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하악 제 1대구치 맹출 장애의 빈도와 치료

^{a)}Department of Orthodontics, School of Dentistry, Pusan National University,

^{b)}Department of Orthodontics, Dental Research Institute,
Pusan National University Dental Hospital

^{c)}Institute of Translational Dental Sciences, Pusan National University Dental Hospital

손우성^{a)}, 송효경^{a)}, 김성식^{a, b, c)*}

ABSTRACT

Prevalence and treatment of mandibular first molar eruption disturbances

^{a)}Department of Orthodontics, School of Dentistry, Pusan National University,

^{b)}Department of Orthodontics, Dental Research Institute, Pusan National University Dental Hospital,

^{c)}Institute of Translational Dental Sciences, Pusan National University Dental Hospital

Woo-Sung Son^{a)}, Hyo-Kyung Song^{a)}, Seong Sik Kim^{a, b, c)}

Introduction: The aim of the current study was to describe the prevalence and treatment of mandibular first molar eruption disturbances.

Methods: A total of 38 mandibular first molars(M1mn) from 36 patients(17 males and 19 females; aged 9 years 2 months~35 years 10 months) were identified from the 13,391 patients that received orthodontic treatment from 1983~2012. The subjects were classified into 3 categories based on panoramic radiographic examination: impaction due to ectopic position of the tooth germ relative to the contra-side same tooth(Group 1), impaction due to obstruction of the eruption path with cyst or calcium mass (Group 2), and primary and secondary retention due to defects in the follicle or periodontal ligament(PDL; Group 3). The treatment outcomes were evaluated into four categories: no treatment(A), orthodontic traction(B), autotransplantation(C), and extraction due to orthodontic traction failure(D).

Results: The prevalence rate of M1mn eruption disturbances in this sample was 0.27%. In Groups 1 and 2, most of the impacted M1mn were erupted successfully by orthodontic traction. In Group 3, most of the retained M1mn were failed to erupt and recommended for extraction.

Conclusions: Treatment prognosis was favorable on Group 1 & 2 than Group 3. After removing an element of the cause in case of Group 1 & 2, orthodontic traction or periodic observation will be recommended.

Key words : Lower first mandibular impaction, primary eruption failure, secondary eruption failure, ankylosis

Corresponding Author

Seong Sik Kim, Professor,

Department of Orthodontics, School of Dentistry, 49 Busandaehak-ro, Mulgeum-eup, Yangsan 50612, Korea.

Tel : +82-55-360-5162, e-mail : softid@pusan.ac.kr

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I. INTRODUCTION

Eruption has been defined as the movement of a tooth from its developmental position within the jaw towards its functional position within the occlusion. Disturbances may occur in any of the phases of eruption. From an etiologic point of view, 3 main causes of eruption disturbances can be distinguished: ectopic position of the tooth germ; obstacles in the eruption path; and failures in the eruption mechanisms(i.e. follicle or periodontal ligament[PDL] defects during eruption). The first 2 conditions lead to impaction and the last to primary or secondary retention¹⁾.

The mandibular first molar teeth(M₁mn) are the first permanent posterior teeth to erupt, and play the major role in occlusion and function. Early diagnosis and treatment of abnormal M₁mn eruption is very important, particularly in the arch development phase. The prevalence of M₁mn eruption disturbances is less than 0.04%²⁻⁴⁾. In fact, only a few studies have examined eruption disturbances of the permanent molars based on the rarity of their occurrence⁵⁻¹⁴⁾. Because there are critical differences between the maxillary and mandibular molars related to the timing of formation, timing of eruption, and direction, the etiology of M₁mn eruption disturbances needs to be distinguished from that of maxillary first molar (M₁mx) and mandibular second molar (M₂mn) eruption disturbances. Previous studies on M₁mn eruption disturbances were mainly case studies with small numbers of patients, and results demonstrated that obvious

difficulties in distinguishing between impaction and retention were underlying the lack of uniformity in the management of these eruption disturbances.

The aim of the current study was to describe the prevalence and treatment of M₁mn eruption disturbances. Towards this end, the etiological factors of eruption disturbances were investigated in order to establish the characteristics of impactions and evaluate treatment results.

