Comparison of Treatment Effects with Modified C-Palatal Plates vs Greenfield Molar Distalizer Appliances in Adolescents

Mohammed Alfaifi*/Jae Hyun Park**/Kiyoshi Tai***/Ja Hyeong Ku****/Nikhilesh R Vaid*****/ Yoon-Ah Kook******/Ahmed M Shoaib*******/Mohamed Bayome********

Objectives: *The aim of study was to evaluate skeletodental and soft tissue treatment effects and the amount of maxillary molar distalization with modified C-palatal plates vs. Greenfield molar distalizer appliances in adolescents.* ***Study design:*** *The samples consisted of pre- and posttreatment lateral cephalograms collected from 39 patients with Class II malocclusion. The MCPP group was comprised of 21 patients (mean age: 11.7 ± 1.3 years) treated with MCPP appliances while the GMD group included 18 patients (mean age: 11.2 ± 0.9 years) treated with GMD. Fixed orthodontic treatment started with the distalization process in both groups. From each cephalograpm, twenty-nine variables were measured for analysis and then the two groups were compared. Descriptive statistics, a paired t-test, and multivariate analysis of variance were performed to compare the treatment effects within and between the groups.* ***Results:*** *There was significant treatment-related change in the sagittal position of the maxilla and the mandible within each group. However, there were no statistically significant inter-group differences. The mean maxillary first molar distalization was 3.96 mm in the MCPP group vs. 2.85 mm in the GMD group. Both groups showed minimal distal tipping, but the maxillary incisors were significantly extruded by 3.04 ± 0.89 mm ($P < .001$) in GMD group. There was no significant difference in treatment duration between the groups.*

Conclusions: *The maxillary first molars of both the MCPP and GMD groups were effectively distalized and there were significant skeletal changes in the maxilla. However, the maxillary incisors were significantly extruded in the GMD group.*

Keywords: *Modified C-palatal plate-Maxillary molar distalization-Greenfield molar distalizer-Skeletal effect.*

* Mohammed Alfaifi, DDS, Graduate Student, The Catholic University of Korea, Seoul, Korea.

**Jae Hyun Park, DMD, MSD, MS, PhD, Professor and Chair, Postgraduate Orthodontic Program, Arizona School of Dentistry & Oral Health, A.T. Still University, Mesa, USA and international scholar, Graduate School of Dentistry, Kyung Hee University, Seoul, Korea.

***Kiyoshi Tai, DDS, PhD, Visiting Adjunct Professor, Postgraduate Orthodontic Program, Arizona School of Dentistry and Oral Health, Mesa, AZ, adjunct assistant professor, Graduate School of Dentistry, Kyung Hee University, Seoul, South Korea, and private practice of orthodontics, Okayama, Japan.

****Ja Hyeong Ku, DDS, Resident, Department of Orthodontics, Seoul St. Mary's Hospital, Catholic University of Korea, Seoul, Korea.

*****Nikhilesh R. Vaid, MDS, PhD, Visiting Professor, European University College, Dubai, United Arab Emirates.

******Yoon-Ah Kook, DDS, PhD, Professor, Department of Orthodontics, Seoul St. Mary's Hospital, College of Medicine, The Catholic University of Korea, Seoul, Korea.

*******Ahmed M. Shoaib, Department of Orthodontics, Seoul St. Mary's Hospital, College of Medicine, The Catholic University of Korea, Seoul, South Korea.

********Mohamed Bayome, Department of Preventive Dentistry, College of Dentistry, King Faisal University, Alhufuf, Saudi Arabia, Department of Postgraduate Studies, Universidad Autonóma del Paraguay, Asunción, Paraguay.

Send all correspondence to:
Yoon-Ah Kook
Department of Orthodontics, Seoul St. Mary's Hospital, College of Medicine, The Catholic University of Korea, 222 Banpo-daero, Seocho-Gu, Seoul, 06591, Korea.
Phone: +82 2 2258 1776
Fax: +82 2 537 2374
E-mail: kook2002@catholic.ac.kr

INTRODUCTION

There has been a trend to treat Class II malocclusions in adolescents with non extraction methods for total arch distalization. Over the past decade, the traditional application of headgear for molar distalization has decreased in favor of intraoral appliances which are independent of patient compliance.[1-3]

Accordingly, intraoral appliances such as the pendulum, Jones jig, and Forsus appliance were developed.[4-6] Unfortunately, unfavorable side-effects have been reported with them including anchorage loss in the reactive parts, distal tipping, extrusion of molars and proclination of mandibular incisors.[4,7-9] In response, Greenfield introduced a piston appliance, the Greenfield molar distalizer (GMD), that can cause bodily movement of the maxillary first molars.[10]

