Received: 21 September 2021 | Revised: 23 June 2022 | Accepted: 29 August 2022

DOI: 10.1111/cga.12493

ORIGINAL ARTICLE

Congenital Anomalies | WILEY

Imaging characteristics of the gubernaculum tracts in successional teeth related to deciduous fused teeth on computed tomography

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Abstract

The purpose of this study was to elucidate the imaging characteristics of the gubernaculum tracts in successional teeth related to fused deciduous teeth on computed tomography. The imaging findings of 15 gubernaculum tracts in successional teeth related to fused deciduous teeth were retrospectively analyzed using cone-beam computed tomography or multidetector computed tomography. In cases without a congenitally defected successor, the two gubernaculum tracts of two successional teeth related to fused deciduous teeth were fused into one. Gubernaculum tracts (GTs) in mesial successors were vertical, but in distal successors they were inclined to mesial. The major abnormalities of the successional teeth related to fused deciduous teeth were delayed eruption and delayed formation. No inclined mesial successors were found, whereas most of the distal successors were inclined to mesial along with the inclined GT. The gubernaculum tracts of successors with a congenital defect of the other successors were vertical, and such successors had no abnormalities. The present study showed the imaging characteristics of gubernaculum tracts in successional teeth related to fused deciduous teeth. The abnormal eruption of successional teeth related to fused deciduous teeth may be associated with the characteristics of their gubernaculum tracts.

KEYWORDS
CT, fused teeth, gubernaculum tract

1 | INTRODUCTION

The gubernaculum tract (GT) is a canal containing the gubernacular cord. It consists of a fibrous band that connects the pericoronal follicular tissue of the successional tooth with the overlying gingiva.[1] Therefore, normal eruption of a permanent tooth is often associated with a GT.

Recently, the imaging characteristics of GTs on cone-beam (CB) computed tomography (CT) or multidetector (MD) CT were first described and analyzed, since these modalities are now extensively used in dentistry.[2–10] The GTs in anterior permanent teeth are visualized as a low-density corticated tract contiguous from each dental follicle to the lingual/palatal site of each predecessor on CT images.[2] Previous studies suggested that the shapes and running paths of GTs on CT could predict

the normal eruption of the successional and accessional teeth.[2–10] Specifically, abnormalities of GTs such as bending or a mass lesion in a GT could obstruct the normal eruption of successors.[2–10]

Fused teeth are representative anomalies of deciduous teeth.[11–13] They tend to induce delayed eruption of the permanent successor teeth.[11,12] However, there has been little evidence to explain why a fused tooth directly induces delayed eruption of the permanent successor, and the causes are obscure and need to be evaluated. Therefore, we hypothesized that the GTs of successional teeth related to fused deciduous teeth have patterns of GT that induce delayed eruption. In the present study, the CT imaging characteristics of the GTs in successional teeth related to fused deciduous teeth were analyzed.

2 | MATERIALS AND METHODS

A retrospective search through the picture archiving and communication system (PACS) of the Division of Oral and Maxillofacial Radiology of Kyushu Dental University Hospital was performed to identify patients less than 10 years old with fused deciduous teeth between

TABLE 1 Distribution of the types of deciduous fused teeth included and excluded in the present CT assessment

	Number of patients					
	Included in the present CT assessment			Excluded from the present CT assessment		
Fused deciduous teeth	Male	Female	Total	Male	Female	Total
UCI and ULI	6	2	8	-	-	-
LCI and LLI	1	1	2	2	-	2
LLI and LC	2	3	5	8	2	10
Total	9	6	15	10	2	12

Abbreviations: LC, lower canine; LCI, lower central incisor; LLI, lower lateral incisor; UCI, upper central incisor; ULI, upper lateral incisor.

