Anatomical study of the external ear muscles of the camel with special reference to the external acoustic meatus and the blood and nerve supply

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Abstract
The purpose of this study was to describe the muscle anatomy of the external ear. Twelve head clinically healthy camels, 1-4 years old, were used in this study. They obtained from the Buraidah slaughterhouse. The study revealed that many ear muscles, which were responsible for the movement of the ear. These muscles distributed as dorsal, ventral, rostral and caudal muscles. The current study presented the external acoustic meatus, which has two parts cartilaginous, and osseous parts and it is covered with skin. The study indicated an external acoustic canal. The canal was long and oblique in camel; It prevents the rapid spread of epidemics, infections and the wounds or lesions of the tympanic membrane. As well as this study showed the external ear derived the nerves supply from the cranial auricular branch and caudal auricular branch. While the blood supply was given by caudal auricular and the rostral auricular arteries.

Key words: Muscles, ears, camels, blood and nerve supply.

1. Introduction
The ear is considered as a sensory organ with distinction and responsible hear and equilibrium. It also acts for the collection of sound waves together with the external acoustic meatus, which conveys these waves to the tympanic membrane [1]. The anatomical study of the external ear was little researched among the domestic animals especially in camel, some authors mentioned the anatomical features of the muscles of ear, Smut [2,3] in camel [4] in bovine, [5] in Buffalo, and [6] in cattle and buffalo [7] in horse and [8,9,10] in domestic animals.

The knowledge anatomy about the auricular muscles and the external acoustic meatus can help in understanding in sheep may be a useful model for surgical training and experimentation in some external and middle ear [11,12] in human and sheep and [13] in human in pig. The shape of the ear is designed by the auricular cartilage in most domestic animals; this is sufficiently stiff to keep the auricle standing permanently [14]. Many of ear muscles is responsible for the movement of the ear these muscles attach the base of the auricle to the bones of the skull adjacent of the ear, these muscles were described in groups according to their position [2,3] in camel [4] in bovine, [6] in cattle and buffalo, [7] in horse and [8,9,10] in domestic animals.

2. Materials and Methods
Twelve head camels of both sexes and different ages from (1-4 years) were used for this study. They were obtained from the Buraidah slaughterhouse, Qassim Region, KSA and used in this study. Ten heads were preserved in 10 % formalin solution, then they were washed by water consequently, these heads were dissected to investigate morphological anatomical study of the auricle including the muscles, cartilage, and ligament, blood, and nerve supply as well measurement the auricle. Two heads were prepared in the normal methods (boiling with 30% NaOH, soaking, drying, immersing in hydrogen peroxide
To describe the shape, dimension of the external acoustic meatus, the measurements of external acoustic meatus were done as following: length of meatus is distance between annular ligament to the internal acoustic meatus, diameter of external acoustic meatus is distance between the two lateral borders of attachment with depth of external acoustic meatus. The nomenclature used was adopted by [16].

3. Results

The anatomy of the external ear of camel include; the pinna (auricle) which is the outer, three cartilages and four sets of muscles, the external acoustic meatus, and the tympanic membrane. The study revealed that many ear muscles, which were responsible for the movement of the ear. These muscles classified into four groups of muscles; rostral, dorsal, ventral and caudal. These muscles are responsible for moving the ears; the camel as like the animals can move of their ears, on the contrary of the human.

A- Musculi auricularis rostrales contains:

1- **Musculus Scutuloauricularis Superficialis (Figures 1,3):** The superficial scutuloauricular muscle is almost circular. It origins from the dorsal face of the scutiform cartilage. It is partly covered by interscutolaris. It covers the most dorsal aspect of the scutulum without its some area, especially in its cranial border. It extends from the caudal border to rostral border of the cartilage and run caudally to attach to the concha and inserted in distal part of the auricular cartilage.

2- **Musculus Scutuloauricularis Profundus (Figure 2):** The deep scutuloauricular muscle is similar to the previous muscle in shape. It origins from the deep surface of the scutiform cartilage. It places on the deep surface of the scutulum. It is well developed and has a circular shape. Its fibers run caudally to insert in the craniodental part of the auricular cartilage.

