An updated study on common dental anomalies in Korean orthodontic patients

Ja Hyeong Ku[1], Byoul Han[2], Jaehyun Kim[3], Jiyoung Oh[4], Yoon-Ah Kook[5], Yoonji Kim[6]

1) Former Resident, Department of Orthodontics, Seoul St. Mary's Hospital, The Catholic University of Korea, Seoul, Korea.
2) Former Graduate student, Graduate School of Clinical Dental Science, The Catholic University of Korea, Seoul, Korea
3, 4) Resident, Department of Orthodontics, Seoul St. Mary's Hospital, The Catholic University of Korea, Seoul, Korea.
5) Professor, Department of Orthodontics, Seoul St. Mary's Hospital, College of Medicine, The Catholic University of Korea, Seoul, Korea.
6) Associate professor and Chair, Department of Orthodontics, Seoul St. Mary's Hospital, College of Medicine, The Catholic University of Korea, Seoul, Korea.

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Corresponding author: Yoonji Kim
Department of Orthodontics, Seoul St. Mary's Hospital, College of Medicine,
The Catholic University of Korea,
222 Banpo-daero, Seocho-Gu, Seoul, 06591, Korea.
Tel: +82 2 2258 1776, Fax: +82 2 537 2374
E-mail: juice@catholic.ac.kr; kyoonji@gmail.com

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ABSTRACT

Objective: The purpose of this study was 1) to investigate the prevalence and pattern of dental anomalies (DAs), 2) to compare them according to malocclusion type, and 3) to investigate the correlation between tooth impaction and other DAs in Korean orthodontic population.

Methods: A total of 3240 orthodontic patients were classified as Class I, Class II, or Class III malocclusion group. The presence and location of the common DAs; impaction, microdontia, agenesis, supernumerary tooth, transposition, and fusion were identified by examining diagnostic records. Furthermore, the same sample was classified as Group 1 without impaction or Group 2 with impaction. The prevalence of other DAs concurrent with impaction was investigated and compared with Group 1.

Results: Impaction was the most prevalent DA, followed by microdontia, agenesis, and supernumerary in the total sample. Class I and Class III groups showed the same order of prevalence, but agenesis was more frequent than microdontia in Class II group. The prevalence of four DAs was lowest in Class III group. Among the total sample, 8.6% of patients were classified into Group 2. The incidence of DAs other than impaction and the prevalence of multiple concurrent DAs were significantly higher in Group 2. Impaction had a significant relationship with supernumerary tooth, transposition, and fusion.

Conclusions: The prevalence and pattern of DAs varied depending on the type of malocclusion. As there was higher risk of other DAs in patients with impacted tooth, early detection of impacted tooth and detailed diagnosis of other possible DAs may be essential.

INTRODUCTION

Dental anomalies (DAs) are defined as changes in the numbers, shapes, structures, exfoliations, and eruptions of teeth during dental development.[1,2] Tooth impaction, microdontia, tooth agenesis, and supernumerary tooth are the most common DAs encountered in clinical practice.[3,4] By affecting the number and size of teeth and arch length discrepancy, these congenital anomalies can deteriorate both aesthetics and function.[5] Also, orthodontic patients tend to have DAs more frequently when compared with non-orthodontic samples.[6,7] Therefore, early diagnosis of DAs enables optimal orthodontic treatment planning, reducing side effects and the complexity of the treatment.[8]

Extensive literature has been reported on the prevalence and distribution of DAs in various populations.[3–9] In contrast, relatively few studies have demonstrated the association between the presence of DAs and the malocclusion type.[10–12] Fernandez et al.[10] found that DAs were most prevalent in Class III malocclusion and microdontia was significantly more frequent in Class III malocclusion. Basdra et al.[11] reported Class III malocclusion showed significantly higher rates of DAs compared to Class II division 1 malocclusion. Uslu et al.[12] demonstrated tooth impaction had a significantly lower prevalence in Class II and Class II division 2 malocclusion. The types of DAs investigated and diagnostic criteria for each DA were different among literature, showing inconsistent results. In addition, due to the differences in ethnicity and environmental factors, discrepancies existed in the prevalence of DAs between various previous studies.[9,13] For Korean population, there has been little literature on the frequency and pattern of DA in relation to the malocclusion type or skeletal feature. To date, few studies only for the prevalence of hypodontia according to malocclusion types were reported.[14,15]

The prevalence of tooth impaction is known to be the highest among various types of DAs even when excluding the impaction of third molars, ranging from 3.1% to 13.7% depending on the characteristics of the population.[4,8,16] Laganà et al.[8] reported that the most frequently impacted teeth were the maxillary canine, followed by maxillary lateral incisors, and maxillary central incisors.

Clinically, this prevalence pattern appears to be different in Korean population.

In patients with impacted teeth, concurrent supernumerary tooth, or small-sized tooth are often encountered. Baccetti[17] demonstrated the existence of associations among various DAs and emphasized the importance of early diagnosis of one anomaly as it being an indicator of higher risk of other DAs. Peck et al.[18] discovered that patients with palatally displaced canine (PDC) have higher incidence of permanent tooth agenesis and small lateral incisors. Sigler et al.[19] also showed that subjects with PDC exhibited significantly higher prevalence of small lateral incisors and distoangulation of mandibular second premolars. However, these studies investigated only the individuals affected by the DA and comparison with control group was absent.[18–20] For Korean population, there has been few studies concerning the association of tooth impaction and other common DAs.

