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Study and evaluation of the gubernacular canal by means of cone beam computed tomography

Thaís Silva Cerqueira[1], Kariza Vargens Diniz Correia[2]

SUMMARY

The aims of this review of the literature were to conceptualize the gubernacular canal, by an approach to its function, importance and characteristics of its image in Cone Beam Computed Tomography. The bibliographic survey of scientific articles was conducted in the following databases: PubMed, Bireme, Scielo and Google Scholar. The gubernacular canal, which carries the gubernacular cord within it, is an anatomic structure that starts in the dental follicle and goes through to the alveolar bone crest behind the deciduous tooth. This set appears to play an important role in the tooth eruption process, serving as guide to the permanent tooth in the eruptive trajectory, in addition to being a possible factor in the etiology of odontogenic tumors. Therefore, knowledge about and visualization of this canal in terminological exams such as Cone Beam Computed Tomography are relevant in dental clinical practice to help with the diagnosis of tumors and abnormalities in the eruptive process, thus enabling early intervention when necessary.

Key words: tooth eruption, cone beam computed tomography, diagnoses by image.

INTRODUCTION

The gubernacular cord (GuCo) is a structure composed of connective tissue, formed from epithelial cells of the dental lamina, which unites the reduced epithelium of the enamel organ to the oral mucosa, participating in the direction of the course of tooth eruption (1, 2). This structure is localized in the alveolar crest behind the deciduous tooth, above the occlusal portion of the dental follicle. The epithelial cells present in this cord release chemical mediators, such as the Epidermal Growth Factor (EGF) that causes stimulus in the clastic cells, resulting in bone resorption in the region (1, 3). The space formed around the GuCo, between this and the alveolar bone, gives rise to a delicate canal denominated the gubernacular canal (GuCa) (1, 3).

Both tooth germs and GuCos release EGFs that constantly stimulate neighboring bone resorption, thereby simultaneously establishing the formation of alveolar crypts and the GuCa (3). The GuCo and GuCa appear to play an important role in tooth eruption, guiding the tooth in formation in direction towards the alveolar process (1, 4). However, little attention has been paid to these structures by professionals in the field of dentistry, and rare are the scientific studies that have pointed out its presence and importance (5, 6).

The GuCa, a narrow structure approximately 1 to 3 mm in diameter, is difficult to visualize in two-dimensional images, such as panoramic radiography, for example. In addition to its narrow diameter, there are inherent limitations to these images, such as superimpositions and magnifications (4, 6). It can, however, be precisely analyzed in Computed Tomography (CT) images (4, 6).

Cone Beam Computed Tomography (CBCT), the type most used in the field of dentistry, produces high quality images with less exposure to radiation when compared with conventional CT (7, 8). Thus, it has become an essential tool for examination of the maxillae and teeth, as it allows better visualization without superimpositions (6, 8).

Few studies that cite the importance of the GuCa have been found in the literature, and in day to day Dentistry. Frequently it is not identified in either two- or three- dimensional radiographic

[1]*Faculdade Independente do Nordeste – FAINOR, Vitória da Conquista, BA, Brasil*
[2]*Departamento de Odontologia, Faculdade Independente do Nordeste – FAINOR, Vitória da Conquista, BA, Brasil*

Address correspondence to Kariza Vargens Diniz Correia, Departamento de Odontologia, Faculdade Independente do Nordeste – FAINOR., Av. Luís Eduardo Magalhães, 1035 – Candeias, Vitória da Conquista, BA, Brasil, CEP: 45055-420.
E-mail: karizacorreia@hotmail.com

