Egyptian Journal of Veterinary Sciences

https://ejvs.journals.ekb.eg/

Computed Tomographic and Radiographic Studies of the Hyoid Skeleton in Dromedary Camels

Abdualaziz Alhussain[1], Mohamed Marzok[1*], Zakriya Al Mohamad[1], Saad Shousha[2], Mohamed Nazih[3] and Mohamed El-Sherif[4*]

[1]*Department of Clinical Studies, College of Veterinary Medicine, King Faisal University, Al Ahsa 31982, Saudi Arabia.*
[2]*Department of Biomedical Sciences, College of Veterinary Medicine, King Faisal University, Al Ahsa 31982, Saudi Arabia.*
[3]*Department of Anatomy, Faculty of Veterinary Medicine, New Valley University, Al-Kharga, 27511, Egypt.*
[4]*Department of Surgery, Faculty of Veterinary Medicine, New Valley University, Al-Kharga, 27511, Egypt.*

Abstract

THE primary objective of this study is to investigate the anatomical structure of the hyoid apparatus in dromedary camels using computed tomography (CT) and X-ray imaging techniques to provide a detailed understanding of its morphology and functional relationships. CT scans were performed on twelve camel cadavers' heads to visualize and assess the hyoid apparatus. X-ray scans performed on twenty-five healthy live camels. The images were analyzed to determine bone composition, articulation points, and any anatomical variations compared to other large mammals. Both CT and X-ray imaging revealed the distinct components of the camel's hyoid apparatus, including the basihyoid, stylohyoid, thyrohyoid, ceratohyoid, and epihyoid bones. Notably, the absence of a lingual process in the basihyoid bone was confirmed. CT images provided superior resolution of articulation points, while X-rays offered adequate overviews of bone structure. No pathological alterations were noted in the scanned specimens. CT scanning offers enhanced visualization of the camel's hyoid apparatus compared to X-rays, allowing for more precise anatomical assessments. This imaging technique can facilitate clinical and surgical applications involving the head and neck of camels, supporting improved diagnosis and treatment planning.

Keywords: Anatomy, Camel, Hyoid bone, Pharynx, Surgery.

Introduction

The hyoid bone, a U-shaped structure located in the neck region of vertebrates, plays a vital role in supporting the tongue and other neck structures, thereby facilitating essential physiological functions such as swallowing and vocalization [1, 2]. Additionally, the hyoid bone plays a role in respiration by maintaining the upper airway's patency and influencing airflow during breathing [3, 4]. In camels, the specialized structure of the hyoid bone aids in efficient swallowing in arid environments and influences vocalizations and respiration [1]. These adaptations highlight the camel's remarkable ability to thrive in harsh environments [1]. Research has shown that the hyoid bone's movements during swallowing are influenced by attached muscles, although the specific roles of these muscles are not extensively studied [5]. Additionally, studies have indicated that the descent of the hyoid bone occurs concurrently with related structures like the larynx and epiglottis, emphasizing its role in coordinating swallowing and airway protection [4]. This study aims to examine the standard radiographic and computed tomographic anatomical characteristics of the hyoid bone in dromedary camels using CT and radiography.

Material and Methods

Cadaveric Computed Tomographic Study

Twelve fresh heads of adult dromedary camels (6 males and 6 females) were used for the study. The age of the camels was determined by observing rostral dentition. The heads were obtained from a local abattoir and examined using a 16-slice CT

*Corresponding authors: Mohamed Marzok, E-mail: mmarzok@kfu.edu.sa.
Mohamed El-Sherif, Email: mohamedelsherif@vet.nvu.edu.eg Tel.: +201008467944
(Received 12 May 2025, accepted 03 June 2025)
DOI: 10.21608/ejvs.2025.384296.2837

scanner (CT-W450-10 A, Hitachi Medical Corporation, Japan). Images were rendered in 3D models to obtain detailed descriptive information about the anatomy of the hyoid bone and its relationship to the cranial bones [6-8].

