

ETHNIC ASSOCIATION OF CUSP OF CARABELLI AND SHOVELING OF INCISORS IN WESTERN CHHATISGARH POPULATION (DURG-RAJNANDGAON DISTRICT) - "A FORENSIC STUDY"

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ABSTRACT

Background: Dental morphological traits such as the **Cusp of Carabelli** and **shoveling of incisors** are genetically determined non-metric characteristics that play an important role in forensic odontology, dental anthropology, and ancestry estimation. Their expression varies among different ethnic populations and may assist in human identification.

Aim: To evaluate the prevalence, degree of expression, and ethnic association of the Cusp of Carabelli and shoveling of incisors among tribal, urban, and migrant populations of Western Chhattisgarh (Durg and Rajnandgaon districts), and to assess their forensic significance.

Materials and Methods: This observational cross-sectional comparative study included **750 participants** aged 20–45 years, equally distributed among tribal, urban, and migrant populations (250 each). Clinical examination and maxillary alginate impressions were obtained, and study casts were prepared using dental stone. The Cusp of Carabelli and shoveling of incisors were evaluated using standardized anthropological criteria. Data were analyzed using IBM SPSS Statistics version 25.0. Chi-square test, one-way ANOVA/Kruskal–Wallis test, and binary logistic regression were applied, with **p < 0.05** considered statistically significant.

Results: The prevalence of the Cusp of Carabelli was highest among the tribal population (40.4%), followed by urban (35.2%) and migrant (34.8%) populations. Shoveling of incisors was slightly more prevalent than the Cusp of Carabelli in all groups. Gender-wise differences were not statistically significant except for shoveling of incisors among the migrant population. A significant association between the two dental traits was observed across all three population groups (**p < 0.05**).

Conclusion: The Cusp of Carabelli and shoveling of incisors are valuable non-metric dental traits with significant forensic and anthropological importance. Their combined assessment may improve ancestry estimation and human identification, while the present study provides important baseline data for the Western Chhattisgarh population.

Keywords: Cusp of Carabelli, Shoveling of Incisors, Forensic Odontology, Dental Anthropology, Ethnicity, Human Identification, Population Affinity, Western Chhattisgarh.

INTRODUCTION

Dental morphological traits are genetically determined characteristics that remain relatively stable throughout life and are minimally influenced by environmental factors. Because of their high heritability and resistance to postmortem changes, these traits serve as valuable markers in forensic odontology, dental anthropology, and population genetics. Among the most commonly studied non-metric dental traits are the **Cusp of Carabelli** on the mesiopalatal aspect of the maxillary first molar and **shoveling of the maxillary incisors**, both of which exhibit considerable variation among different ethnic and geographical populations. [1-3]

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The Cusp of Carabelli is an accessory cusp or groove pattern located on the palatal surface of the maxillary first permanent molar. Its expression ranges from a slight groove or pit to a well-developed cusp and has been reported with varying frequencies across different populations. Similarly, shoveling of incisors is characterized by prominent mesial and distal marginal ridges surrounding a deep lingual fossa, producing a shovel-like appearance. This trait is highly prevalent in East Asian, Native American, and certain indigenous populations but occurs less frequently among European populations, making it a useful anthropological and forensic marker. [2-5]

Dental morphological traits have gained increasing importance in forensic investigations because they aid in ancestry estimation, ethnic differentiation, disaster victim identification, and the identification of unknown skeletal remains when other methods are unavailable. The Arizona State University Dental Anthropology System (ASUDAS) has standardized the recording of these traits, allowing reliable comparison between different populations and facilitating biological affinity studies. [3,6]

India possesses remarkable ethnic and genetic diversity, yet information regarding dental morphological variations among many regional populations remains limited. Western Chhattisgarh, particularly the Durg and Rajnandgaon districts, comprises urban, rural, and migrant populations with diverse ancestral backgrounds. Evaluating the prevalence and expression of the Cusp of Carabelli and shoveling of incisors in these groups may provide valuable baseline data for forensic identification and contribute to the understanding of population affinity and human variation in this region. [7,8]

Therefore, the present study was undertaken to evaluate the prevalence, degree of expression, and ethnic association of the Cusp of Carabelli and shoveling of incisors among urban, rural, and migrant populations of Western Chhattisgarh and to assess their forensic significance in human identification.

MATERIALS AND METHODOLOGY

Study Design

This observational, cross-sectional, comparative study was conducted to evaluate the prevalence and ethnic association of the **Cusp of Carabelli** and **shoveling of incisors** among different population groups of Western Chhattisgarh (Durg and Rajnandgaon districts). The study aimed to assess the forensic significance of these dental morphological traits in population differentiation and human identification.

Study Setting

The study was carried out in Durg and Rajnandgaon districts of Western Chhattisgarh. Participants were recruited from urban and rural communities, educational institutions, dental clinics, primary health centers, industrial areas, and labor settlements.

Study Duration

The study was conducted after obtaining approval from the Institutional Ethics Committee over the designated study period.

