Original Article

Dental and skeletal effects after total arch distalization using modified C-palatal plate on hypo- and hyperdivergent Class II malocclusions in adolescents

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ABSTRACT

Objectives: To compare the dental and skeletal treatment effects after total arch distalization using modified C-palatal plates (MCPPs) on adolescent patients with hypo- and hyperdivergent Class II malocclusion.

Materials and Methods: The study group included 40 patients with Class II malocclusion (18 boys and 22 girls, mean age = 12.2 ± 1.4 years) treated with MCPPs. Fixed orthodontic treatment started with the distalizing process in both groups. Participants were divided into hypo- or hyperdivergent groups based on their pretreatment Frankfort mandibular plane angle (FMA) $\leq$22° or $\geq$28°, respectively. Pre- and posttreatment lateral cephalograms were digitized, and 23 variables were measured and compared for both groups using paired and independent *t*-tests.

Results: The hyper- and hypodivergent groups showed 2.7 mm and 4.3 mm of first molar crown distalizing movement, respectively ($P < .001$). The hypodivergent group had a slight 2.2° crown distal tipping of first molars compared with 0.3° in the hyperdivergent group. After distalization, the FMA increased 3.1° and 0.3°, in the hypodivergent and hyperdivergent groups, respectively ($P <$ .001). SNA decreased in the hypodivergent group, while other skeletal variables presented no statistically significant differences in the changes between the groups.

Conclusions: The hypodivergent group showed more distal and tipping movement of the maxillary first molar and increased FMA than the hyperdivergent group. Therefore, clinicians must consider vertical facial types when distalizing molars using MCPPs in Class II nonextraction treatment. (*Angle Orthod.* 2021;91:22–29.)

KEY WORDS: Modified C-palatal plate; Class II patients; Hypo-/hyperdivergent growth pattern

INTRODUCTION

Recently, temporary skeletal anchorage devices have enabled orthodontists to improve vertical and sagittal relationships. However, vertical control in the treatment of Class II malocclusion is a challenge for clinicians because of its complex and multifactorial etiology.[1–3]

Conventional treatment using headgear in patients with Class II malocclusion frequently causes extrusion of maxillary molars, which induces a deleterious backward mandibular rotation and an increase in anterior facial height.[4–6] Therefore, miniscrews and miniplates have been used to overcome these negative effects.[7–9] Distalization of the posterior teeth using buccal miniscrews showed distal movement of the

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teeth along with less distal tipping and rotation of the molars.[7] Bechtold et al.[8] reported that additional miniscrews were needed in the premolar area to facilitate intrusion and distalization of the entire arch, with positioning selected according to the location of the force vectors. However, there might be a risk of root damage and only a limited amount of distalization possible due to narrow interradicular space in the area of the maxillary posterior teeth.

Unal et al.[10] evaluated the effects of the Forsus fatigue-resistant device using miniplates for Class II malocclusion and showed a significant restraint in the sagittal position of the maxilla; however, flap surgery is invasive. Kook et al.[11] introduced a modified C-palatal plate (MCPP) that did not require additional surgery. MCPPs showed distalization and intrusion of the maxillary molars in adolescents and adults,[9,12] and similar or more distal movement of maxillary first molars compared with cervical headgear and buccal miniscrews.[13,14]

Regarding treatment effects relative to vertical facial patterns in Class II malocclusion, Godt et al.[15] found that vertical growth pattern groups using cervical headgear presented smaller distal movements in the anterior segments than did the horizontal growth pattern groups. Recently, Rogers et al.[16] reported that hyperdivergent patients underwent undesirable backward true mandibular rotation during Herbst treatment, while hypodivergent patients underwent forward true mandibular rotation. On the other hand, Buschang et al.[3] demonstrated forward mandible rotation with the intrusion of posterior teeth using miniscrews in patients with a hyperdivergent retrognathic phenotype.

However, no study has been done to compare treatment effects between hypodivergent and hyperdivergent facial patterns using miniplates on adolescents. Therefore, the purpose of this study was to compare the dental and skeletal changes after total arch distalization using MCPPs between growing patients with hypo- and hyperdivergent Class II maloccusion.

MATERIALS AND METHODS

Sample Description

Forty adolescent patients with Class II malocclusion treated with the MCPP (Jeil Corporation, Seoul, Korea) in combination with fixed appliances were screened. Approval to conduct this study was granted by the Institutional Review Board of Catholic University of Korea (IRB approval number KC19RESI0109).

