Original Article

Maxillary Expansion Via Palatal Mini-Implants: A Preliminary Study

Ayça Arman-Özçırpıcı, DDS, PhD;[1] Alev Yılmaz, DDS, PhD;[2,]* and Ömür Polat-Özsoy, DDS, PhD[3]

ABSTRACT

Objective: This study evaluates the skeletal and dental effects of a mini-implant supported maxillary expansion (MISME) appliance that applied forces directly to the maxilla.

Materials and Method: Records of 9 patients (5 female and 4 male patients; mean age = 12 years 8 months) with indications of maxillary expansion were included in this study. After insertion of four miniscrews (1.6 mm in diameter, 7 mm in length), an acrylic expansion device was bonded on the screws. Two miniscrews were placed in the anterior palate bilaterally, 3–4 mm lateral to the suture and 3–4 mm posterior to the incisive foramen. Two miniscrews were placed bilaterally between the second premolar and first molar roots in the palatal alveolus. The MISME appliance was activated with a semi-rapid protocol until the desired expansion was achieved. The average treatment duration was 97.1 ± 62.2 days. Measurements from cephalometric, posteroanterior radiographs and dental casts taken before and after expansion were evaluated statistically. The nonparametric Wilcoxon test was used for not normally distributed parameters (i.e., Nperp-A), and the parametric paired *t* test was performed for normally distributed parameters. A finding of $p < 0.05$ was considered to be statistically significant.

Results: Forward movement of the maxilla ($p<0.05$) as well as an increase in nasal and maxillary skeletal and dental widths ($p<0.001$) were observed in the sample group. Maxillary intermolar, intercanine, and palatal widths also increased ($p<0.001$) without buccal tipping of molars. A slight posterior rotation of the mandible was seen. Dentoalveolar measurements did not show any significant changes.

Conclusion: The MISME appliance showed successful expansion of the maxilla without such side effects as buccal tipping of molars and bite opening. This appliance, which provides parallel expansion, can be a simple and economic alternative to transpalatal distraction. (*Turkish J Orthod* 2014;27:16–27)

KEY WORDS: Maxillary expansion, Mini-implant, Palatal implant, Skeletal anchorage

INTRODUCTION

Maxillary deficiency is usually accompanied by bilateral or unilateral posterior crossbite, narrow nasal cavity, and crowding.[1,2] Various rapid maxillary expansion (RME) appliances, such as tooth-borne, tissue-borne or tooth-tissue–borne devices, have been widely used in adolescents with skeletal constriction of the palate.[3–7]

Such RME appliances widen the maxillary arch by opening the midpalatal suture. Along with the desired orthopedic effect of separating the maxillary halves, RME often results in undesirable buccal movement or tipping and extrusion of the posterior teeth supporting the appliance.[8–13] These orthodontic effects usually cause bite opening and posterior rotation of the mandible, and there is also an increased tendency for relapse.[10,11,14,15] Tooth-borne expanders are also iatrogenic from a periodontal standpoint and might cause root resorption at the buccal aspects of the supporting teeth, buccal dehiscences, and gingival recession.[7,16] Haas[14] suggested adding acrylic palatal coverage to produce more bodily movement and less dental tipping. On the other hand, the use of bonded expansion appliances with occlusal coverage has been shown to reduce the extrusion and tipping of posterior teeth and contributes to controlling vertical growth.[9,17,18] Although it has been shown that use of tooth-tissue–

[1]Professor, Başkent University, Faculty of Dentistry, Department of Orthodontics, Ankara, Turkey
[2]Assistant Professor, Adnan Menderes University, Faculty of Dentistry, Department of Orthodontics, Aydın, Turkey
[3]Associate Professor, Başkent University, Faculty of Dentistry, Department of Orthodontics, Ankara, Turkey

***Corresponding author:** Alev Yılmaz, Adnan Menderes Üniversitesi, Ortodonti Anabilim Dalı, 09100 Aydın, Türkiye. Tel: +90 256 213 63 47 E-mail: alevcetinsahin@msn.com

To cite this article: Arman-Özçırpıcı A, Yılmaz A, Polat-Özsoy Ö. Maxillary expansion via palatal mini-implants: a preliminary study. *Turkish J Orthod*. 2014;27:16–27. (DOI: http://dx.doi.org/10.13076/TJO-D-13-00010)

Date Submitted: September 2013. Date Accepted: April 2014.

borne appliances (Haas) or bonded RME appliances reduce the undesired effects, they still result in significant dental tipping and have the potential for relapse with limited skeletal effects.[4,9,19–21]

Bone-borne transpalatal distractors have been suggested to avoid these problems but require invasive surgery, have risk of infection and root damage, and are very expensive.[22–24] Recently, implant-supported or implant-assisted expansion devices have been suggested as an alternative method for applying forces directly to the maxilla.[25–28]

The aim of this preliminary study is to evaluate the effects of a new mini-implant supported maxillary expansion (MISME) appliance that incorporates 4 palatal mini-implants for bone anchorage. There are no studies examining the effects of MISME appliances in the literature. We decided to conduct this study to determine whether the appliances may be provide maxillary expansion without unwanted dental effects because of lack of tooth support. This is a pilot study and further studies with large sample sizes will be done to compare the MISME appliance with other expansion appliances.

MATERIAL AND METHODS

This study was designed to evaluate the skeletal and dentoalveolar effects produced by an RME appliance using miniscrew anchorage. The sample consisted of 5 female patients and 4 male patients treated in Department of Orthodontics, Faculty of Dentistry, Başkent University. The mean chronological age at the beginning of the treatment was 12 years and 8 months. All patients or parents consented to the treatment procedure and this retrospective study was approved by Başkent University Institutional review Board (Project no D-KA10/13).