To avoid the side effects of intraoral appliances, temporary skeletal anchorage devices (TSADs) were introduced to distalize molars in the mixed dentition,[11] while bone-anchored pendulums and distal jet appliances were introduced in the early permanent dentition.[12,13]

Han et al. have reported that MCPP is a viable treatment option for full-step Class II in adolescents, especially when the patients or parents decline the extraction option.[14] When Sa'aed *et al* compared the effects of modified C-palatal plates (MCPPs) with headgear in adolescents, they discovered that MCPPs have a significant skeletal effect on the maxilla.[15] Kook *et al* evaluated MCPP treatment effects using cone-beam computed tomography (CBCT) and found it to be effective in minimizing distal tipping and preventing molar extrusion.[16] Shoaib *et al* showed that MCPP is a viable treatment option for maxillary total arch distalization with minimal changes in treatment effects three years posttreatment.[17] However, the comparison of treatment effects with MCPPs vs. conventional intraoral appliances for total arch distalization has not been reported.

Therefore, the aim of this study was to evaluate and compare skeleto dental and soft tissue treatment effects and the amount of molar distalization with MCPPs vs. GMD appliances in adolescents.

MATERIALS AND METHODS

The sample of this retrospective study consisted of lateral cephalograms of 39 Class II division 1 malocclusion patients; 21 (age, 11.7 ± 1.3 years) treated with MCPP appliances at the Department of Orthodontics, Seoul St. Mary's Hospital, The Catholic University of Korea, while 18 (age, 11.2 ± 0.9 years) were treated with GMD appliances at a private practice office in Japan. The inclusion criteria were ages ranging from 10 to 14 years, Class II division 1 malocclusion, moderate maxillary crowding (5 mm) and protrusion, non extraction treatment, molar distalization via either MCPP or GMD appliances exclusively, and the absence of any craniofacial syndromes. Approval to conduct this study was granted by the Institutional Review Board (KC11RASI0790).

Treatment procedures

MCPP appliances have already been described previously.[11] The MCPPs were installed by a single operator using three miniscrews (8 mm long and 2.0 mm in diameter, Jeil Corporation, Seoul, Korea) in the paramedian area to avoid interference with the growth of the suture. A palatal bar with two hooks extending along the gingival margins of the teeth was bonded to the maxillary first molars. Distalization was initiated by engaging elastics or NiTi closed-coil springs between the MCPP arm notches and the hooks on the palatal bar, applying approximately 300 g of force per side (Fig 1A).

All GMD cases were treated by one operator. The Greenfield molar distalizing appliance utilized an enlarged Nance button, reinforced with a 0.040-inch stainless steel wire. The GMD was a fixed piston appliance with 0.036-inch stainless steel tubing soldered to the first premolars and 0.030-inch stainless steel wires soldered to the first molars. Each side had two telescopic units, one on the buccal surface and the other on the lingual surface of the maxillary teeth (Fig 1B). The active force component was comprised of a pair of 0.055-inch internal diameter NiTi open-coil springs that delivered a 50 g force on both the buccal and lingual surfaces of each first molar. The GMD appliance was cemented and allowed to settle passively for two weeks before beginning activation of the distalizing components. The appliance was activated every two months by adding 2 mm split ring stops to the mesial of the buccal and lingual tubes to compress the springs on each piston assembly.

Table 1 shows the demographic data for the two groups including the severity of Class II molar relationship (very mild, 1/4 cusp; mild, 1/2 cusp; moderate, 3/4 cusp; and severe, full cusp), the eruption status of the maxillary second molars, and the skeletal age according to the method of Baccetti *et al*.[18]

Table 1. Demographic Data

Variables		MCPP Group (n = 21)	GDM Group (n = 18)	P value
Gender	Male	9	6	.328
	Female	12	12	
Severity	Full cusp	10	8	.695
	1/2 cusp	7	8	
	1/4 cusp	4	2	
Second molar eruption status	Erupted	11	5	.618
	Coronal	25	22	
	Middle	6	9	
Skeletal age	CVS 1	1	2	.237
	CVS 2	3	4	
	CVS 3	7	9	
	CVS 4	6	3	
	CVS 5	4	0	
	CVS 6	0	0	

Table 1 Demographic Data * MCPP indicates modified C palatal plate; Coronal, the crown of the second molar is within the vertical level of the coronal third of the first molar root; Middle, the crown of the second molar is within the vertical level of the middle third of the first molar root. Chi-square test.

