Research Article

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# Non-Metric Dental Trait Variability in Nepalese Permanent Dentition: A Clinical and Anthropological Study

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## ABSTRACT

**Introduction:** Dental morphology reflects genetic, environmental, and epigenetic influences and can vary across and within populations. Dental traits can be of importance in clinical, anthropological, and forensic contexts. The Nepalese population, being ethnically diverse, presents an ideal cohort for dental profiling; however, limited data exists on morphological dental traits within this population.

**Objective:** The main objective of this study is to examine the morphological variations in permanent dentition among the Nepalese population and to explore the clinical and forensic implications of these variations.

**Methodology:** A descriptive cross-sectional study was conducted on 200 individuals aged 12–60 years attending dental outpatient department of Dhulikhel Hospital, Kathmandu University School of Medical Sciences, Dhulikhel, Nepal. Clinical examination recorded non-metric traits, including cusp of Carabelli, cusp number variations, peg-shaped laterals, shoveling, talon cusp, and others. All the available information were entered in Microsoft Excel and analyzed using statistical software (IBM SPSS Statistical tool Version 23; SPSS Inc, USA). Descriptive statistical analysis was performed, and the difference between Aaryans and Mongolians was compared using Chi-square test.

**Results:** Cusp of Carabelli was found in 85 (42.5%) individual, among which 66 were in Aaryans and 19 in the Mongolians and was found to be significantly more prevalent among Aaryans than in Mongolians. Three-cusped maxillary second molars were common and was found in a total of 88 (44%) individuals, however, without any significant ethnic association. Additional findings included four-cusped mandibular molars in 47 (23.5%) individuals, shoveling in 11 (5.5%) individuals, and congenitally missing teeth in 62 (31%) individuals.

**Conclusion:** Distinct ethnic differences in dental morphology exist within Nepalese populations. These traits can guide prosthodontic rehabilitation, forensic identification, and anthropological research.

**Keywords:** Carabelli; Ethnic; Morphology; Traits.

## INTRODUCTION

Human teeth exhibit a great degree of morphological diversity.[1] Tooth form is affected by genetic, environmental, and epigenetic factors.[2-6] Genetically, tooth form reflects the genealogical relationship

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of animals, while from an environmental aspect, it reflects dietary habits. Epigenetics modification contributes to phenotypic variation and can reflect as a variation within the same species or within the same human population.[4,6] These variations have significant implications in clinical dentistry.

A limited amount of data exists regarding the maxillomandibular skeletal discrepancy, morphological variation and gender-wise differences of human teeth in some groups of Nepalese population.[7-10] However, extensive study to study the dental profiling and non-metric dental traits has not been performed on Nepalese population. Dental profiling refers to the making of a dental profile by studying the variations and traits in dental tissue which comprises a group of more or less specific individual characteristics relating to the oral cavity and/or the teeth.[11] It helps not only in human identification but also in clinical management of patients who are diverse from the normal. Normal variations not being the pathological entity are studied quite rarely in our set of population. Nepalese population having a wide diversity in ethnicity, socio-religious and cultural aspects, can be expected to have diversities in human dental parameters. Nepal's linguistically and culturally diverse population is composed of two racial groups, the Aryans, who are caste Hindus, and the Mongols, who are the country's indigenous peoples.[12]

Due to the limited available data on variations in non-metric dental traits among the Nepalese population, challenges have arisen in forensic identification, clinical rehabilitation and anthropological research. Therefore, the present study aims to investigate these dental variations and develop a database applicable to the Nepalese population.

## METHODS

A cross-sectional descriptive study was conducted on patients visiting the Dental Outpatient Department (DOPD) of Kathmandu University School of Medical Sciences – Dhulikhel hospital (KUSMS-DH)for a period of six months from Jan 2, 2024 to July 2, 2024. Ethical approval was obtained from the Institutional Review Committee of the same institute (IRC-KUSMS Approval No: 222/23) and informed consent was taken from all the participants (parents of the participants in case of minor) prior to the study. Inclusion criteria included participants of age group 12 to 60 years with permanent dentition. The exclusion criteria were the participants with loss of tooth architecture including grossly decayed teeth, severe attrition, fractured teeth, and a history of previous coronoplasty. Convenience sampling method was used for selection of participants from the dental OPD. Primary investigator collected the data. Prior to the beginning of the study training and calibration of the examiner was done.

