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Original Research Article

Computed Tomography and Gross Anatomical Studies on the Temporomandibular and Supraorbital Regions of One-Humped Camel (*Camelus dromedarius*)

Key words

enucleation;
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orbital surgery;
temporal fossa

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Abstract: The objective of this study was to investigate the detailed surgical anatomy of the temporomandibular and supraorbital regions in camels using anatomical dissection and computed tomography (CT) scanning. The study aimed to provide precise anatomical descriptions and assess the feasibility of surgical interventions within the orbital cavity via the orbital fossa. Twelve camel skulls and three fresh cadaveric heads of adult camels were procured from the faculty's morgue and a local abattoir, respectively. Descriptive anatomy of the skull and surgical anatomy of the temporo-orbital region were meticulously examined. Additionally, computed tomography of the heads was conducted to augment the dataset. Results were systematically documented to evaluate the applicability, feasibility, and safety of the orbital fossa approach to the orbital cavity. The temporal fossa of the camel was found to be significantly expansive, extending rostrally to a sizable orbital fossa. The external lining of the orbital fossa comprised skin and a subjacent thick fascia. Notably, no essential muscles or vital structures were identified. The posterior orbital cavity housed a substantial periorbital fat mass, and upon its removal, clear and safe visual access to the ocular structures was achieved, facilitating ease of approach. The orbital fossa approach was determined to be feasible and safe, enabling the performance of various surgical procedures, including enucleation, exenteration, periorbital tumor removal, prosthetic implantation, and other interventions. This approach promises enhanced cosmetic outcomes in the execution of such procedures.

Introduction

Temporal fossa formed by parietal, temporal, and frontal bones and bounded laterally by the zygomatic arch (1, 2). In camels, the temporal fossa is large and extended rostral as large orbital fossa (3-5). In animals, several surgical procedures are indicated within the orbital cavity, mainly the anesthesia administration (6, 7), ocular procedures (8, 9), retrobulbar procedures (10, 11), and post-surgical cosmetic interventions (12-14). Although less common, various conditions necessitate surgical intervention within the orbital cavity in camels (15, 16). Enucleation due to surgically untreatable conditions and removal of tumors are the most common procedures (15, 17-19). This study aims to provide a descriptive anatomy of the temporo-orbital region in camels, coupled with computed tomographic findings. The goal is to evaluate the potential use of this region as a surgical access point to the orbital cavity and its contents.

Materials and methods

The current study was reviewed, permitted, and approved by the research ethics committee (REC) of King Faisal University, KSA (Approval NO. KFU-REC/2024- ETHICS 2,090). All methods were carried out in accordance with relevant guidelines and regulations. All methods are reported in accordance with ARRIVE guidelines.

Specimen selection and anatomical dissection

Nine cadaveric heads of adult camels (6 males and 3 females) were procured from a local abattoir to serve as specimens for the study. Employing a standardized anatomical dissection methodology, the temporo-orbital region was meticulously exposed. Special attention was dedicated to the comprehensive documentation of anatomical structures, with a specific focus on elucidating the intricacies of the orbital fossa. Additionally, morphometric assessments of pertinent anatomical features were conducted to quantify and characterize the observed structures. The utilization of freshly acquired specimens and rigorous dissection techniques ensures the precision and validity of the anatomical data obtained in this study.

Imaging techniques

Prior to anatomical dissection, the cadaveric heads underwent computed tomography (CT) scanning to enhance and complement the anatomical findings. Axial CT images were acquired utilizing parameters of 120 kV, 100-350 mAs, and a slice thickness of 5 mm. The initial recording of orbit and ocular contents was conducted in the axial plane, followed by subsequent reconstruction into multiplanar and three-dimensional (3-D) images. This comprehensive imaging approach facilitated a thorough correlation between the obtained CT images and the anatomical findings, contributing to a more nuanced and in-depth understanding of the temporo-orbital region.