Patients with indication of maxillary expansion due to transversal maxillary deficiency with unilateral or bilateral posterior crossbite were included in the study group. Patients with a tendency to open bite, patients with high vertical facial measurements, and patients with no anchorage teeth to support a conventional RME appliance were given priority for inclusion in group. Of the 9 subjects, 3 had skeletal Class I, 2 had Class II, and 4 had Class III malocclusion. Cephalograms, posteroanterior films, and dental casts were obtained at the beginning of treatment (T1) and at the end of desired expansion (T2).

Table 1. Intraclass correlation coefficients (r) calculated for each variable

Parameter	T1	T2
Cephalometric measurements		
SNA (°)	0.989	0.999
SNB (°)	0.993	0.998
ANB (°)	0.975	0.997
Nperp-A (mm)	0.995	0.999
Nperp-Pg (mm)	0.997	0.991
GoGn-SN (°)	0.976	0.997
FMA (°)	0.993	0.992
Y axis (°)	0.992	0.976
SN/PP (°)	0.993	0.990
SN/OP (°)	0.994	0.984
1-NA (mm)	1.000	1.000
1-NA (°)	0.996	0.998
1-PP (°)	0.989	0.997
1-NB (mm)	0.996	0.997
1-NB (°)	0.998	0.993
IMPA (°)	0.998	0.996
Overjet (mm)	1.000	1.000
Overbite (mm)	1.000	1.000
Posteroanterior measurements		
Nasal width (mm)	0.992	0.996
Maxillary width (mm)	0.993	1.000
Maxillary intermolar width (mm)	0.998	0.996
Mandibular width (mm)	0.998	0.997
Mandibular intermolar width (mm)	1.000	0.999
Dental cast measurements		
Maxillary intermolar width (mm)	0.993	0.996
Maxillary. intercanine width (mm)	0.972	0.999
Maxillary molar angulation (°)	1.000	0.999
Palatal width (mm)	0.998	0.998

The Bone-Anchored Maxillary Expansion Appliance

Four titanium miniscrew implants (Turquoise, Medikodental, Istanbul, Turkey) measuring 1.6 mm in diameter and 7 mm in length were placed under local anesthesia by 2 of the authors (A.A. and A.Y.). Before placement of the implants the palatal region was rinsed with chlorhexidine (0.12%), The 2 anterior palatal implants were placed in the anterior palate bilaterally, 3–4 mm lateral to the suture and 3–4 mm posterior to the incisive foramen. Studies indicate that the thickest bone is located 3–4mm distal to the incisive foramen and 3 mm paramedian to the palatal suture.[29–31]

Two posterior implants were inserted in the palatal alveolus bilaterally, between the projection of the second premolar and first molar roots. It is recommended that the screws be placed perpendicular to the palatal surface and angled toward the teeth roots

Table 2. Chronological ages at the beginning of treatment (T1) and duration of treatment (T2–T1) (days)[a]

T1	T2–T1
Age (year) $\bar{X} \pm$ SD **Median (Minimum–Maximum)**	**Treatment Duration (days)** $\bar{D} \pm$ SD **Median (Minimum–Maximum)**
12.7 ± 2.5 12.5 (8.2–15.6)	97.1 ± 62.15 72 (44–206)

[a] $\bar{X}$ indicates average.

for optimal retention if the anterior hard palate is chosen for the implant placement.[32,33] Therefore, implants inserted with an approximately 60° to 70° of angulation to the long axis of the teeth using a self-drilling method. Meanwhile, care was taken to provide enough space for the expansion screw and to not damage the roots of adjacent teeth (Fig. 1a). After placement of the implants, impressions and dental casts were obtained. The screw heads were blocked out with wax, and the acrylic expansion appliance was constructed on the cast. The biggest screw, which can be placed between the implants, was embedded in the acrylic between the first premolars as close as possible to the palate with the resin covering the mini-implants and the surrounding palatal surface.

The acrylic appliance was connected to the screw heads using cold-curing, methyl methacrylate free acrylic resin (Ufi Gel hard, Voco GmbH, Cuxhaven, Germany). Small holes were made on the appliance so the excess resin could flow out (Fig. 1b).

Strict instructions were given to the patient regarding oral hygiene, and no medication was prescribed. After the expansion appliance was bonded, the screw was activated with a semi-rapid protocol.[34] The patient's parents were instructed to activate the screw by turning it twice a day in the first 7–10 days. Afterward, a maxillary occlusal radiograph was taken and the suture opening was checked; activation then continued 3 times a week until the desired expansion was achieved. No overcorrection of the transversal relationship was done. There were no patient dropouts or appliance failures. In one patient the appliance needed to be redone because of a problem with the screw, and the treatment duration was lengthened. No negative side effects were recorded. At the end of the expansion period, fixed appliance treatment was initiated without waiting for retention.

Cephalometric, Posteroanterior, and Cast Analysis

Lateral cephalometric and posteroanterior (PA) radiographs (Sirona, Siemens, Germany) were taken for each subject at the beginning of treatment (T1) and at the end of desired expansion (T2). The radiographs were traced and measured by one investigator (A.Y.) in random order. In instances of bilateral structures, a single average tracing was made. A total of 27 measurements were made for each patient: 18 measurements (12 angular, 6 linear) on the cephalometric radiographs (Fig. 2), 5 linear measurements on the PA radiographs (Fig. 3), and 4 measurements on the dental models (Figs. 4 and 5). The intercanine and intermolar widths were measured directly on the casts with a digital caliper, whereas the degree of tipping of the molars (molar angulation) and palatal width at the gingival height was determined from photocopy images taken after the posterior portion of the cast was trimmed up to the cusp tips of the first molars (Fig. 5).