Clinical X-ray Imaging Study

The pharyngeal region and hyoid bone in twenty-five camels of both sexes and median age 8 years and median weight 386 Kg were examined using radiographic imaging techniques to assess anatomical structures, detect abnormalities, and evaluate the clinical relevance of these findings in relation to respiratory and swallowing functions. Standard radiographic parameters were used, with an exposure setting of 70-80 kVp and 8-10 mAs, depending on the size and age of the camel. A focal film distance of 90-100 cm was maintained. Ventrolateral X-ray images were analyzed to provide detailed insights into bone morphology and soft tissue characteristics of the region.

Results

Computed Tomographic Findings

The hyoid apparatus in camels, as observed through CT, is composed of several distinct bony elements: the basihyoid, stylohyoid, thyrohyoid, ceratohyoid, and epihyoid bones. These elements form a complex, elongated structure that supports the larynx and tongue. The CT images provide detailed insight into the morphology and spatial relationships of these bones, showing clear differentiation between them and the surrounding soft tissues. The overall structure appears well-developed and robust, with no signs of abnormal mineralization or deformities. Computed tomography of the hyoid bone is illustrated in Fig. 1 (A).

Radiographic Findings

Ventrolateral radiographs of the pharyngeal region show the hyoid skeleton as radiopaque structures. Like the CT images, five distinct components are observed: the stylohyoid process, epihyoid, ceratohyoid, basihyoid, and the thyrohyoid process. The computed tomographic and radiographic findings are illustrated in Figure 1 (B).

Discussion

The aim of this study was to describe the normal radiographic and computed tomographic anatomy of the dromedary hyoid skeleton. The topographic anatomy of the hyoid bone has been studied in dogs, cats [9], and horses [10]. Few reports describe the development and topographic anatomy of the hyoid apparatus in camels [11-13]. Prior studies have illustrated the anatomical uniqueness of the camel's hyoid apparatus, which is composed of a series of bones, including the basihyoid, stylohyoid, thyrohyoid, ceratohyoid, and epihyoid bones. These bones collectively play a vital role in supporting the tongue, larynx, and other associated structures within the head and neck. The CT images of the hyoid bone obtained from this study demonstrated clear demarcation between the individual bones, particularly the well-developed and elongated stylohyoid bone, which is the longest element in the hyoid complex. This finding corroborates [11, 13-15] observations, which highlighted the lack of a lingual process in the camel's basihyoid bone, a feature commonly present in other mammals like horses and cattle. The CT images provide greater detail and clarity, offering high-resolution visualization of bone contours and articulation points [6]. The basihyoid bone is shown on the CT scans as a centrally located, elongated structure, displaying no separate ossification center for the basihyoid, consistent with earlier embryological studies [11]. This contrasts with other domestic species, where the basihyoid often has its own distinct ossification center [16]. Instead, the basihyoid of camels is formed by the fusion of the rostral ends of the thyrohyoid bones, as suggested by developmental studies on the one-humped camel (Camelus dromedarius) [11]. This finding indicates that the camel hyoid bone undergoes a different developmental process compared to other species [15]. The stylohyoid bone, extending dorsally and forming the primary suspensory element, was clearly visualized in the CT images as a long, slightly curved bone. Its articulation with the skull was particularly well-defined, which is important for understanding its role in suspending the larynx and supporting other neck structures. This is in line with traditional anatomical descriptions, which emphasize the stylohyoid bone's structural importance in camels [13]. The CT scans showed no evidence of calcification defects, fractures, or degenerative changes, which is consistent with findings in healthy, non-pathological specimens studied by earlier researchers [13, 15]. The connections between these bones, crucial for the mobility and flexibility of the hyoid apparatus, were also visualized with exceptional clarity. Furthermore, the absence of a lingual process in the basihyoid bone, which is a key distinguishing feature of the camel hyoid apparatus, was once again confirmed through CT imaging. This feature has been repeatedly noted in anatomical literature, distinguishing camels from other large domestic animals, such as horses and ruminants [10, 17, 18].

