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ORIGINAL RESEARCH

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Determination of the range of intervention timing for supernumerary teeth using the Korean health insurance review and assessment service database

Da Hyeo Jang[1], Yong Kwon Chae[2], Ko Eun Lee[2], Ok Hyung Nam[3], Hyo-Seol Lee[3], Sung Chul Choi[3], Mi Sun Kim[4,*]

[1]Department of Pediatric Dentistry, , Kyung Hee University Hospital at Gangdong, 05278 Seoul, Republic of Korea
[2]Department of Pediatric Dentistry, Kyung Hee University Medical Center, 02447 Seoul, Republic of Korea
[3]Department of Pediatric Dentistry, Kyung Hee University College of Dentistry, Kyung Hee University Medical Center, 02447 Seoul, Republic of Korea
[4]Department of Pediatric Dentistry, Kyung Hee University College of Dentistry, Kyung Hee University Hospital at Gangdong, 05278 Seoul, Republic of Korea

***Correspondence**
happystation@empal.com
(Mi Sun Kim)

Abstract

This study aimed to identify the frequency of complications during the diagnosis, observation, and treatment of supernumerary teeth or odontomas and evaluate the relationship between complications and the timing of surgical intervention. This study was conducted based on data from the Korea Health Insurance Review and Assessment Service between January 2008 and December 2019. A 2-year washout period was applied, and a follow-up period of at least 2 years was also included. During the observation period, the age at diagnosis of supernumerary teeth and odontomas was analyzed using major diagnostic codes, and the treatment codes were used to determine the interval between diagnosis and surgical intervention. The incidence rates of supernumerary teeth (1.21%) and odontomas (0.36%) were comparable to that reported in previous studies. The frequency of supernumerary teeth was the highest in the anterior region, followed by the premolar and molar regions. The average ages at diagnosis according to the location of the supernumerary teeth were 7.25, 13.98, and 16.11 years in the anterior, premolar, and molar regions, respectively. The age at diagnosis correlated with the maturity period of the teeth at the corresponding location. For the supernumerary tooth group, surgical intervention was more likely to occur when malocclusion ($p < 0.0001$) or tooth eruption disturbances ($p < 0.0001$) were present or dentigerous cysts were absent ($p = 0.006$). For the odontoma group, malocclusion ($p = 0.251$) was not correlated with surgical intervention. When tooth eruption disturbances ($p = 0.002$) and dentigerous cysts ($p < 0.0001$) were present, surgical intervention was more likely to occur. Pediatric dentists should conduct timely clinical checks and periodic follow-ups to prevent complications and unnecessary orthodontic treatments in patients with supernumerary teeth or odontomas.

Keywords

Supernumerary teeth; Odontoma; Surgical intervention; Optimal intervention timing; Complications

1. Introduction

Supernumerary teeth is a condition in which the number of teeth exceeds normal dentition. This phenomenon, also known as hyperdontia, occurs in various forms, locations, and numbers. Supernumerary teeth are categorized as conical, tuberculate, supplemental, and odontomas. Supernumerary teeth are twice as common in men than in women, with an incidence of 0.3%–0.8% in deciduous dentition and 1.5%–3.5% in permanent dentition [1–3].

If left undiagnosed or managed improperly, supernumerary teeth can have various pathological effects on the development of permanent teeth [4]. The presence of supernumerary teeth should be suspected if the eruption of permanent teeth is delayed, ectopic, or asymmetric [5]. Supernumerary teeth are mostly asymptomatic; however, they can cause complications such as cysts, root resorption of the adjacent teeth, eruption disturbances, and malocclusion [6, 7]. Treatment planning and intervention timing vary depending on the location, development stage, and presence or absence of associated complications. While the immediate removal of supernumerary teeth may pose harmful risks to the adjacent teeth, delayed intervention may result in the loss of the eruption potential of the adjacent permanent teeth and subsequent need for additional surgery and orthodontic treatment. Diagnosing supernumerary teeth early and accurately is essential to avoid orthodontic treatment and additional surgical options and reduce complications [8].