The sample size was calculated using the following formula:

$$\text{Sample Size } (n) = Z^2 p(1-p) / e2$$

$$\text{Prevalence } (p) = 0.87$$

$Z = 1.96$ at 95% of Confidence Interval; Margin of error (e)= 5%

$$n = 174$$

Prevalence rate for calculation of sample size is taken for the appearance of cusp of Carabelli which has the maximum prevalence rate among all the variables in a group of population similar to that of the planned group of population.[13]

After obtaining informed and written consent from the participants, the demographic details were recorded.

Clinical examination of all the teeth was done using standard diagnostic tools including the mouth mirror, probe and explorer. All anatomical variations from the normal morphological features in the teeth were recorded. The parameters studied were the cusps of Carabelli, variation in number of cusps of permanent teeth, peg shaped lateral, Turner's hypoplasia, talons cusp, shoveling, and enamel pearls. All the available information were entered in Microsoft Excel and analyzed using statistical

software (IBM SPSS Statistical tool Version 23; SPSS Inc, USA). Descriptive statistical analysis was performed. Chi-square test was used to compare the difference in the major traits between the Aaryans and the Mongolians. Statistical significance was set at p value of 0.05.

## RESULTS

A total of 200 participants fulfilling the inclusion criteria were examined. The sample size was calculated as 174 based on the prevalence reported by Smitha et al. This figure represented the minimum sample size required to achieve the desired statistical precision and confidence level. During the study period, additional eligible participants meeting the inclusion criteria were available and were therefore included, resulting in a final sample size of 200. Including a sample size larger than the calculated minimum is an accepted epidemiological practice, as it increases the precision of prevalence estimates, improves the reliability of the findings, and compensates for any unforeseen variability in the study population. Since all participants fulfilled the predefined inclusion and exclusion criteria, the inclusion of additional samples did not introduce methodological bias and enhanced the statistical robustness of the study. Out of the 200 samples examined, 29 were male and 171 were female, with an age ranging from 12 to 60 years and a mean age of 26.31 years (±9.65 years). Out of 200 participants, 125 (62.5%) of them were Aaryans and the remaining 75 (37.5%) were Mongolians. Dental examination revealed higher prevalence of cusp of Carabelli, and variation in number of cusps of permanent teeth. Other findings observed were peg shaped lateral, Turner's hypoplasia, talons cusp, shoveling, and enamel pearls.

A total of 85 (42.5%) participants had presence of cusp of Carabelli on their permanent maxillary first molar, whereby 17 (8.5%) of them had unilateral and 68 (34%) of them had bilateral involvement. Of the total Aaryans participating in the present study, 66 (52.8%) of them had cusp of Carabelli, whereas only 19 (25.33%) of the Mongolians had the same (Table 1). Pearson's Chi-square test was used to compare the difference in the presence of Cusp of Carabelli between the Aaryans and the Mongolians (Table 2). Result suggested a significant statistical difference whereby the Aaryans had a higher chance of having the cusp of Carabelli ($\chi^2 = 14.471$, df = 1, $p < 0.05$). Further, Cramer's V rule was used to test the association effect size for the chi-square test of independence. Cramer's V (0.269) showed a medium effect size in association of cusp of Carabelli in the Aaryans in this study.

