

The Prevalence of a Forensic Index the Tubercle of Carabelli for a Moroccan Population

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Abstract

Objectives: The aim of our study was to determine the prevalence, degree of expression and symmetry of the tubercle of Carabelli in a sample of Dentistry students to highlight this sensitive area to dental caries. **Materials and Methods:** We conducted a descriptive transversal survey of students in the 4th year of the academic year 2015/2016 at the Faculty of Dental Medicine of Casablanca. The study is made on plaster models for students, by measuring the mesiodistal diameter of the TC with an electronic calliper. **Results:** Several results were obtained: 64.29% of the study population have CT, while it is absent in 35.71% of cases, 37.50% with a tubercle of Carabelli little developed, 26.71% with a well-developed Carabelli tubercle, 61.11% of cases exhibit TC bilaterally and 38.89% of cases present the TC unilaterally. The results are consistent with those obtained in other surveys conducted in other countries and discordance with others. **Conclusion:** The lack of standardization of the study's methodology makes it difficult to compare the results of various studies, hence the need for similar studies on larger samples. It has some importance in the dental, forensic, and anthropological fields. In orthodontics, the cause of premature caries and periodontal diseases, also in extractions, the molar extraction instruments have no housing for this cusp and can therefore lead to fracture.

Keywords: Odontigeny, Tubercle of Carabelli, Tubercle Symmetry

Background

The study of dental morphological features is important in anthropological research because it can provide information on the phylogenetic relationship between species and variations within a population¹. It is commonly accepted that these dental features, such as size, shape, cusp number and size of the dental arches are genetically determined, therefore the characteristics mentioned above can constantly change due to natural selection and genetic changes². For this reason, Carabelli's Tubercle (TC) has always been a fascinating morphological feature for dentists and anthropologists. It is a small additional cusp located on the lingual surface of the mesio-palatal cusp of the maxillary molars. It is generally present symmetrically on both sides of the maxillary arches; this non-functional

mini cusp is rarely present on the first upper temporary molars and the second and third permanent upper molars. It has been described for the first time by the Austrian dentist George Von Carabelli in 1881. Since that time studies have evaluated its morphology and its anthropological characteristics. However, the etiology of the presence of TC remains unknown, genetic and exogenous theories have been proposed². Most studies agree that the phenotypic aspect of the cusp is genetically determined. There must be a dominant gene responsible for the presence of TC.

The tubercle of Carabelli is a phylogenetically old structure. Gregory (cited in Campbell, 1925) demonstrated the importance of the Carabelli tubercle in the structural and phylogenetic relationships between primitive, anthropoid and more recent hominoids³. Schwartz *et al.*,

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(1998) studied the tubercle of Carabelli in Australopithecus and De Terra (cited in Corrêa, 1921) they considered this dental structure as a character of civilized races. From the point of view of evolution, the tubercle of Carabelli tends to disappear, because of the reduction of the hypocone, which leads to a simplification of the occlusal surfaces¹. From a functional point of view, the tubercle is a compensation structure for the reduction of the mesiodistal diameter of the upper molars, as a result of the excessive biomechanical stress exerted on the first molar. Although this cusp is not clinically important, it has some importance in the dental, forensic and anthropological odontology industries. In orthodontics, in the placement of orthodontic molar rings, the space between these devices and the teeth can be filled by food debris, which can cause premature caries and periodontal diseases. It should be noted that this anatomical feature is sensitive to decay and requires a special interest in the processes of reconstruction and crack sealing. For extractions, the molar extraction instruments have no housing for this cusp and can therefore lead to a fracture of the latter. The purpose of our study is to determine the prevalence, expression and symmetry of the Carabelli tubercle in Dental Medicine students.

Study Design

Type of Investigation: To accomplish our work, we carried out a transversal descriptive survey.

The Sample: The survey focused on the analysis of the models of all students in the 4th year of the faculty of dentistry of Casablanca during the 2015/2016 school year, (121 students).

Inclusion Criteria: We have included all models with intact upper first molars.

Exclusion Criteria: We excluded the models with Upper first molars absent, a loss of substance that is traumatic, pathological or physiological and patients who have an orthodontic ring also all who have conservative restoration encompassing TC.

Place of the Survey: The survey was conducted at the Faculty of Dentistry of Casablanca, under the direction of the Department of Joint Prosthetics.

