Journal of
Advanced Veterinary Research
Volume 4, Issue 3 (2014) 135-141 **Original Research**

Comparative Morphological Studies on Lyssa in Carnivores and Camels with Special Reference to Its Surgical Resection

Mahmoud B. Shoeib[1], Awad Z. Rizk[2*], Amin M. Hassanin[3]

[1]*Department of Anatomy, Faculty of Veterinary Medicine, Mansoura University, 35516 Mansoura, Egypt*
[2*]*Department of Surgery, Anesthesiology and Radiology, Faculty of Veterinary Medicine, Mansoura University, 35516 Mansoura, Egypt*
[3]*Department of Cytology and Histology, Faculty of Veterinary Medicine, University of Sadat City, Menufiya, Egypt*

Accepted 23 July 2014

Abstract

The lyssa is a morphologically supporting structure situated along the median plan on the ventral surface of the apex of the tongue in some animals. The present study aimed to describe the morphological differences of the lyssa in carnivores (dog and cat) and camel using conformist macroscopic and microscopic methods as well as evaluation of its surgical resection in the dog and cat. The lyssa is a rod-shaped in dog, strip like structure in cat and ridge-like structure in camel. It showed straight course in dog and helical appearance in cat. In the studied species, the lyssa was formed from adipose tissue intermingled with irregular connective tissue. However, dense striated muscles fibers were seen in the caudal half of the lyssa in dog. Besides, few bundles of longitudinally running muscle fibers were observed in cat and camel. In dog, the lyssa was defined by a coarse sheath of connective tissue, this capsule was ill-defined in cat and absent in camel. In cat, a pyramidal extension of the adipose tissue of the lyssa was attached to intrinsic striated muscle of the tongue. Full function of the tongue could be achieved after surgical resection of lyssa in dogs and cats.

Keywords: Cats; Dogs; Lyssa; Morphology; Surgical resection

Introduction

In the ancient time, the lyssa was thought to be a worm causing rabies in dogs, and it was sometimes removed to cure the disease (Easley, 1999). In fact, the lyssa derived from the neuroectoderm, was a morphological structure situated ventro-medially at the apex of the tongue in some animals, which can easily be demonstrated on a cross section (Budras *et al*., 1994; Capellari *et al*., 2001). In carnivorous, this fusiform fibrous cord like lyssa extends from the apex to the level of the attachment of the *frenulum linguae* (Evans and La Hunta, 1996). In camel, the lyssa appeared as bulging in the mid-ventral anterior third of the tongue (Kassem *et al*., 1984). In pig, a topographically corresponding streak of fat tissue with a hyaluronic-rich matrix is found, but a connective tissue sheath is missing (Capellari *et al*., 2001).

The defined role of the lyssa in various domestic animals was uncertain. The lyssa in slow Loris, *Nycticebus coucang*, was contained simple sensory nerves seems to play a roles as receptive organs of the tongue (Kubota and Iwamoto, 1967).The contraction of the skeletal muscles of the carnivore's lyssa causing volume reduction and consequently stiffening, straightening and dorsal flexion of the lyssa, and that its relaxation causes the lyssa to become soft and to take an undulating course (Capellari *et al*., 2001). Since previous anatomical descriptions concerning the lyssa in camel and carnivores are rather superficial and/or conflicting, in the present study, we aimed to describe a detailed comparative morphological differences between lyssa of dogs, cats and camels. Additionally, no previous studies were performed on the surgical resection of lyssa in dogs and cats, thus we evaluated

*Corresponding author: Awad Z. Rizk

E-mail address: awad_surgery@yahoo.com

the effect of its resection on the tongue mobility and normal physiological and behavioral changes in carnivorous.

Materials and methods

Six heads of adult healthy Mongrel dogs, Egyptian Mau cats and six heads of young one humped camel (about 2.5-5 years) of both sexes were used as materials for the anatomical and histological study. In addition, four adult healthy Mongrel dogs and three Egyptian Mau cats were used for surgical resection of lyssa. The dog and cat heads were obtained from the available specimens that was used by students in the anatomy laboratory of Mansoura University, Faculty of Veterinary Medicine, Egypt. The camel heads were obtained from Kafr El-Sheikh abattoir, Kafr El-Sheikh, Egypt.