Cephalometric Measurements

The pre- (T1) and posttreatment (T2) lateral cephalograms were digitized using V-Ceph 8 (Cybermed, Seoul, South Korea). The horizontal reference line was the FH plane, and the vertical reference line was a perpendicular line to the FH plane passing through the Sella. Twenty-nine linear and angular measurements were made by one examiner (Figures 2 and 3). The differences between T1

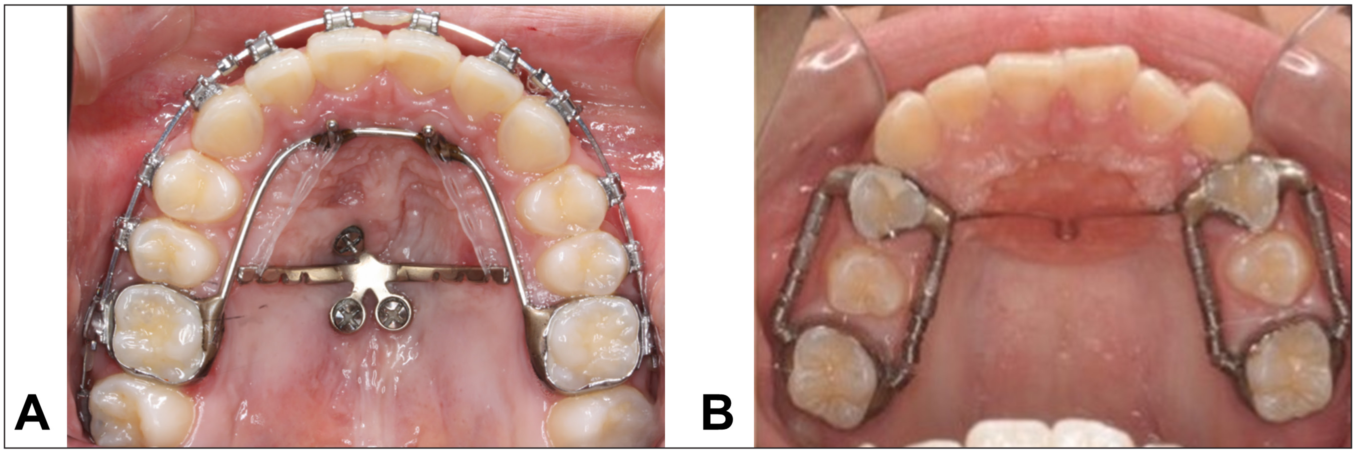

Figure 1A Modified C-palatal plate 1B Greenfield molar distalizing appliance

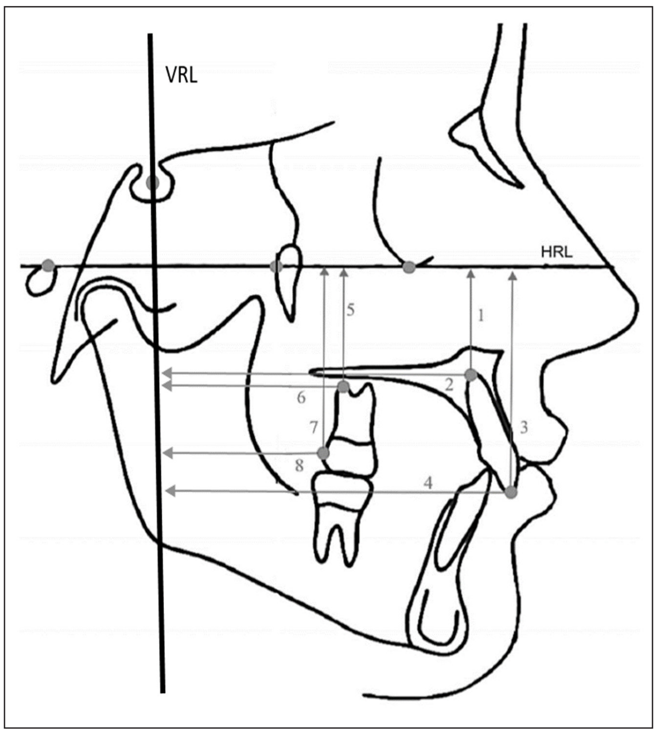

Figure 2 Linear measurements: 1, vertical distance from the maxillary central incisor root apex to the horizontal reference line (HRL); 2, horizontal distance from the maxillary central incisor root apex to the vertical reference line (VRL); 3, vertical distance from the maxillary central incisor crown to the HRL; 4, horizontal distance from the maxillary central incisor crown to the VRL; 5, vertical distance from the maxillary first molar root apex to the HRL; 6, horizontal distance from the maxillary first molar root apex to the VRL; 7, vertical distance from the maxillary first molar crown to the HRL; 8, horizontal distance from the maxillary first molar crown to the VRL.

