

# Ethnic Association of Cusp of Carabelli Trait and Shoveling Trait in an Indian Population

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## ABSTRACT

**Introduction:** Variations in the structure of teeth have always been of great interest to the dentist from the scientific as well as practical point of view. Additionally, ever since decades inter trait relationships have been a useful means to categorize populations to which an individual belongs.

**Aim:** To determine the association between Cusp of Carabelli and Shoveling Trait in a selected Indian population native of Bangalore city, Karnataka, India.

**Materials and Methods:** A cross-sectional study was carried out in 1885 children aged between 7-10 years. Casts of the study subjects were made to study the presence of Cusp of Carabelli of right maxillary permanent molar and shoveling trait of right maxillary permanent central incisor using the Dahlberg's classification and Hrdliucka's classification respectively. Linear

regression was used to assess the association of cusp of carabelli trait with the tooth dimensions and logistic regression was used to evaluate the association of the carabelli trait with gender and presence/absence of shoveling.

**Results:** A 40.5% of subjects had Cusp of Carabelli on first molar and 68.2% had shoveling on upper central incisor. The study revealed positive association between the two traits studied in the population. A significant difference was also found with presence of Cusp of Carabelli and the buccolingual tooth dimension of the maxillary molar ( $p < 0.05$ ).

**Conclusion:** There is an association between the Cusp of Carabelli and the shoveling trait in the present study population, and this will be valuable in the determination of ethnic origin of an individual.

**Keywords:** Children, Ethnic group, Forensic sciences, Molar, Incisor

## INTRODUCTION

Dental anatomic features are used primarily to determine a person's identity, origin and gender. The significance of a dental anatomical trait depends on its frequency of occurrence and distinctiveness in a given population [1]. The Cusp of Carabelli is a characteristic morphological trait often seen on the palatal surface of the mesiopalatal cusp of maxillary permanent molars and maxillary second deciduous molars [2]. It was first described by Carabelli in the year 1842 and since then it has been identified as a significant trait in forensic, anthropological and ethnic studies [3]. Various terminologies have been given to it which includes fifth lobe, supplemental cusp, accessory cusp, mesiolingual elevation, Carabelli's tubercle, etc. Shovel traits are described as the presence of a concave lingual surface and elevated marginal ridges surrounding a central fossa in the maxillary central incisors.

Shovel and cusp of carabelli trait are important parameters observed in human dentition which can aid in predicting the main ethnic differences between populations in anthropometric studies [4].

Although dental inter trait studies have been done before, a very small number of studies have been conducted to comprehend the existence of these two traits and which trait influences the other [Table/Fig-1], [5-9]. Carabelli's trait molars and shovel trait incisors are dental features generally used to differentiate Mongoloid from Caucasoid populations. Two significant dental features among the mongoloids, which are, a high occurrence rate of shovel incisors and a low rate of carabelli trait molars reported by Dalhberg and Harihara lead to the assumption that the former trait repressed the latter [10,11]. On the contrary a different study concluded a positive association between shoveling and carabelli trait [12]. The actual association between these two traits has been unclear

in the Indian population, even though one prevalence study on the same traits has been done previously [13]. Therefore, the aim of the study was to investigate the association of shoveling trait with Cusp of Carabelli in an Indian population of Bangalore city belonging to Dravidian race, which could aid in identifying the ethnic origin of an individual.

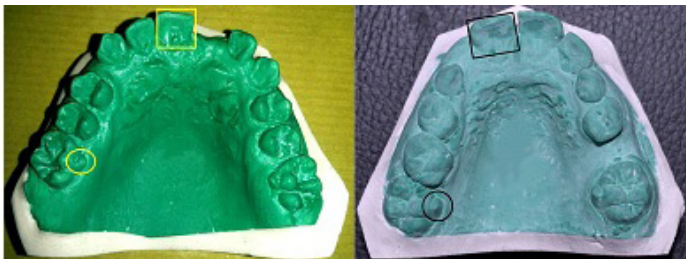
The cosmopolitan nature of the city has resulted in the migration of people from other states to Bangalore. Hence, to reduce population differences in the manifestation of Carabelli's trait, we limited our investigation to people who had ancestral nativity to Bangalore city only, as India is diverse in ethnicity.

