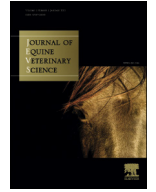




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Original Research

The Occurrence of a Congenital Malformation in the Sixth and Seventh Cervical Vertebrae Predominantly Observed in Thoroughbred Horses



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ABSTRACT

During the dissection and skeletal examination of 123 horses, it was observed that a significant number had a gross skeletal congenital malformation of the sixth and seventh cervical vertebrae. In the sixth cervical vertebra (C6), either a unilateral or bilateral absence of the caudal ventral tubercle (CVT) was noted. In the presence of the C6 malformation, the seventh cervical vertebra (C7) presented either as normal or with a unilateral or bilateral transposition of the CVT from C6 onto the ventral surface of C7 with an arterial foramen. This transposition onto C7 was noted to be present on the corresponding side as the absent CVT on C6. Of the 123 horses examined, the congenital malformation of C6 was noted in 19 of 50 Thoroughbred horses; three of three Thoroughbred derivative horses; one of 15 nondescript bred horses; and none of 55 purpose bred horses of mixed breeds. In total, 23 horses expressed a C6 congenital malformation of which 22 were Thoroughbreds or Thoroughbred derivatives. Of these 22 Thoroughbred and Thoroughbred derivative horses, 11 of 22 expressed either a unilateral or bilateral transposition of the CVT from C6 onto the ventral surface of C7 with an arterial foramen on the corresponding side. This malformation could have functional and clinical ramifications in the postural and locomotive properties of the equine neck and cervicothoracic junction as reported in other species.

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1. Introduction

The function of the equine neck in postural and locomotive presentations has been well researched and documented [1–3]. However, these presentations are reliant on normal symmetry within the cervical musculoskeletal system so that function may follow form without being compromised [4–6]. In principle, the equine form is a skeletal framework with specialized anchor points designed for soft tissue attachments that are primarily governed by muscles. Furthermore, these muscles are specifically attached to the skeletal framework to act in agonistic and antagonistic arrangements, so to articulate

the skeleton and thus provide function, whether it is postural or locomotive [2].

With this in mind, each bone in the equine neck is purposely designed to provide a specific function, and the caudal cervical vertebrae (CCV) with specialized characteristics form a pronounced concave curve that is in the opposite direction to the cranial cervical vertebrae [7]. This curvature lies within the cervicothoracic junction (C5–T2), and C6, C7, and T1 have shortened vertebral bodies that aid in the directional transition, with C7 being at the most ventral point [3,7]. This requires significant stabilization by the perivertebral muscle longus colli that has three layers: superficial, medial, and deep [8]. All three layers use the caudal ventral tubercle (CVT) on C6 as a point of attachment and, in particular, the superficial thoracic part that inserts with a strong tendon on the CVT of C6 and then travels in a fusiform bellied muscle ventral to C7, originating from the vertebral bodies of T1–T6 [7,8].

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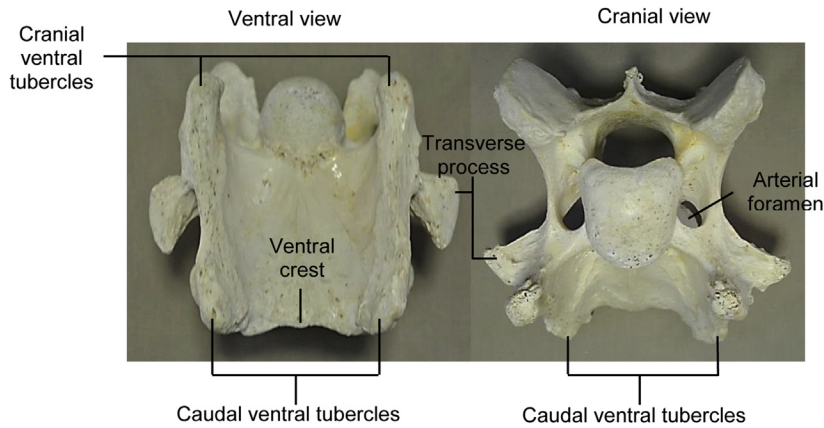


Fig. 1. The ventral and cranial view of a normal C6 in a 19-year-old Australian Stock Horse.