Results

Gross Anatomy

The tempro-orbital fossa, also known as the supra-orbital fossa, extends dorsally from the median external parietal crest, frontal bone, and rostrally from the zygomaticofrontal process. Laterally, it extends from the zygomatic process of the zygomatic bone and the zygomaticotemporal process, while caudally it is bounded by the nuchal and temporal crests. The medial boundary is formed by the parietal, squamous part of the occipital, and squamous part of the temporal bones, along with the pterion, a point where the parietal, basisphenoid, and temporal bones converge (Figure 1). The supra-orbital fossa is directly connected rostrally to the orbital cavity, and ventrally, the pterygopalatine fossa establishes a connection between the tempro-orbital fossa and the orbital cavity. Exhibiting a nearly triangular shape with rounded ends, the outer diameter of the fossa measures approximately (5±1.5 cm). Its depth ranges from (4.8-5.2 cm) measured from the optic foramen to the mid-distance between the external parietal crest and the zygomatic arch. These anatomical details provide a comprehensive description of the spatial relationships and dimensions of the tempro-orbital fossa in the context of the surrounding cranial structures (Table 1).

Table 1: Individual measurements of the outer diameter and depth of the supraorbital fossa in a sample of nine camels

Camel No.	Outer Diameter (cm)	Depth (cm)
1	4.2	5.1
2	6.0	4.9
3	5.8	5.0
4	3.9	4.8
5	4.5	5.2
6	6.3	5.0
7	5.4	4.9
8	3.7	5.1
9	5.2	4.8

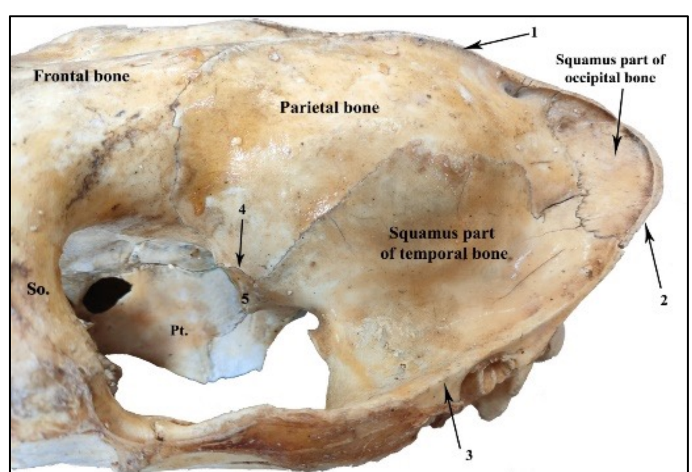

Figure 1: Dorso-lateral view of the caudal cranium of camel. 1) external parietal crest, 2) nuchal crest, 3) temporal crest, 4) pterion, 5) basisphenoid bone, So.) supra orbital process, and Pt.) pterygopalatine fossa

