

Cusp of Carabelli - A Cross Sectional Study Among Trivandrum Population

Abstract

Background: The cusp of Carabelli is a commonly observed non-metric dental trait found on the mesiolingual surface of the maxillary first permanent molars. It exhibits considerable variations in expression, ranging from a well-developed cusp to a groove or pit and may appear unilaterally or bilaterally. The trait is of significant interest in dentistry, anthropology and genetics due to its morphological variability and population-specific prevalence. In addition to its forensic and anthropological relevance, the presence of Carabelli trait has clinical implications, including increased susceptibility to dental caries and treatment difficulties.

Aim: To investigate the prevalence and expression of the cusp of Carabelli among individuals in the Trivandrum population.

Materials and methods: A cross-sectional observational study was conducted involving clinical examination of the maxillary molars in a representative sample of the trivandrum population. The presence, bilateral symmetry, and morphological types of the Carabelli trait were recorded and analyzed.

Results: The prevalence of CuCp in left and right permanent first molars is found to be 35.2% and 37.7% respectively. However, the occurrence of CuCp on both right and left permanent second molars is found to be rare with a lower prevalence percentage of 0.5%. Thus the data suggests that CuCp expression was bilateral in the majority among the surveyed group. Based on Dalhberg's classification, among both right and left permanent first molars and primary second molars, the most occurring type of CuCp was found to be type 1 (small vertical ridge and groove). The least occurring types among permanent first molars and primary second molars were type 7 (large tubercle with a free apex) and type 4 (Y-form). Type 3 (double vertical ridges or slight and incomplete cusp outline) CuCp is also found to be of higher incidence in both left and right first molars among all remaining types. This type also showed significant prevalence among primary second molars. Moreover, type 3 CuCp was the only identified trait on both right and left permanent second molars with a prevalence of 0.5%.

Conclusion: The cusp of Carabelli is a prevalent trait in the Trivandrum population, with notable variation in form and expression. These findings contribute to the better understanding of dental morphological diversity in regional populations and may have implications in clinical, anthropological and forensic contexts.

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I. INTRODUCTION

The trait of cusp of Carabelli is fairly a common dental trait seen on the first permanent maxillary molars. It is present on the lingual surface of the mesiolingual cusp about midway between its cusp tip and the cervical margin. The Carabelli trait can present as a well developed cusp or underdeveloped cusp, or a groove or even a pit. The trait may be unilateral or bilateral. The trait expression can be different on left and right side in the same person.¹

Carabelli trait has always been an intriguing morphological characteristic for dentists, geneticists as well as anthropologists. Enamel being the hardest tissue in the body, preserve longer than any other human remains. Teeth are equally available to investigator both in fossils, in the living, in the laboratory and in the field. Therefore dentition can be used to establish the continuity between living and ancestral populations. Examination of teeth in the oral cavity is noninvasive as well as inexpensive. However, presence of the trait, make the upper molars more prone to caries. The treatment becomes even more difficult due to problems in adopting instruments.¹

The cusp of Carabelli was first described by Carabelli in the year 1842. Since then, it has been used significantly in forensic, anthropological and ethnic studies. Other names include Carabelli tubercle, fifth lobe, supplemental cusp, mesiolingual elevation, accessory cusp, etc.² The occurrence of Carabelli trait is found to vary among populations. Variation in frequencies within the population groups have also been reported. The aim of this study is to observe the occurrence of cusp of Carabelli among the Trivandrum population.

II. REVIEW OF LITERATURE

Carbonell et al reported that the trait has higher prevalence in white Caucasians and lower prevalence in Mongoloids (Chinese and Japanese). Scott (1980), Alvesalo et al. (1975) and Kieser (1984) have reported high frequencies for the trait in white Caucasian populations. The few available studies show that the frequency of the trait in Negroids was comparatively low. Kannapan et al (2001) in his study reported the prevalence of the trait was 52.77%. Dietz (1944) and Tsuji (1958) reported that the Cusp of Carabelli trait may be controlled by a single dominant gene. Kraus (1951) reported that the Carabelli trait is determined by two codominant autosomal alleles. Goose and Lee (1971) proposed a polygenic model of inheritance.