Therefore, the purpose of this study was 1) to investigate the prevalence and pattern of DAs, 2) to compare them according to malocclusion type, and 3) to investigate the correlation between tooth impaction and other DAs in Korean orthodontic population.

MATERIALS AND METHODS

The subjects of the present study were 3753 patients who visited the Department of Orthodontics at Seoul St. Mary's Hospital, the Catholic University of Korea (Seoul, Korea), and underwent diagnostic examination for orthodontic treatment between September 2002 and October 2019. The minimum age of the sample was 6 years, and any patients with previous history of orthodontic treatment, multiple dental prosthesis, tooth loss, craniofacial disorders, incomplete records, or a tooth (or teeth) whose identification was unclear on records were excluded. In addition, if there was uncertainty in the diagnosis of a DA, it was confirmed through follow-up panoramic radiographs or excluded from the sample. The final sample consisting of 3240 patients (mean age, 22.2 ± 11.6 years) was included in the study. The presence and location of the common DAs; tooth impaction, microdontia, tooth agenesis, supernumerary tooth, transposition, and fusion were identified through examination of their initial diagnostic records. This study was approved by the institutional review board of the Catholic University of Korea (KC20RISI0442 and KC21RISI0109).

Characterization of Malocclusion Type

The type of malocclusion in this study was defined as the anteroposterior relationship of the maxilla and mandible. The malocclusion type was classified according to the value of the ANB angle measured in the lateral cephalograms, as follows.

- Class I (ANB angle with values between 0º and 4º)
- Class II (ANB angle with values > 4º)
- Class III (ANB angle with values < 0º)

Diagnosis of Dental Anomalies

Patient's pretreatment diagnostic records including clinical photographs, panoramic radiographs, lateral cephalograms, and CBCT images, if any, were examined to identify the following DAs.

1. Tooth impaction: a tooth that was buried in the bone or gingiva by obstructed on its normal eruption path and failed to erupt after normal eruption period, except for the third molar.[21]
2. Microdontia: a tooth that is smaller than normal tooth size in opposite side when comparing the mesiodistal width of the crown.[22]
3. Tooth agenesis: the developmental absence of at least one permanent tooth, also known as hypodontia and congenitally missing tooth, except for the third molar.[23] To exclude uncertainty, the mandibular central or lateral incisors were counted together.
4. Supernumerary tooth: excess of the regular number of tooth, an additional tooth, which may be erupted or unerupted[8,21]
5. Transposition: an unusual type of ectopic eruption, or positional interchange of two teeth[8]
6. Fusion: the union between the dentin or enamel of two or more separated tooth germs[24]

Group Classification according to the presence or absence of impacted tooth

Subjects were further classified as either Group 1 with no impacted tooth (control group) or Group 2 with impacted tooth (impaction group). The inclusion criteria of the Group 2 were the presence of one or more impacted permanent tooth excluding the impacted third molars. Impacted supernumerary tooth or impacted third molar was not included in the Group 2. The following DAs were detected; tooth impaction, agenesis, supernumerary tooth, microdontia, transposition, and fusion.

Statistical analysis

All measurements were examined by the same investigator and repeated after two weeks. The systemic intra-examiner error between the two measurements was evaluated with a paired t-test. The extent of the measurement error was also assessed by calculating the intraclass correlation coefficient (ICC). No significance was noted in the measurements of the first and the second evaluation. Numbers of patients and rates of DAs were calculated for the overall study sample, and by gender and malocclusion type. To determine the statistical significance of DAs by gender and malocclusion type, Chi-square test (gender) and Chi-square test with Bonferroni correction (malocclusion type) was

conducted respectively. In addition, the chi-square test was used to statistically compare the prevalence of impacted teeth and relation with other DAs in each group. The level of significance in all tests was set at 5% ($P < 0.05$). The Phi correlation coefficient was calculated to assess the correlation between the DAs. A Phi coefficient of 0.1 to 0.3 was interpreted as weak correlation, 0.3 to 0.5 as moderate, and 0.5 to 1.0 as strong correlation.

RESULTS

Sample composition and prevalence of dental anomalies

The total sample (3240 patients) was composed of 1310 male (40.4%) and 1930 female (59.6%) patients. The most common DA was tooth impaction, which showed a prevalence of 8.6%, and it was followed by microdontia (6.8%), tooth agenesis (6.5%), and supernumerary tooth (2.2%) (Table 1). There was no significant difference between genders in the prevalence of DAs, except for supernumerary tooth which was more frequent in males (3.3%) than in females (1.5%, $P < 0.001$). For each DA, the mean number of affected teeth per individual was less than two. However, only for the tooth agenesis, two or more (2.18 ± 0.45) teeth were affected on average. Regarding the reliability of the measurements, no significance was noted in the measurements of the first and the second evaluation.

Table 1 showed a comparison of the prevalence of DAs according to malocclusion type. The number of patients in Class III malocclusion group was 1430 (44.1%), followed by Class II patients with 1178 (36.4%) and Class I patients with 632 (19.5%). When comparing the prevalence of each DA among malocclusion types, it was found that tooth impaction was more prevalent in Class I group (12.2%) than in Class III group (6.7%, $P < 0.001$). On the other hand, tooth agenesis was more frequently detected in Class II group (8.1%) than in Class III group (5.3%, $P < 0.05$). Supernumerary tooth was more common in Class I group (3.8%) than in Class II (1.8%, $P < 0.05$) or Class III group (1.8%, $P < 0.05$).