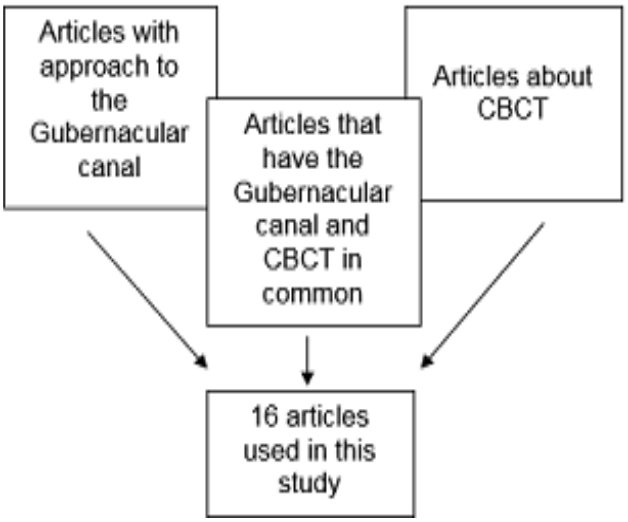

Fig. 1. Bibliographic survey design

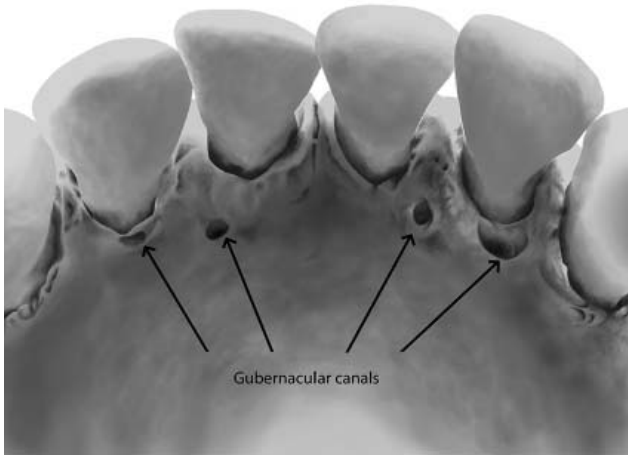

Fig. 2. Indication of gubernacular canals localized on the alveolar crests of mandibular incisors

images. Moreover, this structure is unknown to a large portion of dental surgeons. The aims of this literature review were to conceptualize the GuCa, point out its importance, characteristics and functions, and characterize its image in CBCT.

MATERIAL AND METHODS

For this review of the literature, a search for scientific articles was conducted in the following databases: PubMed – https://www.ncbi.nlm.nih.gov/pubmed; Bireme – http://bvsalud.org; Scielo - http://www.scielo.org/php/index.php; and Google Acadêmico – https://scholar.google.com.br/; in the period from February to May 2018.

The bibliographic survey was performed in three stages: in the first a research about the gubernacular canal was conducted; in the second, the topic researched was Cone Beam Computed Tomography; and in the third stage a search was made for articles that were an intersection of the two topics.

In the search the following terms were used: "cordão gubernacular", "gubernacular cord", "gubernacular canal", "gubernacular tract", "gubernaculum dentis", "gubernaculum tracts", "gubernaculum cord", individually, without combinations among them. Out of a total of 19 articles found, 8 were selected. No chronological inclusion criterion was established, because the authors observed that there were a very limited number of scientific publications that offered an approach to this structure.

The search for scientific articles about Cone Beam Computed Tomography was conducted with the following words: "Cone Beam Computed Tomography" and "Tomografia Computadorizada de Feixe Cônico", using filters for reviews of the literature published between 2012 and 2018. Thus, eight articles were selected. A third research was conducted using the descriptors: "gubernacular cord" or "gubernacular tract" or "gubernaculum tracts" in addition to the descriptor "Cone Beam Computed Tomography" and only 3 articles that coincided with the previous findings were found.

A total of 16 scientific articles were selected and used in this review (Figure 1). The inclusion and exclusion criteria adopted are described in (Table).

REVIEW

Concept and clinical characteristics of the gubernacular canal

The GuCa is a small bony canal that starts from the occlusal portion of the dental follicle,

Table. The criteria for study selection

Inclusion Criteria:	Exclusion Criteria:
• Literature in the English and Portuguese languages; • Clinical Studies; • Scientific Researches; • Literature Reviews; • Literature review of the last 6 years for articles about CBCT.	• Access to resumo/abstract only • Monographs, dissertations and theses; • Studies based on researches with animals; • Studies that cite only the gubernacular cord or canal.

runs through the mandibular/maxillary bone and erupts in the alveolar crest behind the deciduous tooth (Figure 2) (1). Because it is a delicate intraosseous structure, this canal cannot be visualized clinically; moreover, due to its small diameter, it is unlikely to be found in two-dimensional radiographic exams such as panoramic radiographs, but it can be detected and analyzed with precision in CBCT (6).

This anatomic structure may be found in all the groups of permanent teeth in patients with normal dental eruption (6). Running through within it is the GuCo, composed of fibrous tissue associated with remnant epithelial cells of the dental lamina that link the epithelial portion of the dental follicle of the permanent tooth to the gingiva, functioning as an eruptive pathway (4, 9).

Origin and formation of the gubernacular canal

The first known record of the GuCa and GuCo in the literature was made by an Englishman John Hunter 1778; although without scientific proof, he described these structures as a connection between the alveolar bone crypt of the tooth germ and oral mucosa (1). Over one hundred years later, in 1887, the French histologist Louis-Charles Malassez conducted microscopic studies and reported the presence of epithelial cells, remnants of the dental lamina, and fibrous cords filling a canal connecting the dental follicle to the gingiva (1).

