Male Genital Organs in the Red Fox (Vulpes vulpes); Macroanatomic and Three-dimensional Reconstruction Aspect

Erkek Kızıl Tilki Genital Organları (Vulpes vulpes); Makroanatomik ve Üç Boyutlu Rekonstrüksiyon Görünüşü

Ayşe HALIGÜR*, Sema ÖZKADIF

1Çukurova University, Faculty of Ceyhan Veterinary Medicine, Department of Anatomy, Ceyhan-Adana, Turkey

Abstract: In this study, it was aimed to describe the genital organs, the macroanatomical aspect and three-dimensional (3D) reconstruction of penis and os penis using multidetector computed tomography (MDCT) images in the male red fox (Vulpes vulpes). Six dead male red foxes were used as material. After MDCT images of the penis were obtained, they were reconstructed using a 3D modeling program (Mimics) by overlapping the images. Morphometric measurements were taken from reconstructed model of the penis and os penis. Dissections of foxes were carefully carried out under the loupes. Testis, epididymis and penis were measured from different places. In terms of anatomical aspect, in the red foxes were determined to ovoid testis and extend horizontally into the scrotum. The accessory genital glands were only prostate. The prostate was located to surround the urethra. The spongios body of penis had os penis which the urethra was pass through. The length of the penis obtained by mimics program and digital calliper were not difference. These results may contribute to the lack of the literature about male genital anatomy of the fed fox. It is thought that this study, using 3D reconstruction techniques could make anatomical studies easier to do without harming on wild animals.

Keywords: Genital organs, Anatomy, 3D imaging, Red fox.

Öz: Bu çalışmada, erkek kızıl tilkide (Vulpes vulpes) genital organların, makroanatomik görünüşü ve multidedektör bilgisayarlı tomografi (MDBT) görüntüleri kullanarak penis ve os penisin üç boyutlu (3B) rekonstrüksiyonunu ortaya koymak amaçlanmıştır. Materyal olarak alın adet oli erkek kızıl tilki kullanıldı. Penisin MDBT görüntüleri elde edildiken sonra, görüntüler üst üste bindirilerek bir 3B modelleme programı (Mimics) kullanılarak rekonstrüksiyon yapıldı. Penis ve os penisin yeniden yapılandırılması modelin ortaya çıktığı çok parçalı PV olayı dahil. Tıkkıların diseksiyonu, loupların altında dikkatlice yapıldı. Testis, epididimis ve penis farklı yerlerden ölçüldü. Anatomi açıdan, kızıl tikkilerde testis ovalığı ve skrotuma yatay olarak uzanmış tespit edildi. Penisin sıklığı bizim sadece prostat tespit edildi. Prostat uyuşmayı esasleyerek dikkatlice yerleştirildi. Pars spongiosa penisinde, uyuşmanın içinde geçtiği os penisine sahipti. Mimiks programı ve dijital kumpas ile elde edilen penisin uzuşluğunu farkındayız. Bu sonuçlar, literatürde tilki erkek genital anatomisi hakkındaki eksikliklerini gidermesi için katkıda bulunabilir. Bu çalışmada, 3B rekonstrüksiyon teknikleri kullanarak vahşi hayvanlar zarar vermeden anatomik çalışmalan yapmayı kolaylaştırmayı düşünülmüştür.

Anahtar Kelimeler: Genital organlar, Anatomi, 3B görüntüleme, Kızıl tilki.

Introduction

The red fox (Vulpes vulpes) has widest distributions of widespread mammals, (Sibirya, Indian, Europe, Asia, North Africa, America, North Pole etc.) (MacDonald, 2005). The fox is a member of the carnivore and has some characteristic properties such as a slender, like pointed muzzle, prominent erect ears, long slender legs, and relatively small feet. The foxes are generally categorized according to color in three phase as red (red-brown), across (ashen-gray) and silver (silver-white). The fox is a...
very popular animal in carnivores, some of the foxes is feed for post (Demirsoy, 2003).