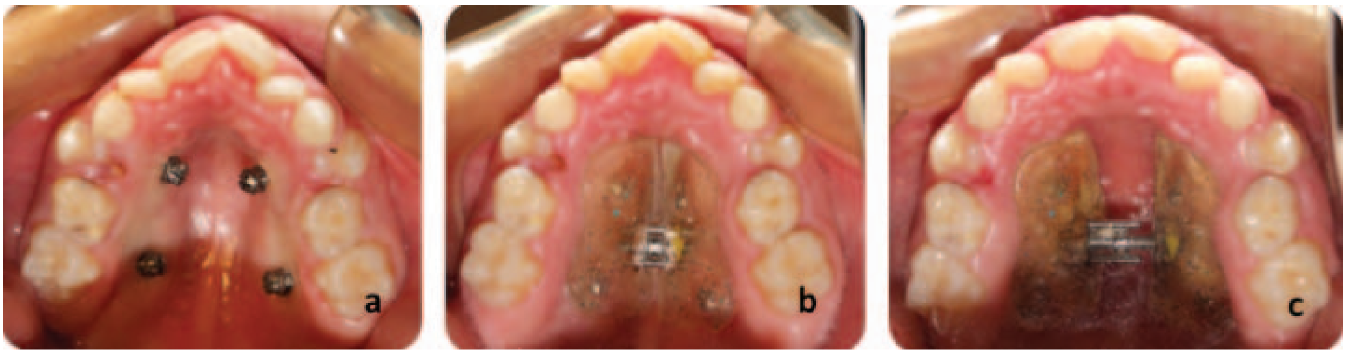

Figure 1. (a) Palatal implants. (b) Mini-implant supported maxillary expansion (MISME) appliance. (c) MISME appliance after expansion.

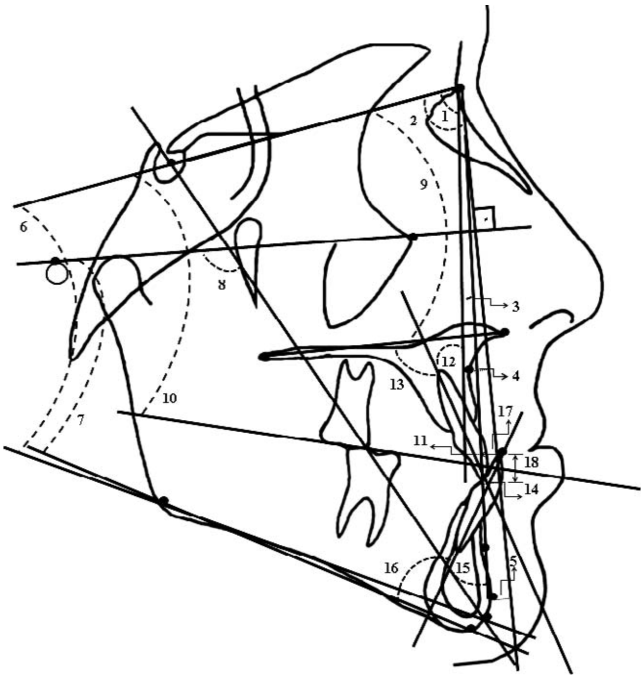

Figure 2. Lateral cephalometric measurements used in the study. 1 indicates SNA; 2, SNB; 3, ANB; 4, Nperp-A; 5, Nperp-Pg; 6, SN-GoGn; 7, FMA; 8, Y axis; 9, SN/PP; 10, SN/OP; 11, U1-NA (mm); 12, U1-NA (°); 13, U1-PP; 14, L1-NB (mm); 15, L1-NB (°); 16, IMPA; 17, overjet; 18, overbite.

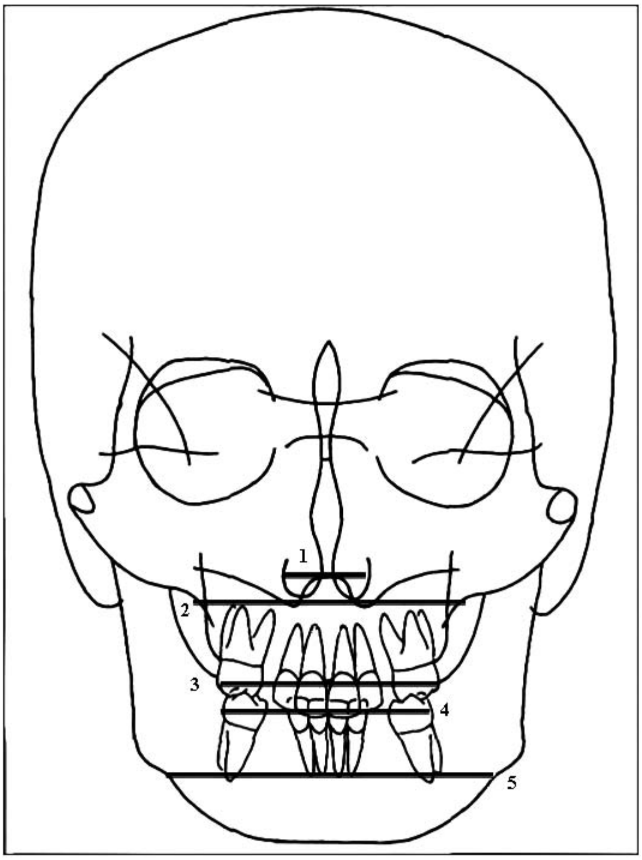

Figure 3. Posteroanterior measurements used in the study. 1 indicates nasal cavity width; 2, maxillary width; 3, maxillary intermolar width; 4, mandibular intermolar width; 5, mandibular width.