Objective

To study the prevalence, the degree of expression and the symmetry of the tubercle of Carabelli in a sample of students of Dental Medicine of Casablanca.

The degree of expression of TC is classified into 3 categories.

This classification is similar to that adopted by the study done at the Faculty of Dental Medicine King Saud in Riyadh: “0”: Absence of Tc; “-”: Tc undeveloped; (0.5_2.99mm) and “+”: Tc well developed; (≥ 3 mm)

The Symmetry: Unilaterality if the Tc is present on only one side. Bilaterality: if the Tc is present on both sides of the maxillary arch.

Collection of Data: We measured with an electronic calliper, which is a length-measuring instrument consisting essentially of two sliding parts relative to each other. This instrument makes it possible to easily and accurately measure the desired diameter.

The results obtained are indicated by numbers on the display screen at 1/100mm.

Conduct of the Survey: The measurements were made on plaster models from the impression taken by students on their pairs in the course of occlusodontics in the 4th year, and they were carried out using an electronic calliper in measuring the TC mesiodistal diameter with the presence of AA and AC examiners

Statistical Analysis: Data analysis was done by Pr C. S., a periodontics professor with training in epidemiology-statistics, using the software Epi info.

Results

In our study we examined 121 plaster models, 9 models were excluded. Of the 112 that met the inclusion criteria, we noted the absence of the Carabelli tubercle in 35.71% and its presence in 64.29%, as shown in Table 1.

The sample presented 66.07% of women and 33.93% of men.

Degree of expression of the Carabelli tubercle in the maxillary first molar is shown in Table 7, the degree of expression was chosen according to the following classification:

“0”: Absence of the tubercle of Carabelli, “Negative”: tubercle of Carabelli undeveloped [from 0.5 to 2.99mm] and “Positive”: Carabelli tubercle developed [≥ 3 mm]

Table 1. Presence of TC

Expression	Effectif	Percentage
Absence of TC	40	35,71%
Presence of TC	72	64,29%
Total	112	100%

Table 2. Frequency and symmetry of TC

Symmetry	Frequency	Percentage
Bilat	44	61,11%
Unilat	28	38,89%
Total	72	100%

We found that 35.71% do not have a Carabelli tubercle, 37.50% have an undeveloped Carabelli tubercle and 26.79% have a Carabelli tubercle developed.

Measurements of the diameter of the tubercle of Carabelli vary between 0.5 and 5 mm. For the right side, the average measurement is 2.87 with a standard deviation of 0.99 for the left side the average measurement is 2.67 with a standard deviation of 1.11

As shown in Table 2, we noted the presence of the Carabelli tubercle bilaterally in 61.11% of cases and unilaterally in 38.89%.

Discussion

Statistically, the size of the sample is not sufficient for the different parameters studied to reliably represent the rest of the Moroccan population. But the positive results obtained from our sample show an interest in carrying out a more extensive study on a larger scale.

The Bias concerning the sample was that our sample does not represent the Moroccan population since we proceeded to a selective sampling methodology, and not random, we targeted a population having an Age group between 21 and 23 years (no notable age difference). And most of the students were from southern Morocco so there was not a big ethnic difference.

Impressions are not always 100% reliable, given the deformations that may be caused by thermal variations, the methods of taking the impression, the treatment and the casting of the models.

Internal Validity of the Study: Since we have implemented a statistical procedure to process the results, we can consider that our study is of good intrinsic value.

Extrinsic Validity of the Study: The usefulness of our results is not to be proved, since our survey is the first of its kind, conducted on the prevalence of Carabelli's tubercle in a sample of Moroccan students. However, the sampling methodology and the size of the sample is to be improved.

Several studies have focused on Carabelli's tubercle, however, each of these studies has analyzed the subject in a different way: at the level of the studied material (namely the age difference, the dental state, etc.), the technique used (in the mouth, on models, or both methods) and the nature of the desired parameters.

Thus, the lack of standardization of the study methodology makes the comparison of the results of different research difficult.

Our study revealed a prevalence of 64.29%. This result is in agreement with that of the study carried out by HSU and COL in 1997⁴, which showed a high prevalence (without having to specify the percentages) in Caucasians.