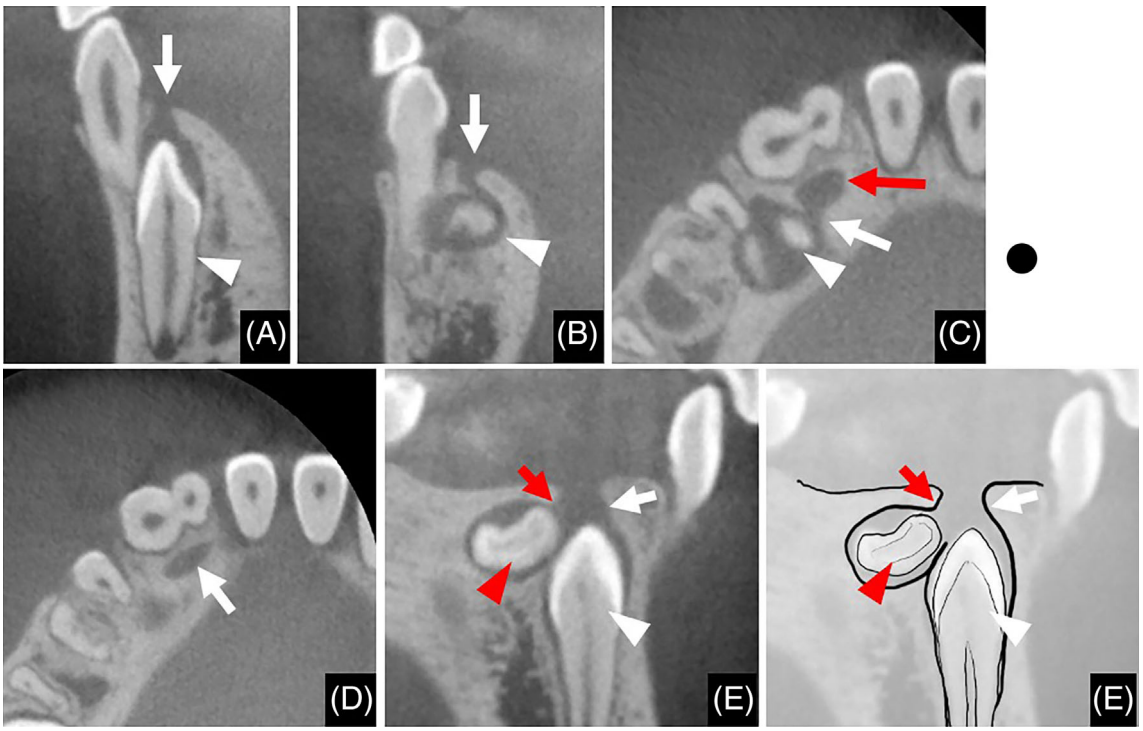

FIGURE 1 Representative cone-beam computed tomography (CBCT) images of gubernaculum tracts (GTs) of the mandibular lateral incisor and canine related to fused deciduous predecessors. (A) The cross-sectional image of the GT (arrow) of the lateral incisor (arrowhead). The running path of the GT is vertical and straight from the tooth to the alveolar top. (B) The cross-sectional image of the GT (arrow) of the canine (arrowhead). The GT of the canine is bent. (C) The axial image of the GTs. The GT (arrow) of the canine (arrowhead) merges to the GT (red arrow) of the lateral incisor. (D) The axial image of the opening level of the GT. The opening area of the GT (arrow) is larger in the mesiodistal direction. (E,F) The panoramic image (E) and traced drawing (F) of the GTs of the lateral incisor and canine. The GT (arrows) of the lateral incisor (arrowheads) runs vertical. The GT (red arrows) of the canine (red arrowheads) is directed mesial and merged to the GT of the lateral incisor.

January 2010 and March 2021. Twenty-six patients (18 boys, 8 girls; mean age, 6.58 years; range, 4–9 years) with fused deciduous anterior teeth of 1163 patients (782 boys, 381 girls; mean age, 7.01 years; range, 1–9 years) were identified on multidetector computed tomography (MDCT), cone-beam computed tomography (CBCT), intraoral x-ray radiographs, and panoramic radiographs. Twenty-five patients had one fused deciduous tooth, and one patient had two fused deciduous teeth. Eight of 27 teeth were excluded because the successors of the fused deciduous anterior teeth were out of the imaging area of CT examinations. In addition, four teeth were excluded because the GTs of the successors were not observed due to eruption of the successors. This retrospective study was based on the findings of 8 MDCT and 7 CBCT images of the remaining 15 fused deciduous anterior teeth with unerupted permanent successors. Eight fused teeth were identified as incidental findings on CT examinations for trauma, periapical periodontitis, and impacted supernumerary teeth of other regions. The other seven CT examinations were performed as preoperative examinations for traction. The study protocol was approved by the institutional review board (IRB) of Kyushu Dental University (No. 20-30), which waived the requirement for informed consent, including patients' informed consent, based on the retrospective nature of the study.

