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Cingulum Tooth Development To Population Variation: An Anthropological Review

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ARTICLE INFO | **ABSTRACT**

The cingulum is a noticeable feature found on the back (lingual or palatal) surface of front teeth, appearing as a small raised ridge near the gum line. It develops from the lingual growth center of the tooth and helps shape the tooth, guide the bite, strengthen the tooth, and protect the gums. Although it is sometimes overlooked in everyday dental work, the cingulum is important in many fields, including fillings and crowns (restorative dentistry), braces (orthodontics), root canal treatment (endodontics), and even forensic studies. Problems during development can cause changes such as a talon cusp—an extra bump growing from the cingulum area—which can affect the bite, increase the risk of decay, and sometimes involve the tooth's nerve.
The study focuses on two female groups- Brahmins and Rajputs of Lucknow, aged between 6 to 25 yrs. The total sample size is 600 (300 females per group). The data has been collected from schools, various households and offices across the city.
This review brings together information about its anatomy, how it develops, how its shape varies in different populations, it also highlights future research needs, especially connecting how teeth develop at the molecular level with how they work and have evolved.

Key Words: Dental Cingulum, Anatomy, Development, Dental Anthropology

Introduction

The cingulum refers to the cervical convexity present on the lingual (or palatal) surface of anterior teeth. Originating from the lingual developmental lobe, it contributes to the formation of the lingual fossa and defines the cervical contour of the crown. In functional terms, it plays a role in anterior guidance and in deflecting food during mastication, while also serving as a key morphological indicator in non-metric dental trait assessment. Contemporary dental anatomy literature maintains alignment with classical definitions, yet increasingly underscores its morphological variability across individual teeth and among different populations.

Microscopically, the cingulum displays the typical crown composition, with enamel forming the outer covering and dentin forming the supporting layer beneath. Where the cingulum is more elevated, enamel thickness may increase, contributing extra strength against lingually directed forces. The enamel–dentin junction follows the shape of the external surface, and its internal pattern is shaped by both the process of enamel formation and the underlying dentin contour.

Tooth crown morphology, including the development of the cingulum, originates from coordinated epithelial–mesenchymal interactions during the bud, cap, and bell stages of odontogenesis. Within these stages, enamel knot signalling centres orchestrate the formation of cusps and ridges. Variations can influence the degree of lingual and labial crown projections in model organisms.

The cingulum is most prominent in maxillary canines, moderately prominent in maxillary central incisors, and smallest in mandibular incisors.

Tooth Type	Relative Cingulum Prominence	Typical Position
Maxillary Canine	Very prominent	Centered or slightly distal
Maxillary Central Incisor	Prominent	Centered
Maxillary Lateral Incisor	Moderate	Slightly distal
Mandibular Canine	Less prominent	Centered
Mandibular Central/Lateral	Slight	Centered

Table 1. *Relative Prominence of the Cingulum by Tooth Type*

In the anthropological context, dental cingulum is recognized as a enamel structure that surrounds of all teeth on the cervical third, and which has the function of protecting the periodontal tissues of the fragments of food during mastication, dissipate the vertical forces during occlusion and provide a platform for the morphogenetic development of some dental morphological features.(Moreno, S. et.al; 2016)
Morphometric and non-metric trait analyses have documented inter-population variation in cingulum expression, ranging from well-developed to reduced or absent forms. In anthropological and forensic research, categorical scoring systems are often employed to quantify this variation. Findings indicate that the cingulum can serve as a useful feature for population differentiation (less prominent among the Asians) and, in certain cases, for estimating sex. However, reported effect sizes and trait frequencies differ considerably across study cohorts and sampling strategies. The development of larger, standardized datasets is necessary to enhance the reliability and applicability of this trait in forensic contexts.
The cingulum plays a key role in anterior guidance and contributes to the functional pathways of occlusion. In restorative and prosthodontic procedures, accurate replication of cingulum morphology is essential to preserve anterior guidance and safeguard posterior occlusion.
The most notable developmental anomaly associated with the cingulum is the talon cusp—an accessory cusp arising from the cingulum or cementoenamel junction (CEJ) area, composed of enamel and dentin, and frequently containing pulp tissue. Epidemiological studies report it as a rare condition, with prevalence varying across populations. Clinically, it may present with occlusal interference, susceptibility to fracture, caries development in associated grooves, and potential pulpal involvement.