## MATERIALS AND METHODS

**Ethical approval :** This study was approved by the Joint Research and Ethics Committee of Syamala Reddy Dental College, Bangalore and each patient's parent/guardian provided informed consent to participate in the study.

**Data acquisition:** Total 1953 casts of patients who visited the Department of Pedodontics and Preventive Dentistry, Syamala Reddy Dental College during the time period of June 2013 - 2015 were included in the study that fitted in the age group between 7-10 years. In order to reduce the confounding effects of the mixture of races on Carabelli's traits, only subjects who had ancestral nativity to Bangalore were chosen. To avoid bias in terms of issues of symmetry and disparity in dentition the presence of shoveling and Cusp of Carabelli (mesiodistal and buccolingual measurements) were studied only on the right side irrespective of whether they were present/absent on the left side [14-16].

If a tooth was missing or measuring points were not defined due to caries or restorations the corresponding contralateral tooth was not used as a substitute.



**[Table/Fig-1]:** Simultaneous occurrence of Cusp of Carabelli and shoveling trait in an eight year old female patient.

Of the total number 1885 met the sufficient criteria for the measurements in the present study. The other 68 casts were eliminated due to presence of extensive restorations or fractures on the teeth of interest.

The classification of Cusp of Carabelli according to Dahlberg [17] was considered over Kraus [18] as the former had more precise grading [Table/Fig-2]. The Cusp of Carabelli present in the right maxillary first molar was recorded. The non-metric categorical trait patterns were dichotomized as presence or absence of Cusp of Carabelli. The presence was coded whenever there was a manifestation of a pit, fissure or a cusp.

Classification of shoveling by Hrdliucka A [19] is as follows: (a) shovel – enamel rim distinct with an enclosed well-developed fossa, (b) semishovel – enamel rim distinct but enclosed fossa shallow, (c) trace shovel – traces of enamel rim which cannot be classed as semishovel, and (d) no shovel – no perceptible trace of rim or fossa. The right upper central incisor was classified using the above and another modified classification [20]. Further, these categories were classified as existence or non-existence of shovel trait. The trait was considered positive whenever there was a rim or fossa present.

The mesiodistal and buccolingual measurements of the right maxillary permanent molars were measured by a sliding electronic digital caliper with 0.01mm resolution. The mesiodistal diameter was measured at the crest of contour between the proximal surfaces of the crown with a vernier caliper held parallel to the occlusal plane. The largest distance between the buccal and the lingual surface of the crown, measured with a vernier caliper held at right angles to the mesiodistal diameter was calculated as the buccolingual diameter.

A single well-trained examiner measured mesiodistal and buccolingual crown dimensions directly on the cast to avoid inter-observer bias. The intra examiner reliability was calculated by randomly selecting 100 casts and examining them at two different occasions. The kappa statistics was found to be 0.95 which reflected a high degree of conformity in the examination. The morphological traits were identified and classified independently by a different examiner, whose erroneous percentage of trait classification was less than three per cent.

## STATISTICAL ANALYSIS

All raw data from the study performa was transformed to Microsoft Excel. The same data was retrieved into SPSS software version

Degree	Expression
0	Smooth mesiobuccal crown surface
1	Small vertical ridge and groove
2	Small pit with minor grooves diverging from depression
3	Double vertical ridges or slight and incomplete cusp outline
4	Y form
5	Small tubercle
6	Broad cusp outline with a moderate tubercle
7	Large tubercle with a free apex

**[Table/Fig-2]:** Classification of cusp of carabelli according to Dahlberg (1963) [17].

17 for statistical analysis. Descriptive statistics was employed to study characteristics of population. Linear regression was used to assess the association of cusp of carabelli trait with the tooth dimensions. Logistic regression was used to evaluate the association of carabelli trait with gender and presence/absence of shoveling. Level of statistical significance was fixed at  $p < 0.05$ .