Reproductive organs are not absolute in each of the animals. However, they have a vital important role in terms of reproduction of species (Massanyi et al., 2003). In most male mammals, reproductive system is studied as histological or reproductive macroanatomy; such as; testis, epididymis, ductus deferens, funiculus spermaticus, accessory glands, penis and preputium: European beaver (Doboszynska and Zurowski, 1981), Anatolian sousslik (Spermophilus xanthopyrnnus) (Cakir and Karatas, 2004), dog and cat (Mantis, 2008), Viscacha (Lagostomus maximus maximus) (Chaves et al., 2011), Arabian oryx (Eljarah et al., 2012); pampas deer (Ozotoceros bezoarticus) (Perez et al., 2013), dog (Souza et al., 2014). In addition, 3D reconstruction of penis and clitoris on the mice is studied (Weiss et al., 2012). However, the anatomy of genital system of wild animals, is lacking. According to literature, just one study was encountered related with the development of external genital organs of hyena. (Cunha et al., 2014). Although fox is one of the animal on which there are quite many anatomic and morphometric studies but there is very limited study on genital system. In literature; a study related with internal organs (Cavallini, 1997), on skeleton (Onar et al., 2005; Jurgelenas, 2015), about vomeronasal organs (Karimi, 2016), physiology of reproductive system (Joffre, 1977; Forsberg and Madej, 1990) and there are only morphometric studies about os penis in literature studies (Gultiken et al., 2004; Canady, 2013). But no studies related to macroanatomy of other genital organs and 3D reconstruction techniques have been found in the red fox. For this reason, it was aimed in this study to describe the macroanatomical aspect of the genital organs and produce a 3D reconstruction of the penis and os penis in the male red fox.

Materials and Methods

This study was performed with permission from the General Directorate of Nature Conservation and National Parks of the Ministry of Forestry and Water Affairs (Permission number: 38002405-445.05-177733).

This study was carried out on six death male red foxes. These materials were collected at different times as a result of traffic accidents on the road. The body weights of male red foxes were in the range of 6 to 9 kg. The lengths of bodies were measured among 45-50 cm. The animals were kept in the freezer until the obtaining the MDCT images and dissection.

**Imaging and 3D reconstruction**

MDCT images of animals in prone position were obtained. The parameters of MDCT (Somatom Sensation 64; Siemens Medical Solutions, Germany) device were adjusted as follows: physical detector collimation, 32×0.6 mm; final section collimation 64×0.6 mm; section thickness, 1 mm; gantry rotation time, 330 ms; kVp, 120; mA, 300; resolution, 512×512 pixel; and resolution range, 0.92×0.92. Dosage parameters and scanning were performed on the basis of standard protocols and literature (Prokop, 2003; Kalra et al., 2004). By this way, we tried to obtain radiometric resolution at the lowest radiation level and with optimum image quality (MONOCROME2; 16 bit). High resolution MDCT images of pelvic cavity were obtained. After stocking obtained axial images as DICOM format, they transferred to a computer loaded with 3D modeling program (Mimics 13.1 Materialise Group, Belgium).

The limits of the penis and os penis were determined (Figure 1). In the places except the limits of the penis and os penis the erasing process was applied section by section with the computer mouse and these places were cleaned. The images whose limits were determined were overlapped and then reconstruction was performed with 3D translator component of Mimics 13.1 program (Figure 2).

In this study, the length of the os penis, width of the os penis, length of the sulcus urethralis, width of the sulcus urethralis and dorsoventral thickness (middle) were measured (Figure 3). And also length of the penis were measured. After
determining the limits of morphometric measurements of penis and os penis they were automatically calculated by the program.

Figure 1: Limitation of penis and os penis on sagittal section. P: penis, OP: os penis.

Figure 2: a. Limitation of os penis on transversal section. b. 3D reconstruction of os penis. (^): sulcus urethralis.
To cite this article: Haligür A, Özkadif S. (2019). Male Genital Organs in the Red Fox (Vulpes vulpes): Macroanatomic and Three-dimensional Reconstruction Aspect. MAKU J. Health Sci. Inst., 7(2), 89-98.

