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Prevalence and characteristics of impacted teeth in Korean orthodontic patients at ten university dental hospitals

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Objective: This study aimed to investigate the prevalence and characteristics of impacted teeth (ITs) in orthodontic patients at university dental hospitals in Korea. **Methods:** This study included 14,774 patients who visited the Department of Orthodontics at 10 university dental hospitals in Korea between 2020 and 2022 and underwent orthodontic diagnosis. The prevalence and characteristics of ITs were investigated using orthodontic diagnostic records, radiographs, and diagnostic casts. **Results:** The prevalence of ITs, excluding third molar impaction, in Korean orthodontic patients was 13.6% (n = 2,014). The prevalence of ITs in pediatric orthodontic patients was 24.5% (n = 1,614). Of these patients, 68.2% had one IT, 27.5% had two ITs, 24.3% had bilateral IT, and 75.7% had unilateral IT. The most frequent IT was the maxillary canine (50.1%), followed by the mandibular second molar (11.7%), and maxillary second premolar (9.6%). An abnormal eruption path (46.5%) was the most frequent etiology. Orthodontic traction after surgical exposure (70.6%) was the most frequent treatment option. Among the patients with ITs, 29.8% had other dental anomalies, such as tooth agenesis (8.7%), microdontia (8.0%), and supernumerary teeth (5.1%). Furthermore, 50.8% had complications such as cystic lesions (18.3%), transposition (17.7%), and root resorption (14.8%). Among the patients with maxillary canine impaction, 62.2% had labial maxillary canine impaction and 21.1% had palatal maxillary canine impaction. **Conclusions:** The prevalence of ITs in Korean orthodontic patients at university dental hospitals was high, particularly in pediatric orthodontic patients.

Key words: Prevalence, Impacted tooth, Orthodontic patient, University dental hospital

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INTRODUCTION

Dental anomalies of permanent teeth are defined as abnormalities in the morphology, number, or position of teeth.[1] They are often derived from deciduous teeth, but they can also occur independently in permanent teeth.[1] They can occur at various stages of tooth formation, and the type of dental anomalies can vary depending on the timing of genetic and environmental perturbations.[2]

Impacted teeth (ITs) are the most common dental anomalies.[3] There are several definitions of ITs.[4-6] Thilander and Jakobsson[5] defined IT as a tooth with clinical and radiographic evidence that will not erupt further. ITs may be caused by systemic diseases such as cleidocranial dysplasia but may also be caused by genetic factors such as abnormality of the tooth germ, or local factors such as odontomas.[7]

Treatment methods for ITs include surgical exposure followed by orthodontic traction, extraction, autoreplantation, and follow-up after extracting the deciduous tooth, expansion, or resolving the etiologies.[8] To select a treatment method, many factors, such as root formation, age, and eruption space, must be considered.[6]

ITs can cause functional problems, such as malocclusion, and aesthetic problems, such as midline deviation.[8] Furthermore, ITs can affect the harmonious development of the maxillofacial region.[9] If the appropriate treatment timing for ITs is missed, treatment may take longer or complications may become more severe.[10] Therefore, early prediction of ITs is necessary.

A study on the prevalence and characteristics of ITs will not only help us understand the current status of ITs but also help us find racial and cultural characteristics by comparing it with studies from other countries or eras. Additionally, these data provide insights into the etiology of ITs and a basis for early prediction.

Various studies on the prevalence of ITs have been conducted targeting the general population[11] or patients visiting a single dental hospital.[3,12] However, its prevalence in the general population may differ from that in patients undergoing orthodontic treatment. In addition, the prevalence of ITs in a single dental hospital may be biased by its regional properties. Therefore, a nationwide study of the prevalence of ITs in orthodontic patients is necessary.

This study aimed to investigate the prevalence and characteristics of ITs in Korean orthodontic patients at university dental hospitals nationwide.

MATERIALS AND METHODS

Participants

The study included 14,774 patients who visited the Department of Orthodontics of all university dental hospitals in the Republic of Korea, excluding Seoul National University Dental Hospital, over the course of 3 years (2020–2022) and underwent examinations for orthodontic diagnosis (Table 1).

