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Comparative Analysis of Ocular Morphology in Dromedary Camels: Insights from Ultrasound and Computed Tomography Imaging Techniques

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Abstract

THIS STUDY investigated the detailed anatomical structures of the dromedary camel eye using ultrasonography and computed tomography (CT) imaging modalities. Due to the limited existing research on comprehensive dromedary ocular anatomy, this study offers valuable insights for camel research. The methodology employs both trans corneal and retrobulbar ultrasonographic examinations, along with high-resolution CT scanning, to ensure meticulous image acquisition. Ultrasonography reveals the intricate anatomy of the anterior chamber, lens, vitreous body, and optic nerve. Ct imaging delineates the bony orbit, globe morphology, and periorbital structures. This study provides specific biometric measurements, encompassing corneal thickness, lens diameter, and vitreous body depth. Results demonstrate the complementary roles of ultrasonography and CT in elucidating dromedary ocular anatomy. These findings enhance foundational knowledge in veterinary medicine, facilitating improved clinical diagnostics in dromedaries. Further, this work establishes a framework for future anatomical studies of camelid species and contributes to the advancement of veterinary care for these unique animals.

Keywords: Camel, Computed tomography, Eye, Radiology, Ocular, Ultrasound.

Introduction

The study of ocular structures in camels through diagnostic imaging techniques, such as ultrasound and computed tomography (CT), is fundamental for understanding their anatomy and pathologies [1, 2]. These non-invasive imaging modalities have been used to visualize anatomical features in diverse species, including camels, and provide detailed, cross-sectional images for a thorough examination of the eye's internal structure [1]. Additionally, the anatomical structure of the camel's head, including the nasal and oral cavities, has been studied, emphasizing the importance of understanding the camel's unique anatomy for diagnostic and research purposes [3]. Furthermore, research on the prenatal development of eye tunics in camels contributes to the understanding of ocular structures at different stages of development [4]. Moreover, ultrasonography has been employed in diagnosing renal disorders in camels, highlighting its significance in veterinary diagnostic imaging [5]. The aim of this study is to comprehensively describe the ocular structures in camels utilizing ultrasound and computed tomography (CT). Through detailed examinations, the research seeks to provide a comprehensive understanding of the morphological aspects of camel eyes.

Material and Methods

Sample Selection and ethical considerations:

Eight fresh cadaveric heads from healthy adult camels were obtained. Thorough clinical examinations were performed prior to slaughter to confirm the absence of pre-existing ocular conditions.

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Ultrasound Imaging

B mode ocular ultrasound scans were systematically performed in sagittal, and transverse planes to capture comprehensive images of diverse ocular structures. Two distinct acoustic windows were utilized in this study. The first, through the trans corneal, and the second, through the retrobulbar via the supraorbital fossa. A micro convex array transducer (7.5-10 MHz, Edan Dus 60, China) was employed for the study. Key parameters, including axial length, anterior chamber depth, and lens thickness, were performed. In order to obtain improved images from the trans corneal window especially for the cornea, a coupling gel pad was used.

Computed Tomography

Cadaveric heads were meticulously positioned for optimal alignment on the CT scan table, ensuring accuracy in imaging. High-resolution cross-sectional images of the eyes were obtained using a 64-slice CT scan machine (GE Optima 520, GE, USA). The rostral side of the heads was carefully oriented towards the gantry during the scanning process. Axial CT images were acquired with specific parameters: 120 KV, 100-350 mAs, and a 1.3 mm slice thickness. Assessments were conducted in both the bone window (Window Width, WW = 2500, Window Level, WL = 450) and the soft tissue window (WW = 300, WL = 40). This comprehensive approach allowed for a detailed anatomical analysis of the scanned structures.

Evaluation and assessments

Ultrasound findings and Comparison of Acoustic Windows:

Measurements of axial length, anterior chamber depth, and lens thickness obtained from ultrasound scans were subjected to descriptive statistical analysis. The mean, standard deviation, and range of each parameter were calculated to provide a comprehensive overview. A comparative analysis was conducted to assess the efficacy of the two acoustic windows (trans corneal and retrobulbar via the supraorbital fossa) in visualizing different ocular structures.

Computed Tomography

High-resolution CT scans were analyzed to extract quantitative information regarding the anatomical features of the camel eyes. Measurements of ocular structures were recorded and subjected to descriptive anatomy.

Ocular structure measurements

Measurements of the ocular structures including the axial length of the globe, vitreous axial length, diameter and thickness of the lens, diameter and depth of the anterior chamber peripheral and central corneal thickness were collected throughout the ultrasound and CT scans and means were recorded.