Maxillomandibular distribution of dental anomalies

The maxillary and mandibular distribution of DAs was further investigated in each malocclusion type (Table 2). Most DAs, except for tooth agenesis, were more common in the maxilla. The majority of microdontia (more than 90%) occurred in the maxilla, and there was no significant difference between malocclusion types. However, the distribution of tooth impaction, tooth agenesis, and

supernumerary tooth, was different according to malocclusion type. Impacted tooth was more likely to exist in the maxilla in Class III group than in Class I ($P < 0.001$) or Class II group ($P < 0.01$). Similarly, the incidence rate of tooth agenesis in the maxilla was higher in Class III group than in Class I ($P < 0.05$) or Class II group ($P < 0.001$). The fraction of supernumerary tooth found in the maxilla was 93.1% in Class I group and it was significantly higher than 64.3% of Class II group ($P < 0.05$).

Most affected teeth for each dental anomaly

Figure 1 showed that the most frequently impacted tooth was the maxillary canine (36.5%), followed by the maxillary second premolar (14.6%), mandibular second molar (12.4%), mandibular second premolar (7.3%). Microdontia was by far the most prevalent in the maxillary lateral incisor (86.6%) and the maxillary second premolar (6.9%) was the next. For tooth agenesis, the mandibular incisor (27.4%) and second premolar (25.5%) were the most frequently affected teeth. The most common site for supernumerary tooth was the premaxilla region (U1~3, 69.4%), followed by the mandibular premolar area (L4,5, 11.1%).

Table 3 described the most frequently affected teeth (areas) of DAs according to malocclusion type. Regarding tooth impaction, the total sample and Class III group showed the same order of prevalence, which is the maxillary canine, the maxillary second premolar, and the mandibular second molar. In Class I and Class II groups, however, the mandibular second molar was more frequently impacted than the maxillary second premolar. The percentage of the maxillary canine impaction was highest in Class III group. Concerning tooth agenesis, mandibular incisor was the most frequently affected teeth, while mandibular second premolar was the most affected only in the Class I malocclusion group. In any malocclusion type, microdontia and supernumerary tooth were most common in the maxillary lateral incisor and premaxilla region, respectively.

Prevalence of multiple dental anomalies

The overall frequency of any of the four DAs in Class III (17.3%) malocclusion was lower than

those in Class I (23.4%), and Class II (21.4%) malocclusions, with statistical significance ($P < 0.05$ and $P < 0.01$, respectively) (Table 4). Also, the prevalence of multiple (two or more) kinds of DAs in Class III (2.9%) was lower than that in Class I (5.4%, $P < 0.05$) malocclusion.

Group Classification according to the presence or absence of impacted tooth

Among a total of 3240 patients, 280 patients (8.6%) presented with at least one impacted tooth and were grouped as Group 2. The other patients with no impacted tooth were grouped as Group 1. The Group 1 (2960 patients; mean age, 22.8 ± 11.7 years) was composed of 1183 male (40.0%) and 1777 female (60.0%) patients, and Group 2 (280 patients; mean age, 15.4 ± 8.2 years) was composed of 126 male (45.0%) and 154 female (55.0%) patients. No statistically significant difference was found by gender in both groups ($P > 0.05$).

The prevalence of dental anomalies other than tooth impaction in Group 1 and Group 2

The prevalence of the five DAs other than tooth impaction in Group 1, Group 2, and total sample is shown in Table 5 and Figure 2. All five DAs were found more frequently in Group 2, and the difference in the prevalence between Group 1 and Group 2 was statistically significant ($P < 0.01$ or $P < 0.001$). Microdontia was the most frequently observed DA in both Group 1 (6.3%) and Group 2 (12.1%). The prevalence of tooth agenesis was 6.3% in Group 1 and 9.6% in Group 2. Supernumerary tooth was also detected more frequently in Group 2 (11.8%), whereas significantly less in Group 1 (1.3%). The incidence of transposition and fusion were very low in both groups.

The prevalence of multiple concurrent DAs other than tooth impaction was also significantly higher in Group 2 than in Group 1 ($P < 0.0001$) (Table 6 and Figure 3). No patient had more than four DAs.

Correlation between tooth impaction and other dental anomalies

Table 7 shows tooth impaction had a significant relationship with supernumerary tooth, transposition, and fusion (weak correlation, $0.1 < Phi < 0.3$). Also, microdontia and tooth agenesis had correlation with supernumerary tooth, transposition, and fusion.

