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ABSTRACT

Prevalence and treatment of mandibular first molar eruption disturbances

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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

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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 retention[1].

The mandibular first molar teeth(M_1mn) are the first permanent posterior teeth to erupt, and play the major role in occlusion and function. Early diagnosis and treatment of abnormal M_1mn eruption is very important, particularly in the arch development phase. The prevalence of M_1mn 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 occurrence[5~14]. 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 (M_1mx) and mandibular second molar (M_2mn) eruption disturbances. Previous studies on M_1mn 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 M_1mn 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_1mn 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_1mn 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_2mn; Level 1), and the marginal ridge of the impacted tooth crown was deeper than one half root of the P_2mn(Level 2). Vertical development of the alveolar process in the area of M_1mn was measured from the distance between the mesial/distal crest of the alveolar process to a line of proximal cementoenamel junction(CEJ) of its adjacent second premolar. Its average and the difference between the distance of the mesial

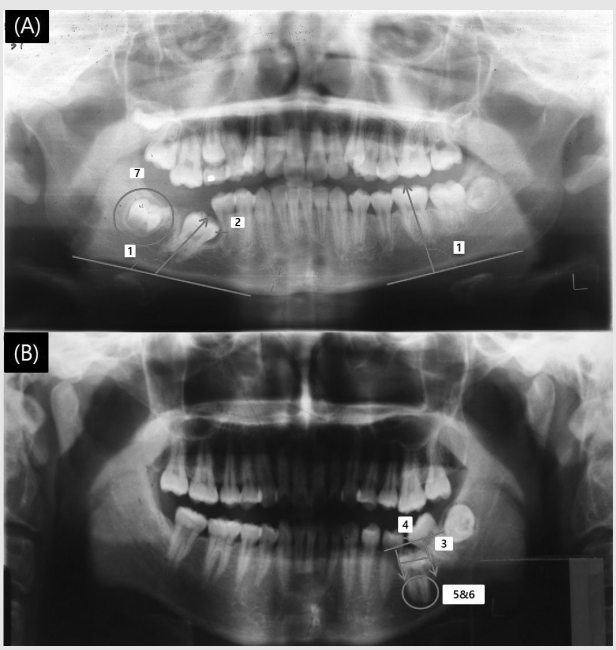

Fig. 1. Panoramic radiograph examination. 1. Tooth inclination difference; 2. Tooth depth(vertical position of affected tooth mesial marginal ridge to second premolar loot length); 3. Vertical development of the alveolar process in the area of M_1mn; 4. Eruption space; 5. Root formation; 6. Abnormal 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 method^2 = $\Sigma d^2/2n$ 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 M1mn 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 M_1mn 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 M_1mn from 36 patients. There were 14 M_1mn impactions with ectopic position of the tooth germ(Group 1), 15 M_1mn 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 M_1mn eruption disturbance with primary retention and 8 M_1mn with secondary retention(Group 3).

Table II. Descriptive statistics and statistical comparisons of values of characters of eruption disturbance of M_1mn 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 ($p < 0.05$)