Literature Review

Dental Cingulum has been studied from various clinical perspectives by Chawla et.al; (1983), Tsutsumi T et.al; (1991), Jowharji N et.al; (1992), M. B Radhika et.al; (2015), Moreno, S. et.al; (2016 & 17), Picoli FF et.al; (2019), Kondo S. et.al; (2022) to name a few, but meagre studies from anthropological perspective like Scott GC, Turner II CG. (1997 & 1998) etc.

Research Gap & Aim of the Study

Vast **morphometrics** differences exists between and within the populations, somato-metrically and odontological. The forensic and anthropological utility of cingulum traits would benefit from the creation of large, standardized morphometric and non-metric datasets representing diverse global populations. Such resources would enable consistent quantification of sexual dimorphism and refine population differentiation models. We need bigger, standardized collections of tooth measurements from people all over the world. This would help us see how cingulum shapes vary between populations and whether it can be used reliably to tell apart male and female teeth.
Therefore, the present study reviews and summarises current knowledge (anatomy, development, morphological variation, clinical consequences, anomalies, biomechanical function, and forensic/anthropological uses) and highlights recent work and open questions.

Research Methodology

A cross-sectional observational study was conducted on 600 females, comprising 300 Rajput and 300 Brahmin individuals of Lucknow, aged between 6 to 25 yrs. The data has been collected from schools, various households and offices across the city.
The sample was obtained using **stratified random sampling**, with caste (Rajput, Brahmin) as the stratification variable to ensure equal representation from each group. Within each stratum, participants were randomly selected from the target population. The presence of a cingulum on maxillary central incisors, lateral incisors, and canines was recorded through direct clinical examination under standardized lighting and using dental mirrors. Data were expressed as counts and percentages. Statistical analysis included Chi-square tests to assess associations between groups and tooth types, and independent two-proportion z-tests for per-tooth comparisons. A p-value < 0.05 was considered statistically significant.

Discussions

Table 2: Occurrence of Cingulum in Maxillary Teeth Among Rajput and Brahmin Females

Tooth Type	Rajput Count (n=300)	Brahmin Count (n=300)	Rajput %	Brahmin %	z-value	p-value
Central incisor.	21.99 = 22	21.99 =22	7.33	7.33	0.000	1.000
Lateral incisor	45.90 =46	33.0	15.30	11.0	1.582	0.114
Canine.	24.99 =25	33.90 = 34	8.33	11.33	- 1.256	0.209

Note. No individual tooth type showed a statistically significant difference between groups. Percentages are based on the group size of 300 each.

Table 3: Comparative Difference

Tooth Type	Rajput %	Brahmin %	Difference (Rajput – Brahmin)	% Difference Relative to Brahmin
Central incisor	7.33	7.33	0.00	0.00 %
Lateral incisor	15.30	11.0	+4.30	+ 39.09 %
Canine	8.33	11.33	- 3.00	- 26.49 %
Total	30.93	29.90	+1.03	+ 3.44 %

Table 4: Overall Statistical Results for Cingulum Occurrence (Maxillary Teeth)

Test / Measure	Value	p-value	Degree of freedom.	Effect Size.
Chi-Square (χ^2)	3.43	0.180	2	Cramér's V = 0.076 (**very small association)**
Independent t-test	0.157	0.885	~2.8	----

