Frequency and degree of inter-trait association of maxillary Non-Metric Dental Crown Traits in the permanent dentitions of two states of India

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ABSTRACT

Non-metric Dental Crown Traits are a principal source of information in forensic dentistry. However, inadequate data on the prevalence of these traits prompted this study to determine the frequency, sexual dimorphism and degree of inter-trait association in two different populations of India. Dichotomized data on the existence of non-metric features were recorded among individuals from Odisha (n=506) and Kerala (n=536) between 15 to 30 years of age. Cusp of Carabelli is the most common trait to occur (48 %) followed by shovelling of incisors (15%) and Bushman canine (14%). Bushman canine (p=0.045) and Cusp of Carabelli (p = 0.041) were found to be significantly expressed in Odisha and Kerala populations respectively. A strong association between shovelling of central incisor and Bushman canine with a likelihood ratio of 14.041 (p=0.001) was observed. This study will help in characterizing the Indian dentition and post-mortem dental profiling.

INTRODUCTION

Morphological characteristics of teeth are informative indicators for the study of human populations, serving as the basis for classifying human groups in taxonomic, phylogenetic and evolutionary categories. This is possible because teeth are commonly preserved even in the extreme conditions in which skeletal remains are found. Although metric and non-metric features of teeth solely cannot identify an individual, they may expedite personal identification by narrowing down the ethnic origin and gender (1). Non-metric dental crown traits (NDCTs) are phenotypic forms of the enamel that are inherited and controlled in their location, growth and orientation; they result from indirect processes of mineral secretion mediated by proteins during tooth development, and they are expressed and regulated by the human genome of each individual (2). Unlike metric traits, non-metric features can be recorded exclusively by visual observation without any specific equipment, even in fragmented remnants. NDCTs can be described as positive (cusps) or negative structures (pits, furrows and grooves) that have the potential to be present or absent in a specific place (frequency), in a different form or grade (variability), and in one or more members of a population group. To date, there are more than 100 non-metric dental crown and root traits described in the human dentition (3). Winging, shovelling, cusp of Carabelli, parastylid, accessory cusp and Bushman canine are a few of the readily definable and

identifiable NDCTs which may help in the assessment of differences in their frequency and degree of expression. NDCTs may also differ from generation to generation because of the ability to become extinct or vestigial. According to the Clonal model theory each trait is the result of interaction between genetic and environmental factors. This may hold true for NDCTs too; therefore, population differences of NDCTs are likely to occur. Although several studies exist in Chinese [4, 5], Japanese [4], Hungarian [6], Nigerian [7], Jordanian [8, 9] and Malaysian [10] populations, there are only a handful of studies evaluating the frequencies of several NDCTs in the Indian population [11-13]. In fact, this study is the first to compare two Indian populations from two distant states, namely Odisha, the eastern state and Kerala, the southern state.

The objective of the present study was to determine the frequency, sexual dimorphism, and degree of association of eleven maxillary NDCTs, namely winging of central incisor (I1), shovelling of central incisor (I1), shovelling of lateral incisor (I2), double shovelling of central incisor (I1) and lateral incisor (I2), peg lateral, Carabelli's trait, parastylid, accessory cusp, Bushman's canine and three cusp first molar (M1) among the age group of 17 to 25 years in a current Indian population comprised of individuals of Odisha, an eastern state and Kerala, a southern state. The objective was also to compare these frequencies in both populations with the purpose of understanding the developmental behaviour of these features, the dominant ethnic influence, and the dental morphological characters of the sample. These findings may contribute to discussions of the usefulness of dental morphology in dental anthropology and forensic dentistry. The findings may also provide statistically useable reference data of the prevalence of these non-metric coronal features in the populations of Odisha and Kerala. This study will test the hypothesis that the development of tooth based anthropological standards differ among generations and populations [14-17].

MATERIAL AND METHODOLOGY

Sample collection

This is a descriptive cross-sectional study evaluating the frequency of eleven NDCTs among 506 maxillary casts (329 female and 175 male) of 17 to 25 years of age recruited from the Department of Orthodontia, Institute of Dental Sciences, Siksha 'O' Anusandhan deemed to be University, Odisha. 536 maxillary casts (293 female and 243 male) of a similar age group recruited from Kerala population. Inclusive criteria are subjects' belonging to Odisha/Kerala, sound dental health without any congenital anomaly, without regressive alterations, and subjects with upper and lower first permanent molars. Each NDCT feature can be categorized into several patterns according to the Arizona State University dental anthropology system (ASUDAS) [18]. The ASUDAS system of recording the expression of NDCTs is based upon the principle of physical representation of minimal and maximal trait expression and various gradations between these two points[19]. Although this method can record the finest level of distinction of any non-metric trait, we have dichotomized the traits into two types as existing and non-existing traits for ease and convenience in recording.