The inclusion criteria were the following: (1) adolescent patients (age range from 10 to 16 years), (2) skeletal Class II malocclusion (ANB angle greater than 4°), (3) moderate maxillary crowding (<4 mm), (4) nonextraction treatment, (5) maxillary molar distalization via MCPPs for more than 9 months, and (6) absence of craniofacial anomalies. Presence of maxillary third molar was not included because no significant differences were shown in the amount of change in position or angulation of teeth between the maxillary third molar extraction and nonextraction groups.[12]

The criteria were met by all 40 participants who were divided into two groups. The hyperdivergent group (mean age, 12.1$\pm$ 1.1 years) included 20 patients with the mandibular plane-Frankfort horizontal plane (FMA) $\geq$28°, whereas the hypodivergent group (mean age, 12.3$\pm$1.5 years) consisted of 20 patients with FMA $\leq$22°. Pretreatment (T1) was defined as the time of MCPP placement, and postdistalization (T2) was defined as the time when Class I molar was achieved. Total duration of treatment was calculated as the difference between T2 and T1.

MCPP Placement and Distalizing Procedure

The MCPPs were installed by a single operator (Y.A.K). using three miniscrews (Jeil Corporation) 8-mm long and 2.0 mm in diameter in the paramedian area to avoid interfering with the growth of the suture. A transpalatal bar with two hooks extending along the gingival margins of the upper teeth was banded to both maxillary first molars. After MCPP placement, distalization was initiated by engaging elastomeric chains or NiTi closed-coil springs between the plate arm notches and the anterior hooks on the transpalatal bar, applying approximately 300 g of force per side. The elastomeric chains were applied to the same notch, which was farthest from the median area (Figure 1).

Cephalometric Methods

Lateral cephalograms were taken uing Dimax3 (Promax, Planmeca, Helsinki, Finland) of the participants in the two groups. All participants were in natural head position, centric occlusion. The pretreatment (T1) and posttreatment (T2) lateral cephalograms were digitized using V-Ceph 8.0 (Cybermed, Seoul, South Korea). The horizontal reference line was the FH plane, and the vertical reference line was a perpendicular line passing through the most distal point of pterygoid. A total of 23 linear and angular measurements were traced and digitized by one orthodontist (Figures 2 and 3). The differences between T1 and T2 were calculated (T2-T1).

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

Figure 1. An MCPP and TPA placed on the palate with an elastomeric chain in an adolescent patient.

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

Sample-Size Estimation

The sample-size estimation for this study was based on a study that compared skeletal and dental effects of molar distalization between a headgear group and an MCPP group.[9] Sample-size calculation showed that at least 20 patients were required in each group to identify an effect size of 1.5 units, provided that alpha was 0.05 and beta was 0.2 (G-Power 3.0).

Statistical Analysis

Statistical evaluation was performed using SPSS 16.0 (SPSS Inc, Chicago, Ill). The distributions of all variables were normally based on the skewness and kurtosis statistics. Independent sample *t*-tests were used to evaluate intergroup differences, while paired *t*-tests were used to evaluate intragroup differences.