Statistical Analysis

Statistical analysis was performed using SPSS Statistical Package for Social Sciences Version 13.0 (SPSS Inc, Chicago, IL, USA). The normality of the distribution of the cephalometric, PA, and cast variables were checked using the Shapiro-Wilk test. According to this test only the Nperp-A variable was not normally distributed. The significance of the treatment changes was examined using nonparametric Wilcoxon test for this variable, whereas a parametric paired *t* test was performed to analyze normally distributed parameters. The results were expressed as mean ± standard deviation $(\bar{X} \pm S_x)$, median, minimum and maximum values. A value of $p < 0.05$ was considered to be statistically significant.

To calculate the error of measurements, cephalometric/PA films and study casts of 5 randomly selected patients were retraced and remeasured 2 weeks later by the same clinician. To assess the reliability of the measurements, intraclass correlation coefficients (*r*) were calculated for each variable and were found to be close to 1.00 (Table I).

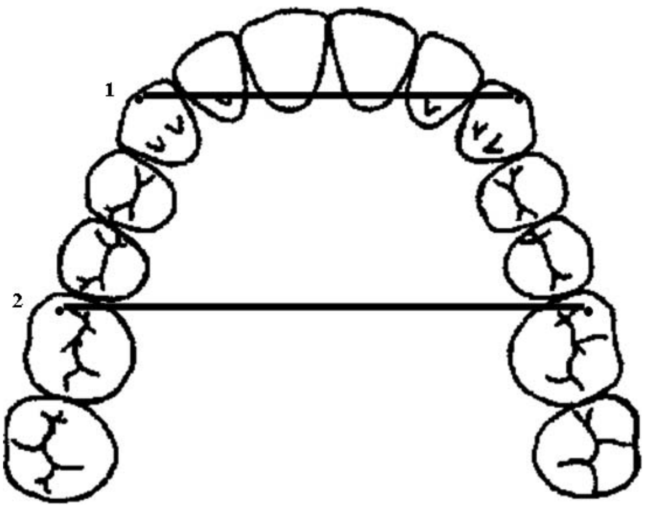

Figure 4. Dental cast measurements used in the study. 1, indicates intercanine width; 2, intermolar width.

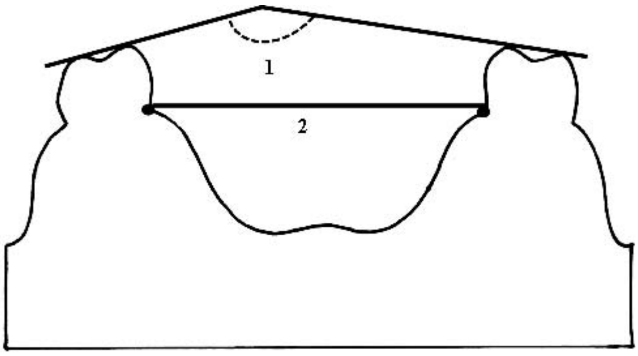

Figure 5. Dental cast measurements used in the study. 1, indicates maxillary molar angulation; 2, palatal width at gingival height.

RESULTS

The maxillary expansion procedure was successful in correcting the posterior crossbite (Figs. 6 through 9).

The mean chronological age at the beginning of the treatment was 12.7 years. Mean treatment duration was 97.1 days (Table 2).

Cephalometric analysis demonstrated significant changes in only 3 skeletal parameters (Table 3). The Nperp-A measurement showed a 0.8 mm increase, demonstrating forward movement of the maxilla ($p<0.05$). A slight posterior rotation of the mandible according to the S-N and FH planes was also noticeable ($p<0.05$). None of the dentoalveolar measurements demonstrated a significant change, including the overbite, which indicated bite control (Table 3).

Posteroanterior measurements showed increases in nasal width, maxillary width, and maxillary intermolar width ($p<0.001$). The mean increase was 4.1 mm in the nasal width, 6.3 mm in the maxillary width, and 7.1 mm in the intermolar width (Table 4).

The model measurements also revealed expansion in the maxillary dental arch. Both the intermolar and intercanine width increased ($p<0.001$), indicating a parallel expansion in the anteroposterior direction (Table 4). The palatal width at the gingival height increased ($p<0.001$), whereas the maxillary intermolar angle, which demonstrated tipping of the

Figure 6. (a) Front view of a patient after placement of palatal implants. (b) Occlusal view after placement of implants. (c) Front view at the end of desired expansion (T2). (d) Occlusal view at T2.

Figure 7. (a) Front view of a patient at the beginning of treatment (T1). (b) Occlusal view at T1. (c) Front view at the end of desired expansion (T2) (d) Occlusal view at T2.

first molars in the buccolingual direction, did not change significantly.

DISCUSSION

Various types of bone anchors have been used for orthodontic and orthopedic purposes.[35–43] Because of their many advantages, miniscrews have become quite popular anchorage sources. The literature features many reports regarding the use of miniscrews for retraction, distalization, intrusion, and uprighting of teeth.[36–40] The MISME appliance incorporates 4 miniscrews for bone anchorage. The palate is one of the mini-implant placement sites that is frequently preferred because it is easily accessible, is relatively safe to work on, is less susceptible to inflammation, and has good bone quantity.[44] The midpalatal area,[45] anterior paramedian area,[44] and palatal area between the level of the first and second premolars[46] are reported to be the most favorable areas for implant placement.