Statistics

We performed the analysis of the obtained study casts manually evaluating eleven maxillary NDCTs in the permanent dentitions. The data were processed using the SPSS® software version 21. Chi-square test was applied for each of the NDCTs. The p value of ≤ 0.05 was considered to be statistically significant.

OBSERVATIONS AND RESULTS

One hundred casts were randomly selected and scored again by the same observers as well as an independent observer. The intra-class correlation coefficient analysis for intra-observer and inter-observer reliability are expressed as r values presented in Table 1. Approximation of r-values towards 1 indicated that the data were highly reliable on multiple observations.

Prevalence analysis

Prevalence analysis of NDCTs in the populations of the two states combined to represent the Indian population (table 2) demonstrated that cusp of Carabelli (figure 1) is the most common trait to occur (48 %) followed by shovelling of incisors (figure 2) (15%) and Bushman canine (figure 3) (14%).

Evaluation of frequency of NDCTs in Odisha (table 2) exhibited an increase in the frequency of cusp of Carabelli (39%), followed by shovelling of upper incisors (22 % for lateral incisor and 16 % for central incisor), and Bushman canine of maxilla (21%). Evaluation of the frequency of NDCTs in Kerala (table 3) presented an increase in frequency of cusp of Carabelli (56%). Chi square test applied to compare the prevalence of traits between Odisha and Kerala showed a statistically significant increased frequency of expression of Bushman canine (p=0.045), parastylid (figure 4) (p=0.024) and three cusp molar (figure 5)

(p=0.021) in Odisha along with increased expression of cusp of Carabelli (p = 0.041) in Kerala. Expression of double shovelling in lateral incisor is similar in both populations.

Table 1. Reliability of inter- and intra-observer assessments

Reliability	R value
Intra-observer	0.900-0.954*
Inter-observer	0.976-0.990*

Figure 1. Photograph of maxillary cast shows cusp of Carabelli (accessory cusp on lingual surface of mesio-lingual cusp) on maxillary first molar

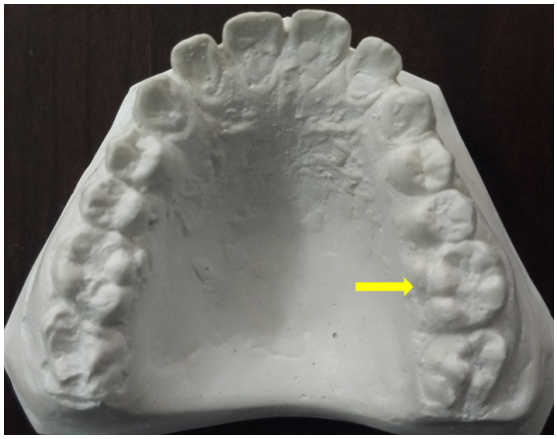


Table 2. Frequency of NDCT in maxilla in Odisha and Kerala population (n=1042)

Jaw	NDCT	Frequency (n=1042)
Maxilla	Winging	74
	Shovelling I1	121
	Shovelling I2	156
	Double Shovelling I1	67
	Double Shovelling I2	38
	Peg lateral	56
	Cusp of Carabelli	498
	AC	1
	BC	149
	Parastylid	8
	Three cusp molar	9

Figure 2. Photograph of maxillary cast shows shovelling (accentuated marginal ridges) of central (a) and lateral (b) incisors