For anatomical study, three heads from the studied species were used, the formalin fixed heads (with their tongues) were investigated both macroscopically and under a stereomicroscope (Nikon SMZ-2T, Nikon Corp., Tokyo, Japan).All measurements were performed using a digital caliper (Mitutoyo 500 171-1 Diagrammatic Caliper 150 mm/6 in, Japan).

For histological examinations, tissue samples of the tongues (including the lyssa) were fixed in 10% buffered-formaldehyde, dehydrated, cleared and embedded in paraffin blocks and cut in 5-µm thick transverse sections which were stained with Hematoxylin and Eosin (H&E) as well as Crossman's trichrome stain (Bradbury and Gordon, 1990).

For surgical resections, the dogs were anesthetized using premedication xylazine Hcl (Xylaject; ADWIA; Egypt) in a dose of 1mg/kg BW and thiopental sodium (Thiopental, EPICO; Egypt) in a dose of 20 mg/kg BW. The cats were anesthetized using a mixture of xylazine Hcl (1mg/kg BW) and ketamine Hcl (Ketamine; Sigma-Tec; Egypt; 5 mg/kg BW). The tongue was retracted dorsally and an elliptical or linear ventral midline incision was made from the base of the tongue toward the apex (Fig. 3A&E). Dissection was performed in the lingual muscle and removal of the lyssa was done. The resulted wound was sutured using non-absorbable suture material silk No. 0 in dogs or synthetic non absorbable suture (prolene) No 2/0 in cats in a simple interrupted pattern (Fig. 3). Dogs and cats were evaluated for their ability to protrude the tongue, eating, drinking, prehension of foods, liking, playing with tongue and behavioral changes.

Results

Anatomical finding

In carnivores

The shape of the lyssa was rod-shaped in dog and strip-like structure in cat. It lied along the median plan on the ventral surface of the apex of the tongue. Rostral, it began from the tip of the tongue and was embedded between the genioglossus muscle. Caudally, it tapered to thread which ends with the septum linguae at the level of the *frenulum linguae*; it did not reach the hypoid bone. There were differences in the course, color and measurements between the lyssa in dogs and cats. The lyssa in both dog and cat was capsulated and could be applied to resection.

In dog

The lyssa had almost straight course and pinkish color; its length range from3-4 cm. Although, the caudal two thirds of the lyssa were instituted deeply among the intrinsic lingual muscles, its rostral third was located superficial just under the mucous membrane of the tongue. It protrudes slightly into the oral cavity; consequently, the rostral portion of the dog's lyssa was readily visible and was palpable on the median plane in the free tip of the tongue. The rostral extremity of the lyssa reaches the tip of the tongue (Fig. 1 A&B).

In Cat

The lyssa had tortuous course and yellow color; its length range from 1.5-1.7 cm. The whole body of the cat's lyssa was buried among the intrinsic lingual muscles.It was mixed caudally with the cranial part of the vertical fibers of the genioglossus muscle. The rostral extremity of the lyssa was slightly elevated under the mucous membrane of the tongue; it was about 3 mm away from the tip of the tongue (Fig.1. C&D).