 ISSN: 2148-2837/ MAKU J. Health Sci. Inst.
**Fig. 4:** Dorsal aspect of excised genital organs of the Red fox. GLP: prostate, LT: left testis, RT: right testis, P: penis, VU: vesica urinaria.

**Figure 5:** Right aspect of external male genital organs. A: anulus inguinalis, F: funiculus spermaticus, LT: left testis, P: penis, RT: right testis.

**Figure 6:** Lateral aspect of the penis. CP: corpus penis, GP: glans penis, PR: prepitium (internal lamina), RP: radix penis.
Table 1: Morphometry of the testis and epididymis.

| Number of foxes | Width of the testis (mm) | Length of the testis (mm) | Width of the epididymis (mm) | Widest of cauda epididymis (mm) | Widest of corpus epididymis (mm) |
|-----------------|--------------------------|--------------------------|-------------------------------|-------------------------------|-------------------------------|
|                 | Right        | Left         | Right        | Left         | Right        | Left         | Right        | Left         | Right        | Left         |
| 1               | 19.78        | 20.12        | 31.17        | 32.83        | 4.32         | 4.89         | 10.10        | 11.77        | 31.41        | 31.83        |
| 2               | 18.70        | 19.05        | 30.98        | 31.45        | 4.27         | 4.38         | 10.02        | 10.98        | 30.02        | 30.44        |
| 3               | 19.02        | 19.22        | 32.15        | 32.88        | 3.99         | 4.25         | 9.89         | 10.38        | 30.28        | 30.75        |
| 4               | 19.65        | 19.97        | 32.11        | 32.79        | 4.21         | 4.76         | 10.08        | 11.12        | 31.06        | 31.86        |
| 5               | 19.20        | 19.86        | 31.29        | 31.92        | 4.29         | 4.45         | 10.12        | 10.92        | 31.35        | 31.72        |
| 6               | 18.82        | 20.01        | 31.03        | 31.47        | 4.30         | 4.42         | 10.35        | 11.07        | 30.52        | 30.86        |

Table 2: Morphometry of penis and part of the penis.

| Number of foxes | Length of bulbus glandis (mm) | Length of corpus penis (mm) | Length of pars libera penis (mm) |
|-----------------|-------------------------------|-----------------------------|----------------------------------|
|                 | Latero-medial | Dorsal-ventral | Latero-medial | Dorsal-ventral | Latero-medial | Dorsal-ventral |
| 1               | 9.32           | 7.42             | 5.49           | 6.41           | 7.71           | 6.02           |
| 2               | 9.17           | 7.15             | 5.30           | 6.15           | 7.60           | 5.97           |
| 3               | 9.20           | 8.01             | 5.42           | 6.33           | 7.46           | 5.81           |
| 4               | 8.67           | 7.35             | 5.18           | 6.20           | 7.29           | 5.88           |
| 5               | 8.98           | 7.28             | 5.11           | 5.89           | 6.98           | 5.67           |
| 6               | 9.14           | 7.24             | 5.17           | 6.24           | 7.32           | 5.76           |

It was determined that the structure of penis consisted of both muscular and cavernous structures. It was observed that this muscular layer started from arcus ischiadicus. It was stated that penis consisted of three sections which are called radix, corpus and glans penis. It was observed that among these sections, radix penis started from arcus ischiadicus as muscular and then shaped the corpus penis. It was determined that penis consisted of both cavernous and spongious layers.

It was observed that the cavernous structure of the penis consisted of an os penis having bony proximal section and gristly distal section through which urethra can pass. In this channeled bone, it was determined that urethra was present and a spongious structure surrounded the urethra. It was also stated that, it shaped the tip of glans penis, had a circular structure and moreover consisted of two different structures (pars longa glandis and bulbus glandis). The measurements of pars longa glandis and bulbus glandis are given in Table 2.

