Original Article

A comparison of treatment effects of total arch distalization using modified C-palatal plate vs buccal miniscrews

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ABSTRACT

Objective: The purpose of this study was to compare the treatment effects of palatally vs buccally placed temporary anchorage devices.

Materials and Methods: Of 40 Class II division 1 malocclusion patients, 22 were treated with modified C-palatal plate (MCPP) appliances (age 21.9 ± 6.6 years), and 18 (age 24.2 ± 6.8 years) were treated with buccally placed miniscrews between the maxillary first molar and second premolar. A total of 26 linear and angular measurements were analyzed on pre- and posttreatment lateral cephalograms. Multivariate analysis of variance was performed to evaluate the treatment effects within each group and to compare the effects between groups.

Results: Overall, the MCPP appliances showed 4.2 mm of distalization, 1.6 mm of intrusion of the first molar with 2° tipping, and 0.8 mm extrusion of incisors. The miniscrew group resulted in 2.0 mm of distalization, 0.1 mm intrusion of the first molar with 7.2° tipping, and 0.3 mm of incisor extrusion. Regarding soft tissue change, in the MCPP group, the upper lip was significantly retracted ($P <$ .001).

Conclusions: Comparing the treatment effects between MCPP appliances and buccal miniscrews, the MCPP appliances showed greater distalization and intrusion with less distal tipping of the first molar and more extrusion of the incisor compared to the buccal miniscrews. (*Angle Orthod.* 2018;88:45–51.)

KEY WORDS: Total arch distalization; Modified C-palatal plate (MCPP) appliances; Buccal miniscrews; Temporary anchorage devices (TADs)

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INTRODUCTION

Temporary anchorage devices (TADs) have become an essential part of orthodontic treatment, especially in nonextraction cases. TADs have overcome the disadvantages of earlier extra- and intraoral appliances, such as dependence on patient compliance, anchorage loss, increased distal tipping, and the extrusion of first molars.[1–4]

TADs have been used indirectly for molar distalization through bone-anchored appliances such as the pendulum and distal jet. However, some disadvantages remain with these appliances, such as the large amount of distal tipping created by the force delivery system.[5,6]

Several methods have been applied for the distalization of the maxillary dentition through buccal placement of TADs.[7–12] Miniplates have been placed in the infrazygomatic region,[12] but this approach requires the surgical placement and removal of one plate on each side. Alternatively, miniscrews can be installed buccally into interradicular spaces.[10,11] This

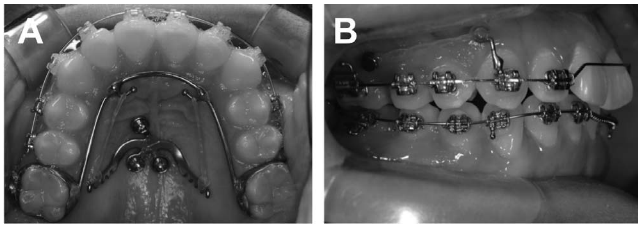

Figure 1. (A) The MCPP appliance was placed on the palate and connected to the palatal bar installed on the maxillary first molars for total arch distalization. (B) A miniscrew was placed buccally between the maxillary first molar and second premolar. An elastic chain was connected between the miniscrew and a hook welded to the distal wing of the canine bracket.

procedure is less invasive than the infrazygomatic plates, but it comes with a higher risk of injury to the roots of the adjacent teeth.

The palatal approach of TAD placement has been suggested by some clinicians.[13–15] Recently, the use of the modified C-palatal plate (MCPP) for maxillary arch distalization was reported for Class II corrections in both adolescents and adults.[1,16–21] The MCPP is a distalization appliance with a large range of action that can be easily placed without raising a flap. It also has been shown to have the capability of vertical control during distalization. Using finite element analysis, distalization with a palatal plate rather than mini-implants on the buccal side provided bodily molar movement without tipping or extrusion[22]; but no clinical comparison has been made between the two approaches.

Therefore, the purpose of this study was to compare the treatment effects of palatally vs buccally placed temporary anchorage devices.

