Original Article

Characteristic Features and Terminologies of Mammalian Dentition – A Conspectus

Sanpreet Singh Sachdev, Zaneta Ivy D'Souza, Tabita Joy Chettiankandy, Manisha Ahire Sardar, Vivek Pakhmode, Trisha D'Souza[1]

From the Department of Oral Pathology and Microbiology, Government Dental College and Hospital, [1]Animal Wellness and Rehabilitation Center, Mumbai Veterinary College, Mumbai, Maharashtra, India

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ABSTRACT

Introduction: Forensic odontology is a relatively recent branch of dentistry that bridges our field with the practice of law. Its scope is not only limited to human dentition but also may extend to involve other animals as well. The present literature with regard to animal dentition is relatively primitive and scattered due to which many forensic odontologists are not familiarized with this vastly unexplored field. In this context, we have attempted to provide a concise overview of various characteristics and terminologies of animal dentition, which could empower dental researchers to further investigate the subject meticulously.
Materials and Methods: Skull specimens of various orders of mammals were observed for various characteristics such as morphologic features of arches, traits of the dentition, and their spatial relation to each other. Various measurements were obtained using Digital Vernier Calipers and digital photographs of the specimen to illustrate the characteristic features that were captured.
Results: The characteristic features of dentition have been collectively described in the text according to the taxonomic orders to which the specimens belong to. Various terminologies relating to these features have been specified as well.
Conclusion: With equipment of basic but essential knowledge pertaining to characteristics and terminologies of various orders of mammals, dental researchers can gain a better understanding of the adaptive and evolutionary changes in animal and human dentition, enabling them to further explore this aspect of forensic odontology with greater confidence.

Key Words: *Animal dentition, dogs, forensic odontology, mammals, order, primates, rodents, terminologies, ungulates*

Introduction

Forensic odontology is one of the contemporary branches of dentistry that elucidates the role of dental interpretations in criminal cases.[1] It is a specialized field of study that links the knowledge of dentists to the interest of justice based on examination and scientific evaluation of dental evidence.[2] A dentist may contribute to the field of forensic science in civil or criminal cases as well as by conducting research pertaining to the identification of dentition.[3] The scope of forensic odontology is not only limited to human dentition and bite marks but also extends to involve animals.[4]

Bitemarks represent the physical alteration or pattern left in an object or a tissue by dentition of an animal or human.[5] Morbidity and mortality from animal bites, especially mammals and reptiles are not uncommon. Thus, animal bites have considerable legal significance, and a better understanding of the dentition of various animals is warranted. Differences in the morphology of arches and dentition amongst various animals can play a substantial role from practical, legal as well as a scientific point of view.[6] A forensic odontologist must not restrain their knowledge to human dentition alone and must strive to have at least a general glimpse of variations in dentition amongst different animals, which in itself is a complex and demanding part of forensic odontology.[1] A dental professional having sound knowledge of this complex aspect of the forensic field standing at the forefront of cases where animal dental evidence is involved may be amply influential in their resolution.[7] The scientific literature pertaining to general descriptive features of the dentition of mammals is relatively primitive and scattered. It is imperative to conduct more research on dentitions other than our own from the point of view of dental researchers to gain a better understanding of the phylogenic and morphologic features of the dentition.[8] In this context, we have attempted to study the morphology of arches and dentition in various orders of mammals aiming to provide a concise overview of various

Address for correspondence:
Dr. Sanpreet Singh Sachdev, E-mail: sunpreetss@yahoo.in

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aspects of animal dentitions, insight about evolutionary adaptations, and various terminologies involved with animal dentition. This would attain the objective of augmenting the knowledge of dental researchers in a vastly unexplored domain of the field of forensic odontology, equipping them with essential information that would enable one to pursue a scientific endeavor pertaining to the animal dentition in future with greater confidence.

Materials and Methods

The skull specimens of various orders of mammals were obtained from the museum of the institutional department. The number of specimens in different categories is mentioned in Table 1.

The specimens were observed for various characteristics such as morphologic features of arches, traits of the dentition, and their spatial relation to each other. The measurements were obtained using Digital Vernier Caliper. The observations were noted promptly using Science Journal App (Google LLC).

Digital photographs of the specimen were taken, keeping the distance and illumination as uniform as possible. However, the photography parameters had to be altered to obtain images to show the intended feature due to wide variation in the range of specimen sizes.