The self-drilling method is preferred for implant placement because of its easier application and higher primary stability.[46–49] Implant insertion with an approximately 60° to 70° of angulation to the long axis of the teeth avoids damage to the roots of the teeth and provides more cortical bone contact for better stability.[50,51]

The primary stability of the implants is also proportional to the increased length and diameter.[52] The miniscrews used in this study were shorter and/or thinner than the palatal implants used in other bone-anchored palatal appliances.[26,38,53] Although bilaterally placed implants—2 at the anterior and 2 at the posterior region—provided sufficient anchorage, the acrylic part of the appliance enhanced the stability of the miniscrews and the appliance.

Various anchorage sources, such as Bioglass-coated aluminum oxide implants,[54] titanium plates

Figure 8. (a) Front view of a patient at the beginning of treatment (T1). (b) Occlusal view at (T1). (c) Front view at the end of desired expansion (T2). (d) Occlusal view at T2.

with osteosynthesis screws,[23] and onplants with miniscrews,[27] have been used to anchor bone-borne distractors. Their invasiveness, higher risk of infection, and higher cost are disadvantages of these applications. On the other hand, a MISME appliance can be easily applied by an orthodontist and can be easily constructed in a clinic laboratory. Two recently published case reports demonstrated successful results of palatal implant–assisted banded hyrax appliances[26,28] Another advantage of a MISME appliance is that they are more comfortable and more hygienic than conventional tooth-borne or bone-tooth–borne appliances. A MISME appliance may also be used if the patient is missing one or more anchorage teeth.

The semi-rapid maxillary expansion, which was introduced by İşeri and Özsoy,[34] is preferred for the expansion procedure. The authors suggested an RME protocol, followed by slow maxillary expansion immediately after the separation of the midpalatal suture to produce less tissue resistance on the surrounding structures. They also indicated that this protocol stimulates the adaptation process in the nasomaxillary complex and thus reduces relapse in the postretention period.

In this preliminary study, the increase in nasion perpendicular to point A, demonstrating the forward movement of maxilla, was statistically significant and may be an advantage in patients with Class III malocclusion and maxillary retrusion. Haas[8] was the first to mention the forward positioning of the maxilla after expansion. Thereafter, some studies[4,55] were in agreement with Haas[8] but others reported variable sagitttal behavior that was clinically insignificant.[10,15,18,51]

In the literature many studies affirm the belief that RME opens the bite.[4,14,52] Bonded RME appliances with full occlusal coverage have been reported to have advantages in controlling the vertical dimension but still have a significant bite-opening effect.[5,9,11] In this study, although patients with steep mandibular plane angles and reduced overbite values were selected, the change in overbite was not significant. The tipping or extrusion of maxillary

Figure 9. (a) Front view of a patient at the beginning of treatment (T1). (b) Occlusal view at (T1). (c) Front view at the end of desired expansion (T2). (d) Occlusal view at T2

teeth was prevented because the MISME appliance is not tooth borne. If we examine the data individually, only one patient showed a decrease in overbite, whereas 5 showed an increase. However, the mean increase in the mandibular plane angle was significant.

The PA measurements revealed significant increases in the nasal (4.1 mm), maxillary (6.3 mm), and maxillary intermolar (7.1 mm) widths, though the mandibular width measurements did not change. An increase in the width of the nasal cavity after RME has been demonstrated by using PA cephalograms and computed tomography studies.[3,8,9,53]

The model measurements indicate a parallel dentoalveolar expansion in the anteroposterior direction as the intermolar and intercanine width increases are similar. A MISME appliance incorporates miniscrews in both the anterior and posterior regions and this could be the reason for the parallel expansion. When traditional tooth-borne expansion appliances are used, the greatest expansion is seen in the posterior dentition and expansion gradually decreases toward the anterior dental arch.[6] The nonsignificant change in the maxillary molar angle (Table 4) also indicated bodily movement of the posterior teeth without significant tipping.

Some studies[3,20] have reported that both tooth-borne and acrylic bonded expanders produced significant buccal tipping of the supporting teeth. Tausche *et al*.[25] reported more skeletal than dental response with a bone-borne expansion appliance. Lagravére *et al*.[27] compared the effects of a bone-anchored device and a conventional expansion device and found similar results and more dentoalveolar response with2 appliances. The reason for the differences between these studies may be differences in appliance design and anchorage area. Lagravére *et al*.[27] used onplants and placed them 6 mm from the suture. In the present study, we placed

Table 3. Descriptive statistics for cephalometric measurements at the beginning of the treatment (T1), changes during expansion treatment (T2–T1), and significance of treatment changes[a]

