

## Hump Attachment Structure of the Two-Humped Camel (*Camelus bactrianus*)

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**ABSTRACT.** The hump attachment structure was morphologically examined in the two-humped camel (*Camelus bactrianus*). The cranial hump is fixed by the trapezius and rhomboid muscles in the thoracic region. The strong collagen sheet in the basement of the hump is attached to the segmented bellies of the trapezius muscle, and the thoracic rhomboid muscle and the nuchal-supraspinous ligament support the attachment function of the trapezius muscle. The basement sheet possesses the line structure of collagen fibers, which are fitted to the segmented bundles of the trapezius muscle, and we observed that the muscle cells of the trapezius muscle are intermingled with the collagen fibers around the attachment line structure. In contrast, the caudal hump is directly attached to the subcutaneous tissue in the superficial region of the lumbar longissimus and lumbar iliocostal muscles. These findings demonstrated that the caudal hump of the two-humped camel is consistent with the hump of the one-humped camel in the attachment structure. —KEY WORDS: hump, rhomboid muscle, trapezius muscle, two-humped camel.

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The hump structure of the camels has been examined in the dromedary [3, 5]. It has been demonstrated that the characteristic hump is attached to the subcutaneous adipose tissue on the latissimus dorsi muscle and fixed on the dorsal part of the lumbar region. While, in the two-humped camel, the cranial hump is expected to be different from the caudal in its attachment structure, since the cranial hump is located on the thoracic region and near the nuchal-supraspinous ligament. So, we dissected the dorsal region of the trunk in the two-humped camel and morphologically examined the attachment mechanism of both cranial and caudal humps.

### MATERIALS AND METHODS

We obtained one male two-humped camel (*Camelus bactrianus*) from a livestock farm in Huhehot district in the Inner Mongolia of China. The animal was exsanguinated from the common carotid artery, and was euthanized. We separated the head and four limbs from the trunk, and set the trunk in horizontal plane, and removed the skin. The animal was dissected in the dorsal superficial area of the trunk, and the hump attachment structure was observed by naked eyes.

The three skeletal specimens of the two-humped camel were examined in the vertebrae related to the attachment of humps. The skeletons have been stored in the Department of Veterinary Anatomy, Inner Mongolian Agricultural University, however, any biological data have not been recorded in the skeletons.

The tissues were excised from the basement sheet of the cranial hump. The tissue blocks were fixed in 10% phosphate-buffered formalin. After 10 days of fixation, the tissues were dehydrated in ethanol, treated by xylene and embedded in paraffin. The blocks were sectioned at 4  $\mu$ m,

stained by haematoxylin and eosin, and observed with the light microscope.

### RESULTS

The cranial and caudal hump bodies consist of the white adipose and connective tissue, and show the sharp triangle in lateral aspect (Fig. 1). The former is located in the dorsal area from the third thoracic vertebra to the eleventh, whereas the latter is dorsally present in the entire region of the lumbar vertebral region (Fig. 1). The articulated vertebral specimen is showed in these hump supporting regions (Fig. 2).

The cranial hump body possesses the thick and strong sheet of collagen fibers in the attachment surface with the trunk skeletal muscles (Fig. 3). The sheet is present just beneath the hump adipose tissue, and does not have any connection to bones. We consider the collagen basement sheet as a part of subcutaneous connective tissues, and the sheet can be regarded neither tendon nor aponeurosis. The parallel-protruded lines of collagen fibers are observed in this basement sheet (Fig. 3). These well-developed lines engage with the segmented bundles of the trapezius muscle. These segments are arranged at the interval of about 3–5 mm. The thoracic part of the trapezius muscle consists of a thick sheet and provides the segmented surface to the ventral sheet of cranial hump body (Fig. 4).