Conclusion

The computed tomographic study of the hyoid bone in camels confirms previously known anatomical features while providing more detailed imaging of the bone structure and articulation points. This technique enhances the understanding of the functional morphology of the hyoid apparatus in camels and could be beneficial for both anatomical research and clinical applications. The CT findings, when compared with traditional anatomical studies,

offer more precise insights into the intricate relationships between the individual bones and their role in the camel's neck and laryngeal support system.

Acknowledgments

The author's sincere acknowledgment to the Deanship of Scientific Research at King Faisal University for the continuous support.

Funding statement

This study was supported through the Annual Funding track by the Deanship of Scientific Research, Vice Presidency for Graduate Studies and Scientific Research, King Faisal University, Saudi Arabia [Proposal Number: KFU251918].

Declaration of Conflict of Interest

The authors declare that there is no conflict of interest.

Ethical of approval

This study follows the ethics guidelines of the College of Veterinary Medicine, King Faisal University.

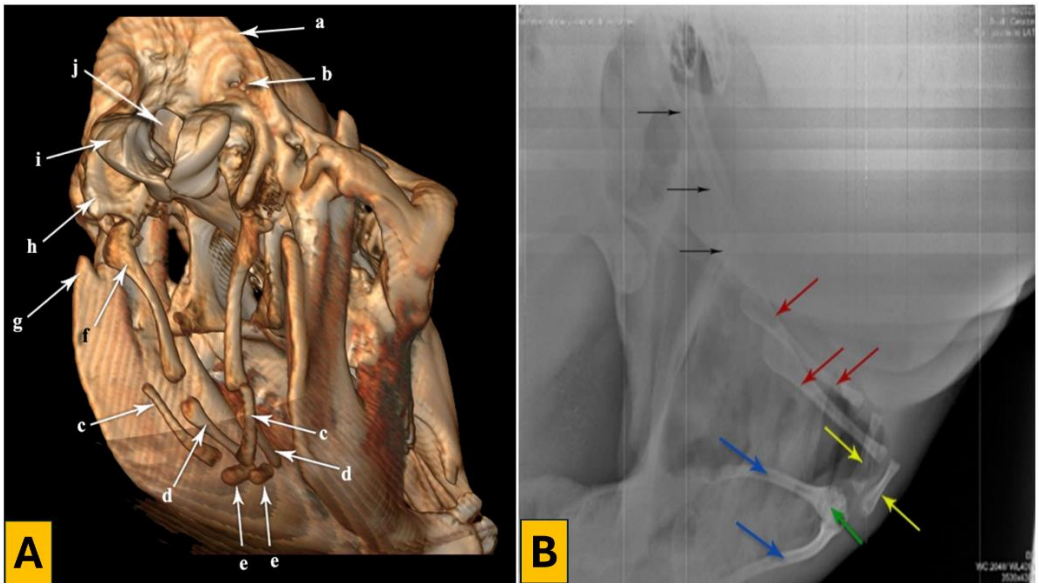

Fig. 1. (A) Computed tomographic image of the caudal ventral region of the head of camel showing the hyoid skeleton. a) Nuchal crest, b) Mastoid foramen, c) Thyrohyoid process, d) Epihyoid, e) Ceratohyoid, f) Stylohyoid process, g) Angular process, h) Jugular process, i) Occipital condyle, j) Foramen magnum. (B) Lateral X-ray image of the pharyngeal region of the camel's head showing the hyoid apparatus. The black arrows indicate the stylohyoid process, the red arrows indicate the epihyoid, the yellow arrows indicate ceratohyoid, the green arrow indicates the basihyoid, the blue arrows indicate the thyrohyoid process.