II. MATERIALS AND METHODS

A total of 38 mandibular first molars from 36 patients(17 males and 19 females; aged 9 years 2 months-35 years 10 months) were identified by reviewing the charts of 13,391 patients who had visited in the Department of Orthodontics, Pusan National University Dental Hospital from 1983-2012 for orthodontic treatment. All experimental processes were accepted by the Institute Review Board of Ethics, Pusan National University Dental Hospital(2014-029). With the exception of the 38 detected M₁mn eruption disturbances, defined as not having erupted at the time when more than two-thirds of the root were formed, all subjects were healthy with no systematic or dental disease. The subjects were classified into 3 categories based on panoramic radiographic examination: impaction due to ectopic position of the tooth germ relative to the contra-side same tooth(Group 1), impaction due to obstruction of the eruption path with cyst or calcium mass, (Group 2), and

primary and secondary retention due to defects in the follicle or PDL(Group 3; Table I)^{1, 4)}. The treatment outcomes were evaluated into four categories: no treatment(A), orthodontic traction(B), autotransplantation(C), and extraction due to orthodontic traction failure(D).

Radiographic evaluations

All radiographic measurements were performed using digital panoramic radiographs generated by an mView Dicom Viewer(ver 5.3, Marotech Inc., Seoul, Korea; Fig. 1). The long axis of the $M_{1,mn}$ was determined as the line connecting from the central point, bisecting the distance between the mesial and the distal cusp of the molar, to the bifurcation. The inclination of

the long axis of the $M_{1,mn}$ was measured to the lower border of the mandibular body. The differences between the inclinations of the affected and non-affected sites were measured. Tooth depth was classified into two levels: the lower side of the marginal ridge of the impacted tooth crown was located above the line that passes the one half root of the second premolar ($P_{2,mn}$; Level 1), and the marginal ridge of the impacted tooth crown was deeper than one half root of the $P_{2,mn}$ (Level 2). Vertical development of the alveolar process in the area of $M_{1,mn}$ was measured from the distance between the mesial/distal crest of the alveolar process to a line of proximal cemento-enamel junction(CEJ) of its adjacent second premolar. Its average and the difference between the distance of the mesial

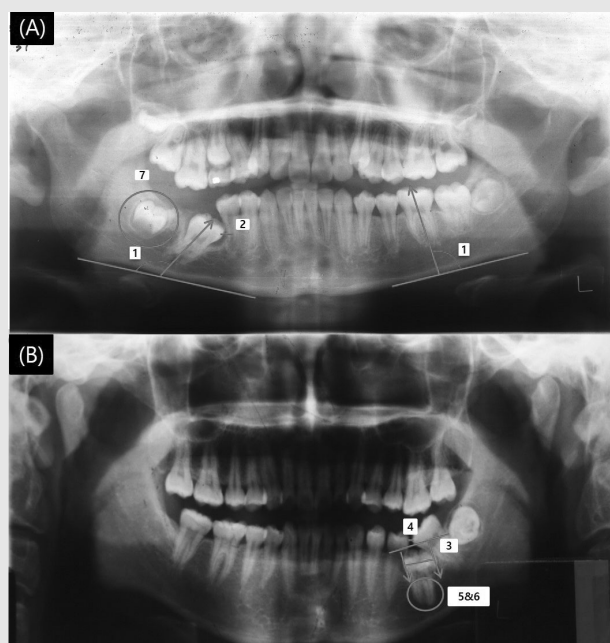


Fig. 1. Panoramic radiograph examination. 1. Tooth inclination difference; 2. Tooth depth(vertical position of affected tooth mesial marginal ridge to second premolar root length); 3. Vertical development of the alveolar process in the area of $M_{1,mn}$; 4. Eruption space; 5. Root formation; 6. Abnormal curvature of the roots; 7. Dental anomalies.

Table I. Classification & etiology of permanent mandibular first molar eruption disturbances

Classification	Categorization	Etiology	Number(38)	Prevalence
Impaction	Group 1	Ectopic position of tooth germ	14	37%
	Group 2	Obstruction of the eruption path(9 Dentigerous cyst, 3 Odontoma, 2 Ameloblastoma, and 1 Distally positioned premolar tooth germ)	15	39%
Retention	Group 3	Eruption failure with primary defects in the follicle or PDL (not visible in the oral cavity)	1	3%
		Eruption failure with secondary defects in the PDL(infraocclusion)	8	21%

and distal side were recorded. Eruption space deficiency was calculated with the difference between both contact points of the adjacent teeth and the crown width of M_{1mn} . The root formation of M_{1mn} was divided into 3 stages: root length was shorter than crown height(Stage 1), root length was longer than crown height, but the ends of the root apex were not closed(Stage 2), and the root apex was completely closed (Stage 3). Curvature of the roots(dilaceration) was defined as an abrupt deviation between the long axis of the crown and the root axis of the tooth. Other dental anomalies were noted, especially those involving the P_{2mn} and M_{2mn} associated with the affected site.