The exclusion criteria were: 1) lack of radiographs (panoramic radiograph, lateral cephalogram, and cone-beam computed tomography [CBCT]), diagnostic casts, or orthodontic diagnostic records and 2) history of orthodontic treatment. The Institutional Review Board approval numbers for each institution are: GWNUDH-IRB2024-A005, KNUDH-2024-04-03-00, KH-DT24003, DKUDHIRB 2024-06-002, PNUDH 2024-04-001, YUDHIRB 2-2024-0035, WKDIRB 202407-02, CNUDH-2024-006, CUH 2024-04-009, and CUDHIRB 2405-004. The requirement to obtain informed consent was waived.

Methods

The presence, characteristics, and complications of ITs were determined by using panoramic photographs and diagnostic casts. The presence of ITs was determined using the definition of Thilander and Jakobsson.[5] Impaction of permanent teeth, excluding the third molars, was included. Patient sex, age, and treatment method were determined from orthodontic diagnostic records. Patients were classified as pediatric if they were 15 years of age or

Table 1. Composition of study population

University dental hospital	Orthodontic patients (n)	Percentage (%)
Gangneung-Wonju National University Dental Hospital	757	5.1
Kyungpook National University Dental Hospital	1,774	12.0
Kyung Hee University Dental Hospital	2,061	14.0
Dankook University Dental Hospital	1,275	8.6
Pusan National University Dental Hospital	1,225	8.3
Yonsei University Dental Hospital	4,372	29.6
Wonkwang University Dental Hospital	725	4.9
Chonnam National University Dental Hospital	832	5.6
Jeonbuk National University Dental Hospital	719	4.9
Chosun University Dental Hospital	1,034	7.0
Total	14,774	100.0

younger.[13]

Based on the point A-nasion-point B (ANB) of the lateral cephalograms, Class I malocclusion was defined as 0° < ANB < 4°, Class II malocclusion as ANB ≥ 4°, and Class III malocclusion as ANB ≤ 0°.[14]

The buccolingual location of the impacted maxillary canines was classified according to the crown position of the impacted maxillary canine using CBCT.[15] That is, we classified impacted maxillary canine as the mid-alveolus position if the crown of the impacted maxillary canine touched the linear line connecting the crowns of the adjacent lateral incisor and first premolar.[15]

The multiple-choice selection method was used to determine the dental anomalies, etiologies, and complications of ITs. In other words, if there was more than one option, all the options were selected. Based on the previous studies,[3,16-20] a list of options was selected.

The following dental anomalies, complications, and etiologies were identified.

1) Supernumerary tooth: a tooth that appears in excess of the normal number of teeth.[16]
2) Tooth agenesis: a congenital lack of a permanent tooth or germ.[16]
3) Microdontia: a tooth smaller than the normal tooth size.[3]
4) Transposition: positional interchange of two teeth.[3]
5) Dens evaginatus: a tooth with a supernumerary tubercle that extends from the occlusal aspect.[16]
6) Dens invaginatus: a tooth where the enamel and dentin fold into the pulp chamber.[16]
7) Root resorption: progressive loss of the tooth's root structure.[17]
8) Cystic lesion: the presence of a peri-coronal radiolucency of more than 3 mm in the area of the dental follicle.[18]
9) Abnormal eruption path: the eruption in an abnormal angle or place.[16,19]
10) Lack of space: lack of eruption space in the arch.[19]
11) Local lesion: the presence of cyst, odontoma, periapical lesion or supernumerary tooth.[19]
12) Systemic disease: cleidocranial dysostosis, hypothyroidism, or osteopetrosis.[20]

Statistical analysis

Differences in parameters between the groups were analyzed using the chi-square test. Statistical analyses were performed using the SPSS (version 27.0; IBM, Armonk, NY, USA). A value of $P < 0.05$ was considered statistically significant.

RESULTS

Prevalence of impacted teeth

The prevalence of ITs in Korean orthodontic patients, excluding those with third molar impaction, was 13.6% (n = 2,014; Table 2). The prevalence of ITs in pediatric orthodontic patients was 24.5% (n = 1,614; Table 3).