In camel

The lyssa was observed as a ridge-like structure,

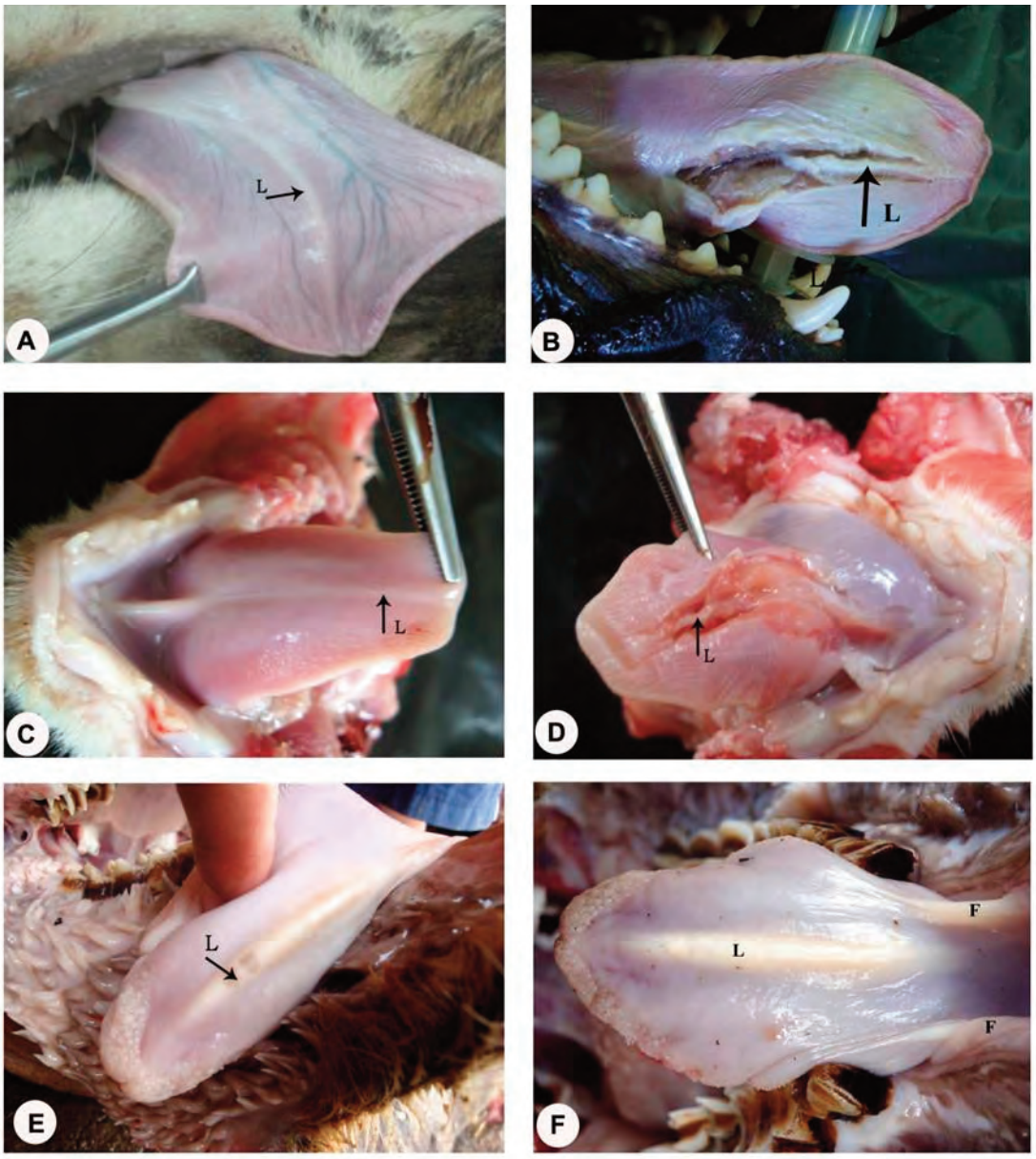

Fig. 1. Macroscopic anatomy of lyssa in dog (A& B); cat (C& D) and camel (E& F). (B) Exposed lyssa in dog; (D) exposed lyssa in cat. L = lyssa; F = lingual frenulum.

thick in its middle and tapered in both extremities. It was located in the median plane of the rostral third of the ventral surface of the tongue. The lyssa was creamy colored and had length ranging from 4-4.5 cm in its length. The rostral extremity of the lyssa did not reach the tip of the tongue. It was about7 mm away from the apex of the tongue (Fig.1. E&F). The lyssa was non capsulated and could not be applied to resections.

