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Chevron Bone and OS Penis in Dog: Structural and Functional Anatomy

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The study was conducted to record the structural and functional anatomy of chevron bone and os penis in dogs. The chevron bone along with coccygeal vertebra and os penis were collected from four adult dogs by natural wet maceration technique. The chevron bone was alphabet capital "V" or "Y" shaped bone which consisted of three processes namely, two lateral process and one ventral process. The two lateral processes were articulated with the haemal process of coccygeal vertebrae to form haemal canal. The chevron bones functionally protect the middle coccygeal artery which has important clinical role in assessing the animal health. The os penis was a heterotrophic bone situated inside the penis. It was triangular in outline with a base, a body and an apex. The body consisted of three surfaces and three borders. The ventral surface was made up of deep urethral sulcus which accommodated and protected the urethra.

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Keywords: Chevron bone; os penis; dog; structure; function; anatomy.

1. INTRODUCTION

The prime intention of this study is to observe and document two important unusual bones present in dog which has peculiar features and clinical importance. The dog is a carnivorous mammal (*Canis familiaris*) closely related to the gray wolf that has been domesticated as a pet. They are broadly classified into different breeds based on their phenotypic characters, like size, shape, coat colour & pattern and is sometimes trained to perform special tasks such as herding, guarding, or acting as a service animal. The skeleton of tail is made up of the coccygeal vertebra in all animals. The chevron bone presents as a separate bone articulated with coccygeal vertebra in domestic, wild even extinct animals like domestic dog [1-3], Beaked whale and Dolphin [4], Mink [5], Wild squirrel [6], Members of Sauropoda (Dinosaurs) [7,8]. The presence of chevron bone in the coccygeal vertebrae helps to protect important arteries and veins, collectively called as vascular bundle which passes through it, which has not only clinically important function in domestic animals but also act as vascular counter current heat exchanger in Whale and Dolphin [4]. The os penis is another special bone present in penis of male dog, it is believed that the distal part of corpus cavernosum was converted into an os penis [1,2,9], which helps during copulation and protect the urethra. Apart from the canine family, the os penis is also observed in members of mink family and some rodent species as well as seals, walruses, and racoons [10]. Although apparent details about chevron bone and os penis are available in few textbooks and articles, but detailed structural and functional anatomy of chevron bones and os penis in dog is not available. Hence the present work was taken to document the detailed morphological features of chevron bone and os penis in dog for its clinical benefits.

2. MATERIALS AND METHODS

This study was conducted in chevron bones and os penis of four adult dogs which were donated by the owner after natural death to the Department of Veterinary Anatomy, Veterinary College and Research Institute, Theni for educational and research purpose. The dead carcasses were collected and processed by natural wet maceration technique [11] to separate the bones from other soft tissues and their attachments. Bones collected after maceration were soaked with 10% bleaching powder solution for overnight to remove the minor tissue debris and make it white [12]. Finally, the coccygeal vertebrae along with chevron bones and os penis were identified and separated carefully. Then, the bones were photographed and studied for its peculiar gross anatomical features.

3. RESULTS AND DISCUSSION

3.1 Chevron Bones

The chevron bone also known as haemal arch was a special bone present in dog which was articulated with the body of third to sixth coccygeal vertebrae at posterior end on its ventral aspect (Fig. 1). The chevron bone and coccygeal vertebrae articulated near its intercentral junction with subsequent coccygeal vertebrae as mentioned by Evans and de Lahunta [2] in dogs, who stated that haemal arches are present as separate bones that articulate with the ventral surfaces of the caudal ends of the bodies of the fourth, fifth, and sixth caudal vertebrae. Budras et al [13] documented in dog, that the haemal processes were developed from the 4th caudal vertebra and became gradually indistinct caudally. On the 4th to the 7th or 8th caudal vertebra, they may unite to form a haemal arch. Singh [1] stated that the haemal arches were found at caudal end of ventral surface of 4th to 6th coccygeal vertebra of dog. But contradicted with Youssef et al [14] in Ruppell's fox, who observed absence of haemal arch, instead presents of triangular haemal foramen in the 4th and 5th coccygeal vertebrae at its anterior centrum. The ventral aspect of coccygeal vertebrae comprised of a pair of processes called as the haemal processes (Fig. 1). The haemal processes were very short and blunt, which alone enclosed a narrow space (haemal canal) at its middle in other domestic animals. Where as in dog, the space was created by the fusion of haemal processes of coccygeal vertebrae with lateral processes of chevron bone (Figs. 1 & 2).