Intraoral radiographs were acquired using a dental x-ray machine (Morita Co. Ltd., Kyoto, Japan). Panoramic radiographs were acquired using a panoramic AUTO-100EXR system (Asahi Roentgen Ind. Co., Ltd., Kyoto, Japan). Images were taken in the incisive occlusion position holding the head by an ear rod with the FH plane parallel to the ground. MDCT was performed with an Activion 16 (Toshiba Co. Ltd., Tokyo, Japan). MDCT images were taken in the axial plane with 0.3-mm-thick contiguous sections from the base of the maxilla to the base of the mandible. Images were obtained with standard algorithms and bone-target windows. CBCT was performed with a 3DX (Morita Co. Ltd., Kyoto, Japan). CBCT images were taken as volume data with 0.08-mm-thick slices around the maxilla and mandible. All CT images were analyzed using a PC-based, digital viewing system (Ziostation 2, Ziosoft,

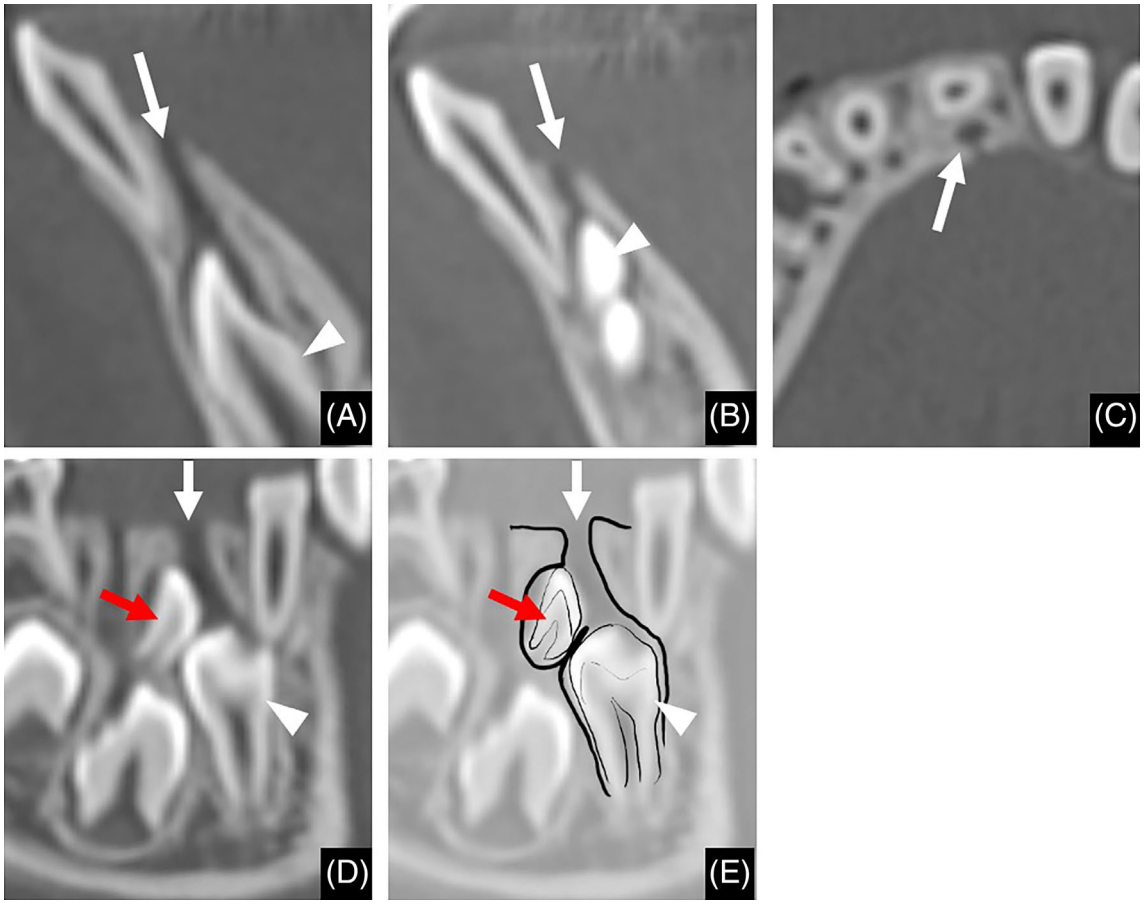

FIGURE 2 Representative multidetector computed tomography (MDCT) images of gubernaculum tracts (GTs) of the mandibular central incisor and lateral incisor related to fused deciduous predecessors. (A) The cross-sectional image of the GT (arrow) of the central incisor (arrowhead). The running path of the GT is vertical and straight from the tooth to the alveolar top. (B) The cross-sectional image of the GT (arrow) of the lateral incisor (arrowhead). (C) The axial image of the opening level of the GT. Only one GT opening (arrow) is identified. No significant enlargement of the opening area of the GT (arrow) is observed. (D,E) The panoramic image (B) and traced drawing (C) of the GTs of the central incisor and lateral incisor. Only one GT (arrows) continuing from the mandibular incisor (arrowheads) and lateral incisor (red arrows) to the top of the alveolar top is identified

Tokyo, Japan). This analysis was performed with multiplanar reconstruction methods that allow the selection of appropriate slices, such as axial, panoramic, or sagittal slices, for comparison of images and for changing the gray scale level in the images.