Preputium was observed as a skin fold covering the penis. It was determined that this skin fold consisted of two layers such as internal and external.
3D reconstruction

Three dimensional reconstruction of the penis and os penis was performed. The measurement values of the measurements as shown in Table 3 and 4. The length of the penis obtained by mimics program and digital calliper were not difference (Table 3).

| Number of foxes | Digital Calliper (mm) | Mimics programme (mm) |
|-----------------|-----------------------|------------------------|
| 1               | 94.98                 | 94.86                  |
| 2               | 93.45                 | 93.39                  |
| 3               | 94.72                 | 94.60                  |
| 4               | 95.16                 | 95.02                  |
| 5               | 94.78                 | 94.67                  |
| 6               | 94.56                 | 94.48                  |

Table 4: Morphometric measurements of os penis obtained by mimics program.

| Number of foxes | Length of the os penis (mm) | Width of the os penis (mm) | Length of the sulcus urethralis (mm) | Width of the sulcus urethralis (mm) | Dorsoventral thickness (middle) (mm) |
|-----------------|-----------------------------|---------------------------|-------------------------------------|------------------------------------|------------------------------------|
| 1               | 66.94                       | 6.02                      | 3.15                                | 45.26                              | 3.63                               |
| 2               | 65.32                       | 5.71                      | 2.97                                | 43.86                              | 3.48                               |
| 3               | 66.84                       | 5.89                      | 3.09                                | 44.78                              | 3.54                               |
| 4               | 67.53                       | 6.25                      | 3.37                                | 45.59                              | 3.74                               |
| 5               | 66.85                       | 5.87                      | 3.01                                | 45.41                              | 3.61                               |
| 6               | 66.76                       | 5.83                      | 3.08                                | 45.35                              | 3.58                               |

Discussion

Scrotum of carnivore was in inguinal region which was parallel to planum medianum (König and Liebich, 2015). It was determined that scrotum of the fox was like the ones in other carnivores and its raphe scroti was not so clear. Scrotum was joined to the body wall through a narrow neck in oryx of ruminants and in a floppy position (Eljarah et al., 2012). Moreover, it was observed that scrotum was not in a floppy position.

Testis volume of dog is significantly larger in the left side than the right side (Souza et al., 2014). Right testis of deer among ruminants (Ozotoceros bezoarticus) was heavier than the left one (Perez et al, 2013). Contrary to deer, it was determined the left testis of fox was larger than the right one as in the case of dog.

Just prostate is present in carnivores as accessory gland. Prostate is quite big and constitutes corpus prostatica as a single lobe (Dursun, 2010). Prostate...
gland might differ due to its structure and position (Cakır and Karatas, 2004). Prostate gland of a dog has an oval shape dorsal face of which is flattened and is in the caudal of urinary bladder. Urethra passes through a little dorsal in the middle of prostate (Mantis, 2008). For deer and oryx, ampullary glands, vesicular glands and prostate as rarely spread were observed as glandular glands (Perez et al., 2013; Eljaraha et al., 2012). For Anatolian souslik, on the other hand, vesicular gland, prostate and bulbourethral gland are placed at the beginning of urethra (Cakır and Karatas, 2004). Prostate in Anatolian souslik is on the dorsal face of beginning of urethra and as a single lobe on the ventral face of rectum (Cakır and Karatas, 2004). Prostate gland of monkey is like a cone (Prakash et al., 2009). Prostate of a fox, on the other hand, is circular and it was observed that it was in the caudal of urinary bladder as similar to dogs. Moreover, it was stated that urethra passed through the middle of prostate.

Epididymis position and location was seen to similar to other carnivore (Dursun, 2010). While the measurement values belonging to epididymis of deer did not differ for right and left sides (Perez et al, 2013), the measurement values belonging to left epididymis of fox were higher than those of right side.

Glans penis in carnivores is quite long and it elongates on the whole length of os penis (Sisson and Grossman, 1975). It was determined that the same properties were observed for the foxes as in the case of other carnivores. Glans penis carries ostium urethra externum in all mammalian pets except little ruminant (König and Liebich, 2015). Glans penis of fox, which is a wild animal, was observed as coming out with ostium urethra externum. Glans penis of a monkey, on the other hand, is triangular in shape or like a button (Prakash et al., 2009). Penis of a hyena, a wild carnivore, is chisel-shaped (Cunha et al, 2014). It was observed that penis and penis glans of a fox are circular.