Results and Discussion

The features of different species are collectively described according to the taxonomic order to which they belong rather than providing an extensive in-depth description of each individual species to minimize digression and fulfill the objectives of the study in a concise manner. Furthermore, only the characteristic findings of permanent dentition are discussed in the following text rather than complete measurements and relations for the same reason.

Rodentia

The rodent specimens comprised of rats (*Muridae*), rabbits (*Lagomorpha*), squirrel (*Sciuridae*) and guinea pigs (*Caviidae*). The rodent dentition is *"monodont"* indicating that they have only one set of dentition throughout their life except for rabbits and some species of squirrels.[9] The characteristic features of rodent dentition observed were two long incisors placed centrally, one on each side of the midline of each jaw. The incisors exhibit variations in color from white to yellowish to orange [Figure 1a] in different species of rodents. This variation in color could be explained by presence of endogenous pigments and fluoride.[10] These incisors are open-rooted and termed as *"elodont"*[11] since they grow continually. Due to constant gnawing, the incisal thirds of these incisors present with *"thegotic facets"*[12] or *"chisel-shaped"* edges with a labial portion more preserved [Figure 1b], which was observed in all the specimens, owing to the presence of enamel.[13] All the incisors showed proclination as they emerged from the alveolus. However, the upper incisors appeared to curve back, and a nearly perpendicular line could be drawn from their point of emergence to the incisal edge. The maxillary incisors of squirrel were almost perpendicular, whereas those in rabbits had yet another pair of miniature incisors present behind the longer central incisors. The lower incisors were longer and showed greater proclination as compared to their upper counterparts [Figure 1c].

Table 1: Number of specimens studied under different categories of mammals

Specimen category	Number of specimens
Rodents	18
Canidae	8
Ungulates	14
Primates	12
Total	52

The incisors were followed distally by the presence of large diastema bilaterally, the span of which was greater for maxillary arch than the mandibular arch. The combined anteroposterior dimension of diastema on both sides was five times the combined mesiodistal width of both the incisors. Furthermore, this dimension was slightly less than half of the total arch perimeter, except in rabbits and squirrel, where it was more than half of the arch perimeter, indicating that the diastema forms a major component of the arches. Their function is primarily to hold the food in readiness for subsequent grinding between the molars and are also said to contain vestigial tooth primordia.[14,15]

Further posteriorly, three *"anelodont"* molars [Figure 2a] (having limited growth) were present in most of the species while some specimen exhibited *"hypselodonty,"* i.e., tall crowns with continual growth.[16] The molars were generally attrited and exhibit enamel crests with dentinal grooves in between forming a sigmoid or zig-zag pattern [Figure 2b] and thus, such rodents are termed as *"sigmodont."*[17] The dental formula may greatly vary among various species of rodents. In some species, one or two premolar-like teeth may be present anterior to the first molars [Figure 2c].[18]

Artiodactylae and perissodactylae

Commonly known as the "ungulates," the animals of these two orders have identical lifestyles and dentitions[19] and

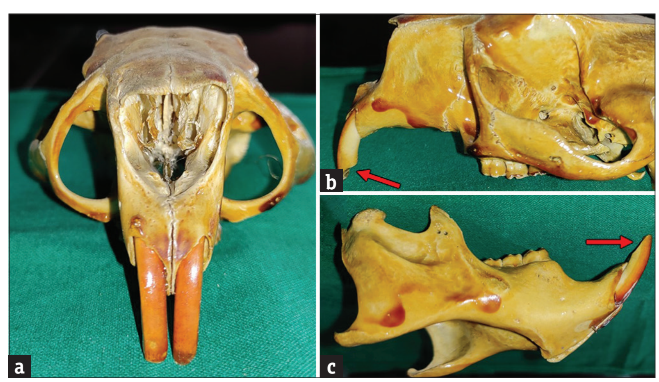

Figure 1: (a) View of long open-rooted orangish maxillary incisors of a guinea pig (Cavidae) from labial aspect. (b) Lateral view of guinea pig (Caviidae) maxillary dentition. Arrow denotes thegotic facets noted on chisel-shaped incisal edge. (c) Lateral view of guinea pig (Caviidae) mandibular dentition showing more proclined incisors

are thus, described together. The specimens comprised of horses (*Equinae*), camels (*Camelidae*), cattle (*Bovidae*) and boar (*Suidae*), deer (*Cervidae*). In contrast to rodent dentition, these groups of higher mammals have *"diphyodont"* dentition, i.e., they have two sets of dentition during their lifetime.[20] The characteristics of the dentition of these orders are elongated U-shaped arches with a similar postcanine dentition consisting of flat and attrited posterior teeth with a roughened occlusal surface comprising of complex groove patterns.[21]