MATERIALS AND METHODS

The sample for this retrospective study consisted of pre- (T1) and posttreatment (T2) lateral cephalograms of 40 patients: 22 were treated with MCPP appliances (age 21.9 $\pm$ 6.6 years) at the Department of Orthodontics, Seoul St. Mary's Hospital, The Catholic University of Korea, and 18 were treated with distalization via miniscrews placed buccally in the interradicular space (age 24.2 $\pm$ 6.8 years) in a private practice office. Sample size calculation showed that at least 16 cases were required in each group to identify an effect size of 1 unit, provided that alpha is .05 and beta is .2 (www.clincalc.com). Approval was granted by the institutional review board of the Catholic University of Korea (KC11RASI0790), and informed consent was obtained according to the Declaration of Helsinki.

The inclusion criteria were the following: (1) adult patients, (2) skeletal class I relationship with dental Class II division 1 malocclusion and normovergent growth pattern, (3) moderate maxillary arch crowding (less than 5 mm) with maxillary protrusion, (4) nonextraction treatment, (5) maxillary molar distalization that was achieved by either MCPPs or buccally placed miniscrews exclusively, (6) absence of craniofacial syndromes, and (7) the availability of good-quality lateral cephalograms and treatment records.

The MCPPs were placed by a single operator using three 8-mm length and 2.0-mm diameter miniscrews (Jeil Corporation, Seoul, Korea). A palatal bar with 2 hooks extending along the gingival margins of the teeth was connected to the maxillary first molars. Immediately after placement, distalization was initiated by engaging elastics (Ormco, Glendora, Calif) between the MCPP arm notches and hooks on the palatal bar, applying approximately 300 g of force per side (Figure 1A).[1]

The buccally placed miniscrews (6.0-mm length and 1.5-mm diameter; Biomaterials Korea, Seoul, Korea) were installed by a single operator between the maxillary first molar and second premolar approximately 5-mm apical to the cementoenamel junction. A closed coil spring (or chain elastic) was connected between the miniscrew and a 7-mm hook welded to the distal wing of the canine bracket (Figure 1B). Distalization was performed on a 0.017 $\times$ 0.025-inch stainless steel archwire on full-fixed 0.018-inch preadjusted orthodontic brackets.

Cephalometric Measurements

The lateral cephalograms of the MCPP group were taken by Dimax3 (Promax, Planmeca, Helsinki, Finland) with 70 kVp and 11 mAs, whereas those of the miniscrew group were taken by DCTP-90-P (Vatech, Hwaseong, Korea). All images were in natural head position, centric relation, and reposed lips. The magnification errors were corrected via digitizing a scale incorporated with each image to achieve the 1:1 ratio.

Lateral cephalograms were digitized using V-Ceph 5.5 software (Cybermed, Seoul, South Korea). The horizontal reference line (HRL) represented the Frankfort horizontal (FH) plane and the vertical reference line (VRL) was perpendicular to the FH plane, passing through the pterygoid point. A total of 26 linear and angular measurements were made by one examiner as shown in Figures 2 and 3. The differences between T1 and T2 were calculated (T1 $-$ T2).

To identify measurement reliability, 10 randomly selected cases from each group were redigitized and analyzed 2 weeks apart by the same examiner.