Table -2 shows that the occurrence of the cingulum in the maxillary dentition of Rajput and Brahmin females was examined across three tooth types—central incisors, lateral incisors, and canines—each with a sample size of n = 300 per group (Table 1). The percentage occurrence for each tooth type was calculated based on the total number of individuals within the group.
For central incisors, both Rajput and Brahmin females exhibited an identical prevalence rate of 7.33% (22 cases each). Statistical analysis using the z-test for the difference in proportions yielded a z-value of 0.000, corresponding to a p-value of 1.000. This indicates complete absence of difference between the two groups for this tooth type.
For lateral incisors, the cingulum was observed in 15.30% of Rajput females (46 cases) compared to 11.00% of Brahmin females (33 cases). Although the proportion was numerically higher in the Rajput group, the z-value of 1.582 produced a p-value of 0.114, which does not meet the conventional significance threshold of $p < 0.05$. This suggests that the apparent difference could be due to sampling variation rather than a true population-level disparity.

For canines, the pattern was reversed, with Brahmin females showing a slightly higher prevalence (11.33%, 34 cases) than Rajput females (8.33%, 25 cases). The z-value of –1.256 and p-value of 0.209 again indicated no statistically significant difference between groups.
Table 3, elucidates that

- **Lateral Incisor** shows the largest relative increase for Rajput females (+39%).
- **Canine** shows a notable relative decrease (–26%).
- Overall percentage difference is small (**+3.44%** total).

When all three tooth types were analysed collectively (Table 4), the Chi-Square test was employed to assess the association between ethnicity and cingulum occurrence. The test yielded a χ^2 value of 3.43 with 2 degrees of freedom, producing a p-value of 0.180. This confirms that, across all maxillary teeth examined, there is no statistically significant relationship between ethnic group and cingulum prevalence. Furthermore, the effect size measure, Cramér's V = 0.076, falls well below the threshold for a small effect (0.10), indicating that any observed differences between groups are minimal and likely to be of negligible practical importance.
To further compare the groups in terms of overall prevalence rates, an independent t-test was conducted on the mean cingulum occurrence values across tooth types. The analysis produced a t-value of 0.157 with an approximate degree of freedom value of 2.8 (due to unequal variances adjustment) and a p-value of 0.885.

These results again confirm that the overall occurrence of cingulum in maxillary teeth is virtually identical between Rajput and Brahmin females.

Taken together, both the tooth-specific and the overall statistical analyses consistently demonstrate that there is no statistically meaningful difference in the prevalence of cingulum between the two ethnic groups studied. The small numerical variations seen in lateral incisors and canines are not large enough to be statistically or clinically significant. From an anthropological perspective, this suggests that cingulum expression in maxillary anterior teeth may be influenced more by general human dental variation rather than by the specific ethnic lineage of these two North Indian populations.

Conclusion

In anthropology, the observation, documentation, and analysis of dental morphology—particularly morphological traits such as the cingulum—provide valuable insights for assessing biological relationships among both ancient and modern human populations. By contrast, in dentistry, the cingulum of anterior teeth is often regarded primarily as an anatomical feature associated with practical concerns: it may favour bacterial plaque retention, thereby increase the risk of dental caries, or contribute to occlusal interferences in the form of premature contacts. Such issues are commonly addressed through selective enameloplasty or restorative procedures.

This contrast underscores the need to bridge the bio-anthropological and dental perspectives on the cingulum, particularly given the ongoing uncertainty surrounding its evolutionary function. Recognizing its significance in both fields is essential, not only for understanding its role in human evolution but also for appreciating its implications in dental health, occlusal function, and morphological diversity across populations.

In light of these considerations, exploring the evolutionary origins of the cingulum becomes a pivotal step in determining whether its persistence reflects an adaptive advantage, a vestigial remnant of ancestral dentition, or a morphological byproduct shaped by developmental constraints. Such an investigation requires integrating fossil evidence, comparative anatomy, and contemporary population studies to trace the functional and phylogenetic trajectory of this structure.

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