Ultrasound and Anatomical Study of the Auricular Cartilages of Camel (*Camelus dromedarius*) Referring to its Surgical Applications in Cosmetic Operations

Allouch G., Al-Hawas A.

Department of Veterinary Medicine, Faculty of Agriculture and Veterinary Medicine, Qassim University, Kingdom of Saudi Arabia.

Abstract

The aim of this study was to describe the anatomical structure of the pinna cartilages as well as to determine and test the importance of high-frequency ultrasound in the measurement of layer-thickness of auricles that known as the base information of surgical applications. Twelve heads of apparently healthy camels, 1-4 years old, were used in this study. The study showed that the pinna consists of a thin lamina of elastic cartilage covered with skin and hair. It is supported by three cartilages namely auricular, scutiform and annular cartilages connected to the skull. They are propped up by ligaments. Moreover, the study reviewed the normal auricular cartilage of the external ear appearance and dimensions. Also, the results of the research showed nerve supply of the cartilages from the cranial and caudal auricular branches of the auriculo-temporal nerve. While the blood supply of the cartilages by two arteries; the caudal and rostral auricular arteries. Also, the results showed ultrasound imaging of the normal auricular cartilage and its true dimensions. This study pointe to the importance of surgical application of the auricular cartilage as a result of its exposure to many injuries and wounds, especially the shearing with a view to cosmetology. Also, the results showed ultrasound imaging of the normal auricular cartilage and its true dimensions. The purpose of this work get detailed information of the cartilages of the ear in camel with an indication of their surgical applications.

Key words: Anatomical External ear, Camels, cartilage, surgical applications.

1. Introduction

The ear is considered a sensory hearing organ responsible for hearing and equilibrium. Moreover, it also gathers sound waves together to the external acoustic meatus, which conveys these waves to the tympanic membrane [1]. Pinna skin is thin and exactly attached to the periosteum of the cartilage [2].

The anatomical researches of the cartilages of the external ear was scarce in the domestic animals, especially the camel. Few veterinary researchers and human ear specialist described the anatomical features of the cartilages of the external ear in camel [3,4], in buffalo and cattle [5], in buffalo and bovine [6], in cattle [7], in horse [8] in domestic animals [9,10,11]. They mentioned that cartilages of the external ear were composed of three cartilages; auricular, scutiform and annular cartilage except in dogs which is composed of only two cartilages, auricular and annular cartilages [12]. The shape of the ear is designed by the auricular cartilage in most domestic animals, which gives it permanent hardness [13]. The pinna has many appearances that make it particularly evaluable by ultrasound [14]. Some animals such as sheep may be a useful model for surgical training in some external and
middle ears in humans and sheep [15,16] in humans and pig [17].

2. Materials and methods

Twelve healthy camel’s heads of both sexes and different ages (1-4 years) were used in this study. They were obtained from the Buraidah slaughterhouse, Qassim region, and the Veterinary Teaching Hospital, Qassim University, KSA. Eight heads were preserved in 10% formalin solution, and then were washed by water consequently.

These heads were dissected to investigate morphological anatomical study of the cartilages, ligament, blood and nerve supply as well as the measurement of the auricle.

The measurements of the auricular cartilage were performed as follows: The length of the head is the distance extension between the top of a noose to the nickel crest. The length of the auricle is the distance between the annular ligament to the top of the auricular cartilage. The diameter of the pinna was the distance between its two borders. The distance between the two pinna on the parietal bone according to the midline. The nomenclature used was adoptive by [19].

Ultrasonography Technique

To confirm the normal sonography of ear pinna, of four camel’s heads (female and male) were studied. The sonography apparatus used was Eickemeyer, MAGIC P1 attached with prop convex, Frequency range (MAGIC P1): 2.5-5 MHz extended field-of-view software was used to acquire images of the whole pinna length and thickness. A great quantity of water was used in the camel ear to allow the typical image of the pinna. A piece of cotton inside the pinna was used during the examination to prevent the entrance of the water. Longitudinal, and extended field-of-view images were obtained.

Measurements of the camel were taken to establish the thickness of the cartilage in millimeters at the middle of the antihelix in the longitudinal axis, and measurements of the lobule in millimeters were taken from the dorsal to the ventral aspects of the epidermal layer in the longitudinal axis.