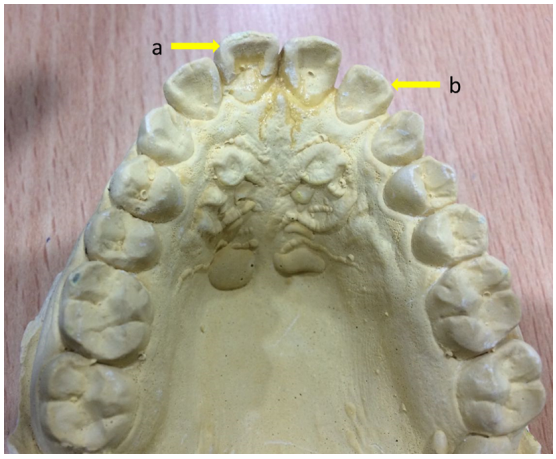


Figure 3. Photograph of maxillary cast shows Bushman canine of left maxillary canine (prominent marginal ridges and cingulum resembling premolar)

Figure 4. Photograph of maxillary cast shows Parastylid (accessory cusp on buccal surface) in maxillary second molar

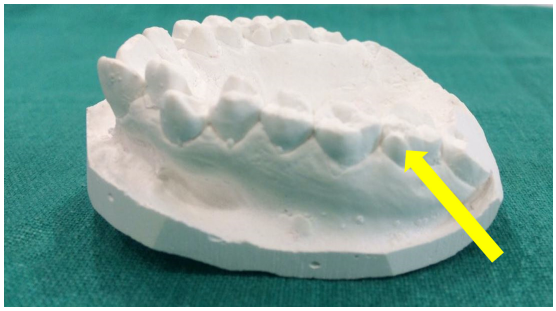
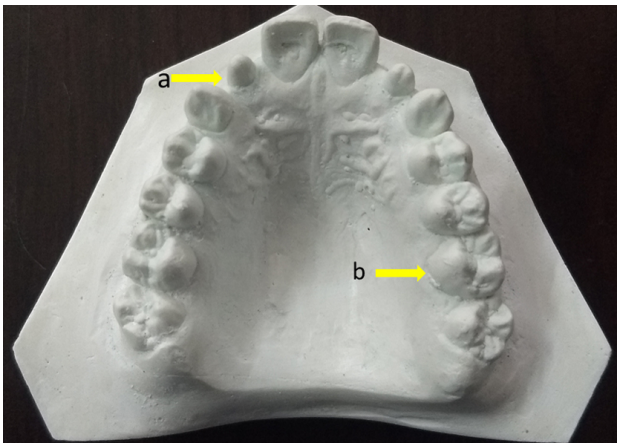


Table 3. Statistical comparison of frequency of NDCT of maxilla between Odisha and Kerala population (both genders combined)

	NDCT	Frequency Odisha (n=506)	Frequency Kerala (n=536)	P value
Maxilla	Winging	21	53	0.453
	Shovelling I1	80	41	0.631
	Shovelling I2	113	43	0.229
	Double Shovelling I1	23	44	0.248
	Double Shovelling I2	20	18	0.524
	Peg lateral	32	26	1.000
	Cusp of Carabelli	148 - Bilateral 37- Unilateral	215- Bilateral 86- Unilateral	0.288
	Accessory cusp	1	0	.....
	Bushman Canine	104	45	0.045
	Parastylid	6	2	0.024
	Three cusp molar	9	0	0.021

Figure 5. Photograph of maxillary cast shows peg shaped lateral incisor (a) and three cusps of maxillary first molar (b)



Among Odisha and Kerala males (table 4) there was no statistically significant difference in expression of NDCTs whereas there was statistically significant higher prevalence of winging of incisors (0.05) followed by cusp of Carabelli (0.004) in Kerala females compared to that of Odisha females (table 5)

Table 4. Statistical comparison of the frequency of non-metric NDCT between Odisha and Kerala (Male)

Jaw	NDCT	Frequency Odisha (n=175)	Frequency Kerala (n=243)	P value
Maxilla	Winging	11	20	0.604
	Shovelling I1	31	22	0.469
	Shovelling I2	42	26	0.780
	Double Shovelling I1	0	10	
	Double Shovelling I2	0	8	-do-
	Peg lateral	8	7	1.000
	Cusp of Carabelli	60- Bilateral 15- Unilateral	103- Bilateral 35- Unilateral	
	Accessory cusp	1	0	ACKe a constant
	Bushman Canine	35	28	0.478
	Parastylid	1	1	1.000
	Three cusp molar	4	0	

Sexual dimorphism

Chi square test and discriminant function analysis were used in assessing sex differences with respect to individual NDCTs using the SPSS 21 version. Both tests did not show any significant sexual dimorphism with regard to any of the NDCTs.