Parameter	T1 $\bar{X} \pm$ SD Median (Minimum–Maximum)	T2–T1 $\bar{D} \pm$ SD Median (Minimum–Maximum)	*p*
Cephalometric measurements			
Skeletal measurements			
SNA (°)	74.9 ± 4.1 75.0 (69.0–81.0)	0.5 ± 0.7 0.5 (0.0–2.0)	0.053
SNB (°)	74.2 ± 2.9 75.0 (70.0–80.0)	–0.4 ± 0.7 0.0 (−1.5–0.0)	0.111
ANB (°)	0.7 ± 3.4 1.0 (−3.0–5.0)	0.4 ± 1.3 0.5 (−2.5–2.0)	0.410
Nperp-A (mm)	–4.7 ± 3.1 –5.5 (−7.5–2.5)	0.8 ± 1.0 0.5 (0.0–3.0)	0.047*
Nperp-Pg (mm)	–8.9 ± 7.2 –10.0 (−19.0–2.5)	1.5 ± 4.4 0.0 (−2.0–12.5)	0.331
GoGnSN (°)	40.0 ± 6.4 40.5 (29.0–50.0)	1.2 ± 1.4 0.5 (0.0–3.5)	0.030*
FMA (°)	31.6 ± 5.3 30.0 (23.5–38.5)	0.8 ± 1.0 0.5 (−0.5–2.5)	0.049*
Y Axis (°)	62.0 ± 4.5 63.0 (54.0–69.5)	0.5 ± 0.8 0.5 (−1.0–1.5)	0.081
SN.PP (°)	8.1 ± 3.4 7.0 (2.0–13.0)	0.4 ± 1.0 0.5 (−1.0–2.0)	0.288
SN.OP (°)	19.5 ± 4.2 20.0 (13.5–24.0)	1.5 ± 2.1 1.0 (−1.5–5.0)	0.059
Dentoalveolar measurements			
U1i-NA (mm)	5.7 ± 4.2 6.0 (1.0–11.5)	–0.7 ± 1.3 –0.5 (−2.5–2.0)	0.169
U1.NA (°)	25.2 ± 6.9 24.5 (15.0–34.0)	–1.9 ± 3.1 –2.5 (−4.5–6.0)	0.570
U1.PP (°)	109.3 ± 5.3 108.0 (100.0–117.0)	–1.2 ± 3.6 –2.0 (−4.0–8.0)	0.355
L1i-NB (mm)	3.8 ± 2.5 4.5 (1.0–8.5)	0.7 ± 1.0 0.5 (−0.5–3.0)	0.056
L1.NB (°)	19.8 ± 5.8 19.5 (12.5–30.0)	1.7 ± 2.6 1.0 (−2.0–5.5)	0.089
IMPA (°)	83.2 ± 5.9 83.0 (73.0–92.0)	0.9 ± 2.2 1.0 (−2.0–5.5)	0.234
Overjet (mm)	2.9 ± 3.5 2.0 (−3.0–9.0)	–0.1 ± 1.2 0.0 (−1.0–1.5)	0.834
Overbite (mm)	–0.1 ± 2.7 0.0 (−5.0–5.0)	0.5 ± 1.2 0.5 (−2.0–2.0)	0.256

[a] $\bar{X}$ indicates average; $\bar{D}$, difference.
* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

the mini-screws in both the anterior palate and the posterior palatal alveolus bilaterally.

A number of researchers have reported that overcorrection and a retention phase of 3 months are needed for the stability of RME. Also, buccolingual tipping of posterior teeth should be corrected and the overexpansion should be reduced in the fixed appliance stage.[10,11,12,54,55] The MISME appliance was activated until the desired expansion was achieved. Overcorrection of the transversal relationship was not required as the molars expanded without clinically evident tipping. Therefore, the transversal changes are not directly comparable to the short-term changes obtained with tooth-borne

Table 4. Descriptive statistics for posteroanterior and dental cast measurements at the beginning of the treatment (T1), changes during expansion treatment (T2–T1), and significance of treatment changes

Parameter	T1 $\bar{X} \pm s$ Median (Minimum–Maximum)	T2–T1 $\bar{D} \pm s_D$ Median (Minimum–Maximum)	*p*
Posteroanterior measurements			
Nasal width (mm)	29.1 ± 3.5 30.0 (23.0–33.5)	4.1 ± 2.3 4.0 (2.0–9.0)	0.001***
Maxillary width (mm)	63.5 ± 5.7 63.0 (56.0–72.0)	6.3 ± 2.5 7.0 (2.5–9.0)	0.000***
Maxillary intermolar width (mm)	54.8 ± 4.7 54.5 (47.5–62.0)	7.1 ± 2.6 8.0 (2.5–10.5)	0.000***
Mandibular width (mm)	88.9 ± 7.9 86.0 (73.5–98.0)	0.1 ± 0.7 0.0 (−1.0–1.0)	0.665
Mandibular intermolar width (mm)	60.8 ± 4.4 60.0 (56.0–70.0)	0.4 ± 0.9 0.0 (−1.0–1.0)	0.211
Dental cast measurements			
Maxillary intermolar width (mm)	46.0 ± 3.0 45.4 (41.6–52.3)	5.4 ± 1.5 5.3 (3.1–7.8)	0.000***
Maxillary intercanine width (mm)	31.9 ± 3.1 31.8 (26.5–36.5)	5.3 ± 1.4 5.6 (2.8–6.8)	0.000***
Maxillary molar angulation (°)	148.0 ± 14.5 147.0 (125.0–174.0)	6.2 ± 9.0 5.5 (−11.5–19.5)	0.071
Palatal width (mm)	30.9 ± 3.5 29.1 (26.8–36.1)	5.2 ± 1.8 5.0 (2.2–8.8)	0.000***

expanders, in which overexpansion is inevitable to overcome the relapse potential.

At the end of the expansion period the MISME appliance was left in place and removed 3–6 months after initiation of fixed appliance therapy, when rigid rectangular archwires were applied. There is no need to wait for a retention period as a MISME appliance allows for usage of fixed appliances at the same time. Removal of the appliance was quite easy under topical and/or infiltrative anesthesia and only a slight soft tissue irritation was observed, which was later solved by routine oral maintenance (Fig. 10).

In this study, the short-term effects of a MISME appliance used on 9 patients were evaluated. New prospective studies using 3-dimensional images with larger sample sizes and long-term results are required when the results of this system are considered.

CONCLUSION

The MISME appliance can be considered an easily applicable and hygienic alternative method for growing patients. The bone-tissue–borne appliance is especially suggested in patients with missing anchorage teeth and decreased overbite values.

REFERENCES

1. Harrison JE, Ashby D. Orthodontic treatment for posterior crossbites. *Cochrane Database Syst Rev.* 2001(1): CD000979.

Figure 10. Occlusal views of a patient (a) after placement of implants. (b) after expansion, and (c) after removal of the appliance.