Mouse which is a rodentia has an os penis. Os penis constitutes of two sections such as proximal and distal. Distal section has a structure of fibrocartilaginous whereas proximal section has a bony structure (Weiss et al., 2012). In the study of Canady (2013), it was stated that a cartilaginous structure was not observed on the distal tip of os penis belonging to the fox. The absence of cartilaginous structure might be attributed to the fact that the materials were brought from a museum. In this study, as similar to mouse and according to Gultiken et al. (2004), it was determined that the os penis of the fox has a bony proximal section and cartilaginous distal section.

In this study os penis was measured from 3D reconstruction images, length of it 65.32-67.53 mm, width of it 5.71-6.25 mm, and dorsoventral thickness 3.48-3.74 mm. The sulcus urethralis was measured from 3D reconstruction images, length of it 2.97-3.37 mm, width of it 43.86-45.59 mm. Canady (2013) measured with digital calliper as length of the os penis 47.01-63.41 mm, dorsoventral thickness 2.64-4.60 mm, length of the sulcus urethralis 31.02-46.41 mm, width of sulcus urethralis 1.70-3.59 mm, in red fox. In this study morphometric measurement was similar to literature (Canady, 2013).

In this study, macroanatomic and morphometric measurements of male genital organs in red fox were performed. In addition, 3D reconstruction of the penis and os penis was performed and morphometric measurements were taken from the images. The measurements taken from 3D reconstruction images were similar to digital calliper measurements. So it is thought that this study, using 3D reconstruction techniques could make anatomical studies easier to do without harming on wild animals.

Acknowledgement

This paper is based on the poster presentation at the 3rd International VetIstanbul group Congress, 17-20 May, Sarajevo, Bosnia and Herzegovina. The authors thanks to Cukurova University.
References

Canady, A., 2013. Variability of the baculum in the red fox (Vulpes vulpes) from Slovakia. Zoology and Ecology 23, 165–170.

Cavallini, P., 1997. Internal organ masses of the red fox Vulpes vulpes: data from the wild. Acta Theriologica 42, 91-98.

Chaves, E. M., Aguilera-Merlo, C., Filippa, V., Mohammed, F., Dominguez, S., Scardapane, L., 2011. Anatomical, histological and immunohistochemical study of the reproductive system accessory glands in male Viscacha (Lagostomus maximus maximus). Anatomia Histologia Embryologia 40, 11–20.

Cunha, G. R., Risbridger, G., Wang, H., Place, N. J., Grumbach, M., Cunha, Tj., Weldele, M., Conley, A. J., Barcellos, D., Agarwal, S., Bhargava, A., Drea, C., Hammondi, G. L., Siliteri, P., Coscia, E. M., Mc Phaul, M. J., Baskin, L. S., Glickman, S. E., 2014. Development of the external genitalia: Perspectives from the spotted hyena (Crocuta crocuta). Differentiation 87, 4–22.

Cakır, M., Karatas, A., 2004. Histo-anatomical studies on the accessory reproductive glands of the Anatolian souslik (Spermophilus xanthobrymum) (Mammalia: Sciuridae). Anatomia Histologia Embryologia 33, 146-150.

Demirsoy, A., 2003. Yaşamın Temel Kuralları. Omurgalılar/Amniyota (Sürüngenler, Kuşlar ve Memeliler) Cilt-III/Kısım 5. Baskı. Meteksan A.Ş. Ankara, pp. 745-750.

Doboszynska, T., Zuwrowski, W., 1981. Anatomical studies of male genital organs of the European beaver. Acta Theriologica 26, 331-340.

Dursun, N., 2010. Veteriner Anatomi II. Medisan Yayınevi, Ankara. pp.139-160.

Eljarah, A., Al-Zghoul, MB., Jawasreh, K., Ababneh, M., Alsamadi, M., Alhalah, A., Ismail, Z. B., 2012. Characterization of male reproductive anatomy of the endangered Arabian oryx (Oryx leucoryx). Theriogenology 78, 159-164.

