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Araştırma Makalesi/Research Article

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

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

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Abstract: In this study, it was aimed to describe to the genital organs, the macroanatomical aspect and three-dimentional (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 reconsruction 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) görüntülerini kullanarak penis ve os penisin üç boyutlu (3B) rekonstrüksiyonunu ortaya koymak amaçlanmıştır. Materyal olarak altı adet ölü erkek kızıl tilki kullanıldı. Penisin MDBT görüntüleri elde edildikten sonra, görüntüler üst üste bindirilerek bir 3B modelleme programı (Mimics) kullanılarak rekonstrüksiyonu yapıldı. Penis ve os penisin yeniden yapılandırılmış modelinden morfometrik ölçümler alındı. Tilkilerin diseksiyonu, lupların altında dikkatlice yapıldı. Testis, epididimis ve penis farklı yerlerden ölçüldü. Anatomik açıdan, kızıl tilkilerde testis ovalliği ve skrotuma yatay olarak uzandığı tespit edildi. Genital aksesuar bez olarak sadece prostat tespit edildi. Prostat uretrayı çevreleyecek şekilde yerleştiği görüldü. Pars spongiosa penisde, uretranın içinden geçtiği os penisine sahipti. Mimiks programı ve dijital kumpas ile elde edilen penisin uzunluğu farklılık göstermedi Bu sonuçlar, literatürde tilki erkek genital anatomisi hakkındaki eksikliğin giderilmesine katkıda bulunabilir. Bu çalışmada, 3B rekonstrüksiyon teknikleri kullanarak vahşi hayvanlara zarar vermeden anatomik çalışmaları yapmayı kolaylaştıracağı düşünülmektedir.

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

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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-brawn), across (ashen-gray) and silver (silver-white). The fox is a

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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 souslik (*Spermophilus xanthoprymnus*) (Cakır 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 (MONOCHROME2; 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 (Figure1). 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

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determining the limits of morphometric measurements of penis and os penis they were automatically calculated by the program.

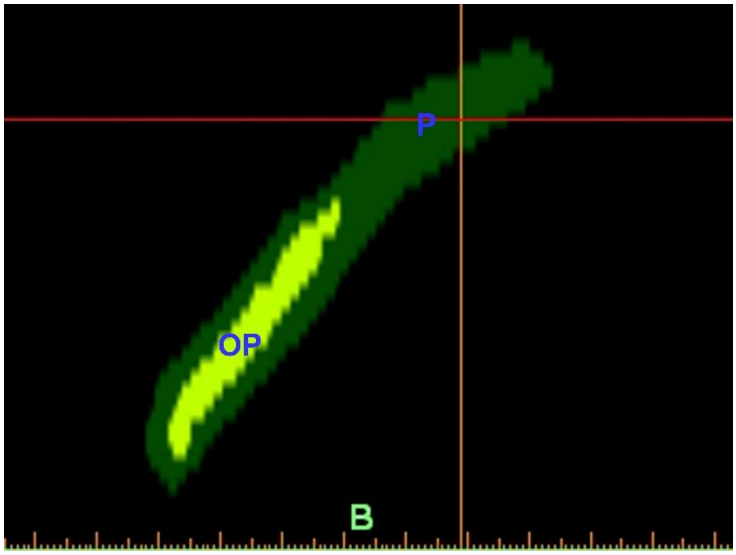

Figure 1: Limitation of penis and os penis on sagittal section. P: penis, OP: os penis.