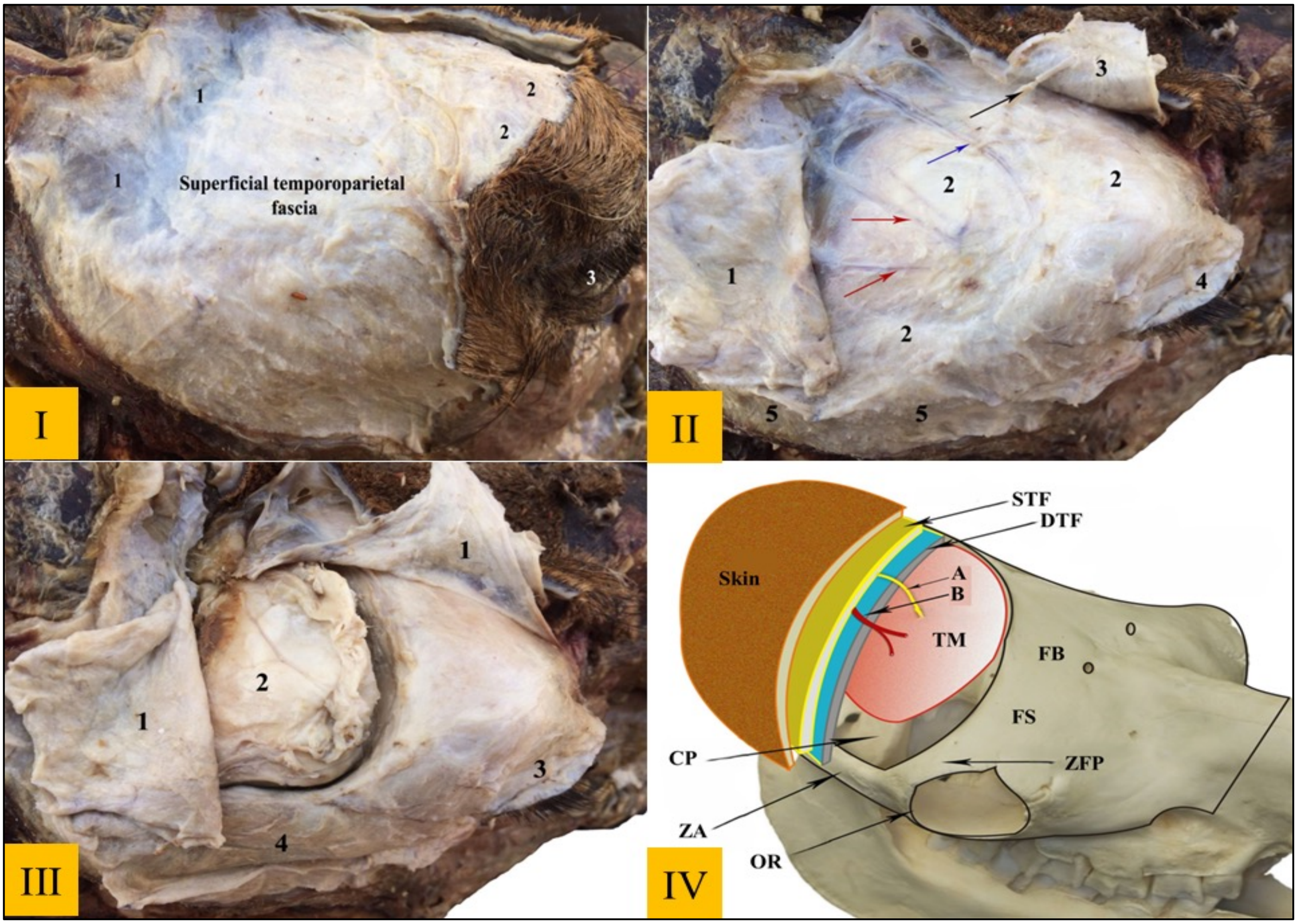

Figure 2: I) dorso-lateral view of the right caudal part of the head of camel. 1) facial part of the auricular muscles, 2) malaris muscle, and 3) upper eye lid. II) 1) superficial tempro-orbital fascia (cut), 2) deep tempro-orbital fascia, 3) malaris muscle, 4) upper eye lid, and 5) zygomatic arch. The red arrows indicate the frontal branches of the superficial temporal artery. The blue arrow indicates the superficial branch of the zygomatico temporal artery. The black arrow indicates the palpebral branch of the auriculopalpebral nerve of facial. III) 1) deep tempro-orbital fascia (cut), 2) periorbital fat, 3) upper eyelid, and 4) zygomatic arch. IV) a diagram showing the different anatomical layers on the tempro-orbital fossa. A) temporal artery and vein, B) temporal nerve, TM) temporalis muscle, STF) superficial temporoparietal fascia, DTF) deep temporoparietal fascia, CP) coronoid process, ZA) zygomatic arch, OR) orbital rim, FB) frontal bone, FS) frontal sinus, ZFP) zygomatico-frontal process

The integument covering the tempro-orbital fossa extends over the superficial temporal fascia externally (Figure 2-a, b & c). This robust layer envelops the supra-orbital fossa, extending both rostrally and dorsally in conjunction with the frontal fascia. Ventral attachment occurs at the temporal crest, providing anchorage for the frontal part of the external auricular muscles and the Malaris muscle. In deeper layers, the thinner deep tempro-orbital fascia envelops the temporalis fossa and its contents. On the external surface of this fascia, the palpebral branch of the auriculo-palpebral nerve of the facial nerve courses rostrally, passing over the Malaris muscle. Simultaneously, the frontal branch of the superficial temporal artery and the superficial branch of the zygomaticotemporal artery traverse towards the dorsolateral angle of the orbital cavity (Figure 2-d). This detailed account elucidates the intricate layers and neurovascular structures within the tempro-orbital fossa, offering a comprehensive understanding of its anatomical characteristics.