2. Ramires T, Mais RA, Barone JR. Nasal cavity changes and the respiratory standard after maxillary expansion. *Braz J Otorhinolaryngol*. 2008;74:763–769.
3. Christie KF, Boucher N, Chumg CH. Effects of bonded rapid palatal expansion on the transverse dimensions of the maxilla: a cone-beam computed tomography study. *Am J Orthod Dentofacial Orthop*. 2010;137:S79–S85.
4. Asanza S, Cisneros GJ, Nieberg LH. Comparison of Hyrax and bonded expansion appliances. *Angle Orthod*. 1997;67:15–22.
5. Akkaya S, Lorenzon S, Üçem TT. A comparison of sagittal and vertical effects between bonded rapid and slow maxillary expansion. *Eur J Orthod*. 1999;21:175–180.
6. Davidovitch M, Efstathiou S, Sarne O, Vardimon AD. Skeletal and dental response to rapid maxillary expansion with 2- versus 4-band appliances. *Am J Orthod Dentofacial Orthop*. 2005;127:483–492.
7. Garib DG, Henriques JFC, Janson G, de Freitas MR, Fernandes AY. Periodontal effects of rapid maxillary expansion with tooth-tissue-borne and tooth-borne expanders: a computed tomography evaluation. *Am J Orthod Dentofacial Orthop*. 2006;129:749–758.
8. Haas AJ. Rapid expansion of the maxillary dental arch and nasal cavity by opening the mid palatal suture. *Angle Orthod*. 1961;31:73–90.
9. Memikoglu UT, İşeri H. Effects of a bonded rapid palatal expansion appliance during orthodontic treatment. *Angle Orthod*. 1999;69:251–256.
10. Wertz RA. Skeletal and dental changes accompanying rapid mid-palatal suture opening. *Am J Orthod*. 1970;58:41–66.
11. Bishara SE, Staley RN. Maxillary expansion: clinical applications. *Am J Orthod Dentofacial Orthop*. 1987;91:3–14.
12. Silva Filho OG, Montes LA, Torelly LF. Rapid maxillary expansion in the deciduous and mixed dentition evaluated through posteroanterior cephalometric analysis. *Am J Orthod Dentofacial Orthop*. 1995;107:268–275.
13. Rungcharassaeng K, Caruso JM, Kan JYK, Kim J, Taylor G. Factors affecting buccal bone changes of maxillary posterior teeth after rapid maxillary expansion. *Am J Orthod Dentofacial Orthop*. 2007;132:428.e1–428.e8.
14. Haas AJ. The treatment of maxillary deficiency by opening the mid-palatal suture. *Angle Orthod*. 1965;35:200–217.
15. Sarnas KV, Björk A, Rune B. Long-term effect of rapid maxillary expansion studied in one patient with the aid of metallic implants and roentgen stereometry. *Eur J Orthod*. 1992;14:427–432.
16. Odenrick I, Karlander EL, Pierce A, Kretschmar U. Surface resorption following two forms of maxillary expansion. *Eur J Orthod*. 1991;13:264–270.
17. Gryson JA. Changes in mandibular interdental distance concurrent with rapid maxillary expansion. *Angle Orthod*. 1977;47:186–192.
18. Sarver DM, Johnson MW. Skeletal changes in vertical and anterior displacement of the maxilla with bonded rapid palatal expansion appliances. *Am J Orthod Dentofacial Orthop*. 1989;95:462–466.
19. Erverdi N, Okar I, Kucukkeles N, Arbak S. A comparison of two different rapid palatal expansion techniques from the point of root resorption. *Am J Orthod Dentofacial Orthop*. 1994;106:47–51.
20. Kılıç N, Kiki A, Oktay H. A comparison of dentoalveolar inclination treated by two palatal expanders. *Eur J Orthod*. 2008;30:67–72.
21. Parr JA, Garetto LP, Wohlford ME, Arbuckle GR, Roberts WE. Sutural expansion using rigidly integrated endosseous implants: an experimental study in rabbits. *Angle Orthod*. 1997;67:283–290.
22. Mommaerts MY. Transpalatal distraction as a method of maxillary expansion. *Br J Oral Maxillofac Surg*. 1999;37:268–272.
23. Matteini C, Mommaerts MY. Posterior transpalatal distraction with pterygoid disjunction: a short-term model study. *Am J Orthod Dentofacial Orthop*. 2001;120:498–502.
24. Gerlach KL, Zahl C. Transversal palatal expansion using a palatal distractor. *J Orofac Orthop*. 2003;64:443–449.
25. Tausche E, Hansen L, Hietschold V, Lagravére MO, Harzer W. Three-dimensional evaluation of surgically assisted implant bone-borne rapid maxillary expansion: a pilot study. *Am J Orthod Dentofacial Orthop*. 2007;131:S92–S99.
26. Garib DG, Navarro RL, Francischone CE, Oltramari PVP. Rapid maxillary expansion using palatal implants. *J Clin Orthod*. 2008;42:665–671.
27. Lagravére MO, Carey J, Heo G, Toogood RW, Major PW. Transverse, vertical, and anteroposterior changes from bone-anchored maxillary expansion vs traditional rapid maxillary expansion: a randomized clinical trial. *Am J Orthod Dentofacial Orthop*. 2010;137:304.e1–304.e12.
28. Lee KJ, Park YC, Park JY, Hwang WS. Miniscrew-assisted nonsurgical palatal expansion before orthognathic surgery for a patient with severe mandibular prognathism. *Am J Orthod Dentofacial Orthop*. 2010;137:830–839.
29. Bernhart T, Vollgruber A, Gahleitner A, Dortbudak O, Hass R. Alternative to the median region of the palate for placement of an orthodontic implant. *Clin Oral Implants Res*. 2000;11:595–601.
30. Kang S, Lee SJ, Ahn SJ, Heo MS, Kim TW. Bone thickness of the palate for orthodontic mini-implant anchorage in adults. *Am J Orthod Dentofac Orthop*. 2007;131:S74–S81.
31. King KS, Lam EW, Faulkner MG, Heo G, Major PW. Vertical bone volume in the paramedian palate of adolescents: a computed tomography study. *Am J Orthod Dentofac Orthop*. 2007;132:783–788.
32. Crismani AG, Bernhart T, Tangl S, Bantleon HP, Watzek G. Nasal cavity perforation by palatal implants: false-positive records on the lateral cephalograms. *Int J Oral Maxillofac Implants*. 2005;20:267–273.
33. Cousley R. Critical aspects in the use of orthodontic palatal implants. *Am J Orthod Dentofac Orthop*. 2005;127:723–729.
34. İşeri H, Özsoy S. Semirapid maxillary expansion—a study of