Characteristics of impacted teeth

The most common IT was the maxillary canine (50.1%,

Table 2. Prevalence of impacted teeth in orthodontic patients

Year	Orthodontic patients (n)	Patients with impacted tooth (n)	Prevalence (%)
2020	4,767	621	13.0
2021	5,205	720	13.8
2022	4,802	673	14.0
Total	14,774	2,014	13.6

Table 3. Prevalence of impacted teeth in pediatric orthodontic patients

Year	Pediatric orthodontic patients (n)	Patients with impacted tooth (n)	Prevalence (%)
2020	2,081	486	23.4
2021	2,170	571	26.3
2022	2,346	557	23.7
Total	6,597	1,614	24.5

Table 4. Prevalence of impacted teeth

Tooth type	Patients (n)	Percentage (%)
U1	69	3.1
U2	40	1.8
U3	1,128	50.1
U4	39	1.7
U5	216	9.6
U6	36	1.6
U7	88	3.9
L1	4	0.2
L2	20	0.9
L3	144	6.4
L4	36	1.6
L5	121	5.4
L6	49	2.2
L7	263	11.7
Total	2,253	100.0

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

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n = 1,128), followed by the mandibular second molar (11.7%, n = 263), and maxillary second premolars (9.6%, n = 216) (Table 4 and Figure 1). An abnormal eruption path (46.5%, n = 1,206) was the most common etiology, followed by lack of space (25.3%, n = 658) and local lesions (21.6%, n = 560) (Figure 2). Orthodontic traction after surgical exposure (70.6%, n = 1,421) was the most frequent treatment method for ITs, followed by follow-up (17.1%, n = 344) and ITs extraction (12.0%, n = 242) (Figure 3).

Characteristics of patients with impacted teeth

Of the patients with ITs, 46.2% (n = 930) were male and 53.8% (n = 1,084) were female. The most frequent age class was 15 years or older (Table 5). Among patients with ITs, Class I malocclusion was the most common (44.9%, n = 905), and Class II division 2 malocclusion (5.9%, n = 119) was the least common malocclusion (Figure 4). Of the patients with ITs, 29.8% (n = 600) had other dental anomalies such as tooth agenesis (8.7%, n = 176), microdontia (8.0%, n = 162), and supernumerary tooth (5.1%, n = 102) (Figure 5). Of the patients with ITs, 50.8% (n = 1,024) had complications such as cystic lesions (18.3%, n = 368), transposition (17.7%, n = 357), and root resorption (14.8%, n = 299).

Of the patients with ITs, 68.2% (n = 1,373) had one IT, and 27.5% (n = 553) had two ITs (Figure 6). Among patients with one or two ITs (n = 1,926), 24.3% (n = 468) had bilateral IT and 75.7% (n = 1,458) had unilateral IT. Among the patients with one IT (n = 1,458), 51.6% (n = 753) had right-sided unilateral IT and 48.4% (n = 705) had left-sided unilateral IT.

Characteristics of maxillary canine impaction

Among the patients with maxillary canine impaction (n = 1,128), the percentages of patients with labial, mid-alveolus, and palatal maxillary canine impaction were 62.2% (n = 702), 16.7% (n = 188), and 21.1% (n = 238), respectively. Among the patients with labial or palatal maxillary canine impaction, the prevalence of

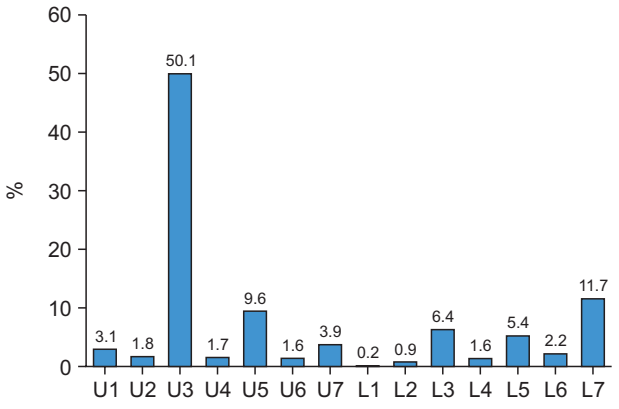

Figure 1. Bar graphs of impacted teeth prevalence.
U, maxilla; L, mandible; 1, central incisor; 2, lateral incisor; 3, canine; 4, first premolar; 5, second premolar; 6, first molar; 7, second molar.

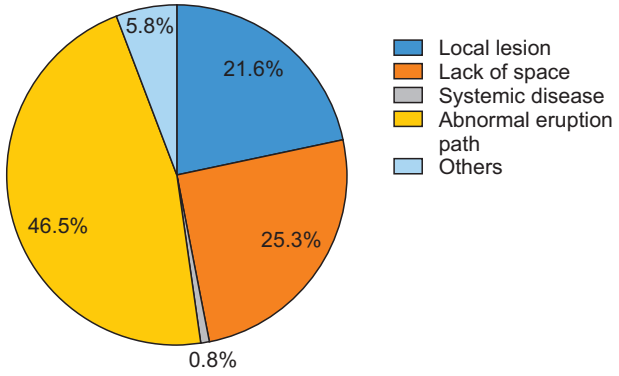

Figure 2. Etiologies of impacted teeth.