The potential deviation of the attachment of the thoracic part of longus colli because of the absence of the CVT on C6 implies dysfunction and therefore instability in the cervicothoracic junction. Yovich et al [9] reported that any deviation of alignment in the cervicothoracic junction can lead to malarticulation and possible cervical static stenosis (CSS). However, research of the equine CCV has focused largely on arthropathy of the caudal articular processes and measurements of the vertebral canal [10,11]. This is primarily because of the belief that congenital malformations in cervical vertebrae are rare [7,10–13]. Although the absence of the CVT in C6 [7,11] and transposition of the CVT onto the ventral surface of C7 have already been noted in Thoroughbreds [12], the prevalence within the breed has not been reported.

Therefore, the purpose of this study was to investigate the prevalence of congenital malformation in C6 and C7 with particular reference to the absence of the CVT on C6 and its transposition onto the ventral surface of C7 in conjunction with an arterial foramen in Thoroughbreds and other breeds.

2. Materials and Methods

According to Sisson and Grossman [7], C6 is an atypical cervical vertebra that displays a transverse process with three branches; the third branch is known as the CVT [14] as shown in Fig. 1.

In C7, the transverse process has only one branch and no ventral tubercles or arterial foramen [7] as shown in Fig. 2.

Postmortem examinations were collected from 123 horses that either died from natural causes or were euthanized for purposes unrelated to this study. The horses were sourced from Australia, England, North America, and Japan; they were of mixed gender and aged between 0 (stillborn) and 30 years. They were placed in four categories according to breed: Thoroughbreds, Thoroughbred derivatives, purpose bred, and nondescript breeding. Observations of the gross skeletal architecture of C6 and C7 were further divided into normal anatomy; unilateral (left or right) absence of the CVT in C6 (Fig. 3); bilateral absence of the CVT in C6; unilateral (left or right) transposition of the CVT onto the ventral surface of C7 (Fig. 4); bilateral

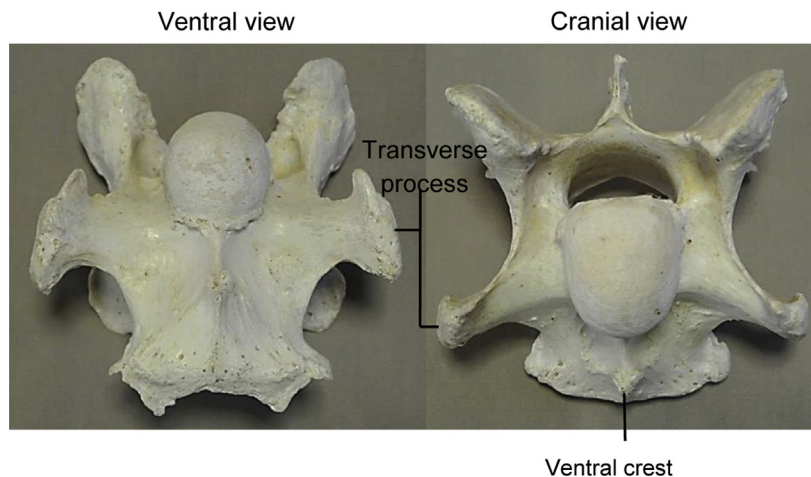


Fig. 2. The ventral and cranial view of a normal C7 in a 19-year-old Australian Stock Horse.

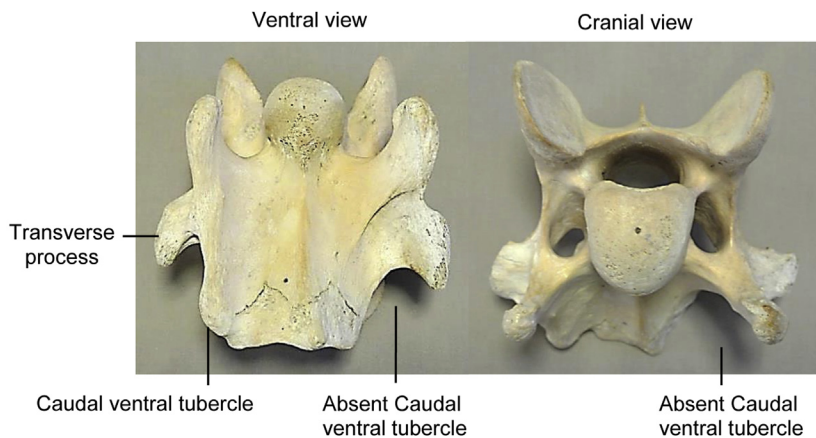


Fig. 3. The ventral and cranial view of an absent caudal ventral tubercle on C6 in a 6-year-old Thoroughbred racehorse.

transposition of the CVT onto the ventral surface of C7; and the unilateral or bilateral addition of an arterial foramen in C7 (Fig. 4).

