurement reliability; therefore, the first data set was used for analysis.

RESULTS

Baseline data

The TBB group included 15 adults (7 male and 8 female) aged 19–29 years (mean age, 22.3 ± 3.4 years), whereas the BB group comprised 19 adults (7 male and 12 female) aged 18–27 years (mean age, 21.7 ± 3.0 years). Baseline characteristics were not significantly different between the groups (Table 3).

Primary outcomes

The frequency of midpalatal suture separation in the TBB and BB groups was 73.3% (11/15) and 73.7% (14/19), respectively, with no significant differences between the groups (Table 4). Patients with failure of midpalatal suture separation were excluded from the statistical analysis related to skeletal and dentoalveolar changes.

Table 3. Patient characteristics in the TBB and BB groups

Variable	TBB group (n = 15)	BB group (n = 19)	*P* value
Age (yr)			
Range	19 to 29	18 to 27	
Mean (SD)	22.3 (3.4)	21.7 (3.0)	0.61*
Sex, n (%)			0.56†
Male	7 (46.7)	7 (36.8)	
Female	8 (53.3)	12 (63.2)	
ANB (°)			
Range	-2.8 to 5.3	-3.7 to 8.6	
Mean (SD)	1.8 (2.1)	1.5 (3.6)	0.76‡
YTI (mm)			
Range	-6.6 to 3.5	-7.7 to 3.5	
Mean (SD)	-2.4 (2.5)	-2.3 (3.1)	0.92‡
Turn (mm)			
Range	6.0 to 8.8	6.2 to 9.4	
Mean (SD)	7.3 (1.0)	7.7 (1.0)	0.22†

TBB, tooth-and-bone-borne; BB, bone-borne; SD, standard deviation; YTI, Yonsei Transverse Index; Turn, jackscrew expansion amount.
*P value was calculated using Mann–Whitney U test.
†P value was calculated using chi-square test.
‡P value was calculated using independent t test.

Skeletal changes

Significant increases after expansion were observed in both skeletal measurements (nasal alare and processus zygomaticus) in both groups ($P < 0.001$; Table 5). The change in the processus zygomaticus position was significantly different between the two groups after expansion. The extent of expansion over time was greater in the BB group (mean ± standard deviation, 2.46 ± 0.52 mm) than in the TBB group (1.94 ± 0.34 mm) (time × group $P = 0.012$; Table 5).

Dentoalveolar changes

Regarding the dentoalveolar linear measurements, the extent of expansion at the furcation of the maxillary first molar was greater in the TBB group (4.57 ± 0.80 mm) than in the BB group (2.78 ± 1.04 mm) (time × group $P < 0.01$; Table 5). Similarly, expansion at the central fossa of the maxillary first molar was greater in the TBB group (5.98 ± 0.91 mm) than in the BB group (3.92 ± 1.34 mm).

The inclinations of both the maxillary first premolar and first molar were significantly greater in the TBB group (4.09° ± 1.50° and 4.14° ± 1.54°, respectively) than in the BB group (0.82° ± 1.63° and 1.80° ± 2.19°, respectively; time × group, $P < 0.01$ and $P < 0.008$; Table 5). The dental expansion ratio, which reflects the degree of dental expansion, was 65.0% and 35.7% in the TBB and BB groups, respectively ($P < 0.001$; Table 5).

Periodontal changes

The reduction in the buccal alveolar-bone thickness was significantly greater in the TBB group than in the BB group at all measurement points. In the premolar region, it was −0.66 ± 0.42 mm and −0.10 ± 0.22 mm in the TBB and BB groups, respectively ($P < 0.002$). At the mesial and distal roots of the maxillary first molar, it was −0.83 ± 0.42 mm; and −0.08 ± 0.38 mm ($P < 0.01$) and

Table 4. Comparison of the frequency of midpalatal suture opening between the TBB and BB groups

	TBB group (n = 15)	BB group (n = 19)	*P* value
Suture opening			0.640
Success	11 (73.3)	14 (73.7)	
Failure	4 (26.7)	5 (26.3)	

Values are presented as number (%).
P values were calculated with Fisher's exact test.
TBB, tooth-and-bone-borne; BB, bone-borne.