Statistical analysis

Each measurement performed for 10 of the subjects was repeated after 21 days to ensure the objectivity and reproducibility of the method in each case. Based on the results of intraclass correlations, the error of measurement was 0.47° for angular measurements and 0.37mm for distance measurements. The standard error was estimated by Dahlberg's formula: Error of

method² = $\Sigma d^2/2n$ where d is the difference between two measurements and n is the number of double determinations. The standard errors for the angular measurements and the distance measurements were 0.98° and 0.37mm, respectively. These error of measurement levels were considered to be small and acceptable.

The chi-square test and Fisher's exact test were used to analyze the differences in the prevalence of M_{1mn} eruption disturbances based on sex and site distribution, respectively. The values for the etiologic factors in Groups 1-3 were compared statically using an analysis of variance with Bonferroni post-hoc tests.

III. RESULTS

Prevalence of M_{1mn} eruption disturbances

Of the 13,121 patients in the sample, 36 patients had M_{1mn} eruption disturbances, revealing a prevalence rate of 0.27%. There was no difference in the prevalence of M_{1mn} eruption disturbances based on sex, however, a significant difference was detected in the prevalences noted

between the left and right sites. The majority of eruption disturbances were affected unilaterally; 70.6% were on the left site and 29.4% were on the right site. Two patients of 4 bilateral impacted/retained M₁mn were inclined lingually.

Etiology of M₁mn eruption disturbance (Table II; Fig. 2)

Descriptive statistics and the results of statistical analyses are reported in Table 2. There

were a total of 38 retained or impacted M₁mn from 36 patients. There were 14 M₁mn impactions with ectopic position of the tooth germ(Group 1), 15 M₁mn impactions with obstruction(9 dentigerous cysts, 3 odontomas, 2 ameloblastomas, and 1 distally positioned secondary premolar tooth germ) of the eruption path(Group 2), and 1 M₁mn eruption disturbance with primary retention and 8 M₁mn with secondary retention(Group 3).

Table II. Descriptive statistics and statistical comparisons of values of characters of eruption disturbance of M₁mn between groups

Variables	Group 1 N=14	Group 2 N=15	Group 3 N=9
Radiographic examination			
Tooth inclination difference(°)	31.5±18.5	8.8±25.1*	-5.0±16.5
Tooth depth(level)	1.4	1.7	1.3
Vertical development of the alveolar process			
Average of mesial and distal(mm)	5.8	-	7.9±4.6
Difference (Δ mesial- distal)(mm)	7.5	-	0.1±1.5
Eruption space deficiency(mm)	-5.0±4.8	-1.3±3.9	-4.8±5.
Root formation(level)	2.7	2.7	2.9
Root dilacerations(%)	33.3	42.9	12.5
Tooth anomalies associated with(%)			
Mandibular second molar	57.1	33.3	55.6
Mandibular premolar	0	33.3	22.2
Maxillary lateral incisor	7.1	6.7	11.1
Other			11.1
Treatment outcome(%)			
No treatment	14.3	0	33.3
surgical exposure and orthodontic traction	64.3	86.6	22.2
Autotransplantation	7.1	6.7	11.1
extraction.	14.3	6.7	33.4

* Group 2 showed statistically significant difference with Group 1 & 3 in ANOVA post-hoc tests ($p < 0.05$)