The caudal area of the flat trapezius muscle arises from the nuchal-supraspinous ligament in the most dorsal part. However, in the cranial and ventral parts, this muscle runs from the superficial surface of the thoracic rhomboid muscle (Fig. 5). The thoracic rhomboid muscle can be separated into two bundles. The cranial part is thin and flat, whereas the caudal appears thick and triangular in lateral

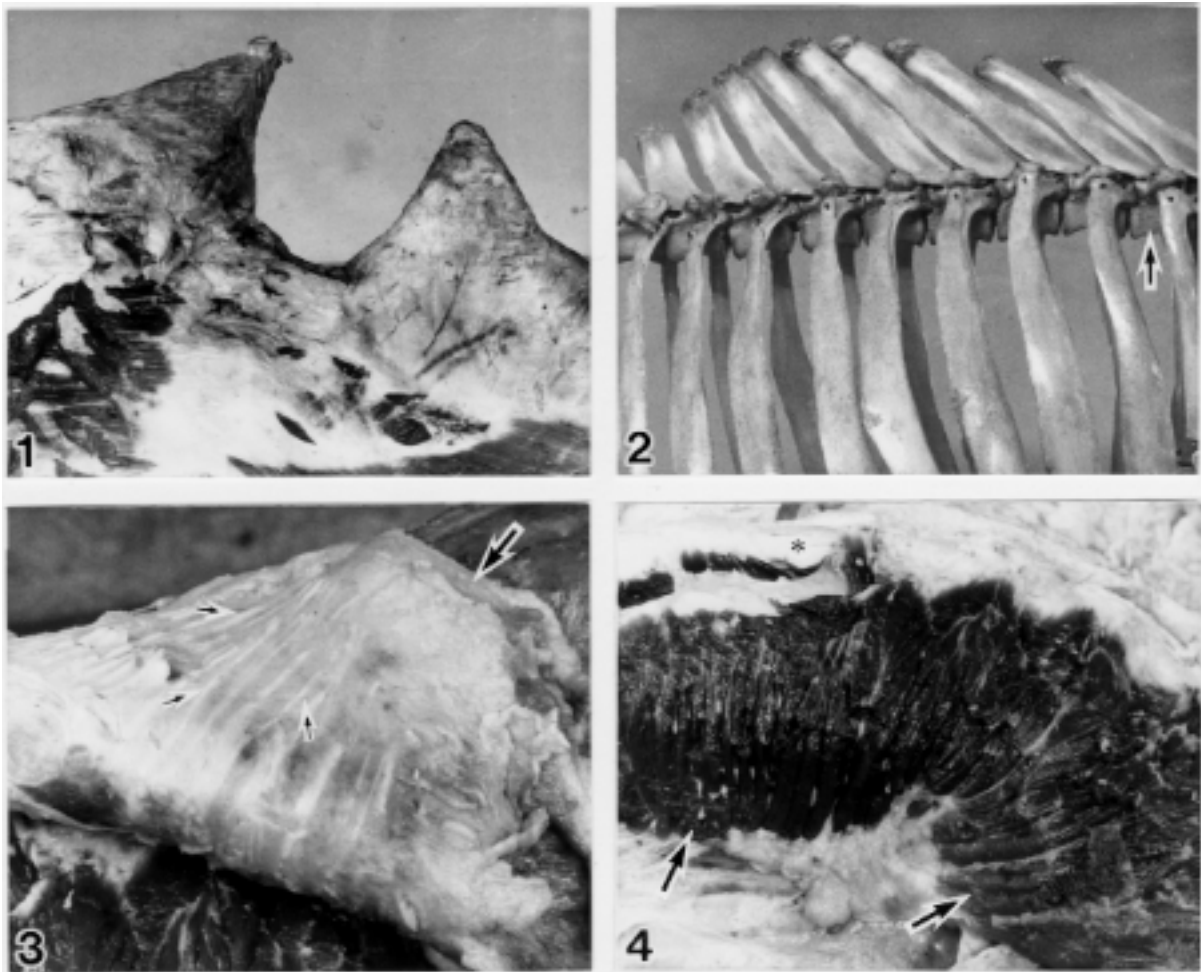


Fig. 1. The humps in the two-humped camel. Left side after removing the skin. The humps consist of extraordinarily enlarged gray-white adipose tissues.

