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SUPPLEMENT ARTICLE

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Factors associated with the maxillary third molar position after total arch distalization using a modified C-palatal plate in adolescents

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Abstract

Introduction: The purpose of this study was to evaluate the long-term position of erupted third molars after maxillary total arch distalization using modified C-palatal plates (MCPPs) in adolescents and to identify factors associated with these positions.

Setting and Sample Population: Sixty-two third molars (male: 20, female: 42) in Class II patients treated with MCPPs and thirty-nine teeth for the Control group (male: 22, female: 17).

Materials and methods: Samples were analyzed using panoramic radiographs taken initially (T0), after treatment (T1) and after >3 years retention (T2). Third molars were classified as downward (Group A, N = 31; males: 12, females: 19) and upward (Group B, N = 31; males: 8, females: 23) based on their vertical position after treatment. Analysis of variance and multiple logistic regression analysis were performed.

Results: The vertical position of the third molars of Group A, Group B, and the Control showed a 2.2, 3.5 and 2.7 mm downward movement at T2. However, there was no difference in the amount of third molar eruption among the groups. Regarding factors affecting the vertical distance of the third molar, Age, C8-OP, ∠8-OP and D7-T at the initial affected vertical position of the third molars after molar distalization ($P < .05$).

Conclusions: Group A and B showed no difference in the third molar eruption during retention after total arch distalization. This study suggests that it might be unnecessary to extract the developing third molar before molar distalization in Class II adolescents.

KEYWORDS

maxillary third molar, modified C-palatal plate, molar distalization, panoramic radiographs

Hyojeong Kang and Nam-Ki Lee contributed equally to this work

1 | INTRODUCTION

Total arch distalization is one nonextraction method of treating Class II malocclusion using temporary anchorage devices in adolescents.

Traditionally, several devices such as headgear and pendulum appliances have been used to distalize maxillary molars during nonextraction treatment,[1-3] but some studies achieved successful distalization using buccal miniscrews.[4-7] In addition, anchor plates in the zygomatic buttress and modified C-palatal plates (MCPPs) have been reported to distalize maxillary molars.[8-16]

When using nonextraction treatment to achieve posterior movement of molars in adolescents, the third molars' initial position needs to be considered. Kinzinger et al[17] reported that a third molar bud could sometimes act as a fulcrum, affecting the second molar when a modified pendulum is used. In contrast, Kang et al[18] reported that the presence or absence of a third molar follicle had no significant effect on molar movement.

Regarding the eruption of the maxillary third molars after treatment, Årtun et al[19] reported that the most predictive factors affecting third molar impaction were mesial angulation and more than 30° of distal angulation. In addition, Janson et al[20] showed that third molars were more favorable to the eruption in a premolar extraction group than in a nonextraction group. Kim et al[21] suggested that a lack of eruption space was a high-risk factor of impaction.

Flores-Mir et al[22] showed minimal effects on the second and third molar eruption stages with distalization. In addition, regarding third molar positional changes after molar distalization, a couple of studies have reported that unerupted third molars moved backwards and upwards in the short-term. In contrast, in the long-run, the second molars fully erupted, and the third molars were favorable.[23,24]

There are some reports that third molars erupted after extraction and treatment with various methods and types of appliances.[17-21,23] However, no study investigated factors associated with positional changes of the third molars after total arch distalization in adolescents.

Therefore, the purpose of this study was to compare the position of these third molars with a control group during long-term retention and to identify factors that influence the position of the third molars after maxillary total arch distalization using MCPPs in adolescents. The null hypothesis is that the position of the third molars after molar distalization does not affect their eruption during retention.