All the teeth typically comprise extremely long roots and high crowns, termed as *"hypsodont"* teeth[21,22] and erupt throughout their life (hypselodont)[22] to keep up with the amount of wear [Figure 3a], similar to rodent incisors. Horses and boars possess three pairs of maxillary incisors, whereas, camels have only two pairs with a wide midline diastema having thick gum pads. The incisors are acutely proclined are followed by large sharp canines in boars [Figure 3b] and camels that help them dig wood and thick bushes.[23] The incisors in the equines curve, had an edge-to-edge relation while the canines, separated by a diastema from the incisors, were short and not so well-developed [Figure 3c].

Cattle [Figure 4a] and deers [Figure 4b] do not have anterior teeth in the maxillary arch instead, they have an adaptive thick gum pad that helps them in grazing tough plant parts.[24] The mandibular arch comprises three pairs of incisors and one pair of canines in all the animals exhibiting features similar to their maxillary counterparts. In cattle and deer specimens, these were observed to be relatively small and grossly attrited, with the canines appearing much similar to the incisors.[25] These anterior teeth have been considered for estimation of age by various researchers.[25-27]

Another diastema, collectively spanning one-fifth of the total arch perimeter, was followed by posterior teeth that comprised of three pairs of premolars, except four pairs in horses and maxillary arch in boars, and three pairs of molars. The premolars and molars of most of these species exhibited similar features characteristically seen in the dentition of herbivores except for an obvious difference in size.[28] The features that were observed in these teeth can be described as *"lophodont,"*[29] i.e., transverse ridges on the grinding surfaces rather than well-developed cusps while tubercles or low rounded cusps, which was observed in some species (e.g. Suidae), termed as *"Bunodont"*.[30,31] In addition, specimens of some species (e.g. Bovidae) had molars with short crowns [Figure 4b and c] referred to as *"brachydont"*.[32] Crescent-like ridges were observed on the occlusal surface on posterior teeth running anteroposteriorly, approximately linked to each other. Thus, the teeth are also termed as *"selenodont"* which is another characteristic of artiodactylae and perissodactylae.[31] These ridges formed extremely complex patterns, commonly seen in equines [Figure 4d], together with roughened or attrited occlusal surface aid in grinding of tough herbivorous diet.[33]

Canidae

Dog bites are perhaps the most frequent of all the animal bites[34] and these usually cause avulsion of human tissue.[35] Their dentitions were typically characterized by large and prominent canines with V-shaped elongated arches that were narrow anteriorly. Three pairs of relatively small incisors were present. These were followed by the canines in the mandibular arch, while in the maxillary arch, they were followed by a diastema that accommodates the mandibular canine when the mouth is closed [Figure 5a].

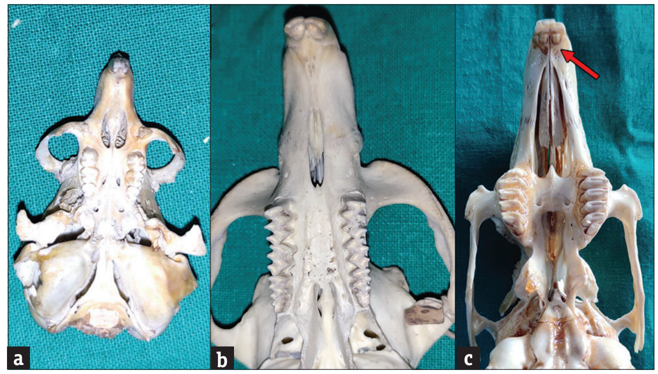

Figure 2: Images of maxillary dentition from occlusal aspect of (a) Squirrel (Sciuridae) having anelodont molars. (b) Rat (Muridae) presenting zig-zag pattern formed by ridges when viewed from occlusal aspect. (c) Rabbit (Lagomorpha) possessing additional pair of incisors i.e. peg teeth on the lingual aspect of maxillary central incisors (indicated by red arrow) and a pair of premolars anterior to the molars