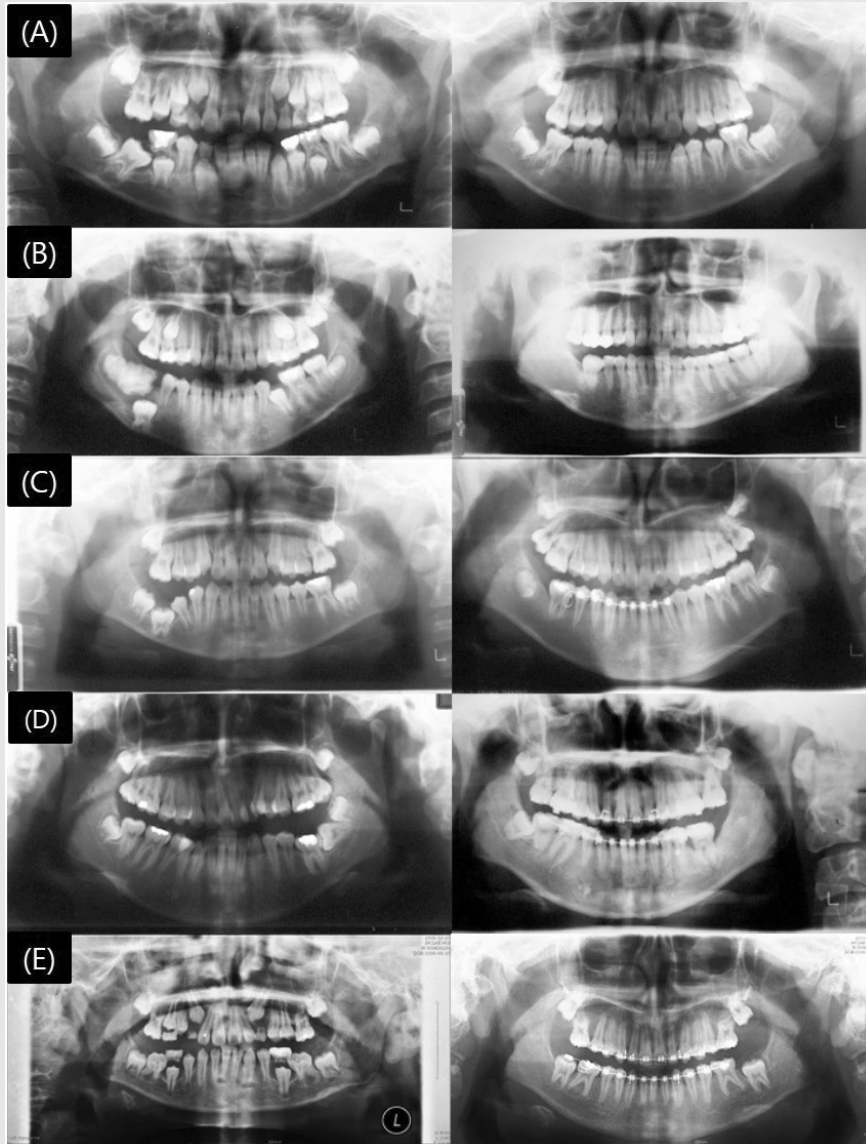


Fig. 2. Dental panorama of various mandibular first molar impaction cases. Left side; before treatment, Right side: after treatment. (A) A boy(10 years 6 months) with a right impacted M₁.mn(Group 1). The molar was angulated mesially and struck to the distal root of second deciduous molar. Surgical exposure and orthodontic traction successfully was done. (B) A girl(16 years 5 months) with a right impacted M₁.mn(Group 2). A large odontoma was above the impacted M₁.mn. Agenesis of the second and third molar is also present in the affected site. After removal of odontoma, then right side impacted lower first molar was successfully erupted. (C) A boy(10 years 6 months) with a right primary retained right M₁.mn (Group 3). Affected lower right M₁.mn was surgically extracted. Adjacent lower right M₂.mn have erupted and drifted into the space. (D) A girl(16 years 11 months) with a left secondary retained M₁.mn(Group 3). Occlusal amalgam restoration was detected. And M₂.mn of the affected site was impacted horizontally. After removal of M₂.mn and M₃.mn, retained left M₁.mn was surgically repositioned. (E) A boy(10 years 4 months) with impacted M₁.mns(Group 1). Both of M₁.mn and M₂.mns were inclined lingually. After removal of second deciduous molar, Both M₁.mns were successfully erupted.

Radiographic examination

Tooth inclination results showed that 8 teeth were positioned with a mesial inclination, 2 were distally inclined, and 4 were lingually inclined in Group 1. The values of angulation in Group 1 were larger than those in Group 3. Other comparisons between the groups were not significant. The tooth depth of Group 2 was greater than in Group 3. Considering the vertical development of the alveolar process in the area of M₁mn, the comparison between Groups 1 and 3 showed statistically significant differences, but not Group 2. Many cases in Group 2, vertical development of alveolar process was inhibited by follicular cyst or calcified mass. The average of the distance between the mesial/distal crest of the alveolar process and a line of proximal CEJ of its immediate non-affected neighbors in Group 3 was deeper than in Group 1. There were no significant differences among the 3 groups regarding eruption space deficiencies, root formation, or the abnormal curvature of the roots. Significantly greater prevalence rates for tooth anomalies including problems of the M₂mn and P₂mn were found in all groups. In Group 1, 57% of the M₂mn associated with the affected site had anomalies including agenesis, impaction, and underdevelopment. Additionally, 33% and 56% of the M₂mn associated with the affected sites in Groups 2 and 3, respectively, showed impaction or retention. In group 2, 33% of P₂mn showed agenesis of the tooth germ. In Group 3, 22% of P₂mn also had a secondary retention. There was 1 patient who had a secondary retained maxillary

right canine in addition to secondary retained M₁mn and M₂mn in Group 3. There were no significant differences pertaining to the small maxillary lateral incisors among the 3 groups.

