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ERUPTION PATTERN AND MORPHOLOGICAL CHARACTERISTICS OF PERMANENT CANINES IN SOUTH INDIAN SCHOOL BOYS: A CROSS-SECTIONAL STUDY

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ABSTRACT

Background: Dental eruption patterns provide an accurate basis for the estimation of age in the pediatirc age group. Permanent canines are of importance due to their durability, delayed eruption, and their value in identification. Accurate medico-legal age estimation requires eruption patterns specific to particular population and gender.This study was undertaken to assess the eruption patterns of permanent canines and their morphological characteristics in 9–13 years old school boys of the South Indian population.

Materials and Methods: This was a cross-sectional study conducted among 600 school-going boys from the Kozhikode district of Kerala. The eruption status of permanent canines in each of the four dental quadrants were observed and recorded by clinical examination. The morphological characteristics of the canines, their odontometric measurements, and intercanine distance were also recorded.

Results: The eruption of canines was observed to occur earlier in mandible compared to maxilla, with the right mandibular canine emerging first and the right maxillary canine showing the latest eruption. The mandibular canine eruption was observed to be almost complete by the age of 11–12 years. Age-related variations were observed with respect to the morphology of canines and their odontometric measurements.

Conclusion: In South Indian school boys, permanent canine eruption showed a quadrant-specific sequence of eruption, earlier in the mandible compared to the maxilla. Permanent canines erupt earlier on the right side compared to the left, and by the age of 11-12 years the eruption of canines was complete. The findings of this study provide specific eruption patterns of permanent canines, which would be of great value for accurate age estimation.

Keywords: Forensic age assessment, Canine eruption, Odontometry, Pediatric dentistry, Dental morphology.

INTRODUCTION

Forensic odontology is a branch of forensic science that applies dental knowledge to solve medico-legal problems, with special consideration given to the identification of individuals, analysis of bite marks, maintenance of legally admissible dental records, and contribution to other forensic disciplines.[1] Among the wide range of applications, the estimation of age remains one of the most important function in the medico-legal practice, especially in situa-tions such as cases involving criminal

responsibility, consent, identification, and judicial decision-making.

The scientific determination of age in medico-legal practice is critical in assisting law-enforcement agencies and judicial authorities. The unique forensic value of teeth lies in their resistance to decomposition. Teeth have the ability to withstand high temperatures without significant changes to their microstructure. According to Williams, the structural integrity of tooth enamel and dentine starts to deteriorate only at exceedingly high temperatures.[1] The eruption pattern, morphology, position, and arrangement of teeth in dental arches are unique to every individual. The unique value of teeth in medico-legal practice lies in their individuality.

The accurate estimation of age in living individuals in medico-legal practice is critical, especially in situations in which the actual age of an individual impacts criminal responsibility and judicial decision-making. The estimation of age in medico-legal practice involves a combination of physical, dental, and radiological examinations. In children, dental indicators such as tooth eruption have been regarded as reliable and viable means of estimating age. In the mixed dentition stage, which includes ages between 6 and 12 years, the sequential eruption of permanent teeth in children takes a predictable course. Permanent canines generally erupt when an individual is between 9 to 12 years of age. These teeth are usually used as preliminary tools for estimating age before radiographic analysis. Due to their excellent intra-osseous support and durable crown morphology, permanent canine teeth are usually well-preserved, which maximizes their value to the field of forensic dentistry. As such, this age range of 9–13 years therefore represents a critical developmental window for assessing permanent canine eruption as well as validating population-specific eruption standards.

Estimation of age, whether of living or deceased individuals, is an important area of practice for forensic pathologists. The estimation of dental development, i.e., dental age, through the counting of teeth is an easy and convenient method. This method, however, can be used for the estimation of age only up to the time of the emergence of teeth.[2]

The eruption of permanent teeth has been studied among different ethnic groups. It has been observed that there is a variation in the eruption time of permanent teeth, which could be due to several racial factors. For example, Negroid people have larger teeth with more cusps on their molar teeth, with a maximum of eight cusps and two lingual cusps on their premolars.[3] It has also been observed that the eruption of teeth occurs earlier in females compared to males.[4] It has also been observed that there is a correlation between the eruption time of teeth and body mass index (BMI) in children. A study in Finnish population of young children, attempted to estimate the age of the children. They cautioned that the estimation of age cannot be done through the counting of teeth because of considerable variation in an apparently homogeneous group.[5] Kaushal et al observed statistically significant sexual dimorphism in the mandibular canine teeth.[6]

The basic concept of forensic odontology is the recognition and comparison of dental patterns.[7] Previous studies have demonstrated different relationships between dental development and other parameters of maturation, thus emphasizing the necessity to examine each population separately.[8]

The age group of 9–13 years has considerable medico-legal significance in the Indian context, especially in the context of criminal responsibility and consent.[9] Therefore, the precise estimation of the age of individuals in this developmental phase is of considerable value to the legal system and medico-legal practice.