3. Results

The anatomy of the external ear cartilages in the camel includes; the pinna (auricle) which is the externally and three cartilages as well as the arteries and nerves supply.

The auricle or pinna (Figure 1) is a cartilage projection from two sides of the caudal part of the head, with its large end-directed dorsolateral. It is reinforced by a number of cartilages of different shape and location. It consists of a thin lamina of elastic cartilage covered with skin containing hair.

The skin is thin and closely attached to the auricular cartilage with hair, closely attached and connected to the parts surrounding the muscles and the beginning of the external acoustic meatus. The auricle is funnel slanted laterally, the middle part is wider than the apex and distal part. It has two borders and two surfaces.

The two borders are lateral and medial, the medial border is larger than the lateral one and convex along its extension, while the lateral border is convex proximally and concave distally, while the two surfaces are caudal and rostral.

The caudal surface of the pinna is convex and smooth with little hair, while the rostral surface is concave, covered by hair and presents simple prominent longitudinal ridges called antihelix ridges. Depressions are not as complex as human as well as the antihelix fosses (Figure 1), the fosses approach at the ear opening forms the auricular conchae. So the antihelix is described as curved around a deep capacious cavity forming the concha. Near the concha and in the distal part of the auricle forms the tragus, which is spherical bump small that partially covers the ear hole that demarcates the lateral margin of the opening of the ear canal. It is separated from pinna by cranial and caudal intertragic incisures.

Figure 1: A photograph shows auricle (pinna) and its parts in camel.

The Cartilages of the ear:
The external ear has three cartilages that comprise of:
**The auricular cartilage** (Figures 2,3,5,6,7,8,10,11):

It is the outer portion of the ear. It identifies the shape of the ear, which is funnel-shaped. It composes of a single piece and supports the external ear. It is connected with the skull by annular cartilage through the auricle.

It has two borders and two surfaces: The two borders are lateral and medial, the medial border is larger than the lateral one and convex along its extension, while the lateral border is convex proximally and concave distally. The two surfaces are caudal and rostral.

The caudal surface is convex, while the rostral surface is concave, and presents simple prominent longitudinal ridges called antihelix ridges and depressions are antihelix fosses (Figure 1). The distal part of the auricle forming the tragus is spherical small bump that partially covers the ear hole.

![Figure 2: A photograph shows auricular cartilage (A.c) in camel.](image)

**The scutiform cartilage** (Figures 3,11):

It has a disc shape located on the skull in the temporal region in connection with the ear and temporal muscles. Cranially to the auricular cartilage, it has two facets; superficial and deep. The superficial facet is somewhat convex from side to side while the deep one is concave. The cranial border is thin and rounded; however, the caudal border is wider and thicker. Its medial angle is prolonging by appointed process of about 0.5 cm in length. It is covered with some rostral muscles of the ear.

![Figure 3: A photograph shows auricular cartilage (A.c) and scutiform cartilages (S.c) in camel.](image)

**The annular cartilage** (Figures 4,9):

It lies at the lower part of the auricular cartilage. It has a round shape like a ring. It is united medially by elastic tissue and rolled into a short tube, with a diameter of about 1 cm. It consists of two curare; left and right crus. It contacts the distal extremity of the auricular cartilage and contributes a cartilaginous part forming of the entrance of the external acoustic meatus. Furthermore, it surrounds the external acoustic meatus.

The results also showed that the average thickness of normal auricular cartilage was 0.4, the sub cutis and cartilage layer was 0.8 mm thick. The average thickness of the auricular cartilage in the camel's ear was 3 ± 1 mm (range, 2.5-3.5 mm).

![Figure 4: A photograph shows annular cartilage in camel.](image)

Concerning the applied anatomy of the auricular cartilage, the auricular cartilage is liable for many diseases and injuries turn to require treatment. The sonography is considered basic for the inference of diseases to distinguish between persuasion, vascular lesions, and tumors.

The length and thickness of the auricle cartilage are essential for cosmetic cheating (shearing), especially in the top of auricular cartilage in camels that increase the animal's beauty.

The ratio between the length of the ear and the length of the head was, for example, 1/8 in all cases.
The results showed that the relationship between the head length to ear length ratio was almost constant. Also, the relationship between both the length and the width of the ear was almost constant. The width of the ear was about 1/2 lengths in most of the studied specimens.