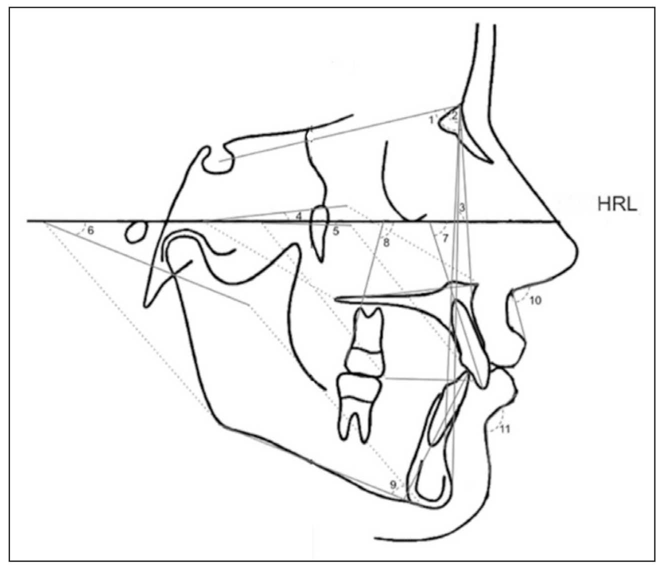

Figure 3 Angular measurements: 1, SNA; 2, SNB; 3, facial angle (FH/N-Pg); 4, palatal plane angle (FH/ANS-PNS); 5, occlusal plane angle (FH/OP); 6, mandibular plane angle (FH/Go-Me); 7, maxillary central incisor inclination; 8, maxillary first molar inclination; 9, incisor mandibular plane angle (IMPA); 10, nasolabial angle; 11, mentolabial fold angle.

and T2 were calculated. Ten randomly selected cases from each group were redigitized and analyzed two weeks later by the same examiner. Intraexaminer reliability was evaluated by the intraclass correlation coefficient and was found to be > 0.90.

Statistical Analysis

Statistical evaluation was performed using SPSS 16.0 (SPSS Inc, Chicago, Ill). A paired t-test was used to evaluate the skeletal, dental, and soft tissue changes from T1 to T2 within each group. A multivariate analysis of variance was performed to evaluate the differences between the groups at T1 and T2, and changes from T1 to T2 (T2–T1). An independent-sample t-test showed no significant difference in age (P = .127), and a chi-square test showed no significant differences in frequency distribution of gender (P = .328), severity (P = .695), second molar eruption status (P = .618); or skeletal age (P = .237) between the groups. The statistical significance level was initially set at 0.05, and after Bonferroni correction, it became 0.009.

Table 2. Comparison of Pretreatment Cephalometric Variables of MCPP and GMD Groups

Variables	GMD		MCPP		P value
	Mean	SD	Mean	SD	
SNA, °	82.59	1.33	81.97	3.06	.431
SNB, °	76.95	1.56	77.53	3.01	.468
ANB, °	5.88	0.62	4.45	1.81	.068
Wits, mm	2.29	2.04	2.56	1.50	.634
Facial angle, °	84.44	3.41	86.41	3.20	.070
PP angle, °	0.94	3.65	1.24	1.85	.739
FMA, °	29.63	3.73	28.73	3.93	.468
A point-N perp, mm	1.23	0.77	1.20	2.09	.958
A-point to TVL, mm	12.59	1.93	11.90	1.80	.259
B-point to TVL, mm	20.59	3.91	19.30	2.20	.204
U6-SVL, mm	25.87	2.73	26.93	4.11	.358
U6r-SVL, mm	31.84	2.88	34.41	3.97	.029
U6-FH, mm	42.91	2.21	41.85	3.27	.252
U6r-FH, mm	30.18	2.96	28.65	2.74	.101
U6 axis-FH, °	113.74	3.20	114.85	4.00	.354
U1-SVL, mm	64.36	4.25	66.47	5.10	.174
U1r-SVL, mm	56.91	3.13	57.59	4.74	.605
U1-FH, mm	50.20	3.92	50.59	3.72	.752
U1r-FH, mm	29.95	3.12	30.88	2.64	.315
U1axis-FH, °	60.37	4.78	60.65	6.76	.885
Occ plane angle, °	8.70	6.57	8.16	3.42	.742
IMPA, °	93.70	4.38	93.76	4.00	.963
Overjet, mm	4.13	1.53	4.45	1.41	.500
Overbite, mm	3.97	1.36	3.55	1.64	.395
Nasolabial angle, °	98.49	8.88	91.84	4.58	.005
Mentolabial fold, °	132.91	9.87	130.13	8.93	.362
Ls-TVL, mm	3.89	1.43	4.94	1.98	.070
Li-TVL, mm	1.79	1.56	1.84	1.36	.923
Soft pog- TVL, mm	7.26	2.49	7.41	2.26	.849

Table 2 Comparison of Cephalometric Variables of MCPP vs GMD Groups at Pretreatment* *Values are presented as mean ± standard deviation. MCPP, Modified C-palatal plate. GMD, Greenfield molar distalizer. By MANOVA: main effect (P = .066); after Bonferroni correction: P < .009.