References

1. D'Souza, D.H., Harish, S.S. and Kiran, J. Fusion in the hyoid bone: usefulness and implications. *Medicine, Science and the Law*, **50**(4), 197-199 (2010). DOI: 10.1258/msl.2010.010027.
2. Mayerl, C.J., Edmonds, C.E., Gould, F.D.H. and German, R.Z. Anatomical and physiological variation of the hyoid musculature during swallowing in infant pigs. *Journal of Experimental Biology*, **224**(21), jeb242990 (2021). DOI: 10.1242/jeb.242990.
3. Werner, H.M., Ponce, D.P., Püschel, K. and Ottone, N.E. Growth and sexual dimorphism of the hyoid bone and its relationship to the mandible from birth to 19 years: A three-dimensional computed tomography study. *Anatomical Record*, **304**(9), 1901-1917 (2021). DOI: 10.1002/ar.24571.
4. Fisher, E., Austin, D., Werner, H.M., Chacon, A., Algee-Hewitt, B., Püschel, T., Püschel, K., Sehner, S., Ottone, N.E. and Ponce, D.P. Hyoid bone fusion and bone density across the lifespan: prediction of age and sex. *Forensic Science, Medicine, and Pathology*, **12**(2), 146-157 (2016). DOI: 10.1007/s12024-016-9769-x.
5. Okada, T., Aoyagi, Y., Inamoto, Y., Saitoh, E., Kagaya, H., Shibata, S., Ota, K. and Ueda, K. Dynamic change in hyoid muscle length associated with trajectory of hyoid bone during swallowing: analysis using 320-row area detector computed tomography. *Journal of Applied Physiology*, **115**(8), 1138-1145 (2013). DOI: 10.1152/japplphysiol.00621.2013.

6. Alsafy, M.A., El-Gendy, S.A., Abumandour, M.M. Computed tomography and gross anatomical studies on the head of one-humped camel (Camelus dromedarius). *Anatomia, Histologia, Embryologia*, **297**(4), 630-642 (2014). DOI: 10.1111/ahe.12124.

7. El-Sherif, M.W. and Nazih, M.A. A comprehensive examination of camel (Camelus dromedaries) otic prominence through morphological and CT imaging studies. *Journal of Basic and Applied Zoology*, **85**(1), 15 (2024). DOI: 10.1186/s41936-024-00350-4.

8. Marzok, M., Alkhodair, K. M., Nazih, M., and El-Sherif, M. W. Computed tomography and gross anatomical studies on the temporomandibular and supraorbital regions of one-humped camel (Camelus dromedarius): Tempro-orbital anatomy in camel. *Slovenian Veterinary Research*, **62**(1), Early View (2025). DOI: 10.26873/SVR-2136-2025.

9. Gioso, M.A. and Carvalho, V.G. Oral anatomy of the dog and cat in veterinary dentistry practice. *Veterinary Clinics of North America: Small Animal Practice*, **35**(4), 763-780 (2005). DOI: 10.1016/j.cvsm.2005.03.004.

10. Hartl, B., Egerbacher, M. and Kneissl, S.M. Correlated imaging of the equine hyoid apparatus using CT, micro-CT, and histology. *Frontiers in Veterinary Science*, **8**, 652563 (2021). DOI: 10.3389/fvets.2021.652563.

11. Shoghy, K.M. and Saber, A.S.M. Development of the hyoid bone (Os hyoideum) in the one-humped camel (Camelus dromedarius). *Journal of Veterinary Anatomy*, **6**(1), 23-29 (2013).

12. Jain, R.K., Kumar, P. and Gupta, A.N. Anatomy of the hyoid bone in camel (Camelus dromedarius). *Indian Journal of Animal Sciences*, **72**(3), 212-214 (2002).

13. El Allali, K., Achaâban, M., Ouassat, M. Anatomy of the dromedary head skeleton revisited. *Journal of Morphological Sciences*, **34**(2), 73-88 (2017). DOI: 10.4322/jms.091715.

14. Li, L., Zhang, H., Wang, J., Yan, D. and Zhao, Y. Anatomy and three-dimensional reconstruction of hyoid bone in the Bactrian camel (Camelus bactrianus). *Journal of Camel Practice and Research*, **18**(2), 191-196 (2011).