2 | MATERIALS AND METHODS

The study sample included 101 third molars in Class II patients who visited the Department of Orthodontics at Seoul St. Mary's Hospital, Catholic University of Korea from January 2009 to December 2013. A total of 62 samples were treated with maxillary molar distalization using MCPP appliances (MCPP group: mean age, 13.2 ± 1.3 years). The control samples (N = 39; males: 22, females: 17) were orthodontically untreated samples for whom panoramic radiographs had been taken for other reasons such as impacted teeth or a pathology (control group: mean age, 15.9 ± 0.76 years). The MCPP group was divided into two sub-groups according to the vertical positional changes of the third molars after treatment. The positions were determined based on criteria in a previous study,[23] in which the mesiobuccal cusps of the third molars moved 0.47 mm in an upward direction to the Frankfort horizontal plane on CBCT after distalization. According to this criteria, Group A (N = 31; males: 12, females:

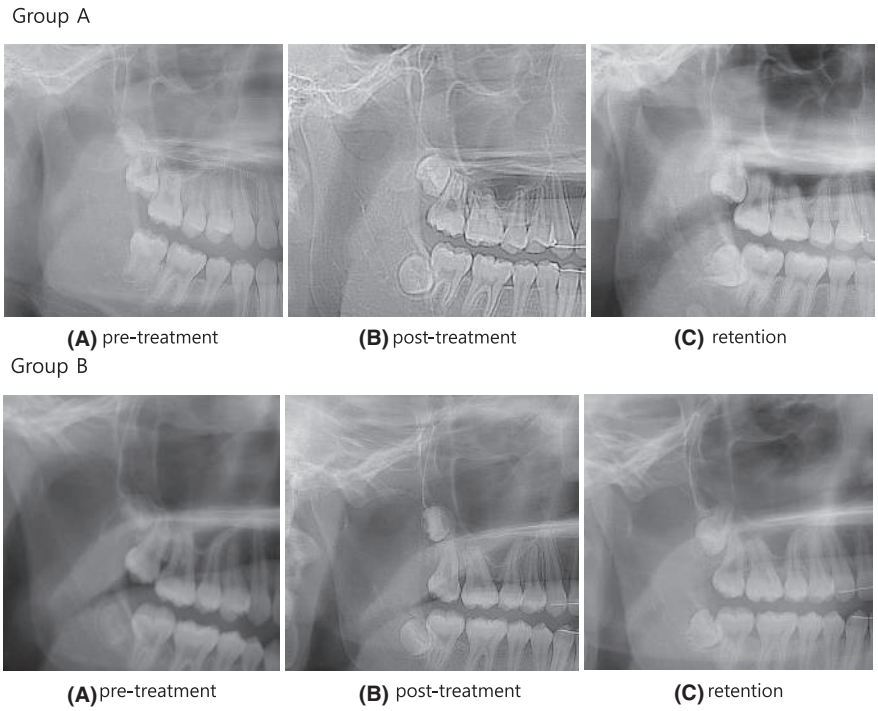

FIGURE 1 Panoramic radiographs at pre-treatment, post-treatment, and retention of Group A and Group B. (A) pre-treatment, (B) post-treatment, (C) retention