3. Results

Of the 50 Thoroughbred horses examined, 19 exhibited a unilateral or bilateral absence of the CVT on C6, nine exhibited either a unilateral or bilateral transposition of the CVT onto the ventral surface of C7, and nine exhibited either a unilateral or bilateral addition of the arterial foramen in C7 (Table 1). Forty-seven of the 50 Thoroughbred horses examined in this study were located in Australia, one in Great Britain, one in North America, and one in Japan.

Of the 19 Thoroughbred horses exhibiting a congenital malformation on C6, 17 of 19 were Australian bred, one of 19 located in North America (unilateral), and one of 19 located in Japan (bilateral). The youngest Thoroughbred horse exhibiting a congenital malformation was a 10-month-old male with a unilateral C6, C7, and arterial foramen.

Of the three Thoroughbred derivative horses examined, three of three exhibited a unilateral or bilateral absence of the CVT on C6, two of three exhibited the transposition of the CVT from C6 onto the ventral surface of C7 (one

unilateral and one bilateral), and two of three exhibited the addition of the arterial foramen in C7 (one unilateral and one bilateral) (Table 1). The Thoroughbred derivative horses were Arabian cross Thoroughbred (30 years old), Warmblood cross Thoroughbred (15 years old), and a Quarter Horse cross Thoroughbred (stillborn foal). The three Thoroughbred derivative horses examined in this study were located in Australia.

Of the 22 Thoroughbred and Thoroughbred derivative horses exhibiting either a unilateral or bilateral absence of the CVT on C6, 11 of 22 transposed either a unilateral or bilateral CVT onto the ventral surface of C7 with an arterial foramen in direct correlation.

Of the 55 purpose bred horses examined, no congenital malformations were noted (Table 1). The breeds observed were miniatures (12), Spanish Mustangs (8), Arabians (6), Quarter Horses (5), Shetlands (5), Australian Stock Horses (4), Clydesdales (3), Japanese Pony (3), Morgan (2), Standardbred (2), Warmblood (2), Andalusian (1), Quarter Horse cross Arabian (1), and Welsh Mountain Pony (1).

Of the nondescript bred horses, one of 15 exhibited an absent left CVT on C6 (Table 1). The nondescript horse exhibiting an absent left CVT on C6 was located in Australia.

Of the 23 Thoroughbred horses exhibiting an absent CVT on C6, 21 were located in Australia. Of the two non-Australian Thoroughbred horses exhibiting a C6

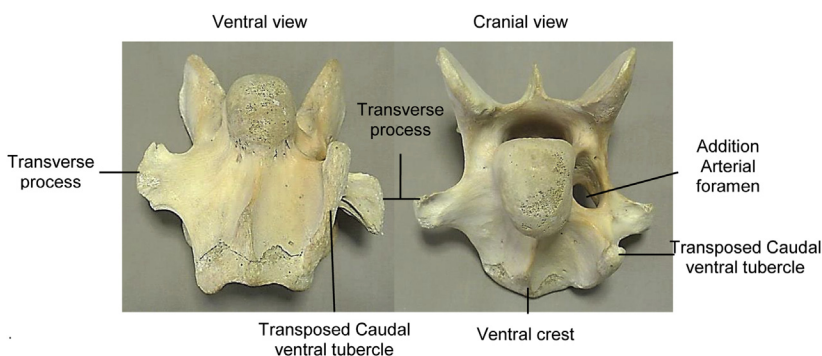


Fig. 4. The ventral and cranial view of a transposed caudal ventral tubercle from C6 onto the ventral surface of C7 in a 6-year-old Thoroughbred racehorse.

Table 1

Noted observations of 123 horses of mixed gender aged between 0 (stillborn) and 30 years, exhibiting normal presentation of C6 and C7 and congenital malformation of C6 and C7.

Breed	No.	Normal	C6 L-Ab	C6 R-Ab	C6 Bilat	C7 L-Tr	C7 R-Tr	C7 Bilat	C7 L-AF	C7 R-AF	C7 Bilat
Thoroughbred	50	31	11	2	6	6	1	2	6	1	2
Thoroughbred derivative	3	0	1	1	1	1	1	0	1	1	0
Purpose bred	55	55	—	—	—	—	—	—	—	—	—
Nondescript	15	14	1	—	—	—	—	—	—	—	—
Total	123	100	13	3	7	7	2	2	7	2	2

Abbreviations: Ab, absent; AF, arterial foramen; Bilat, bilateral; L, left; R, right; Tr, transposed.

malformation, neither exhibited the transposition of an absent CVT from C6 onto the ventral surface of C7.