Degree of association

There was a strong association between shovelling of central incisor and Bushman canine with a likelihood ratio of 14.041 (p=0.001) in the Indian population. No other variables are associated significantly.

Table 5. Statistical comparison of the frequency of non-metric NDCT between Odisha and Kerala (Female)

	NDCT	Frequency Odisha (n=331)	Frequency Kerala (n=293)	P value
Maxilla	Winging	10	33	0.092
	Shovelling I_1	49	19	1.000
	Shovelling I_2	71	17	0.233
	Double Shovelling I_1	23	34	0.088
	Double Shovelling I_2	20	10	0.516
	Peg lateral	24	17	1.000
	Cusp of Carabelli	96-Bilateral 22-Unilateral	112-Bilateral 51-Unilateral	0.016
	Accessory Cusp	0	0	.....
	Bushman Canine	69	17	0.474
	Parastylid	5	1	1.000
	Three cusp molar	5	0	

DISCUSSION

A clue to the evaluation of racial variations attributed to micro-evolutionary processes may be obtained by the analysis of NDCTs which in turn possess a high taxonomic value and forensic importance. The importance is more noticeable when there is a need to focus the investigation of personal identification into potential gender and race from unknown remains. Several bioarchaeological studies have established consistencies in the manifestation and occurrence of non-metric dental traits among various ethnic groups in ancestry determination in the context of forensic dental anthropology [20]. NDCTs have the potential for physical profiling of skeletonised remains of different populations in forensic and anthropological scenarios. This will be possible when population specific data exists on the frequency of NDCTs. This research aims to determine the frequency of several NDCTs in the Indian population.

The world renowned palaeontologist William King Gregory (1922) opined that tooth crown morphology varied scarcely among the major races of mankind. However in the recent past, variations have been noted with respect to non-metric dental crown traits like shovelling, double shovelling, cusp of Carabelli etc. [21-23]. Although there are hundreds of NDCTs, cusp of Carabelli and shovelling have remained as the important pointers with almost no studies on other NDCTs primarily because of their extremely rare occurrence. This research is the first of its kind to evaluate the frequency, sexual dimorphism and degree of inter-trait association of eleven maxillary NDCTs in the permanent dentition of 1038 Indians. Because of the reported regional variations, we have attempted the comparison of these NDCTs in 506 individuals of Odisha and 536 individuals of Kerala, two states of India.

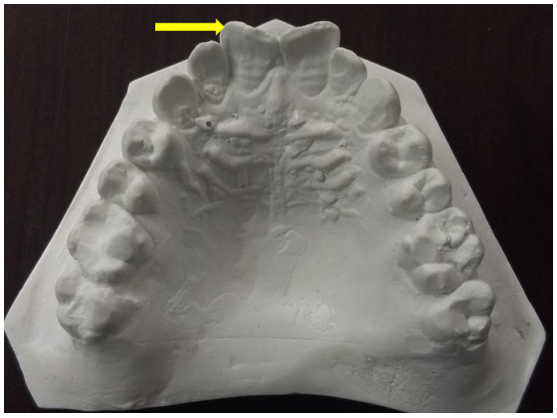
Elevation of the mesial and distal lingual ridges on the incisors produces a unique but quite variable NDCT known as shovel-shaped incisor. Carabelli's traits are found on the lingual aspect of the mesio-lingual cusp of the upper first molar teeth on which the traits may take the form of a pit, fissure or cusp. The presence or absence of Carabelli's trait was recorded for the upper right first molar. The higher frequency of cusp of Carabelli has been reported in Chinese [4, 5, 24], Japanese [4], Hungarian [6], Nigerian[7], Jordanian [8, 9], Malaysian [10] and other Caucasoid [25] populations. Only two studies [11, 26] conducted on an Indian population, restricted to southern Indian states opine a higher frequency of cusp of Carabelli whereas another two southern Indian studies [12, 13] stressed the higher frequency of shovelling and double shovelling. Our finding indicated that the frequency of cusp of Carabelli among the studied NDCTs are highest (48%) followed by shovelling of lateral incisor (15%) and Bushman canine (14%). According to Zubov (1973), evolutionary tendencies, too, are quite different: while in the Eastern groups the trait remained stable or tended to become more common, the frequencies of the shovelling gene in the West decreased quite markedly and in a regular fashion. At present, the frequency of the