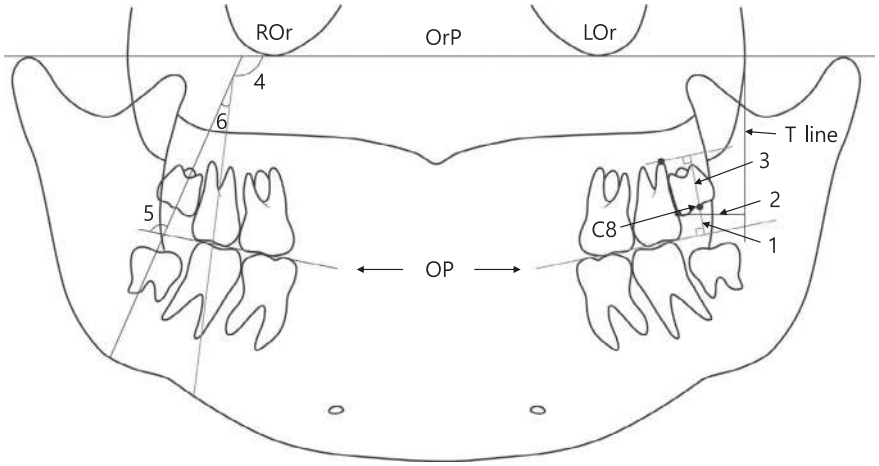

FIGURE 2 Landmarks and reference lines used in this study. Right orbital (Ror), most inferior point of the right orbital cavity; Left orbital (Lor), most inferior point of the left orbital cavity. Orbital plane (OrP), the line between right orbitale and left orbitale (the lowest point of the orbital cavity). Occlusal plane (OP), connecting the buccal cusp tip of the second molar. The maxillary tuberosity line (T line) is passing the most posterior point of the maxillary tuberosity. Crown of the third molar (C8), center of the occlusal surface of the third molar. (1) C8-OP: vertical position of the third molar, which is measured along a line perpendicular to the occlusal plane. (2) D7-T: tuberosity distance, which is the horizontal distance from the posterior end of the CEJ line of the second molar to the posterior end of the maxillary tuberosity. (3) R7-C8: vertical length between the second and third molar, which is the distance between root apex of the second molar and cente of the occlusal surface of the third molar. (4) ∠8-OrP: the angle between the long axis of the third molar and the orbital plane. (5) ∠8-OP: the angle between the long axis of the third molar and the occlusal plane. (6) ∠7,8: the angle between the long axis of the second molar and the third molar

19) moved in a downward direction, Group B (N = 31, males: 8, females: 23) moved in an upward direction as seen in Figure 1.

Approval was obtained from the Institutional Review Board of the Catholic University of Korea (KC20RISI0679), and informed consent was provided according to the Declaration of Helsinki.

The inclusion criteria for all groups were (1) third molars at Nolla stage 4 or greater (2) dental Class II relationship by more than a quarter cusp, (3) mild-to-moderate maxillary crowding of up to 5 mm, (4) available panoramic radiographs. In addition, (5) unerupted unilateral or bilateral maxillary third molars at T0 for the MCPP groups and T1 for the control group.

The MCPP and control groups' exclusion criteria were an eruption path of the third molars in a buccal and palatal direction as assessed in the panoramic radiographs.

For the MCPP groups, panoramic radiographs were acquired initially (T0), and after treatment (T1), and at a long-term retention point more than three years later (T2). The control group T1 and T2 panoramic radiographs were taken between January 2014 and December 2019 when the patients were at an age similar to those of the MCPP groups.

The anatomical structures, landmarks and reference lines on the panorama view are illustrated in Figure 2. The occlusal plane was set as a line connecting the mesiobuccal and distobuccal cusp tips of the second molars. The following measurements were made on the panoramic radiographs and were analyzed to determine the factors affecting the third molar positions.

1. Nolla stage
2. Distance from maxillary third molar to the occlusal plane (C8-OP)
3. The angle of the maxillary third molar to the orbital plane (∠8-OrP)
4. The angle of the maxillary third molar to the occlusal plane (∠8-OP)
5. The angle of the third and second molars (∠7,8)
6. Distance from maxillary second molar to maxillary tuberosity (D7-T)
7. Distance between root apex of the second molar and center of the occlusal surface of the third molar (R7-C8)

All linear and angular measurements were traced and digitized by one examiner (H-J-K). The same observer repeated measurements to calculate the intraclass correlation coefficient (ICC) and ICC values, ranging from 0.98 to 0.99 for intraobserver reliability.

The sample size calculation is based on a previous study using MCPPs that showed at least 87 third molar samples were required in total to identify an effect size of 0.344 units, with an alpha of 0.05 and beta of 0.2.[22]

2.1 | Statistical analysis

The Shapiro-Wilk test was used to confirm the normal distribution of the measurements. All linear measurements showed a normal distribution. To evaluate the differences among panoramic images in each group, Analysis of variance (ANOVA) and t test were used. Analysis of Covariance (ANCOVA) was performed to assess the differences between posttreatment and retention of the treatment effects among the groups using a covariance as T1 and retention period (T2-T1). Multiple logistic regression analysis was performed to determine the factors affecting the third molar's angle and the distance to the occlusal plane for each period.