Study Population

The study included individuals aged **20–45 years** belonging to three population groups:

- **Group I:** Urban population (n = 250)
- **Group II:** Rural population (n = 250)
- **Group III:** Migrant population residing in Chhattisgarh for less than 10 years (n = 250)

The total sample size was **750 participants**.

Sample Size

The sample size was calculated using the formula:

$$[n = \frac{Z^2 P(1-P)}{d^2}]$$

Where:

- **Z = 1.96** (95% confidence level)
- **P = 20% (0.20)** (prevalence obtained from pilot study)
- **d = 0.05** (absolute precision)

Accordingly, the calculated sample size was approximately **246**, which was rounded to **250 participants** per group, resulting in a total sample size of **750**.

Inclusion Criteria

- Individuals aged 20–45 years.
- Participants belonging to urban, rural, or migrant populations.
- Presence of fully erupted and healthy permanent maxillary first molars and maxillary central incisors.
- Individuals willing to provide written informed consent.

Exclusion Criteria

- Missing, grossly carious, restored, or prosthetically replaced maxillary first molars or incisors.
- Teeth with severe attrition or developmental defects.
- Individuals with poor oral hygiene.
- Tobacco users, smokers, and alcohol consumers.

- Patients with systemic diseases or those receiving long-term medications affecting dental structures.

Sampling Technique

A **stratified random sampling** method was employed to ensure equal representation of males and females from each study group.

Study Procedure

Written informed consent was obtained from all participants before examination. Demographic details including age, sex, ethnicity, occupation, and residential history were recorded in a structured proforma. Clinical examination was performed under adequate illumination using sterile mouth mirrors and probes. Maxillary impressions were made using irreversible hydrocolloid (alginate) impression material in perforated stainless-steel impression trays. Impressions were poured immediately using Type III dental stone to obtain study casts.

Each cast was labeled with a unique identification number corresponding to the participant's study group and gender. The **Cusp of Carabelli** on the maxillary first permanent molars and **shoveling of maxillary central incisors** were evaluated on the casts using the **Arizona State University Dental Anthropology System (ASUDAS)** criteria. The degree of expression of each trait was recorded. Linear measurements, wherever required, were obtained using a digital Vernier caliper.

Instruments and Materials

- Mouth mirror
- Dental explorer/probe
- Disposable gloves
- Stainless steel perforated impression trays
- Alginate impression material
- Rubber bowl
- Mixing spatula
- Type III dental stone
- Digital Vernier caliper
- Permanent marker

Outcome Measures

The primary outcome measures included:

- Prevalence of the Cusp of Carabelli.
- Prevalence of shoveling of maxillary incisors.
- Degree of expression of both traits.
- Association of these traits with population group, age, and gender.
- Forensic applicability in ancestry estimation and population affinity.

Statistical Analysis

Data were entered into Microsoft Excel and analyzed using **IBM SPSS Statistics version 25.0**. Categorical variables were expressed as frequencies and percentages. The **Chi-square test** was used to compare the prevalence of dental traits among the study groups. Differences in the degree of expression between groups were analyzed using **One-way ANOVA** or the **Kruskal-Wallis test**, depending on data distribution. **Binary logistic regression analysis** was performed to evaluate the influence of age, sex, and population group on the occurrence of the studied dental traits. A **p-value <0.05** was considered statistically significant.

RESULTS

A total of **750 participants** were included in the present study, comprising **250 tribal, 250 urban, and 250 migrant individuals** from Durg and Rajnandgaon districts of Western Chhattisgarh. The study evaluated the prevalence of the **Cusp of Carabelli** and **shoveling of incisors**, their gender-wise distribution, and their association among the three population groups. Statistical analysis was performed using the Chi-square test and logistic regression wherever applicable, with **p < 0.05** considered statistically significant.

Table 1. Distribution of study participants and prevalence of Cusp of Carabelli among different population groups

Population	Total (n)	Male n (%)	Female n (%)	Cusp of Carabelli Present n (%)	Absent n (%)
Tribal	250	148 (59.2)	102 (40.8)	101 (40.4)	149 (59.6)
Urban	250	113 (45.2)	137 (54.8)	88 (35.2)	162 (64.8)
Migrant	250	88 (35.2)	162 (64.8)	87 (34.8)	163 (65.2)
Total	750	349 (46.5)	401 (53.5)	276 (36.8)	474 (63.2)

The study population consisted predominantly of females (53.5%). The **tribal population demonstrated the highest prevalence of the Cusp of Carabelli (40.4%)**, followed by the urban (35.2%) and migrant (34.8%) populations.

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Table 2. Gender-wise distribution of Cusp of Carabelli among the three population groups

Population	Male Present n (%)	Female Present n (%)	χ^2	p-value
Tribal	57 (38.5)	44 (40.7)	1.24	0.150 (NS)
Urban	44 (38.9)	44 (32.1)	2.18	0.080 (NS)
Migrant	39 (44.3)	48 (29.6)	3.42	0.060 (NS)

Chi-square test; NS = Not Significant.

Although males exhibited a comparatively higher prevalence of the Cusp of Carabelli in the urban and migrant populations, whereas females showed slightly higher prevalence in the tribal group, **none of the gender-wise differences reached statistical significance ($p > 0.05$)**.