Table 3. Comparison of Posttreatment Cephalometric Variables of MCPP and GMD Groups

Variables	GMD		MCPP		P value
	Mean	SD	Mean	SD	
SNA, °	80.47	1.44	79.79	3.25	.415
SNB, °	77.25	1.69	77.47	3.08	.786
ANB, °	3.22	1.94	2.35	2.12	.192
Wits, mm	1.23	0.99	0.86	1.75	.433
Facial angle, °	85.22	3.65	85.26	3.40	.973
PP angle, °	1.53	3.77	2.51	1.89	.305
FMA, °	30.68	5.06	29.11	3.19	.245
A point-N perp, mm	-2.23	3.02	-0.18	2.10	.017
A-point to TVL, mm	13.64	2.29	14.01	1.75	.569
B-point to TVL, mm	21.03	4.52	20.49	4.22	.700
U6-SVL, mm	23.03	2.56	22.97	4.09	.960
U6r-SVL, mm	30.01	2.49	31.16	3.78	.275
U6-FH, mm	45.18	2.03	43.45	3.30	.061
U6r-FH, mm	31.00	3.59	30.27	3.49	.526
U6 axis-FH, °	118.39	3.05	116.71	4.07	.158
U1-SVL, mm	62.52	4.07	62.69	5.40	.912
U1r-SVL, mm	55.32	3.15	56.66	4.60	.303
U1-FH, mm	53.24	3.76	53.74	3.60	.676
U1r-FH, mm	32.26	3.01	31.94	3.03	.749
U1axis-FH, °	65.07	4.96	67.78	6.72	.165
Occ plane angle, °	9.48	5.39	10.42	2.79	.492
IMPA, °	92.27	2.96	92.32	6.71	.978
Overjet, mm	2.88	0.68	2.59	0.72	.205
Overbite, mm	2.48	0.60	2.68	1.05	.479
Nasolabial angle, °	97.67	10.30	93.03	4.27	.067
Mentolabial fold, °	132.41	9.95	128.48	9.07	.205
Ls-TVL, mm	2.91	1.23	4.50	1.66	.002
Li-TVL, mm	2.73	1.65	0.83	1.74	.001
Soft pog- TVL, mm	6.10	2.40	7.53	2.19	.059

Table 3 Comparison of Cephalometric Variables of MCPP vs GMD Groups at Posttreatment* *Values are presented as mean ± standard deviation. MCPP, Modified C-palatal plate. GMD, Greenfield molar distalizer. By MANOVA: main effect (P = .066); after Bonferroni correction: P < .009.

 doi 10.17796/1053-4625-44.3.12

RESULTS

There was a significant treatment-related change in the sagittal position of the maxilla and the mandible in either group. ANB decreased by 2.1 ± 0.9º in the MCPP group and 2.3 ± 1.2º in the GMD group. The Wits also decreased by 1.7 ± 0.5 mm and 1.1 ± 0.5 mm, respectively (P < .001). There was no significant difference between the groups regarding all of the skeletal variables based on multivariate analysis.

The mean maxillary first molar distalization was 4.0 mm in the MCPP group and 2.9 mm in the GMD group. Meanwhile, the first molar roots were distalized 3.3 ± 0.8 mm and 1.8 ± 0.8 mm, respectively. The maxillary first molars were extruded (1.6 ± 1.5 mm) in the MCPP group and were significantly extruded (2.3 ± 0.6 mm; P <.001) in the GMD group. In addition, neither group showed any significant distal tipping of the maxillary first molars (P = .432 and .685, respectively). In addition, multivariate analysis showed no significant difference between the groups regarding dental variables.

The maxillary incisors were significantly retroclined in the MCPP group (P < .001), but not significantly in the GMD group although the GMD group showed significant extrusion (P < .001).

Significant soft tissue change of the upper lips was seen in the MCPP group (0.4 ± 0.4 mm; P < .001). Soft tissue variables demonstrated no significant difference between the MCPP and GMD groups (Table 4).

There was no significant difference in the duration of treatment between the MCPP (38.6 ± 17.6 months) and GMD (35.9 ± 15.3 months) groups.