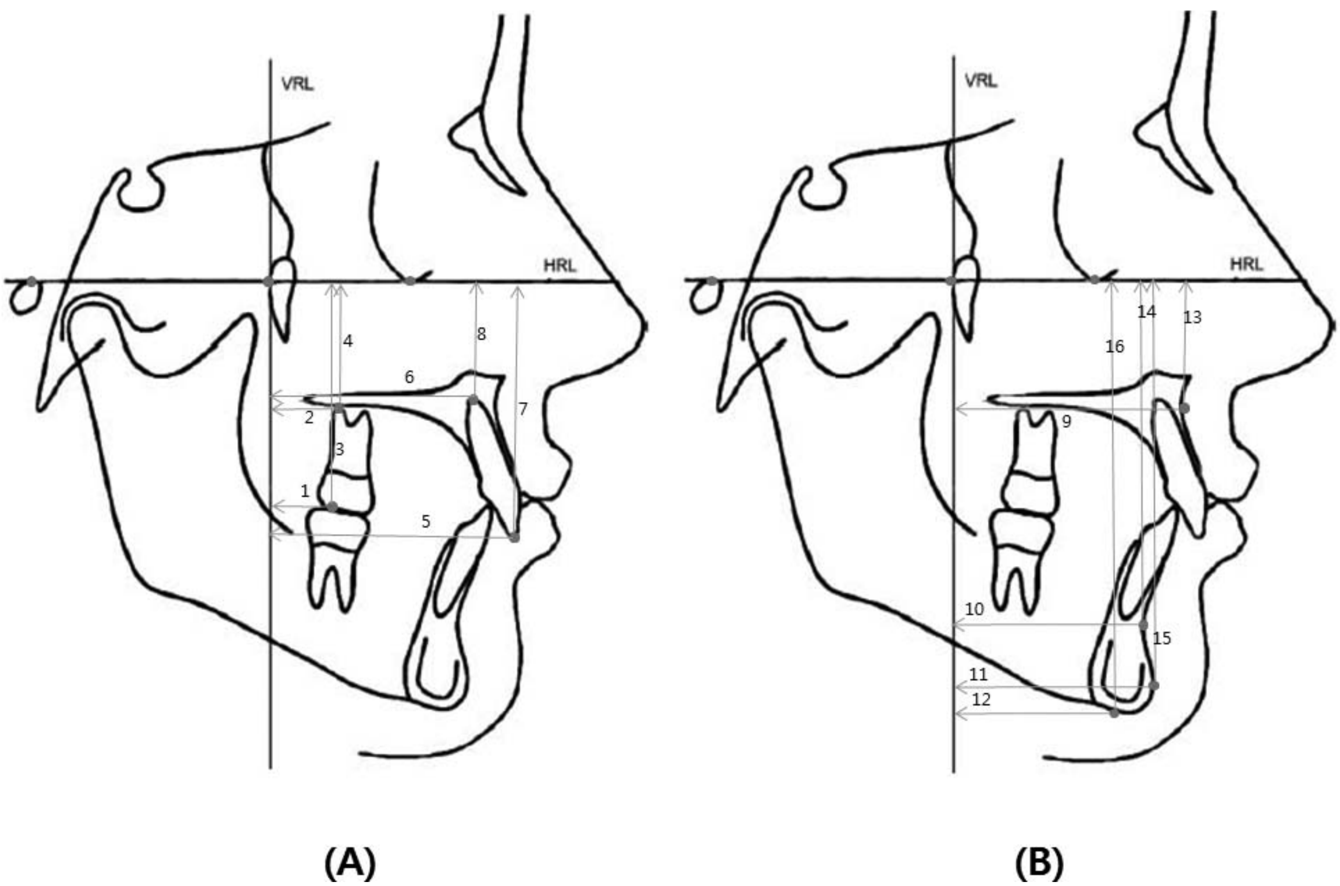

Figure 2. Linear measurements. (A) Dental: 1, horizontal distance from the maxillary first molar crown to VRL (vertical reference line); 2, horizontal distance from the maxillary first molar root to VRL; 3, vertical distance from the maxillary first molar crown to HRL (horizontal reference line); 4, vertical distance from the maxillary first molar root to HRL; 5, horizontal distance from the maxillary central incisor crown to VRL; 6, horizontal distance from the maxillary central incisor root to VRL; 7, vertical distance from the maxillary central incisor crown to HRL; 8, vertical distance from the maxillary central incisor root to HRL. (B) Skeletal: 9, horizontal distance from A point to VRL; 10, horizontal distance from B point to VRL; 11, horizontal distance from pogonion to VRL; 12, horizontal distance from menton to VRL; 13, vertical distance from A point to HRL, 14; vertical distance from B point to HRL, 15; vertical distance from pogonion to HRL; 16, vertical distance from menton to HRL.

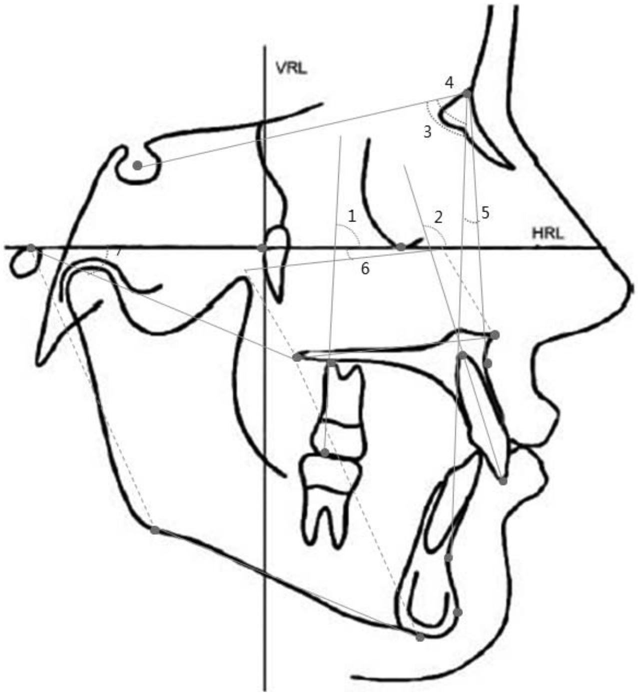

Figure 3. Angular measurements. 1, Maxillary first molar to FH plane angle; 2, Maxillary central incisor inclination (U1 to FH plane angle); 3, SNA; 4, SNB; 5, ANB; 6, palatal plane angle (FH/ANS-PNS); 7, Mandibular plane angle (FH/Go-Me).

