

The cusp of Carabelli: Frequency, distribution and type in the Bengaluru population

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Abstract

Aims: Detailed description and study of teeth traits could provide valuable information regarding phylogeny of man and distinctions between races and subraces. But morphological variations of the human dentition have not been utilized to their full potential by anthropologists concerned with patterns of human biological variation in Indian population. The aim of the present study is to detect the frequency and degree of expression of Carabelli's trait in Bengaluru population, this helps to develop a probabilistic model to distinguish individuals from specific human populations, particularly for forensic purposes.

Materials and Methods: A total number 400 of age and sex matched individuals from four different ethnic groups – Hindu, Islam, Christian and Iranians were examined clinically and study casts were made. Permanent maxillary first molars were examined for the expression of Carabelli's trait, Dahlberg classification system was used to score the trait on the teeth. The scores were recorded on Osteoware Dental Morphology software. The cast were examined by 2 observers independently to eliminate intra observer variation in interpretation and mean of 2 was taken for analysis. The data so obtained was statistically analysed especially emphasizing on differences between above mentioned 4 ethnic groups.

Results: Cusp of Carabelli was present in 87% of the study population in maxillary first permanent molar. Type 3 was the most frequently expressed and Type 6 was the least frequently expressed and both type being expressed in Islamic groups. The expression of trait was bilateral in 90% of the surveyed groups.

Conclusions: It was concluded that the prevalence of cusp of Carabelli in the small population from Bengaluru considered in the present study was found to possess a high degree of Carabelli trait expression.

Keywords: Bengaluru population, cusp of carabelli, forensic odontology, permanent maxillary first molar

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INTRODUCTION

Teeth can provide evidence about the nature and extent of diversity between human populations. Dental anthropology is concerned with the study of morphological variation and

dimensions of the dentition of human populations over time and space and their relation with the processes of adaptation and dietary changes that led to the evolution of the dental system and the human race.^[1] This is possible because tooth

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size, number and morphology have a sufficiently strong genetic basis to make them useful variables for assessing biological relationships and microevolutionary trends.

A nonmetric feature is likely to provide the most comprehensive and discriminatory description of human dentitions.^[2] Detailed description and study of such trait could provide valuable information regarding phylogeny of human and distinctions between races and subraces. The frequency of occurrence of a trait may be low in a specific population because that trait is becoming progressively more or less well developed in that population. Hence, it is not inconceivable that a trait could inadvertently be considered to be an anomaly, even though it may be a characteristic feature of that population. Thus, what may be considered to be an anomaly in one population may be a trait in another population. Although teeth have proven to be an extremely valuable fossil material for scientists to study the history of human, unusual anomalous morphological features were mistakenly regarded by some early observers as aberrations and not considered to represent normal biological variation.^[3,4] One of the first traits to be recorded was the Carabelli's trait in 1842 by Sir Georg Carabelli [Figure 1].^[5] Carabelli's trait is one of the most studied nonmetric traits. It is characterized by a Cingular derivative expressed on the mesiolingual or lingual aspect of the protocone of the upper molars. The Carabelli's trait has been used as a critical ethnic indicator for several decades, most likely because it can be simply observed in both living individuals and skeletal material, and can, therefore, be used to show major ethnic differences in dentition.^[6] Analyses of different dental morphological features, particularly the Carabelli's trait, have not been utilized to their full potential by anthropologists concerned with patterns of human biological variation in the Indian population. Hence, this study forms part of a larger



Figure 1: Sir Georg Carabelli (1787–1842)

investigation aimed at using a nonmetric dental crown feature to develop a probabilistic model to distinguish individuals from specific human populations, particularly for forensic purposes and considering these findings in relation to genetic and environmental influences.^[7-10]

MATERIALS AND METHODS

This is a quantitative, cross-sectional, descriptive study of the frequency, variability and bilateral symmetry of Carabelli's trait in permanent dentition. A total number 400 of age- and sex-matched individuals from four different ethnic groups – Hindu, Islam, Christian and Iranians – were examined clinically, and the study casts were made.