A 2010 study by Hunter and colleagues examined the developmental processes that lead to the morphological conditions under which Carabelli's cusp is expressed. According to a model of tooth morphogenesis composed in a 2002 paper by Salazar-Ciudad and Jernvall, Hunter and colleagues examined the relationship between cusp spacing, crown area, and Carabelli expression. The study reported that as intercuspal spacing reduces, in relation to tooth size, Carabelli expression increases. These findings support the predictions of the developmental model proposed by Salazar-Ciudad and Jernvall.^{2,3,4}

III. OBJECTIVES

This study aims to evaluate the prevalence of the Cusp of Carabelli (CuCp) in primary and permanent dentition, analyzing its distribution based on age and gender.

IV. MATERIALS AND METHODS

The study sample consists of 199 patients who visited Noorul Islam College of Dental Sciences, Thiruvananthapuram. Subjects who had undergone extraction of upper first molars/or restoration of the same teeth were excluded from the study. Photographs and casts were used to aid in the study. After obtaining the permission from the institution's ethical committee, the study was carried out over a period of 6 months from February 1 2023 to September 19 2023. Healthy primary second molars/permanent first molars and permanent second molars were included. The required consent and assent from the parents and children were obtained after explaining them about the examination method and those willing to participate were included in the study. During the study period, a total of 199 individuals were recruited into the study and the minimum age is 4 years and maximum age is 24 years (median age: 14 years). Intraoral examination (Type III examination in good illumination using mouth mirror and probe) of children was done to determine the presence and level of expression of Carabelli's trait of maxillary deciduous second molar and permanent first molar and if possible the observation of the same was done in second permanent molars according to the age of the assessed individual child. To avoid interexaminer bias, only one examiner was employed to record the degree of expression of this trait and evaluation was done on the basis of the classification developed by Kraus and standards developed by Dahlberg.⁵

Kraus's classification of Carabelli's trait to be used in the present study is as follows: 1. pronounced tubercle
2. slight tubercle 3. groove
4. pit
5. absence

Dahlberg's classification is used with prevalence of Carabelli trait in the group of individuals from the following gradations:

- 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 (moderate grooves bending occlusally in opposite directions)
- 5-small tubercle
- 6-broad cusp outline with a moderate tubercle
- 7-large tubercle with a free apex^{5,6}

In Dahlberg's classification, four grades (1 through 4) can be termed negative and 3 grades (5 through 7) can be termed positive.⁵

STUDY DESIGN

A cross-sectional study was conducted to assess the prevalence of Cusp of Carabelli in 199 participants aged 4 to 24 years. Presence of cusp of Carabelli was assessed in permanent first and second molars and primary second molars. Data were analyzed to determine prevalence of cusp of Carabelli by age and gender.

DATA COLLECTION:

Data collected included:

- Age
- Gender
- Presence of CuCp on the left permanent first molar 6L
- Presence of CuCp on the right permanent first molar 6R
- Presence of CuCp on the left permanent second molar 7L
- Presence of CuCp on the right permanent second molar 7R
- Presence of CuCp on the left primary second molar (L E)
- Presence of CuCp on the right primary second molar (R E)
- Type of CuCp present on 6L, 6R, 7L, 7R, L E, R E

STATISTICAL ANALYSIS. Mann Whitney U test and Chi-square tests were used to determine the association between gender and presence of Cusp of Carabelli (CuCp) and age-wise prevalence.

V. RESULTS

The sample size consists of 106 females and 93 males which makes it to a total of 199 individuals.

It has been found that there is no significant association was found between age and occurrence of CuCp. Further longitudinal studies might be needed to confirm such an association. [Table 1,2,3,4].

Also no significant association between gender and presence of CuCp . [Table 5,6,7,8; Graph 1]. The prevalence of CuCp in left and right first molars is found to be 35.2% and 37.7% respectively. However the occurrence of CuCp on both left and right second molars is found to be rare with a lower prevalence percentage of 0.5%. Thus the data suggests that CuCp expression was bilateral in the majority of the surveyed group. [Tables 9,10,11,12].

Based on Dahlberg's classification, among both left and right first molars, as well as primary second molars, the most occurring type of CuCp was found to be type 1 (small vertical ridge and groove). The least occurring types among permanent first molars and primary second molars were type 7 (large tubercle with a free apex) and type 4 (Y-form).