Table 4. Comparison of Treatment Effects of the MCPP and GMD Groups

Variables	GMD			MCPP			P value
	Mean	SD	P value within group	Mean	SD	P value within group	
SNA, °	-2.13	0.39	.981	-2.19	0.84	.859	.771
SNB, °	0.30	1.11	.655	-0.05	0.55	.882	.204
ANB, °	-2.32	1.21	< .001	-2.10	0.91	< .001	.532
Wits, mm	-1.06	0.54	< .001	-1.71	0.51	.031	.307
Facial angle, °	0.79	1.65	.039	-1.15	2.43	.952	.007
PP angle, °	0.60	1.67	.097	1.27	1.59	.952	.210
FMA, °	1.05	2.69	.289	0.38	1.62	.722	.341
A point-N perp, mm	-3.46	3.03	.548	-1.38	0.95	.052	.005
A-point to TVL, mm	1.06	1.26	.215	2.11	1.56	.912	.027
B-point to TVL, mm	0.44	2.44	.088	1.71	2.53	.218	.121
U6-SVL, mm	-2.85	0.87	< .001	-3.96	1.46	< .001	.548
U6r-SVL, mm	-1.84	0.78	.345	-3.25	0.83	< .001	.214
U6-FH, mm	2.28	0.64	< .001	1.60	1.45	.882	.077
U6r-FH, mm	0.81	2.71	.048	1.04	0.70	.588	.708
U6 axis-FH, °	4.65	2.46	.685	1.86	1.94	.432	.754
U1-SVL, mm	-1.84	0.81	.098	-3.77	1.46	< .001	.098
U1r-SVL, mm	-1.60	0.32	.788	-0.94	0.35	.788	.185
U1-FH, mm	3.04	0.89	< .001	3.15	0.47	.095	.636
U1r-FH, mm	2.31	1.19	< .001	1.06	1.18	.076	.002
U1axis-FH, °	4.69	5.62	.571	7.13	2.90	< .001	.090
Occ plane angle, °	0.78	3.03	.933	2.26	1.19	.298	.046
IMPA, °	-1.43	1.76	.127	-1.44	6.59	.956	.993
Overjet, mm	-1.25	1.11	.145	-1.86	1.30	.902	.126
Overbite, mm	-1.49	0.97	.127	-0.87	1.50	.214	.140
Nasolabial angle, °	-0.82	1.95	.275	0.38	1.81	.495	.465
Mentolabial fold, °	-0.50	8.53	.225	-1.65	2.05	.754	.551
Ls-TVL, mm	-0.98	0.64	.734	-0.44	0.35	< .001	.221
Li-TVL, mm	0.94	0.36	.709	-1.42	0.94	.298	.485
Soft pog- TVL, mm	-1.16	0.55	.598	-0.12	0.50	.633	< .001

Table 4 Comparison of MCPP Group vs. GMD Group Treatment Effects* *Values are presented as mean ± standard deviation. MCPP, Modified C-palatal plate. GMD, Greenfield molar distalizer. By MANOVA: main effect (P = .066); after Bonferroni correction: P < .009.

DISCUSSION

Palatal application of TSADs is more feasible for distalization in mixed dentition and early permanent dentition than the buccal approach as the palate is a non-tooth bearing area, so there is no risk of root damage. Moreover, the bone density, bone quality, and soft tissue of the palate are adequate for TSAD application in adolescents.[19-21] The aim of this study was to compare the amount of molar distalization in the maxilla with MCPP vs. GMD appliances.

Regarding the amount of molar distalization, conventional noncompliance treatment using distal jet appliances for molar distalization produced 3.2 mm of molar distalization with 3.1° distal crown tipping and 1.3 mm of anchorage loss at the first premolars with 2.8° distal crown tipping.[2] In comparison, molar distalizers reinforced with TSADs showed 3.3–6.4 mm of distalization of the maxillary first molars without unwanted mesial incisor tipping.[22]

In our study, the first molar was distally tipped 4.7º in the GMD group, which was demonstrated 6.5º by Ferguson *et al*.[23] However, Joseph and Butchart reported the Pendulum appliance showed 15.7º distal tipping. GMD appliance showed relatively less distal tipping of maxillary molar.[24]

A previous report showed MCPP to be the best choice for chin retrusion and moderate skeletal discrepancies that require more than 3 mm of distalization in both adolescents and adults.[25] Meanwhile, Burhan showed 5.51 mm of molar distalization, 4.96º of distal tipping, and a 2.70 mm loss of anchorage with a Frog appliance. He concluded that this appliance can effectively distalize the maxillary molars, reducing unfavorable changes when used with high-pull headgear.[26]

Sar *et al* demonstrated 2.81 mm of first molar distalization in their miniscrew implant supported distalization system (MISDS) group and 2.93 mm in the bone-anchored pendulum appliance (BAPA) group.[27] They showed an almost translatory distal movement in the MISDS group, and substantial distal tipping of the maxillary molars accompanied by distalization in the BAPA group. In our study, the amount of first molar distalization of the MCPP group was 3.96 mm with 3.77 mm of incisor retraction, and there was 2.85 mm of first molar distalization with 1.84 mm of incisor retraction in the GMD group. The first molars were distally tipped 1.86° in the MCPP group, less than the 4.65° of tipping in the GMD group.