## RESULTS

In the present cross-sectional study 1885 subjects were included with the mean age of 8.38 ( $\pm 1.11$ ) years. Among them 48.6% were males and remaining females. On examination of their casts, 40.5% subjects had Cusp of Carabelli on first molar and 68.2% had shoveling on upper central incisor. The descriptive data of the study population of the namely age, tooth dimensions, gender, presence/absence of shoveling and presence/absence of Cusp of Carabelli is tabulated as [Table/Fig-3]. Linear regression analysis shows significant association of Cusp of Carabelli with both buccolingual and mesiodistal width of maxillary first molar ( $p = 0.001$ ) [Table/Fig-4]. The presence of Cusp of Carabelli increases buccolingual width of maxillary molar by 2.4mm on an average (odd's ratio), but it has negligible effect on mesiodistal width of maxillary first molar (odd's ratio - 0.0934). Logistic regression analysis between shoveling of 11 and Cusp of Carabelli of 16 shows positive association of both traits with p value 0.001 and an odd's ratio of 3.0 (C.I. 2.4 – 3.7) [Table/Fig-5]. However there is no statistically significant association found between gender and Cusp of Carabelli of 16 ( $p = 0.834$ ).

Variables		
	Age	8.38 (1.110)*
	BL	9.2 (1.37)*
	MD	10.43 (0.058)*
Gender	Male	916 (48.6)^
	Female	969 (51.4)^
Shoveling 11	Absent	599 (31.8)^
	Present	1286 (68.2)^
COC 16	Absent	1122 (59.5)^
	Present	763 (40.5)^

**[Table/Fig-3]:** Descriptive analysis of age, dimensions, gender, presence/absence of shoveling and carabelli trait.

\*Mean (SD) ^N (%)

	Mean (SD)	Estimate	95% C.I.		
			Lower	Upper	p-value
BL	9.2 (1.37)	2.437*	2.37	2.5	0.001
MD	10.43 (0.058)	0.097*	0.094	0.1	0.001

**[Table/Fig-4]:** Linear regression analysis showing association of COC with BL and MD width of teeth.

\*Linear regression

		COC 16		Estimate	95% C.I.		p-value
		Absent	Present		Lower	Upper	
shoveling 11	Absent	457	142	3.005*	2.417	3.737	0.001
	Present	665	621				
gender	Male	543	373	0.981*	0.816	1.179	0.834
	Female	579	390				

**[Table/Fig-5]:** Logistic regression analysis showing association of COC with gender and presence/absence of shoveling.

\*Linear regression

## DISCUSSION

This investigation was done in 7-10 year old school children who were native of Bangalore, India. This study is the first of its kind in the Indian population where the association of shoveling and the cusp of carabelli trait have been done. Only a handful number of studies have been done in this area and it remains unexplored still

		COC 16		Estimate	95% C.I.	
		Absent	Present		Lower	Upper
Author	Year	Population	Prevalence of Shoveling (%)	Prevalence of Cusp of Carabelli (%)	% of children with both traits	Positive association
Tsai PL et al., [12]	1996	Mongoloid	84.9	48.07	44.2	Yes (p <0.001)
Tsai PL et al., [9]	1999	Chinese	81.7	36.8	34.6	Yes (p <0.001)
Kirthiga M et al., (present study)	2015	Indian	68.2	40.5	40.4	Yes (p = 0.001)

**[Table/Fig-6]:** Tabulated results of previous studies on association of shoveling and cusp of carabelli trait

[9, 12]. There is definitely a need for studies in this topic, especially on the interaction between the shoveling and carabelli trait as it serves biological, forensic and archeological importance.

Ethnic association of shoveling and carabelli trait provides information on the evolutionary development and diversification between two or more populations. It will also add data regarding variation of shoveling and carabelli trait within a population [3].