The GuCo together with the bone canal, the gubernacular canal, which surrounds it, constitute an anatomic structure denominated the gubernaculum dentis (2). This structure and the alveolar bone crypts are formed simultaneously after the period of the dental germ formation (3).

Initially the GuCo is formed; this process occurs when the dental germ has been constituted and the dental lamina undergoes apoptosis, but strategically some of its cells are not destroyed (3). These remnant cells organize themselves in a manner interlaced with connective fibers to form cords that start from the reduced epithelium of the enamel organ, go through to the oral mucosa, and connects them (1, 3).

Due to the presence of epithelial cells, the GuCo releases EGF, a mediator that stimulates bone resorption in the region, inducing the activity of clastic cells (3). Thus, an area surrounding the GuCo and maintaining a space between it and the alveolar bone is always respected, giving origin to the GuCa (1-3).

The dental germs present epithelial tissue in their constitution, represented by the reduced epithelium of the enamel organ, therefore, in a manner similar to that of the GuCos, they also release EFG and maintain the bone tissue at a distance, due to bone resorption induced by this mediator (3). Thus, at the time of new bone tissue formation by the mesenchyme, circumscription of the dental germ occurs, keeping it away from the bone, and the alveolar crypts are established simultaneously with formation of the GuCa (3).

Function and importance of the gubernacular canal

The GuCa appears to perform the important function of guide for the normal eruption of the permanent teeth (1, 3, 6, 10). As the eruptive process advances, this canal becomes smaller, and disappears when the tooth reaches the alveolar crest (6). Therefore, the closer the dental follicle were to the alveolar crest, the shorter would be the length of the GuCa (6).

During the eruptive stage, as the successor tooth moves in the direction of the oral mucosa, the diameter of the GuCa is enlarged due to the osteoclastic activity in the region (1, 3). This widening occurs for the purpose of accommodating the crown of the tooth in the process of eruption (1, 3). As the permanent tooth moves in the direction of the gingiva, islets and epithelial cords of the GuCo are incorporated into the coronal follicle, increasing its epithelial component (1, 3).

The delay in tooth eruption may be directly associated with some defect of the GuCa, because a significant angulation of this canal in relation to the long axis of the tooth, and deformation may be found in unerupted teeth (6, 10). In situations in which there is complaint of delay in tooth eruption, the shape, angulation and localization of the GuCa must be minutely analyzed, using CBCT, because when the canal cannot be detected, or it presents and abnormal angulation, this may result in delay in eruption of the tooth with which it is associated (6, 10).

In addition to influence tooth eruption, the GuCa and GuCo may represent one of the origins of some odontogenic tumors, which develop from the dental lamina or from its remnant epithelial cells present in the GuCo (4, 5). Abnormal cell proliferation of the epithelial component of this structure has been pointed out as the cause of the appearance of lesions such as the odontoma and adenomatoid odontogenic tumor (2, 4, 5, 9).

Cone Beam Computed Tomography

Cone Beam Computed Tomography, developed specifically for dentistry, allows precise evaluation of the mineralized tissues in the maxillofacial region (8). The first reports of its use date back to the end of the 1990s, in Italy, when a new CT appliance created for the area of dentistry was presented (8, 11). The appliance used the technique of circular scanning around the vertical axis of the patient's head, using the beam in the shape of a cone (8, 11, 12).

Different structures of the maxillofacial region cannot be well interpreted by means of radiographs, therefore CBCT is an extremely important imaging exam for the diagnosis and planning of dental cases in which the details are determinant (16). The quality of its 3D images and the possibility of good visualization of the three spatial planes (axial, coronal and sagittal) allow dentists to make a precise analysis of the bone tissue and teeth, helping to make diagnosis and take decisions with regard to the treatment to be adopted (13-16).

Tomographic Characteristics of the gubernacular Canal

By means of CBCT the GuCa can be identified in the majority of patients with normal tooth eruption, during different periods of their growth and development (6, 10). Characterized in the sagittal and coronal cuts as a low density bone canal connected to the dental follicle of unerupted permanent teeth, the GuCa may also be observed by means of the axial cut as a narrow, low density circular structure, with a diameter of approximately 1 to 3 mm, localized in the lingual region of the deciduous predecessors (6, 10).