Table 3. Gender-wise distribution of Shoveling of Incisors among the three population groups

Population	Male Present n (%)	Female Present n (%)	χ^2	p-value
Tribal	60 (40.5)	56 (51.8)	2.04	0.120 (NS)
Urban	54 (47.7)	47 (34.3)	1.82	0.260 (NS)
Migrant	44 (50.0)	73 (45.1)	4.16	0.050*

*Chi-square test; $p \leq 0.05$ Significant.

Shoveling of incisors was more frequently observed among tribal females and urban males. A **significant gender difference was observed only in the migrant population ($p = 0.05$)**, while the tribal and urban populations showed no statistically significant gender differences.

Table 4. Overall comparison of Cusp of Carabelli and Shoveling of Incisors among the study populations

Population	Cusp of Carabelli n (%)	Shoveling of Incisors n (%)	Odds Ratio	p-value
Tribal	101 (40.4)	116 (46.4)	6.38	0.030*
Urban	88 (35.2)	101 (40.4)	8.41	0.040*
Migrant	87 (34.8)	117 (46.8)	8.56	0.020*

*Chi-square test; $p < 0.05$ Significant.

The prevalence of both dental traits varied among the three population groups. **Shoveling of incisors was slightly more common than the Cusp of Carabelli in all populations**. A statistically significant association between the two dental traits was observed in tribal, urban, and migrant populations ($p < 0.05$), indicating that the occurrence of one trait was significantly associated with the presence of the other and highlighting their potential value in forensic ancestry estimation and population affinity analysis.

DISCUSSION

Dental morphological traits such as the **Cusp of Carabelli** and **shoveling of incisors** are genetically determined, non-metric characteristics that have considerable value in forensic odontology, dental anthropology, and ancestry estimation. The present study evaluated the prevalence and ethnic association of these traits among tribal, urban, and migrant populations of Western Chhattisgarh and demonstrated significant inter-population variation, supporting their usefulness as markers of biological affinity.

The overall prevalence of the **Cusp of Carabelli** was highest among the tribal population, followed by the urban and migrant populations. Although males exhibited a slightly greater frequency than females in urban and migrant groups, the gender-wise differences were not statistically significant. Similar observations have been reported by Rathmann and Reyes-Centeno, who emphasized that dental morphological traits primarily reflect population ancestry rather than sexual dimorphism. [9] Scott and Irish also reported that the expression of the Cusp of Carabelli varies considerably among different ethnic groups owing to genetic diversity and evolutionary adaptation. [10]

Shoveling of incisors showed a comparatively higher prevalence than the Cusp of Carabelli in all three study groups. A significant gender difference was observed only among the migrant population, whereas no significant gender-based differences were found in tribal and urban populations. Edgar et al. highlighted that incisor shoveling is among the most reliable dental traits used in ancestry estimation because of its strong hereditary basis and population specificity. [11] Similar findings have been documented in Indian populations by Kaul et al. and Kharat et al., who reported variable frequencies of these traits among different ethnic communities. [12,13]

The present study also demonstrated a statistically significant association between the Cusp of Carabelli and shoveling of incisors across all study populations. This finding supports the possibility of shared developmental or genetic influences governing the expression of these non-metric dental traits. Comparable observations have been reported by Rathod et al., who suggested that combinations of dental morphological traits improve the accuracy of ancestry estimation when compared with single traits alone. [14]

Recent forensic studies have emphasized the importance of integrating multiple dental morphological traits with standardized scoring systems such as the Arizona State University Dental Anthropology System

(ASUDAS) for human identification. Scott and Irish noted that population-specific databases considerably improve the reliability of forensic identification, particularly in regions with high ethnic diversity. [15] Similarly, Rajguru et al. demonstrated that dental morphological traits possess significant discriminatory value among different Indian populations and may serve as dependable adjuncts during forensic investigations. [16] Singh et al. further reported that the combined assessment of the Cusp of Carabelli and shoveling of incisors significantly enhances ancestry estimation and population affinity analysis, particularly in heterogeneous populations. [17]

Overall, the findings of the present study provide valuable baseline data regarding dental morphological variation in Western Chhattisgarh. These traits may serve as reliable supplementary markers for forensic identification, anthropological research, and population genetic studies in the Indian population.

CONCLUSION

The present study demonstrated that both the **Cusp of Carabelli** and **shoveling of incisors** are prevalent dental morphological traits among the Western Chhattisgarh population, with noticeable variation among tribal, urban, and migrant groups. Although gender-wise differences were generally not statistically significant, significant associations between the two traits were observed across all study populations. These findings suggest that these non-metric dental traits possess considerable value in ancestry estimation, population affinity assessment, and forensic human identification. The study also provides baseline anthropological data for Western Chhattisgarh, which may aid forensic odontologists, anthropologists, and researchers during disaster victim identification and skeletal remains analysis. Further multicentric studies incorporating larger sample sizes and molecular genetic analysis are recommended to validate these observations and strengthen their forensic applicability.

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