Permanent maxillary first molars were examined for the expression of Carabelli's trait using an illuminated magnifying glass (×2) to diagnose the presence or absence of a trait. The Carabelli's trait was identified and scored in accordance with the odontoscopic system developed from the Arizona State University Dental Anthropology System (ASUDAS). The ASUDAS uses standard recording forms and three-dimensional reference plaques [Figure 2].^[5] Dahlberg classification system was used to score the trait on the teeth [Figure 3].^[9] The scores were recorded using Osteoware 2.4.037 data collection program was created in partnership with the Smithsonian Institute as a means for standardization



Figure 2: Odontoscopic system developed from the Arizona State University Dental Anthropology System for Carabelli's trait

of data collection procedures [Figure 4]. The casts were examined by two observers independently to eliminate intraobserver variation in interpretation, and the mean of two was taken for the analysis to enhance the accuracy of the diagnoses and to maintain the level of examiner reliability.

The data obtained from the Carabelli's trait observation were entered into a template on Excel® and processed with

the statistical package for the social sciences SPSS (version 16; IBM corp., IL, USA) through Chi-square test for each of the morphological features. $P < 0.05$ was considered statistically significant.

RESULTS

The occurrence of Carabelli's trait in the sample will be compared with the trait variation of as described by Scott and Turner 1997. For every individual, it is presented whether the trait is present, absent or not observable. When one of the observed teeth expresses the trait at the break point, it is scored as present. When none of the observed teeth express the trait, it is scored as absent. When the traits are scored as absent on one tooth and unidentifiable on another, the trait is finally classified as unidentifiable. Percentages are calculated using the traits scored as present and as absent. Unidentifiable scorings are not considered because it is not known which traits they might have

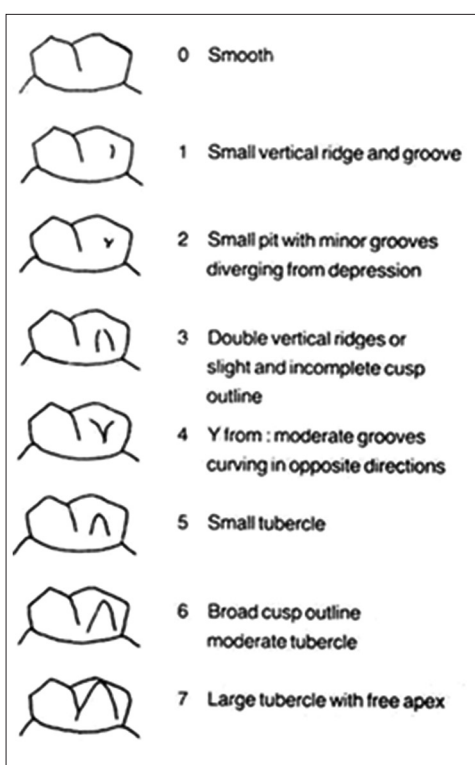


Figure 3: Dahlberg's (1963) scale for the determination of degree and expression of Carabelli cusps

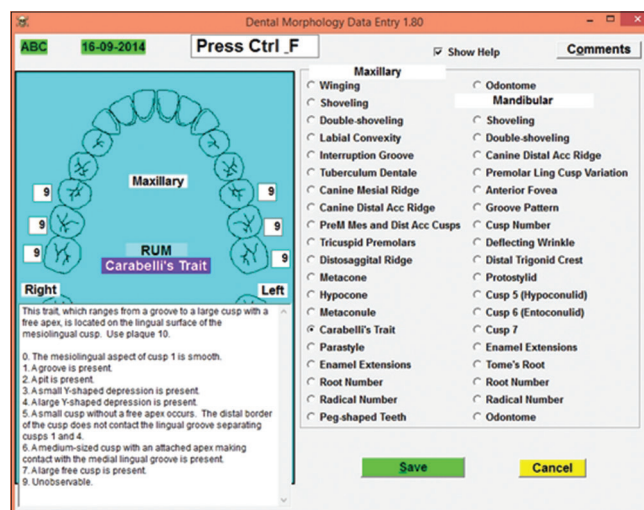


Figure 4: Carabelli's trait – scores recorded using OsteoWare Dental Morphology software