The chevron bones were capital "V" or "Y" shaped individual bone as reported by Evans and de Lahunta [2] with three processes (Figs. 1 & 2). These are in accordance with the observations of Zavodszky and Russo [15] in carnivores. They were two lateral processes and one ventral process. The lateral processes were

short, thin, flat and became thick after fused with each other and continued as ventral process. The ventral process also known as haemal spine was extended from the fused part of two lateral processes (Fig. 1). It was thin at its origin and became thick then ended as blunt in some coccygeals and pointed in some coccygeals. The articulation between the proximal end of lateral processes of chevron bone and haemal process of coccygeal vertebra were transformed from cartilaginous nature to ossified state as the age advances, which makes the separate chevron bone as a part of coccygeal vertebra (Fig. 3A & B).

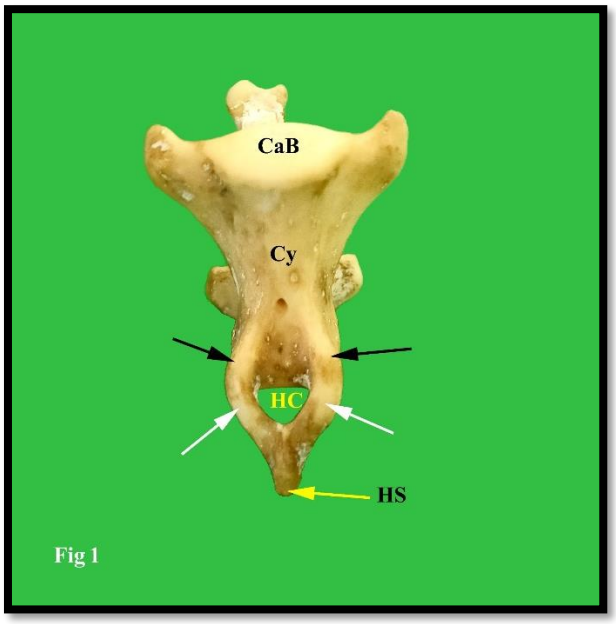

Fig. 1. Showing ventral view of 'Y' shaped chevron bone fused with coccygeal vertebra (Cy). Haemal spine (HS), Haemal canal (HC), Caudal end of vertebral body (CaB), Haemal processes of coccygeal vertebrae (Black arrows), Lateral processes of chevron bone (White arrows)

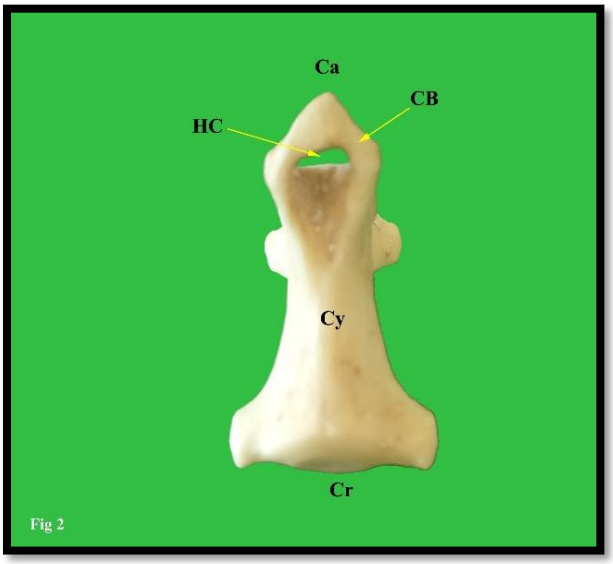

Fig. 2. Showing ventral view of 'V' shaped chevron bone (CB) fused with coccygeal vertebra, Haemal canal (HC), Cranial end of vertebral body (Cr) and Caudal end of vertebral body (Ca)

The haemal spine was directed downward and backward, the spine presented with shallow groove dorsally, which may provide protection to the structure that passes through the chevron bones. Based on the length of the haemal spine, the chevron bones get the shape either as alphabet 'V' or 'Y' (Figs. 1 & 2). Similar findings were also recorded by Mannion et al [8] in carnivores, who stated that "V-shaped" chevron bones consisted of two dorsal rami that created a haemal canal, converged ventrally to a point, and articulated either directly with the ventral side of the vertebral bodies or with haemal processes extending ventrally from the vertebrae. "Y-shaped" chevron bones similarly possessed two rami, but instead of simply merging into a point, an additional process was extended ventrally, like the stem of an uppercase "Y." The space between the lateral processes of chevron bone and haemal processes of coccygeal vertebrae was known as haemal canal where middle coccygeal artery was lodged, which is used for recording the pulse in animals. The free movement and bending of tail in dog mostly likely take place at the level of third to sixth coccygeal vertebrae. Hence the extensive free movement of the tail in dog makes the middle coccygeal artery to easily get strangulated at inter-central articulation between adjacent vertebrae. To prevent the artery from damage, the chevron bones might have developed in coccygeal vertebrae especially between second to sixth coccygeal vertebrae of dog.