RESULTS

In Table 1, the hyper- and hypodivergent groups showed pretreatment mandibular plane angles of 30.6° and 21.8° , respectively ($P < .001$). The hyperdivergent group also showed larger mandibular and maxillary vertical positions. However, there was no difference in sagittal positions between the groups.

In Table 2 and Figure 4, the hyper- and hypodivergent group showed 2.7 mm and 4.3 mm of distalizing movement of the first molar crowns at posttreatment, respectively ($P < .001$). In both groups, the vertical position of the first molars after treatment was slightly intruded but not significantly.

The hypodivergent group had a slight 2.2° crown distal tipping of the first molars compared with 0.3° in the hyperdivergent group. The hyper- and hypodivergent groups showed 1.6 mm and 2.3 mm of distalizing movement and 2.8 mm and 3.7 mm of extrusion of the incisor crowns, respectively.

Skeletal variables presented no statistically significant differences between the groups. The hypodivergent group mandibular plane angle increased significantly by 3.1° compared to the hyperdivergent group ($P < .001$).

Mean treatment duration was 15.4 ± 1.3 and 14.9 ± 1.5 months in hyperdivergent and hypodivergent

Table 1. Comparison Between Cephalometric Variables of Hyperdivergent and Hypodivergent Groups at Pretreatment (T1)

	Hyperdivergent (T1) (n = 20)		Hypodivergent (T1) (n = 20)		
	Mean	SD	Mean	SD	*P*-Value[a]
Dental					
First molar crown-VRL, mm	14.62	2.29	15.28	3.59	.501
First molar root-VRL, mm	18.76	2.11	18.57	2.11	.791
First molar crown-FH, mm	40.79	2.24	40.49	3.28	.740
First molar root-FH, mm	25.54	2.16	24.48	2.69	.184
First molar-FH, °	72.85	4.49	77.18	4.89	>.007
Central incisor crown-VRL, mm	51.88	3.25	53.19	3.26	.220
Central incisor root-VRL, mm	42.48	2.47	43.54	3.21	.259
Cental incisor crown-FH, mm	50.01	2.70	47.81	3.78	>.046
Central incisor root-FH, mm	30.86	2.42	28.84	2.73	>.020
U1 to FH,°	114.43	6.01	116.06	8.63	.500
Skeletal					
SNA, °	82.42	3.67	81.59	2.46	.411
SNB, °	76.89	3.51	76.34	2.79	.588
ANB, °	5.52	1.63	5.24	1.04	.527
Palatal plane angle, °	–.56	2.63	–2.05	2.46	.076
Mandibular plane angle, °	30.58	3.13	21.78	1.86	>.000
A point to VRL, mm	46.12	2.13	47.27	2.56	.137
B point to VRL, mm	39.15	3.43	41.32	3.41	.056
Pog to VRL, mm	39.2	3.74	42.07	3.98	>.027
Me to VRL, mm	32.76	3.41	35.03	4.51	.085
A point to FH, mm	29.01	2.15	27.10	2.46	>.015
B point to FH, mm	65.09	2.97	61.80	3.85	>.005
Pog to FH, mm	78.06	3.64	74.11	4.70	>.006
Me to FH, mm	82.42	3.56	78.96	4.63	>.014

[a] Independent *t*-test.

Table 2. Comparison of Treatment Effects Between Hyperdivergent and Hypodivergent Groups (T2-T1) [a,b]