TABLE 1 Comparison of variables in each group with downward direction (Group A) and upward direction (Group B) and Control

	T0[a]			T1[b]				T2[b]			
	Group A	Group B	*P* value	Group A	Group B	Control	*P* value	Group A	Group B	Control	*P* value
Age (y)	13.8 ± 1.2	12.7 ± 1.2	.001	16.3 ± 2.0	14.8 ± 1.3	15.9 ± 0.8	<.001(b < a,c)	19.1 ± 2.5	18.5 ± 2.0	19.3 ± 0.5	.18
Nolla stage	5.9 ± 1.3	4.9 ± 1.0	.003	7.9 ± 1.0	6.6 ± 1.0	6.9 ± 0.9	<.001(a > b,c)	9.8 ± 0.3	9.5 ± 0.5	9.4 ± 0.7	.01(a > c)
C8-OP (mm)	9.4 ± 2.3	9.0 ± 2.0	.49	7.7 ± 2.6	12.4 ± 2.2	7.3 ± 1.7	<.001(b > a,c)	5.5 ± 3.0	8.8 ± 3.4	4.5 ± 2.8	<.001(b > a,c)
∠8-OrP (°)	115.3 ± 18.8	121.3 ± 26.0	.30	109.4 ± 21.8	135.9 ± 19.9	109.5 ± 16.8	<.001(b > a,c)	101.5 ± 24.7	120.3 ± 20.5	103.4 ± 15.2	<.001(b > a,c)
∠8-OP (°)	89.7 ± 18.2	92.8 ± 19.0	.50	82.1 ± 23.2	110.2 ± 23.7	85.1 ± 15.0	.001(b > a,c)	78.9 ± 22.9	98.7 ± 20.9	84.7 ± 14.6	<.001(b > a,c)
∠7,8 (°)	14.2 ± 11.1	14.1 ± 12.7	.98	19.5 ± 14.5	26.2 ± 16.5	13.4 ± 8.1	<.001(b > c)	17.9 ± 17.9	17.5 ± 14.0	11.8 ± 10.0	.12
D7-T (mm)	7.8 ± 2.4	7.5 ± 2.0	.53	7.0 ± 2.7	5.1 ± 1.9	8.1 ± 2.0	<.001(b < a,c)	7.0 ± 2.2	6.4 ± 2.5	11.5 ± 10.4	<.001(c > a,b)
R7-C8 (mm)	2.5 ± 1.3	2.5 ± 0.9	.95	3.1 ± 1.6	1.4 ± 1.0	3.0 ± 0.9	<.001(b < a,c)	4.6 ± 1.8	3.4 ± 2.0	5.0 ± 1.4	.001(b < a,c)

Note: Group A, n = 31; Group B, n = 31; Control, n = 39.
Values are presented as mean ± standard deviation.
[a]values between Group A and B were compared with student *t* test.
[b]values among Group A, B and Control were compared with ANOVA.

All statistical analyses were performed using IBM SPSS Statistics (version 20.0; IBM Corp, Armonk, NY), and statistical significance was set at $P < .05$.

3 | RESULTS

In the comparison of variables before distalization (T0), Group A was 1.1 years older than Group B (13.8 and 12.7, respectively), Nolla stage also higher in Group A than Group B (5.9 and 4.9, respectively) ($P < .05$). After distalization (T1), tuberosity distance (D7-T) of Group B was 5.1 mm, which was less than Group A and the Control (7.0 mm, 8.1 mm, respectively; $P < .001$) (Table 1).

At T1, Group A showed 1.6 mm of downward movement and a 7.5° mesial tipping angle between the long axis of the third molar and the occlusal plane. The third molars in Group B revealed 3.3 mm of upward movement and 17.3° of distal tipping ($P < .001$). Also, R7-C8 in Group B showed a 1.0 mm decrease while there was a 0.5 mm increase in Group A. There was a significant difference in the aggregate vertical distance between the second and third molars (R7-C8) in the two treated groups ($P < .001$).