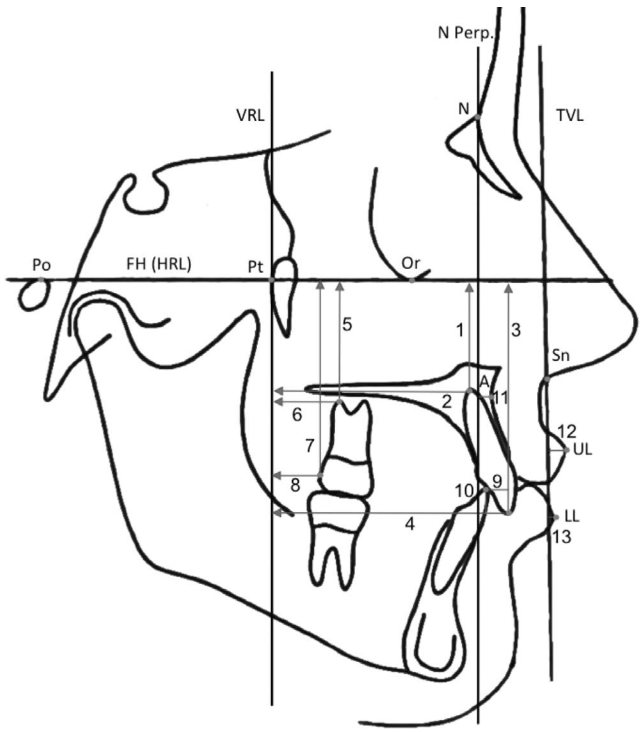

Figure 2. Linear cephalometric variables. P indicates porion; Pt, pterygoid; Or, orbitale; Sn, subnasale; UL, upper lip; LL, lower lip; N, nasion; FH, Frankfort horizontal plane; HRL, horizontal reference line; VRL, vertical reference line; TVL, true vertical line; N Perp., N perpendicular to FH; 1, A point to N Perp; 2, central incisor apex to HRL; 3, central incisor apex to VRL; 4, central incisor crown to HRL; 5, central incisor crown to VRL; 6, first molar apex to HRL; 7, first molar apex to VRL; 8, first molar crown to HRL; 9, first molar crown to VRL; 10, overjet; 11, overbite; 12, UL to TVL; 13, LL to TVL.

Intraexaminer reliability was evaluated using the intraclass correlation coefficient, which was >0.90.

Statistical Analysis

Statistical evaluation was performed using SPSS 16.0 (SPSS Inc., Chicago, Ill). Paired *t*-tests were used to evaluate the skeletal, dental, and soft tissue changes that occurred from T1 to T2 for variables following the normal distribution within each group.

The variables that were significantly different from the normal distribution were compared between T1 and T2 within each group using the Wilcoxon rank sum test. Multivariate analysis of variance was performed to evaluate the differences in pre- and posttreatment and the treatment effects between the groups for variables following the normal distribution. Mann-Whitney *U*-test was used to compare these differences in variables that did not follow the normal distribution. Statistical significance was set at .05. Bonferroni correction was applied for multiple comparisons.

RESULTS

Comparing the treatment effects between the MCPP appliances and buccal miniscrews, the MCPP appliance showed greater distalization and intrusion of the maxillary first molar with less distal tipping and less extrusion of the incisor compared to the buccal miniscrews. Multivariate analysis resulted in no significant main effect in the comparison of pretreatment variables for the groups; however, there was a significant main effect between the groups in the comparison of posttreatment variables (Tables 1 and 2).

In the MCPP group, the mean value of A point decreased by 1.9 mm ($P < .001$). However, in the miniscrew group, there were no significant differences between pre- and posttreatment values.

Overall, the MCPP appliances showed 4.2 mm of distalization, 1.6 mm of intrusion with 2° tipping, and 0.8 mm extrusion of the incisors. The miniscrew group showed 2.0 mm of distalization and 0.1 mm intrusion of the first molar with 7.2° tipping and 0.3 mm of incisor extrusion (Figure 4).

The apex of the palatal root of the first molar was significantly distalized in the MCPP group by 3.8 mm ($P < .001$), but it showed a nonsignificant change of 0.3 mm in the miniscrew group. Therefore, the miniscrew group showed a significant distal tipping of the maxillary first molars.

Regarding soft tissue changes in the MCPP group, the upper lips were significantly retracted ($P < .001$). All soft tissue variables demonstrated no significant differences between the groups (Table 3).

DISCUSSION

In the treatment of Class II cases, palatal plates and buccal miniscrews are highly effective appliances that can be easily placed and managed by clinicians. However, an analysis of the treatment effects between palatal plates and buccal miniscrews in lateral cephalograms has not been studied previously.

Distalization of the maxillary dentition has been applied as one of the treatment approaches for the correction of Class II malocclusions. Traditional approaches such as headgear and noncompliance devices such as the pendulum and distal jet were designed for molar distalization.[3,4,23,24] They have been marked by untoward side effects including extrusion, distal tipping, and the distal rotation of the maxillary first molars.[25–28]

Previously, the treatment effects of a single buccally placed miniscrew on each side resulted in 1.4 to 2.0 mm of molar distalization and 1 mm intrusion with approximately 3.5° of distal tipping.[10] In the current study, the miniscrew group showed 2.0 mm of