Results

Ultrasound findings

Trans corneal ultrasonographic findings

The ultrasonographic examination of the orbital contents explain the anatomical structures of the eyeball, periorbital cone, and the optic nerve. In the eyeball, it shows the anterior chamber, it appears as fusiform area occupies the rostral aspect of the eye lens and iris. The eye lens shines just caudally to the anterior chamber as glistening white ovoid spot. It surrounded by very thin pale layer, the lens capsule. The intraocular cavity is filled by the vitreous body, which appears as dark ovoid mass encloses the eye lens rostrally, the retina laterally and caudally. The body filled by viscus vitreous humor, it gives the eyeball its rigidity and fixes the retinal peripherally. The latter, lines the internal boundaries of the eyeball internal cavity. It appears homogeneous except at the circumscribed pale elliptical spot, the optic papilla. The papilla is the blind spot and leads to the optic nerve. The nerve passes as the dark twisted cord extends within the orbital cone. It emerges from the caudal pole of the eyeball rostrally to the apex of the orbital cone caudally. The orbital cone is the triangular pale area, its base is related to the eyeball rostrally, and its apex directed caudally. Its outer wall is formed by thick layer of the orbital fascia, internally it envelopes the orbital fat and ocular muscles as well as the optic nerve. An image from the trans corneal window is illustrated in Figure (1-A).

Retrobulbar ultrasonographic findings

The ultrasonographic examination of the eye from the retrobulbar acoustic window showed a less details than the peribulbar view. the optic nerve and muscular cone of the eye viewed as homogeneous hyperechoic with less details. The eyeball showed as more circular hypoechoic structure. Retina is not well defined. Iris is evident in this view as hyper echoic structure. The eye lens is homogeneous not well defined from the surrounding and the capsule not clear. Retrobulbar window image is showed in Figure (1-B).

Computed tomographic findings

CT images offered excellent discrimination between bone and soft tissue structures within the orbit, presenting detailed insights into osseous structures visible as hyperattenuating elements. The axial and multiplanar reconstructed CT images facilitated a comprehensive visualization of the orbit. The circular globe, encircled by the bony orbit formed by the frontal, zygomatic, and lacrimal bones, was well-delineated. This aligns with observations in axial and 3-D reconstructed CT images. The anterior chamber, eye lens, vitreous chamber, peri-orbital fat, ocular muscles, and optic nerve path were clearly discernible in both axial and dorsal planes of CT images. The globe appeared as a hypoattenuating structure, contrasting with the hyperattenuating round structure of the lens at the globe's center. Fluid attenuating densities in the aqueous and vitreous chambers, ocular muscles represented as hyperattenuating bands intercalated with fat, and the optic nerve pathway were evident. These findings corroborate with the documented periocular details in dromedaries by Alsafy et al. (2014). Comparatively, CT scanning emerged as a superior imaging modality for periocular details when contrasted with other modalities. Performing CT imaging immediately post-mortem minimized post-mortem changes, aligning with the approach advocated by Blanco et al. (2015). The technique allowed for a comprehensive assessment of the anterior eye chamber, lens, scleral ring, posterior ocular wall, retrobulbar space, ocular nerve, and the entire skull. Nevertheless, CT was deemed inadequate for examining the cornea and uvea, highlighting its limitations in certain aspects of ocular anatomy. The use of technical parameters (kV, mA) consistent with previous studies on camel and equine head imaging ensured reliable and comparable results. The appearance of the lens, orbit, and globe during CT imaging aligned with previous reports, further supporting the reliability and consistency of CT findings in the anatomical study of the dromedary eye. Computed tomographic image of the eye is shown in Figure 2.

Ocular structure measurements

From a biometric perspective, the cornea demonstrates a thicker center compared to the periphery in both the right and left eyes. Additionally, in both eyes, the lens diameter exceeds its thickness, and the vitreous body depth is observed to be less than the axial length of the globe. The ocular dimensions for both right and left camel eyes are concisely presented in Table 1. There was no significant difference between measurements obtained from the three imaging techniques.