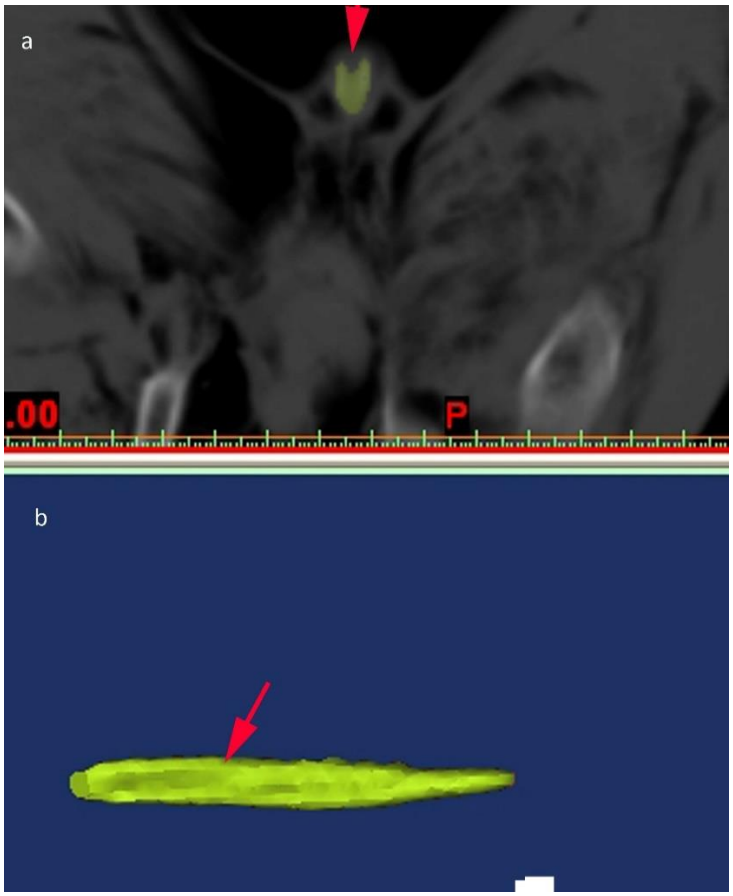

Figure 2: a. Limitation of os penis on transversal section. b. 3D reconsruction of os penis. (^): sulcus urethralis.

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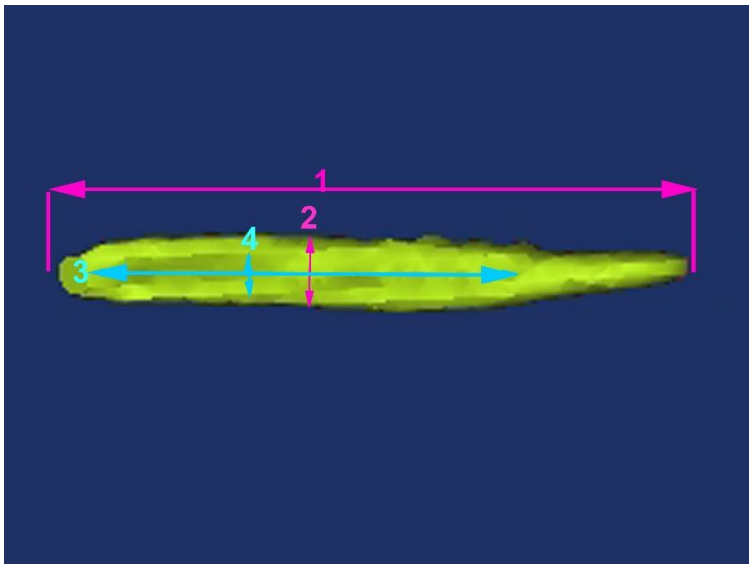

Figure 3: Measurements on facies ventralis of os penis. 1: length of the os penis, 2: width of the os penis, 3: length of sulcus urethralis, 4: width of sulcus urethralis.

Dissection

After obtaining the MDCT images of animals, the simple dissection was performed under loupes. The ventral abdominal wall was removed for each animal. Before, the organs of animals were examined to localization and position.

Width and length of the testis, width of the epididymis, widest of the cauda and corpus epididymis, length of the penis, bulbus glandis, corpus penis and pars libera penis (between pars libera and ostium urethra externum) were measured with digital calliper. The male genital organs were removed to pelvic cavity. Photographs were taken with Canon digital camera. Terms used are in agreement with the Nomina Anatomica Veterinaria (2017).

Results

Dissection

The genital organs belonging to male red foxes were investigated in terms of macroanatomic point of view (Figure 3 and 6). Testis, epididymis and penis were measured from different places (Table 1 and 2). Scrotum was located in the inguinal region near the body and established on it. The scrotum of red foxes were found to be oval and extend horizontally to scrotum. The left testis was determined as larger than the other side (Table 1).