DISCUSSION

DAs can be classified into various types in relation to the number, shape, size, and location of teeth.[25] Some are observed relatively often and should be considered timely during orthodontic treatment planning because they affect function, aesthetics, or occlusion.[12] Tooth impaction, microdontia, tooth agenesis, and supernumerary tooth, which are known as the four most common DAs,[3,4] were mainly investigated here. As in many other studies, tooth impaction showed the highest prevalence. In addition, the prevalence of the four DAs was similar or higher than those of the previous reports[4,10,11]. Investigations with general population or general dental patients showed a lower prevalence, while studies with orthodontic patients at university affiliated general hospitals indicated similar prevalence rates with this study. In other words, orthodontic patients at general hospitals are more likely to be referred due to various DAs as well as skeletal discrepancies.[6,26]

With regard to gender, there was significant difference only in the prevalence of supernumerary tooth. Supernumerary tooth is known to occur twice as often in male as in females and the prevalence is 1.5 – 3.5% in permanent dentition.[27,28] The results of this study showed the same range of prevalence and the males were more frequently affected than females at a ratio of 2.2:1. Also, the average number of affected teeth per individual was investigated and only tooth agenesis affected more than two teeth, which is consistent with a previous study by Fernandez et al.[10]

The prevalence of the four DAs was highest in Class I (23.4%), followed by Class II (21.4%), and Class III (17.3%) malocclusion regardless of the type of DA (Table 4). For each DA, however, significant differences among different malocclusion types were found for tooth impaction, tooth agenesis, and supernumerary tooth (Table 1). Tooth agenesis was more frequently detected in Class II (8.1%) malocclusion than in Class III (5.3%) malocclusion in this study. However, Celikoglu et al.[29] found that hypodontia was significantly less in patients with skeletal Class II malocclusion, and Chung et al.[14] showed hypodontia was associated with skeletal Class III malocclusion.

Maxillary teeth were more often affected by DAs than the mandibular teeth, except for tooth agenesis (Table 2). In Class III malocclusion, both tooth impaction and tooth agenesis were found to be more common in the maxilla than in Class I or Class II malocclusion. Therefore, it may be postulated that the relative size of the maxilla and mandible appears to be related with the distribution of these two DAs, i.e., tooth impaction and tooth agenesis.

Within the scope of our knowledge, there has been no study examining the most frequently affected teeth of various DAs according to malocclusion types. For tooth agenesis, the most frequently affected teeth was in the order of the mandibular incisors, mandibular second premolars, and maxillary second premolars, showing same results with Chung et al.[14] The proportion of the missing mandibular incisors was particularly high (33.1%) in Class II group. This result may indicate that increased difficulty of treatment in Class II patients with missing mandibular incisors. This high prevalence of the mandibular incisor agenesis was suggested as a characteristic of hypodontia pattern of "mongoloids" by Kim.[15]

The most frequently affected teeth by microdontia were the maxillary lateral incisors, known as peg lateralis. In addition, the majority of supernumerary tooth occurred in the premaxilla, for example, mesiodens (Figure 1). The same results have already been reported in various literature.[8–10] The most commonly impacted tooth was the maxillary canine in all malocclusion types (Table 3). The second most impacted tooth was the mandibular second molar in Class I and Class II malocclusion, and the maxillary second premolar in Class III malocclusion and in the total sample. Since Class III patients (n = 1430, 44.1%) account for a large proportion of the total sample, the overall trend would have been the same as that of Class III group. The impaction of the maxillary second premolar may induce decrease in the maxillary arch length, making it more difficult to treat the Class III malocclusion already complicated with anteroposterior jaw disharmony.

Since tooth impaction was the most common DAs and may cause severe side effects such as root resorption, tooth loss, and gingival problems[30], the total sample was grouped

according to the presence or absence of impacted tooth. The prevalence of impacted teeth (Group 2) was 8.6% (n = 280) which was higher than 3.09% by Lee et al.[4] In other study by Fardi et al.[16] with North Greek population, the incidence of impacted teeth was 13.7%. One of the reasons for this may be due to the methodological differences, for example, the definition of impacted tooth and selection of the sample. They regarded unerupted supernumerary tooth as an impacted tooth,[16] while in this study, supernumerary tooth as well as impacted third molars were considered as an extra tooth and not included as an impacted tooth.

When the prevalence of all other DAs except impacted tooth was compared between groups (Table 5 and Figure 2), it was significantly higher in impaction group (Group 2) than in control group (Group 1). In particular, the prevalence of supernumerary with impacted tooth in Group 2 (11.8%) was approximately ten times higher than the solitary presence of supernumerary tooth in Group 1 (1.3%). Furthermore, the prevalence of multiple concurrent DAs such as simultaneous tooth agenesis, microdontia, supernumerary tooth or teeth, were also significantly higher in Group 2 than in Group 1 (Table 6 and Figure 3). From the result of this study, the most common patterns of concurrent DA with tooth impaction are summarized in Figure 4, since understanding these common patterns would be clinically useful.

Regarding the associations between impacted teeth and other DAs, tooth impaction indeed had a significant relationship with supernumerary tooth, transposition, and fusion ($0.1 < Phi < 0.3$, Table 7). Also, microdontia and tooth agenesis had correlation with supernumerary tooth, transposition, and fusion. The associations between tooth impaction and supernumerary/transposition and between tooth agenesis and transposition have been also reported by Laganà et al.[8] Baccetti[17] also demonstrated significant reciprocal associations among agenesis of second premolars, peg lateralis, and palatal displacement of maxillary canines, suggesting their common heredity. In this study, tooth agenesis was often discovered as multiple missing teeth state. Most supernumerary teeth were found in

the maxillary anterior region, including mesiodens which located between the two maxillary central incisors. Since maxillary canines, excluding third molars, were the most commonly impacted teeth also in many previous reports,[4,16,21] a number of investigations dealing only with impacted maxillary canines were described. Several previous reports have demonstrated a statistically significant association between palatally displaced canines and other tooth impactions, agenesis, transposition, and peg-shaped maxillary lateral incisors.