	Hyperdivergent (T2-T1) (n = 20)		Within-Group	Hypodivergent (T2-T1) (n= 20)		Within-Group	Between-Group
	Mean	SD	Test *P*-Value	Mean	SD	Test *P*-Value	Test, *P*-Value
Dental							
First molar crown-VRL, mm	–2.69	1.76	>.000	–4.26	1.68	>.000	>.007
First molar root-VRL, mm	–2.57	1.58	>.000	–3.28	1.29	>.000	.140
First molar crown-FH, mm	–0.57	1.90	.201	–0.15	1.76	.170	.486
First molar root-FH, mm	–0.49	1.63	.194	–0.01	1.44	.988	.331
First molar-FH, °	–0.28	3.24	.706	–2.18	2.82	>.003	.057
Central incisor crown-VRL, mm	−1.63	3.12	>.031	−2.33	2.80	>.002	.463
Central incisor root-VRL, mm	−0.97	2.09	.052	0.54	1.49	.135	.456
Cental incisor crown-FH, mm	2.82	1.84	>.000	3.71	2.45	>.000	.212
Central incisor root-FH, mm	1.38	1.90	>.004	2.42	2.02	>.000	.106
U1 to FH, °	–7.97	7.36	>.000	–8.20	6.89	>.000	.920
Skeletal							
SNA, °	–0.51	1.10	.054	–0.82	1.26	>.011	.413
SNB, °	–0.37	1.41	.252	–0.11	1.12	.662	.530
ANB, °	–0.13	1.11	.593	–0.71	0.67	>.000	.059
Palatal plane angle, °	0.09	1.48	.770	0.64	1.29	>.045	.230
Mandibular plane angle ,°	0.26	1.08	.293	3.05	1.13	>.000	>.000
A point to VRL, mm	0.61	1.81	.150	–0.11	1.46	.737	.179
B point to VRL, mm	0.42	4.29	.665	–0.13	3.02	.850	.642
Pog to VRL, mm	0.06	5.18	.958	–0.83	3.48	.308	.527
Me to VRL, mm	–0.96	5.29	.425	–1.52	4.13	.126	.718
A point to FH, mm	0.42	1.68	.279	2.03	2.06	>.000	>.011
B point to FH, mm	2.91	2.48	>.000	3.69	2.83	>.000	.358
Pog to FH, mm	4.04	3.07	>.000	4.19	2.81	>.000	.871
Me to FH, mm	3.42	2.97	>.000	4.75	2.51	>.000	.140

[a] T1 indicates retreatment; T2: postdistalization.
[b] Paired *t*-test/independent *t*-test.

patients, respectively, and showed no statistically significant difference.

DISCUSSION

In the correction of skeletal Class II malocclusion, there is a significant increase in total mandibular length with functional appliances or by inhibiting maxillary growth using headgear and Herbst appliances in adolescents.[17,18] In addition, getting favorable functional and esthetic results with vertical growth control in patients with Class II hyperdivergent malocclusion is challenging for clinicians. However, no studies have reported the treatment effects of Class II malocclusion using temporary skeletal anchorage devices depending on vertical facial types. Therefore, this study aimed to find the difference in the amount and pattern of tooth movement after total arch distalization with MCPPs between hypo- and hyperdivergent growth patterns.

In this study, the hypodivergent group presented a greater pretreatment maxillary first molar angle (more upright) than the hyperdivergent group. This was consistent with findings of a previous study in which patients with average FMA of 34° showed mesial inclination of posterior dentition as one of the dentoalveolar characteristics at the baseline.[19]

The hypo- and hyperdivergent groups showed 4.3 mm and 2.7 mm of distalization with 2.2° and 0.3° distal tipping of the maxillary first molars, respectively. This means that more distalizing movement of the molar crowns occurred in the hypodivergent group. It might have been because the fixed length of the prefabricated MCPP arms had a tendency to be placed in a relatively high position in hyperdivergent patients, resulting in an upward direction of force to reduce distal tipping movement and reinforce the bodily movement of the first molars as shown in Figure 5. In addition, for morphometric covariation between palatal shape and skeletal pattern, Paoloni et al.[20] demonstrated that the hyperdivergent group had a deeper palatal vault depth than the hypodivergent group. However, each patient's palatal depths were not measured in this study. Analysis of the pattern of molar distalization is required according to the palatal depth of the patients.

Regarding the vertical positional change of the maxillary first molars, Ding et al.[21] reported that it was easier to intrude molars in hyperdivergent patients, who had lower bone density in the molar apical area compared to hypodivergent patients. Zhang et al.[22] showed that the molars were erupted approximately