Epididymis was attached along the testis and located on the upper side of testis. Epididymis was divided into three parts. These parts were caput, corpus and cauda epididymis, similar the other animals. For epididymis measures, it was observed that the right side was shorter than the left side (Table 1). Ductus deferens originated from the cauda epididymis. Ductus deferens, musculus cremaster, arteria and vena testicularis was formed to funiculus spermaticus. Funiculus spermaticus was entered to abdomen trough the canalis inguinalis and then separated from each other.

Each other elements of funiculus spermaticus was turn to caudal and toward to pelvic cavity.

Accessory genital gland was only prostate in the red fox. It was observed that the shape of the prostate was circular and it surrounded the whole urethra.

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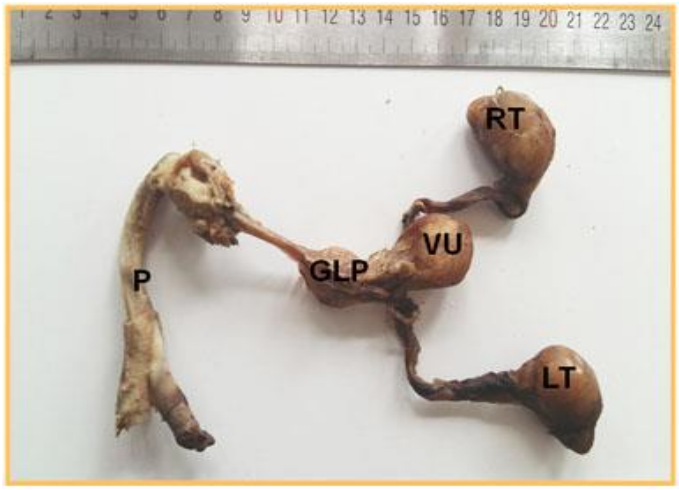

Fig. 4: Dorsal aspect of excised genital organs of the Red fox. GLP: prostate, LT: left testis, RT: right testis, P: penis, VU: vesica urinaria.

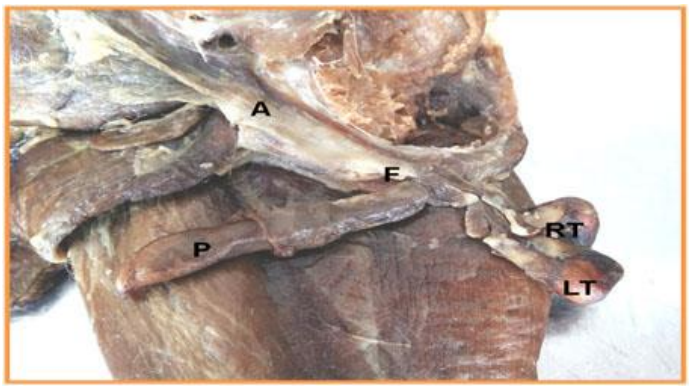

Figure 5: Right aspect of external male genital organs. A: anulus inguinalis, F: funiculus spermaticus, LT: left testis, P: penis, RT: right testis.

Figure 6: Lateral aspect of the penis. CP: corpus penis, GP: glans penis, PR: prepitium (internal lamina), RP: radix penis.

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Table 1: Morphometry of the testis and epididymis.

Number of foxes	Width of the testis (mm)		Lenght 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	**Dorso-ventral**	**Latero-medial**	**Dorso-ventral**	**Latero-medial**	**Dorso-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.

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3D reconstruction

Three dimentional 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).

Table 3: Morphometric measurements of red fox penis obtained by digital calliper and mimics program.

Number of foxes	Length of the penis	
	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 floppily position (Eljarah et al., 2012). Moreover, it was observed that scrotum was not in a floppily 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 prostatae as a single lobe (Dursun, 2010). Prostate

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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 begining 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 carnivors 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 urehtra 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, widht 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 reconsruction techniques could make anatomical studies easier to do without harming on wild animals.

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