Discussion

The comprehensive examination of dromedary ocular anatomy through both ultrasonography and CT imaging has revealed intricate details of the eye, periorbital structures, and optic pathways. Previous reports provided data about the normal ocular ultrasonographic and biometric images of the Indian camel [6] and Arabian camel [7]. Results obtained aligned with prior reports. The trans corneal ultrasonographic findings unveiled the anterior chamber, eye lens, vitreous body, and optic nerve within the eyeball, offering a detailed view of these structures. Previous studies used this acoustic window as standard technique [6-10]. The retrobulbar ultrasonographic perspective, while less detailed, provided insights into the caudal aspect of eyeball and retrobulbar structures especially the optic nerve, peribulbar corneal fat and ocular muscular cone. To our knowledge this is the first report provide a description of this approach. Findings from ultrasonography contribute to the understanding of ocular anatomy and its potential applications in clinical settings [7, 10]. The CT imaging results further enriched our anatomical understanding, with detailed delineations of the dromedary eye and periorbital structures as reported by [10]. The axial and multiplanar reconstructed CT images provided excellent discrimination between bone and soft tissue structures, presenting a complete visualization of the circular globe surrounded by the bony orbit [11, 12]. The identification of the anterior chamber, eye lens, vitreous chamber, peri-orbital fat, ocular muscles, and optic nerve in both axial and dorsal planes corroborate the findings from ultrasonography [1]. However, it is noteworthy that trans corneal imaging was deemed less suitable for examining the cornea and uvea. The application of ultrasound standoff pad was helpful to provide more detailed images of the cornea [13, 14]. The integration of both imaging modalities revealed a more holistic understanding of dromedary ocular anatomy. Ultrasonography, with its real-time imaging capability, contributed detailed insights into the internal structures of the camel's eye. CT imaging, with its ability to discriminate between bone and soft tissue, offered a comprehensive visualization of the bony orbit and surrounding structures. The combination of these modalities provided a more thorough understanding of the spatial relationships and structural details of the eye and its adjacent tissues. The immediate post-mortem CT imaging approach minimized post-mortem changes, aligning with recommended practices in the literature [11]. The consistency of technical parameters used in CT imaging with previous studies ensured reliable comparisons. However, the limitations of CT imaging in assessing certain aspects of ocular anatomy, such as the cornea and uvea, should be acknowledged [11].

Conclusion

The amalgamation of trans corneal ultrasonography and CT imaging has enhanced our comprehension of dromedary ocular anatomy. These findings hold implications for both clinical diagnosis and anatomical studies in veterinary medicine. Future research may delve deeper into the clinical applications of these imaging modalities and explore their utility in diagnosing ocular conditions and guiding therapeutic interventions in dromedaries.

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Declaration of Conflict of Interest

The authors declare that there is no conflict of interest.

Ethical of approval

Experiment performed with adherence to ethical standards in animal research (ARRIVE 2.0, 2020), approval obtained from the ethical review board of the faculty of veterinary medicine, King Faisal University.

TABLE 1. Mean values of the biometric measurements of the ocular structures of the camel eye in mm.

Structure/ parameter	Left eye	Right eye
Axial length of the globe	342	335
Vitreous axial length	170	166
Diameter of the lens	1.88	1.84
Thickness of the lens	1.21	1.19
Diameter of the anterior chamber	20.1	19.5
Depth of the anterior chamber	2.8	2.6
Peripheral corneal thickness	1	1.1
Central corneal thickness	1.1	1.2

-Count for different products with different superscript letters in the same rows are significantly different at ($P<0.05$).