GTs in successional teeth related to fused deciduous teeth were carefully evaluated on CBCT or MDCT. In detail, the presence or absence and the shape of the GTs in unerupted permanent successors related to deciduous fused teeth were evaluated in the respective teeth on CBCT or MDCT. The images were assessed by a single, experienced, oral and maxillofacial radiologist (O. M.). At the same time, the status of the unerupted permanent successors related to fused deciduous teeth was also evaluated by an experienced oral and maxillofacial radiologist (O. M.) and experienced pediatric dentist (N.I.). In detail, delayed eruption, delayed formation, microdontia, congenital defects, inclination, displacement, and rotation were evaluated. At the discretion of an experienced pediatric dentist, these images were comprehensively evaluated based on the normal eruption/formation period, on the basis of left–right asymmetry of the same teeth, in comparison with other teeth, and/or over 1 standard deviation (*SD*) of the age of each tooth's eruption/formation.[14–17]

3 | RESULTS

3.1 | Distributions of fused deciduous teeth and the related successional teeth

There were 26 patients with one or two fused deciduous teeth in 1163 children (2.24%). The occurrence rate was 2.3% (18/782) in boys and 2.1% (8/381) in girls, with no significant difference (Fisher's exact test, $p = 1.00$). There were 8 patients with deciduous fused teeth of the upper central incisor (UCI) and upper lateral incisor (ULI) (0.68%). The occurrence rate was 0.77% (6/782) in boys and 0.52% (2/381) in girls, with no significant difference (Fisher's exact test, $p = 1.00$). There were 4 patients with deciduous fused teeth of the lower central incisor (LCI) and lower lateral incisor (LLI) (0.34%). The occurrence rate was 0.38% (3/782) in boys and 0.26% (1/381) in girls, with no significant difference (Fisher's exact test, $p = 1.00$). Fourteen patients had deciduous fused teeth of the LLI and the lower canine (LC) (1.29%). One of the patients had bilateral deciduous fused teeth of the LLI and the LC (0.09%). The occurrence rate was 1.28% (10/782) in boys and 1.31% (5/381) in girls, with no significant difference (Fisher's exact test, $p = 1.00$). No other types of fused deciduous teeth were found in the previous study. The types of fused deciduous teeth included and excluded in the present CT assessment as the next step are shown in Table 1.

3.2 | Imaging characteristics of GTs in successional teeth related to fused deciduous teeth on CT

In cases without a congenitally defected successor, the two GTs of two successional teeth related to fused deciduous teeth were fused into one. GTs in mesial successors were vertical, but in distal successors, they were inclined to mesial. The representative CT images of the GTs of the mandibular lateral incisor and canine related to fused deciduous teeth that involved fusion of the mandibular deciduous lateral incisor and canine are shown in Figure 1. The GTs of the successors related to the mandibular fused deciduous lateral incisor and canine were observed as a corticated tract of low density contiguous from the dental follicle of the unerupted mandibular lateral incisor and canine. The running path of the GT of the lateral incisor was vertical and straight from the tooth to the top of the alveolar bone on the panoramic section and cross-sectional image. However, the GT of the canine inclined mesially on the panoramic section and bent on the cross-sectional image. The GTs of the lateral incisor and canine merged under the level of the opening to the alveolar top. The opening area of the GT was larger in the mesiodistal direction than of the GT of the lateral incisor or canine without an abnormality.

The CT images of the GTs of the mandibular incisor and lateral incisor related to a fused deciduous predecessor in the other case are shown in Figure 2. A single GT continuing from the mandibular incisor and lateral incisor to the top of the alveolar top was identified. No significant magnification of the opening was observed in this case.