Oteroa et al [7] observed four subtypes of Y-shaped haemal arches, Straight and open Y-shaped; Straight and closed Y-shaped; Curved and open Y-shaped and Curved and closed Y-shaped and Six subtypes of V-shaped haemal arches were Straight and open V-shaped; Curved and open V-shaped; Curved and closed V-shaped; Forked and open V-shaped; Forked and closed V-shaped and Asymmetric and open V-shaped in members of sauropods. But in the present study, all chevron bones were "curved and open Y shaped" and "open V shaped" in all the dogs.

3.2 OS Penis

The os penis also known as baculum [16] or os priapi [17] was a rare heterotrophic bone situated inside the penis of male dog. The os penis was triangular in outline with three sides, which extended from the proximal part of body of penis to the tip of penis (Fig. 4). The maximum length of os penis in this study was 11.5 cm and length of urethral sulcus was 7.5 cm (Fig. 5C), whereas, minimum length of os penis was 8.0 cm and length of urethral sulcus was 6.0 cm (Fig 5A). These observations were in accordance with Evans and de Lahunta [2,18,19], who observed that the length of os penis in large dog was 10 cm. But [9] observed 13 cm long os penis in local dog in his study. Also, Sharir et al [16] measured the overall length of the bacula varied between 83 and 128 mm (n = 9) with a mean: 104.4 mm. The os penis was made up of three surfaces, three borders, a base, a body and an apex (Fig. 6) as reported by Sharir et al [16,20] in dogs. But Arnold [17] in dog, along with base, body, apex, he also considered cartilage as a part of os penis.

The thickness of the os penis was broad at the base then decreased gradually and ended as blunted narrow tip. The three surfaces were two lateral surfaces and one ventral surface, three borders were one dorsal border and two lateral borders. The dorsal border was in form of sharp crest which separated the two lateral surfaces distinctly. The two lateral surfaces presented with a groove and pitted rough areas for the attachment of muscles (Fig. 5B). The two lateral borders were thick, convex and blunt, which curved downward and inwards, so that it enclosed a deep groove in the ventral surface from the base of the os penis till anterior one third length of the os penis. This deep groove in the ventral surface was called as urethral sulcus, since it accommodated urethra during life (Fig. 6) as already observed by Alaa [9,21]. The body was the longest portion among the three parts of os penis. Most of its length was triangular in outline, then continued cranially with apex.

The position of urethra inside the urethral sulcus makes it as clinical importance because of the narrow entrance of the urethral sulcus at base of os penis may block the passage of urinary calculi via the urethra. Hence, it leads to positive as well as negative impact on functionality of the os penis. Positively, the urethra was well protected by the os penis from the external injury or damage. Whereas, negatively the urethra was covered by the os penis in dorsal, lateral and to some extend ventro-lateral aspect, leaving the ventral aspect of urethra uncovered by the os penis. This uncovered portion leads to dilatation or bulging out of urethra ventrally due to the pressure exerted by the caliculi obstruction. The depth of the urethral groove was deeper at the level of junction between base and body of os penis, which decreases gradually towards anterior end as stated by Misk et al [20] in dogs.

Due to the deep location of urethra inside the os penis, caused frequent obstruction of urethra due to caliculi which get easily lodged at the base of the urethral sulcus as opined by Venugopalan [22,23] in dog. The preferred site for approaching urethra was mid ventral plane of penis, where the urethra was covered only by corpus spongiosum muscle.

