Original Article

Factors associated with spontaneous mesialization of impacted mandibular third molars after second molar protraction

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ABSTRACT

Objectives: To investigate factors associated with spontaneous mesialization of impacted third molars after second molar protraction to close the space caused by a missing mandibular first molar (L-6) or retained deciduous mandibular second molars with a missing succedaneous premolar (L-E).

Materials and Methods: Panoramic radiographs of patients treated with mandibular second molar protraction to close the space due to missing L-6 or L-E (14 males, 36 females, mean age = 18.6 ± 4.4 years) were analyzed before treatment (T1) and after second molar protraction (T2). Factors associated with the amount of third molar mesialization were investigated using regression analyses.

Results: Mandibular second molars were protracted by 5.1 ± 2.1 mm and 5.8 ± 2.7 mm, measured at the crown and root furcation, respectively. After second molar protraction, third molars showed spontaneous mesialization by 4.3 ± 1.6 mm and 3.8 ± 2.6 mm, measured at the crown and root furcation, respectively. Nolla's stage of the third molar at T1 ($B = 0.20$, $P = .026$) and second molar protraction time ($B = 0.04$, $P = .042$) were significantly associated with the amount of third molar mesialization.

Conclusions: Greater third molar mesialization was observed when Nolla's stage of the third molar was higher before treatment and when the second molar protraction time was longer. (*Angle Orthod.* 2020;90:181–186.)

KEY WORDS: Molar protraction; Impacted third molar; Missing posterior teeth

INTRODUCTION

The prevalence of missing mandibular molars and premolars is high because they are frequently extracted due to caries.[1,2] Additionally, the highest rate of congenital absence has been observed for mandibular premolars,[3] often with prolonged retention of the deciduous second molar. Orthodontic closure of the space due to missing posterior teeth, such as mandibular first molars (L-6) or retained deciduous mandibular second molars with missing succedaneous premolars (L-E), is possible. In cases of anterior crowding or protrusion, incisors can be aligned and retracted to close the space due to missing posterior teeth.[4,5] In contrast, in patients with no anterior crowding or protrusion, the space can be closed through molar protraction, which can be challenging for clinicians. Using temporary anchorage devices (TADs), the molars could be more easily protracted.[6–11] This treatment option might be ideal in the presence of an impacted third molar in the same quadrant as the missing tooth as it can erupt in the posterior line of occlusion using the increased available posterior space after molar protraction. After the spontaneous eruption of the third molar, it could be protracted and aligned to replace the missing molar.[12]

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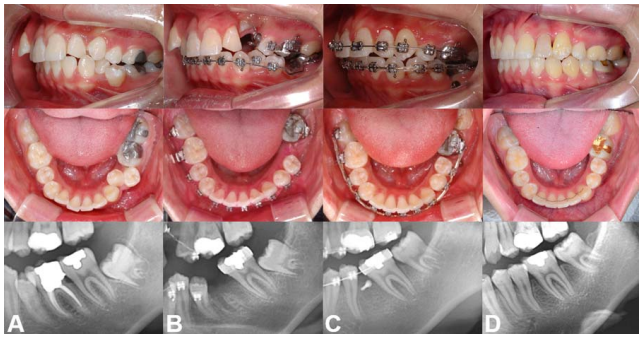

Figure 1. A case with complete spontaneous mesialization of the mandibular third molar after second molar protraction. (A) Before treatment. (B) During protraction. (C) After protraction. (D) After treatment.

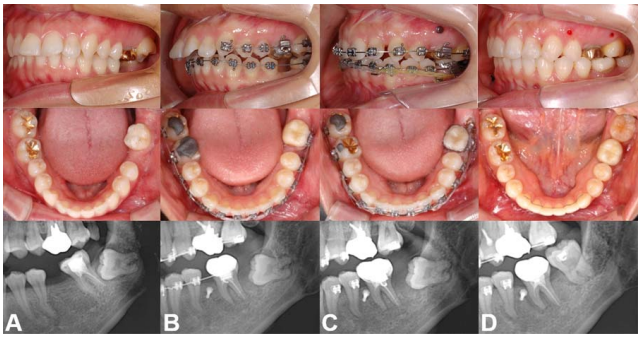

Figure 2. A case with limited mesialization of the mandibular third molar after second molar protraction. (A) Before treatment. (B) During protraction. (C) After protraction. (D) After treatment.

Spontaneous movement of impacted third molars after molar protraction has been previously documented. Baik et al.[7] reported vertical spontaneous eruption of impacted third molars in patients with second molar protraction, which was affected by the initial vertical location of the impacted third molars and the available space due to protraction of the second molar. Regarding the angular changes, Richardson and Richardson[13] reported that, in cases of second molar extraction, angular changes in third molars vary greatly during eruption. However, in patients whose second molars were protracted to replace the missing posterior teeth, Baik et al.[14] reported that third molars had an increased tendency of spontaneous uprighting in the greater Nolla stage and those that erupted faster.

