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Evaluation of gubernacular tract with cone beam computed tomography in impacted supernumerary teeth

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SUMMARY

The gubernacular canal or gubernacular tract is filled by the gubernacular cord, which includes fibrous connective tissue containing peripheral nerves, blood and lymphatic ducts besides the epithelial cells from the fragmented dental laminae, including epithelial growth factor. The purpose of this study was to evaluate the gubernacular tract in unerupted supernumerary teeth by cone beam computed tomography. Sixty-four unerupted supernumerary teeth were selected from 44 patients (21 females, 23 males, 12-68 years). Gubernacular tract characteristics were evaluated in five different groups: No alteration, bending of gubernacular tract, contraction of gubernacular tract, obliterations of gubernacular tract, difference between erupted direction. Unerupted supernumerary teeth were classified according to their position. The presence and characteristics of the gubernacular tract in the supernumerary teeth were evaluated by cone beam computed tomography.

In our study, the frequency of the gubernacular tract was found to be 31.7%. There was no significant difference between the presence of gubernacular tract and gender, age and gubernacular tract characteristics. It was found that gubernacular tract characteristics did not change according to gender, quadrant, age and unerupted positions. Cone beam computed tomography is an efficient method for the evaluation of the gubernacular tract in unerupted supernumerary teeth. Conducting these studies in larger populations will provide more detailed information about the prognosis of impacted supernumerary teeth.

Key words: Cone beam computed tomography – Gubernacular canal – Gubernacular tract – Supernumerary teeth

INTRODUCTION

Dental development in humans is a complex process also called tooth morphogenesis or odontogenesis. This process begins when the embryo is six weeks old. Teeth are formed as a result of reciprocal signals occurring between the epithelium and mesenchyme originating from the neural crest (Thesleff, 2000; Bei, 2009).

Tooth eruption is a complex and multifactorial growth process. This process refers to the transition of teeth from a non-functional position in the bone to a functional position in the dental arch. A better understanding of the eruption process and potential eruption deviations significantly affects the orthodontic treatment process and treatment options. There are theories explaining the path of

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eruption in the literature. However, none of these theories have been able to explain the eruption process alone, and this indicates that the eruption is the result of multifactorial mechanisms (Massler and Schour, 1941; Cahill and Marks, 1980; Shroff and Siegel, 2000).

The gubernacular cord is a conjunctive tissue structure that connects the dental follicle to the gingiva, and guides the process of tooth eruption. The formation of this structure begins from the residual cells of the tooth lamina, leaving the decreased epithelium of the enamel toward the oral mucosa. The gubernacular canal or gubernacular tract (GT) is filled by the gubernacular cord, which includes fibrous connective tissue containing peripheral nerves, blood and lymphatic ducts besides the epithelial cells from the fragmented dental laminae, including epithelial growth factor (Philipsen and Reichart, 2004). There are few studies in the literature about gubernacular cord and tract, and there are studies on its role in dental eruption (Cahill, 1974; Ferreira et al., 2013). Malassez was the first to associate the dental follicle with the process of tooth eruption by describing the histology of the gubernaculum dentis and the epithelial residue of the dental lamina (Shroff and Siegel, 2000).

Although the etiology of supernumerary teeth is not known, it can be as an incidental finding of intraoral and radiologic examination. If these teeth remain unerupted, many problems such as resorption, pathologies and malocclusion of the teeth in the region can be observed (Garvey et al., 1999). This condition increases the importance of understanding the eruption pathways of the supernumerary teeth.

Cone beam computed tomography (CBCT) is one of the most reliable and useful imaging modalities in maxilla and mandible examination including teeth. The use of CBCT in dentistry has increased over the last decade due to its many advantages such as high bone resolution, low radiation dose, ease of use and accessibility (Scarfe et al., 2006; Kumar et al., 2015). Considering these benefits, GT can be evaluated by CBCT.

The purpose of this study was to evaluate the GT in unerupted supernumerary teeth by CBCT.