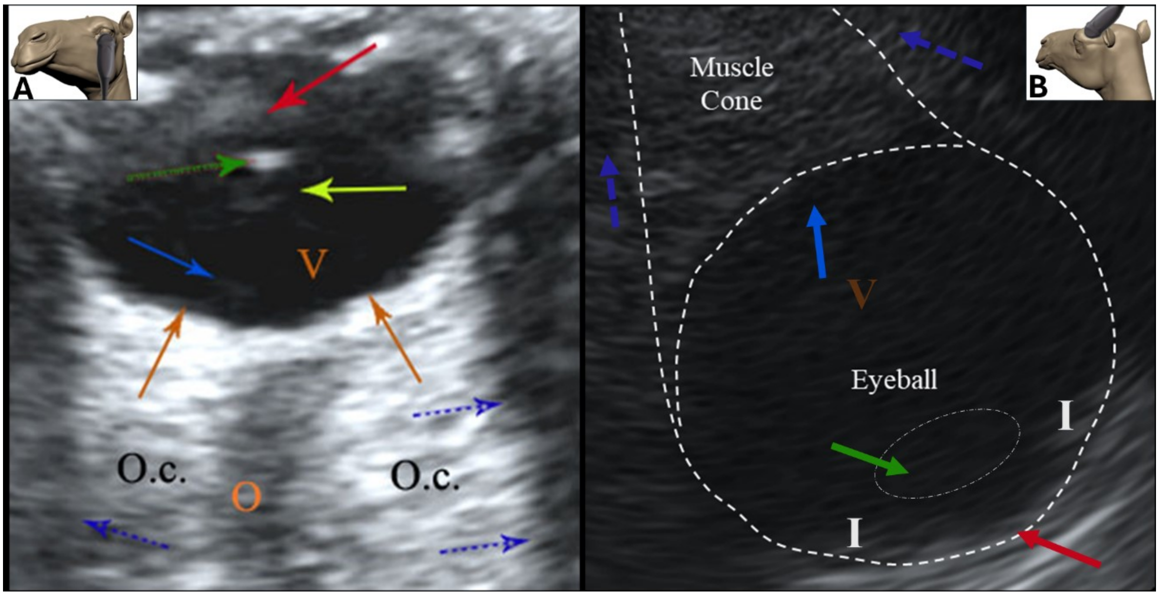

Fig. 1. Photographs showing A) Trans corneal and B) retrobulbar ultrasonographic findings: The red arrow indicates the anterior chamber, The green arrow indicates the eye lens, The yellow arrow indicates eye lens capsule, The blue arrow indicates the optic papilla, The brown arrows indicate the retina, The dotted arrows indicate the outer layer of the orbital fascia, the white dotted area referred as lens, I) iris, O) indicates the optic nerve, V) indicates the vitreous body, O.c) indicates the orbital muscle cone.

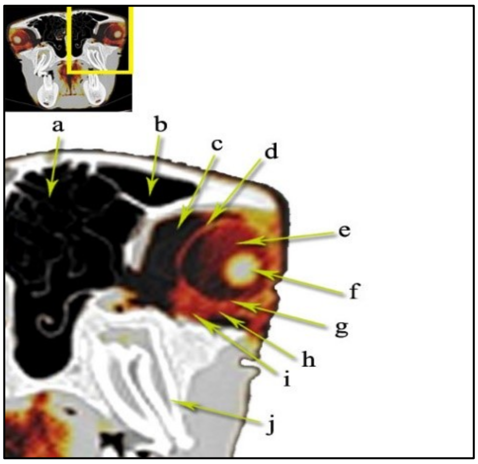

Fig. 2. A photograph showing rendered 3D computed tomographic imaging (CT scan) at the level of the orbital cavity. (coronal section). a) Nasal cavity proper, b) Frontal sinus, c) Orbital cavity, d) Sclera, e) Vitous body f) Eye lens, g) Retina, h) Orbital cone, i) Optic nerve, j) Upper molar tooth.

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دراسة مقارنة لمورفولوجيا العين في الجمال العربية باستخدام تقنيات التصوير بالموجات فوق الصوتية والاشعة المقطعية

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الملخص

بحثت دراسته في الهياكل التشريحية التفصيلية لعين الجمل العربي باستخدام التصوير بالموجات فوق الصوتية وطرق التصوير المقطعي المحوسب .(CT) نظرا للبحوث المحدودة الموجودة حول تشريح العين للجمل العربي، تقدم هذه الدراسة رؤى قيمة لأبحاث الإبل . تستخدم المنهجية كلا من فحوصات الموجات فوق الصوتية عبر القرنية ومن خلف العين وهي طريقة مستحدثة في هذه الدراسة، جنبا إلى جنب مع التصوير المقطعي المحوسب عالي الدقة، لضمان الحصول على صورة دقيقة .يكشف التصوير بالموجات فوق الصوتية عن التشريح المعقد للغرفة الأمامية والعدسة والجسم الزجاجي والعصب البصري .يحدد التصوير المقطعي المحوسب المدار العظمي ومورفولوجيا العين والهياكل المحيطة بالحجاج .توفر هذه الدراسة قياسات بيومترية محددة، تشمل سمك القرنية وقطر العدسة وعمق الجسم الزجاجي .تظهر النتائج الأدوار التكميلية للتصوير بالموجات فوق الصوتية والتصوير المقطعي المحوسب في توضيح تشريح العين في الجمال العربية .تعزز هذه النتائج المعرفة الأساسية في التشخيص والعلاج في مجال العيون، مما يسهل تحسين التشخيص السريري في الجمال العربية .علاوة على ذلك، يضع هذا العمل إطارا للدراسات التشريحية المستقبلية لأنواع الإبل ويساهم في النهوض بالرعاية البيطرية للجمال العربية.

الكلمات الدالة: الجمال، الموجات فوق الصوتية، العين، الأشعة المقطعية.