According to this study, there was higher possibility that patients with tooth impaction would have other DAs at the same time. Also, significant relationships among DAs suggest that one anomaly may present a potential risk of other anomalies. Therefore, more thorough examination and follow-ups would be required for the patients with tooth impaction. In addition, early detection and accurate diagnosis of other possible DAs can decrease treatment complexity and provide optimal treatment for orthodontic patients.

CONCLUSION

1. The prevalence and pattern of DAs varied depending on the type of malocclusion.
2. The overall prevalence of the four common DAs was lower in Class III than in Class I and II malocclusion.
3. The patients with impacted teeth had a significantly higher incidence of other DAs.
4. The prevalence of multiple concurrent DAs was also significantly higher in the patients with impacted teeth.

Therefore, early detection of impacted tooth and detailed diagnosis of other DAs may be essential to provide better treatment.

REFERENCES

1. Brook AH. Multilevel complex interactions between genetic, epigenetic and environmental factors in the aetiology of anomalies of dental development. *Arch Oral Biol* 2009;54:S3–17.

2. Baron C, Houchmand-Cuny M, Enkel B, Lopez-Cazaux S. Prevalence of dental anomalies in French orthodontic patients: A retrospective study. *Arch Pediatr* 2018;25:426–30.

3. Patil S, Doni B, Kaswan S, Rahman F. Prevalence of dental anomalies in indian population. *J Clin Exp Dent* 2013;5:183–6.

4. Lee JH, Yang BH, Lee SM, Kim YH, Shim HW, Chung HS. A study on the prevalence of dental anomalies in Korean dental-patients. *Korean J Orthod* 2011;41:346–53.

5. Guttal KS, Naikmasur VG, Bhargava P, Bathi RJ. Frequency of developmental dental anomalies in the Indian population. *Eur J Dent* 2010;4:263–9.

6. Thongudomporn U, Freer T. Prevalence of dental anomalies in orthodontic patients. *Aust Dent J* 1998;43:395–8.

7. Al-Jabaa AH, Aldrees AM. Prevalence of dental anomalies in Saudi orthodontic patients. *J Contemp Dent Pract* 2013;14:724–30.

8. Laganà G, Venza N, Borzabadi-Farahani A, Fabi F, Danesi C, Cozza P. Dental anomalies: Prevalence and associations between them in a large sample of non-orthodontic subjects, a cross-sectional study. *BMC Oral Health* 2017;17:1–7.

9. Altug-Atac AT, Erdem D. Prevalence and distribution of dental anomalies in orthodontic patients. *Am J Orthod Dentofacial Orthop* 2007;131:510–4.

10. Avelar Fernandez CC, Cruz Alves Pereira CV, Luiz RR, Vieira AR, De Castro Costa M. Dental anomalies in different growth and skeletal malocclusion patterns. *Angle Orthod* 2018;88:195–201.

11. Basdra EK, Kiokpasoglou MN, Komposch G. Congenital tooth anomalies and malocclusions: A genetic link? *Eur J Orthod* 2001;23:145–51.

12. Uslu O, Akcam MO, Evirgen S, Cebeci I. Prevalence of dental anomalies in various

malocclusions. *Am J Orthod Dentofacial Orthop.* 2009;135:328–35.

13. Dang HQ, Constantine S, Anderson PJ. The prevalence of dental anomalies in an Australian population. *Aust Dent J* 2017;62:161–4.

14. Chung CJ, Han JH, Kim KH. The pattern and prevalence of hypodontia in Koreans. *Oral Dis* 2008;14:620–5.

15. Kim YH. Investigation of hypodontia as clinically related dental anomaly: Prevalence and Characteristics. *ISRN Dent* 2011;1–6.

16. Fardi A, Kondylidou-Sidira A, Bachour Z, Parisis N, Tsirlis A. Incidence of impacted and supernumerary teeth - A radiographic study in a North Greek population. *Med Oral Patol Oral Cir Bucal* 2011;16:e56-61.

17. Baccetti T. A controlled study of associated dental anomalies. *Angle Orthod* 1998;68:267–74.

18. Peck S, Peck L, Kataja M. Prevalence of tooth agenesis and peg-shaped maxillary lateral incisor associated with palatally displaced canine (PDC) anomaly. *Am J Orthod Dentofacial Orthop.* 1996;110:441–3.

19. Sigler LM, Baccetti T, McNamara JA. Effect of rapid maxillary expansion and transpalatal arch treatment associatedcanine with deciduous extraction on the eruption of palatally displaced canines: A 2-center prospective study. *Am J Orthod Dentofacial Orthop* 2011;139:e235–44.

20. Peck S, Peck L, Kataja M. Concomitant occurrence of canine malposition and tooth agenesis: Evidence of orofacial genetic fields. *Am J Orthod Dentofacial Orthop* 2002;122:657–60.

21. Patil S, Maheshwari S. Prevalence of impacted and supernumerary teeth in the North Indian population. *J Clin Exp Dent* 2014;6:116–20.

22. Agurto S. P, Nicholson C, Del Sol M. Proposal of anatomical terms for alterations in tooth size: "Microdontia and macrodontia." *Int J Morphol* 2019;37:375–8.

23. Al-Ani AH, Antoun JS, Thomson WM, Merriman TR, Farella M. Hypodontia: An update on its etiology, classification, and clinical management. *Biomed Res Int* 2017;2017.