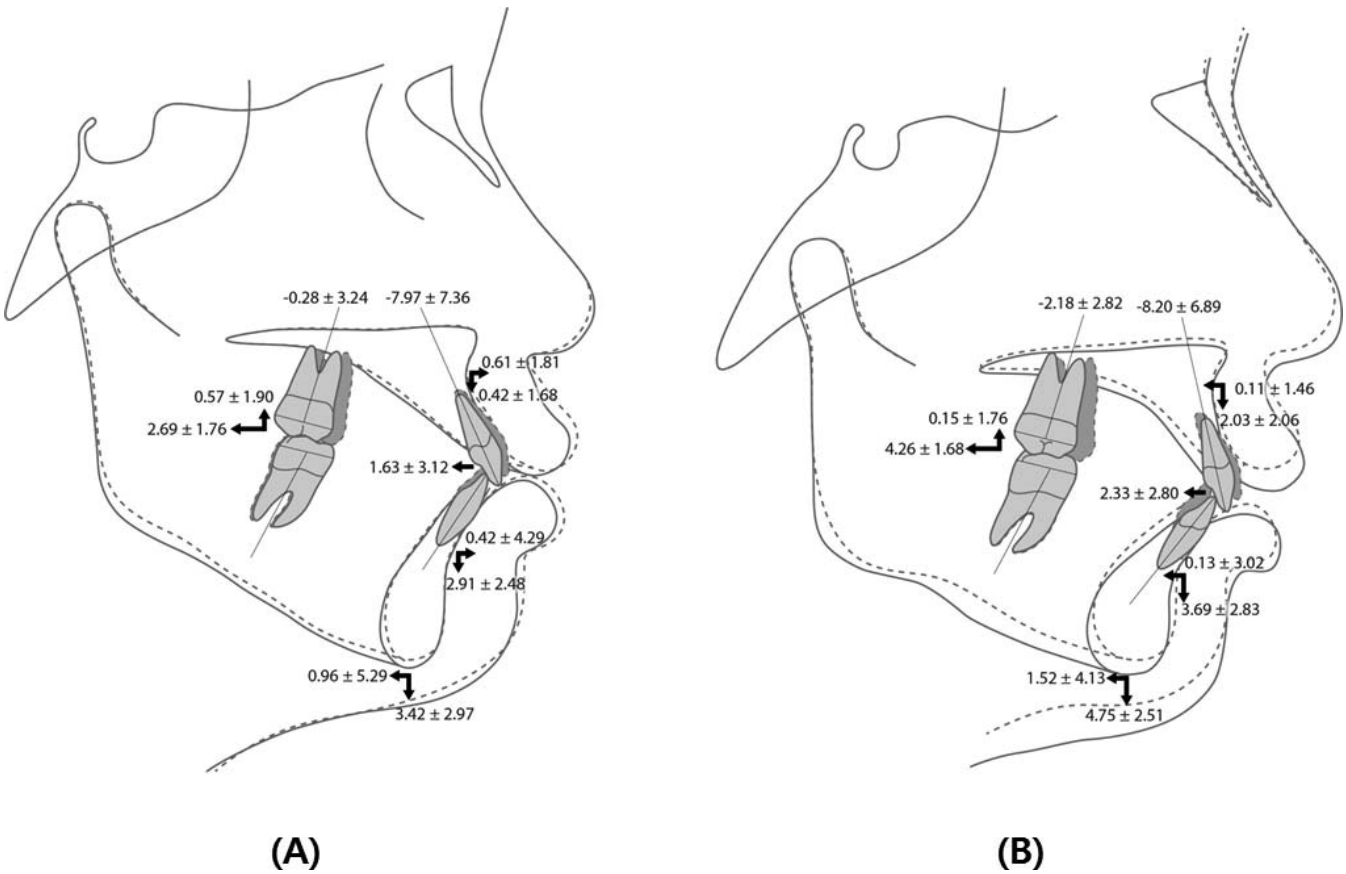

Figure 4. Superimposition after distalizing using an MCPP in patients with (A) hyperdivergent and (B) hypodivergent Class II malocclusion.

1.7 mm per year in adolescents with normal growth. In the current study, the first molars were slightly intruded, but there was no significant difference in the amount of intrusion between the groups. MCPPs generated a direction of the force that caused intrusion of the maxillary molars relative to the difference in vertical height between the plate arm and hook of the palatal retraction arch.

Bilbo et al.[23] demonstrated that treatment with high-pull headgear for hyperdivergent patients had no effect on vertical skeletal changes. In addition, cervical headgear and other noncompliance intraoral devices for distalization of maxillary molars tended to result in an increase of the FMA.[24–29] In this study, the FMA increased by 3.1° and 0.3° in the hypodivergent and hyperdivergent groups, respectively. This increase of

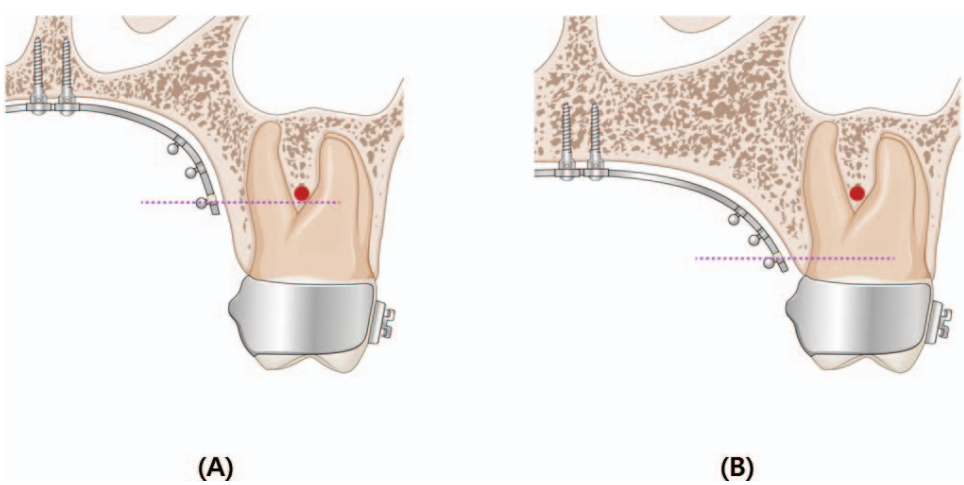

Figure 5. Schematic drawing of position of MCPP in patients with (A) hyperdivergent and (B) hypodivergent Class II malocclusion.