The present study showed that gender did not have any significant difference when the presence or absence of Carabelli's trait was considered. Similar findings have been observed in a few other studies [14,21,22], but this result is incongruent when compared with few other studies [23,24]. Hence, it appears difficult to conclude that gender differences exist in Carabelli's trait. The prevalence of carabelli trait in the present population was found to be 40.5% which was well within the range (2.1–85.7%) of previous studies [13, 25-27]. Of the total children under study shoveling was seen in 68.2% of population. This finding was consistent with one more study conducted in Indian population where a prevalence of 65.7% was found [13]. The effect of tooth dimensions (mesiodistal and buccolingual diameter) on the presence or absence of carabelli trait has also been considered in the present study. Linear regression analysis showed significant association between the two ( $p < 0.001$ ). However, considering odd's ratio we can infer that the presence of Cusp of Carabelli increases the buccolingual diameter by 2.4mm on an average. But, the trait has negligible effect on the mesiodistal width of the tooth. This observation is in agreement with two other studies that have been performed in Chinese population [9,12].

According to Dahlberg [17], the Cusp of Carabelli could be an adaptation to enlarge the occlusal surface buccolingually compensating for the evolutionary reduction in mesiodistal dimension [10]. One more study has reported that larger first molars and Carabelli's cusp are interrelated large but not based on increase in buccolingual diameter alone [20]. The Cusp of Carabelli is suggested to be a primitive structure that would gradually disappear in line with human evolution [28,29]. Another study on Chinese population established the view point that as the molar size decreases, the occurrence of carabelli trait decreases. This supports the fact that Carabelli's trait is a disappearing feature [9]. A functional argument for the existence of Carabelli's trait has been that it may be a structure that resists excessive biomechanical stresses on the maxillary first molar [26].

Little interest is paid to the association of shoveling trait and Cusp of Carabelli, although studies have been done on dental traits in different populations. Inadequate studies have been done in this area and have been tabulated [Table/Fig-6]. In the present study, a positive association was revealed. The presence of Cusp of Carabelli was associated with the shoveling trait approximately every time it was present. This result coincides with that of a few more studies done in Mongoloid and Chinese populations [9,12]. According to former studies, [10,11] shovel trait occurs almost unanimously, and occurs particularly frequently in the Chinese, Taiwan aborigines, Eskimos, American Indians, and Australian Aborigines. Carabelli's trait is less commonly found in these populations [4]. This finding is in concurrence with the present

study. In contrast to this, European populations were found to have a low frequency of shovel trait and a high frequency of Carabelli's trait [4,19,27]. There is remarkable difference in the expression of shovel trait on the upper right central incisor teeth and Carabelli's trait on the upper right first molar in Chinese and Caucasoid population based on literature search. Hence, these traits have been considered as significant dental indicators of Chinese and Caucasoid ancestry [4].

A few studies reported that genetic as well as environmental factors are necessary for the association of shoveling and Cusp of Carabelli [21,30]. Although the generalization of the association between Cusp of Carabelli and shoveling trait seen in Indian population to other populations may be limited, this study promotes a method to investigate the association between shovel and Carabelli's trait entities in other populations, which are of critical importance as well [31].

## LIMITATION

Further studies with the same methodology in various Indian populations are necessary to evaluate an association between the shoveling and cusp of carabelli trait. The main limitation of the study was that this study was restricted to one group of Indian population, hence cannot be considered universal.

## CLINICAL IMPLICATIONS

- A thorough knowledge and careful assessment of these traits is required for a dentist to increase efficiency and effectiveness of treatment procedures, identification of deep fissures/incipient caries, application of pit and fissure sealants, extension of fissures during cavity preparation, etc.
- Ante mortem dental record of every patient should be recorded and maintained, which could be of forensic significance for the identification of an individual or to categorize the population to which he belongs.

## CONCLUSION

Within the study limitations, this cross-sectional study provided evidence that there is a positive association between shoveling and cusp of carabelli trait. The presence of Cusp of Carabelli increased the likelihood of the presence of shoveling almost 100% in the Indian population under study.

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