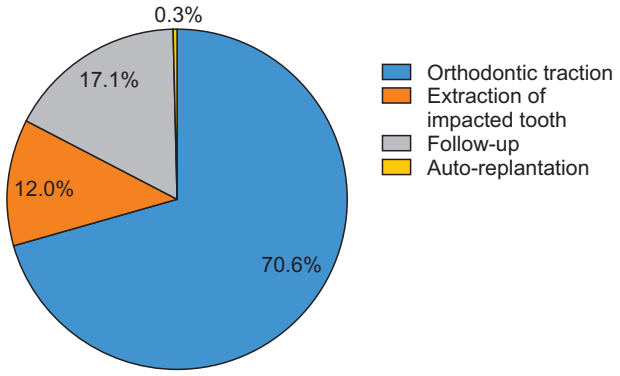

Figure 3. Treatment methods for impacted teeth.

Table 5. Age distribution of patients with impacted teeth

Age (yr)	Patients (n)	Percentage (%)
6 <	9	0.4
6–7	25	1.2
7–8	86	4.3
8–9	183	9.1
9–10	263	13.1
10–11	291	14.4
11–12	260	12.9
12–13	206	10.2
13–14	168	8.3
14–15	123	6.1
≥ 15	400	19.9
Total	2,014	100.0

lateral incisor anomalies was 8.4% (n = 59) and 21.8% (n = 52), respectively (Table 6). This difference was statistically significant ($P < 0.001$).

DISCUSSION

IT is a major concern for orthodontists, owing to the potential for traction failure and complications. Furthermore, as the patient age increases, orthodontic treatment of ITs may become more difficult.[19,21] Therefore, early diagnosis through regular checkups is important.

This study investigated the prevalence and characteristics of ITs in Korean orthodontic patients at university dental hospitals nationwide. The prevalence of ITs among Korean orthodontic patients, excluding those with third molar impaction, was 13.6%. This prevalence was higher than the estimates for the general population in Italy (3.9%)[11] and orthodontic patients who visited a single dental hospital in Korea (8.6%).[3] This was similar to that of patients who visited a single university dental hospital in northern Greece (13.7%).[22] These differences among studies may be explained by differences in race, region, and methodologies, such as the definition of ITs, subject selection, and age range of the subjects.

The prevalence of ITs in pediatric orthodontic patients was 24.5%, which was approximately 1.8 times higher than in orthodontic patients. The higher prevalence in pediatric patients is likely due to earlier dental visits and increased opportunities for diagnosis in younger age groups.

The percentage of patients with a single IT was 68.2%, which is similar to previous estimates of 75.9%[22] and 64.1%.[23] The percentage of patients with one or two ITs was 95.7%.

The male-to-female ratio of patients with ITs was 1:1.16, which is consistent with some previous estimates.[19,23] However, in a previous study[18] in the Korean population, the frequency of maxillary canine impaction was 1.5 higher in women than in men. This suggests that maxillary canine impactions may be genetically determined to some extent.

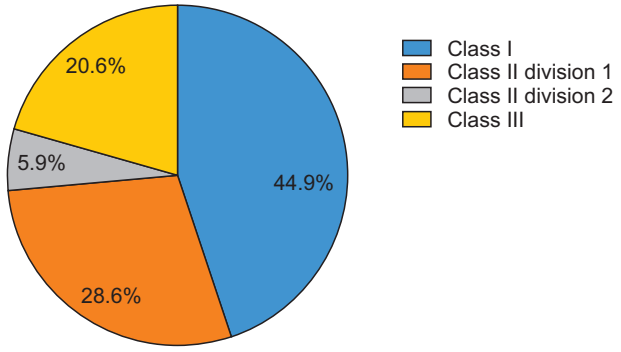

Figure 4. Skeletal anteroposterior malocclusion of patients with impacted teeth.