The auricular cartilages of the external ear derive the nerve supply (Figure 12) from the cranial auricular branch and a caudal auricular branch from auricular-temporal nerve from the facial nerve. The cartilages received the blood supply by two arteries; the caudal and rostral auricular arteries (Figure 13).

The caudal auricular artery origins from the external carotid artery directly, while the rostral auricular artery arises from the superficial temporal which emerges from the external carotid artery. The caudal auricular artery branches into three arteries on the convex surface of the auricle, the medial, intermediate and lateral auricular branches supply the caudal surface of the auricle, while the venous drainage of the ear occurs by the caudal auricular vein that comes from the external carotid vein. It drains lateral auricular, intermediate auricular and medial auricular veins.

Figure 5: Longitudinal ultrasonography image of the normal pinna showing the skin layers and auricular cartilage of camel.

Figure 6: Longitudinal ultrasonography image of the middle part of normal pinna of camel showing the skin layers and auricular cartilage.

Figure 8: Longitudinal ultrasonography image showing the normal caudal part of the auricular cartilage of camel.

Figure 9: Longitudinal ultrasonographic image showing normal of the annular cartilage of camel.

Figure 10: A photograph shows the position of the shearing of the auricular cartilage (A.c) of camel.
Figure 11: A photograph shows auricular cartilage (A.c) and scutiform cartilage (S.c) after dissection in camel.

Figure 12: A photograph shows the nerves supply of the cartilages of the camel ear; Auricular temporal nerve (Au.t.N), Cranial auricular branch (Cr.A.b) and Caudal auricular branch (Cd.A.b).

Figure 13: A photograph shows the blood supply of the cartilages of the camel ear; Caudal auricular artery (Cd.A.A), Medial auricular branch (Med.A.b), Intermediate auricular branch (Inter.A.b), Lateral auricular branch (Lat.A.b).

Figure 14: A diagram showing the relationship between the ear and head lengths in camel.

Figure 15: A diagram showing the relationship between ear length and width in camel.

Knowing the scales of the length, width and thickness of the auricular cartilage can have an indication of the consistency of the length and width of the ear with the head sizes to be considered as a sign of camel beauty, and this relates to a type of strain that often has the highest degrees of beauty, especially in camel festivals.
Table 1: The following table shows the relationship between the lengths of the head and the ratio between them, as well as the distance between the two ears and the thickness of the auricular cartilage in the camels.

<table>
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<th>Number of specimens</th>
<th>Length cm</th>
<th>Width cm</th>
<th>Length of head/cm</th>
<th>Relation bet. the length of the head and ear/cm</th>
<th>The distance between the ears/cm</th>
<th>Thickness of auricular cartilage m/m</th>
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4. Discussion

The gross anatomy of cartilages of the external ear of the dromedary camel was nearly similar to the other domestic animals. In this study, the external ear consisted of the pinna including the auricular cartilage (external cartilage), internal cartilage (The scutiform cartilage and the annular cartilage).

The pinna was supported by two cartilages, the scutiform and annular cartilages. It was flattened sheets of elastic cartilage in domestic animals [18]. Moreover, it was a wonderfully diverse structure with breed-related differences in shape and conformation in the canine [21].

The current results concerning the description of the auricular cartilage in agreement with those of [4] in camel, [6,7], in domestic animals and [18] in buffalo and cattle. Moreover, our results were different than that of dogs which contain two cartilages, the auricular and annular only [12].

The auricular cartilage designates the shape of the ear as a funnel. A similar finding was observed in buffalo and cattle [18], in cattle sheep and deer.
[22]. They recorded that the basal part of the auricular cartilage was coiled to form a tube, which enclosed the cavity of the concha.

The shape of the auricle is determined by supporting the auricular cartilage in most domestic animals, this is sufficiently stiff to keep the auricle erect at all times [15]. The auricular cartilage was flattened and sheet of elastic cartilage in pet animals [6,7] while the structure diverse with strains differences in shape, size, and Morphology in dogs [19].

Concerning the scutiform and annular cartilage, this study observed that the scutiform was disc shape lamina while the annular cartilage was circular, like a ring, and united medially by elastic tissue. It formed the cartilaginous part at the distal part of the auricular cartilage. Our results agreed with those of [4] in camel, in domestic animals [6,8], in buffalo and cattle [18], in cattle sheep and deer [22]. In camel which observed the scutiform cartilage was a diamond plate, triangular plate of cattle and buffalo [23,24].