FMA in the hypodivergent group might have been due to molar extrusion and vertical growth of the mandible.

Recently, a Forsus fatigue resistant device with miniplates showed a significant restraint in the sagittal position of the maxilla and forward movement of the mandible where there was no classification of the vertical pattern.[10] Rogers et al.[16] reported that the SNA angle was reduced in hypodivergent patients using a Herbst appliance, but it had less effect on vertical control. Similarly, in the current study, SNA decreased. The MCPPs caused a significant restraint effect in the sagittal position of the maxilla, which is similar to the effects with high pull headgear.[23]

Other studies have found that condylar growth was directed more posteriorly and horizontal chin projection increased more in hyperdivergent participants.[30,31] In this study, after MCPP treatment, horizontal mandibular growth showed no difference between the two groups. This might have occurred because the distalization force was only applied to the maxillary first molar.

Clinically, the vertical facial pattern should be evaluated in the treatment of Class II malocclusion. With the use of MCPPs in this study, the difference in hyperdivergent and hypodivergent growth patterns might be clinically considered a palatal morphology difference. Therefore, a customized plate based on the patient's palatal morphology and depth, rather than a preformed one, are recommended for effective tooth movement.

Limitations of this study were heterogeneity of samples and no control group to analyze the treatment effect of different facial types. A future study should be conducted to evaluate the treatment effects of customized and preformed MCPPs. In addition, a prospective study needs to be conducted to evaluate the difference between hypo- and hyperdivergent types when the force is applied to the molar at the same vertical level in the two patterns.

CONCLUSIONS

- Hypo- and hyperdivergent groups displayed 4.3 mm and 2.7 mm of distalization with 2.2° and 0.3° of distal tipping of maxillary first molars, respectively. The hypodivergent group showed more distal and tipping movement of the maxillary first molar.
- The FMA of the hyperdivergent group was maintained while that of the hypodivergent group increased by about 3°. The hypodivergent group showed more increased FMA than the hyperdivergent group.
- Therefore, clinicians must consider vertical facial types when distalizing molars using MCPP in Class II nonextraction treatment.

REFERENCES

1. Lee J, Miyazawa K, Tabuchi M, Kawaguchi M, Shibata M, Goto S. Midpalatal miniscrews and high-pull headgear for anteroposterior and vertical anchorage control: cephalometric comparisons of treatment changes. *Am J Orthod Dentofacial Orthop*. 2013;144:238–250.
2. Kook YA, Park JH, Bayome M, Sa'aed NL. Correction of severe bimaxillary protrusion with first premolar extractions and total arch distalization with palatal anchorage plates. *Am J Orthod Dentofacial Orthop*. 2015;148:310–320.
3. Buschang PH, Jacob H, Carrillo R. The morphological characteristics, growth, and etiology of the hyperdivergent phenotype. *Semin Orthod*. 2013;19:212–226.
4. Lima Filho RM, Lima AL, de Oliveira Ruellas AC. Mandibular changes in skeletal class II patients treated with Kloehn cervical headgear. *Am J Orthod Dentofacial Orthop*. 2003; 124:83–90.
5. Kirjavainen M, Hurmerinta K, Kirjavainen T. Facial profile changes in early Class II correction with cervical headgear. *Angle Orthod*. 2007;77:960–967.
6. Kirjavainen M, Kirjavainen T, Haavikko K. Changes in dental arch dimensions by use of an orthopedic cervical headgear in Class II correction. *Am J Orthod Dentofacial Orthop*. 1997; 111:59–66.
7. Oh YH, Park HS, Kwon TG. Treatment effects of microimplant-aided sliding mechanics on distal retraction of posterior teeth. *Am J Orthod Dentofacial Orthop*. 2011;139:470–481.
8. Bechtold TE, Kim JW, Choi TH, Park YC, Lee KJ. Distalization pattern of the maxillary arch depending on the number of orthodontic miniscrews. *Angle Orthod*. 2013;83: 266–273.
9. Sa'aed NL, Park CO, Bayome M, Park JH, Kim YJ, Kook YA. Skeletal and dental effects of molar distalization using a modified palatal anchorage plate in adolescents. *Angle Orthod*. 2015;85:657–664.
10. Unal T, Celikoglu M, Candirli C. Evaluation of the effects of skeletal anchoraged Forsus FRD using miniplates inserted on mandibular symphysis: a new approach for the treatment of Class II malocclusion. *Angle Orthod*. 2015;85:413–419.
11. Kook YA, Kim SH, Chung KR. A modified palatal anchorage plate for simple and efficient distalization. *J Clin Orthod*. 2010;44:719–730.
12. Kook YA, Bayome M, Trang VT, et al. Treatment effects of a modified palatal anchorage plate for distalization evaluated with cone-beam computed tomography. *Am J Orthod Dentofacial Orthop*. 2014;146:47–54.
13. Lee SK, Abbas NH, Bayome M, et al. A comparison of treatment effects of total arch distalization using modified C-palatal plate vs buccal miniscrews. *Angle Orthod*. 2018;88: 45–51.
14. Park CO, Sa'aed NL, Bayomeb M, et al. Comparison of treatment effects between the modified C-palatal plate and cervical pull headgear for total arch distalization in adults. *Korean J Orthod*. 2017;47:375–383.
15. Godt A, Berneburg M, Kalwitzki M, Göz G. Cephalometric analysis of molar and anterior tooth movement during cervical headgear treatment in relation growth patterns. *J Orofac Orthop*. 2008;69:189–200.
16. Rogers K, Campbell PM, Tadlock L, Schneiderman E, Buschang PH. Treatment changes of hypo- and hyperdivergent Class II Herbst patients. *Angle Orthod*. 2018;88:3–9.