METHODS

Patient selection

Patients were randomly selected from our radiographic follow-up database. This retrospective study adhered to all relevant principles of the Declaration of Helsinki. In 2016 and 2017, 64 unerupted supernumerary teeth were selected from 44 patients 63 teeth (21 females, 23 males, 12-68 years) who underwent CBCT for GT. The Clinical Research Ethics Committee of the Eskisehir Osmangazi University Faculty of Medicine approved the study (approval no. 25; July 23, 2019). No patient had any known syndrome or any history of neurological disease or surgical intervention in the region of interest. Written informed consent was obtained from all patients or their legal guardians prior to CBCT.

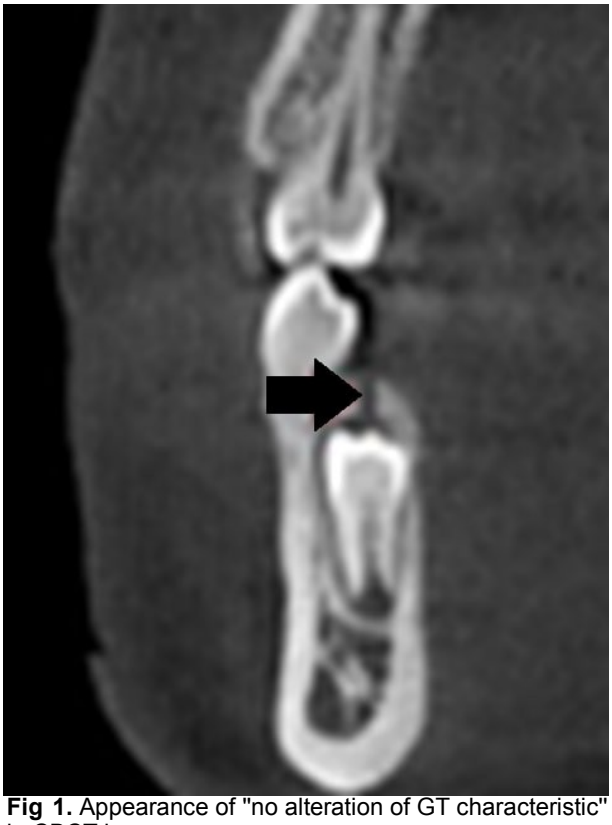

Fig 1. Appearance of "no alteration of GT characteristic" in CBCT images.

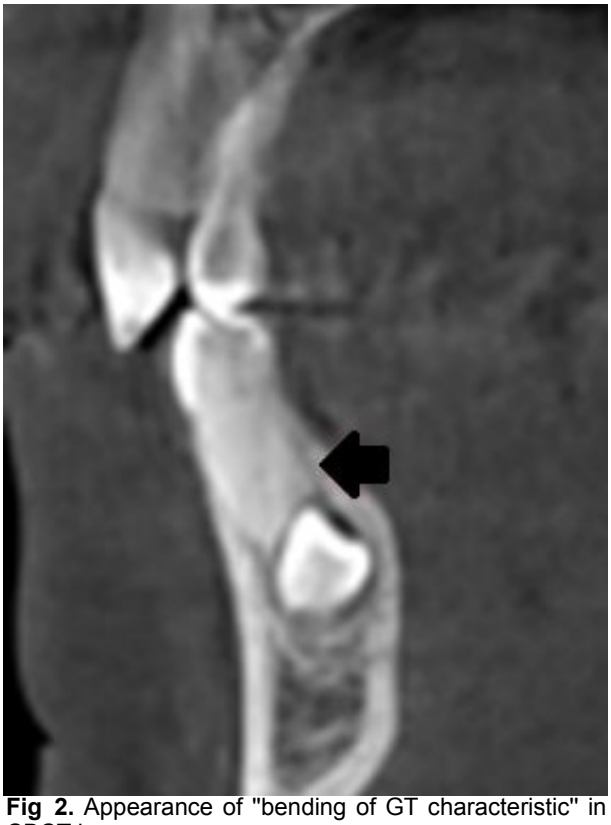

Fig 2. Appearance of "bending of GT characteristic" in CBCT images.