There are few studies regarding horizontal movement of third molars after second molar protraction. In most cases, impacted third molars show spontaneous mesialization as they erupt to the level of posterior plane of occlusion after second molar protraction (Figure 1). However, in some cases, the impacted third molars erupt but show limited mesial movement, thus requiring active protraction after eruption (Figure 2). The purpose of this study was to investigate factors related to the spontaneous mesialization of impacted third molars after mandibular second molar protraction to close the space caused by missing L-6 and L-E by using TADs.

MATERIALS AND METHODS

This retrospective clinical study was approved by the institutional review board of Korea University Anam Hospital (IRB 2018AN1657), and the requirement for informed consent from patients was waived. The treatment records of patients who underwent mandibular second molar protraction to close the space due to missing L-6 or L-E at a dental clinic were collected for analysis. The inclusion criteria for this study were as follows: (1) missing L-6 or L-E, (2) impacted mandibular third molars at the pretreatment time point (T1), (3) space caused by missing L-6 or L-E that had been closed by second molar protraction using TADs, and (4) second molar roots parallel with the adjacent teeth at the time of space closure. Exclusion criteria were as follows: (1) fully or partially erupted third molar at the start of treatment, (2) malformation of the impacted third molar, and (3) orthodontic brackets bonded to the third molar during second molar protraction. For each patient, panoramic radiographs were obtained at T1 and at the end of second molar protraction (T2). A total of 50 patients (14 males, 36 females, mean age = 18.6 $\pm$ 4.4 years at T1) met the inclusion and exclusion criteria.

The panoramic radiographs at T1 and T2 were digitized by a single operator (Dr Kang). Panoramic radiographs were imported and analyzed using V-ceph software (version 6.0, Osstem, Seoul, Korea). To calibrate linear measurements, magnification of the panoramic radiograph was calculated by measuring the mesiodistal width of the mandibular second molar on the diagnostic model and panoramic radiograph of each patient. Figure 3 and Table 1 show the landmarks and linear and angular measurements used in this study. The vertical reference line, the J line, was defined as the line perpendicular to the occlusal plane that passes through point J, the intersection point between the occlusal plane and the anterior ramus of the mandible. Horizontal movement of the mandibular second and third molars measured at the crown and the root furcation, vertical eruption of third molars, and angular changes of the third molars were also analyzed.

Nolla's developmental stage of the third molar was assessed at T1 and T2 (Table 2).[15] Radiographs were reexamined by the same investigator (Dr Kang) 4 weeks after the first examination, and the intraclass coefficient ranged from 0.91 to 0.96. There was no

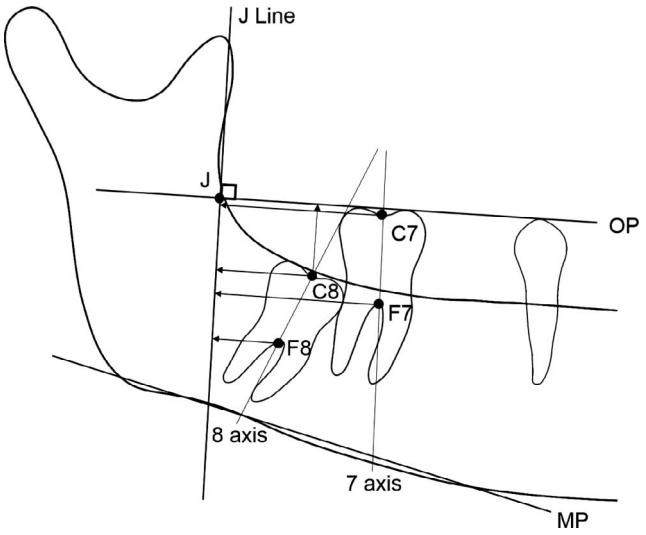

Figure 3. Study variables and their definitions. JC7 (mm), the shortest distance between the J line and C7; JF7 (mm), the shortest distance between the J line and F7; JC8 (mm), the shortest distance between the J line and C8, JF8 (mm); the shortest distance between the J line and F8; C8OP (mm), the shortest distance between C8 and OP; 8MP (°), angle between 8 axis and MP; 7MP (°), angle between 7 axis and MP.

systematic error. Random error ranged from 0.07 mm to 0.28 mm.