Fig. 2. The skeletal specimen of the two-humped camel. Right side of the thoracic dorsal region. The cranial hump is located in the dorsal area between the third (arrow) and the eleventh thoracic vertebrae.

Fig. 3. The basement sheet of the cranial hump. The cranial hump (large arrow) has been cut and turned to another side. The line structure of collagen fibers can be seen (small arrows). These parallel lines are arranged in the ventral surface and fitted to the segmented bundles of the trapezius muscle.

Fig. 4. Left side of the thoracic part of the trapezius muscle (arrows). The cranial hump has been completely turned to the right side. The thin bundle shows the segmentation and receives the line structure of the basement sheet of the cranial hump. Dorsal part of the nuchal-supraspinous ligament is shown (asterisk).

aspect (Fig. 5). These bundles arise from the lateral surface of the nuchal-supraspinous ligament in the dorsal region, and from the adipose and connective tissues in the ventrolateral area of the ligament. The nuchal-supraspinous ligament is enlarged in the thoracic vertebral region on both sides from lateral aspect, and supplies the origin surfaces of the trapezius and rhomboid muscle bundles in the thoracic region (Figs. 2 and 6). Since the scapula has been separated from the trunk, the cervical area and the insertion of these two muscles are not observed.

The collagen fibers are well-developed in the basement sheet in the cranial hump (Figs. 7 and 8). The collagen fibers compose the thick bundles and run in various

directions. The small accumulation of adipose tissue and some blood vessels are confirmed among collagen fibers and bundles (Fig. 7). The collagen fiber bundles of various orientations are intermingled and strengthen the sheet around the protruded line structure (Fig. 8).

The caudal hump also possesses the strong sheet in the dorsal basement attaching to the trunk. However, the sheet does not contain the developed lines of connective tissue. The caudal hump is simply attached to the superficial subcutaneous adipose tissue and supraspinous ligament (Fig. 9). Beneath the subcutaneous adipose tissue, the lumbar longissimus muscle and the lumbar iliocostal muscle occupies the large space. The latissimus dorsi

