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MAGNETIC RESONANCE IMAGING AND CROSS-SECTIONAL ANATOMY OF THE BRAIN OF THE RED FOX (VULPES VULPES)

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SUMMARY

This article presents the detailed anatomy of the red fox brain and associated structures using magnetic resonance imaging (MRI). The heads of five clinically normal adult foxes were used for this study. Contiguous T2-weighted transverse magnetic resonance images were acquired from just caudal to the level of cribriform plate to the caudal aspect of cerebellum, using 1.5-T Philips NT scanner. MR images were compared with corresponding frozen and formalinized cross sections of the heads of foxes at different levels. Most features of the brain that were identified on anatomic sections could be identified on the corresponding MR scans despite the low contrast between structures, particularly if adjacent bony and soft tissue structures were used as landmarks. Different anatomic and neuroanatomic structures were identified and labeled on the images as reference for MR morphology of the fox brain and related structures.

Key words: anatomy, magnetic resonance image, brain, fox.

INTRODUCTION

Magnetic resonance imaging (MRI) is potential in revealing normal anatomy as well as pathologic changes in tissues specially the CNS diseases (Buonanno et al., 1982; Panciera et al., 1987).

MRI detects changes in the magnetic properties

of the cellular nuclei of tissues. Computers receive detected signals and apply Fourier transformation to produce a series of voxels (volume elements) with a varying gray scale on X-ray film. On the T2-weighted images, the cerebral structures (cerebral hemispheres, thalamus, cerebellar hemispheres, pons, etc) and different muscles of the head appeared grey while CSF had a high signal intensity and appeared bright white in the subarachnoid spaces and the cerebral ventricles (Chaffin et al., 1997).

Magnetic resonance imaging (MRI) is commonly used for the study of the normal anatomy of the brain of dogs (Kraft et al., 1989; Karkkainen et al., 1991), cats (Hudson et al., 1995), neonatal foals (Chaffin et al., 1997) and camels (Arencibia et al., 2005). But there is no previous published material describing the MR imaging anatomy of the brain of the fox.

The purpose of the current study was to document the normal cross-sectional anatomy of the fox brain as depicted using series of MR images and transverse macroscopic anatomic sections.

MATERIALS AND METHODS

Normal five heads of the red fox (*Vulpes vulpes*) were used in this study. The foxes were adult and of different sexes (two females and three males). The foxes were killed and the heads were sectioned at the level of atlantoaxial joint. The heads were obtained immediately, cooled and imaged within 12 hours to minimize post-mortem changes.

MRI technique

A 1.5-T Philips NT scanner was used for the study. The fox head was placed in standard head coil. Initially, a midsagittal T2-weighted spin-echo image was obtained for anatomic orientation. The sagittal image facilitated positioning of subsequent transverse image slices. Contiguous T2-weighted transverse magnetic resonance images were acquired from 1 cm caudal to the center of cribriform plate to the levelof the osseous tentorial process. Imaging protocol parameters were: repetition time (TR) = 4759 ms, echo time (TE) = 120 ms, matrix = 245 x 256 pixels, Field of view = 160 mm, 6 mm slice thickness with 6 mm interslice spacing.

After MR images were obtained, the heads were frozen then sectioned using an electric band saw, with the slabs cut transversely to correspond with the MR images. All sections were cleaned, photographed and kept in formaldehyde solution for the future studies.

All identifiable anatomical structures of the fox brain were labeled in the axial plane images. The magnetic resonance images were compared with the gross anatomical sections (Hillmann, 1975; Schaller, 1992; Evans, 1993; Hudson et al., 1995; Arencibia et al., 2005).

RESULTS

The midsagittal section of the fox brain was represented with a macroscopic image in Fig. 1. Figure 2 shows the location of each slice of the transverse MR and gross images. Figs 3-10 display the sequence of the anatomically labeled originally acquired 6 mm thick transverse scans and cross gross images. The transverse images were oriented so that the right side of the head was to the viewer's left and the dorsal at the top. Figures 3-10a also includes inset images of fox brain showing the approximate orientation of each transverse section.

Clinically anatomic structures of the head of fox were identified and labeled. All features of forebrain anatomy that were found in other canine brain were clearly visualized in fox brain, including cingulate gyrus (Figs. 4, 6, 7), caudate nucleus (Fig. 6), internal capsule (Fig. 6), corpus callosum (Figs. 1, 7) and hippocampus (Fig. 7).

The cerebellum of the fox was large and located posterior to and on a level with the rest of the brain (Figs. 9, 10). The ventricles appeared clearly in the MR images.