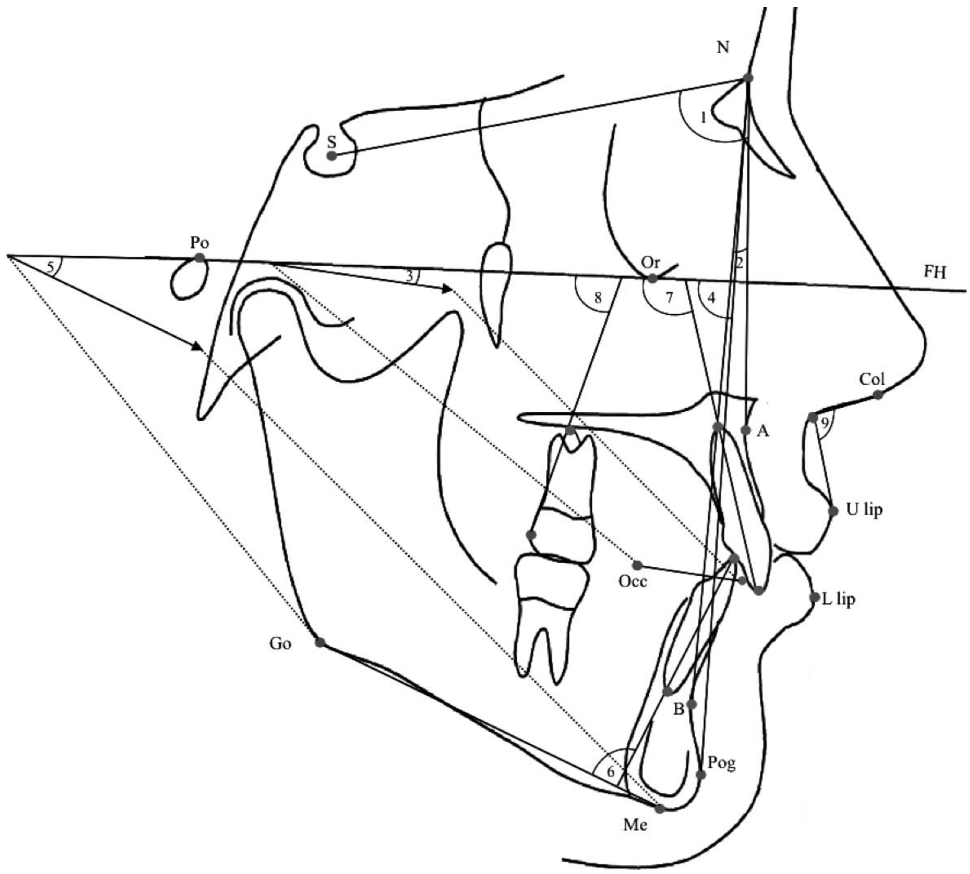

Figure 3. Angular cephalometric variables. S indicates sella; N, nasion; Po, porion; Or, orbitale; FH, Frankfort horizontal plane; PNS, posterior nasal spine; ANS, anterior nasal spine; Col, columella; A, A point; U, upper; Occ, occlusal plane point; L, lower; Go, gonion; B, B point; Pog, pogonion; Me, menton; 1, SNA, sella, nasion, A point; 2, ANB, A point, nasion, B point; 3, occlusal plane angle; 4, facial angle; 5, mandibular plane angle; 6, IMPA, incisor madibular plane angle; 7, central incisor inclination; 8, first molar angulation; 9, nasolabial angle.

distalization and 0.1 mm of intrusion of the first molar with 7.2° of tipping and 0.3 mm of incisor extrusion.

Recently, Bechtold et al.[11] demonstrated a difference in the distalization pattern depending on the number of miniscrews. A single miniscrew produced 1.8-mm distalization, 0.8-mm intrusion, and 3.2° distal tipping of the first molar with 0.5-mm extrusion of the incisors, whereas two miniscrews on each side resulted in 2.9-mm distalization, 1.4-mm intrusion, and 1.6° distal tipping of the molar, with 1.6-mm intrusion of the incisors.[11] However, the placement of four miniscrews, relocation of miniscrews as a result of root proximity, and technique sensitivity within narrow interradicular spaces were limitations of this approach.