The author of this study classified the different populations into 3 categories:

High TC prevalence (frequency of 2/3 of the study population), moderate TC prevalence (between 1/3 and 2/3 of frequency) and low TC prevalence (frequency 1/3), in the same study, the authors report that Russians, Brazilians citing (Ferreira *et al.*, 2010, Sousa *et al.*, 2000)⁵; Male and mixed Europeans (citing Diamond, 1952)⁶ have a moderate prevalence.

However, the population of eastern Greenland did not have a Carabelli tubercle⁷.

According to our study, sexual dimorphism regarding the frequency and expression of the Carabelli tubercle is absent, which is consistent with several studies such as that of Scott, Castro (1989)⁸, Tsai *et al.*, who reported no significant difference between the sexes¹⁹. Another Malaysian study¹ has confirmed that there is no sexual dimorphism in the occurrence of the tuber¹⁰. In Nepal, a study has shown that the sex parameter has no implication in the expression of the TC¹¹.

On the other hand, the results of the studies carried out by Townsend *et al.*, (1999)¹², show the existence of a sexual dimorphism concerning the expression of Carabelli's tubercle, namely that it had a large increase in prevalence among men¹². And through a Jordanian study, a significant sexual dimorphism has been shown in the prevalence of Carabelli tubercle on the first molar⁶.

Thus, Bermúdez De Castro JM³ has shown that the prevalence of the Carabelli tubercle for the first permanent upper molars is slightly higher in men, and this is also true for the degree of expression which is a little higher than that of women¹⁴ and as noted by Kieser and Col JA⁹. there was sexual dimorphism regarding the presence /absence

of the tubercle, but there was no significant association between the degree of tubercle expression and sex¹⁵.

Another study done in Pakistan showed that the prevalence of CT in men is (31.5%) while in women is (26.5%)¹⁶.

This was in agreement with the Haris report¹⁷. This can be explained by the anatomical complexity of teeth in men compared to women.

Our study was carried out on models of students of the 4th year with an age group of 21 and 23 years which means that we worked only on permanent teeth, whereas a study made in India¹⁸ selected a sample with a wider age range between 4 and 16 years to compare the prevalence of Carabelli's tubercle in both the temporary and permanent dentition.

This study demonstrated that there was no significant statistical difference between the left and right sides of the primary and permanent dentition, and it was observed that there were variations in the degree of expression of the TC.

The same study reports, regarding age, that some studies have shown similar correspondence between the right and left sides while others have reported a discrepancy.

Several methods and classifications have been carried out to qualify the expression level of the Carabelli tubercle.

For our study, we classified Carabelli's Tubercle into 3 classes, specifying the measures for each category: "0": smooth surface or absence of structure, "-": Depression poorly developed [0,5_2,99mm] and "+": developed cusp [≥ 3 mm].

This classification is similar to that adopted by the study made at the King Saud School of Dental Medicine in Riyadh, which classified the Tubercles into 3 categories without specifying the measures: "1": Smooth surface or lack of structure, "2": Depression or groove and "3": prominent cusp.

On the other hand, Batujeff¹⁰, who has examined pits, dental grooves and their functional manifestations, has developed with other researchers, such as Dahlberg *et al.*, (2000)¹⁴, an ordinal scale with 7 grades, the absence of the line (0) until the presence of a large tuberosity (7).

While Alvesalo *et al.*,¹⁹ who examined 233 patients in a Finnish rural population, used a different classification¹⁹: "1": Smooth surface, "2": pit or single furrow, "3": Double furrow or Y-shaped furrow, "4": slight protuberance or small cusp and "5": prominent cusp, due to the variety of classifications described in the literature, it is difficult to find precise morphological criteria that allow objective comparisons between studies.

Regarding our study, we found the following results:

35.71% do not have a Carabelli tubercle, 37.50% have an undeveloped Carabelli tubercle and 26.79% with a developed Carabelli tubercle.

This prevalence of the presence of TC found in our study was close to that found in the study done at the Faculty of Dental Medicine of Riyadh with a percentage of 56.2%, during which a higher frequency was recorded for a prominent cusp of 33.5% compared to a slight depression of 22.7%²⁰.

On the other hand, several studies have found different results with varying percentages as presented.