Upon removal of the deep temporo-parietal fascia, the contents of the temporal fossa become clearly delineated. Predominantly, the fossa is occupied by the temporalis muscle and periorbital fat. The temporalis muscle attaches dorsally to the parietal bone from the external sagittal crest, extending rostrally along the temporal line and inserting into the coronoid process of the mandible. In conjunction, the periorbital fat fills the space between the caudal aspect of the temporalis muscle and the rostral aspect of the orbital cavity.

This adipose tissue forms a robust, pyramidal mass with its base directed dorsally and closely related to the deep tempro-orbital fascia.

Its apex extends ventrally, reaching towards the pterygopalatine fossa. This comprehensive description elucidates the specific anatomical structures within the temporal fossa, providing a detailed understanding of their attachments, relationships, and spatial configurations. The

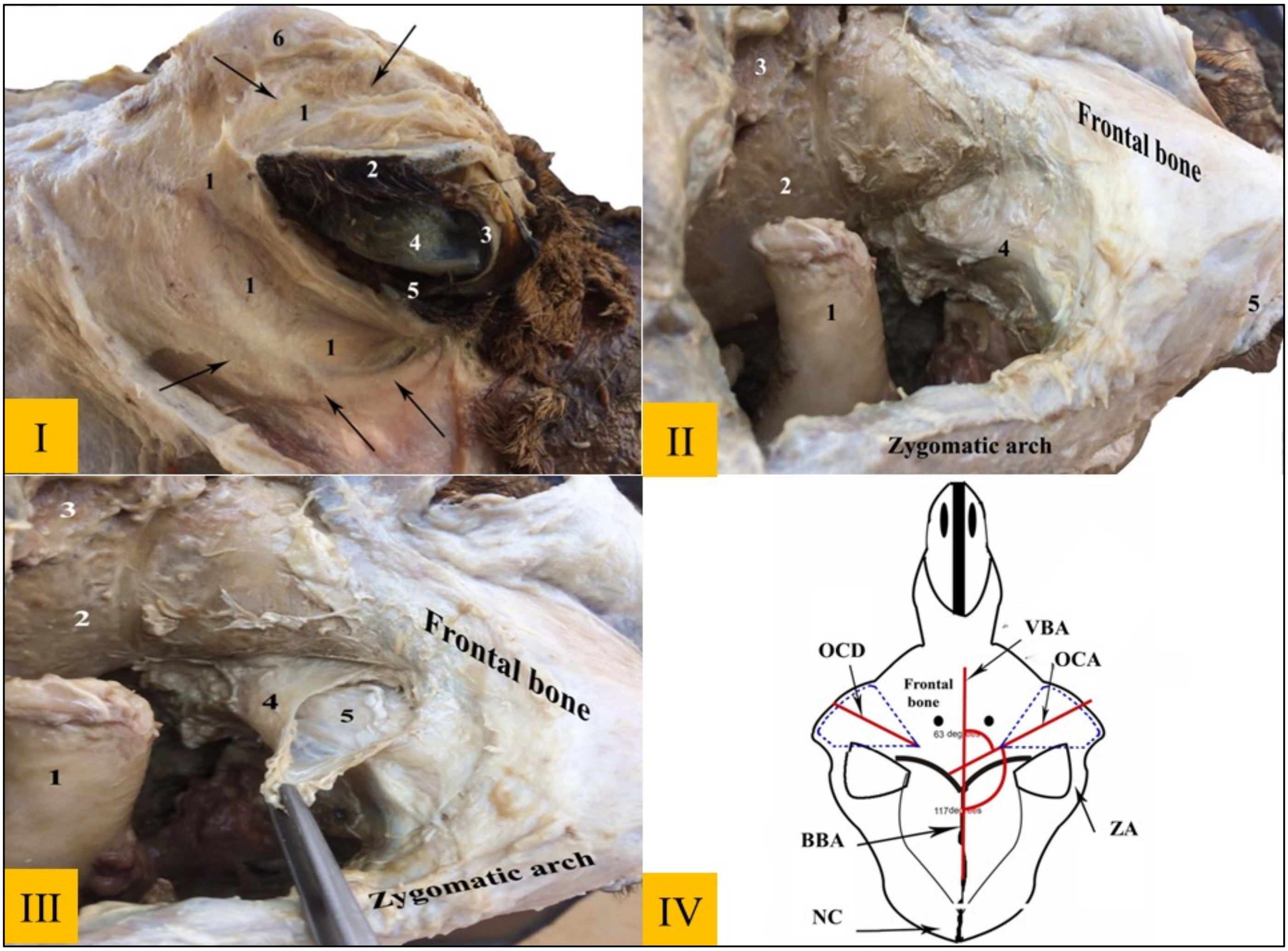

Figure 3: I) A photograph showing the entrance of the right orbital cavity. 1) orbital septum, 2) upper eyelid, 3) third eyelid, 4) cornea, and 5) lower eyelid. The black arrows indicate the orbital rim. II) a deep dissection of the right tempro-orbital fossa, dorsal view. (The periorbital fat removed). 1) coronoid process of the mandible, 2) parietal bone, 3) temporalis muscle (cut), 4) periorbital layer of the orbital fascia, and 5) upper eyelid. III) a photograph showing the right tempro-orbital fossa (deep dissection), dorsal view. (The periorbital fat removed). 1) coronoid process of the mandible, 2) parietal bone, 3) temporalis muscle (cut), 4) periorbital layer of the orbital fascia, and 5) collateral layer of the orbital fascia. IV) a diagram showing the skull of camel (dorsal view). NC) nuchal crest, BBA) basi-sphenoid bone axis, ZA) zygomatic arch, OCA) orbital cavity axis, OCD) orbital cavity depth, VBA) vomor bone axis