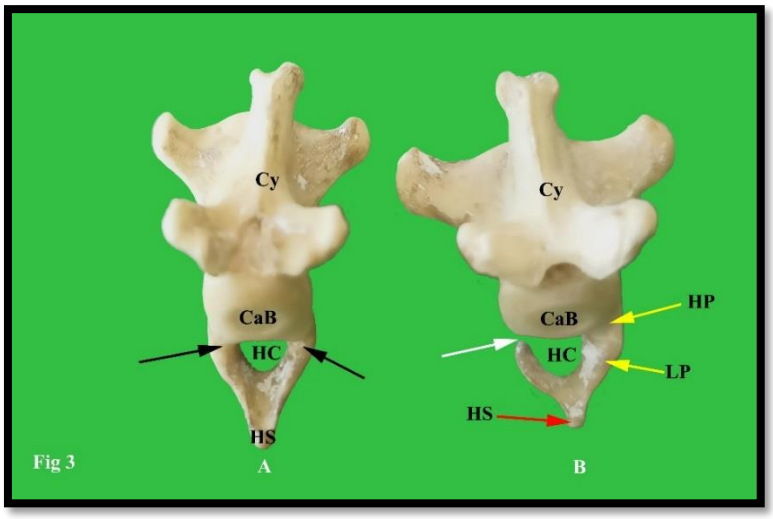

Fig. 3A. Showing Posterior view of 'Y' shaped chevron bone fused (Black arrows) with coccygeal vertebra (A). Fig. 3B: Showing chevron bone right side process fused with coccygeal vertebra, leaving left process open (White arrow), due to decomposed cartilaginous articulation. Coccygeal vertebra (Cy), Caudal end of vertebral body (CaB), Haemal canal (HC), Haemal spine (HS), Haemal process of coccygeal vertebra (HP) and Lateral process of chevron bone (LP)

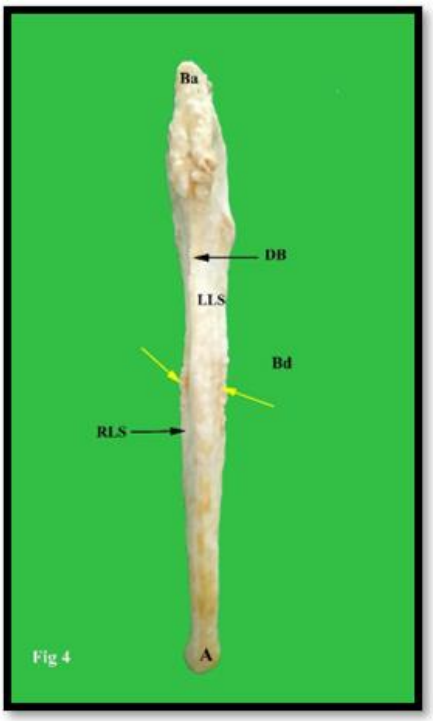

Fig. 4. Showing dorsal view of os penis of adult male dog. Base (Ba), Apex (A), Right lateral surface (RLS), Left lateral surface (LLS), Dorsal border (DB) in the form of sharp crest, Body of os penis (Bd), Pitted rough areas presented on both lateral surfaces (Yellow arrows)

Fig. 5A. Showing smallest os penis of this study with laterally curved body and hook like apex (Red arrow). Fig. 5B: showing os penis with Dorsal border (DB), Grooves (yellow arrows) in Right lateral surface (RLS) and Left lateral surface (LLS). Fig. 5C: Showing thick and wide base with rough pitted area and bifid dorsal border (White arrow) in longest os penis of this study