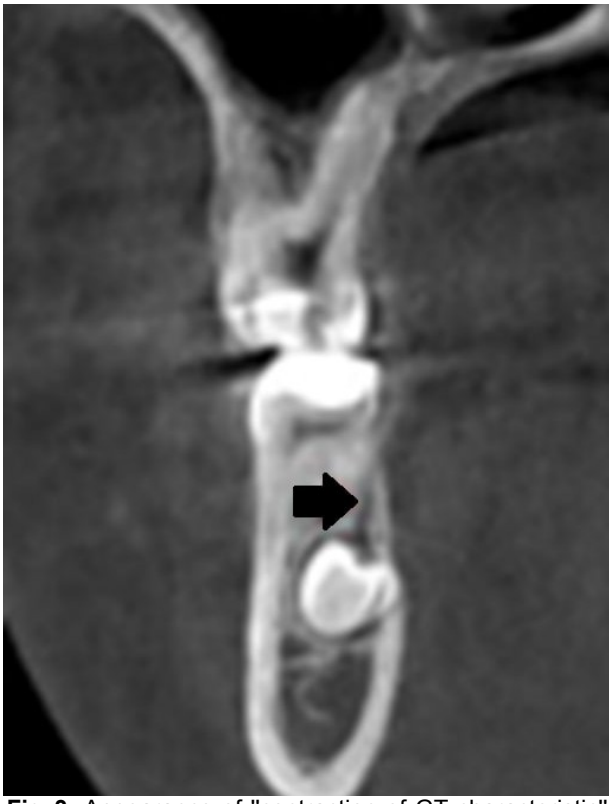

Fig 3. Appearance of "contraction of GT characteristic" in CBCT images.

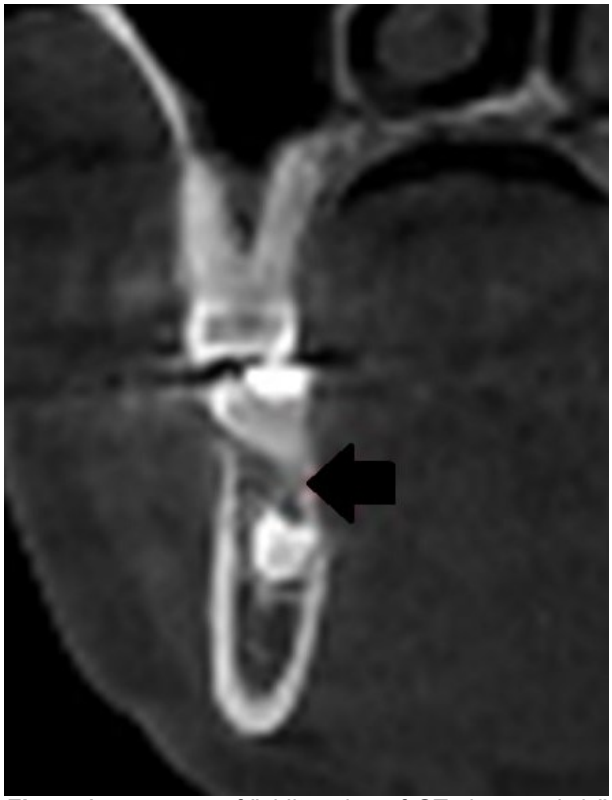

Fig 4. Appearance of "obliteration of GT characteristic" in CBCT images.

Imaging

The same CBCT device (Promax 3D Mid; Planmeca, Helsinki, Finland) was used to image all patients in the standing position. The imaging parameters were: tube voltage 94 kVp, X-ray tube current 14 mA, rotation 360º, scan time 27 s, and voxel sizes 0.4 µm-0.6 µm. All scans were evaluated by the same operator (F.A.K.) using a dedicated workstation. Planmeca Romexis imaging software (4.3.0.R; Planmeca, Helsinki, Finland) was used to detect GT.

Evaluation of Gubernacular Tract in CBCT

CBCT images were converted to volume data with 0.2-0.4 mm slice thickness around the maxilla and the mandible, and then were visualized on axial and sagittal images through multiplanar reconstruction methods. The presence and shape of GT in the supernumerary teeth were evaluated by CBCT. GT characteristics were classified according to the classification used by Nishida et al. GT characteristics were evaluated in 5 different groups: No alteration (Fig. 1), bending of GT (Fig. 2), contraction of GT (Fig. 3), obliterations of GT (Fig. 4), difference between erupted direction (Fig. 5).[16] The unerupted positions of these teeth were evaluated by CBCT. Unerupted supernumerary teeth were classified according to their position (mesioangular, distoangular, vertical, horizontal, unerupted in the palatine/lingual, unerupted in the buccal, unerupted in both palatine/lingual and buccal).