24. Tailor M. Tooth fusion, a rare dental anomaly: analysis of six cases. *International Journal of Oral and Maxillofacial Prthology 2012;4:50-3.*

25. Shulze C. *Dental developmental abnormalities of the teeth and jaws*. 6th ed. St Louis: CV Mosby; 1970.

26. Silverman N, Ackerman J. Oligodontia: a study of its prevalence and variation in 4032 children. *ASDC J Dent Child* 1979;46:470–7.

27. Garvey M, Barry H, Blake M. Supernermary teeth-an overview of classification, diagnosis and management. *J Can Dent Assoc* 1999;65:612–6.

28. Kinirons M. Unerupted premaxillary supernumerary teeth. A study of their occurrence in males and females. *Br Dent J* 1982;153:110.

29. Celikoglu M, Kazanci F, Miloglu O, Oztek O, Kamak H, Ceylan I. Frequency and characteristics of tooth agenesis among an orthodontic patient population. *Med Oral Patol Oral Cir Bucal* 2010;15:3–7.

30. Bedoya MM, Park JH. A review of the diagnosis and management of impacted maxillary canines. *J Am Dent Assoc* 2009;140:1485–93.

Figures

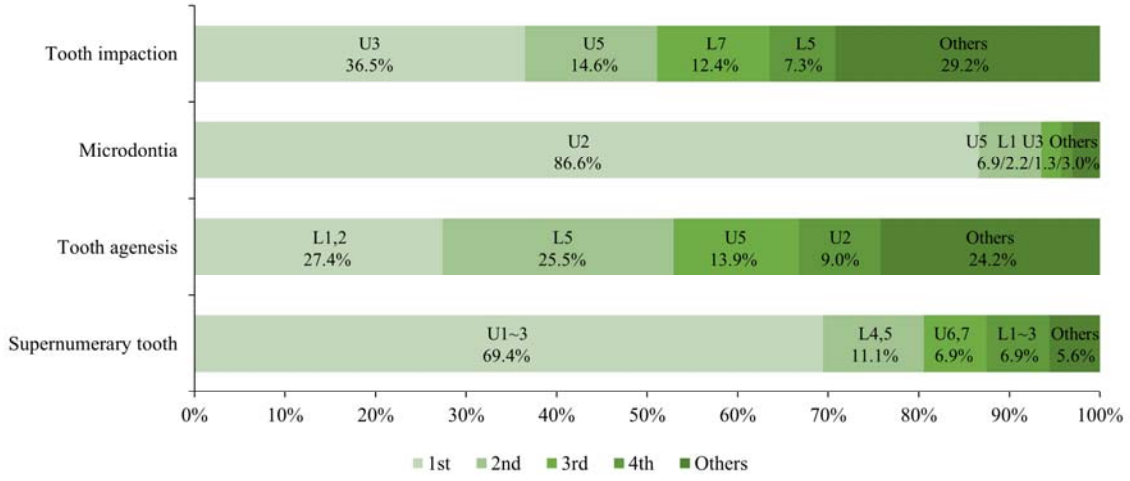

Figure 1. Most frequently affected teeth(areas) for each dental anomaly in the total sample

U, maxillary teeth; L, mandibular teeth; 1, central incisor; 2, lateral incisor; 3, canine; 4, first premolar; 5, second premolar; 6, first molar; 7, second molar.

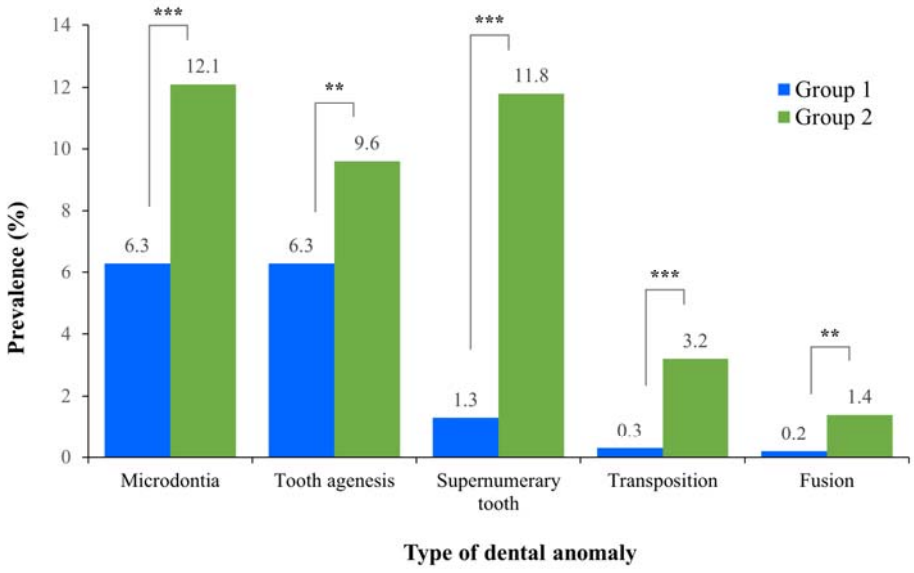

Figure 2. Comparison of the prevalence of dental anomalies other than tooth impaction in Group 1 and Group 2

The prevalence of all the dental anomalies was significantly higher in Group 2 than in Group 1. (Chi-square test) $^{*}P < .05$; $^{**}P < .01$. $^{***}P < .001$