This study was carried out to evaluate the pattern of eruption, timing, and morphological characteristics of permanent canines in South Indian school boys of the 9–13 years age group and to assess their potential application in forensic age estimation.

MATERIALS AND METHODS

Study Design and Setting: A cross-sectional study was conducted by the Department of Forensic Medicine in collaboration with dental specialists, among school-going children in the Kozhikode district, Kerala, India.

Study Population and Sample Size: The study included 600 school-going boys in the age range of 9–13 years. The study population was divided into four age groups of 150 each: 9-10 years, 10-11 years, 11-12 years, and 12-13 years.

Inclusion and Exclusion Criteria

The participants included children aged 9 to 12 years and 11 months with verified dates of birth and no history of systemic illness, craniofacial anomalies, major dental procedures, and trauma to teeth. The participants excluded were those with retained deciduous canines and unreliable age records.

Data Collection and Dental Examination: The participants were divided into four groups of 150 boys each. The participants were examined during school hours. The dental examination was conducted using a dental mirror and torch. The upper and lower jaws were examined to assess the pattern of eruption of permanent canine teeth in all four quadrants. The eruption of canine teeth was noted to be present when any part of the crown of the canine tooth had penetrated the gingiva.

Eruption Stages and Classification: The eruption of canine teeth was assessed and classified into stages. The classification was further subdivided into stages A1, A2, A3, B1, B2, B3, C1, C2, C3, C4, C5, and C6. The stages were further subdivided as follows: Stage A refers to the eruption of the first premolar along with all incisors and the first molar.

Stage B refers to the eruption of the second premolar along with Stage A. Stage C refers to the eruption of canine teeth. The numbers 1, 2, and 3 refer to the eruption of teeth in the lower jaw, upper jaw, and both jaws, respectively. C4, C5, and C6 refer to the eruption of canine teeth in the lower jaw, upper jaw, and both jaws before the eruption of the second premolar.

Morphological and Odontometric Assessment: The measurements of mesiodistal length, cervico-incisal length, and intercanine distances were obtained using a vernier caliper and were recorded in millimeters. The measurements were doocumented systematically for statistical analysis.

Ethical considerations

The study was approved by the Institutional Ethics Committee of Government Medical College, Kozhikode. The study was conducted in accordance with the principles of the Declaration of Helsinki. Approval was obtained from the District Education Officer and the School authorities. Informed consent was obtained from parents or legal guardians of all participants, and assent was obtained from the children prior to clinical examination.

Statistical analysis

The data obtained were tabulated. The data analysis was done using statistical software jamovi (version 2.6.45.0, Jonathon Love, Damian Dropmann, and Ravi Selker, Sydney, Australia). The categorical variables were expressed as frequencies and percentages, and the continuous variables were expressed using mean and standard deviation.

RESULTS

A total of 600 school-going boys between the ages of 9 and 13 years were included in the final analysis, with the sample being stratified into four different age groups with 150 boys in each group. The age of the study subjects was calculated by using the recorded date of birth from the school records.

Age-wise Prevalence of Permanent Canine Eruption in Boys: The overall prevalence of eruption of atleast one permanent canine among boys increased progressively with an increase in age [Table 1]. In the 9–10 year age group, eruption of any permanent canine was observed in a small proportion of boys. The prevalence increased significantly in the 10–11 year age group, with over three-fourths of the study participants exhibiting eruption of at least one permanent canine. The eruption of at least one permanent canine was observed in all the school boys in the 11-12 years and 12–13 year age groups.