shovelling gene in the West appears to continue dropping, making the East-West differences even more pronounced. Two features of the Mongoloid dental complex, namely a high frequency of shovel incisors and a low frequency of Carabelli's trait molars, were reported by Dahlberg in 1951 and by Hanihara in 1968. The regional variations among NDCTs are significant with respect to cusp of Carabelli being high in Kerala population whereas Bushman canine, parastylid and three cusp molar being higher in Odisha population. A larger representative sample size involving different regions of India would be an important area of further research to assess the overall frequency of NDCTs in India and perhaps throwing light on existing regional variations of NDCTs, if any, in different parts of India. High frequency of shovelling and low frequency of Carabelli's trait are significant Mongoloid features which individually may predict inter-population ethnic differences and may aid in personal identification; the degree of association of these two traits may further facilitate the process. Multiple studies opine a positive [27] as well as a negative [28] association of these traits. There is preliminary evidence of a positive association [26] between shovel and Carabelli's traits in Indian populations but the degree of association is obscure. This study demonstrates no significant association of these two traits in the Indian population although a very significant degree of association is found between shovelling of incisor with Bushman's canine. This noteworthy finding will definitely aid in inter-population analysis and personal identification.

Due to the greater development of the cingulum, canines may resemble premolars and are referred to as Bushman's canine.[29] This trait is most common in African populations especially the bushmen but has also been reported in other geographical locations.[29] We have seen a reasonable frequency of grade 1 of Bushman canine in an Indian population (10%) with a significantly higher level in Odisha compared to Kerala. Because of lack of studies on this trait in Indian as well as other populations, studies of this kind should be encouraged to make use of these traits in the forensic identification process.

A wing-like appearance formed by maxillary incisors initially observed among American Indians due to the rotation of distal margins of the incisors in a labial direction has been termed winging by Dahlberg. Mesio-lingual rotation of incisors bilaterally is considered as distinctive of Native American populations while the rotation of a single tooth or both in a disto-lingual direction is attributed to crowding [30]. Frequency of winging in the Indian population, according to our study (Figure 6) was found to be 7.2 % which is considerably lower than Colombia [2]. The lack of recent studies evaluating frequency of winging makes this particular study worth presenting.

Figure 6. Photograph of maxillary cast shows winging (mesio-lingual rotation) of maxillary central incisors



A maxillary molar has four major cusps and one minor cusp named as disto-lingual cusp or hypocone. Because it is the smallest and latest to develop odontogenetically [31] it is most likely to reduce with evolution leading to the three cusped maxillary molar. Therefore, with the objective of evaluating hypocone reduction in modern humans we estimated the frequency of the three cusp maxillary first molars in the Indian population. Our study showed a frequency of 9 bilateral three cusp maxillary permanent first molars among 504 individuals of Odisha (1.8%) with none found in Kerala population which contradicts an Indian study [32] conducted in Madhyapradesh, India showed a prevalence of (0.32%) four cases of permanent maxillary first molars with three cusps. The four cases having three cusp permanent maxillary first molars were present unilaterally and only in females. This trait is showing significant regional variation and rarity of this trait may be important in personal identification.

Paramolar tubercles have long been recognized as non-metric dental traits influenced by ethnic and racial background for its occurrence. They are presented as anomalous cusp, supernumerary

inclusion or eminence occurring on the buccal surfaces of both upper and lower premolars and molars.[33] Dahlberg [33] in 1945 introduced paleontological nomenclature when he referred to this structure as "parastyle" when present in the upper molars and as "protostylid" when present in the lower molars. This study emphasizes the rare incidence of paramolar tubercle or parastylid as 6 out of 504 in the Odisha population and 2 out of 536 in the Kerala population. Bilateral occurrence of all cases is worth reporting which contradicts the unilateral occurrence reported previously.[32, 34] The occurrence of this structure is very low in upper first molars (0% to 0.1%) as compared with upper second molars (0.4% to 2.8%) or upper third molars (0% to 4.7%) in all the given populations [34, 35].

Sexual dimorphism of any trait impacts the personal identification process to a great extent. If significant sexual dimorphism exists for a trait, pooling of two genders influences the identification process and individuals of unknown sex should not be used whereas in the absence of sexual dimorphism gender may be ignored for inter-population comparisons. Sexual dimorphism is not demonstrated by any of the NDCTs taken up in this study indicating that these traits may be conveniently adopted for personal identification process for the Indian population.