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Table 5. Skeletal and dentoalveolar measurements according to groups in different periods

Outcome variable	T0	T1	T1–T0 difference	*P* value		
				Time†	Group†	Time × Group†
Skeletal (mm)						
Interalare width				< 0.001***	0.561	0.823
TBB group	10.61 (1.33)	12.78 (1.24)	2.16 (0.52)			
BB group	10.26 (1.37)	12.47 (1.61)	2.21 (0.47)			
Interprocessus zygomaticus width				< 0.001***	0.497	0.012*
TBB group	63.32 (4.68)	65.27 (4.63)	1.94 (0.34)			
BB group	64.17 (3.41)	66.63 (3.37)	2.46 (0.52)			
Dentoalveolar (mm)						
Interectocanine width				< 0.001***	0.837	0.098
TBB group	36.17 (3.25)	38.52 (3.28)	2.34 (0.44)			
BB group	35.72 (2.32)	38.51 (2.30)	2.79 (0.72)			
Interectomolare width				< 0.001***	0.976	0.100
TBB group	57.29 (3.49)	61.10 (3.42)	3.81 (0.58)			
BB group	57.61 (3.26)	60.86 (3.13)	3.24 (0.95)			
Interfurcation width				< 0.001***	0.851	< 0.001***
TBB group	45.30 (3.69)	49.87 (3.63)	4.57 (0.80)			
BB group	45.96 (2.64)	48.74 (2.64)	2.78 (1.04)			
Intercentral fossa width				< 0.001***	0.861	< 0.001***
TBB group	46.96 (3.83)	52.94 (3.43)	5.98 (0.91)			
BB group	47.75 (3.73)	51.67 (2.83)	3.92 (1.34)			
Dentoangular (°)						
Inclination of maxillary first premolar				< 0.001***	0.832	< 0.001***
TBB group	81.40 (6.24)	85.49 (5.92)	4.09 (1.50)			
BB group	83.65 (6.48)	84.48 (6.02)	0.82 (1.63)			
Inclination of maxillary first molar				< 0.001***	0.857	0.008*
TBB group	95.87 (5.43)	100.02 (5.34)	4.14 (1.54)			
BB group	97.46 (6.03)	99.26 (4.89)	1.80 (2.19)			
Thickness of alveolar bone (mm)						
PM-BBPT				< 0.001***	0.050	0.002**
TBB group	1.00 (0.55)	0.34 (0.16)	−0.66 (0.42)			
BB group	1.09 (0.45)	0.99 (0.47)	−0.10 (0.22)			
M-BBPT (mesial root)				< 0.001***	0.616	< 0.001***
TBB group	1.77 (0.98)	0.94 (0.66)	−0.83 (0.42)			
BB group	1.54 (0.66)	1.46 (0.61)	−0.08 (0.38)			
M-BBPT (distal root)				< 0.001***	0.110	< 0.001***
TBB group	2.18 (0.97)	1.21 (0.85)	−0.97 (0.30)			
BB group	2.18 (0.68)	2.22 (0.61)	0.05 (0.40)			

Values are presented as mean (standard deviation).
Comparison was only done for suture opening success group (TBB group [n = 11], BB group [n = 14]) and were tested with an RM ANOVA.
TBB, tooth-and-bone-borne; BB, bone-borne; T0, before treatment; T1, after a 3-month consolidation period; PM-BBPT, premolar buccal bone plate thickness; M-BBPT, molar buccal bone plate thickness.
*$P < 0.05$, **$P < 0.01$, ***$P < 0.001$.
†By repeated-measures analysis of variances.