Statistical evaluations were performed using SPSS software for Windows (version 20.0, IBM Corp, Armonk, NY). The Mann-Whitney U test was used to evaluate the difference in characteristics between male and female patients. The Fisher's exact test was used to determine the difference in distribution of the missing tooth (L-6 or L-E) according to sex. The paired *t*-test was used to assess differences in the study variables between T1 and T2. Linear regression analysis was performed to investigate factors associated with the amount of third molar mesialization. The level of statistical significance was set at $P < .05$.

Table 1. Definitions of the Landmarks Used in This Study

Landmark	Definition
OP	Occlusal plane: line passing through the cusp of the first premolar and mesial cusp of the mandibular second molar
MP	Mandibular plane: line passing through Go and Mn body
J point	Intersection between the occlusal plane line and the anterior ramus
J line	Vertical reference line perpendicular to the occlusal plane and passing the J point
C7	Central fossa of the mandibular second molar
C8	Central fossa of the mandibular third molar
F7	Root furcation of the mandibular second molar
F8	Root furcation of the mandibular third molar
7 axis	Long axis of the second molar passing through C7 and F7
8 axis	Long axis of the third molar passing through C8 and F8

Table 2. Nolla's Stages of Tooth Development

Stage	Description
0	Absence of crypt
1	Presence of crypt
2	Initial calcification
3	1/3 of crown completed
4	2/3 of crown completed
5	Crown almost completed
6	Crown completed
7	1/3 of root completed
8	2/3 of root completed
9	Root completed, apex open
10	Apical end of root completed, apical foramen closed

RESULTS

Patient characteristics such as age, Nolla's stage of third molars at T1 (Nolla_T1) and T2 (Nolla_T2), and the second molar protraction time for males and females are shown in Table 3. There were 31 patients who had missing L-6 and 19 patients who had missing L-E. The distribution of males and females according to missing tooth (L-6 or L-E) showed a significant difference ($P = .025$; Table 3).

Mandibular second molars were protracted by 5.1 ± 2.1 mm and 5.8 ± 2.7 mm, measured at the crown and root furcation, respectively (Table 4). After second molar protraction, third molars showed spontaneous mesialization by 4.3 ± 1.6 mm and 3.8 ± 2.6 mm, measured at the crown and root furcation, respectively (Table 4). Third molars erupted 1.8 ± 2.1 mm vertically, and third molar angulation changes were not significant from T1 to T2 ($P = .346$; Table 4).

Factors associated with the amount of third molar mesialization were Nolla_T1, second molar protraction time, vertical position of the third molar at T1

Table 3. Patient Characteristics[a]

Variables	Male (n = 14)	Female (n = 36)	Total	*P*
Age (y)	17 ± 3.3	19.3 ± 4.7	18.6 ± 4.4	.098[b]
Nolla's stage at T1 (n)	6.6 ± 2.1	7.2 ± 2.2	7.0 ± 2.2	.417[b]
Nolla's stage at T2 (n)	8.4 ± 2.0	8.6 ± 1.6	8.6 ± 1.7	.865[b]
Protraction time (T1-T2, y)	2.0 ± 0.8	2.0 ± 0.7	2.0 ± 0.7	.778[b]
Missing tooth (n)				.025[c]
L-6	5	26	31	
L-E	9	10	19	

[a] L-6 indicates mandibular first molar; L-E, retained deciduous molar with missing mandibular second premolar.
[b] Difference between male and female participants.
[c] Difference in patient distribution between male and female participants.

Table 4. Position and Angulation Changes of the Second and Third Molars From Pretreatment (T1) to the End of the Second Molar Protraction (T2)[a]

Variables	T2-T1	P[b]
ΔJC7 (mm)	5.1 ± 2.1	<.001
ΔJF7 (mm)	5.8 ± 2.7	<.001
Δ7MP (°)	6.0 ± 14.3	.005
ΔJC8 (mm)	4.3 ± 1.6	<.001
ΔJF8 (mm)	3.8 ± 2.6	<.001
Δ8MP (°)	1.9 ± 14.1	.346
ΔC8OP (mm)	1.8 ± 2.1	<.001

[a] ΔJC7 indicates amount of second molar protraction measured at the crown; JF7, amount of second molar protraction measured at the root furcation; Δ7MP, angulation changes of the second molar; ΔJC8, amount of the third molar mesialization measured at the crown; ΔJF8: amount of the third molar mesialization measured at the root furcation; Δ8MP, angulation changes of the third molar; ΔC8OP, amount of third molar eruption.
[b] Significance of changes from T1 to T2.