Type 3 (double vertical ridges or slight and incomplete cusp outline) CuCp is also found to be of higher incidence in both left and right first molars among all remaining types. This type also showed significant prevalence among primary second molars. Moreover, Type 3 CuCp was the only identified trait on both right and left permanent second molars with a prevalence of 0.5

%. [Table 13,14; Graph 2]

Comparison of age with Cusp of Carabelli trait on left first molar using Mann Whitney U test

	E/6L	N	Mean	Std. Deviation	Std. Error Mean	Mean difference	Mann Whitney test statistic	p value
Age	positive	18	16.56	5.490	1.294	1.056	423.5	0.548
	negative	52	15.50	6.131	.850			

Comparison of age with Cusp of Carabelli trait on right first molar using Mann Whitney U test

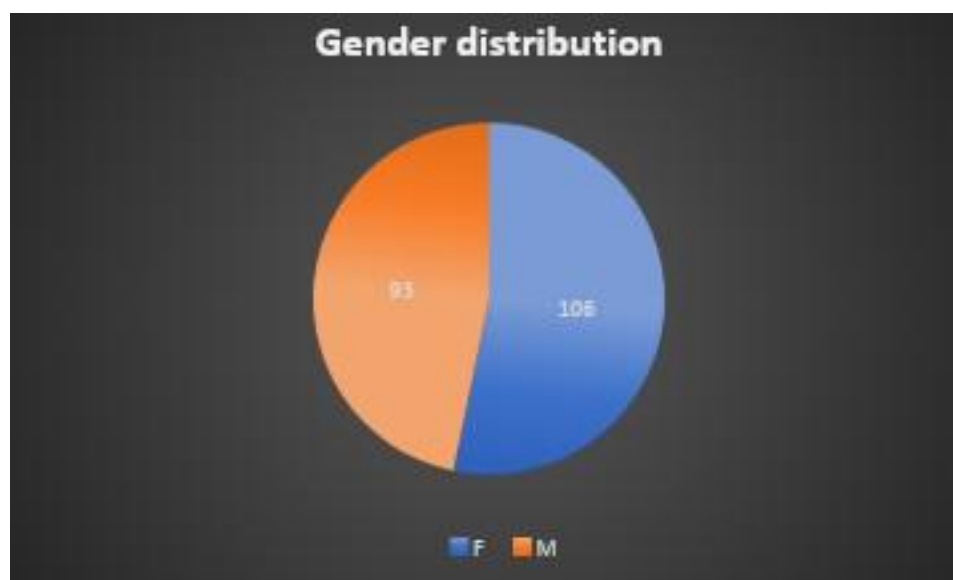
	E/6R	N	Mean	Std. Deviation	Std. Error Mean	Mean difference	Mann Whitney test statistic	p value
Age	positive	21	16.10	5.761	1.257	-0.053	562	0.953
	negative	54	16.15	5.537	.753			

Comparison of age with presence of cusp of Carabelli on left first molar using Mann Whitney U test

	E/6L	N	Mean	Std. Deviation	Std. Error Mean	Mean difference	Mann Whitney test statistic	p value
Age	present	70	15.77	5.952	.711	1.050	4992	0.215
	absent	129	16.82	5.124	.451			

Comparison of age with presence of cusp of carabelli on right first molar using Mann Whitney U test

E/6R		N	Mean	Std. Deviation	Std. Error Mean	Mean difference	Mann Whitney test statistic	p value
Age	Present	75	16.13	5.561	.642	0.512	4964	0.421
	Absent	124	16.65	5.376	.483			



Association of gender with Cusp of Carabelli trait on left first molar using Chi-square test

			E/6L		Total	Chi-squ are statistic	p value
			positive	negative			
Gende r	F	Count	9	24	33	0.079	0.778
		% within Gender	27.3%	72.7%	100.0%		
	M	Count	9	28	37		
		% within Gender	24.3%	75.7%	100.0%		
Total		Count	18	52	70		
		% within Gender	25.7%	74.3%	100.0%		

Association of gender with Cusp of Carabelli trait on right first molar using Chi-square test

			E/6R		Total	Chi-squ are statistic	p value
			positive	negative			
Gende r	F	Count	9	31	40	1.286	0.257
		% within Gender	22.5%	77.5%	100.0%		
	M	Count	12	23	35		
		% within Gender	34.3%	65.7%	100.0%		
Total		Count	21	54	75		
		% within Gender	28.0%	72.0%	100.0%		

Association of presence of cusp of Carabelli on left first molar with gender using chi-square test

E/6L			Total	p value
	present	absent		

Gender	F	Count	33	73	106	0.207
		% within Gender	31.1%	68.9%	100.0%	
	M	Count	37	56	93	
		% within Gender	39.8%	60.2%	100.0%	
Total		Count	70	129	199	
		% within Gender	35.2%	64.8%	100.0%	

Association of presence of cusp of Carabelli on right first molar with gender using chi-square test