The representative CT images of the GTs of the maxillary incisor and lateral incisor related to fused deciduous predecessors are

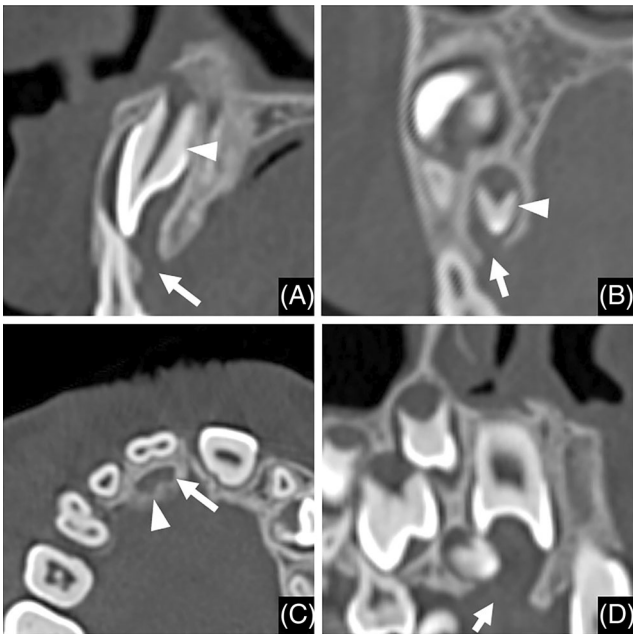

FIGURE 3 Representative multidetector computed tomography (MDCT) images of the gubernaculum tracts (GTs) of the maxillary central incisor and lateral incisor related to fused deciduous predecessors. (A) The cross-sectional image of the GT (arrow) of the central incisor (arrowhead). The running path of the GT is vertical and straight from the tooth to the alveolar top. (B) The cross-sectional image of the GT (arrow) of the lateral incisor (arrowhead). (C) The axial image of the opening level of the GT. The GTs of the central incisor (arrow) and lateral incisor (arrowhead) are partially merged, and the opening at the alveolar top is pear-shaped. (D) The panoramic image of the GTs of the central incisor and lateral incisor. The GTs (arrows) of the central incisor and lateral incisor are merged

shown in Figure 3. The GTs of the maxillary incisor and lateral incisor were partially merged, and the opening at the alveolar top was pear-shaped.

The GTs of successors with a congenital defect of the other successors were vertical, and such successors had no abnormalities. Representative CT images of the GT of the mandibular canine related to fused deciduous lateral incisor and deciduous canine with a congenital defect of the permanent lateral incisor are shown in Figure 4. The running path of the GT of the canine was normal, but enlarged.

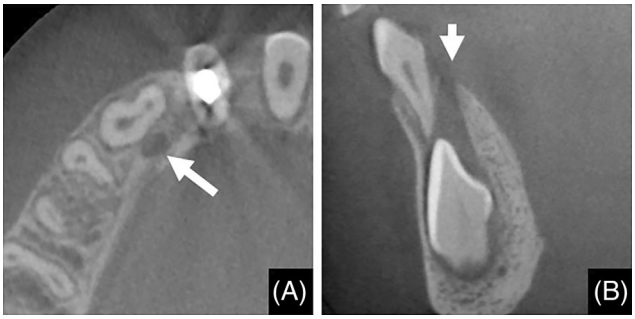

FIGURE 4 Representative cone-beam computed tomography (CBCT) images of the gubernaculum tract (GT) of the mandibular canine related to fused deciduous predecessors with a congenital defect of the permanent lateral incisor. (A) The axial image of the opening level of the GT. The GT of the canine (arrow) is enlarged. (B) The cross-sectional image of the GT. The running path of the GT of the canine (arrow) is normal, but enlarged

Fusion of the GTs was observed in all 10 cases with no congenital defect of successor teeth. All of the running paths of the GTs of mesial successors were vertical, but the GTs of the distal successors were inclined mesially. Enlargement of the GTs was detected in 11 of 15 cases. A pear-shaped opening of the GTs was seen in seven cases, and all of them were cases related to fusion of a maxillary deciduous central incisor and lateral incisor.