Table 5. Factors Associated With the Amount of Spontaneous Mesialization in the Mandibular Third Molars After the Second Molar Protraction (Dependent Variable: ΔJC8)[a]

Variable	B[b]	Standard Error	P	Observed Power
Nolla_T1	.195	.085	.026	2.298
Protraction time	.044	.021	.042	2.090
C8OP_T1	−.156	.092	.097	1.693
ΔJF7	.445	.070	<.001	6.397

[a] Nolla_T1 indicates Nolla's stage of third molar at pretreatment; C8OP_T1, vertical position of third molar at pretreatment; ΔJF7, amount of second molar protraction measured at the root furcation.
[b] Regression coefficients.

(C8OP_T1), and amount of second molar protraction measured at the furcation (ΔJF7; Table 5). According to the regression coefficients (B), third molar mesialization increased proportionately with the amount of second molar protraction (ΔJF7; B = 0.45). Greater Nolla_T1 was associated with increased third molar mesialization (B = 0.20). Additionally, an increase in second molar protraction time was related to greater third molar mesialization (B = 0.04). Impacted third molars close to the occlusal plane led to greater third molar mesialization (B = –0.16), but this association was not statistically significant ($P = .097$).

DISCUSSION

Eruption and spontaneous mesialization of third molars after second molar protraction is favorable, leading to proper posterior occlusion by replacing the missing molar.[12] It also eliminates or decreases the need for additional third molar protraction after second molar protraction. However, the amount of third molar mesialization varied among the participants, indicated by the mean ratio of third molar mesialization to second molar protraction of 0.8 ± 0.3. A majority of patients (n = 43, 86%) showed full spontaneous mesialization, and contact between the proximal surfaces of the third molar and the second molar was established. Others (n = 7, 14%) showed limited or almost no mesial movement. These third molars were not ankylosed as they showed vertical eruption but lacked spontaneous mesial movement and required active protraction using a fixed appliance. Therefore, factors associated with the amount of third molar mesialization were investigated to guide treatment decisions for ensuring predictable results in cases requiring molar protraction.

More developed third molars showed greater spontaneous mesialization. The mean Nolla's stage of third molars in patients showing complete mesialization at T1 was 7.2 ± 2.0; in those who showed incomplete mesialization, it was 5.4 ± 3.2. As teeth erupt with root development,[16] third molars located close to the occlusal plane showed a tendency for a greater amount of mesialization. As has been reported previously, these occlusally located third molars also show greater eruption speed.[7] Thus, the developmental stage of third molars should be considered when determining the treatment timing for molar protraction. Higher eruption speed is associated with increased age and higher Nolla's stage.[17,18]

Based on clinical experience, the mesially angulated third molars were expected to show decreased mesialization. However, third molar angulation was not associated with the amount of third molar mesialization. The mean third molar angulation (8 MP) showed no significant changes from T1 to T2, but the change in third molar angulation from T1 to T2 (Δ8MP) showed a high range from –36.8° to 32.7, indicating great variability in angulation changes during eruption and mesialization. Third molars that showed mesial tipping as a result of second molar protraction mainly exhibited crown mesialization only and lacked true bodily mesial movement; orthodontic uprighting was required after second molar protraction using fixed appliances.

Only patients who underwent second molar protraction to close the space caused by L-6 or L-E were included, and those patients had minimal incisor crowding. Presence of third molars causes incisor crowding by exerting force on the mandibular teeth in the mesial direction.[19,20] In patients with missing mandibular molars, the third molars would not cause incisor crowding in this way. Space due to L-6 or L-E was used for decrowding during the initial stages of leveling and alignment, with the rest of the space being closed through molar protraction using TADs.

A limitation of this study was that panoramic radiographs were used. Although linear and angular measurements acquired from panoramic radiographs

have been reported to be reliable,[21–23] inherent errors due to image distortion may still have been present, especially in the horizontal dimensions.[24] Three-dimensional studies of third molar movements using cone-beam computed tomography may provide more accurate results. A second limitation was that the horizontal position of the third molar was analyzed at the end of second molar protraction. As a longer protraction time was associated with greater third molar mesialization, there might be further spontaneous mesialization of third molars in cases of incomplete third molar mesialization at the end of second molar protraction. However, further observation of third molar movement was not feasible due to the increased treatment time. Finally, only patients with impacted third molars before treatment were included. As the vertical position of the impacted third molar is associated with the amount of mesialization, a further study on the mesialization of third molars that have erupted before treatment initiation is warranted.

CONCLUSIONS

- When mandibular second molars were protracted to close the missing space of L-6 or L-E, impacted mandibular third molars showed varying amounts of spontaneous mesialization.
- Greater third molar mesialization was observed when Nolla's stage of the third molar was higher before treatment and when the second molar protraction time was longer.
- Patient's age, sex, and initial angulation of the third molar were not associated with the amount of third molar mesialization.

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