At retention (T2), the third molars (C8-OP) vertical position of Group A, Group B and the Control showed a 2.2, 3.5 and 2.7 mm downward movement, respectively. However, there was no difference in the amount of third molar eruption among the groups. ∠8-OrP (°) and D7-T (mm) had a significant difference among groups during retention ($P < .05$) (Table 2).

In Table 3, factors that affected the third molar position at T1 were Age, C8-OP, ∠8-OP and D7-T. Omnibus tests of model coefficients indicated that the $\chi 2$ value of the logistic regression model was 27.26, and the *P*-value was <.001. Significant factors were Age (OR = 3.891), C8-OP (OR = 0.741), ∠8-OP (OR = 1.078) and D7-T (OR = 1.497). ($P < .05$).

4 | DISCUSSION

The maxillary molar distalization in Class II treatment could cause posterior crowding, including crowding of the second and third molars. This may influence positional changes of the molars during adolescence.[23,25,26]

A recent study reported on the short-term positional change of the maxillary third molars after molar distalization.[23] Also, several researchers have focused on factors related to the development and the position of the lower third molars.[27-31] But, no study has reported on the factors affecting the position of the maxillary third molars for long-term evaluation.

Our long-term retrospective study showed that the vertical position of the third molars of Group A, Group B and the Control showed a 2.2, 3.5 and 2.7 mm downward movement during retention. There was no difference in the amount of third molar eruption among the groups. These results suggest that third molars erupt spontaneously long-term despite their position after distalization.

TABLE 2 Positional changes of the molarsduring retention (T2-T1) among Group A, Group B, and Control

Retention (T2-T1)							
	Group A	*P* value[a]	Group B	*P* value[a]	Control	*P* value[a]	*P* value[b]
C8-OP (mm)	-2.2 ± 2.0	<.001	-3.5 ± 3.2	<.001	-2.7 ± 2.6	<.001	.1031
∠8-OrP (°)	-7.8 ± 19.5	<.001	-15.5 ± 17.8	<.001	-6.0 ± 18.0	.044	.0019
∠8-OP (°)	-3.2 ± 16.2	<.001	-11.5 ± 19.3	<.001	-0.3 ± 15.1	.875	.0696
∠7,8 (°)	-1.5 ± 11.4	<.001	-8.6 ± 14.3	.001	-1.6 ± 11.4	.384	.0360
D7-T (mm)	0.0 ± 2.3	<.001	1.3 ± 1.8	<.001	3.3 ± 10.4	.049	.0294
R7-C8 (mm)	1.4 ± 1.3	<.001	1.9 ± 1.4	<.001	1.9 ± 1.4	<.001	.1621

Note: T0 means at initial; T1, after treatment; T2, three years retention.
Values are presented as mean ± standard deviation.
[a]values between T1 and T2 were compared with student *t* test.
[b]values among Group A, B, and Control were compared with ANCOVA using covariance as T1 and retention period.

On the other hand, the T2 - T1 interval of Group A, B, and Control was 2.4, 3.8 and 3.4 years, respectively. This means the retention period for Group B was more than 63% longer than that of Group A. However, there was no difference in the amount of eruption during the retention period in Table 2.

Regarding angulation, Lee et al[23] used CBCT images to show 9.2° angulation reduction after distalization, but these results did not reflect long-term conditions. In our study, Group B had 15.5 ° of mesial tipping, and all groups showed mesial tipping movement after long-term retention.

Park[24] reported that the second molars fully erupted, and the third molars were favorably positioned in a long-term evaluation. However, they did not identify the factors related to the vertical change of the third molars. In our study, age, C8-OP, ∠8-OP and D7-T were significant factors. However, there was no significant difference in the positional changes in Group A, Group B and Control during the retention period.