Supernumerary teeth are identified through routine clinical and radiographic examinations. Currently, the optimal time for the surgical removal of impacted supernumerary teeth is debated [4, 9]. Some researchers claim that immediate sur-

TABLE 1. Incidence of supernumerary tooth diagnostic codes according to sex.

SNT	K001		K0010		K0011		K0012		K0019		Total	
	n	%	n	%	n	%	n	%	n	%	n	%
Sex												
Male	15942	67.78	83700	71.75	4060	60.57	3096	51.85	16472	68.85	123270	69.73
Female	7579	32.22	32959	28.25	2643	39.43	2875	48.15	7454	31.15	53510	30.27
Total	23521		116659		6703		5971		23926		176780	

SNT: supernumerary tooth.

gical removal is necessary post-diagnosis to allow for the spontaneous eruption of permanent teeth and prevent potential surgical and orthodontic complications [10], whereas other researchers support a delayed approach to avoid iatrogenic damage to the adjacent developing teeth [11, 12]. Although no consensus has been reached regarding the ideal timing of the intervention, surgical removal of supernumerary teeth is recommended owing to the high possibility of complications if left untreated [5].

This study aimed to identify the frequency of complications during the diagnosis, observation, and treatment of supernumerary teeth and odontomas and evaluate the relationship between the increased risk of complications and appropriate interventions.

2. Materials and methods

The health insurance system in Korea operates as the medical insurance system for the entire nation, and the Korean Health Insurance Review and Assessment (KHIRA) service examines whether diagnoses, treatments, and medical claims are accurately imposed. During the study period, the average national health insurance enrollment rate of children aged 0–19 was >99%. Therefore, access to the KHIRA database allows for big data analyses.

All statements requested by dentists and dental hospitals to the KHIRA service are included in the KHIRA database. From January 2008 to December 2019, all statements of children (aged 0–19) diagnosed with major diagnostic codes K001-ST (impacted supplementary teeth), K0010-SNT (ant) (supernumerary teeth, anterior region), K0011-SNT (pre) (supernumerary teeth, premolar region), K0012-SNT (molar) (supernumerary teeth, molar region), K0019-SNT (unsp) (supernumerary teeth, unspecified), and K0025-Odont (dens invaginatus (dens in dente) (dilated odontoma) and incisor anomalies) were included. K001-ST was only used to register supernumerary tooth diagnoses until 2011 and was applied washout period for the first 2 years for statistical significance in this study. K0010-SNT (ant), K0011-SNT (pre), K0012-SNT (molar), and K0019-SNT (unsp) are diagnostic codes that were established in 2011; therefore, the washout period could not be included. A follow-up period of at least 2 years after diagnosis was included for all diagnostic codes. Currently, K0025-Odont is the only diagnostic code that can be applied for clinical diagnoses of odontoma in Korea; therefore, in this study, those with K0025-Odont diagnostic codes were considered to have been diagnosed with odontoma, regardless of the type. Similarly, a washout period of 2 years and a follow-up period of at least 2 years were applied for patients with diagnostic code K0025-Odont.

The timing of surgical intervention was analyzed based on various surgical indicators during the observation period. In Korea, the surgical treatment of supernumerary teeth or odontomas is covered by the Korea National Health Insurance. Therefore, a designated treatment code must be assigned when surgery is performed. To determine the timing of surgical intervention in this study, the treatment codes for supernumerary tooth or odontoma surgery, which included U4415 (impacted teeth (simple)), U4416 (impacted teeth (complex)), U4417 (complete impacted teeth (bone and teeth resection)), U4801 (benign maxillary neoplasm resection <3 cm), U4802 (benign maxillary neoplasm resection >3 cm), U4871 (benign mandibular neoplasm resection <1/3 of the mandibular body), U4872 (benign mandibular neoplasm resection >1/3 and <1/2 of the mandibular body), and U4873 (benign mandibular neoplasm resection >1/2 of the mandibular body) were used.