orbital cavity spans laterally from the orbital rim to the optic foramen medially, remaining entirely concealed ventrally by the frontal bone, sinus, and the zygomaticofrontal process. The circular perimeter of the orbital rim measures approximately (17±0.4 cm), and the depth of the orbital cavity to the optic foramen ranges from (8.7-9 cm). This cavity houses the eyeball along with its associated structures, including the lacrimal gland, eyelids, and periorbita. The periorbita, serving as the orbital fasciae and spaces, plays a crucial role in fixing and covering the eyeball and its accessories in their anatomical positions.

Comprising three superimposed layers – external periorbital, middle collateral, and internal muscular – along with orbital spaces between them, the periorbita is a key component of the orbital anatomy. The external periorbital layer takes the form of a thicker, cone-shaped capsule closely adhering to the periosteum of the orbital cavity. Caudally, it is associated with periorbital fat. Externally, the base of the cone is affixed to the orbital rim, where it reflects and inserts into the substance of the eyelids, creating the orbital septum. The apex of the cone attaches internally to the optic foramen. The longitudinal axis of the periorbital sac forms an acute angle of about (63-65 degrees) with the axis of the vomer process and approximately (117-115 degrees) with that of the basisphenoid. This detailed account provides a comprehensive understanding of the dimensions, structures, and relationships within the orbital cavity and its associated fascial components. Findings illustrated in Figure 3.

Internally, the periorbital fascia envelops the periorbital space, creating a boundary around the collateral orbital fascia. The collateral orbital fascia is thinner compared to the external fascia and encompasses the middle orbital space, extending from the sclera to the apex of the orbital cavity. The muscular coat of the eyeball (Figure 4) is composed of extraocular muscles, which encircle the eye