Treatment outcome

In Groups 1 and 2, most of the impacted M₁mn were erupted successfully by orthodontic traction. However, 3 subjects demonstrated failed orthodontic traction, 2 of whom underwent autotransplantation, and 1 of whom underwent extraction. Two bilateral lingually inclined M₁mn were extracted due to severe crowding. Two patients refused the treatment. In Group 3, most of the retained M₁mn were failed to erupt and recommended for extraction. However, two spontaneous eruptions of a secondary retained molar were possible after regaining space by uprighting of the adjacent teeth.

IV. DISCUSSION

The current study was conducted to test the possibility that M₁mn eruption disturbances could distinguish between prognoses by classifying impaction/retention based on their characteristics, and to evaluate the treatment of impacted/retained mandibular M₁mn. According to the results of 1 study, M₁mn eruption disturbances occur in less than 0.04% of Caucasian populations²⁾. In the current study, the prevalence rate of M₁mn eruption disturbances was found to be 0.27%. It may be the reason that

the patients who has eruption disturbance of $M_{1,mn}$ were referred to the general hospital for severity of cases. There were no significant differences between the sexes, but a difference was detected in the site of $M_{1,mn}$ eruption disturbances, with a left to right site ratio of 2:1. The prevalence of $M_{1,mn}$ eruption disturbances increased from 1996-2009. It is interesting to note that Evans¹⁵⁾ also showed an increase in the prevalence of impacted/retained $M_{2,mn}$ in the UK from 1976-1986. This result may have been attributable to increased patient interest in need of dental care. In Group 1, 37% of $M_{1,mn}$ eruption disturbances were impacted due to an ectopic eruption path. In Group 2, 39% of $M_{1,mn}$ eruption disturbances were impacted due to obstruction of the eruption path.

There was a different characteristic in impacted $M_{1,mn}$. In Group 1, the inclination of the long axis of the $M_{1,mn}$ was steeper than in Group 2 by approximately 31.5° with respect to the lower border of the mandibular body. Additionally, the direction of inclination was mesial in 86% and distal in 14%. Impacted $M_{1,mn}$ with mesial inclination may have been attributable to the germ position of $M_{1,mn}$, which was as low as the distal root of the deciduous molar and may have led to collisions. During the eruption of the mandibular molar, it migrates mesially, then buccally¹⁶⁾. In 4 cases in the current study, mesially inclined impacted $M_{1,mn}$ were obstructed against under the adjacent distal root of the deciduous molar. Therefore, 7 $M_{1,mn}$ were impacted deep to the line that passes the one half root of the adjacent teeth. Furthermore, it seems

that there are differences regarding $M_{2,mn}$ of follicular collision between $M_{2,mn}$ and $M_{3,mn}$ ¹⁷⁾. Unfortunately, the patients in the cited study visited clinics in permanent dentition, so an exact correlation could not be assessed. A second possible explanation for impacted $M_{1,mn}$ with mesial inclination is that $M_{1,mn}$ came into contact apical to the non-resorbed distal root or the distal surface of the second deciduous molar, and the root development had been completed(Fig 2-A). From this, 2 $M_{1,mn}$ were impacted shallow to the line that passes the one half root of the adjacent teeth. As for impacted $M_{1,mn}$ of distal inclination, the germ position of $M_{2,mn}$ was higher than that of $M_{1,mn}$ such that $M_{1,mn}$ could not erupt along its normal pathway and erupted distally. Two cases of $M_{1,mn}$ eruption disturbances were inclined distally and impacted under the crown of $M_{2,mn}$.