Since distinct classification systems are used to assign the diagnostic and treatment codes of supernumerary teeth and odontomas, they were analyzed separately. During the subsequent observation period, the following diagnostic codes were used to identify complications: K074 (malocclusion, unspecified), K0069 (disturbances in tooth eruption, unspecified), K0068 (other specified disturbances in tooth eruption), and K090.001 (dentigerous cyst). Patients who were diagnosed with supernumerary teeth or odontomas more than once were excluded because it was difficult to know which diagnosis the surgical intervention or complications were associated with because of constraints associated with using big data.

The significance level of all statistical methods was set at $p < 0.05$. The collected data were entered into a spreadsheet (MS Excel) and analyzed using IBM SPSS Statistics for Windows version 25.0.0 (IBM Corp., Armonk, NY, USA).

3. Results

Of the total number of children aged 0–19 years registered with the KHIRA service from 2008 to 2019 (14654400), 176780 and 5305 were diagnosed with supernumerary teeth and odontomas, respectively. For supernumerary teeth, the incidence and the male-to-female ratio were 1.21% and 2.2:1, respectively (Table 1), whereas those for odontomas were 0.36% and 1:1.03, respectively (Table 2).

Excluding cases with an unknown location (diagnostic codes K001-ST and K0019-SNT (unsp)), 116,659, 6703, and 5971

cases were diagnosed with supernumerary teeth in the anterior, premolar, and molar regions, respectively. The number of supernumerary teeth in the anterior region was 17–19 times higher than that in the premolar and molar regions. The average ages at diagnosis of supernumerary teeth in the anterior, premolar, and molar regions were approximately 7.25, 13.98, and 16.11 years, respectively (Tables 3 and 4).

TABLE 2. Incidence of odontoma according to sex.

Odontoma	K0025	
	n	%
Sex		
Male	2608	49.16
Female	2697	50.84
Total	5305	

In total, 34197 (19.34%) and 84 (1.52%) surgical interventions were performed in the supernumerary tooth group and odontoma group, respectively, during the observation period. In the supernumerary tooth group, surgical interventions were performed in 82.2% (n = 29768), 7.1% (n = 2420), and 2.9% (n = 992) of cases within 1, 2, and 3 years of diagnosis, respectively. For the supernumerary tooth group, the average intervals between diagnosis and treatment were 133.1, 96.9, and 46.0 days for the anterior, premolar, and molar regions, respectively. However, for cases with diagnostic codes K001-ST and K019-SNT (unsp), the average intervals between diagnosis and treatment were 26.3 and 74.2 days, respectively (Table 5). The mean interval between diagnosis and treatment for the odontoma group was 45.8 days, and 98.8% (n = 83) of cases received surgical treatment within 1 year (Table 6).

In the supernumerary tooth group, associated complications of dentigerous cysts, malocclusion, and tooth eruption disturbances were observed in 0.7% (n = 1283), 3.2% (n = 5705), and 7.9% (n = 14023) of the total cases, respectively. Surgical extraction was performed in 18.4% (n = 237) of the cases with dentigerous cysts, 28.0% (n = 1599) of those with malocclusion, and 26.5% (n = 3721) of those with tooth eruption disturbances. Surgical extractions were more likely to occur earlier when malocclusion ($p < 0.0001$) or tooth eruption disturbances ($p < 0.0001$) were present or when dentigerous cysts were absent ($p = 0.006$).

In the odontoma group, 1.4% (n = 76), 5.0% (n = 266), and 6.7% (n = 354) of the cases had dentigerous cysts, malocclusion, and tooth eruption disturbances, respectively. Surgical extractions were performed in 9.2% (n = 7), 0.8% (n = 2), and 3.7% (n = 13) of the patients with dentigerous cysts, malocclusion, and eruption disturbances, respectively. Therefore, in the odontoma group, surgery was more likely to occur earlier in the presence of tooth eruption disturbances ($p = 0.002$) and dentigerous cysts ($p < 0.0001$), whereas malocclusion did not have a significant effect on surgical intervention timing ($p = 0.251$, Table 7). All statistical analysis was done through a cumulative hazard test.