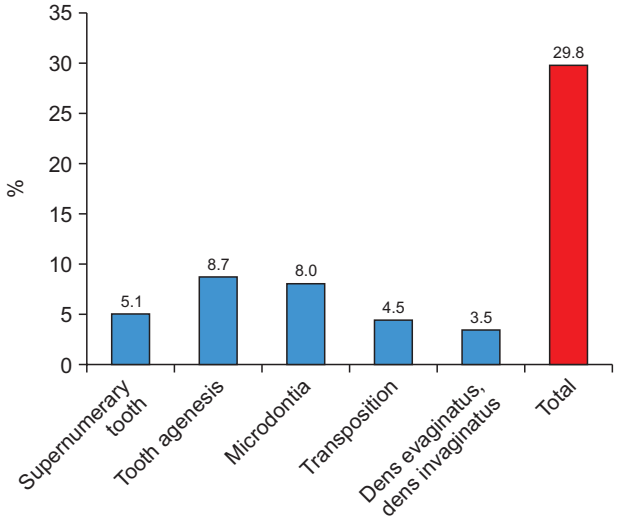

Figure 5. Other dental anomalies of patients with impacted teeth.

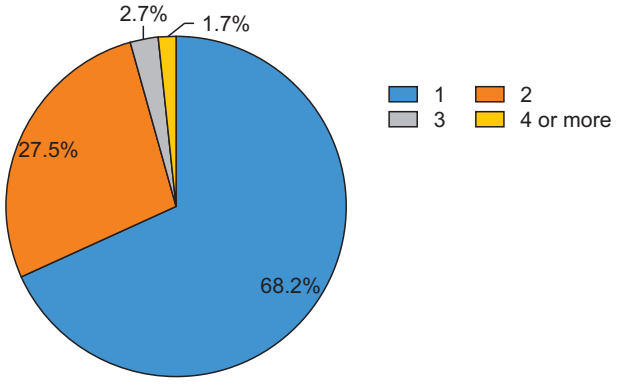

Figure 6. Number of impacted teeth per patient.

Table 6. Lateral incisor anomalies according to the buccolingual position of impacted maxillary canines

Buccolingual position	Labial	Mid-alveolus	Palatal	Total	Chi-square (*P* value)
Patients (n)	702	188	238	1,128	31.5 (< 0.001)
Lateral incisor's anomalies (n)	59	20	52	131	
Prevalence of lateral incisor anomalies (%)	8.4	10.6	21.8	11.6	

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Among pediatric patients, those aged 10–11 years were the most common. It is presumed that patients aged 10–11 years might be related to impacted maxillary canines, which accounted for the largest percentage of ITs.

There were approximately 3.1 times more patients with unilateral than bilateral IT. In a previous study[24] investigating maxillary canine impaction, 8% of the patients had bilateral impaction and 92% had unilateral impaction.

The left-to-right ratio of patients with unilateral IT was 1:1.1. A previous study[18] investigating maxillary canine impactions in Korea reported a similar ratio.

The maxillary canines were the most common ITs, whereas the mandibular central incisors were the least common. This is because maxillary canines are formed at the deepest position and have a long eruption path,[25] whereas mandibular central incisors are the first to erupt among permanent teeth and therefore exhibit fewer eruption obstacles. In a previous study[26] performed in a single dental hospital in Korea, the most commonly ITs were the maxillary canines, followed by the mandibular second premolars and the mandibular canines, which differs from the results of this study. In another study[11] targeting the general population of Italy, the order was the maxillary canines, maxillary lateral incisors, and maxillary central incisors.

The prevalence of maxillary canine impaction was 7.6%, which is higher than that reported in a previous study[27] targeting the general population (1–3%). This may be because the maxillary canines are aesthetically important, and many patients visit university dental hospitals for orthodontic treatment.

The percentage of maxillary impactions was approximately 2.7 times higher than that of mandibular impactions, similar to the results of other surveys.[23,28] This is probably because the maxilla includes the maxillary canine, which has the highest prevalence of ITs and a separate genetic pathway for the regulation of tooth growth.[29]

Labial maxillary canine impaction was approximately 2.9 times more common than palatal maxillary canine impaction. Similar results were obtained in a previous study[18] on the Korean population. However, in a Caucasian population, palatal maxillary canine impaction was approximately 2.0 times more common than labial maxillary canine impaction.[8] Genetic factors may also contribute to maxillary canine impaction.

Among patients with palatal maxillary canine impaction, the percentage of patients with lateral incisor anomalies was approximately 2.6 times higher than that in patients with labial maxillary canine impaction. These findings may support the guidance theory, which states that the etiology of palatal maxillary canine impaction involves abnormalities in the lateral incisors.[7]

An abnormal eruption path (46.5%) was the most common etiology, followed by lack of space (25.3%). In a previous study,[19] an abnormal eruption path (38.0%) was the most common etiology, followed by local lesions (35.0%).