Statistical analyses

Descriptive statistics and chi-squared tests were performed using the Statistical Package for the Social Sciences (ver. 20; IBM Corporation, Armonk, NY, USA). Results were statistically significant at $P < 0.05$.

RESULTS

The age range of the samples in our study group was 12 to 68 (23.8 ± 11.6). Of the 63 teeth samples, 27 (42.9%) were female and 36 (57.1%) were male. The incidence of GT in the total population is 31.7%. However, the frequency of GT did not change according to gender, teeth quadrant, age and unerupted positions ($p > 0.05$). When evaluated by gender, the presence of GT was observed in 33.3% of female and 30.6% of male. GT was most frequently seen in the first quadrant (41.2%), followed by 31.3%, 28.6%, 25.0% in the second, fourth and third quadrants, respectively. GT was observed 46.2% in the incisor region, 50% in the canine region, 33.3% in the premolar region and 12.5% in the molar region. Of the 63 supernumerary teeth examined in the study group, 8 (12.7%) were mesiodens. GT was found in 3 of 8 mesiodens (37.5%). GT was observed to be 34.0% and 25.0% in the unerupted supernumerary teeth in the vertical and horizontal positions, respectively. When the unerupted supernumerary tooth was classified as palatinal / labial, buccal and in both

Fig 5. Appearance of "GT difference between erupted direction" in CBCT images.

palatinal / labial and buccal unerupted, GT presence frequency was 26.8%, 45.5%, 37.5% respectively. Statistical findings are summarized in Table 1 and Table 2.

When evaluated presenced of GT in the supernumerary teeth, "no alteration of GT characteristic" (40.0%) was found to be the most common in the supernumerary teeth whereas "contraction of GT characteristic" (10.0%) was found to be the least. However, this difference was not statistically significant (P = 0.24). It was found that GT characteristics did not change according to gender, quadrant, age and unerupted positions (P> 0.05). Statistical findings are summarized in Table 3.

DISCUSSION

The first reference to the gubernacular cord and the gubernacular canal was made in 1778 by an English scientist named John Hunter (Ferreira et al., 2013). This reference was supported in 1887 by microscopic research by French histologist Louis Charles Malassez (Malassez, 1885). According to Hodson, these structures are present only in association with the permanent teeth with temporary predecessor, a truth confirmed by Cahill and Marks (1980), Hodson (1971) and Philipsen and Reichart (2004).

Cahill and Marks (1980) examined the role of gubernaculum dentis in dental eruption by surgical interruption and ablation of gubernaculum gingival attachment. This study shows that the eruption rate and the final position of the tooth do not change with gubernacular ablation just before eruption begins. However, it is not exact that the GT is ineffective, as the study is performed after the eruption is activated.

The gubernacular canal is filled by the gubernacular cord and this canal expands with osteoclastic activity in the eruptive stage. Philipsen et al. signified that the gubernacular cord may affect the development of adenomatoid odontogenic tumor (AOT), because it included the remains of this dental lamina. These epithelial remnants are close to the crown portion of the permanent tooth and can act together with the gubernacular canal during tooth eruption to induce AOT formation (Philipsen and Reichart, 2004). In our study, there was no supernumerary tooth with AOT or tumor formation.

GT might be misdiagnosed with various anatomical variations in the jaws. Lingual foramina and their canals can be observed on the mandibular lingual surface (Wang et al., 2015). Accessory mental foramen appears around the mental foramen and on the buccal or lingual surface of the mandible (Naitoh et al., 2009; Iwanaga et al., 2016). The retromolar canal and foramen are present on the retromolar fossa (Ossenberg, 1987). However, GT is found around the impacted dental follicle and odontomas (Cahill, 1974).