3.3 | Status of successional teeth related to fused deciduous teeth on CT

The statuses of 30 successional teeth including five congenital defects related to fused deciduous teeth are shown in Table 2. Regarding the eruption of successional teeth related to fused deciduous teeth, 14 successional teeth of a fused UCI and ULI, 2 successional teeth of a fused LCI and LLI, and 2 successional teeth of a fused LLI and LC tended to be impacted, based on the comparison with the same kind of tooth on the opposite site. Delayed tooth formation was detected in 13 successional teeth of a fused UCI and ULI, 2 successional teeth of a fused LCI and LLI, and 2 successional teeth of a fused LLI and LC. Delayed eruption and delayed formation were detected in mesial and distal successors with a high abnormality. Inclinations were detected in 6 successional teeth of a fused UCI and ULI, 1 successional tooth of a fused LCI and LLI, and 1 successional tooth of a fused LLI and LC. Seven successors inclined mesially along with the inclined GT, and one inclined lingually. Microdontia was detected in 6 successional

TABLE 2 Distributions of the abnormalities of successional teeth related to deciduous fused teeth

		Mesial successors		Distal successors	
Fused deciduous teeth	**Abnormality of the successors**	**Number of teeth**	**Rate (%)**	**Number of teeth**	**Rate (%)**
UCI and ULI ($n = 8$)					
	Delayed eruption	7	87.5	7	87.5
	Delayed formation	7	87.5	6	75.0
	Inclination (mesial)	-	-	6	75.0
	Microdontia	-	-	6	75.0
	Displacement (distal)	-	-	1	12.5
	Rotated tooth	1	12.5	-	-
	Congenital defect	-	-	1	12.5
LCI and LLI ($n = 2$)					
	Delayed eruption	1	50.0	1	50.0
	Delayed formation	1	50.0	1	50.0
	Inclination (mesial)	-	-	1	50.0
LLI and LC ($n = 5$)					
	Delayed eruption	1	20.0	1	20.0
	Delayed formation	1	20.0	1	20.0
	Inclination (lingual)	-	-	1	20.0
	Microdontia	-	-	1	20.0
	Congenital defect	4	80.0	-	-

Abbreviations: LC, lower canine; LCI, lower central incisor; LLI, lower lateral incisor; UCI, upper central incisor; ULI, upper lateral incisor.

TABLE 3 Relationship between with or without congenital defects of successors and presence of abnormalities

	Number of teeth		
	Normal	Abnormal	Abnormal rate (%)
Case without congenital defect of successors	2	18	90.0
Partner of congenitally defected successors	5	-	0.0

teeth of a fused UCI and ULI, and 1 successional tooth of a fused LLI and LC. All inclinations and microdontia were detected in distal successors. Apart from that, 1 displacement to distal and 1 rotated tooth were detected.

Five of 30 successors were congenitally defected. The relationships between with and without congenital defects of successors and the existence of abnormalities in 25 successional teeth excluding 5 congenital defects are shown in Table 3. Regarding 20 successors in cases without congenital defects of successors, 18 successors were judged to be "abnormal." Two successors in cases without congenital defects of successors were judged to be "normal," and those were a pair set of successors in one patient. For all five successors, the partners of the congenitally defected successors were considered "normal."

4 | DISCUSSION

Until recently, the GT could not receive adequate attention in dental fields including pediatric dentistry and oral and maxillofacial radiology. Before the extensive use of CBCT or MDCT in dentistry, GTs would be seen as very thin and round radiolucent structures and be very difficult to visualize on two-dimensional radiographs such as dental and panoramic radiographs.[2,3,6,7] In addition, the majority of dentists are interested only in tooth-related or alveolar bone-related diseases, and not normal structures such as the GT.[2–8] However, rapid and extensive attention to radiological analysis of GTs is needed because previous reports showed that abnormal eruption of a permanent tooth and the origin of odontogenic masses appear to be associated with a GT.[2–5] Fused deciduous teeth are among the representative anomalies of teeth, and they are related to abnormal eruption of the permanent successor teeth.[11,12] Therefore, we hypothesized that GTs in successional teeth related to fused deciduous teeth could have specific characteristics that would induce impacted and/or delayed eruption. In the present study, CT imaging characteristics of GTs in successional teeth related to fused deciduous teeth were analyzed. The most interesting result of the present study is that the GTs of two successional teeth related to fused deciduous teeth became fused on MDCT and CBCT. To our surprise, fusion of GTs could be visualized in all cases without a congenital defect of successor teeth in the present study. The present investigation is the first to demonstrate the imaging characteristics of the GTs of successional teeth related to fused deciduous teeth.