3- **Musculus Frontoscutularis (Figures 1, 3, 6):** The frontoscutular muscle has a trapezoidal shape with its smaller base located rostrally. It has two parts: cranial part is frontal and caudal part is temporal) which are arising from the zygomatic process of the frontal bone and temporal line and inserted in the rostral border of the scutiform cartilage.

4- **Musculus Zygomatic auricularis (Figures 1, 3, 6):** The zygomatic auricular muscle has a rectangular shape. It arises from the zygomatic arch directly to the rostolateral border of the scutiform cartilage. It extends on the zygomatic bone, it fuses partially to the scutuloauricularis superficialis ventrally, and inserts in the lateral border of the auricular cartilage.

5- **Musculus Zygomaticoscutularis (Figures 1, 3, 6):** The zygomaticoscutular muscle. It is located ventrally to the zygomatic auricular muscle. It has a triangular shape. It’s compared to the previous two muscles. It arises from the base of the zygomatic process of the frontal bone to insert on the rostral border of the scutiform cartilage.

B- Musculi auricularis dorsalis consists of:

1- **Musculus interscutularis (Figures 4,8):** The interscutular muscle locates on the parietal bone. It is a thick, elongated muscle. It connects right and left scutiform cartilages that arise from the base of the auricular cartilage, and inserts in the external sagittal crest and temporal line.

2- **Musculus cervicoscutularis (Figure 4):** The cervicoscutular muscle takes specially shaped, triangle with a hypotenuse in the form of arch. It arises from the base of the occipital bone and is inserted in the sagittal crest and temporal line.

3- **Musculus Scutoauricularis dorsalis (Figures 5,6):** The dorsal scutoauricular muscle extends from the scutiform cartilage to inserted in rostolateral on auricle.

4- **Musculus Scutoauricularis medius (Figures 5,6):** The middle scutoauricular muscle extends from the scutiform cartilage to inserted in the middle of the distal part of auricle. These muscles attach the scutiform cartilage to the auricular cartilage.
Figure 1: A photograph shows the rostral muscles of the ear in camel; superficial scutuloauricular muscle (s sa.m), frontoscutular muscle (f s.m), zygomaticoauricular muscle (z a.m) and zygomaticoscutular muscle (z s.m).

Figure 2: A photograph shows deep scutuloauricular muscle (sa p.m) and temporal muscle (t.m).

Figure 3: A photograph shows the rostral muscles of the ear in camel; superficial scutuloauricular muscle (s sa.m), frontoscutular muscle (f s.m), zygomaticoauricular muscle (z a.m), zygomaticoscutular muscle (z s.m) and auricular cartilage (a.c).

Figure 4: A photograph shows the interscutolar muscle (In s.m) and the cervicoscutolar muscle (ce s.m). Auricle cartilage (a c) and scutiform cartilage (sc).

Figure 5: A photograph shows dorsal scutoauricular muscle (d sa.m), middle scutoauricular muscle (m sa.m) and auricle cartilage (a c).

Figure 6: A photograph shows the rostral and dorsal muscles of the ear in camel; superficial scutuloauricular muscle (s sa.m), frontoscutular muscle (f s.m), zygomaticoauricular muscle (z a.m), zygomaticoscutular muscle (z s.m), dorsal scutoauricular muscle (d sa.m), middle scutoauricular muscle (m sa.m) and auricular cartilage (a.c).
C- Musculi auricularis ventrals comprises:

1- Musculus Parotidoauricularis (Figure 7): The Parotidoauricular muscle is superficial muscle. It covers the lateral surface of the parotid gland. It is narrow and thin in a ribbon-like muscle. It originates from the ventral part of the parotid fascia and passes dorsally to insert to ventrolateral on the base of the auricular cartilage.

D- Musculi auricularis caudals:
Theses muscles are very developed and clear. They pull the scutulum caudally.