Microscopic finding

In dog

Transverse section of the dog's lyssa showed that it was enclosed by a dense connective tissue capsule formed mainly of collagen fibers. The body of the lyssa was formed entirely of adipose tissue in its cranial part; however, from the middle toward the caudal part, dense striated muscle fibers were seen dorsally to the adipose tissue (Fig. 2A).The capsule of the lyssa showed highly vascularized dense connective tissue that extended between the adipose tissue and muscle bundles. Moreover, isolated muscle fibers were intermingled with the adipose tissue in the body of the lyssa (Fig. 2B).

In cat

The lyssa was encircled by indistinctive thin connective tissue capsule. The entire body of the lyssa was formed from adipose tissue; however, isolated

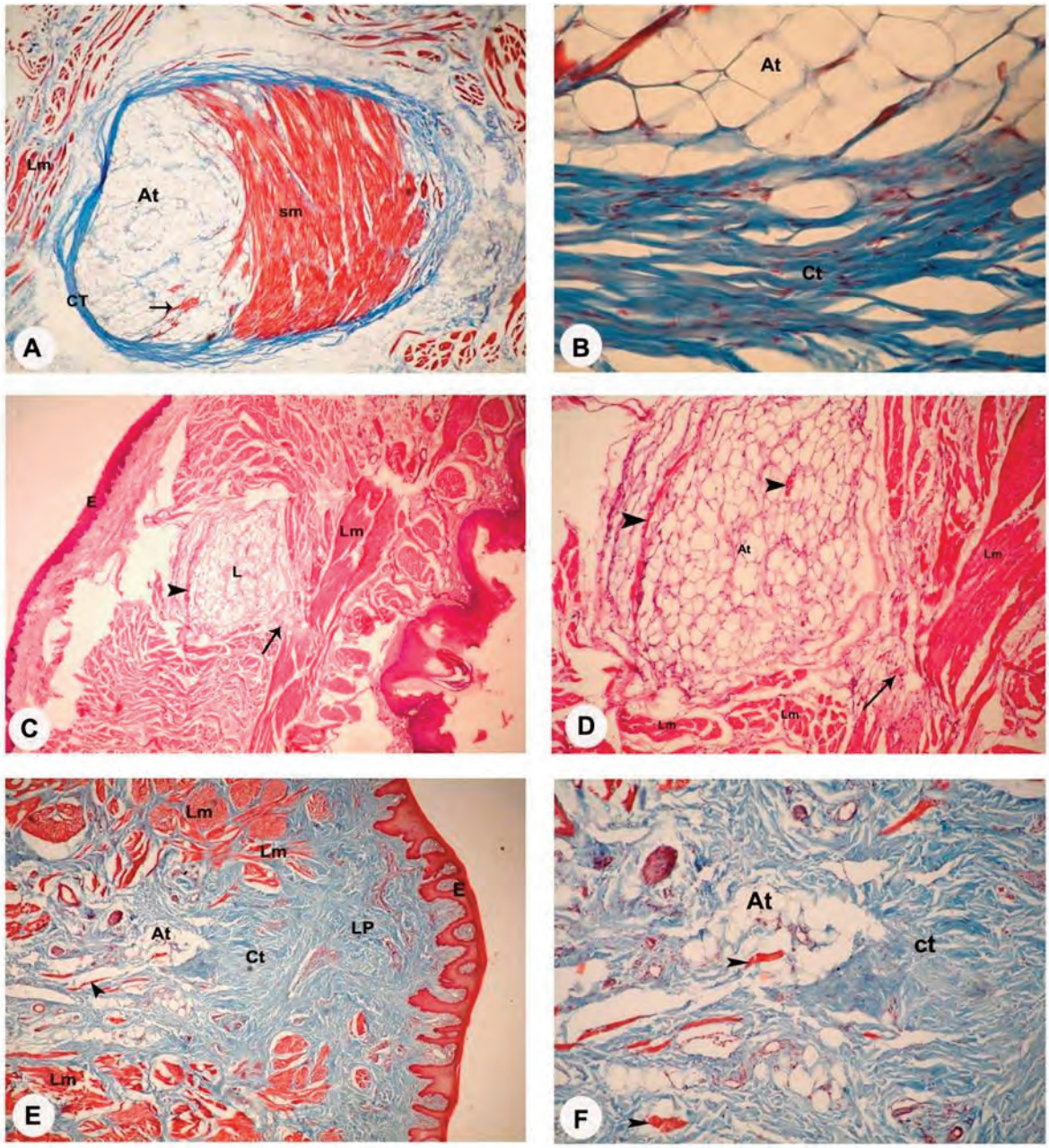

Fig. 2. Photomicrographs of the transverse sections in the lyssa of dogs (A & B); cats (C & D) and camels (E & F). In dogs (A) the lyssa showed connective tissue capsule (CT) enclosed adipose tissue (At) and striated muscle fibers (sm); (B) higher magnification illustrated capsule and adipose cells. A x100; B x400 (trichrome stain). In cat (C) ill-defined capsule; the (arrow) indicated the pyramidal extension in the dorsum of the lyssa. (D) The lyssa formed of adipose tissue with scarce of striated muscle (arrowhead). C x40; D x100 (H&E stain). In camel (E) the lyssa was devoid of CT capsule. (F) Dense irregular CT, adipose cells and striated muscle fibers (arrowhead). E x40; F x100 (Trichrome stain). At, adipose tissue; Ct, connective tissue; E, Epithelium; L, lyssa; Lm, lingual skeletal muscle; Sm, skeletal muscle fibers; Lp, lamina propria.

striated muscle fibers were found inbetween the adipose tissue (Fig. 2C). There was a pyramidal extension of the adipose tissue that was encircled and attached to the intrinsic striated muscle of the tongue and seemed to support the Lyssa dorsally (Fig. 2D).

In camel

The Lyssa was devoid from the connective tissue capsule; however, it was surrounded by bundles of longitudinally arranged striated muscles (Fig. 2E). It was formed mainly of dense irregular connective tissue, strands of striated muscle fibers and adipose tissues (Fig. 2F).

Results of surgical resection

All dogs and cats were not able to eat and drink normally by themselves for three days after surgery