Compared with Group 1, impacted $M_{1,mn}$ in Group 2 had marked obstructions of dentigerous cysts, odontomas, ameloblastomas, and distally positioned secondary premolar tooth germs. They were impacted deep to the line that passes the one half root of the adjacent teeth, and before penetrating the oral mucosa. However, there was at least 1 similar characteristic in impacted $M_{1,mn}$ between Groups 1 and 2. The patients with $M_{1,mn}$ eruption disturbances showed significantly higher numbers of dental anomalies, especially in $P_{2,mn}$ and $M_{2,mn}$ ¹⁷⁾. These findings point to a common biologic cause for the appearance of eruption failure of molar teeth and other disturbances in tooth eruption and position, most likely under genetic influence. Therefore, eruption of $M_{2,mn}$ and $P_{2,mn}$ will require

continuous observation in patients with impacted M_{1mn} .

Regarding treatment outcomes, most of the impacted M_{1mn} , with the exception of 3 cases, were erupted successfully by orthodontic traction. The 3 aforementioned cases might have been misdiagnosed primary retention as impaction. In Group 3, primary retained M_{1mn} , which is an arrest in the eruption process before the molar has penetrated the oral mucosa, or secondary retained M_{1mn} , which is an arrest in the eruption process after the molar has penetrated the oral mucosa, have defects in the follicle or PDL^{6,7)}. Primary retention was a rare phenomenon, and no specific characteristic have been noted¹⁸⁾. Therefore, it was difficult to classify between impaction and primary retention. Only 1 subject was diagnosed with a primary retention at the initial visit. In Group 3, 21% of M_{1mn} eruption disturbances were secondary retained and had very low vertical processes of alveolar bone development. As such, adjacent teeth had erupted and drifted into the space. In the multiple tooth environment, 5 subjects had retained teeth distal to the most mesially affected tooth with inadequate eruption, similar to the findings of studies by Frazier-Bowers et al¹⁶⁾.

Once retention has been diagnosed, treatment options were limited. Orthodontic traction was attempted in 4 subjects but failed, and 2 did not undergo any treatment. However, 2 cases showed spontaneous eruptions after solving problems involving space deficiencies. This is in accord with the theory that secondary retention is caused

by local occurrences of ankylosis that can be resorbed during the normal remodeling process or misdiagnosed eruption disturbances of space deficiency as retention¹⁹⁾.

In the current study, M_{1mn} eruption disturbances were rare and the subjects could be classified based on their specific radiographic characteristics. Treatment results of impacted M_{1mn} were excellent by orthodontic traction, and retained M_{1mn} was poor. However, some impacted M_{1mn} could not be erupted by orthodontic traction, and some spontaneous eruption of a secondary retained molar was possible. Therefore, treatment prognosis cannot be entirely distinguished by impaction/retention. Nielsen et al. suggested that a unilaterally retained M_{1mn} represents a temporary delay in eruption rather than permanent failure, if treatment is undertaken before apical root closure¹⁸⁾. In subjects in the current study, however, most of the M_{1mn} apex were closed, and permanent failure was detected. Therefore, after removing an element of the cause, orthodontic traction or periodic observation will be needed. Recognizing the status of the lower 1st molar using panoramic radiography in preschool children from the age of 6 years would be recommended annually. Early detection of eruption disturbances is essential for a good prognosis.

The current study had some limitations. The sample size was small and not amenable to reliable statistical analyses. In addition, there was no consideration for growth patterns in the mandible. In order to establish diagnostic

guidelines for the detection of M1mn eruption disturbances, additional larger studies that examine skeletal patterns would be required.

V. CONCLUSION

M₁mn eruption disturbances were retrospectively examined to determine their characteristics and treatment outcomes. The prevalence of M₁mn eruption disturbances was found to be 0.27%. Approximately 76% of impacted M₁mn were due to ectopic position of the tooth germ or obstacles of the eruption path. Primary and secondary retained M₁mn due to defects in the follicle or PDL accounted for the remaining 24%. Impacted M₁mn due to an ectopic eruption path were inclined mesially and impacted M₁mn due to obstruction were

associated with dentigerous cysts, odontomas, ameloblastomas, and abnormally positioned adjacent tooth germs. They showed significantly higher dental anomalies including agenesis, impaction, and underdevelopment, especially in the P₂mn and M₂mn. Treatment by orthodontic traction of the impacted M₁mn was excellent, however, orthodontic traction failed in 3 cases. Secondary retained M₁mn were associated with infraocclusion, and adjacent teeth had erupted and drifted into the space. Five cases showed multiple retained teeth adjacent to P₂mn and M₂mn. Based on the results of the current study, it would appear that treatment results cannot be entirely distinguished by impaction/retention. After removing an element of the cause, orthodontic traction or periodic observation will be required.

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