Our study showed that 61.11% of cases presented a Carabelli tubercle bilaterally, which is consistent with the study done at the King Saud Dental Faculty in Riyadh which showed that tubercle bilateralism was high with a percentage of 54.7%. This confirms the findings of other researchers, who agree that TC bilateralism is more common¹¹, so this high bilateralism was found in 73.7% of the cases on upper first molars in a study done in Nepal², with 70.71% in a Nigerian study¹⁶, 82.2% and 91.2% in studies in Saudi Arabia²⁰, 75.6% in Pakistan¹⁶ and 65% in a study in India¹⁸.

Another result shows that if the upper second molars had a bilaterally prominent cusp, the upper first molars would have bilaterally prominent cusps²².

But it is also true for less marked tubercles, this could be attributed to genetics, as some researchers have pointed out. Thus, Iwai-Liao Y and Coll¹¹, showed that Carabelli tubercles on the upper first molars were always bilateral¹⁴.

Alvesalo¹⁹ stated in his study that if there is no tubercle on one side of the jaw, it is never found on the other side¹⁰. This is in contradiction with studies done by other researchers, such as Batujeff¹⁰, who suggested that bilateralism or mirroring is not a determining factor for TC²³. Regarding our study, we found that 38.89% of cases have the tubercle on one side only.

Also, the study conducted in December 2011 at the Khyber Dental School in Pakistan found that some patients present the Carabelli tubercle on one side, while on the other side, no evidence of this structure was observed¹⁶.

These results are in agreement with the Falomo study which declared unilaterality in only 25.99% of cases.

Other parameters that can influence TC and we did not study in our survey such as:

Hereditary Nature: At the beginning of the last century, Black G.V, confirms that this dental structure is hereditary, appearing regularly in children when it is

present in the parents, it is found in a modified way when it is present in a single ancestor⁸.

In studies of quantification of the presence and absence of the Carabelli tubercle the tubercle is most often found on the first molar, whereas its presence on the second molar occurs only when it is encountered on the first molar²⁴.

Kraus²⁵ suggested in his first analysis a simple autosomal transmission model corroborated by other studies, he then considered that the homozygote was responsible for a labelled tubercle, as well as the heterozygous genotype determined the presence of a tubercle less marked (small grooves, wells).

Later, Lee *et al.*,²⁶ (1999) proposed a multifactorial model in which gene expression and environmental factors contributed to a high bilateral expression of Carabelli tubercle in twins. Thus the high level of symmetry that has been found in various studies (Scott, 1980) has shown that gene expression and environmental factors influence the degree of expression of the Carabelli tubercle⁹.

The Odontogenesis: Several studies have demonstrated the role of ontogeny in the expression of the Carabelli tubercle, for example, the Salazar Ciudad and Jernvall model of tooth morphogenesis²⁷.

In this study, they tested this model for predictions about the size and symmetry of the Carabelli tubercle in humans. The tubercle of Carabelli emerges from the lingual surface of the protocone (the mesio-lingual point of the upper molars). Usually, this tubercle begins to form after the four main cusp points of the molar (If the Carabelli tubercle is as large as the other cusp points, then it starts with them). The tubercle varies in the expression of a shallow furrow at a cusp with a free apex that rivals the hypocone, one of the four main cusps of the molar¹⁵.

In this prediction, the pattern is of cascading pattern that may explain the presence and size of the Carabelli cusp, so teeth with smaller intercuspid distances compared to crown size would be more likely to possess the Carabelli tubercle⁵.

Conclusion

The survey that we conducted with students in the 4th year of the Faculty of Dental Medicine of Casablanca and whose objective was to assess the prevalence, degree of expression and symmetry of the Carabelli tubercle in the sample with 66.07% of women and 33.93% of men, the following results were obtained:

35.71% do not have a Carabelli T, 37.50% have an undeveloped Carabelli T, and 26.79% have a Carabelli T, developed, the presence of the Carabelli tubercle bilaterally in 61.11% of cases and unilaterally in 38.89%.

Dentists must take into account this high prevalence and give more importance to this structure during the dental examination because it has a caries-sensitive area which can cause subsequent dental and periodontal damage.

Manufacturers of dental equipment should also create instruments adapted to the existence of this structure, particularly in terms of forceps for the extraction of upper 1st molars, crampons for rubber dams, orthodontic rings etc.


The tubercle of Carabelli remains a fascinating morphological feature of interest to anthropologists because of its great variability from one population to another, which is why other similar studies carried out on larger samples should be carried out in wider age groups.

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