Chi-Square Test of Independence						
E/6R					Total	p value
			Present	absent		
Gender	F	Count	40	66	106	0.988
		% within Gender	37.7%	62.3%	100.0%	
	M	Count	35	58	93	
		% within Gender	37.6%	62.4%	100.0%	
Total		Count	75	124	199	
		% within Gender	37.7%	62.3%	100.0%	

Prevalence of cusp of Carabelli in left first molar

E/6L					
E/6L		Frequency	Percent	Valid Percent	Cumulative Percent
	positive	18	9.0	25.7	25.7
	negative	52	26.1	74.3	100.0
	Total	70	35.2	100.0	
Missing	System	129	64.8		
Total		199	100.0		

Prevalence of cusp of Carabelli in right first molar

E/6R		Frequency	Percent	Valid Percent	Cumulative Percent
	positive	21	10.6	28.0	28.0
	negative	54	27.1	72.0	100.0
	Total	75	37.7	100.0	
Missing	System	124	62.3		
Total		199	100.0		

Prevalence of left second molar

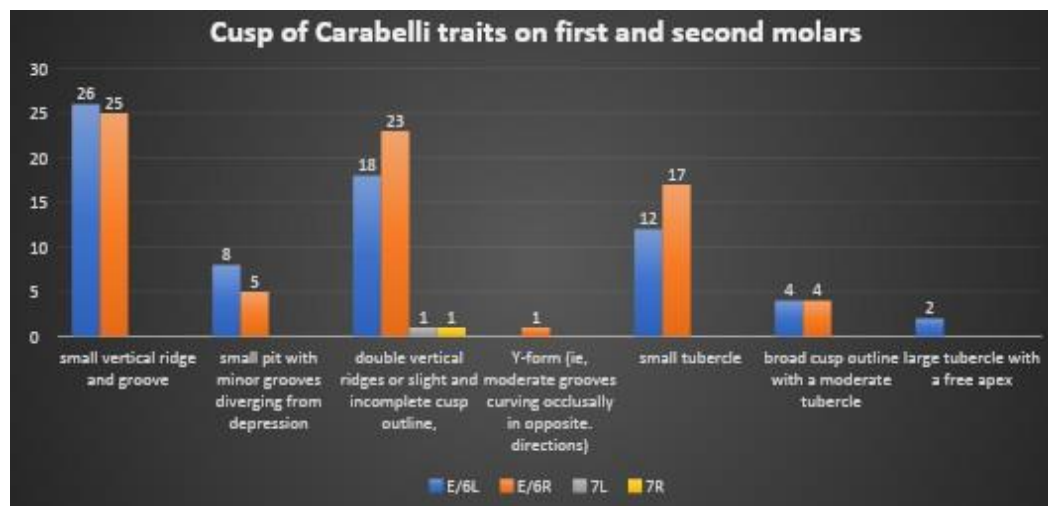
7L		Frequency	Percent	Valid Percent	Cumulative Percent
	negative	1	.5	100.0	100.0
Missi ng	System	198	99.5		
Total		199	100.0		

Prevalence of right second molar

7R		Frequency	Percent	Valid Percent	Cumulative Percent
	negative	1	.5	100.0	100.0
Missi ng	System	198	99.5		
Total		199	100.0		

E/6L		Frequency	Percent	Valid Percent
	small vertical ridge and groove	26	13.1	37.1
	small pit with minor grooves diverging from depression	8	4.0	11.4
	double vertical ridges or slight and incomplete cusp outline,	18	9.0	25.7
	small tubercle	12	6.0	17.14
	broad cusp outline with a moderate tubercle	4	2.0	5.7
	large tubercle with a free apex	2	1.0	2.9
	Total	70	35.2	100
	No cusp of carabelli	129	64.8	64.8
	Total	199	100.0	100.0

E/6R		Frequency	Percent	Valid Percent
	small vertical ridge and groove	25	12.6	33.3
	small pit with minor grooves diverging from depression	5	2.5	6.7
	double vertical ridges or slight and incomplete cusp outline,	23	11.6	30.7
	Y-form (ie, moderate grooves curving occlusally in opposite. directions)	1	.5	1.33
	small tubercle	17	8.5	22.7
	broad cusp outline with a moderate tubercle	4	2.0	5.3
	Total	75	37.7	100
	10	124	62.3	62.3
	Total	199	100.0	100.0