Because the palatal area provides easy access, ample keratinized tissue, and the necessary bone thickness and density,[29,30] it might be a superior option for the placement of miniscrews. In the current study, MCPP appliances showed 4.2-mm distalization and 1.6 mm of intrusion with 2° tipping and 0.8-mm extrusion of the incisors: greater distalization and intrusion with less distal tipping and less extrusion of the incisor compared to the outcomes of the buccal miniscrews.

A previous finite element study compared distalization of the maxillary dentition using buccally placed miniscrews and MCPP appliances. It reported that distalization with a palatal plate would result in bodily molar movement and insignificant displacement of the incisors, whereas distalization with mini-implants on the buccal side would cause the first molar to be distally tipped and extruded while the incisors were flared labially and intruded.[22]

In agreement, the current results showed that distalization with MCPP appliances provided much less distal tipping when moving molars than with the buccal miniscrew group. The treatment outcome with MCPP appliances might achieve better stability for long-term retention as a result of the greater root movement.

Regarding stability, a longitudinal study with pendulum appliances for distalization reported that 43% of the distalization relapsed during fixed appliance therapy.[31] A recent case reported using buccal miniscrews

Table 1. Comparison of Pretreatment Cephalometric Variables Between the MCPP and Buccal Miniscrew Groups[a]

	MCPP		Buccal Miniscrew		
Measurement	Mean	SD	Mean	SD	*P* Value[b]
Skeletal					
A point - N perp. (mm)	2.95	3.63	2.10	1.70	.338
SNA (°)	82.23	3.85	80.23	2.69	.121
ANB (°)	3.31	2.70	2.66	1.68	.545
Facial angle (°)	88.17	4.44	87.43	2.34	.421
Occ. plane angle (°)	8.23	5.16	6.89	4.92	.454
FMA (°)	25.29	4.89	28.46	5.96	.082
Dental					
U1 crown to VRL (mm)	53.32	9.55	53.66	4.73	.87
U1 root to VRL (mm)	43.32	7.33	43.96	2.74	.924
U1 crown to FH (mm)	53.46	7.90	53.33	3.30	.289
U1 root to FH (mm)	32.24	5.51	32.02	3.22	.455
U1 to FH (°)	115.20	10.32	114.20	6.11	.683
U6 crown to VRL (mm)	16.59	5.40	15.99	3.04	.759
U6 root to VRL (mm)	23.22	4.99	21.36	2.80	.206
U6 crown to FH (mm)	43.01	6.86	41.96	2.80	.265
U6 root to FH (mm)	29.80	5.86	28.50	2.55	.192
U6 to FH (°)	63.32	8.93	68.01	6.63	.073
U7 crown to VRL (mm)	7.93	4.33	7.46	2.71	.693
U7 crown to FH (mm)	39.25	7.09	38.66	3.23	.714
U7 root to FH (mm)	27.63	5.54	25.82	2.22	.052
U7 to FH (°)	55.04	11.01	59.77	7.44	.131
IMPA (°)	96.35	8.73	94.11	9.24	.575
Overjet (mm)	4.05	1.32	3.90	1.62	.799
Overbite (mm)	2.56	1.44	2.22	1.36	.491
Soft tissue					
U lip to TVL (mm)	5.77	2.77	5.80	2.31	.986
L lip to TVL (mm)	3.90	4.05	3.64	2.36	.625
Nasolabial angle (°)	90.98	8.16	86.58	12.41	.121

[a] Multivariate analysis of variance. MCPP indicates modified C-palatal plate; SD, standard deviation; perp., perpendicular; Occ., occlusal; FMA, Frankfort mandibular plane angle; VRL, vertical reference line; FH, Frankfort horizontal plane; TVL, true vertical line; U, upper; and L, lower.

[b] Significance level at $P < .002$ with Bonferroni correction.