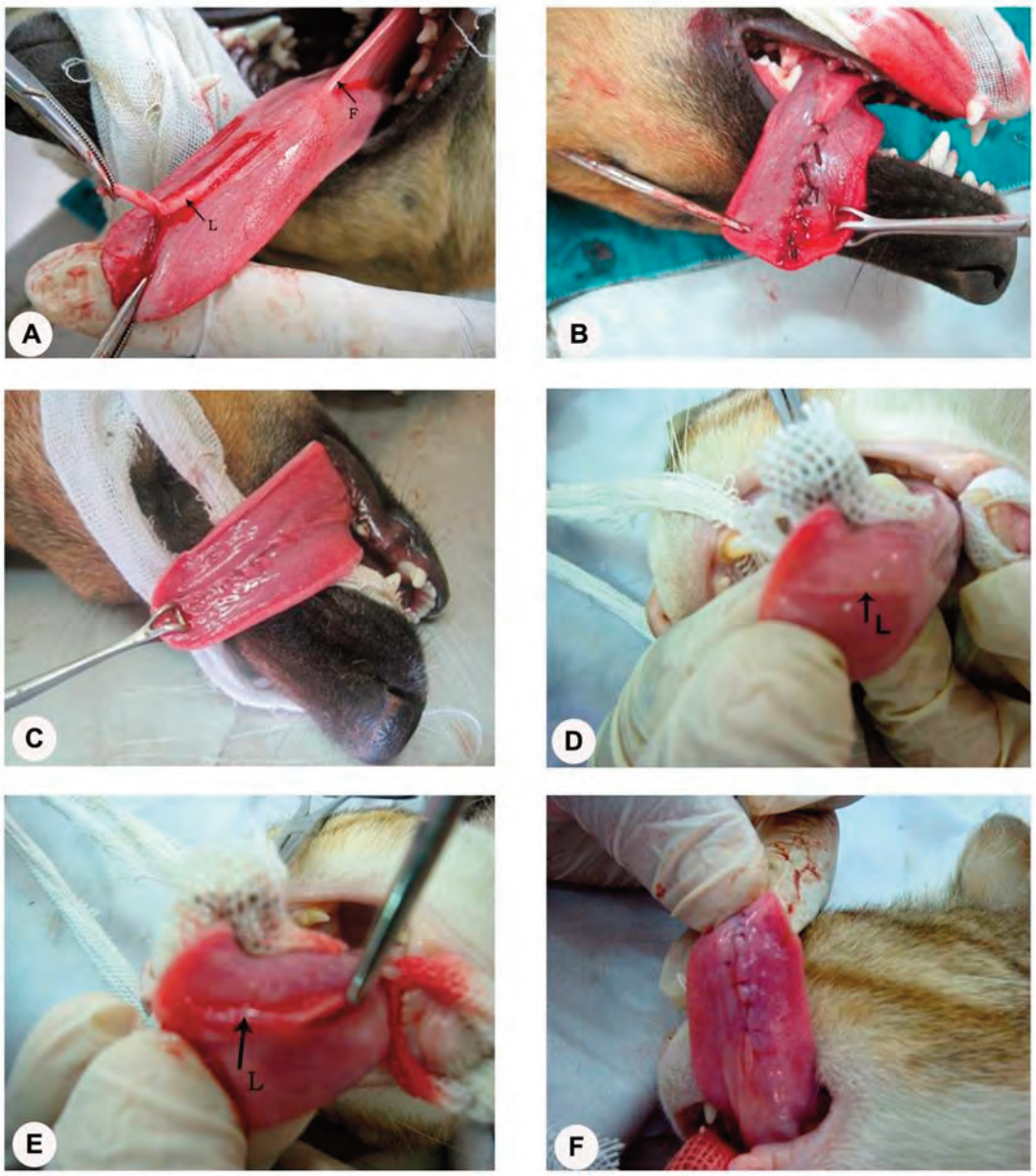

Fig. 3. Surgical resection oflyssa in dogs (A-C) and cats (D-F). (A): Linear incision anddissection of lyssa at the ventral midline of tongue in dog. (B):Closure of tongue incision in dog. (C): Healing of tongue wound 7days after removal of lyssa in dog. (D): Linear incision of thetongue in cat. E: Exposing the lyssa in cat. (F): Closure of thewound in cat. L = lyssa; F = lingual frenulum.

and unable to protrude their tongue properly. From the 4th day after surgery, they could hardly drink water while the ability of eating started from the 5th day. Sutures were removed 8 days after surgery and complete healing of the tongue was noticed (Fig. 3C). After that all dogs and cats have a normal condition for protrusion of the tongue, prehension of foods, liking and playing with the tongue with no abnormal behavioral changes.

Discussion

Based on the anatomical findings of our study, the lyssa was cord-like structure in dog, strip like structure in cat and ridge-like structure in camel. The Lyssa has an almost straight course in dog and spiral one in cats. These results were agreed with Capellari *et al*. (2001) in carnivorous, Correa *et al*. (2012) in crab-eating raccoon and (Kassem *et al*., (1984) in camel, who stated that the lyssa was observed as laciform structure. However, the present result was partially agree with Besoluk *et al*. (2006), who stated that in the dog the lyssa was J-shaped and in cat it was spiral shaped. The previous authors proposed that the spiral structure of cat's lyssa makes its very quick and/or short-time lengthening possible, and therefore the cat can effectively use its tongue for speedy lingual movements.

In the current work, it was noticed that the rostral extremity of the lyssa reached the tip of the tongue in only in dog while it was about 3 mm and 7 mm away from the tip of the tongue in cat and camel, respectively. This finding was differ from that observed by Besoluk *et al*. (2006) who stated that, the cranial extremity of the lyssa was about 3 mm and 2 mm away from the apex of the tongue in the dog and cat, respectively. However, no data concerned the camel.