VI. DISCUSSION

In this study, the prevalence of CuCp in left and right first molars is found to be 35.2% and 37.7% respectively. The occurrence of CuCp on both left and right second molars is found to be rare with a lower prevalence percentage of 0.5%. R.Bhavyaa et al. conducted a study on prevalence of CuCp among 1064 children of 3 to 4 years and the prevalence was found out to be 90.6%.⁷ Shanmathy Suresh Babu et al conducted a study to evaluate the non-metric dental

traits and their variation among the South Indian population where the prevalence of CuCp was found to be 52%.⁸

Numerous studies have been conducted on various countries, races and populations and there is no perfect prevalence on percentage of occurrence. Kamatham R et al studied the distribution of Carabelli trait in a group of children from Nellore where the prevalence of CuCp was 89.8% in primary second molars, 63.7% in permanent first molars and 8% in permanent second molars.⁵ K. Mavrodiz et al studied the prevalence of CuCp in a contemporary Hungarian population and the prevalence was found to be 65.34%.⁹

Type 3 CuCp was the only identified trait on both right and left permanent second molars with a prevalence of 0.5%. A similar study conducted among the Bengaluru population by T Smitha et al. showed an increased frequency of occurrence of type 3 CuCp.¹⁰

It has also been found that there is no significant association between gender and presence of CuCp. Also no significant association was found between age and occurrence of CuCp. Further longitudinal studies might be needed to confirm such an association.

VII. CONCLUSION

The cusp of Carabelli is an anatomical predisposing factor for dental caries in upper molars. Therefore studying the prevalence of Carabelli trait can help in the assessment of caries risk in upper molars in children. It might appear crucial in routine clinical procedures such as sealant placement, band adaptation etc.,. Also, it is of great significance in anthropometric studies as well as for forensic purposes like post mortem profiling.

This comprehensive analysis provides a detailed view of CuCp prevalence in both primary and permanent dentition. The expression of the CuCp trait was found to be bilateral among the positively identified cases. Age and gender differences were not statistically significant. This might be due to the small sample size of the study. However, these findings contribute to a better understanding of CuCp and the need for further research into the factors influencing its development. Future research should explore the underlying genetic and developmental factors contributing to these variations. This can be helpful in studying the degree of intercourse between different populations and races.

REFERENCE

- [1]. Upul Dissanayake, MS Chandrasekera, ER Wikramanayake. The prevalence and mode of inheritance of Carabelli trait in the Sinhalese. The Ceylon Journal of Medical Science 2004;47:7-15.
- [2]. M Krithika, M Manju, R Praveen, W Umesh. Ethnic association of cusp of Carabelli trait and shovel trait in an Indian population. Journal of Clinical and Diagnostic Research. 2016 Mar, Vol-10(3):ZC78-ZC81.
- [3]. Hunter JP, Guatelli-Steinberg D, Weston TC, Durner R, Betsinger TK. Model of tooth morphogenesis predicts carabelli cusp expression, size, and symmetry in humans. PLoS One. 2010 Jul 29;5(7):e11844.
- [4]. Salazar-Ciudad I, Jernvall J. A gene network model accounting for development and evolution of mammalian teeth. Proc Natl Acad

- Sci U S A. 2002;99:8116–8120.
- [5]. Kamatham R, Nuvvula S. Expression of Carabelli trait in children from Southern India-A cross sectional study. *J Forensic Dent Sci* 2014;6:51-7.
- [6]. Dahlberg AS. Analysis of American Indian dentition. In: Brothwell DR, editor. *Dental Anthropology*. Oxford: Pergamon Press; 1963. pp. 149–78.
- [7]. Bhavyaa R, Sujitha P, Muthu MS, Kirthiga M. Prevalence of Cusp of Carabelli and its caries susceptibility - an ambidirectional cohort study. *Aust Dent J*. 2020 Dec;65(4):294-301.
- [8]. Sureshbabu S, Ramadoss R, Arthanari A, Ramalingam K. Dental Anomalies: An Identification Marker in Forensics. *Cureus*. 2024 May 8;16(5):e59922.
- [9]. Mavrodisz K, Rozsa N, Budai M, Soos A, Pap I, Tarjan I. Prevalence of accessory tooth cusps in a contemporary and ancestral Hungarian population. *Eur J Orthod*. 2007;29:166-68
- [10]. Smitha T Venkadesh D, Veeresh M, Hema KN, Sheethal HS, Vidya MA. The cusp of Carabelli: Frequency, distribution and type in the Bengaluru population. *J Oral Maxillofacial Pathology* 2018;22:418-22.