Nolla stage was used to evaluate the developmental phase of the third molars in our study.[32] De-la-Rosa-Gay et al[33] demonstrated unsuccessfully erupted third molars were found in patients with higher Nolla developmental stages. In our study, the Nolla stage for Group A and B were 5.9 and 4.9, respectively, which was a significant difference. However, it was not a factor affecting the vertical position of the third molars after distalization.

Regarding the ectopic eruption of the third molar, Årtun et al[34] have reported that the third molars' mesial angulation was the most predictive indicator of impaction in adolescents. Our study excluded severe buccal or palatal ectopic positioned third molars at T0 because these molars had not erupted normally after molar distalization as shown in Figure 3. Therefore, it is recommended that CBCT images be taken to evaluate the ectopic position before distalization.

In the clinical application of the molar distalizers during developing the third molar, Kinzinger et al[17] have demonstrated the efficiency of a pendulum appliance for molar distalization. They recommended a germectomy of the third molar before molar distalization due to the fulcrum effect. However, our results suggest that it is unnecessary to extract the third molar before distalization in adolescents.

TABLE 3 Factors affecting vertical distance from third molars to the occlusal plane after molar distalization

				95% CI of OR	
X	Wald χ2	*P* value	OR	Lower	Upper
Sex	1.8887	.1693	2.749	0.650	11.624
Age	10.6044	.0011	3.891	1.718	8.814
Nolla stage	0.9639	.3262	0.741	0.407	1.348
C8-OP (mm)	6.9702	.0083	0.504	0.303	0.838
∠8-OP (°)	6.9507	.0084	1.078	1.019	1.140
D7-T (mm)	4.797	.0285	1.497	1.043	2.147
R7-C8 (mm)	1.5854	.2080	0.589	0.258	1.343

Note: Values at T0 were compared with logistic regression analysis. C8-OP at T1 (Y) was used as a dependent variable. Omnibus tests of model coefficients indicated that the χ2 value of the logistic regression model was 27.26 and the *P* value was <.001.

A limitation of this study was the two-dimensional panoramic radiographs that were used to measure and analyze factors affecting the third molar position. With panoramic images, improper head position may affect the interpretation of the positional changes of the third molars. Therefore, it would be advisable for a future study to evaluate additional variables affecting three-dimensional positional changes of the third molars in MCPP and control groups using CBCT.

5 | CONCLUSIONS

This long-term study evaluated the vertical positional changes of maxillary third molars resulting from molar distalization using MCPP in adolescents. Third molars were classified as downward (Group A) and upward (Group B) based on their vertical position after treatment. We failed to reject the null hypothesis and concluded the following:

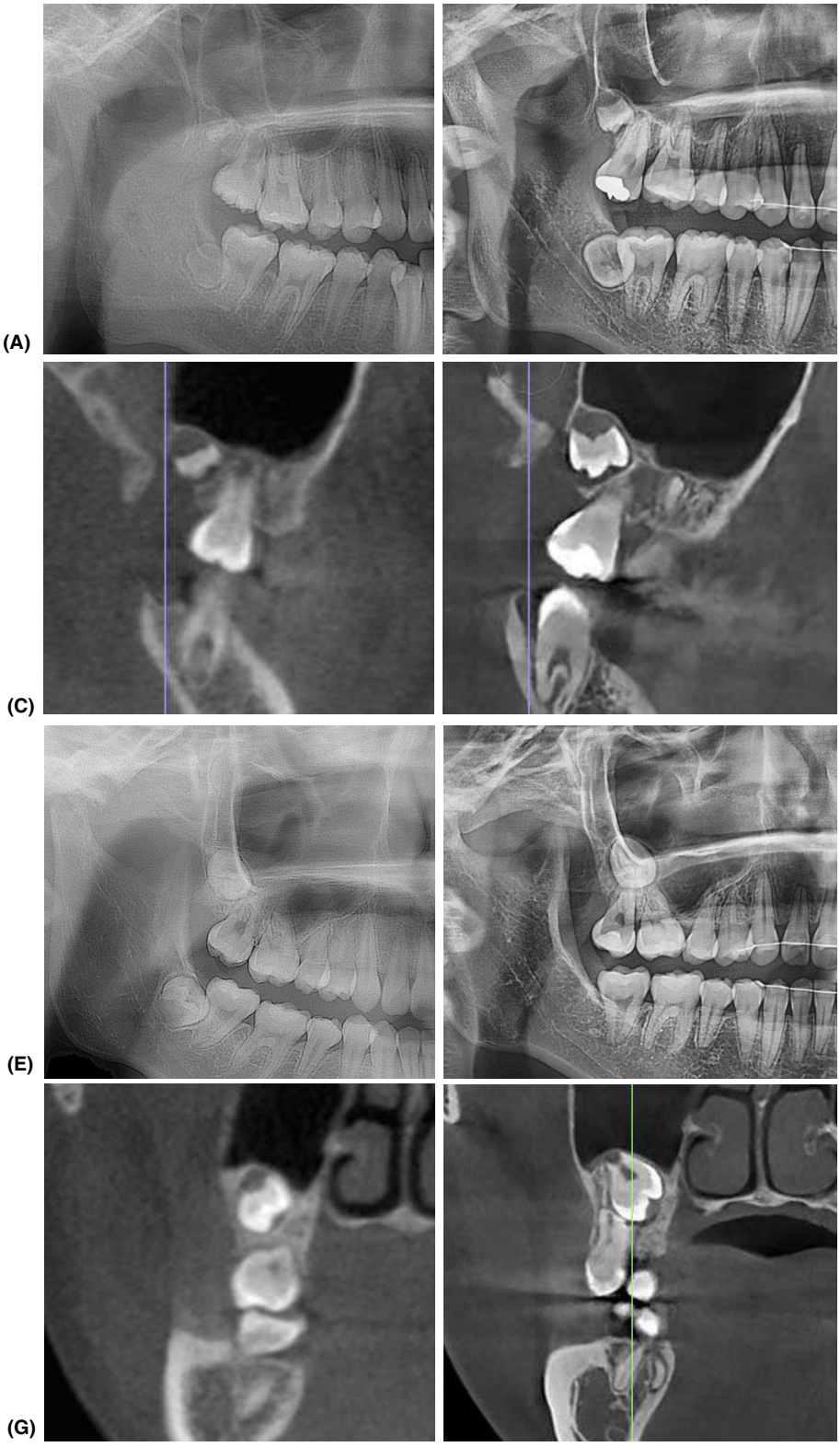

FIGURE 3 The abnormal positioned third molar. (A-D) Severe mesial ectopic position at T0 and T1 and (E-H) severe palatal ectopic position at T0 and T1. (A, E): pre-treatment and (B, F): post-treatment in panoramic radiographs. (C, G): pre-treatment and (D, H) : post-treatment in CBCT

1. Group A, B and the Control showed a 2.2, 3.5 and 2.7 mm downward movement during retention; however, there was no difference among the groups.
2. Age, C8-OP, ∠8-OP and D7-T at T0 were factors affecting the third molars' vertical position after molar distalization.
3. Sex and Nolla stage at T0 were not significant factors related vertical position of the third molars.

Considering the favorable eruption of the third molar in the long-term, these results suggest that it might be unnecessary to extract the third molar before molar distalization in Class II adolescents.

CONFLICT OF INTEREST

The authors deny any conflicts of interest.

AUTHOR CONTRIBUTION

Hyojeong Kang; contributed to data collection and writing the article. **Nam-Ki Lee**; contributed to data collection and writing the article. **Jaehyun Kim**; contributed to the statistical analysis and critical revision of the article. **Jae Hyun Park**; contributed to critical revision of the article and reviewing the literature. **Yoon-Ah Kook**; contributed to supervising overall project and overall responsibility. All authors have completed and submitted the ICMJE Form for Disclosure of Potential Conflicts of Interest, and none were reported.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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