long-term transverse effects in older adolescents and adults. *Angle Orthod*. 2004;74:71–78.

35. Roberts WE, Marshall KJ, Mozsary P. Rigid endosseous implant utilized as anchorage to protract molars and close atrophic extraction site. *Angle Orthod*. 1990;60: 135–152.
36. Miyawaki S, Koyama I, Inoue M, Mishima K, Sugahara T, Takano-Yamamoto T. Factors associated with the stability of titanium screws placed in the posterior region for orthodontic anchorage. *Am J Orthod Dentofacial Orthop*. 2003;124: 373–378.
37. Liou EJ, Pai BC, Lin JC. Do miniscrews remain stationary under orthodontic forces. *Am J Orthod Dentofacial Orthop*. 2004;126:42–47.
38. Polat-Özsoy Ö, Kırcelli BH, Arman-Özçırpıcı A, Pektaş ZO, Uçkan S. Pendulum appliances with 2 anchorage designs. *Am J Orthod Dentofacial Orthop*. 2008;133:339.e9–339.e17.
39. Polat-Özsoy Ö, Arman-Ozcirpici A, Veziroğlu F. Miniscrews for upper incisor intrusion. *Eur J Orthod*. 2009;31: 412–416.
40. Polat-Özsoy Ö, Arman-Ozçırpıcı A, Veziroğlu F, Cetinşahin A. Comparison of intrusive effects of miniscrews and utility arches. *Am J Orthod Dentofacial Orthop*. 2011;139:526–532.
41. Kaya B, Arman A, Uçkan S, Yazıcı AC. The comparison of zygoma anchorage system with cervical headgear in buccal segment distalization. *Eur J Orthod*. 2009;31:417–424.
42. Çetinşahin A, Dinçer M, Arman-Özçırpıcı A, Uçkan S. Effects of Zygoma Anchorage System on canine retraction. *Eur J Orthod*. 2010;32:505–513.
43. Şar Ç, Arman-Özçırpıcı A, Uçkan S, Yazıcı AC. Comparative evaluation of maxillary protraction with or without skeletal anchorage. *Am J Orthod Dentofacial Orthop*. 2011;139:636–649.
44. Moon SH, Park SH, Lim WH, Chun YS. Palatal bone density in adult subjects: implications for mini-implant placement. *Angle Orthod*. 2010;80:137–144.
45. Kyung HM, Park HS, Bae SM, Sung JH, Kim IB. Development of orthodontic micro-implants for intraoral anchorage. *J Clin Orthod*. 2003;37:321–328.
46. Baumgaertel S. Quantitative investigation of palatal bone depth and cortical bone thickness for mini-implant placement in adults. *Am J Orthod Dentofacial Orthop*. 2009;136: 104–108.
47. Kim JW, Ahn SJ, Chang YI. Histomorphometric and mechanical analyses of the drill-free screw as orthodontic anchorage. *Am J Orthod Dentofacial Orthop*. 2005;128:190–194.
48. Bumgaertel S, Razavi MR, Hans MG. Mini-implant anchorage for the orthodontic practitioner. *Am J Orthod Dentofacial Orthop*. 2008;133:621–627.
49. Chen Y, Shin, HI, Kyung HM. Biomechanical and histological comparison of self-drilling and self-tapping orthodontic microimplants in dogs. *Am J Orthod Dentofacial Orthop*. 2008;133:44–50.
50. Kyung HM, Park HS, Bae SM, Kwon OW, Sung JH. *Handbook for the Absoanchor Orthodontic Microimplant*. 3rd ed. Daegu, South Korea: Dentos; 2004.
51. Deguchi T, Nasu M, Murakami K, Yabuuchi T, Kamioka H, Yamamoto TT. Quantitative evaluation of cortical bone thickness with computed tomographic scanning for orthodontic implants. *Am J Orthod Dentofacial Orthop*. 2006;129: 721 e7–e12.
52. Deguchi T, Takano-Yamamoto T, Kanomi R, Hartsfield JK Jr, Roberts WE, Garetto LP. The use of small titanium screws for orthodontic anchorage. *J Dent Res*. 2003;82:377–381.
53. Gelgör IE, Büyükyılmaz T, Karaman AI, Dolanmaz D, Kalaycı A. Intraosseous screw-supported upper molar distalization. *Angle Orthod*. 2004;74:838–850.
54. Turley PK, Shapiro PA, Moffett BC. The loading of Bioglass coated aluminium oxide implants to produce sutural expansion of the maxillary complex in the pigtail monkey (*Macaca nemestrina*). *Arch Oral Biol*. 1980;25:459–469.
55. Sandıkçıoğlu M, Hazar S. Skeletal and dental changes after maxillary expansion in the mixed dentition. *Am J Orthod Dentofacial Orthop*. 1997;11:321–327.