4. Discussion

Previous studies have reported 0.3%–0.8% and 1.5%–3.5% as the incidence rates of supernumerary teeth in deciduous dentition and permanent dentition, respectively [1, 13–15]. Although most of these studies have suggested that supernumerary teeth occur more frequently in men than in women at a ratio of 2:1 [1, 13, 14, 16–19], some authors have reported ratios ranging from 1.7:1 to 3.1:1 [7, 16, 17, 19, 20]. In our study, the incidence of supernumerary teeth was 1.21%, and the male-to-female ratio was 2.2:1, whereas the male-to-female ratio in the odontoma group was 1:1.03, suggesting no significant difference in the incidence according to sex. Since odontomas are a type of supernumerary tooth, this result suggests that the sex ratio may vary depending on the type of supernumerary tooth. To the best of our knowledge, this study included the largest patient cohort to date to assess supernumerary teeth and odontomas. Therefore, it is significant that the sex ratio and incidence of supernumerary teeth in this study were similar to those reported in previous studies. However, the incidence was somewhat lower in this study because this study included both primary and permanent dentition [1, 13–15].

Most previous studies have found supernumerary teeth most commonly in the anterior region, followed by the molar and premolar regions. According to Ranalli *et al.* [21], mesiodens represents 80% of supernumerary teeth. Antonappa *et al.* [22], Liu *et al.* [16], and de Oliveira Gomes *et al.* [6] reported that approximately 95% of supernumerary teeth are located in the maxillary anterior region, which is consistent with our finding of 90.2%. However, since children aged <19 years were targeted in this study, more cases of supernumerary teeth were identified in the premolar region than in the molar region. These results may have been affected by the finding that approximately a quarter of the total teeth analyzed (26.84%) had diagnostic codes with an unspecified location.

In this study, the age at diagnosis gradually increased from the anterior to the posterior region and was synchronous with the period of tooth maturation in the respective regions. Appropriate clinical and radiographic examinations are necessary for the detection of supernumerary teeth; thus, occlusal, periapical, and cone-beam computed tomography radiographs are important for diagnosing and distinguishing the location of supernumerary teeth [16, 23]. Since diagnosing supernumerary teeth early reduces additional treatments or complications, dentists should perform periodic clinical and radiographic examinations that correspond with tooth generation and maturation [24].

While radiographic examination results were not included in this study, clinicians must provide radiographic findings to diagnose patients with supernumerary teeth or odontomas and register them with the KHIRA service. If diagnoses do not include radiographic examinations, they removed the claim and statement. Therefore, it is safe to assume that all diagnoses registered in the KHIRA database have been confirmed by clinical and radiographic examinations.

No clear consensus has been reached regarding the optimal timing for the surgical removal of impacted supernumerary teeth [2]. Authors' opinions, especially with respect to the timing of the extraction, are mixed [25]. Surgery is recommended

TABLE 3. Average age at diagnosis according to the supernumerary tooth diagnostic code.

SNT	K001		K0010		K0011		K0012		K0019	
	n	SD	n	SD	n	SD	n	SD	n	SD
Age (years)	8.26	3.80	7.26	3.30	13.99	4.43	16.11	4.24	8.43	4.16

SNT: supernumerary tooth; SD: standard deviation.

TABLE 4. Average age at odontoma diagnosis.

Odontoma	K0025	
	n	SD
Age (years)	10.50	3.88

SD: standard deviation.

between ages 8 and 10 years, particularly if supernumerary teeth are located in the anterior maxillary region [20]. This is consistent with our study findings, as the average age at diagnosis for supernumerary teeth in the anterior region was 7.25 years, with 82.2% of cases treated within 1 year and >90% treated within 3 years.

Alternatively, the intervention can be deferred in cases in which supernumerary teeth do not cause complications or interfere with function or aesthetics [3]. This is consistent with our study findings, as approximately 20% of the patients in the supernumerary tooth group received surgical intervention during the observation period, whereas approximately 1.5% in the odontoma group received surgical intervention.