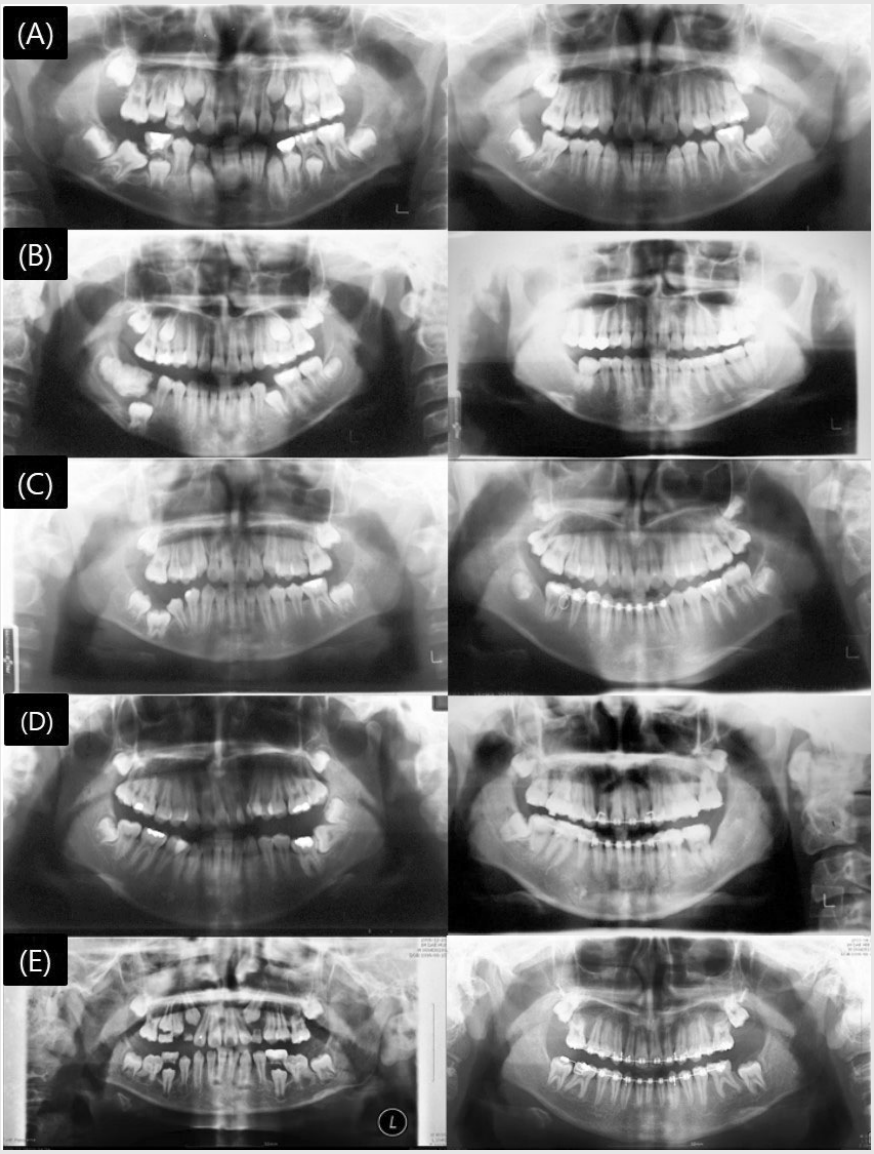

Fig. 2. Dental panorama of various mandibular first molar impaction cases. Left side; before treatment, Right side: after treatment. (A) A boy(10 years 6 months) with a right impacted M_1mn(Group 1). The molar was angulated mesially and struck to the distal root of second deciduous molar. Surgical exposure and orthodontic traction successfully was done. (B) A girl(16 years 5 months) with a right impacted M_1mn(Group 2). A large odontoma was above the impacted M_1mn. 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 M_1mn (Group 3). Affected lower right M_1mn was surgically extracted. Adjacent lower right M_2mn have erupted and drifted into the space. (D) A girl(16 years 11 months) with a left secondary retained M_1mn(Group 3). Occlusal amalgam restoration was detected. And M_2mn of the affected site was impacted horizontally. After removal of M_2mn and M_3mn, retained left M_1mn was surgically repositioned. (E) A boy(10 years 4 months) with impacted M_1mns(Group 1). Both of M_1mn and M_2mns were inclined lingually. After removal of second deciduous molar, Both M_1mns 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 M_2mn and P_2mn were found in all groups. In Group 1, 57% of the M_2mn associated with the affected site had anomalies including agenesis, impaction, and underdevelopment. Additionally, 33% and 56% of the M_2mn associated with the affected sites in Groups 2 and 3, respectively, showed impaction or retention. In group 2, 33% of P_2mn showed agenesis of the tooth germ. In Group 3, 22% of P_2mn also had a secondary retention. There was 1 patient who had a secondary retained maxillary right canine in addition to secondary retained M_1mn and M_2mn 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 M_1mn 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 M_1mn were extracted due to severe crowding. Two patients refused the treatment. In Group 3, most of the retained M_1mn 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 M_1mn eruption disturbances could distinguish between prognoses by classifying impaction/retention based on their characteristics, and to evaluate the treatment of impacted/retained mandibular M_1mn. According to the results of 1 study, M_1mn eruption disturbances occur in less than 0.04% of Caucasian populations[2]. In the current study, the prevalence rate of M_1mn eruption disturbances was found to be 0.27%. It may be the reason that

the patients who has eruption disturbance of M_1mn 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_1mn eruption disturbances, with a left to right site ratio of 2:1. The prevalence of M_1mn eruption disturbances increased from 1996-2009. It is interesting to note that Evans[15] also showed an increase in the prevalence of impacted/retained M_2mn 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_1mn eruption disturbances were impacted due to an ectopic eruption path. In Group 2, 39% of M_1mn eruption disturbances were impacted due to obstruction of the eruption path.

There was a different characteristic in impacted M_1mn. In Group 1, the inclination of the long axis of the M_1mn 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_1mn with mesial inclination may have been attributable to the germ position of M_1mn, 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 buccally[16]. In 4 cases in the current study, mesially inclined impacted M_1mn were obstructed against under the adjacent distal root of the deciduous molar. Therefore, 7 M_1mn 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_2mn of follicular collision between M_2mn and M_3mn[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_1mn with mesial inclination is that M_1mn 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_1mn were impacted shallow to the line that passes the one half root of the adjacent teeth. As for impacted M_1mn of distal inclination, the germ position of M_2mn was higher than that of M_1mn such that M_1mn could not erupt along its normal pathway and erupted distally. Two cases of M_1mn eruption disturbances were inclined distally and impacted under the crown of M_2mn.

Compared with Group 1, impacted M_1mn 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_1mn between Groups 1 and 2. The patients with M_1mn eruption disturbances showed significantly higher numbers of dental anomalies, especially in P_2mn and M_2mn[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_2mn and P_2mn 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 M1mn, 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 noted[18]. 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 al[16].

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 retention[19].

In the current study, M1mn 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 closure[18]. 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

M_1mn eruption disturbances were retrospectively examined to determine their characteristics and treatment outcomes. The prevalence of M_1mn eruption disturbances was found to be 0.27%. Approximately 76% of impacted M_1mn were due to ectopic position of the tooth germ or obstacles of the eruption path. Primary and secondary retained M_1mn due to defects in the follicle or PDL accounted for the remaining 24%. Impacted M_1mn due to an ectopic eruption path were inclined mesially and impacted M_1mn 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 P_2mn and M_2mn. Treatment by orthodontic traction of the impacted M_1mn was excellent, however, orthodontic traction failed in 3 cases. Secondary retained M_1mn were associated with infraocclusion, and adjacent teeth had erupted and drifted into the space. Five cases showed multiple retained teeth adjacent to P_2mn and M_2mn. 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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