Among the patients with ITs, 29.8% had other dental anomalies. A previous study[3] has also reported that patients with ITs have a high rate of other dental anomalies. It is possible that various dental anomalies are genetically linked.

The most common skeletal anteroposterior malocclusion in patients with ITs was Class I malocclusion (44.9%), followed by Class II division 1 malocclusion (28.6%) and Class III malocclusion (20.6%). Uslu et al.[16] reported that among patients with IT, Class II malocclusion was the least common, and Ku et al.[3] reported that among patients with IT, Class III malocclusion was the most common. However, the malocclusion patterns in the general population may differ from those observed in patients with ITs. In a previous study[30] of the general population aged 7–18 years in Seoul, 60.8% had Class I malocclusion, 16.7% had Class II division 1 malocclusion, and 19.0% had Class III malocclusions, respectively. A previous study[31] on orthodontic patients in Korea showed a distribution similar to that in this study. Because the definition of anteroposterior malocclusion may vary between studies, these findings should be interpreted with caution.

Of the patients with ITs, 50.8% exhibited complications such as cystic lesions, transposition, and root resorption, emphasizing the need for early detection and treatment of ITs. The most common complications were cystic lesions (18.3%). However, it is difficult to determine whether the cystic lesion in these cases was a complication of ITs or its etiology. Nevertheless, this result indicates that IT and cystic lesions often coexist.

The most common treatment option for ITs was orthodontic traction after surgical exposure (70.6%). In a previous study,[19] orthodontic traction was used in 46.1% of cases. These findings suggest that the use of orthodontic traction after surgical exposure has been increasing.

Because this study focused on orthodontic patients who visited university dental hospitals, the observed prevalence of ITs may differ from that in the general population. Nevertheless, these results are expected to be helpful in inferring the prevalence of ITs in the general population because many patients with ITs are referred to university dental hospitals. The results of this study provide guidance for the development of oral health policies. Yu et al.[32] indicated that periodic epidemiological investigations are needed, because orthodontic treatment reflects parameters that vary over time.

Additional research on the perception of ITs and satisfaction with orthodontic treatment from the perspective of patients is needed.

Understanding the prevalence and characteristics of health issues in certain populations is crucial for effective disease prevention. This can enable a precise diagnosis and early action. To our knowledge, this study is the first to provide information on the prevalence and characteristics of ITs in Korean orthodontic patients at university dental hospitals nationwide based on extremely high-quality data.

This study has some limitations. First, inter- and intra-investigator reliabilities were not assessed. However, since all investigators majored in orthodontics and a consensus was reached among many orthodontists, including residents and professors, during the orthodontic diagnostic process, the study results are likely to be reliable. Second, the study did not include other departments that patients with ITs visited, such as pediatric dentistry and oral and maxillofacial surgery. Finally, this study may have included many patients with severe ITs because many were referred from local dental clinics to university dental hospitals.

CONCLUSIONS

This study, which included 14,774 patients who visited the Department of Orthodontics at 10 university dental hospitals nationwide in Korea between 2020 and 2022 and underwent an examination for orthodontic diagnosis, yielded several key results.

1) The prevalence of ITs in Korean orthodontic patients at university dental hospitals was high, particularly in pediatric patients.
2) The most frequent ITs was the maxillary canine, followed by the mandibular second molar and maxillary second premolar.
3) As patients with ITs had a high rate of other dental anomalies, patients with dental anomalies need a thorough examination and regular checkup.
4) As patients with ITs have many complications, early detection of IT is necessary.
5) Maxillary canine impaction may be genetically determined.

AUTHOR CONTRIBUTIONS

Conceptualization: YKC, SHK, YIK, SSK, SBP. Data curation: DSC, HJK, KAK, MHL, SHC, SKC, KCL, YMJ, SO, SJ. Investigation: DSC, HJK, KAK, MHL, SHC, SKC, KCL, YMJ, SO, SJ. Methodology: YKC, SHK, YIK, SSK, SBP. Visualization: YKC, SHK, YIK, SSK, SBP. Writing–original draft: YKC, SHK, YIK, SSK, SBP. Writing–review & editing: YKC, SHK, YIK, SSK, SBP.

CONFLICTS OF INTEREST

No potential conflict of interest relevant to this article was reported.

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