Fig. 1

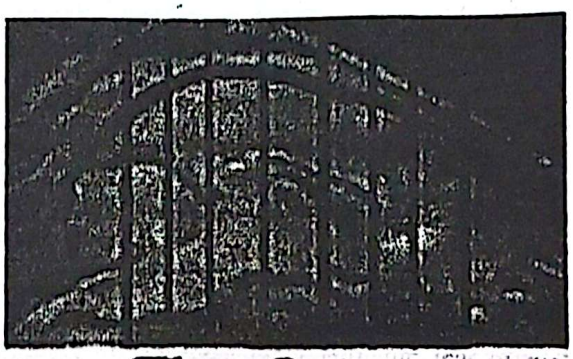

Fig. 2

Figure 1. Macroscopic image of Midsagittal section of normal fox brain. Rostral is to the right and dorsal is to the top of the image. 1, Ethmoturbinalia (Ethmoturbinates); 2, Cerebrum; 3, Gyrus cinguli (Cingulate gyrus); 4, Septum telencephali; 5, Thalamus; 6, Corpus callosum; 7, Fornix; 8, Frontal bone; 9, Parietal bone ; 10,Tentorium cerebelli; 11, Cerebellum; 12, Pons; 13, Medulla oblongata; 14, Ventriculus quartus (Fourth ventricle); 15, Medulla spinalis (Spinal cord); 16, Cavum subarachnoidale (Subarachnoid space); 17, Aqueductus mesencephali (Mesencephalic aqueduct); 18, Pedunculus cerebri; 19, Hypothalamus; 20, N. opticus (Optic nerve).

Figure 2. Labeled image of Midsagittal section of normal fox brain demonstrating levels of MR. Rostral is to the right and dorsal is to the top of the image. Each number represents the figure number and each vertical line represents the location of each MR image and gross cross section of the following transverse images (Figs. 3-10).

Fig. 3A

Fig. 3B

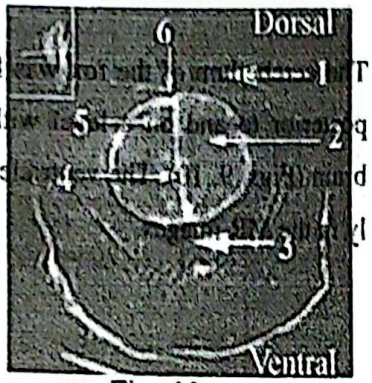

Fig. 4A

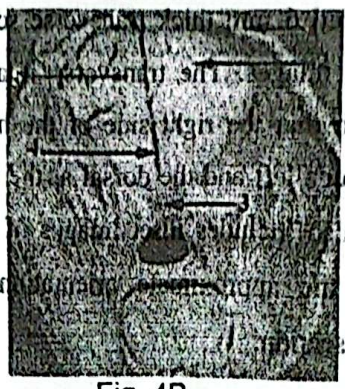

Fig. 4B.

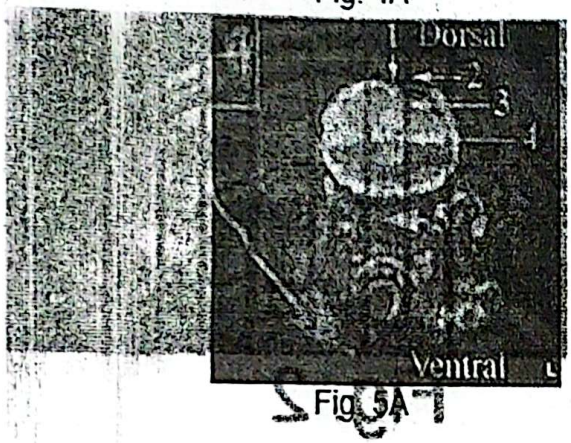

Fig. 5A

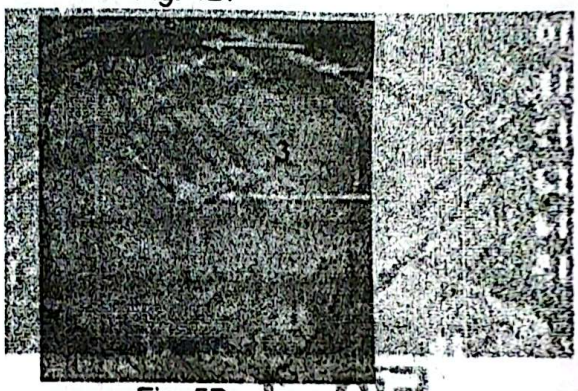

Fig. 5B

Figure 3. (A) T2-weighted transverse MR image and (B) gross cross section of the brain of fox at a level of 1 cm caudal to center of cribriform plate. See Fig. 2 for exact slice location. 1, Fissura longitudinalis cerebri (Cerebral longitudinal fissure); 2, Cerebral hemisphere; 3, Body of presphenoid bone; 4, Meatus nasopharyngeus; 5, Frontal pole; 6, Bulbus oculi.

Figure 4. (A) T2-weighted transverse MR image and (B) gross cross section of the brain of fox at a level of 1.6 cm caudal to center of cribriform plate. See Fig. 2 for exact slice location. 1, Os parietale (Parietal bone); 2, Cerebral hemisphere; 3, Body of basisphenoid bone; 4, Fissura longitudinalis cerebri (Cerebrall longitudinal fissure); 5, Gyrus cinguli (Cingulate gyrus); 6, Sinus sagitalis dorsalis (Dorsal sagittal sinus).