Table 2. Comparison of Posttreatment Cephalometric Variables Between the MCPP and Buccal Miniscrew Groups[a]

	MCPP		Buccal Miniscrew		
Measurement	Mean	SD	Mean	SD	*P* Value[b]
Skeletal					
A point - N perp. (mm)	1.05	3.64	2.49	1.98	.157
SNA (°)	81.16	3.34	79.74	2.65	.150
ANB (°)	2.99	2.51	2.68	2.30	.833
Facial angle (°)	87.39	4.08	86.67	2.59	.429
Occ. plane angle (°)	12.30	5.15	9.48	4.70	.097
FMA (°)	25.59	5.00	28.82	5.50	.068
Dental					
U1 crown to VRL (mm)	50.43	10.23	51.18	3.47	.967
U1 root to VRL (mm)	42.18	8.40	43.15	2.82	.849
U1 crown to FH (mm)	54.22	9.74	53.65	3.00	.128
U1 root to FH (mm)	32.52	6.54	31.87	3.17	.254
U1 to FH (°)	110.78	8.86	110.29	5.31	.763
U6 crown to VRL (mm)	12.37	5.20	13.99	2.76	.223
U6 root to VRL (mm)	19.45	5.07	21.04	2.04	.206
U6 crown to FH (mm)	41.37	8.18	41.83	2.80	.870
U6 root to FH (mm)	28.27	6.62	29.15	2.69	.605
U6 to FH (°)	61.33	9.05	60.80	8.31	.911
U7 crown to VRL (mm)	4.30	4.40	5.23	2.72	.439
U7 crown to FH (mm)	38.07	8.16	38.66	2.97	.693
U7 root to FH (mm)	26.79	6.22	26.56	2.47	.693
U7 to FH (°)	52.06	11.13	57.13	8.60	.125
IMPA (°)	95.03	9.29	93.21	7.28	.664
Overjet (mm)	3.51	1.01	2.77	0.60	.011
Overbite (mm)	3.02	1.24	1.68	0.56	<.001
Soft tissue					
U lip to TVL (mm)	4.59	2.73	4.90	1.91	.754
L lip to TVL (mm)	3.24	3.18	2.67	1.93	.828
Nasolabial angle (°)	96.69	11.26	90.19	9.82	.065

[a] Multivariate analysis of variance. MCPP indicates modified C-palatal plate; SD, standard deviation; Perp., perpendicular; Occ., occlusal; VRL, vertical reference line; FH, Frankfort horizontal plane; TVL, true vertical line; U, upper; and L, lower.

[b] Significance level at $P < .002$ with Bonferroni correction.

for distalization and showed that the resultant occlusion was stable throughout a 5-year retention period.[32] However, long-term treatment stability should be evaluated in future studies in large samples.

Karisson and Bondemark[33] suggested that it is more effective to distalize the maxillary first molars before eruption of the second molars. However, Flores-Mir et al.[34] showed minimal effect of the maxillary second and third molar eruption stages on molar distalization, demonstrated by both linear and angular measurements. In the current study, the second molar was distalized 3.6 mm in the MCPP group and 2.2 mm in the miniscrew group. However, the effect of the third molar on distalization was not evaluated.

The current study was conducted on two-dimensional lateral cephalograms. It was affected by their inherent shortcomings and the difficulty in identifying landmarks because of the superimposition of anatomical structures.[35] In future studies, the evaluation of the distalization of the maxillary arch using cone-beam computed tomography would be recommended for more accurate assessments of the treatment outcome. In addition, a study on the long-term stability of total arch distalization might be warranted.

CONCLUSIONS

- There was significantly greater distalization and intrusion with a smaller amount of distal tipping of the maxillary first molars associated with the MCPP as compared to the buccal miniscrews.
- Only the MCPP group showed a significant retraction of the upper lip. However, there were no significant differences between the groups in their soft tissue treatment effect.
- The application of the MCPP appliance may be recommended as one of the treatment modalities for maxillary molar or total upper arch distalization with better root control.