Broadly, the world may be divided into three geographical evident groups namely 1) Europe/ Mediterranean (Europe, West Asia, North Africa), 2) Northeast Asia/New World (South Siberia, China-Mongolia, Northeast Asia, American Arctic, North and South Native Americans), and 3) Australia/Oceania (Southeast Asia, Australia, Melanesia, Micronesia, Polynesia). Dental characterization could be conducted using these types of study eventually assisting in personal identification as well as inter-population comparison. With all the relevant data of this study, the Indian population may be characterized by 48% cusp of Carabelli followed by almost equal prevalence of shovelling of lateral incisors and Bushman canine with considerable low prevalence of shovelling central incisor, bilateral winging of central incisors, peg lateral, three cusp first molars and negligible prevalence of double shovelling, accessory cusp and parastylid. This characterization is between the Caucasoid and Mongoloid dental characterization. The study of the influence of evolutionary process upon NDCTs would measure the distance of modern human from ancient human that may be deduced from such types of prevalence study. However maxillary NDCTs must be looked for as a group rather than as isolates for personal identification. It is hoped that this paper helps fill, to some extent, the great void in Indian dental characterization.

REFERENCES

1. Brooks S. The human skeleton in forensic medicine. By W.M. Krogman and M. Y. Işçan. Springfield: Charles C. Thomas. 1986.
2. Díaz E, García L, Hernández M, Palacio L, Ruiz D, Velandia N, et al. Frequency and variability of dental morphology in deciduous and permanent dentition of a Nasa indigenous group in the municipality of Morales, Cauca, Colombia. Colombia Médica 2014; 45(1):15–24.
3. Ullinger JM, Sheridan SG, Hawkey DE, Turner CG, Cooley R. Bioarchaeological analysis of cultural transition in the southern Levant using dental nonmetric traits. American Journal of Physical Anthropology. 2005;Oct;128(2):466–76.
4. Cardoso HFV. Testing discriminant functions for sex determination from deciduous teeth. Journal of Forensic Sciences. 2010;Nov;55(6):1557–60.
5. Franklin D, Freedman L, Milne N. Sexual dimorphism and discriminant function sexing in indigenous South African crania. HOMO. 2005;55(3):213–28.
6. Ross AH, Konigsberg LW. New formulae for estimating stature in the Balkans. Journal of Forensic Sciences. 2002; Jan;47(1):165–7.
7. Zorba E, Moraitis K, Manolis SK. Sexual dimorphism in permanent teeth of modern Greeks. Forensic Science International. 2011; Jul 15;210(1–3):74–81.
8. Greene DL. Book review. Advances in dental anthropology. Edited by M. A. Kelley and C. S. Larsen. New York: Wiley-Liss, 1991, American Journal of Human Biology. 1991;3(6):693–4.
9. Khudaverdyan AY. Non-Metric Dental Traits in Human Skeletal Remains from Transcaucasian Populations: Phylogenetic and Diachronic Evidence. Anthropological Review. 2014; Jul 15;77(2):151–74.
10. Hanihara T. Metric and nonmetric dental variation and the population structure of the Ainu. American Journal of Human Biology. 2010;22(2):163–71.
11. Manabe Y, Rokutanda A, Kitagawa Y. Nonmetric tooth crown traits in the Ami tribe, Taiwan aborigines: comparisons with other east Asian populations. Human Biology. 1992; Oct;64(5):717–26.
12. Peiris HRD, Arambawatta AKS, Hewapathirana TN, Nanayakkara CD, Chandrasekara M, Wickramanayake E. Nonmetric tooth crown traits in a Sri Lankan