The lyssa in dog and cat was capsulated and could be applied to resections; however, in camel it was non-capsulated and could not be applied to resections. This finding was in agreement with that mentioned by Nickel *et al*. (1979); Konig and Liebich (2004); Besoluk *et al*. (2006) in carnivores. On contrary, Kassem *et al*. (1984) noticed a thin connective tissue capsule surrounding the lyssa in camel.

The microscopic examination of the lyssa in carnivores and camels revealed that the body of the lyssa was formed mainly of adipose tissue; irregular connective tissues with dense striated muscle fibers in the lyssa of dog while scarce striated muscle in lyssa of cat and camel. These results were in agreement with Nickel *et al*. (1979); Eurell and Frappier (2006); Banks (1993) in carnivorous and with Kassem *et al*. (1984) in camel. However, Besoluk *et al*., (2006) stated that no skeletal muscle was observed in the cat's lyssa. Budras *et al*. (1994) considered the adipose tissue of the lyssa as structural because no change appeared during life in its adipose tissue

With regards to the existence of cartilaginous structure in the lyssa of the studied species, the present study showed that the cartilage had never been demonstrated. This result was in consistent with Capellari *et al*. (2001); Eurell and Frappier (2006); Besoluk *et al*. (2006) in carnivores and with Moustafa *et al*. (1976); Kassem *et al*. (1984) in camel. Moreover, Kassem *et al*. (1984) added that, the cartilage existences was related to the age of the camel, where in young (about 22.5-5 years) and adult camels (about 8-15 years), no existence of the cartilage while in aged camels at about 13 to 22 years, islets of hyaline cartilage were observed. Per contrary, Evans and Christensen (1979); Nickel *et al*. (1979); Schaller (1992); Budras *et al*. (1994); Frewein and Vollmerhaus (1994) reported that the cartilaginous tissue existed in the structure of the lyssa in dog and occasionally in cat. Moreover, Konig and Liebich (2004) mentioned that occasionally island of cartilage present in the lyssa of carnivores.

Although Besoluk *et al*. (2006) reported that the dog's lyssa had a well-developed connective tissue sheath with muscle spindles in its middle portion. In the present study, the muscle spindle has never been demonstrated in connective tissue sheath of the carnivorous lyssa. It was stated that the muscle spindles, an important proprioceptor, lie among myofibrils and are monitoring devices of the nervous system for body position, tactile input, joint movement. However, since the muscle fibers of the genioglossus muscle in the dog and cat were connected with the aboral extremity of the lyssa, they possibly substitute for muscle spindles in order to regulate the lingual extending position (Gartner and Hiatt, 2001).

Based on the findings of our study, it was concluded that the lyssa of the studied species serves as an elastic limb and/or skeleton of the free portion of the tongue. It must be taken into consideration not only in surgical operations of pathologic structures such as intermandibular and dermoid cysts found in the mouth and tongue (Liptak *et al*., 2000), but also in *frenulum linguae* operations such as partial or complete ankyloglossia and sublingual frenectomy (Eisenmenger and Zetner, 1985).

In this study, surgical resection of lyssa in dogs and cats was easily performed through linear or slightly elliptical incision, as it was superficially located. In contrary, anatomical findings in camel found that, the lyssa was deeply seated through the lingual muscle, so its surgical removal appeared difficult and leads to disfiguring of the lingual muscle.

The dogs and cats appeared to be able to use their tongues normally and could protrude their tongues when panting after a week post-resection of lyssa in dogs and cats and became normal in eating and drinking, so the resection of lyssa has neither considerable effect on the mobility of the tongue nor normal physiological and behavioral changes.

The authors claim that further embryological and physiological studies are required to understand thoroughly the functional importance of the lyssa in carnivores and camel. They also suggest that the results from this study shed light on the future experimental studies on the lyssa, and that they contribute considerably to the present anatomical

knowledge regarding the lyssa in the cat, dog and camel. Additionally, more studies are needed to evaluate the role of lyssa resection in dogs on the epidemiological pattern of certain infectious diseases.

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