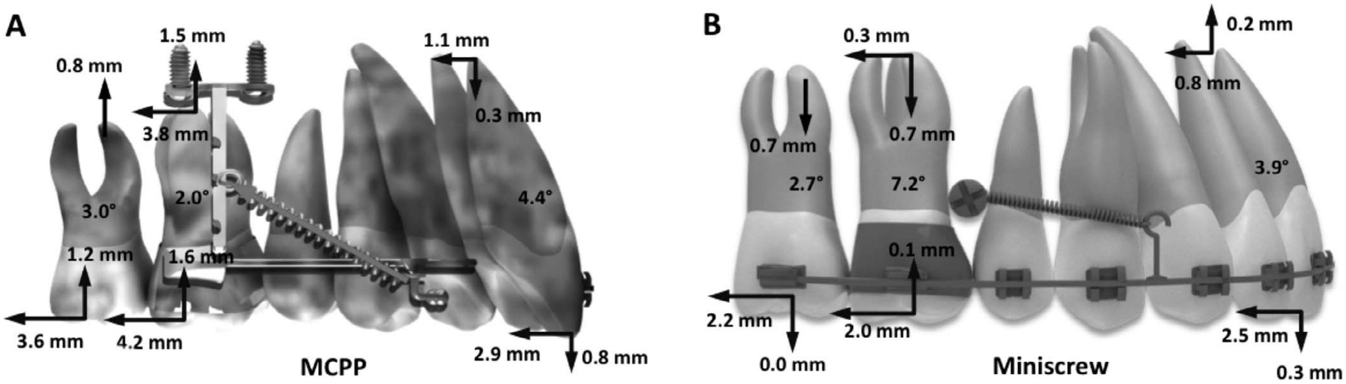

Figure 4. (A) Mean treatment changes of the maxillary first molar and central incisor in the MCPP group (palatal view) and (B) the buccally placed miniscrews group (buccal view).

Table 3. Comparison of Treatment Effects Between the MCPP and Buccal Miniscew Groups[a]

Measurement	MCPP		Within-Group Test, *P* Value[b]*	Buccal Miniscrew		Within-Group Test, *P* Value[b]*	Between-Group Test, *P* Value[b]†
	Mean	SD		Mean	SD		
Skeletal							
A point - N perp. (mm)	−1.90	1.36	<.001	0.39	1.01	.267	<.001
SNA (°)	−0.82	1.16	.003	−0.49	0.81	.021	.376
ANB (°)	−0.32	1.39	.297	0.02	1.20	.946	.525
Facial angle (°)	−0.78	1.75	.049	−0.76	1.51	.048	.922
Occ. plane angle (°)	4.07	3.91	<.001	2.58	3.91	.012	.246
FMA (°)	0.30	1.47	.358	0.36	1.14	.198	.900
Dental							
U1 crown to VRL (mm)	−2.89	2.93	.001	−2.48	2.72	.049	.684
U1 root to VRL (mm)	−1.14	2.47	.028	−0.80	1.28	.016	.277
U1 crown to FH (mm)	0.76	2.85	.053	0.32	2.13	.537	.59
U1 root to FH (mm)	0.29	2.26	.194	−0.16	1.81	.715	.513
U1 to FH (°)	−4.42	5.39	.001	−3.90	7.72	.047	.842
U6 crown to VRL (mm)	−4.22	1.25	<.001	−2.00	1.26	<.001	<.001
U6 root to VRL (mm)	−3.77	1.61	<.001	−0.31	1.63	.425	<.001
U6 crown to FH (mm)	−1.64	2.06	<.001	−0.13	1.88	.776	.036
U6 root to FH (mm)	−1.53	2.32	.008	0.65	1.51	.086	.002
U6 to FH (°)	−1.98	4.20	.038	−7.21	5.22	<.001	.002
U7 crown to VRL (mm)	−3.64	1.71	<.001	−2.23	1.38	<.001	.008
U7 crown to FH (mm)	−1.18	1.94	.011	0.01	1.70	.984	.052
U7 root to FH (mm)	−0.84	2.31	.050	0.74	1.95	.126	.028
U7 to FH (°)	−2.98	7.81	.096	−2.65	6.54	.104	.888
IMPA (°)	−1.32	4.36	.171	−0.90	6.61	.571	.806
Overjet (mm)	−0.54	1.24	.055	−1.13	1.85	.019	.328
Overbite (mm)	0.46	1.25	.097	−0.54	1.43	.126	.027
Soft tissue							
U lip to TVL (mm)	−1.18	0.99	<.001	−0.90	1.20	.005	.465
L lip to TVL (mm)	−0.67	2.09	.390	−0.97	1.96	.052	.646
Nasolabial angle (°)	5.72	8.27	.004	4.52	6.60	.010	.609

[a] MCPP indicates modified C-palatal plate; SD, standard deviation; Perp., perpendicular; Occ., occlusal; VRL, vertical reference line; FH, Frankfort horizontal plane; TVL, true vertical line; U, upper; and L, lower.
[b] Significance level at $P < .002$ with Bonferroni correction.
* Paired *t*-test.
† Multivariate analysis of variance.

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