Table 1: Age-wise distribution of eruption of atleast one permanent canine among boys (n=600)

Age group (Years)	Yes n (%)	No n (%)
9–10	5 (3.3)	145 (96.7)
10–11	116 (77.3)	34 (22.7)
11–12	150 (100)	0 (0.0)
12–13	150 (100)	0 (0.0)

Quadrant-wise Eruption Pattern of Permanent Canines in Boys: The quadrant-wise analysis shows that the mandibular (lower) canines erupted earlier compared to the maxillary (upper) canines. In the 9–10 year age group, the permanent canine eruption was observed only in the right lower quadrant, with a low prevalence. There was a marked increase in the eruption rate in the 10–11 year age group, especially for the right lower canine. The eruption of the right lower canine was almost complete in the 11–12 year age group. In the 12-13 year group, all boys had completed the eruption of the canine. [Table 2] The left lower canine erupted after the right lower canine. Eruption of the left lower canine was not observed before 10 years of age. However, by the completion of 11 years, most boys had erupted the left lower canine, showing a delay in the left lower canine compared to the right. [Table 2] The left upper canine was observed to erupt most commonly between 12 and 13 years of age. The right upper canine erupts last in all quadrants, with eruption occurring predominantly after 12 years of age. The eruption pattern of canines in boys was observed as follows: right mandibular (lower), left mandibular (lower), left maxillary (upper), and right maxillary (upper). [Table 2]

Table 2: Age and quadrant-wise eruption pattern of permanent canine teeth in boys (N=600)

Age group (Years)	Right Upper n(%)	Left Upper n (%)	Right Lower n (%)	Left Lower n (%)
9–10	0 (0)	0 (0)	5 (3.3)	0 (0)
10–11	3 (2.0)	4 (2.7)	101 (67.3)	35 (23.3)
11–12	9 (6.0)	48 (32.0)	148 (98.7)	141 (94.0)
12–13	53 (35.3)	`124 (82.7)	150 (100)	144 (96.0)

Morphological Characteristics of Permanent Canines in Boys: The morphology of erupting permanent canines was classified into three types: incisor-like, typical canine, and premolar-like. Before the age of 11 years, the majority of erupting canines had typical canine morphology. Eruption was low in the 9 to 10 year age group, 5 (3.3%) participants, with most being in the right mandibular quadrant. There was a significant rise in the number of boys with erupting canines in the 10-11-year age group, with 101 (67.3%) boys. The majority had typical canine morphology in the right lower quadrant. [Figure 1]

In the 11–12 years age group, there was almost complete eruption in the mandibular quadrants. In the right lower quadrant, incisor-like morphology was seen in 87 (58.0%) boys, while typical canine morphology was seen in 61 (40.7%) boys. In the left lower quadrant, typical canine morphology was seen in 93 (62.0%) boys, while incisor-like morphology was seen in 48 (32.0%) boys. In the 12–13 year age group, there was almost complete eruption in all quadrants, with a progressive shift toward premolar-like morphology. In the right lower quadrant, 91 (60.7%) boys showed premolar-like morphology, while in the left lower quadrant, 72 (48.0%) boys demonstrated premolar-like morphology. Incisor-like morphology was seen in 66 (44.0%) boys in the left lower quadrant and 45 (30.0%) boys in the right lower quadrant. [Table 3, Figure 1]

Table 3: Age-wise Distribution of Morphological Types of Permanent Canines in Boys (n=600)

Age group (Years)	Incisor-like n (%)	Typical canine n (%)	Premolar-like n (%)
9–10	0 (0.0)	5 (3.3)	0 (0.0)
10–11	0 (0.0)	136 (90.6)	0 (0.0)
11–12	162 (54.0)	123 (41.0)	0 (0.0)
12–13	157 (26.2)	51 (8.5)	264 (44.0)

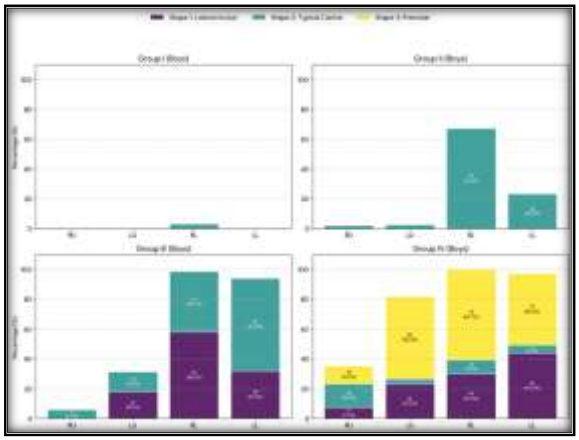

Figure 1: Age-wise and Quadrant-wise Distribution of Morphological Types of Permanent Canines in South Indian School Boys (n=600)

Legend: Stacked bar chart showing the distribution of the three morphological types of permanent canines (incisor-like, typical canine, and premolar-like) across four age groups (Group I: 9–10 years; Group II: 10–11 years; Group III: 11–12 years; Group IV: 12–13 years) and the four quadrants (RU – Right Upper; LU – Left Upper; RL – Right Lower; LL – Left Lower). The percentages show the proportion of participants in the respective age groups exhibiting the respective morphology in each quadrant.