Vertically, our results showed 1.60 mm maxillary first molar extrusion in the MCPP group compared to 2.28 mm in the GMD group. Interestingly, Sa'aed *et al* reported 2.87 mm of first molar extrusion with headgear in adolescents,[15] while there was intrusion with distalization in adult patients in the MCPP treatment group of another study.[16] In our study, MCPP showed less first molar extrusion, but there was no significant difference compared to GMD and headgear. This might be because the GMD and headgear had limited control over the downward growth of the maxilla and downward movement of the upper first molars.[28]

Regarding the retraction of the anterior teeth in the MCPP group, there was a slight but insignificant extrusion, while the GMD group showed a significant extrusion. This might be due to difference in treatment modalities. In the MCPP group, the upper lip was more protruded and the nasolabial angle was smaller than that of the GMD group. However, there was no significant difference after treatment between the two groups. This might be due to more distalization of molars and retraction of anterior teeth in the MCPP group.

Various studies have demonstrated the effect of the eruption status of second molars on distalization. [5,29,30] There was a minimal or insignificant effect on the first molar movement in our study, however, Kinzinger *et al* have reported that the second molar eruption status might negatively affect the first molar movement.[30] Our study did not evaluate the maxillary molar position after distalization with and without the second molar eruption as a factor. Therefore, further long-term evaluation of molar position after distalization with and without second molar eruption is needed. In addition, extensive evaluation of how these modalities might be affected by the presence and position of 3rd molars is needed.

Finally, the MCPP and GMD produced significant skeletal changes in the maxilla, but the differences were about the same with either appliance. Both the MCPP and GMD resulted in significant distalization of the maxillary first molars and retraction of anterior teeth. The minimal differences in some aspects of treatment necessitate careful balance between patient needs and the appliance that is chosen. Further study is required to evaluate the treatment effects with a control group and long-term retention.

CONCLUSIONS

The modified C-palatal anchorage plate showed significant skeletal changes in the maxilla. However, this was not significantly different from the GMD group.

Both MCPP and GMD resulted in significant distalization of the maxillary first molars, 4.0 mm and 2.9 mm respective, with no significant difference between them. In addition, both groups showed minimal distal tipping. The maxillary incisors were significantly extruded in the GMD group.

Therefore, these results suggest that clinicians should consider using MCPPs, especially in noncompliant Class II adolescent patients.