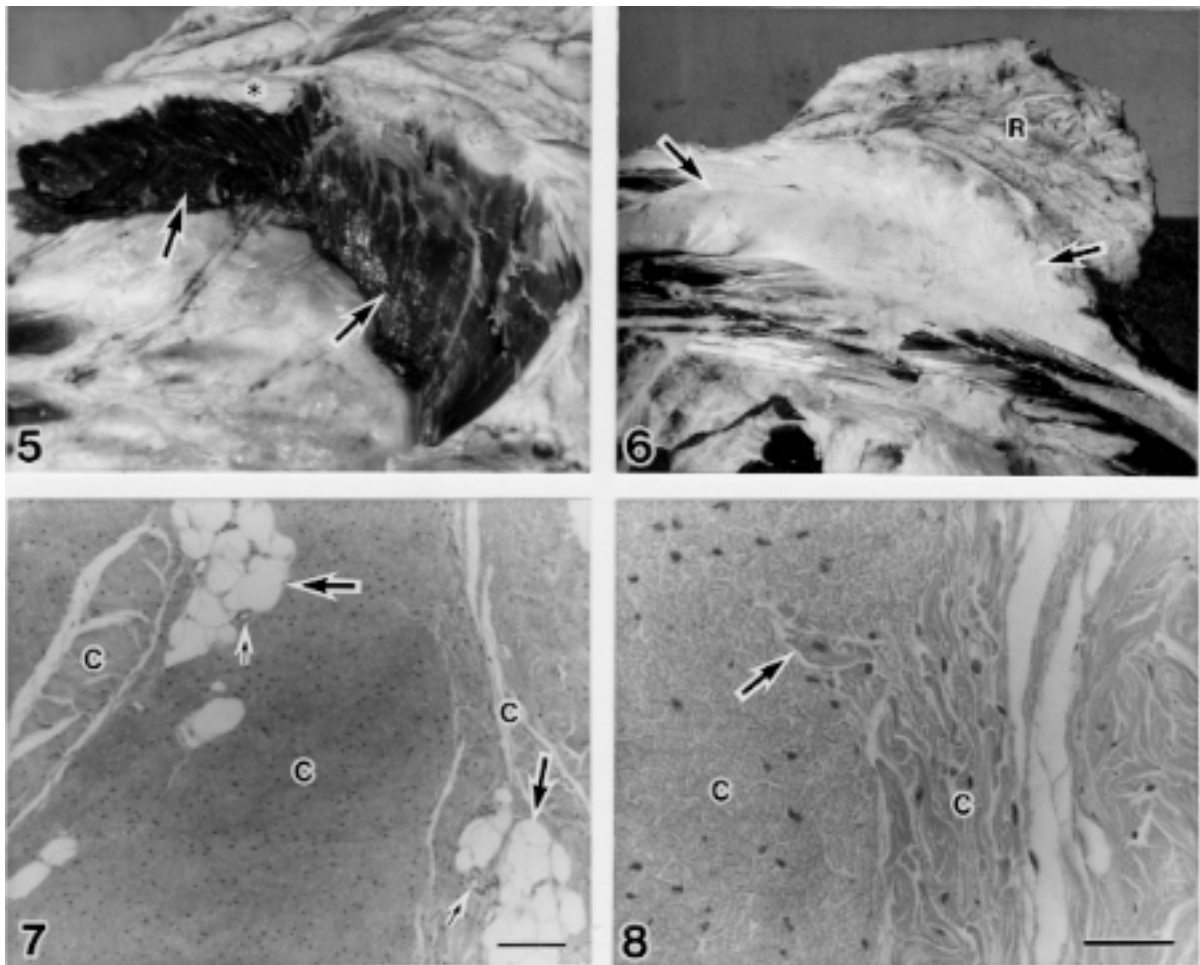


Fig. 5. Left side of the thoracic rhomboid muscle. The trapezius muscle has been removed from the origin in the nuchal-supraspinous ligament. The two bundles (arrows) originate from the lateral side of the nuchal-supraspinous ligament. Asterisk, the nuchal-supraspinous ligament.

Fig. 6. Left side of the nuchal-supraspinous ligament of the thoracic region (arrows). The well-developed enlarged ligament runs beneath the thoracic rhomboid muscle and provides the origin surface with the trapezius and rhomboid muscles. In the most dorsal part, the cranial hump basement attaches to the ligament. R, basement of the turned cranial hump.

Fig. 7. The collagen fibers are well-developed in the basement sheet in the cranial hump. The collagen fibers compose the thick bundles and run in various directions (C). Large arrows, adipose accumulations. Small arrows, blood vessels. Haematoxylin and eosin. Scale bar=10  $\mu$ m.

Fig. 8. The histological section around the line structure in the basement sheet of the cranial hump. The collagen fiber bundles of various orientation (C) are intermingled and strengthen the sheet structure. Haematoxylin and eosin. Scale bar=30  $\mu$ m.

muscle is present in the more cranial region of the trunk. However, the caudal hump does not directly contact with these muscles. The contrast between the cranial and caudal humps is shown on the attachment structure in Fig. 10.

## DISCUSSION

Since the nuchal and supraspinous ligaments cannot be distinguished around the dorsal thoracic region, we used the name of nuchal-supraspinous ligament. The cranial hump is directly fixed by the thoracic part of the trapezius muscle bundle, and this muscle is supported by the nuchal-

supraspinous ligament and the thoracic rhomboid muscle. The thoracic rhomboid muscle was distinguished into the superficial and deep parts [5], however, these parts should be named as cranial and caudal in this animal. We demonstrated that the trapezius and thoracic rhomboid muscles might function as an attachment structure of the adipose storage of the cranial hump. In contrast, the caudal hump is directly fixed by the subcutaneous adipose tissue in the lateral area of the lumbar part. Certainly the lumbar longissimus muscle possesses well-developed bellies in the one-humped camel [3, 5], however, we conclude that the caudal hump only mounts on the subcutaneous adipose