Stages of Eruption Pattern in boys: In the 9–10 year age group, Stage A3 was found to be the eruption stage. Among the boys aged 10 to 11 years, Stage C4 was found to be dominant, indicating that the eruption of the permanent canine of the mandibular dentition occurred before the eruption of the second premolar. For the 11–12 year age group, Stage C4 was the most common stage, with a notable increase in Stage C3. For boys aged 12–13 years, Stage C3 was found to be the predominant eruption stage. [Table 4]

Table 4: The age-wise distribution of stages of eruption of permanent teeth in boys (n=600)

Age group (Years)	A1 n(%)	A2 n(%)	A3 n(%)	B1 n(%)	B2 n(%)	B3 n(%)	C1 n(%)	C2 n(%)	C3 n(%)	C4 n(%)	C5 n(%)	C6 n(%)
9–10	16 (10.7)	2 (1.3)	127 (84.7)	–	–	–	–	–	–	5 (3.3)	–	–
10–11	1 (0.7)	3 (2.0)	14 (9.3)	2 (1.3)	3 (2.0)	10 (6.7)	–	–	4 (2.7)	110 (73.3)	1 (0.7)	6 (1.3)
11–12	–	–	–	–	–	–	1 (0.7)	18 (12.0)	25 (16.7)	81 (54.0)	1 (0.7)	24 (16.0)
12–13	–	–	–	–	–	–	1 (0.7)	–	97 (64.7)	–	–	52 (34.7)

* Footnote: Stage A = Eruption of the first premolar along with all permanent incisors and the first molar. Stage B = Eruption of the second premolar in addition to Stage A. Stage C = Eruption of permanent canine teeth. Subcategories 1, 2, and 3 = Eruption in the lower jaw, upper jaw, and either upper or lower jaw, respectively. C4, C5, and C6 indicate eruption of canine teeth in the lower jaw, upper jaw, and either upper or lower jaw, respectively, occurring before eruption of the second premolar.

Odontometric Measurements of Permanent Canines in Boys: The mesiodistal and cervico-incisal measurements showed an increase with the increase in age. By 12–13 years of age, the cervico-incisal and mesiodistal dimensions approached comparable values. [Table 5]

Table 5: Odontometric measurements of permanent canines in boys (N=600)

Parameter	Tooth / Jaw	Age group (years)	Measurement, (millimeters) (Mean ± SD)
Mesiodistal length	Right Upper	10–11	2.33 ± 0.12
		11–12	2.49 ± 0.20
		12–13	3.22 ± 0.16

	Right Lower	9–10	2.24 ± 0.22
		10–11	2.83 ± 0.23
		11–12	3.15 ± 0.61
		12–13	5.36 ± 1.47
Cervico-incisal length	Right Upper	10–11	1.17 ± 0.06
		11–12	1.27 ± 0.14
		12–13	2.95 ± 0.15
	Right Lower	9–10	1.24 ± 0.09
		10–11	1.57 ± 0.31
		11–12	2.64 ± 0.53
		12–13	5.06 ± 1.71
Intercanine distance	Upper jaw	12–13	3.17 ± 0.19
	Lower jaw	12–13	2.57 ± 0.12

The maxillary intercanine distance was consistently greater than the mandibular intercanine distance in all the age groups. The mandibular intercanine distance was approximately 0.5–0.8 cm less than the maxillary intercanine distance, which may prove useful in bite mark analysis. [Table 5]

DISCUSSION

Age estimation in medico-legal practice is based on the combined assessment of physical, dental, and radiological parameters. Among these, dental development is considered a sensitive and reliable indicator for age estimation in both the living and the dead, as well as in skeletal remains. During the growing years, the sequential development and eruption of teeth allow age estimation with a reasonable degree of accuracy. Several investigators have attempted to establish age ranges corresponding to various stages of dental development. Clinical assessment of tooth eruption by visual examination is particularly advantageous, as it avoids radiation exposure and its associated health risks in living individuals. Tooth eruption is a dynamic biological process rather than a single event. Although genetic and environmental factors have been proposed to influence eruption timing, several investigators have suggested that tooth eruption is largely independent of environmental influences.[10] Each tooth exhibits a characteristic eruption pattern. Conventionally, eruption of the first permanent premolars is completed by 9 years of age, second premolars by approximately 10 years, and permanent canines by around 11 years.

In the present study, gingival emergence was considered as the criterion for tooth eruption. In addition to eruption status, parameters such as tooth shape, tooth size, and intercanine distance were evaluated for their forensic relevance. The study population consisted exclusively of South Indian School boys aged 9–13 years, representing various socioeconomic backgrounds.