15. Jain, R.K., Kumar, P. and Gupta, A.N. Anatomy of the hyoid bone in camel (Camelus dromedarius). *Indian Journal of Animal Sciences*, **72**(3), 212-214 (2002).

16. Hartl, B., Egerbacher, M. and Kneissl, S.M. Correlated imaging of the equine hyoid apparatus using CT, micro-CT, and histology. *Frontiers in Veterinary Science*, **8**, 652563 (2021). DOI: 10.3389/fvets.2021.652563.

17. Chalmers, H.J., Cheetham, J., Yeager, A.E. and Ducharme, N.G. Computed tomographic diagnosis - stylohyoid fracture with pharyngeal abscess in a horse without temporohyoid disease. *Veterinary Radiology & Ultrasound*, **47**(2), 165-168 (2006). DOI: 10.1111/j.1740-8261.2006.00124.x.

18. Rezk, H.M. Anatomical investigation on the axial skeleton of the cattle egret (Bubulcus ibis). *Alexandria Veterinary Medicine Journal*, **61**(145), 12-21 (2015).

دراسات التصوير المقطعي المحوسب والتصوير بالأشعة السينية للهيكل العظمي اللامي في الإبل وحيدة السنام

عبد العزيز الحسين[١]، محمد مرزوق[١]، زكريا المحمد[١]، سعد شوشه[٢]، محمد نزيه[٣] ومحمد الشريف[٤]

[١] قسم الدراسات الاكلينيكية، كلية الطب البيطري، جامعة الملك فيصل، المملكة العربية السعودية.

[٢]قسم الدراسات الطبية الحيوية، كلية الطب البيطري، جامعة الملك فيصل، المملكة العربية السعودية.

[٣]قسم التشريح والأجنة، كلية الطب البيطري، جامعة الوادي الجديد، مصر.

[٤]قسم الجراحة، كلية الطب البيطري، جامعة الوادي الجديد، مصر.

الملخص

كان الهدف الرئيسي من هذه الدراسة هو التحقيق في البنية التشريحية للجهاز اللامي في الإبل باستخدام تقنيات التصوير المقطعي المحوسب (CT) والأشعة السينية لتوفير فهم مفصل لشكله وعلاقاته الوظيفية. تم إجراء فحوصات التصوير المقطعي والأشعة السينية على جثث إبل سليمة لتصور وتقييم الجهاز اللامي. تم تحليل الصور لتحديد تكوين العظام ونقاط المفاصل وأي اختلافات تشريحية مقارنةً بثدييات كبيرة أخرى. كشفت كل من تقنيات التصوير المقطعي والأشعة السينية عن المكونات المميزة للجهاز اللامي في الإبل، بما في ذلك العظم اللامي القاعدي(basihyoid) ، والعظم اللامي الإبري (stylohyoid)، والعظم اللامي الدرقي(thyrohyoid) ، والعظم اللامي القرني(ceratohyoid) ، والعظم اللامي فوق اللامي .(epihyoid) ومن الملاحظ، تم تأكيد عدم وجود ناتئ لساني (lingual process) في العظم اللامي القاعدي. وقد وفرت صور التصوير المقطعي دقة أعلى في تصوير نقاط المفاصل، بينما قدمت الأشعة السينية نظرة عامة كافية عن بنية العظام. ولم يتم ملاحظة أي تغيرات مرضية في العينات المفحوصة. يقدم التصوير المقطعي المحوسب تصورًا أفضل للجهاز اللامي في الإبل مقارنةً بالأشعة السينية، مما يتيح تقييمات تشريحية أكثر دقة. يمكن لهذه التقنية أن تسهل التطبيقات السريرية والجراحية المتعلقة برأس ورقبة الإبل، مما يدعم تحسين التشخيص وتخطيط العلاج.

لكلمات الدالة: الجمل، العظم اللامي، التشريح الجراحي، الاشعة المقطعية.