**Table 1: Distribution of cusp of Carabelli in Aryans and Mongolians; n (%).**

| | Aryans (125) | Mongolians (75) |
|---|---|---|
| With cusp of Carabelli | 66 (52.80%) | 19 (25.33%) |
| Without Cusp of Carabelli | 59 (47.20%) | 56 (74.67%) |

**Table 2: Cross tabulation of Cusp of Carabelli traits and ethnicity.**

| | | | Ethnicity | | Total |
|---|---|---|---|---|---|
| | | | Aaryans | Mongolians | |
| Cusp of Carabelli | Presence | Count | 66 | 19 | 85 |
| | | Expected Count | 53.1 | 31.9 | 85 |
| | Absence | Count | 59 | 56 | 115 |
| | | Expected Count | 71.9 | 43.1 | 115 |
| Total | | Count | 125 | 75 | 200 |
| | | Expected Count | 125 | 75 | 200 |

Chi-square value = 14.471; p<0.05; Cramer's V value = 0.269

**Table 3: Distribution of variation in number of cusps in permanent molars, n (%).**

| | 5 Cusped maxillary 1st molar | 3 Cusped maxillary 2nd molar | 4 Cusped mandibular 1st molars | 6 Cusped mandibular 1st molars |
|---|---|---|---|---|
| Unilateral | 2 | 22 | 14 | 7 |
| Bilateral | 2 | 66 | 33 | 29 |
| Total | 4 (2%) | 88 (44%) | 47 (23.50%) | 36 (18%) |

**Table 4: Cross tabulation of 3 cusped permanent maxillary 2nd molar traits and ethnicity.**

| | | Ethnicity | | |
|---|---|---|---|---|
| | | Aaryans | Mongolians | Total |
| 3 cusped Permanent Maxillary 2nd Molar | Presence | 55 | 33 | 88 |
| | Absence | 70 | 42 | 112 |
| | Total | 125 | 75 | 200 |

Another morphological trait examined in this study was the variation in the number of cusps of the permanent teeth. Of the total studied population, majority of them showed variation in the number of cusps in maxillary second molars followed by mandibular first molars (Table 3). A total of 88 (44%) of the participants had only 3 cusps in their maxillary second molars, with missing distopalatal cusp. Three cusped maxillary second molar, however, did not show any predilection for the ethnicity, and the present study did not find any statistical differences among the ethnicity for this trait (Table 4). Similarly, 47 (23.50%) of the participants had only four cusps in their mandibular first molar, with missing distal cusp. Moreover, 36 (18%) and 4 (2%) of the participants demonstrated additional cusp in their mandibular and maxillary 1st molars respectively.

Data from the present study showed that clinically missing teeth (either congenitally missing or impacted) was another common finding. Of the total studied population, 62 (31%) participants had a history of clinically missing one or more teeth, majority of being maxillary and/or mandibular molars. Out of 62 participants with missing teeth, 49 had missing third molars, and minority of the remaining had either maxillary or mandibular laterals or premolars missing from their dental arches.

Other minor findings included peg-shaped malformed maxillary lateral incisors, shoveling of maxillary central and lateral incisors, talons cusps, deep lingual fissure. In the present population, 12 (6%) of the participants were found to have peg-shaped malformed maxillary lateral incisors, with eight of the participants showing bilateral presentation. Shoveling was seen in 11 (5.5%), talons cusp in 5 (2.5%) and deep lingual fissure in 2 (1%) of the studied population. None of the studied population showed the presence of dens evaginatus, dens invaginatus and enamel pearl.

## DISCUSSION

The present study examined the dental features and morphological traits of 200 Nepalese population of Aaryans and Mongolians - the two major population origin in Nepal. The study revealed the prevalence of morphological traits in teeth including cusp of Carabelli, variation in number of cusps and other non-metric traits. The study also suggested population-specific differences in some of the traits that could aid in clinical, forensic and anthropological applications. These dental traits and variations are particularly significant in

prosthodontics, as cusp number and occlusal pattern affect tooth morphology, restoration, and prosthesis design.