There have been many reports that the presence of deciduous fused teeth could cause delayed and impacted eruption of the permanent successor teeth.[11–13] Interestingly, the GTs in mesial successors run vertically, and the GTs in distal successors were inclined to mesial. The mesial successors were not inclined, and the distal successors inclined mesially along with the inclined GT. Simultaneously, delayed tooth formation, such as delayed crown formation and root formation, was detected at the same rate in successional teeth. The tendency to impaction or delayed eruption of successors related to fused deciduous teeth may be caused by the fusion of GTs that are involved in eruption guidance. One of the causes of impaction or delayed eruption of successors may have been that two successors collided with each other in the middle of eruption, because eruption guidance fused to one. This is based on the result that the GTs of successor teeth with a congenital defect of the other successor teeth were vertical, and such successors were considered "normal." However, we cannot explain the cause of the delayed tooth formation from the perspective of fused GTs. More histopathological research is needed to answer these questions.

There have been no reports of the formative cause of specific GTs. However, it has been reported that the causes of fused deciduous teeth might be physical force or pressure from the follicles of adjacent teeth, hereditary conditions at the local site, and/or contiguity between two dental sacs.[12,18,19] A possible explanation is that one of the causes of fused teeth might also cause the fusion of GTs in two successor teeth. Unexpectedly, non-fusion GTs in successional teeth related to deciduous fused teeth were not observed. If such cases did exist, the GTs of successors might be vertical. The appropriate explanation for such cases could not be determined. In the present study, the occurrence rates of fused deciduous teeth and abnormalities of successors were higher than in previous studies.[11–13,20,21] Of course, the patients involved in the present study could be biased because the present study was retrospective, and 7 of 15 patients involved in this study had a clinical need for CT examinations for fused tooth sites. If the GTs of all successional teeth related to fused deciduous teeth of cases that did not require CT examinations clinically would be analyzed clinically and pathologically, an as yet unknown formative mechanism for the fusion of GTs and/or fused deciduous teeth might be discovered. We expect that many more reports of the structure will be published in the future. The present study demonstrated that the abnormality in the GTs of the successional teeth related to fused deciduous teeth would obstruct the normal eruption of teeth.

Why is this very characteristic imaging finding of GTs in successional teeth related to fused deciduous teeth often overlooked? This could probably be due to the lack of attention given to the GT in the dental field, especially pediatric dentistry and oral and maxillofacial radiology, so far, despite its important role in tooth eruption, as mentioned above.[2–13,22,23] Most dentists are perhaps only interested in tooth-related or alveolar-related diseases, and not in normal structures such as the GT. Another reason might be that the GTs could not always be visualized as radiolucent tracts on panoramic and dental

radiographs. Dentists must pay more attention to the GT, and we expect many more reports on this structure in the future.

The present study had some limitations. First of all, the present study was a retrospective study including patients with a clinical need for CT examinations of fused tooth sites, as mentioned above. Therefore, prominent abnormal successional teeth, such as disturbed eruption, might have been limited in the present sample. However, the imaging characteristics of GTs in successional teeth related to fused deciduous teeth on CT were elucidated for the first time. In addition, based on the present data, dentists must pay more attention to the relationships between abnormal successional teeth related to fused teeth and the GTs of fused teeth, and we expect that many more reports of the structure will be published in the future. Second, it was not possible to analyze the pathological findings of fused teeth and GTs because this was a retrospective study. Third, the present study was a retrospective study of patients with a clinical need for CT examinations, as mentioned above. A further limitation of this study was that only Japanese subjects were examined.

The present study showed the CT imaging characteristics of GTs in successional teeth related to fused deciduous teeth. The abnormalities of successional teeth related to fused deciduous teeth may be associated with the characteristics of their GTs.

ACKNOWLEDGMENTS

Permission has been obtained from the patients for presentation of the MDCT and CBCT images. The authors received no financial support for the research, authorship, and/or publication of this article.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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REFERENCES