In some cases of impacted and supernumerary teeth, evaluation by means of CBCT images is indispensable (13). In these teeth abnormal tomographic characteristics of the GuCa may be observed, with changes capable of occurring in their angulation, as well as deformation and obliteration (10).

DISCUSSION

The GuCa and GuCo are anatomic structures that help tooth eruption, however, few studies elucidating their participation in this process could be found in the scientific literature (1, 6). Professionals from different areas of Dentistry, including pediatric dentists and radiologists often neglect the importance of the GuCa and GuCo, which have not received adequate attention (6).

For some authors the relationship of GuCa and GuCo with the eruptive process is evident and significant, since the guide teeth in the direction of the alveolar crest (5, 6, 10). According to Consolaro (3) these structures appear to influence the eruption of permanent teeth, however this correlation still needs to be elucidated. The authors appear to agree that although the gubernacular canal and cord have been known about for a long time, there is a need for further studies to make their participation in the eruptive process clearer (1, 3, 6, 10).

Historically, the existence of the GuCa was pointed out only in the permanent teeth with deciduous predecessors, and in deciduous dentition, their absence was reported (1). However, at present this canal can be identified in the incisors, canines, premolars and also in the permanent molars that do not have deciduous predecessors (1, 6).

Recent studies have been conducted with the purpose of localizing and characterizing the GuCa in teeth found to be in different stages of eruption (6, 10). With the use of CBCT, Multidetector Computed Tomography (MCT) and even in panoramic radiographs, it was possible to observe a significant difference in the angulation of the GuCa of maxillary central incisors in a normal process of eruption in comparison with incisors with delayed eruption (4). Furthermore, it was also demonstrated that the group of teeth with delayed eruption presented a smaller canal than those teeth with normal eruption (4).

In another study, by means of tridimensional images a low rate of visualization of the GuCa in supernumerary teeth was presented (6). Changes in shape, position and in some cases obliteration of the canal were noted in teeth with delayed eruption, corroborating the idea that the characteristics of the GuCa may indicate abnormality of the eruptive process (6, 10).

A relationship between the GuCa and the etiology of odontogenic tumors was described in the literature (4). Due to the fact that the gubernaculum dentis presented remnant epithelial cells of the dental lamina in its histological composition, this structure was pointed out as one of the origins of the adenomatoid odontogenic tumor (AOT) and of the odontoma (5, 9, 10). In the literature researched, no clear association of the ameloblastoma odontogenic tumor and of the Dentigerous Odontogenic Cysts with GuCa was found.

The association of the AOT with GuCo was proposed by different authors (2, 5, 9). This hypothesis perhaps explains the fact that this tumor is rarely associated with deciduous teeth (5). In CBCT images it was possible to visualize the abnormal widening of the GuCa associated with the lesion. Histologically the continuity of the fibrous capsule of the AOT with the GuCo and dental follicle could be observed (5).

Although it is more common in incisors and canines, the AOT could also be found in association with the GuCa of permanent molars (9). Although the GuCo was pointed out in one study (5) as being the origin in 96% of the AOTs in incisors, canines and premolars, the tissues present in the pericoronal region of unerupted teeth, including the GuCo must be studied and explored in greater depth, to make it possible to affirm that the proliferation of the AOT occurs from its epithelial cells (5, 9).

The majority of odontomas are found in association with unerupted teeth (4). By using tridimensional CBCT and MCT images it was possible to find that 70% of the odontomas of unerupted teeth showed no connection with the GuCo (4). This ratified the need to be aware of this structure that is frequently forgotten or unknown to dentists (4, 5, 9).

In this scenario, CBCT is considered the best terminological method for identifying and observing the characteristics of the GuCa and its stages of development, due to the possibility of visualizing it without superimpositions (6, 10). In all the groups of teeth these canals could be seen in detail in the axial, sagittal and coronal cuts of the CBCT, described as a low density rounded area, contiguous to the dental follicle in the region of the unerupted permanent tooth crown (6, 10). Particularly in panoramic Computed Tomography images the GuCas of maxillary and mandibular molars were visualized with a rectangular shape (6). However, in the majority of cases it is not possible to detect this structure in radiographs and panoramic tomographs, in spite of it being present (6, 10).

CONCLUSION

Evaluation of characteristics such as shape, diameter, angulation and localization of this canal, precisely observed by means of CBCT, may help to indicate abnormalities in the eruptive process, and to predict the development of odontogenic tumors, thereby making early intervention possible, whenever necessary. However, little attention has been paid to this structure by professionals in the field of dentistry, and rare are the scientific studies that have emphasized its presence and importance.

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