Principal findings: The most significant finding of this study was the consistent quadrant-specific sequence of permanent canine eruption. The right mandibular canine was consistently observed to erupt earlier than canines in other quadrants. Eruption of the right mandibular canine before ten years of age was observed in a small proportion of boys. By the age of 10–11 years, a marked increase in eruption frequency was noted, and evaluation of boys above 11 years revealed that eruption of the right mandibular canine was nearly complete. These findings suggest that, in the majority of boys, eruption of the right mandibular canine occurs between 10 and 11 years of age. The left mandibular canine erupted subsequent to the right mandibular canine. It was not observed to erupt before the age of ten years. By the completion of 11 years, eruption of the left mandibular canine was observed in the majority of boys, indicating a slightly delayed eruption compared to the right mandibular canine. Maxillary canines erupted later than mandibular canines. The left maxillary canine was most commonly observed to erupt between 12 and 13 years of age. The right maxillary canine was the last among all quadrants to erupt, with eruption occurring predominantly after 12 years of age. Based on these observations, the sequence of eruption in boys was: right mandibular canine, left mandibular canine, left maxillary canine, and right maxillary canine. The findings reinforce the importance of quadrant-wise assessment in forensic age estimation rather than relying solely on generalised eruption timelines.

Comparison with previous studies: The age of eruption of the mandibular canine observed in the present study differs from earlier reports suggesting eruption between 9 and 10 years.[10,11] These discrepancies highlight the population-specific nature of tooth eruption patterns rather than a uniform species-specific timeline. A study from Delhi reported earlier eruption of the right maxillary canine compared to the findings of the present study,[11] further emphasizing regional variability. Many previous studies have not analyzed eruption patterns on a quadrant-specific basis. Given the observed differences between quadrants, eruption studies with quadrant-specific analysis may provide more accurate forensic reference data. A previous study from Kerala reported maximum canine eruption between 11 and 12 years in both jaws, which partially aligns with the findings of our study.[12] A comparison of eruption pattern of canine between maxillary and mandibular jaw cannot be made as the period of eruption is different in each quadrant of the upper and lower jaw.

Morphological changes of permanent canines with age: Morphological evaluation of permanent

canines included assessment of tooth shape, tooth size, and intercanine distance. Immediately following eruption, the canine crown typically exhibited a conical morphology. In the 11–12 year age group, a gradual transformation towards a parabolic outline was observed. By 12–13 years of age, a square-cut appearance became more frequent. This progressive change in morphology may be attributed to functional factors such as occlusal pressure during mastication and attritional changes over time.

Odontometric measurements: Mesiodistal and cervico-incisal dimensions of permanent canines demonstrated progressive increase with age, and by 12–13 years of age, the cervico-incisal and mesiodistal measurements approached comparable values. These findings reflect growth-related changes in tooth exposure following eruption. Unlike some previous studies reporting sexual dimorphism in canine dimensions,[13] the present analysis was restricted to boys and therefore reflects growth-related dimensional changes rather than sex-based differences.

Intercanine distance and Forensic implications : Intercanine distance demonstrated consistent age-related changes, with maxillary intercanine distance exceeding the mandibular intercanine values by approximately 0.5–0.8 cm. This parameter has potential forensic relevance in the analysis of bite marks, as it may assist in distinguishing between maxillary and mandibular bite impressions and contribute to reconstruction of the relative positions of the assailant and the victim.

Limitations

The cross-sectional design of the study limits precise determination of the exact timing of canine eruption. Gingival emergence was used as the criterion for eruption, which provides prevalence rather than incidence data. Furthermore, the study population was limited to a single geographic region, and the findings may not be generalizable to other populations.

CONCLUSION

The present study reveals a specific pattern of permanent canine eruption in South Indian school boys between 9 and 13 years of age. The mandibular canines—especially the right mandibular (lower) canine—were the earliest to erupt compared to the maxillary canines. The right maxillary (upper) canine was found to have the most delayed eruption. The observed eruption sequence of canines was right mandibular, left mandibular, left maxillary, and right maxillary canine. The study findings emphasize the significance of population- and sex-specific dental eruption data in improving the accuracy of age estimation. Moreover, the details of the morphological characteristics and odontometric measurements of erupting canines are useful in providing forensic information, especially in context of bite mark analysis and jaw involvement. The present study shows the use of permanent canine eruption as a reliable adjunct in medico-legal age estimation among boys in the pediatric age group.

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