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−0.97 ± 0.30 mm and 0.05 ± 0.40 mm in the TBB and BB groups, respectively ($P < 0.01$), indicating significant time × group interactions (Table 5).

DISCUSSION

In this study, both TBB and BB MARPE achieved clinically significant skeletal expansion of approximately 2 mm in young adults, which is consistent with the findings in previous studies by Park et al.[6] and Choi et al.[4] This expansion is crucial for correcting transverse discrepancies and ensuring the long-term stability of orthodontic treatment. Interestingly, skeletal expansion at the nasal alare was slightly greater in the BB group, although the difference was not statistically significant, whereas the processus zygomaticus showed a significant increase of 0.52 mm. At the end of activation, the BB group exhibited greater expansion (7.7 mm) than the TBB group (7.3 mm). However, the TBB group demonstrated significantly greater transverse expansion at the central fossa and furcation of the maxillary first molar. The TBB expansion pattern was triangular, with the crown as the base (Figure 4A), whereas the BB expansion showed a cylindrical pattern with a narrower base (Figure 4B). These distinct expansion patterns offer valuable clinical insights for selecting the most suitable appliance based on the individual patient's needs.

Greater increases in the inclinations of the maxillary first premolar and first molar were observed in the TBB group than in the BB group. Additionally, the decrease in the buccal alveolar-bone thickness was significantly more pronounced in the TBB group than in the BB group in the maxillary first premolar region and the mesial and distal regions of the maxillary first molar. This finding indicates that in the TBB group, the anchor teeth were excessively tipped accompanied by a reduction in the buccal alveolar-bone thickness. This finding aligns with that of Bazzani et al.,[11] who suggested that TBB MARPE involves tipping movements, whereas BB MARPE results in bodily tooth movements. Thus, TBB MARPE may result in crown expansion accompanied by buccal tipping. Lim et al.[5] reported the relapse of posterior tooth expansion and inclination 1 year after MARPE; therefore, overexpansion may be necessary to compensate for potential relapse during the leveling phase of the posterior segment. Further studies are needed to evaluate the long-term stability and effect on alveolar-bone thickness and height.

In this study, successful midpalatal suture separation was achieved in 73.3% and 73.7% of patients in the TBB and BB groups, respectively, with no significant differences between the groups. These rates are lower than the previously reported success rates for suture separation achieved with MARPE (86.96%) in adults aged 18–29 years,[4] but similar to the overall success rate reported across all age groups (79.53%).[20] According to a finite-element analysis conducted by Seong et al.,[14] BB MARPE concentrates expansion forces around the miniscrews and does not effectively transfer forces to the basal bone compared to TBB MARPE, suggesting that TBB MARPE may be more effective for suture separation in adults. However, they used 7-mm miniscrews, whereas