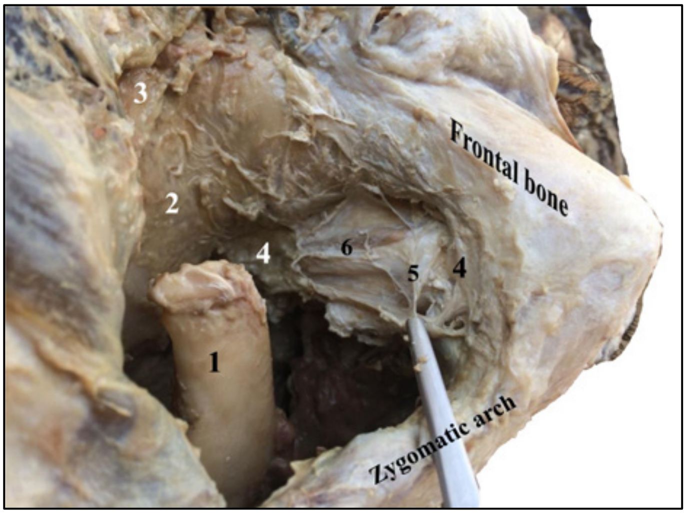

Figure 4: A photograph showing the right tempro-orbital fossa (Deep dissection), dorsal view. (The periorbital fat removed). 1) coronoid process of the mandible, 2) parietal bone, 3) temporalis muscle (cut), 4) periorbital layer of the orbital fascia, 5) collateral layer of the orbital fascia, and 6) muscular layer of the orbital fascia

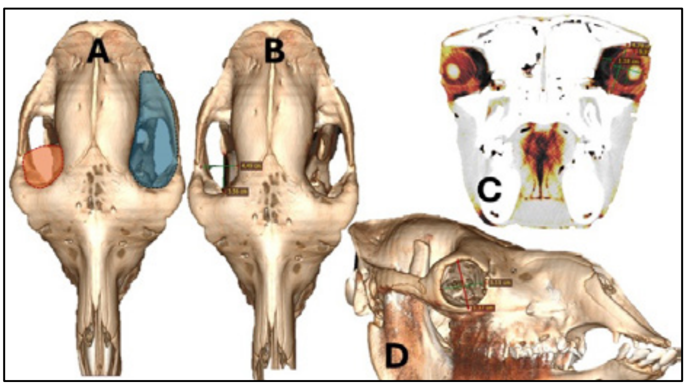

Figure 5: Showing the computed tomographic findings. A) dorsal view of the skull of camel, the orange shaded area is the orbital fossa, blue shaded area is the tempro-orbital fossa. B) dorsal view showing the dimensions of the orbital cavity. C) a slice shoeing the dimensions of the orbital cavity to that of the eye. D) lateral view showing the orbital cavity dimensions

from the rostral aspect of the sclera to the caudal extent of the optic foramen. These muscles are organized into two layers: the outer layer, which includes the recti and oblique muscles, and the inner layer closely adhering to the sclera and the optic nerve caudally. The space between these layers is termed the internal orbital space. Given the anatomical configuration of the orbital and temporo-parietal regions, it is noteworthy that surgical access to the orbital and supraorbital cavities is advantageous through the tempro-orbital fossa. Surgical interventions are indicated for a variety of vital structures, whether located in the temporo-parietal fossa or the orbital cavity. This observation underscores the clinical relevance of understanding the anatomical intricacies of these regions for precise and effective surgical procedures.

Computed tomographic findings

Computed tomographic imaging provided clear visualizations of the temporo-orbital fossa, allowing for precise measurements of the orbital fossa (Figure 5-A and B). Ocular dimensions were accurately documented and subsequently compared to those of the orbital cavity (Figure 5-C). Additionally, measurements of the orbital cavity, obtained from a lateral view, were compared with those of the supraorbital fossa (Figure 5-D). The temporal fossa in camel is extensively large and extended rostrally as orbital fossa. The mean diameter of the orbital fossa was 4.04 cm. While the mean diameter of the orbit rim was 5.24 cm. The mean diameter of the eyeball was 3.32 cm, and the mean diameter of the deep orbital cavity was 4.62 cm. The mean retrobulbar area diameter was 2.98 cm.