4. Discussion

In this study, the CVT was absent on C6 in 38% of Thoroughbred horses, which negates the concept of this condition being a rare occurrence as previously reported [11,13]. A function of the CVT on C6 is to provide a strong anchor point for the thoracic part of the longus colli muscle in the cervicothoracic junction, so to stabilize, fixate, flex, and rotate the vertebra [7,8,15]. This raises the question as to where the muscle actually attaches when the CVT on C6 is absent and whether function is impeded. Furthermore, the transposition of the absent CVT from C6 onto C7 must interfere with the function of the longus colli muscle as it passes ventral to C7. If biomechanical forces have been altered because of asymmetrical structures, it should be noted at sites of muscle attachment such as transverse process symmetry (Figs. 3 and 4) and articulation of cervical articular process joints, as shown in Fig. 5.

Previous studies have reported congenital CCV malformations in humans, canines, felines, Holstein calves, and alpacas, and of particular note, the absence of the transverse process appeared more frequently in humans on C6 [16–20]. In addition, CCV malarticulation, vertebral column deviation, and neurological dysfunction were also reported in previously mentioned species. Vertebral column deviation and neurological dysfunction were also noted in this study in those horses examined before euthanasia expressing a C6 and/or C6 and C7 malformation. Furthermore, asymmetry of diarthrodial articulations were noted in C6 and C7 (Fig. 5), and this has been reported as a potential cause of CSS [9]. It could therefore be postulated that

CCV malarticulation, vertebral column deviation, and neurological dysfunction are conditions associated with horses, as with other species, in the presence of CCV malformation.

Furthermore, as articulations between C6–C7 and C7–T1 are highly mobile [21–23] and have no nuchal ligament lamellae to stabilize axial rotation on C6 and C7 [24], the probability that malarticulation and arthropathy in the CCV is substantially increased. In addition, without the CVT on C6, the superficial, medial, and deep divisions of longus colli must attach in a new location, and this will undoubtedly impair function along with performance, for example, “self-carriage” a disciplinary requirement in dressage and eventing [4,25]. Therefore, any deviation from normal anatomy is likely to place undue stresses on those structures involved in neck mobility and compromise the biomechanical effectiveness of locomotion.

5. Conclusions

This study verifies the presence of a congenital malformation in the sixth and seventh cervical vertebrae. Its prevalence in Thoroughbred horses was at 38%, and in Thoroughbred derivative horses, it was 100%. The presence of a single horse exhibiting the unilateral absence of the CVT on C6 in the nondescript category does not negate a Thoroughbred influence in the breeding. In fact, none of the mixed purpose bred horses had the congenital malformation, and this implies that it is breed related to Thoroughbreds. In addition, the congenital malformation existed in both Northern and Southern hemisphere Thoroughbred bred horses. Furthermore, in those Thoroughbred and Thoroughbred derivative horses exhibiting the congenital malformation in C6, 50% transposed the absent CVT onto C7.

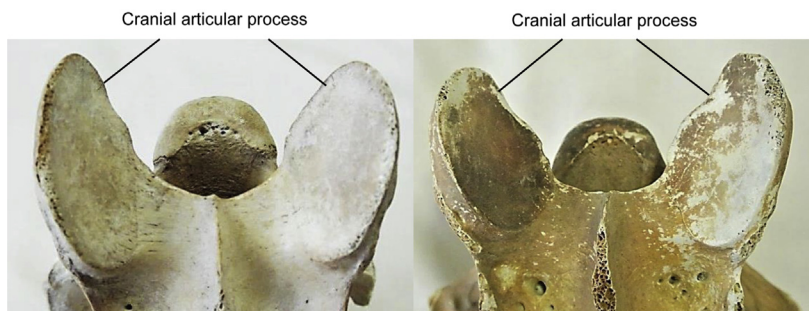


Fig. 5. Noted asymmetry in cranial articular processes of C6 in two Thoroughbred horses. Left: a 6-year-old Thoroughbred racehorse with left absence of the caudal ventral tubercle (CVT). Right: a 12-year-old Thoroughbred eventer (purpose bred for eventing) with right absence of the CVT.

This study was designed to investigate the prevalence of a congenital malformation in the sixth and seventh cervical vertebrae; however, the significant number of Thoroughbred and Thoroughbred derivative horses expressing this condition was surprising. Therefore, it would be the recommendation of this author that further studies be implemented to fully understand the possible ramifications of this congenital malformation and its effect on horses.

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