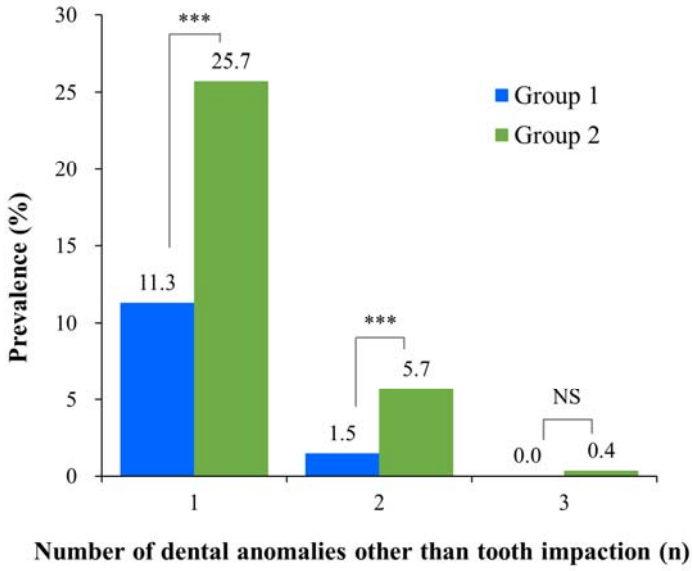

Figure 3. Comparison of the prevalence of multiple dental anomalies other than tooth impaction in Group 1 and Group 2

The prevalence of the concurrent two dental anomalies in Group 2 was significantly higher than Group 1 ($p < 0.0001$). No patient had more than four dental anomalies. (Chi-square test) NS indicates no statistical significance between groups. $^{*}P < .05$; $^{**}P < .001$; $^{***}P < .0001$.

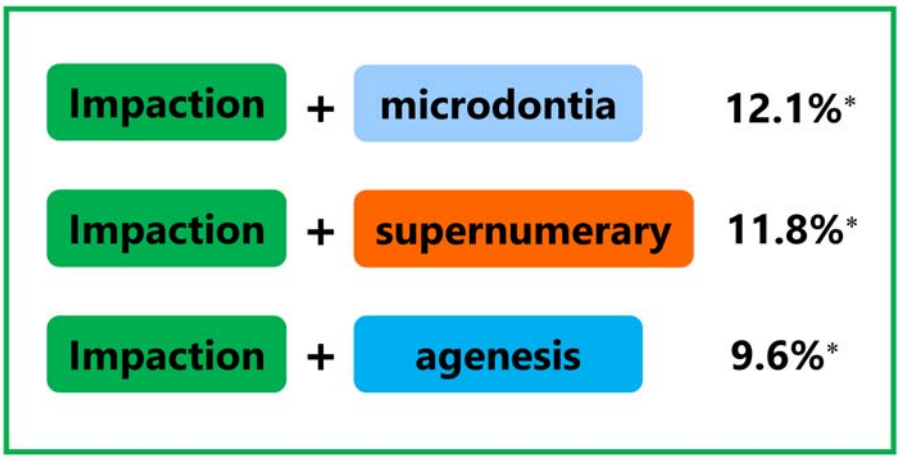

Figure 4. The most common patterns of concurrent dental anomaly with impacted teeth in Group 2

Impacted tooth and microdontia was the most common pattern of concurrent dental anomaly found in Group 2, followed by impacted tooth and supernumerary tooth, impacted tooth and tooth agenesis. The numbers* indicates their prevalence in Group 2.

Tables

Table 1. Prevalence of the four most common dental anomalies according to malocclusion type

Type of dental anomalies	Total	Mean No. of affected teeth per individual (SD)	Class I (n = 632)	Class II (n = 1178)	Class III (n = 1430)	*P* value
Tooth impaction	8.6% (279)	1.31 (± 0.74)	12.2% (77)	9.0% (106)	6.7% (96)	0.0003*** (I > III)
Microdontia	6.8% (221)	1.75 (± 0.62)	7.4% (47)	6.9% (81)	6.5% (93)	NS
Tooth agenesis	6.5% (212)	2.18 (± 0.45)	6.3% (40)	8.1% (96)	5.3% (76)	0.0111* (II > III)
Supernumerary tooth	2.2% (71)	1.27 (± 0.38)	3.8% (24)	1.8% (21)	1.8% (26)	0.0261* (I > II), 0.0213* (I > III)

P values are based on Chi-square test and adjusted using the Bonferroni correction.

NS indicates no statistical significance between groups. *$P < .05$; **$P < .01$; ***$P < .001$

Table 2. Comparison of maxillary and mandibular distribution of dental anomalies according to malocclusion type

	Total		Class I		Class II		Class III		*P* value
Type of dental anomaly	Maxilla	Mandible	Maxilla	Mandible	Maxilla	Mandible	Maxilla	Mandible	
Tooth impaction	70.7% (261)	29.3% (108)	60.4% (64)	39.6% (42)	66.9% (87)	33.1% (43)	82.7% (110)	17.3% (23)	0.0003*** (III - I), 0.0096** (III - II)
Microdontia	96.6% (373)	3.4% (13)	98.6% (72)	1.4% (1)	98.0% (144)	2.0% (3)	94.6% (157)	5.4% (9)	NS
Tooth agenesis	40.9% (189)	59.1% (273)	36.8% (32)	63.2% (55)	33.0% (68)	67.0% (138)	52.7% (89)	47.3% (80)	0.0477* (III - I), 0.0003*** (III - II)
Supernumerary tooth	77.8% (70)	22.2% (20)	93.1% (27)	6.9% (2)	64.3% (18)	35.7% (10)	75.8% (25)	24.2% (8)	0.0228* (I - II)

P values are based on Chi-square test and adjusted using the Bonferroni correction.