Discussion

The current study investigated the anatomic and computed tomographic imaging findings of the temporo-orbital region of the camel with special reference to the orbital cavity. Previous CT studies were conducted to study the paranasal sinuses in buffalos (20), head cavities in donkey (21), anatomical description of Ossimi sheep (22), and anatomy of the head of the one humped camel (23). Results of the current study were in agreement with El Allali, Achaâban (3) and Elsafy et. al., (23). The orbital fossa was large depression with a mean diameter of 4.04 cm bordered caudally with the coronoid process of the mandible, parietal bone medially and bounded by the orbital process of the frontal bone rostrally and zygomatic process laterally as mentioned in previous reports (3, 4, 23). The extensive size of the orbital fossa in camels provides a circular ceiling to the orbital cavity. The orbital fossa is covered by a dense connective tissue fascia and outer skin. There were no large blood vessels or nerves transversing this area. That makes the surgical incision applicable without essential precautions. Following the creation of a skin flap in the orbital fossa, a significantly large periorbital fat body is revealed. This fat serves as a protective cushion for the globe, easing its movements within the orbit (24). The vascularized fat requires ligation before excision to minimize bleeding. Following removal, the orbital cavity is distinctly exposed, with the Tenon's capsule clearly visible. This observation signifies the capability to access the periorbital area for the removal of extraocular lesions (10). Dissecting the Tenon's capsule reveals the extraocular muscular cone. This finding indicates ability for the correction of eye position. Through this approach, the surgeon can manipulate the eyeball both anteriorly and posteriorly. Additionally, the surgeon can readily dissect the posterior attachment of the ocular cone from the bony orbit without applying traction to the eyeball, that safeguards the optic chiasm from trauma, preventing further inflammation or blindness (25). Following the extraction of the eyeball and associated ocular structures through dissection from the bulbar conjunctiva, the bony orbital cavity becomes fully visible, with the eyelids preserved intact. This finding allows the surgeon to easily apply an orbital prosthesis within the orbital cavity or fill the space with an appropriate sterile filler and facilitate drainage post-surgical procedures. The resulting advantages encompass enhanced healing, diminished infection and inflammation, and improved cosmetic outcomes, all of which are indicative of successful ocular surgeries (25-27). The computed tomographic findings disclosed comparable diameters of the orbit and supraorbital entrance, with a mean diameter approximately 1.2 units less than that of the orbit. This finding reinforces the viability of utilizing the supraorbital window for procedures through the orbital cavity. A continuous study is examining the experimental and clinical application of the described approach for eye enucleation and orbital prosthesis placement. Further investigations are required to assess both short-term and long-term complications associated with this approach.

Conclusion

The supraorbital fossa in camel serves as a secure surgical entrance to the orbital cavity, facilitating various procedures on the periorbital, extraocular, and ocular regions with minimized complications and improved cosmetic outcomes.

Acknowledgements

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Računalniška tomografija in grobe anatomske študije temporomandibularnega in supraorbitalnega področja enogrbe kamele (*Camelus dromedarius*)

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Izvleček: Cilj študije je bil raziskati podrobno kirurško anatomijo temporomandibularnega in supraorbitalnega področja pri kamelah z anatomsko disekcijo in računalniško tomografijo (CT). Namen študije je bil zagotoviti natančne anatomske opise in oceniti izvedljivost kirurških posegov v očesni votlini prek očesne jame. Iz fakultetne secirnice in lokalne klavnice smo pridobili dvanajst kameljih lobanj in tri sveže kadavrske glave. Skrbno smo pregledali opisno anatomijo lobanje in kirurško anatomijo temporo-orbitalne regije. Poleg tega smo opravili računalniško tomografijo glav, da bi se povečal nabor podatkov. Rezultate smo sistematično dokumentirali za oceno uporabnosti, izvedljivosti in varnosti pristopa v očesno votlino iz očesne jame. Ugotovili smo, da je senčnična jama kamele precej velika in se razteza rostralno do obsežne očesne jame. Zunanja stena očesne jame je sestavljena iz kože in pod njo ležeče debele fascije. Pri tem nismo ugotovili pomembnih mišic ali vitalnih struktur. V zadnjem delu očnice se je nahajala obsežna orbitalna maščobna masa, po njeni odstranitvi pa smo dosegli jasen in varen vizualni dostop do očesnih struktur, kar je olajšalo pristop. Pristop iz očesne jame je izvedljiv in varen ter omogoča izvajanje različnih kirurških posegov, vključno z enukleacijo, eksenteracijo, odstranitvijo periorbitalnega tumorja, implantacijo proteze in drugimi posegi. Ta pristop obeta boljše estetske rezultate pri izvajanju takšnih posegov.

Ključne besede: enukleacija; kamela; kirurgija orbite; senčna jama