17. LaHaye MB, Buschang PH, Alexander RG, Boley JC. Orthodontic treatment changes of chin position in Class II Division 1 patients. *Am J Orthod Dentofacial Orthop*. 2006; 130:732–741.
18. Cozza P, Baccetti T, Franchi L, De Toffol L, McNamara JA Jr. Mandibular changes produced by functional appliances in Class II malocclusion: a systematic review. *Am J Orthod Dentofacial Orthop*. 2006;129:599.e1–599.e12.
19. Ellis E, McNamara JA, Lawrence TM. Components of adult Class II open-bite malocclusion. *J Oral Maxillofac Surg*. 1985;43:92–105.
20. Paoloni V, Lione R, Farisco F, Halazonetis DJ, Franchi L, Cozza P. Morphometric covariation between palatal shape and skeletal pattern in Class II growing participants. *Eur J Orthod*. 2017;39:371–376.
21. Ding WH, Li W, Chen F, et al. Comparison of molar intrusion efficiency and bone density by CT in patients with different vertical facial morphology. *J Oral Rehabil*. 2015;42:355–362.
22. Zhang X, Baumrind S, Chen G, Chen H, Liang Y, Xu T. Longitudinal eruptive and posteruptive tooth movements, studied on oblique and lateral cephalograms with implants. *Am J Orthod Dentofacial Orthop*. 2018;153:673–684.
23. Bilbo EE, Marshall SD, Southard KA, Allareddy V. Long-term skeletal effects of high-pull headgear followed by fixed appliances for the treatment of Class II malocclusions. *Angle Orthod*. 2018;88:530–537.
24. Ghosh J, Nanda RS. Evaluation of an intraoral maxillary molar distalization technique. *Am J Orthod Dentofacial Orthop*. 1996;11:639–646.
25. Byloff FK, Darendeliler MA. Distal molar movement using the pendulum appliance. Part 1: Clinical and radiological evaluation. *Angle Orthod*. 1997;67:249–260.
26. Rana R, Beefier MK. Class II correction using the bimetric distalizing arch. *Semin Orthod*. 2000;6:106–118.
27. Runge ME, Martin JT, Bukai F. Analysis of rapid maxillary molar distal movement without patient cooperation. *Am J Orthod Dentofacial Orthop*. 1999;115:153–157.
28. Brickman CD, Sinha PK, Nanda RS. Evaluation of the Jones jig appliance for distal molar movement. *Am J Orthod Dentofacial Orthop*. 2000;118:526–534.
29. Bussick TJ, McNamara JA Jr. Dentoalveolar and skeletal changes associated with the pendulum appliance. *Am J Orthod Dentofacial Orthop*. 2000;117:333–343.
30. Pancherz H, Michailidou C. Temporomandibular joint growth changes in hyperdivergent and hypodivergent Herbst participants. A long-term roentgenographic cephalometric study. *Am J Orthod Dentofacial Orthop*. 2004;126:153–161.
31. Deen E, Woods MG. Effects of the Herbst appliance in growing orthodontic patients with different underlying vertical patterns. *Aust Orthod J*. 2015;31:59–68.