REFERENCES

1. Nanda RS, Dandajena CT, Nanda R. Nonextraction Class II correction. In: Nanda R, editor. Esthetics and biomechanics in orthodontics. 2nd ed. St Louis: Elsevier Health Sciences, 206, 2015.
2. Bolla E, Muratore F, Carano A, Bowman SJ. Evaluation of maxillary molar distalization with the distal jet: a comparison with other contemporary methods. Angle Orthod, 72:481-494, 2002.
3. Park CO, Sa'aed NL, Bayome M, Park JH, Kook YA, Park YS, Han SH. Comparison of treatment effects between the modified C-palatal plate and cervical pull headgear for total arch distalization in adults. Korean J Orthod, 47:375-383, 2017.
4. Hilgers JJ. The pendulum appliance for Class II non-compliance therapy. J Clin Orthod, 26:706-714, 1992.
5. Ghosh J, Nanda RS. Evaluation of an intraoral maxillary molar distalization technique. Am J Orthod Dentofacial Orthop, 110:639-646, 1996.
6. Johes G, Buschang PH, Kim KB, Oliver DR. Class II non-extraction patients treated with the Forsus Fatique Resistant Device versus intermaxillary elastics. Angle Orthod, 78:332-338, 2008.
7. Johes G, Buschang PH, Kim KB, Oliver DR. Class II non-extraction patients treated with the Forsus Fatique Resistant Device versus intermaxillary elastics. Angle Orthod, 78:332-338, 2008.
8. Cacciatore G, Alvetro L, Defraia E, Ghislandzoni LT, Franchi L. Active-treatment effects of the Forsus fatique resistant device during comprehensive Class II correction in growing patients. Korean J Orthod, 44:136-142, 2014.
9. Madurantakam P. Fixed or removable function appliances for Class II malocclusion. Evid Based Dent, 17:52-53, 2016.
10. Greenfield RL. Fixed piston appliance for rapid Class II correction. J Clin Orthod, 29:174-183, 1996.
11. Kook YA, Kim SH, Chung KR. A modified palatal anchorage plate for simple and efficient distalization. J Clin Orthod, 44:719-730, 2010.
12. Kinzinger GS, Gulden N, Yildizhan F, Diedrich PR. Efficiency of a skeletonized distal jet appliance supported by miniscrew anchorage for noncompliance maxillary molar distalization. Am J Orthod Dentofacial Orthop, 136:578-586, 2009.
13. Kircelli BH, Pektas ZO, Kircelli C. Maxillary molar distalization with a bone-anchored pendulum appliance. Angle Orthod, 76: 650-659, 2006.
14. Han SH, Park JH, Jung CY, Kook YA, Hong M. Full-step Class II Correction Using a Modified C-palatal Plate for Total Arch Distalization in an Adolescent. J Clin Pediatr Dent, 42:307-313, 2018.
15. Sa'aed NL, Park CO, Bayome M, Park JH, Kim Y, Kook YA. Skeletal and dental effects of molar distalization using a modified palatal anchorage plate in adolescents. Angle Orthod, 85:657-664, 2015.
16. Kook YA, Bayome M, Trang VT, Kim HJ, Park JH, Kim KB et al. Treatment effects of a modified palatal anchorage plate for distalization evaluated with cone-beam computed tomography. Am J Orthod Dentofacial Orthop, 146:47-54 2014
17. Shoaib AM, Park JH, Bayome M, Abbas NH, Alfaifi M, Kook YA, Treatment stability after total maxillary arch distalization with modified C-palatal plates in adults. Am J Orthod Dentofacial Orthop. 156:832-839, 2019.
18. Baccetti T, Franchi L, McNamara JA Jr. The cervical vertebral maturation (CVM) method for the assessment of optimal treatment timing in dentofacial orthopedics. Semin Orthod, 11:119-129, 2005.
19. Ryu JH, Park JH, T Vu Thi Thu, Bayome M, Kim Y, Kook YA. Palatal bone thickness compared with cone-beam computed tomography in adolescents and adults for mini-implant placement. Am J Orthod Dentofacial Orthop, 142:207-212, 2012.
20. Han S, Bayome M, Lee J, Lee YJ, Song HH, Kook YA. Evaluation of palatal bone density in adults and adolescents for application of skeletal anchorage devices. Angle Orthod, 82:625-631, 2012.
21. Lee SM, Park JH, Bayome M, Kim HS, Mo SS, Kook YA. Palatal soft tissue thickness at different ages using an ultrasonic device. J Clin Pediatr Dent, 36:405-409, 2012.
22. Fudalej P, Antoszewska J. Are orthodontic distalizers reinforced with the temporary skeletal anchorage devices effective? Am J Orthod Dentofacial Orthop, 139:722-729, 2011.
23. Ferguson DJ, Carano A, Bowman SJ, Davis EC, Gutierrez Vega ME, Lee SH, A comparison of two maxillary molar distalizing appliances with the distal jet. World J Orthod, 6:382-390,2005.
24. Joseph AA, Butchart CJ. An evaluation of the pendulum distalizing appliance. Semin Orthod, 6:129-135,2000.
25. Kook YA, Lee DH, Kim SH, Chung KR. Design improvements in the modified C-palatal plate for molar distalization. J Clin Orthod, 47:241-248, 2013.
26. Burhan AS. Combined treatment with headgear and the Frog appliance for maxillary molar distalization: a randomized controlled trial. Korean J Orthod, 43:101-109, 2013.
27. Sar C, Kaya B, Ozsoy O, Ozcirpici AA. Comparison of two implantsupported molar distalization systems. Angle Orthod, 83:460-467, 2013.
28. Buschang PH, Roldan SI, Tadlock LP, Guidelines for assessing the growth and development of orthodontic patients, Semin Orthod, 23:321-335, 2017.
29. Bussick TJ, McNamara JA Jr. Dentoalveolar and skeletal changes associated with the pendulum appliance. Am J Orthod Dentofacial Orthop, 117:333-343, 2000.
30. Kinzinger GS, Fritz UB, Sander FG, Diedrich PR. Efficiency of a pendulum appliance for molar distalization related to second and third molar eruption stage. Am J Orthod Dentofacial Orthop, 125:8-23, 2004.