The cusp of Carabelli is a common dental morphological feature found as a small cusp on the mesiopalatal aspect of maxillary first molars. It was found in 42.5% of total population studied, with a higher prevalence among Aaryans (52.8%) than Mongolians (25.33%). This finding is in agreement with previous studies conducted in Nepal. A study by Subedi and colleague reported 68.3% of the maxillary first molar had cusp of Carabelli presenting with varying degree of expression.[14] Similarly, Acharya and Mainali in Nepal reported a prevalence of 48.6% in their sample, which aligns closely with the current data.[15] A study in the Indian population showed that 40.5% of subjects had Cusp of Carabelli on maxillary first molar, and also that this trait was common in population of Aaryan origin, which aligns closely with the current data.[16] Further, a study in African population emphasized that the Carabelli trait occurs with high frequency in European-derived populations and is markedly less common among Mongoloid and Sub-Saharan groups.[17] The difference in presence of cusp of Carabelli between Aryan and Mongolian populations in this study may reflect underlying genetic and evolutionary differences, supporting the utility of this trait in forensic anthropological classification and population affinity assessment.[5,6]

Variation in molar cusp number is another non-metric dental trait that finds high level of importance in with clinical and evolutionary applications. The present study found a high prevalence (44%) of three-cusped maxillary second molars, with a notably frequent absence of the distopalatal cusp. The pattern of relative variation in maxillary molar cusp areas reflected the ontogeny of crown development, with earlier-forming cusps showing less variation than later-forming cusps. An analysis of the design of occlusal surfaces of maxillary molars reveals, only three major cusps as primary, the mesiopalatal cusp and the two buccal cusps. The characteristic triangular figure, made by tracing the cusp outlines of these cusps, the mesial marginal ridge, and the oblique ridge of the occlusal surface, is representative of all maxillary molars and is called the maxillary molar primary cusp triangle. This triangular arrangement of cusps is reflected in the outline of the root trunks of maxillary molars thereby highlighting its role in clinical application.

The variation in number of cusps of mandibular first molar is particularly significant in prosthodontics, as these morphological variations affect tooth morphology, restoration, and prosthesis design. The occurrence of four-cusped mandibular first molars in 23.5% and six-cusped molars in 18% of participants provides further evidence of morphologic diversity. In prosthodontics, such variations must be carefully assessed during occlusal reconstruction and full mouth rehabilitation, as additional or missing cusps can alter occlusal dynamics. Four-cusped mandibular molars, often missing the distal cusp, are typical of Mongoloid dentition patterns. This is supported by studies from East Asia, which identify this trait as part of the "Mongoloid dental complex".[18]

The present study identified congenitally missing or impacted teeth in approximately one third of the population, mostly third molars. Agenesis of third molars is widely reported. Our earlier study reported 50.34% of population from the same population with a variable number of third molar missing.[19] This is of importance in treatment planning in prosthodontics and orthodontics as well as forensic age estimation. Additional traits such as peg-shaped maxillary lateral incisors, shoveling of incisors, and talon cusps were found in few studied populations and these traits provide useful morphological markers.[2,5] Shovel-shaped incisors are strongly associated with Mongoloid ancestry and have been consistently documented in East Asian and Native American populations.[4,20] Their presence reinforces the ancestral linkage and helps in ethnic identification during forensic profiling.[5]

Although enamel pearls, dens evaginatus, and dens invaginatus were absent in this sample,

their detection in other populations should not be underestimated due to their clinical implications including occlusal balance in prosthodontics and orthodontics, periodontal complications or endodontic complexity.

## CONCLUSION

The present study examined the permanent dentition in a 200 Nepalese population and highlighted the significant differences in the prevalence of dental morphological traits between Aryan and Mongolian ethnic groups in Nepal. Traits such as the cusp of Carabelli, molar cusp variation, and incisor shoveling demonstrate high relevance in prosthodontic diagnosis and treatment planning, while their recognition is equally critical for population differentiation in forensic odontology. Understanding cusp patterns and dental anomalies helps clinicians design restorations, crowns, and prostheses that are anatomically accurate and functionally sound, especially in cases requiring occlusal rehabilitation. These non-metric traits, when combined with other dental data, can serve as ethnic markers aiding in personal identification and bioarchaeological profiling in forensic odontology.

**CONFLICT OF INTEREST:** The authors declare no conflict of interest in this study.

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