Studies in which radiological evaluation of GT is performed in impacted teeth, supernumerary teeth and odontomas are existing in the literature (Ahmed et al., 2015; Nishida et al., 2015; Oda et al., 2016a; Koc et al., 2019). These studies are limited and there are no studies examining GT only in supernumerary teeth. In this study, it was investigated whether GT is effective in the burial of impacted supernumerary teeth. Also in our study, the characteristic of supernumerary teeth in the presence of GT was evaluated.

GT was visualized for the first time by Nishida et al. They evaluated GT on panoramic radiography,

Table 1. Distribution of GT presence according to jaw quadrant and tooth regions

	Jaw Quadrant				
	First Quadrant	Second Quadrant	Third Quadrant	Fourth Quadrant	Total
GT Presence	41,2%	31,3%	25,0%	28,6%	31,7%
	Tooth Region				
	Incisive	Canine	Premolar	Molar	Total
GT Presence	46,2%	50,0%	33,3%	12,5%	31,7%

Table 2. Distribution of GT presence according to unerupted supernumerary tooth positions

	Unerupted supernumerary tooth positions			
GT Presence	vertical		Horizontal	Total
	34,0%		25,0%	31,7%
	Unerupted supernumerary tooth positions			
GT Presence	Palatine/Lingual	Buccal	Both Palatine/Lingual both buccal	Total
	26,8%	45,5%	37,5%	31,7%

Table 3. Distribution of GT presence according to GT characteristics

	GT Characteristics					
	no alteration of GT	Bending of GT	contraction of GT	obliteration of GT	GT difference between erupted direction	Total
GT Presence	8 40,0%	4 20,0%	2 10,0%	3 15,0%	3 15,0%	20 100,0%

CBCT and multidetector computed tomography (MDCT) images. On CT examination, they observed GT in 1.6% (1/62) of central supernumerary teeth (Nishida et al., 2015). In our study, GT was observed in 3 of 8 impacted mesiodens. Although our mesiodens sample number was low compared to Nishida et al., we observed a higher rate of GT in our study. However, the low unerupted mesiodens in our study is low. Further studies are needed to determine the presence of GT in a large Turkish population where only mesiodens are evaluated.

Oda et al., in their study with CBCT and MDCT, observed 49 GT of 56 odontoma subjects. They found a spatial relationship between odontomas and GT (Oda et al., 2016a). In another study, they also detected intact or expanded GTs on MDCT images on almost all odontogenic tumors or cysts (Oda et al., 2018). These studies show that there may be a relationship between GT and odontogenic tumors. Furthermore, Oda et al. (2016b) evaluated GTs in maxillary anterior teeth of 205 patients with impacted mesiodens were retrospectively analyzed by using MDCT and CBCT. They found the rate of observing GT presence in mesiodens as 23.4%. This result is consistent with the findings in our study.

In a study with CBCT, Koç et al. observed 83% (386/465) of the unerupted teeth in the maxilla and 83.3% (240/288) of the unerupted teeth in the mandible (Koc et al., 2019). Compared to our study, Koç et al. (2019) examined GT in a large number of unerupted teeth. In addition, they did not examine the supernumerary teeth in their studies.

Gaeta-Araujo et al. evaluated GT with CBCT in a total of 159 patients with 423 teeth with normal eruption, 140 impacted teeth, and 35 teeth with delayed eruption. They found detection rate of GC was 90.6%. These rates were 94.1%, 87.1%, and 62.9% for normal eruption, impacted teeth, and delayed eruption, respectively (Gaeta-Araujo et al., 2019). Although this study was extensive, they did not analyze supernumerary teeth.

CONCLUSIONS

As a result, in our study, GT was the most common in the first quadrant and canine tooth region. GT was observed more frequently in teeth with vertical position than those with horizontal position. However, it was common in buccally positioned compared to palatal / lingual-impacted supernumerary teeth. The most common is no alteration of GT and the least observed contraction of GT. It was found that the presence of GT varies according to tooth regions and impacted positions. As a limitation of the study, it was studied in a short period of time and in a relatively small population. Therefore, data on the clinical prognosis of impacted supernumerary teeth could not be obtained. It is recommended to study the presence of GT in a

wider population and longer time intervals.

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