NS indicates no statistical significance between groups. **P* < .05; ***P* < .01; ****P* < .001

Table 3. Most frequently affected teeth(areas) for each dental anomaly according to malocclusion type

Type of dental anomaly	Total			Class I			Class II			Class III		
	Tooth(area)	n	%	Tooth(area)	n	%	Tooth(area)	n	%	Tooth(area)	n	%
Tooth impaction	U3	115	36.5	U3	26	28.6	U3	41	35.0	U3	48	44.9
	U5	46	14.6	L7	15	16.5	L7	16	13.7	U5	19	17.8
	L7	39	12.4	U5	12	13.2	U5	15	12.8	L7	8	7.5
	Others	115	36.5	Others	38	41.8	Others	45	38.5	Others	32	29.9
Microdontia	U2	201	86.6	U2	43	89.6	U2	74	87.1	U2	84	84.8
	U5	16	6.9	U5	4	8.3	U5	6	7.1	U5	6	6.1
	L1	5	2.2	L1	1	2.1	U4	2	2.4	L1	3	3.0
	Others	10	4.3	Others	0	0	Others	3	3.5	Others	6	6.1
Tooth agenesis	L1,2	85	27.4	L5	21	35.6	L1,2	45	33.1	L1,2	26	22.6
	L5	79	25.5	L1,2	14	23.7	L5	34	25.0	L5	24	20.9
	U5	43	13.9	U5	9	15.3	U5	14	10.3	U5	20	17.4
	Others	103	33.2	Others	15	25.4	Others	43	31.6	Others	45	39.1
Supernumerary tooth	U1~3	50	69.4	U1~3	18	72.0	U1~3	10	47.6	U1~3	22	84.6
	L4,5	8	11.1	U6,7	2	8.0	L4,5	4	19.0	L4,5	3	11.5
	U6,7	5	6.9	U4,5	2	8.0	U6,7 / L1~3	3	14.3	L1~3	1	3.8
	Others	9	12.5	Others	3	12.0	Others	4	19.0	Others	0	0

U, maxillary teeth; L, mandibular teeth; 1, central incisor; 2, lateral incisor; 3, canine; 4, first premolar; 5, second premolar; 6, first molar; 7, second molar.

Table 4. Prevalence of multiple dental anomalies according to malocclusion type

Number of dental anomalies	Total	Class I	Class II	Class III	*P* value
None	80.0% (2593)	76.6% (484)	78.6% (926)	82.7% (1183)	
Yes (≥1)	20.0% (647)	23.4% (148)	21.4% (252)	17.3% (247)	0.0234* (I > III), 0.0033** (II > III)
One	16.2% (524)	18.0% (114)	17.4% (205)	14.3% (205)	NS
Two	3.4% (111)	4.6% (29)	3.6% (42)	2.8% (40)	NS
Multiple (≥2)	3.8% (123)	5.4% (34)	4.0% (47)	2.9% (42)	0.0198* (I > III)

P values are based on Chi-square test and adjusted using the Bonferroni correction.

NS indicates no statistical significance between groups. **P* < .05; ***P* < .01; ****P* < .001

Table 5. Comparison of the prevalence of dental anomalies other than tooth impaction in Group 1 and Group 2

Type of dental anomaly	Total sample	Group 1 (Control)	Group 2 (Impaction)	*P* value
Microdontia	6.8%	6.3% (188)	12.1% (34)	<.0001***
Tooth agenesis	6.5%	6.3% (186)	9.6% (27)	0.0064**
Supernumerary tooth	2.2%	1.3% (38)	11.8% (33)	<.0001***
Transposition	0.5%	0.3% (8)	3.2% (9)	<.0001***
Fusion	0.3%	0.2% (6)	1.4% (4)	0.0026**

(Chi-square test) $^{*}P < .05$; $^{**}P < .01$; $^{***}P < .001$

Table 6. Comparison of the prevalence of multiple dental anomalies other than tooth impaction in Group 1 and Group 2

Number of concurrent dental anomalies	Group 1 (Control)		Group 2 (Impaction)		*P* value
1	11.3%	(335)	25.7%	(72)	<.0001***
2	1.5%	(44)	5.7%	(16)	<.0001***
3	0.0%	(1)	0.4%	(1)	NS

NS indicates no statistical significance between groups (Chi-square test) *$P < .05$; **$P < .01$; ***$P < .001$

Table 7. Correlation between impaction and other dental anomalies in Group 2

φ coefficient	Tooth impaction	Microdontia	Tooth agenesis	Supernumerary tooth	Transposition	Fusion
Tooth impaction	-	0.039	0.016	0.161*	0.198*	0.211*
Microdontia		-	0.023	0.127*	0.167*	0.182*
Tooth Agenesis			-	0.147*	0.185*	0.199*
Supernumerary tooth				-	0.055	0.080
Transposition					-	0.032
Fusion						-

Phi (φ) correlation analysis was performed. .1≤φ< .3 (small); **.3≤φ<.5 (medium); ***φ>.5 (large)