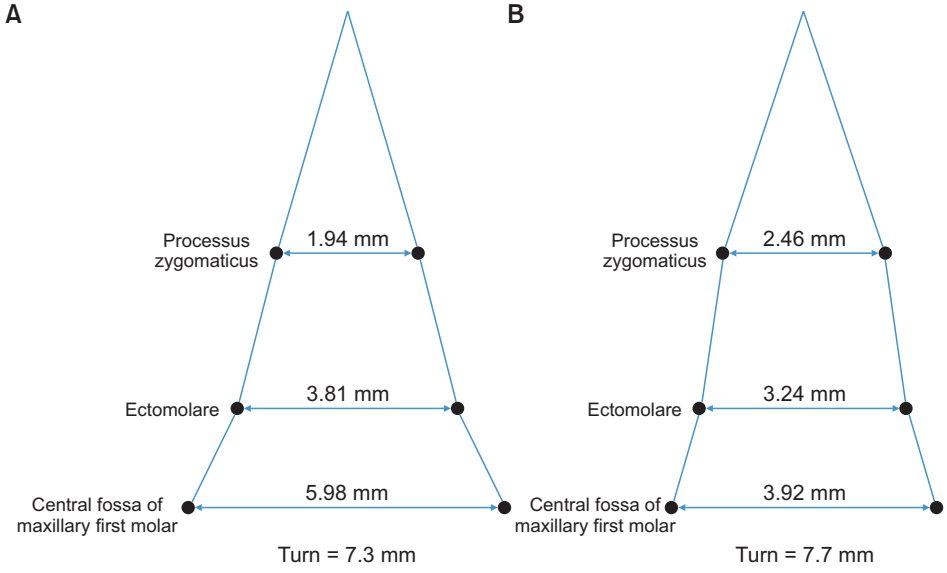

Figure 4. Diagram of transverse changes. **A**, TBB group exhibits a pyramidal expansion pattern. **B**, BB group exhibits a cylindrical expansion pattern. Values are the mean differences (mm).
TBB, tooth-and-bone-borne; BB, bone-borne; Turn, jackscrew expansion amount.

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our study used longer screws measuring 11–13 mm for BB MARPE. This may account for the comparable success rates of suture separation observed between TBB MARPE and BB MARPE in our study.

Several factors may contribute to the failure of midpalatal suture separation, including age, sex, miniscrew failure, and maturity of circummaxillary sutures.[20,21] In this study involving young adults, suture separation failed in nine patients, of whom 66.7% (6/9) were male and 33.3% (3/9) were female. This finding is consistent with that of a previous study[20] which reported a lower likelihood of suture separation in male patients. Nonetheless, owing to the retrospective design and small sample size of our study, further randomized clinical trials are necessary to conclusively evaluate success rates.

The dental expansion ratios in the TBB and BB groups were 65.0% and 35.7%, respectively. Thus, the BB group exhibited significantly less dental expansion than the TBB group, suggesting that this appliance may be less suitable for cases requiring greater dental expansion.

The design of the BB MARPE appliance allows for early initiation of posterior tooth movement during the consolidation period, facilitating procedures such as scissor-bite correction and rotation control and the use of clear aligners. In addition, an extension arm can be attached to the expander to function as an indirect anchor. In cases with minimal transverse dental discrepancy requiring significant nasal floor expansion, such as in patients with obstructive sleep apnea, BB-MARPE can be used to achieve greater expansion of the nasal floor.

This study had some limitations. First, this was a retrospective study, and future prospective studies are necessary to determine the frequency of midpalatal suture opening. Second, we used BB MARPE devices from two manufacturers. Although no statistically significant differences were found between the two manufacturers (Mann–Whitney U test, $P > 0.05$) and the devices were analyzed as a single group (BB group), the limited sample size and morphological differences in the appliances might have affected the outcomes. Further research using controlled appliances is required to investigate this issue. Third, because we only evaluated short-term effects T1, further research is required to clarify long-term stability of the outcomes.

CONCLUSIONS

This study showed that both TBB and BB MARPE successfully achieved separation of midpalatal sutures in young adults. In the coronal plane, the expansion obtained with TBB MARPE exhibited a triangular pattern with the crown serving as the base, whereas that achieved with BB MARPE demonstrated a cylindrical pattern with a narrow base. TBB MARPE can be used in clinical situations where both skeletal and dental expansions are required, whereas BB MARPE can be used in cases where greater skeletal expansion is needed with minimal dental expansion.

AUTHOR CONTRIBUTIONS

Conceptualization: SR, JYC. Data curation: SR. Formal analysis: SR, JL, SHC, HSY, JYC. Investigation: SR, EHAC. Methodology: All authors. Project administration: SR, JYC. Resources: SR, JYC. Supervision: JYC. Validation: SR, EHAC, JL, JYC. Visualization: SR, JYC. Writing–original draft: SR, JYC. Writing–review & editing: EHAC, JL, SHC, HSY, JYC.

CONFLICTS OF INTEREST

No potential conflict of interest relevant to this article was reported.

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