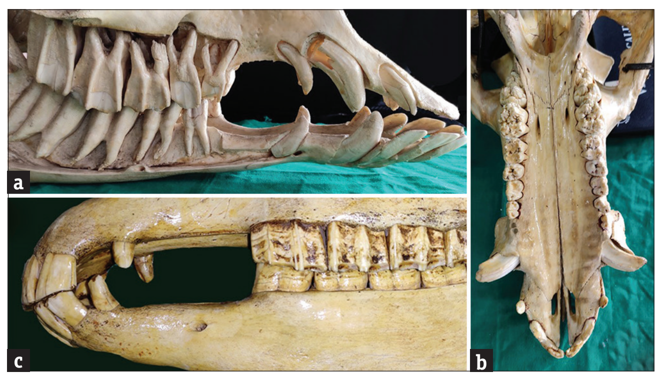

Figure 3: (a) Dentition of camel (Camelidae) exhibiting hypselodont teeth. (b) Maxillary dentition of boar (Suidae) exhibiting large prominent canines and bunodont molars. (c) Dentition of horse (Equine) exhibiting edge-to-edge relation of incisors and smaller canines

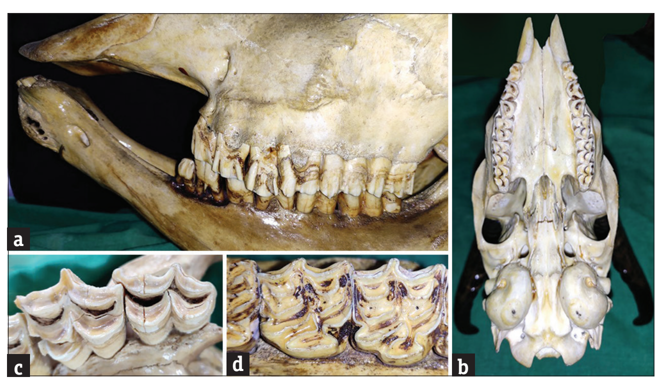

Figure 4: (a) Dentition of cattle (Bovidae) having absent maxillary anterior teeth with attrided mandibular anteriors. (b) Maxillary dentition of deer (Cervidae) exhibiting absence of maxillary anterior teeth and selenodont molars (c) Selenodont molars having crescent-shaped grooves on the occlusal aspect. (d) Equine molars exhibiting complex pattern of occlusal ridges and grooves

Table 2: Summarizes the general and characteristic features of dentition of various orders of mammals. I: Incisors, C: Canines, PM: Premolars, M: Molars

Order	Family	General Dentition Features	Characteristic Tooth Features
Rodentia	Muridae (Rat) Caviidae (Guinea pig) Sciuridae (Squirrel) Lagomorpha (Rabbit)	Monophydonty (except rabbit and squirrel) Long curved incisors followed by a large diastema comprising of half the length of arch perimeter Sigmodont pattern seen from occlusal aspect of molars	Thegotic facets or "chisel- shaped" incisal edges Hypselodont incisors (continually growing with open roots) Orangish incisors due to presence of pigments Anelodont molars i.e limited growth (hypselodont molars in some species) Lophodont molars for grinding
Artiodactylae	Bovidae (Cow) Cervidae (Deer)	Thick gum pads instead of maxillary anterior teeth Large diastema followed by premolars and molars	Hypselodont anterior teeth (except cattle and deer) Lophodont molars with complex pattern of lophs for grinding on tough plant parts
	Camelidae (Camel) Suidae (Boar)	Sharp proclined anterior teeth with diastema present in between Large diastema followed by premolars and molars	Bunodont molars in some species indicating more evolved tooth lobes (e.g Suidae) Selenodont molars
Perissodactylae	Equinae (Horse)	Curved incisors meeting edge-to-edge Short canines followed by diastema	
Carnivora	Canidae (Dog)	Shorter incisors followed by large prominent canines Diastema distal to canines followed by triconodont teeth	Carnassial pair for slicing meat Tribosphenic upper molars suggesting evolutionary link Talonid basin seen in maxillary 4th Premolar and mandibular 1st molar
Primates	Hominoidea (Apes and Monkeys)	Sharper compared to corresponding human teeth Generalised spacing between teeth	Large canines in older species Molars exhibiting Dryopithecus pattern