1- Musculus cervicoauricularis superficialis (Figure 8): The superficial (superior) cervicoauricular muscle is thin and has a rectangular shape. This muscle extends from the dorsal part of the neck nearly the auricle, which arises from the Atlanta fascia near appendicular part of the nuchal ligament. It locates superficially to the other caudal muscles of the external ear. It inserts in the distal part of the caudal surface of the auricular cartilage

2- Musculus cervicoauricularis medius (Figure 8): The middle cervicoauricular muscle has a spindle shape with clear muscle belly. It fuses with deep cervicoauricular muscle at the origin. It originates from the atlantal fascia near the appendicular part of the nuchal ligament ventral to the superficial cervicoauricular muscle. It locates between superficial cervicoauricular muscle and deep cervicoauricular muscle. It inserts below the superficial cervicoauricular muscle at the level of the previous muscle in the distal part of the caudal surface of the auricular cartilage

3- Musculus cervicoauricularis profundus (Figure 8): The deep (inferior) cervicoauricular muscle arises from the atlantal fascia near the appendicular part of the nuchal ligament ventral to the middle cervicoauricular muscle. It locates below the middle cervicoauricular muscle. It inserts below the middle cervicoauricular muscle in the distal part of the caudal surface of the auricular cartilage.

The ligament auricularia (Figure 9):
They connect the auricle to the side of the head. It is the external and annular ligaments. The annular ligament wraps around the distal part of the auricle to the root of the zygomatic process of the temporal bone forming ring around the concha. While the other ligaments connect the auricle o the side of the head.

Meatus caustic externa (Figure 10):
The external acoustic meatus is the passage which extends from the floor of the auricle to the tympanic membrane. It directs ventrally and then rostromedially. It is supported by the rolled-up part of the annular cartilage. It forms the tube beginning from the external ear opening at the to the tympanic membrane. It has two parts; the cartilaginous and the osseous part. The cartilaginous part is the outside of the canal wall. It consists of cartilage, it is covered by hair. While the osseous part is the inner part of the wall, it consists of bone. It is formed by the petrous portion of the temporal bone and leads to the tympanic membrane. This part separates the external ear from the middle ear. The external acoustic meatus is oval and has a large oval opening caudal located to the zygomatic arch. Its average length it's about 4 cm, and its diameter is 0.8 cm respectively. The meatus are related laterally and ventrally to the parotid gland and the facial nerve which crosses on the ventral surface of a caustic meatus deeply to the parotid gland. It covers the proximal of the vertical portion of the external a caustic meatus.

Figure 7: A photograph shows the parotidoauricular muscle (pa.m) and auricle (a).
branch and caudal auricular branch given by auriculotemporal nerve from the facial nerve as well as some cutaneous auricular branches given by the vagus nerve to the skin of external acoustic meatus.

The blood supplying of the external ear muscles given by two arteries; the caudal and rostral auricular arteries. The caudal auricular artery arises from the external carotid artery directly, while the rostral auricular artery emerges from the superficial temporal which arises from the external carotid artery. The caudal auricular artery gives off three arteries on the convex surface of the auricle, the medial, intermediate and lateral auricle branches supply the caudal surface of the auricle. While the veins draining of the ear from the caudal auricular vein comes from the external carotid vein. It drains lateral auricular, intermediate auricular vein and medial auricular vein. While the rostral auricular vein drains the superficial temporal vein.

**The Nerve and Blood supply of the ear in camel (Figures 11,12):**

The external ear and auricular muscles derive the nerves supplying from the cranial auricular

Figure 8: A photograph shows the caudal auricular muscles presented by superficial cervicoauricular muscle (s ce a.m), middle cervicoauricular muscle (m ce a.m), deep cervicoauricular muscle (d ce a.m), interscutolar muscle (in s.m) and auricle cartilage (a c).

Figure 9: A photograph shows the external ligament of the auricle (a.l) auricle cartilage (a c).

Figure 10: A photograph shows the external acoustic meatus in camel.