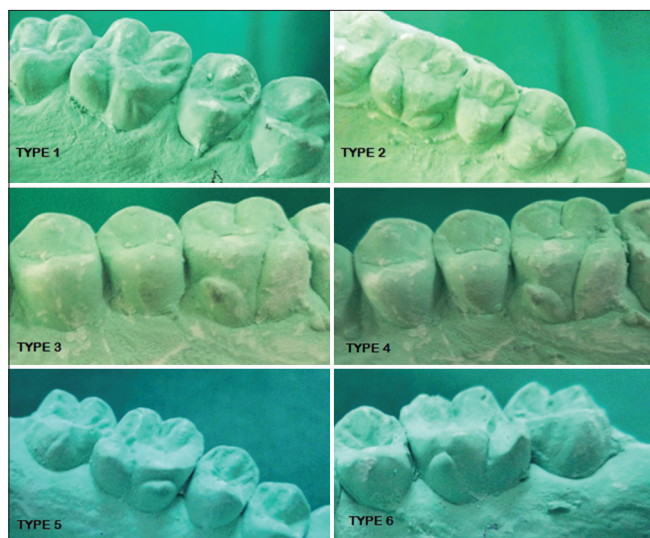


Figure 5: Maxillary first molar exhibiting various grades of Carabelli's trait in the study sample

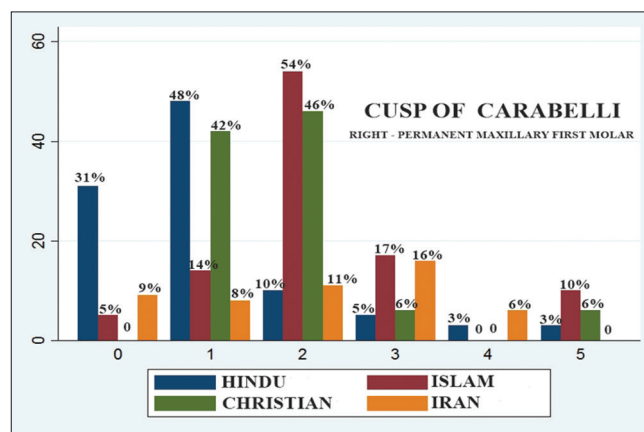


Figure 6: Prevalence (%) of maxillary first right molar Carabelli's trait in the four ethnic groups

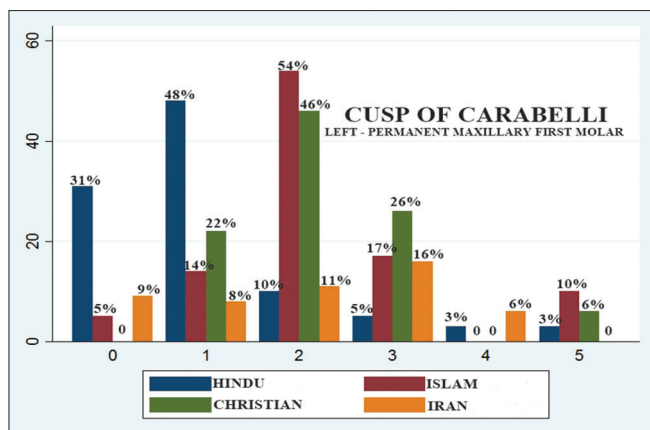


Figure 7: Prevalence (%) of maxillary first left molar Carabelli's trait in the four ethnic groups

possessed. The eight-grade scale indicates the wide range in degrees of trait presence varying from small grooves to large tubercles.

When a cusp of Carabelli's trait expression was statistically analyzed using Chi-square test, it showed statistically significant results, with 87% of prevalence in the surveyed group. Type 3 was the most frequently expressed and Type 6 was the least frequently expressed and both type being expressed in Islamic groups [Figure 5]. The expression of trait was bilateral in 90% of the surveyed groups [Table 1 and Figures 6, 7].

DISCUSSION

The frequency and variability of tooth crown morphologic traits have traditionally been used to compare human populations, geographical distributions and to make inferences about migratory patterns and population affinities.^[11] An analysis of samples from the same geographical area, but from different ethnic groups, can provide a unique opportunity to analyze and interpret inter and intrapopulation changes using the frequency and expression of the Carabelli's trait.