1. Carollo DA, Hoffman RL, Brodie AG. Histology and function of the dental gubernacular cord. *Angle Orthod*. 1971;41(4):300-307.
2. Nishida I, Oda M, Tanaka T, et al. Detection and imaging characteristics of the gubernacular tract in children on cone beam and multidetector CT. *Oral Surg Oral Med Oral Pathol Oral Radiol*. 2015;120(2):e109-e117.
3. Oda M, Nishida I, Miyamoto I, et al. Characteristics of the gubernaculum tracts in mesiodens and maxillary anterior teeth with delayed eruption on MDCT and CBCT. *Oral Surg Oral Med Oral Pathol Oral Radiol*. 2016;122(4):511-516.
4. Oda M, Miyamoto I, Nishida I, et al. A spatial association between odontomas and the gubernaculum tracts. *Oral Surg Oral Med Oral Pathol Oral Radiol*. 2016;121(1):91-95.
5. Oda M, Nishida I, Miyamoto I, et al. Significance and usefulness of imaging characteristics of gubernaculum tracts for the diagnosis of odontogenic tumors or cysts. *PLoS ONE*. 2018;13(7):e0199285.
6. Caudhry A, Sobti G. Imaging characteristics of gubernacular tract on CBCT—a pictorial review. *Oral Radiol*. 2021;37(3):355-365.
7. Gaeta-Araujo H, da Silva MB, Tirapelli C, Freitas DQ, de Oliveira-Santos C. Detection of gubernacular canal and its attachment to the dental follicle may indicate an abnormal eruption status. *Angle Orthod*. 2019;89(5):781-787.
8. Koc N, Boyacioglu Dogru H, Cagirankaya LB, Dural S, van der Stelt PF. CBCT assessment of gubernacular canals in relation to eruption disturbance and pathologic condition associated with impacted/unerupted teeth. *Oral Surgery, Oral Medicine, Oral Pathology and Oral Radiology*. 2019;127(2):175-184.
9. Cavalcante DS, Fonteles CSR, Ribeiro T, et al. Mandibular regional odontodysplasia in an 8-year-old boy showing teeth disorders, gubernaculum tracts, and altered bone fractal pattern. *Int J Clin Pediatr Dent*. 2018;11(2):128-134.
10. Kamarthi N, Gupta D, Gotur SP. Radiographic demonstration of association of gubernaculum dentis (gubernaculum tract) in odontogenic cysts and tumors—a CBCT finding. *Indian J Radiol Imaging*. 2020;30(3):340-343.
11. Aydinbelge M, Sekerci AE, Caliskan S, Gumus H, Sisman Y, Cantekin K. Clinical and radiographic evaluation of double teeth in primary dentition and associated anomalies in the permanent successors. *Niger J Clin Pract*. 2017;20(7):847-851.
12. Acikel H, Lbis S, Tunc ES. Primary fused teeth and findings in permanent dentition. *Med Princ Pract*. 2018;27(2):129-132.
13. Lochib S, Indushekar KR, Saraf BG, Sheoran N, Sardana D. Occlusal characteristics and prevalence of associated dental anomalies in the primary dentition. *J Epidemiol Glob Health*. 2015;5(2):151-157.
14. Arita K, Abe Y, Nakano K. Chronology of deciduous and permanent dentition in Japanese children II. Part 2: permanent dentition. *Jpn J Ped Dent*. 2019;57(3):363-373.
15. Moorrees CF, Fanning EA, Hunt EE Jr. Age variation of formation stages for ten permanent teeth. *J Dent Res*. 1963;42:1490-1502.
16. Nouri M, Hosseini SK, Asefi S, Abdi AH, Bagheban AA. Three-dimensional measurement of tooth inclination: a longitudinal study. *Dent Res J (Isfahan)*. 2019;16(4):225-232.
17. The Japanese Society of Pediatric Dentistry. *Pediatric Dentistry Glossary 2019*. Ishiyaku Publishers Inc.; 2019 pp. 63, 75, 93, 103.
18. Santos LM, Forte FSD, Rocha MJC. Pulp therapy in maxillary fused primary central and lateral incisor: a case report. *Int J Paediatr Dent*. 2003;13(4):274-278.
19. Duncan WK, Helpin ML. Bilateral fusion and gemination: a literature analysis and case report. *Oral Surg Oral Med Oral Pathol*. 1987;64(1):82-87.
20. Tsujino K, Yonezu T, Shintani S. Effects of different combinations of fused primary teeth on eruption of the permanent successors. *Pediatr Dent*. 2013;35(2):64-67.
21. Zengin AZ, Celenk P, Gunduz K, Canger M. Primary double teeth and their effect on permanent successors. *Eur J Paediatr Dent*. 2014;15(3):309-312.
22. Koenig LJ. Gubernaculum dentis. In: Koenig LJ, Tamimi D, Harnsberger HR, et al., eds. *Diagnostic Imaging Oral and Maxillofacial*. Amirsys; 2012:II.1.58-II.1.59.
23. Ide F, Mishima K, Kikuchi K, et al. Development and growth of adenomatoid odontogenic tumor related to formation and eruption of teeth. *Head Neck Pathol*. 2011;5(2):123-132.

How to cite this article: Oda M, Nishida I, Saeki K, et al. Imaging characteristics of the gubernaculum tracts in successional teeth related to deciduous fused teeth on computed tomography. *Congenit Anom*. 2022;62(6):241-247. doi:10.1111/cga.12493