The annular cartilage was quadrilateral plate carved to form about three-fours of a ring and united by elastic tissue and rolled into a short tube. Moreover; The presence of scutiform cartilage was not reported in dogs [12].

In this work, we found the cartilages of the external ear derived the nerves supply from the cranial auricular and caudal auricular branches. The blood supply was given by caudal auricular and rostral auricular arteries coming from the superficial temporal arising from the external carotid artery. Similar finding was observed in camel [4], in domestic animals [7], in human [9,10], in bovine [17], in cattle and buffalo, in horse [18]. Whilst their results disagree with those of [1] that reported, the skin of the ear canal is innervated by four cranial nerves: the trigeminal; the facial; the glossopharyngeal; and the vagus nerves. Arrangement of the nerves and blood vessels in conjunction with the ridges on the rostral surface was observed [22]. The spaces between the ridges were relatively free of larger blood vessels, nerves and hair.in cattle, sheep, and deer. The vertical ramus of the mandible in equine was described [27], whereas; the caudal auricular artery was not described. Except for small arteries supply, the cranial surface of the auricular cartilage in a rabbit, pig, and cattle was used for many years in the tissue engineering of human auricular cartilage [28,29]. According to the ultrasound and the applied anatomy of the auricular cartilage of the external ear, the pinna has many features that render amenable for evaluation to injuries and treatment [14]. This study confirmed that auricular cartilage was an important surgical land.

Our results showed the distance between the ears was age-dependent. In large camels, it is up to approximately 10 cm, while in camel calves was only 4 cm. This explains the growth of parietal and temporal bones in large camels than in camel calves where these bones were small and cartilaginous [26] that maintained the two parietal bones that arise from two primary ossification centers for each bone, which appear at the parietal eminence. Ossification progresses radially from the central focus toward the periphery of the bone. Nonetheless, at term, the parietal bones are relatively broad, particularly in the Prieto-temporal region [26,27].

Any cut of one or both of the ears, to beautify the animal will change the proportions obtained, especially in some breeds that are characterized by long ears from the level of the head, in contrast to the strains studied.

The ear-shearing process close to the top of the auricular cartilage does not cause any bleeding or pain to the animal or any complications because this area lacks blood and nerves supply.

Concerning the shearing operations, our result agreed with those of [28,32] that reported cartilage wound healing was a tentative balance between deposition of type I collagen in the form of cartilage and repair by expression of type I collagen. Small full-thick cartilage defects are replaced by fibrocartilage.

These results demonstrated an approximation of the thicknesses of the different layers of reconstructed and natural external ears [29]. On the other hand, the cartilage formation makes the sonography diagnostic without the necessity of using intravenous contrast agents that can play an advantage over magnetic resonance imaging [14]. The 20-MHz B-Mode ultrasound was suitable for the evaluation of the methods of plastic surgery in malformed auricles. This results are consistent with those of [29]. The ultrasound image analysis allows non-invasive follow-up of inflammatory skin diseases, like atopic dermatitis, psoriasis and may be used for monitoring the effectiveness of therapy in skin lymphomas and sclerotic skin diseases [30,31].
Finally, the gross anatomy of the cartilage of the external ear helps in increasing the scientific knowledge of the shape and structure of the ear. Ultrasound of the ear is a valuable complement method of examination of the ear of camels that can be easily readied in the field.

Besides, ultrasonography provides information about the condition of the auricular cartilage (shearing case) and could be used as a reference for more searches concerning ear injuries in camels.

**Conclusion**

The findings of the current study showed detailed information on the anatomical features of the external ear of camel using gross anatomy and blood and nerves supply. Ultrasonography findings allow practical application of auricular cartilage in injuries diagnosis. Such findings are essential in the subject-shearing ear of camels.

**Authors contributions** G. A. (Syria) planned and conceived the search. The data. G. A. (Syri), interpreted the results and designed the figures. Wrote the manuscript. The author read and approved the final manuscript.

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**Competing interests**

The authors declare that it has no financial or personal relationships, which may have inappropriately influenced them in writing this article.

**References**