Figure 11: A photograph shows the nerve supply of the camel auricle; the cranial auricular nerve (cr a.n) and caudal auricular nerve (ca a. n).

Figure 12: A photograph shows the blood supply of the camel auricle; superficial temporal artery (s t.a) rostral auricular artery (r a.a) and maxillary artery (m.a).
4. Discussion

The gross anatomy of the external ear in dromedary camel was somewhat similar to the domestic animals. In this study, the external ear was consisted of the pinna included (auricle, external cartilage), internal cartilages, muscles, the external acoustic meatus, and the tympanic membrane.

This study has shown that the muscles of the ear in camel were four groups: rostral, dorsal, ventral and caudal group, each one includes one or more muscles were responsible for the movement of the ear. The origin, position, direction, and insertion of these muscles similar to these muscles in domestic animals similar observation finding by [2,3] in camel [4] in bovine, [6] in cattle and buffalo [7] in horse. [8,9] in domestic animals. On the contrary; we did not find the styloauricular muscle in this work which was described by the [2] in camel, [4] in bovine [6] in cattle and buffalo and [7] in horse. The styloauricular and parotidoauricular muscles are united therefore the styloauricularis appears to be absent morphology similar findings were also report by [17] in ruminant and pig. Also in our finding the interscutolar muscle was protracted, thick, elongate muscle, while the cervicoscutolar muscle was taken specially shaped, triangle with a hypotenuse in the form. These results were under [6]in cattle and buffalo reported that the interscutularis is well-developed muscle in cattle and buffalo, however [17] that showed that this muscle was weak in the ox.

The current study explained that the external acoustic meatus was long tube extends from the floor of the auricle to the tympanic membrane. It was long and curved directed ventrally and then rostromedially. It was oval, had two parts cartilage and bone, long due to the external ear fairly long in camel as the most mammals. In this study, the shape of the external acoustic meatus was oval in camel that similar finding we investigated by [18] in camel, [6] in buffalo but not similar in cattle where it was circular. Our results agreed with [2] in camel and [8,9]reported that the external acoustic meatus was curved in sheep, goat, and dog. On the other hand; we found we disagree with [6] in cattle and buffalo that mentioned the external acoustic meatus was short in length and striated. They were added the length and diameter of external acoustic meatus in buffalo more than in cattle.

The external acoustic meatus had an anatomical significance where the tympanic cavity could be easily examined and the length and width of the external acoustic meatus this explains the prevention and obstruction of the rapid spread of any epidemics or infections or lesions of the tympanic membrane.

We found in this study the external ear and auricular muscles derived the nerves supply from the cranial auricular branch and caudal auricular branch given by auriculotemporal nerve from the facial nerve as well as the cutaneous branches from the vagus nerve to the skin of the external ear. While the blood supply was given by caudal auricular and the rostral auricular arteries from the superficial temporal from the external carotid artery. While the veins draining of the cartilage and muscles ear of the camels by the veins accompanying the arteries, which have the same name as the arteries. Similar finding was observed by [2] in camel, [4] in bovine, [6] in cattle and buffalo, [7] in horse, [8,9]in domestic animals and [19,20] in human. Whilst my results disagree with [1] that reported that the skin of the ear canal is innervated by four cranial nerves: the trigeminal; the facial; the glossopharyngeal; and the vagus nerves and added [21] vertical ramus of the mandible in equine. On the other hand, [22] stated that The arrangement of nerves and blood vessels in association with the ridges on the rostral (concave) surface was observed. The spaces between the ridges were relatively free of larger blood vessels, nerves, hair in cattle, sheep, and deer. While [23] statement that the caudal auricular branch was not observed, except as a small vessel supplying the rostral auricular base in a rabbit.

Conclusion

The finding of the current study showed the anatomical features of muscles external ear and external acoustic meatus of camel with special reference to its blood and nerve supply. This important for determining the areas of the nerve block to attain successful regional anesthesia of this region and avoid injury blood vessels supply of the ear during the surgery in this region.

Authors' contributions G. A. (Syri) 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.

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