aboriginal Vedda population. Homo. 2011;Dec;62(6):466–77.
13. Guo L, Sun DL, Ren L, Shen J, Pan KF, Shen J, et al. A comparative morphologic study of Carabelli cusp between Chinese and Japanese students. Shanghai Journal of Stomatology. 1995 ;Jun;4(2):66–7.
14. Hsu JW, Tsai PL, Hsiao TH, Chang HP, Liu LM, Liu KM, et al. Ethnic dental analysis of shovel and Carabelli's traits in a Chinese population. Australian Dental Journal. 1999;44(1):40–5.
15. Huang ST, Miura F, Soma K. A dental anthropological study of Chinese in Taiwan. Dental trait. The Kaohsiung journal of medical sciences. 1992;Dec;8(12):665–78.
16. Mavrodisz K, Rózsa N, Budai M, Soós A, Pap I, Tarján I. Prevalence of accessory tooth cusps in a contemporary and ancestral Hungarian population. European Journal of Orthodontics. 2007;Apr;29(2):166–9.
17. Falomo OO. The cusp of Carabelli: frequency, distribution, size and clinical significance in Nigeria. West African Journal of Medicine. 2002;Dec;21(4):322–4.
18. Khraisat A, Alsoleihat F, Subramani K, Taha ST, Al-Rabab'ah MA, Al-Bitar ZB. Hypocone reduction and Carabelli's traits in contemporary Jordanians and the association between Carabelli's trait and the dimensions of the maxillary first permanent molar. Collegium antropologicum. 2011;35(1):73-8.
19. Khraisat A, Taha ST, Jung RE, Hattar S, Smadi L, Al-Omari IK, et al. Prevalence, association, and sexual dimorphism of Carabelli's molar and shovel incisor traits amongst Jordanian population. Tropical dental journal. 2007;30(119):17-21.
20. Rusmah M. The cusp of Carabelli in Malaysians. Tropical dental journal. 1992;15(1):13-5.
21. Hsu JW, Tsai P, Liu K, Ferguson D. Logistic analysis of shovel and Carabelli's tooth traits in a Caucasoid popul a t ion. For ens i c s c i ence inte rna t iona l . 1997;89(1-2):65-74. 22.
22. Kamatham R, Nuvvula S. Expression of Carabelli trait in children from Southern India - A cross sectional study. Journal of forensic dental sciences. 2014;6(1):51-7.
23. Kirthiga M, Manju M, Praveen R, Umesh W. Ethnic Association of Cusp of Carabelli Trait and Shoveling Trait in an Indian Population. Journal of clinical and diagnostic research : JCDR. 2016;10(3):ZC78-81.
24. Kirthiga M, Manju M, Praveen R, Umesh W. Prevalence of aberrant dental morphological details in 6-10 year old school children in an Indian population. Contemporary clinical dentistry. 2015;6(Suppl 1):S175-80.
25. Uthaman C, Sequeira PS, Jain J. Ethnic variation of selected dental traits in Coorg. Journal of forensic dental sciences. 2015;7(3):180-3.
26. Tsai PL, Hsu JW, Lin LM, Liu KM. Logistic analysis of the effects of shovel trait on Carabelli's trait in a Mongoloid population. American Journal of Physical Anthropology. 1996;100(4):523-30.
27. Harris RG. The san blas indians. American Journal of Physical Anthropology. 1926;9(1):17-63.
28. Irish JD, Morris DH. Technical note: canine mesial ridge (Bushman canine) dental trait definition. American Journal of Physical Anthropology. 1996;99(2):357-59.
29. Scott GR, Turner CG. The Anthropology of Modern Human Teeth: Dental Morphology and its Variation in Recent Human Populations. Cambridge: Cambridge University Press; 1997.
30. Kondo S, Townsend GC, Yamada H. Sexual dimorphism of cusp dimensions in human maxillary molars. American Journal of Physical Anthropology. 2005;128(4):870-7.
31. Jain S. Variation in Cuspal Morphology in Maxillary First Permanent Molar with Report of 3 Cusp Molar- A Prevalence Study. Journal of clinical and diagnostic research. 2016;10(9):ZC34-ZC6.
32. Dahlberg AA. The evolutionary significance of the protostylid. American Journal of Physical Anthropology. 1950;8(1):15-25.
33. Ooshima T, Ishida R, Mishima K, Sobue S. The prevalence of developmental anomalies of teeth and their association with tooth size in the primary and permanent dentitions of 1650 Japanese children. International journal of paediatric dentistry. 1996;6(2):87-94.
34. Ishida R, Mishima K, Adachi C, Miyamoto A, Ooshima T, Amari E, Kamiyama K, Higaki M, Akasaka M, Yoshida S, et al. Frequency of the developmental disturbances of tooth structure. The Japanese journal of pedodontics. 1990;28(2):466-85.
35. Pietrusewsky M. The anthropology of modern human teeth: Dental morphology and its variation in recent human populations. American Journal of Physical Anthropology. 1998;106(1):101-3.