Jurgelėnas, E., 2015. Ostometric analysis of the pelvic bones and sacrum of the red fox and raccoon dog. Veterinarija ir Zootechnika 70, 42-47.

Forsberg, M., Madej, A., 1990. Effects of melatonin implants on plasma concentrations of testosterone, thyroxine and prolactin in the male silver fox (Vulpes vulpes). Journal of Reproduction and Fertility 89, 351-358.

Gültiken, M. E., Yildiz, D., Bolat, D., 2004. The anatomy of os penis in red fox (Vulpes vulpes). Ankara Universitesi Veteriner Fakültesi Dergisi 51, 71–73.

Kalra, M. K., Maher, M. M., Toth, T. L. et al. 2004. Strategies for CT radiation dose optimization. Radiology 230, 619- 628.

Karimi, H., Hassanzadeh, B., Razmaraii, N., 2016. Structure of vomeronasal organ (Jacobson) in the male red fox (Vulpes vulpes). Anatomical Science International 13, 47-54.

Joffre, M., 1977. Relationship between testicular blood flow, testosterone secretion and spermatogenic activity in young and adult wild red foxes (Vulpes vulpes). Journal of Reproduction and Fertility 51, 35-40.

König, H. E., Liebich, H. G., 2014. Veterinary Anatomy of Domestic Mammals. 6th. Ed. (Turkish version). pp. 413-428.

MacDonald, D., Reynolds, J., 2005. Red fox (Vulpes vulpes) (On-line). IUCN Canid Specialist Group Accessed September 27, 2007 at http://www.canids.org/species/Vulpes_vulpes.htm. (05.01.2016)

Mantis, P., 2008. Ultrasonography of the urinary and genital system of the dog and cat. International Journal of Veterinary Sciences 3, 63-71.

Massanyi, P., Jancova, A., Uhrin, V., 2003. Morphometric study of male reproductive organs in the rodent species Apodemus sylvaticus and Apodemus flavicollis. Bulletin of the Veterinary Institute in Pulawy 47, 133-138.

Nomina Anatomica Veterinaria. 2017. Prepared by the International Committee on Veterinary Gross Anatomical Nomenclature. 6th ed., Hannover, Columbia, Ghent, Sapporo: World Association of Veterinary Anatomists.

Perez, W., Vazquez, N., Ungerfeld, R., 2013. Gross anatomy of the male genital organs of the
Pampas deer (*Ozotoceros bezoarticus*, Linnaeus 1758). Anatomical Science International 88, 123-9.

**Prakash, S., Suresh, S., Prithiviraj, E., 2009.** Anatomical aspects of the male reproductive system in the bonnet monkey (*Macaca radiata*). Anatomical Science International 84, 53-60.

**Prokop, M., 2003.** General principles of MDCT. European Journal of Radiology 45, 4-10.

**Sisson, S., Grossman, J. D., Getty, R., 1975.** The Anatomy of the Domestic Animals, vol. II, 5th edn. W.B. Saunders Co., Philadelphia. pp.1580-1584.

**Souza, M. B., Filho, A. C. M., Sousa, C. V. S., Monteiro, C. L. B., Carvalho, G. G., Pinto, J. N., Linhares, J. C. S., Silva, L. D. M., 2014.** Triplex doppler evaluation of the testes in dog of different sizes. Pesquisa Veterinaria Brasileira 34, 1135-1140.

**Onar, V., Belli, O., Owen, P. R., 2005.** Morphometric examination of red fox (*Vulpes vulpes*) from the Van-Yoncatepe Necropolis in Eastern Anatolia. - International Journal of Morphology 23, 253-260.

**Weiss, D. A., Rodrique, E., Cunha, T., Menshenina, J., Barcellos, D., Chan, L. Y., Risbridger, G., Baskin, L., Cunha, G., 2012.** Morphology of the external genitalia of the adult male and female mice as an endpoint of sex differentiation. Molecular and Cellular Endocrinology 354, 94-102.