Table 3: Summarizes the rationale behind various adaptations in different classes of teeth shared commonly amongst various orders of mammals

Incisors	Large Diastema	Canines	Molars
Absent (Maxillary) Seen in: Cattle and Deers Rationale: Presence of thick gum pads instead of incisors suited primarily for grazing	Rationale in Rodents: For holding food in mouth until it is ready to be pushed towards the molars for crushing	Sharp and Proclined In Boars and Camels: Seen in: Boars and Camels Rationale: To dig through tough wood or desert plants	Presence of lophs on occlusal surface - "Lophodont" Seen in: Rodents, Artiodactylae and Perissodactylae Rationale: To dig through tough wood or desert plants
Elongated with open roots - "hypselodonty" Seen in: Rodents, Camel, Horse, Boar Rationale: To keep up with constant attrition throughout lifetime	Rationale in Artiodactylae and Perissodactylae: For holding plant parts in mouth while they are chewed slowly	Large and Sharp Seen in: Canidae and Primates Rationale: To tear through resilient flesh and bones of the prey	"Triconodont teeth" having three cusps aligned in a line Seen in: Dogs Significance: Evolutionary link between primitive reptilian teeth and tribosphenic molars seen in higher mammals
Large and Sharp/Pointed Seen in: Boar, Camel, Male Primates Rationale: Adaptation for coarse and tough diet	Rationale in Canidae: To hold the flesh in mouth after tearing it from the prey Hold the food in mouth while the animal runs away to a safer place	Strong and Prominent In Camels and Primates: Rationale: Adaptation for asserting social domination in Male-to-Male competition	"Dryopithecus" or Y-5 Pattern Seen in: Hominidae Significance: Evolutionary link between primitive reptilian teeth and tribosphenic molars seen in higher mammals

The canines are obviously the most prominent features of this carnivorous order that aid them in tearing on meat and bones. They were discerned to be large and conical, with the maxillary canines being longer than the mandibular canines.

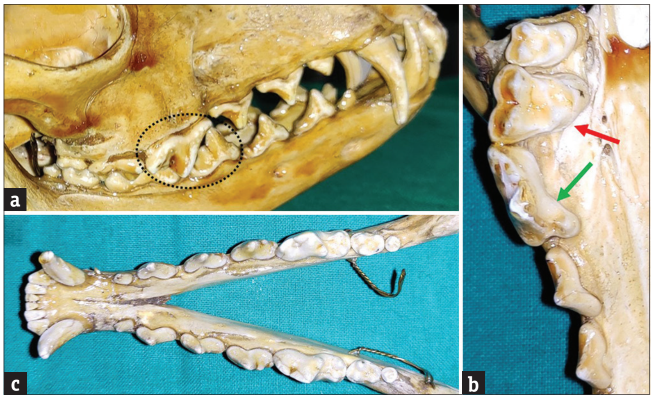

Figure 5: (a) Dentition of a dog (Canidae) from lateral aspect exhibiting triconodont teeth; Carnassial pair indicated by dotted circle. (b) Maxillary posterior teeth of dog (Canidae); Fourth premolar having talonid basin indicated by green arrow; Tribosphenic molars with trigonal outline indicated by red arrow. (c) Mandibular dentition of dog (Canidae) from occlusal aspect

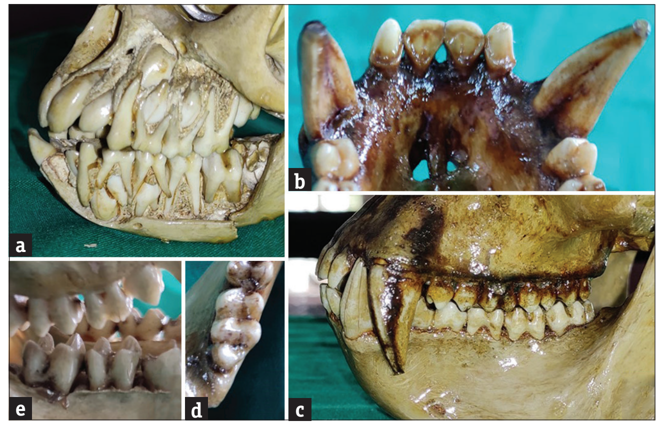

Figure 6: (a) Mixed dentition of a primate exhibiting diphyodonty. (b) Maxillary anterior teeth of early primates with coarse features. (c) Dentition of primate exhibiting large prominent canines in their spatial relation on occlusion. (d) Dryopithecus pattern of mandibular molars. (e) Prominent ridges, grooves and coarse features of primate molars

The mandibular canines presented a more curved architecture. Distal to the canines, a relatively larger span of diastema was present, the function of which could be primarily to hold the food while the animal tears it away from its prey.