In most cases, surgery was performed within 100 days of diagnosis. If there is no indicator that surgery should be perform early, the observation period appears to be long.

Supernumerary teeth may be asymptomatic [16, 20] or have associated complications such as tooth impaction, delayed or ectopic eruption of adjacent teeth, space deficiency, eruption through the nasal cavity, root dilaceration, root malformation, and cystic changes [6, 7, 20]. The most common complication is delayed eruption, which is occasionally seen with crowding, diastema, and root dilaceration [26]. Bereket *et al.* [27] and Celikoglu *et al.* [28] have reported that 38.36% and 45.83% of supernumerary teeth, respectively, were associated with complications, the most common of which was eruption disturbances. Bereket *et al.* [27] observed cystic changes in 0.63% of patients, whereas Celikoglu *et al.* [28] did not observe cystic formation in their study. In another study, 25.1% of the supernumerary teeth showed eruption disturbances and 13.5% showed cystic changes [15]. In the present study, of the patients diagnosed with supernumerary teeth, 0.7%, 3.2%, and 7.9% also had dentigerous cysts, malocclusion, and eruption disturbances, respectively. In the odontoma group, 1.4% of cases had dentigerous cysts, 5.0% had malocclusion, and 6.7% had eruption disturbances. The observed rate of eruption disturbance was lower than that reported in earlier studies. This may be due to the fact that dentists neglected to register malocclusion cases that were not covered by health insurance, whereas other previous studies had more accurate diagnoses of malocclusion because they were mainly based on radiographic findings [6, 7, 20, 29]. Complications such as malocclusion and eruption disturbances have been reported at a significantly higher rate than cystic changes because surgery is performed before the onset of cystic changes. Diastema and tooth rotation have also been reported as common complications associated with supernumerary teeth [6, 29]. One of the main clinical implications of supernumerary teeth and odontomas is their tendency to interfere with the development of normal occlusion [17, 24, 30].

Patients who had been diagnosed with supernumerary tooth or odontoma more than once were excluded from this study because of the difficulty associated with accurately determining the interval between the diagnosis, development of complications, and surgical intervention. However, multiple supernumerary teeth very lately occurs in one individual, unless other related diseases or syndromes are present, such as cleidocranial dysplasia, Apert syndrome, Down syndrome, Crouzon syndrome, or Gardner syndrome [31]. Additionally, <1% of all cases involve three or more supernumerary teeth [32].

In the supernumerary tooth group, surgery was performed earlier when malocclusion or eruption disturbances were present or dentigerous cysts were absent because surgery was performed prior to the development of dentigerous cysts or surgical interventions were performed early to correct the malocclusion or eruption disorder. In the odontoma group, surgeries were also more earlier performed in cases with dentigerous cysts or eruption disturbances; however, malocclusion did not appear to have any significant effect on surgical decision-making. This finding can be attributed to the accompanying cystic changes that are characteristic of odontomas. Odontoma is often accompanied by eruption disturbances. If the odontoma, which is the cause of the eruption disorder, has been removed, additional malocclusion does not occur. The fact that there were very few cases (n = 2) is also important to note.

Asymptomatic supernumerary teeth are often identified through radiographic findings; thus, periodic follow-up and radiographic examinations are essential. Most supernumerary teeth are in the anterior region, but depending on the developmental stage of the teeth, they may appear in other areas. The use of orthopantomography to observe the developmental state of permanent teeth in mixed dentition and following up annually is recommended. In this study, radiologic findings were not reviewed. However, all supernumerary teeth and odontoma diagnosis included in the KHIRA system must have accompanying radiographic imaging. Nevertheless, complications, such as malocclusion, may have been underestimated because there is no radiographic examination. Although radiographs cannot be reviewed, the analysis of diagnosis and treatment can be seen as very accurate in big data analysis based on data from KHIRA. Therefore, in the future, various studies based on this are expected to have a significance influence on dentistry.