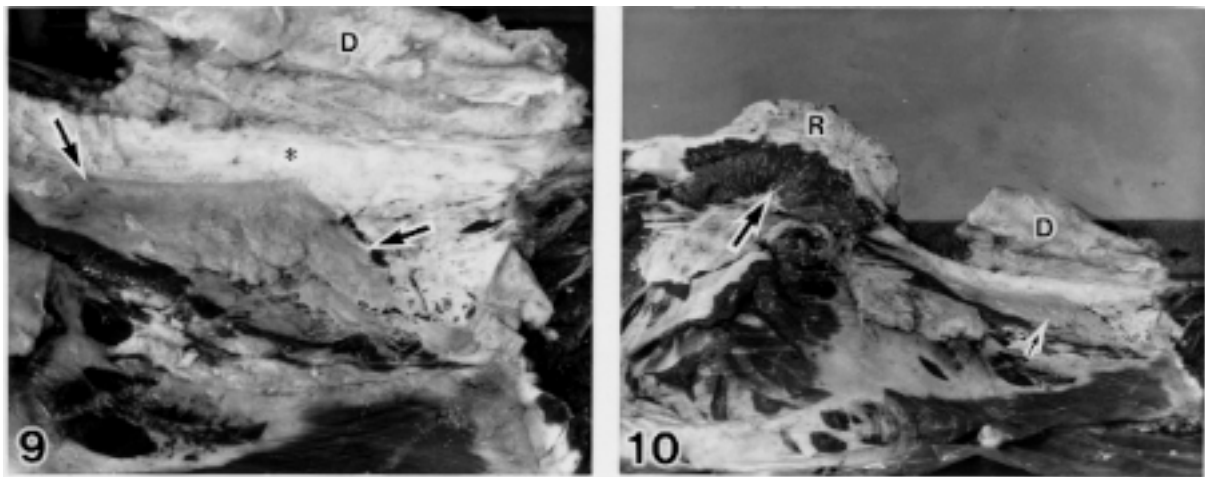


Fig. 9. Left side of the attachment area of the caudal hump. The caudal hump (D) has been turned to the right side. The thick layer of superficial adipose tissue can be seen in the lateral side of the lumbar longissimus and lumbar iliocostalis muscles (arrows). Asterisk, the supraspinous ligament.

Fig. 10. Left side aspect. The cranial hump (R) is attached to the trapezius muscle bundles (large arrow) and the nuchal-supraspinous ligament, whereas the caudal hump (D) to the subcutaneous adipose tissue (small arrow) and the supraspinous ligament.

tissue and is fixed by the thin connective tissue.

The basement collagen fiber sheet is completely fitted to the segment bundles and strongly fixed the cranial hump to the trunk. And the nuchal-supraspinous ligament and the thoracic rhomboid muscle may play a role of support of the attachment function of the trapezius muscle. The nuchal-supraspinous ligament is extraordinarily developed in the thoracic region of the one-humped camel [3–5] in comparison with the horse and cow [2]. It has been thought that the nuchal-supraspinous ligament may bear the long neck weight and support the action of the head in the camel or the giraffe [1], however, we suggest that the nuchal-supraspinous ligament is a substantial attachment apparatus of the cranial hump in the two-humped camel.

The hump has been morphologically examined in the one-humped camel in the monograph [5]. The hump of the one-humped camel is directly attached to the subcutaneous adipose tissue in the dorsal area of lumbar region. Its attachment structure is basically consistent with that of the caudal hump of the two-humped camel [5]. We suggest that the cranial hump structure might be established independently of the caudal hump of the two-humped camel and the hump of the one-humped camel in the evolutionary history of the genus *Camelus*.

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