Four premolars followed this diastema with ascending sizes with the first premolar being the smallest and the fourth premolar being the largest. The premolars were observed to be *"triconodont"* having three cusps in line [Figure 5a and b] with the central cusp (protocone) being the most prominent and the anterior cusp (metacone) being the smallest.[36] The maxillary fourth premolars were as large as the canines in both the arches and exhibited a *"talonid basin"* on the lingual aspect of the tooth [Figure 5b], a feature also seen in certain nonhuman primates.[37] It is a shallow depression circumscribed by marginal ridges. The maxillary fourth premolars, thus, comprised intermediary features of premolars and molars.

In the two maxillary molars, of which the first molar was observed to be larger, these cusps assumed a trigonal outline, and these are termed as *"tritubercular"* teeth or *"tribosphenic"* molars [Figure 5b].[38] The buccal cusps were much sharper than the palatal cusp, and these teeth perform the scissoring action, identified as *"carnassial pair"* [Figure 5a] in carnivores.[39] When seen from the occlusal aspect, the crowns were found to be off-centered in a distal direction. In the case of mandibular molars, there were three pairs, with the mandibular first molars being the largest [Figure 5c]. In the case of the mandibular arch, the mandibular first molars were as large as the canines and exhibited intermediary features of premolars and molars. The mandibular second and third molars were comparatively much smaller, with the smallest third molars having an oval occlusal outline and tipped distally.

Primates

The specimens primarily belonged to the *Hominidae* family which are diphyodonts [Figure 6a], and features of the dentition of specimens excluding the human specimens are described subsequently. The classes of teeth and the number of teeth belonging to each class were also identical to those of human dentition. A characteristic feature observed was prominent bimaxillary protrusion with sharp incisors. The maxillary lateral incisors had a distally sloping incisal ridge [Figure 6b], making it resemble a canine.[40] A diastema was found to separate the lateral incisors from the canines, which receive the large lower canine [Figure 6b and c]. The canines are much more prominent in apes and older species of monkeys with a large curved crown, even larger in males than females, which is a representative of their aggressive behavior and related to male-to-male competition in these species.[41] Furthermore, the crowns of maxillary canines (mean size 2.3 cm) were measurably larger and less curved than mandibular canines (mean size 1.65 cm) [Figure 6c].

The canines were separated by premolars by yet another diastema, which is smaller than that present anterior to canines. The premolars were tall and trenchant[42] with sharp cusps with prominent connecting ridges.[43] The mandibular molars were commonly characterized by a *"Dryopithecus"* or Y-5 pattern having 5 cusps present and a pattern of sulci separating these cusps [Figure 6d].[42] The maxillary molars were similar to those in human dentition except for the cusps, ridges, and grooves being more prominent, making the molars appear as a fusion of two premolars [Figure 6e].[44] The root-to-crown ratio, especially of molars, was measured to be larger as compared to human dentition.[45] These characteristics and sexual dimorphism are representative of a rough primitive diet and social lifestyle.[41,45,46] The readers may find a summarization of general and characteristic dental features of various mammalian orders in Table 2. Many of the orders share common adaptational features, the possible rationale behind which have been summarized in Table 3.

Conclusion

Dentition plays a key role in our understanding of mammalian adaptation and the evolution process. The characteristic features of dentition can provide valuable information regarding the dietary and social habits of an animal. Various species or orders of mammals possess certain similar or linking features that provide insight into their phylogenic or evolutionary relation. Understanding general aspects and various terminologies of animal dentition could certainly empower forensic odontologists to pursue further research in the field and provide valuable inputs in the evolutionary process from the point of view of a dental researcher. This further research in forensic odontology using this information as a benchmark may be extended to aspects such as age and gender determination of animals, comparative bite mark analysis, further descriptive analysis of various orders, and descriptive analysis of various species.

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Conflicts of interest

There are no conflicts of interest.

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