The use of standardized methods and calibrated uniform assessments of the examined trait in this analysis guarantees that the obtained results can be compared with other series. This is an important consideration when planning research. The study of Carabelli's trait on dental casts is indeed be more reliable than direct clinical examinations, for which instant clinical decisions have to be made and visual access is restricted in the oral cavity. The use of an oral examination may result in information being inadvertently not collected. For example, the line form of the Carabelli's trait cannot be easily detected in the clinical environment because the quality and direction of the light can be critical factors.^[12,13] Thus, the studying of

Table 1: Prevalence (%) of maxillary first molar Carabelli's trait in the four ethnic groups

Score	Hindu	Islam	Christian	Iran	P (χ^2)
Upper permanent first molar - right					
1	31	5	0	9	<0.001
2	48	14	42	8	
3	10	54	46	11	
4	5	17	6	16	
5	3	0	0	6	
6	3	10	6	0	
Upper permanent first molar - left					
1	31	5	0	9	<0.001
2	48	14	22	8	
3	10	54	46	11	
4	5	17	26	16	
5	3	0	0	6	
6	3	10	6	0	

dental casts was considered to be superior to the clinical method of examination. However, it is essential that the dental casts are a true and accurate reproduction of the original teeth and that they have not been damaged during preparation or storage.

A diagnostic criterion for the trait analysis was difficult to develop even with the aid of previously published literature because there is a lack of universally accepted classifications for each trait. Hence, the diagnostic criterion used in this study has been described by ASUDAS.^[5] This system enables the researcher to get familiar with the different nonmetric traits and reliably compares them for assessing different grades of presence. Furthermore, caution and repeat observations serve to minimize intraobserver error.

The Carabelli trait is said to be an inherited characteristic. Data from the studies of twins support this etiological hypothesis. However, although an autosomal dominant mode of inheritance has been proposed, the degree of expression of the trait in twins has varied from fully concordant to fully discordant. Thus, because of the varying manifestations and the prevalence of Carabelli's trait, the mode of inheritance is probably not a simple Mendelian pattern.^[14-17] A high degree of equivalence of Carabelli trait expression between primary and permanent molars was demonstrated by Kieser.^[18] It was then hypothesized that the high degree of within individual equivalence suggests a low epigenetic and high genetic influence on Carabelli trait expression and that the findings support the clonal rather than the field theory of tooth morphogenesis.^[19]

For the permanent dentition, Carabelli's trait appears to be generally the most common among the European populations, followed by the African populations and American Indians, with the lowest prevalence occurring

in the other Mongoloid races. However, the present study showed an overall prevalence of 87.6% in the surveyed group, which is higher than that in previous reports. Among the Indians, 52.77% of maxillary first permanent molars displayed a Carabelli tubercle while Iranians showed the prevalence of 58.7%.

Dahlberg's classification is the most commonly applied method for determining the degree and expression of Carabelli cusps. In this study, Class 3 was the most frequent Carabelli cusp configuration (54%) and Class 6 was the least frequent (10%), both types being expressed in Islam. Few researchers stated that Carabelli's tubercle is invariably bilateral; however, the majority describes it as usually bilateral. In the present study, most cases (90%) had bilaterally the same configuration and only 20 cases (10%) did not have Carabelli cusp, bilaterally. Therefore, the expression of Carabelli's tubercle is invariably bilateral.

The term "dental complex" refers to the characterization of large population groups, according to a specific combination of tooth crown morphologic traits, and since modern human groups have the same number of these features in both the dentitions, the only detectable difference is in the frequencies of these traits. Based on the combined dental characteristics of the Northeast and Southeast Asian populations, two major dental morphological variation groups among the Asian populations have been described, namely, Sinodonty and Sundadonty (Turner, 1990). According to the results obtained from this study, it can be said that the indigenous groups of the sample who formed the sample for this study have high frequencies of nonmetric dental characteristic of the Sundonts – Hindus, Muslims and Christians (Indians). While Iranians fall under Sinodonts and similarly with other Colombian and American indigenous groups, the findings are consistent with those reported by Turner, Hanihara, Zoubov and Rodríguez, which also coincide with the theory of the Mongoloid origin of the indigenous tribes of South America.^[11,14,19]

CONCLUSION

Analysis of dental morphology in the context of dental anthropology consists of phenotypic enamel forms expressed and regulated by the genome of an individual and population during odontogenesis. A small population from South India considered in the present study was found to possess a high degree of Carabelli trait expression, and the differences in the phenotypic expression of this trait in the different dentitions type, as reported by some workers (including the present study), may suggest that the Carabelli trait is under a polygenic influence and all

of the data generated by this study show that these dental traits do not develop independently from each other but are instead interrelated.

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Conflicts of interest

There are no conflicts of interest.

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