TABLE 5. Rate of operation according to the supernumerary tooth diagnostic codes.

SNT	K001		K0010		K0011		K0012		K0019		Total	
	n	%	n	%	n	%	n	%	n	%	n	%
Surgical treatment												
No	17959	76.35	93886	80.48	5898	87.99	5010	83.91	19830	82.88	142583	80.66
Yes	5562	23.65	22773	19.52	805	12.01	961	16.09	4096	17.12	34197	19.34
Total	23521		116659		6703		5971		23926		176780	
Time to operation (days)												
Mean	26.26		133.09		96.88		45.98		74.16			
SD	49.27		280.12		353.55		227.6		184.68			

SNT: supernumerary tooth; SD : standard deviation.

TABLE 6. Rate of operation for odontomas.

Odontoma	K0025	
	n	SD
Surgical treatment		
No	5221	98.42
Yes	84	1.58
Total	5305	
Time to operation (days)		
Mean	45.85	
SD	101.13	

SD: standard deviation.

TABLE 7. Presence or absence of complications at treatment time according to diagnosis.

Time to operation (within)	Total		Dentigerous cyst		Malocclusion		Eruption disturbances	
	SNT	Odontoma	SNT	Odontoma	SNT	Odontoma	SNT	Odontoma
None	126503	5221	1047	69	4106	264	10302	341
0–1 years	29768	83	208	6	1372	2	3109	12
1–2 years	2420	0	18	0	113	0	362	0
2–3 years	992	1	5	1	55	0	155	1
3–4 years	414		3		26		60	
4–5 years	189		1		19		24	
5–6 years	90		0		3		7	
6–7 years	39		0		3		2	
7–8 years	32		1		6		1	
8–9 years	18		0		2		1	
Total	160465	5305	1283	76	5705	266	14023	354

SNT: supernumerary tooth.

While the evidence remains inconclusive regarding the exact timing for surgical intervention of supernumerary teeth or odontomas, in this study, most clinicians postpone surgical treatment and follow-up when no specific complications are present. In other words, the presence of complications affects the likelihood of surgical intervention. Additionally, most interventions were performed within 1 year if complications were present and surgery was deemed appropriate. The results of this study provide reliable indicators of present practices that could aid in difficult clinical decision-making. In our study, big data were used to analyze diagnosis and complications, resulting in clinically meaningful results. A follow-up study is needed to provide accurate guidelines for the appropriate treatment timing of various diseases by studying more diverse diagnosis, complications, and treatment timing.

5. Conclusions

In this study we found that (1) supernumerary teeth are more common in boys than in girls, whereas odontomas do not appear to be associated with either sex and are frequently observed in the anterior part of the oral cavity. (2) The age at diagnosis of supernumerary teeth corresponds to the maturation of permanent teeth in the respective areas. (3) Surgical interventions for supernumerary teeth and odontomas are performed within a year of diagnosis or followed up over time in the absence of a surgical indication. (4) Finally, eruption disturbances, malocclusion, and dentigerous cysts are associated with early surgical treatment of impacted supernumerary teeth, and eruption disturbances and dentigerous cysts are associated with surgical treatment of odontomas, but malocclusion is not.

AUTHOR CONTRIBUTIONS

DHJ—wrote the manuscript. DHJ and MSK—designed the research study and draw the flow chart. DHJ, KEL and YKC—performed research. DHJ, SCC and OHN—analyzed data and make the table. OHN and HSL—provide help and advice on the study. All authors read and approved the final manuscript.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

All methods were carried out in accordance with relevant guideline and regulation under the Helsinki Declaration. This retrospective study was conducted using big data that was anonymously processed and stored by the Korea Health Insurance Review and Assessment Service. The exemption from the informed consent form was approved by Kyung Hee University Medical center IRB (Institutional Review Board).This study was conducted with the approval of the Clinical Research Ethics Committee of Kyung Hee University Medical Center at Gang-dong (IRB approval no. KHNMC 2021-05-002).

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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