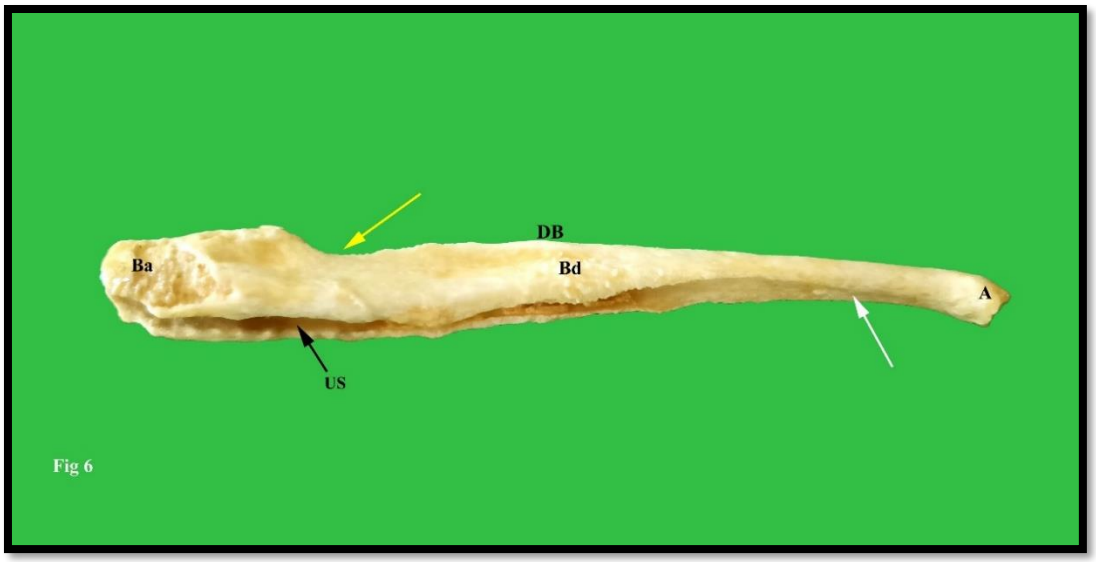

Fig. 6. Showing lateral view of os penis. Base (Ba), Body (Bd), Apex (A), Dorsal border (DB), Urethral sulcus on ventral aspect (US), Depression on dorsal border just cranial to base for attachment of bulbous glandis (Yellow arrow) and flat ventral surface of apex of os penis with no sulcus (White arrow)

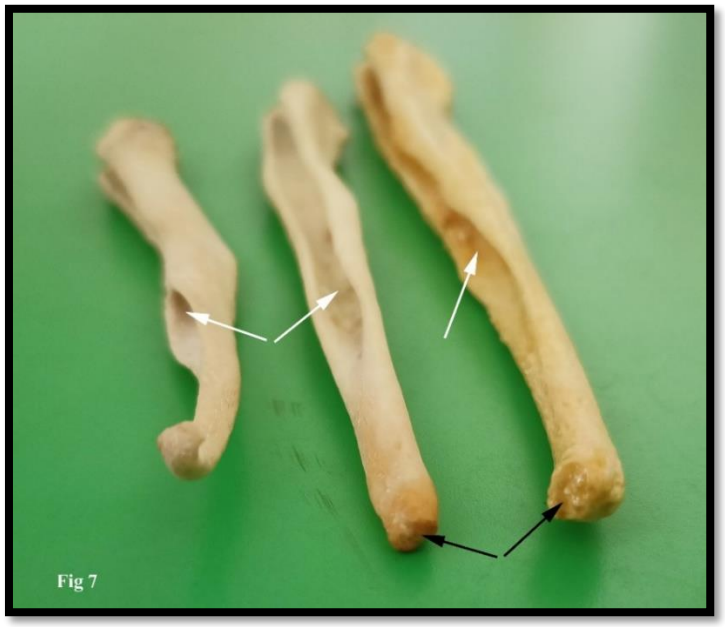

Fig. 7. Showing rough and pitted anterior end of the apex of os penis (Black arrows) and Urethral sulcus (White arrows)

The base of the os penis was thick and wide contained rough thick pitted areas (Fig. 4) on both lateral aspect for the attachment of ligaments and other muscular structures. Just anterior to the base of the os penis, a depression was observed on its dorsal border for the attachment of bulbous glandis muscle (Fig. 6). At the base of os penis, the dorsal border was bifid in appearance and ended as small tubercle, which was restricted to base posterior to the groove where bulbous glandis was attached (Fig. 5C).

The apex of os penis was conical in shape with slightly flat ventral surface with no urethral sulcus (Fig. 6). The anterior end of the apex of os penis was rough and pitted in appearance, which indicated its fibrocartilaginous continuation (Fig. 7). This coincides with [24] in dog, who observed terminal cartilaginous portion of os penis at its apex end. The thickness of the apex of os penis varied between the individual animals was determined by their age, sex, breed, nutritional status and sexual activity. In the present study, the varied apex of the os penis observed was less thick and blunt, pointed, even the tip was directed downward, twisted and turned backward formed hook like bend. These structural variations were also observed by Baryshnikov et al [25] who reported almost ten different types of os penis in mustelidae family. Likewise, the varied structural differences in body of os penis observed were straight, dorsally curved body, ventrally curved body and laterally curved body.

The line of demarcation between base, body and apex in os penis was indistinct. Arbitrarily the body of os penis started from the groove where bulbous glandis attached. Apex started from the region, where the urethral sulcus ended. Structure of the os penis directly influenced its functionality and surgical conditions. The importance of os penis in dog is to provide rigidity to penis for act of intromission, due to the delayed erection of bulbous glandis and glans penis during copulation as opined by Arnold [17].

4. CONCLUSION

In conclusion, the chevron bones and os penis are two fascinating anatomical special bones that play critical roles on the canine health. The chevron bones provide vital support and protection to the middle coccygeal artery and other structures passes through it. While, the os penis supports the penis during copulation and micturition as well as protect the urethra. Understanding these two structures is essential for the veterinarians, academicians, researchers, and dog owners to recognize and address potential health issues, surgical conditions and to develop effective treatment and management strategies related to it.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Authors hereby declare that, NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

ETHICAL APPROVAL

Animal Ethic committee approval has been collected and preserved by the author(s)

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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