Figure 5. (A) T2-weighted transverse MR image and (B) gross cross section of the brain of fox at a level of 2.2 cm caudal to center of cribriform plate. See Fig. 2 for exact slice location. 1, Sinus sagittalis dorsalis (Dorsal sagittal sinus); 2, Parietal bone; 3, Cerebral hemisphere; 4, Ventriculus lateralis (Lateral ventricle); 5, Os basisphenoidale (Body of basisphenoid bone).

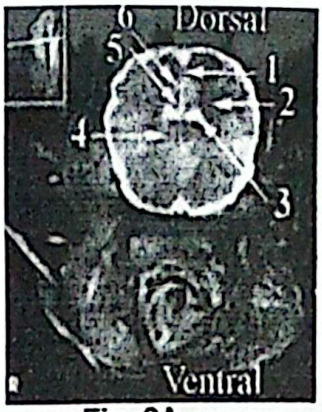

Fig. 6A

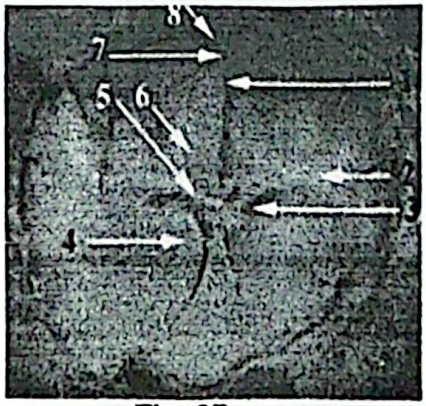

Fig. 6B

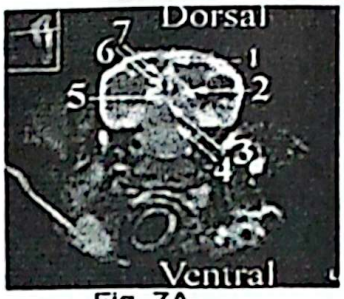

Fig. 7A

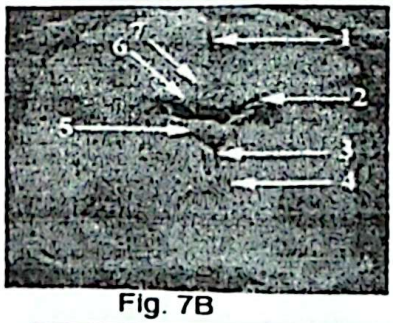

Fig. 7B

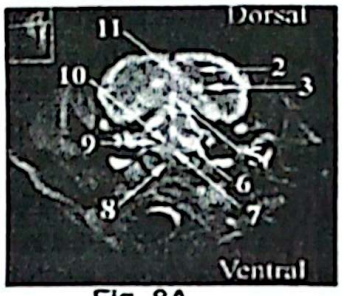

Fig. 8A

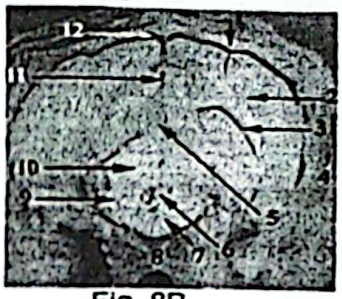

Fig. 8B

Figure 6. (A) T2-weighted transverse MR image and (B) gross cross section of the brain of fox at a level of 2.8 cm caudal to center of cribriform plate. See Fig. 2 for exact slice location. 1, Fissura longitudinalis cerebri (Cerebral longitudinal fissure); 2, Capsula interna (Internal capsule); 3, Ventriculus lateralis (Lateral ventricle); 4, Head of caudate nucleus; 5, Corpus callosum; 6, Gyrus cinguli (Cingulate gyrus); 7, Falx cerebri; 8, Sinus sagittalis dorsalis (Dorsal sagittal sinus).

Figure 7. (A) T2-weighted transverse MR image and (B) gross cross section of the brain of fox at a level of 3.4 cm caudal to center of cribriform plate. See Fig. 2 for exact slice location. 1, Fissura longitudinalis cerebri (Cerebral longitudinal fissure); 2, Ventriculus lateralis (Lateral ventricle); 3, Ventriculus tertius (Third ventricle); 4, Hypothalamus; 5, Hippocampus; 6, Corpus callosum; 7, Gyrus cinguli (Cingulate gyrus).

Figure 8. (A) T2-weighted transverse MR image and (B) gross cross section of the brain of fox at a level of 4.0 cm caudal to center of cribriform plate. See Fig. 2 for exact slice location. 1, Os parietale (Parietal bone); 2, Cerebral hemisphere; 3, Ventriculus lateralis (Lateral ventricle); 4, Muscle temporalis; 5, Third ventricle; 6, Region of mesencephalic aqueduct; 7, Cerebral peduncle (Crus cerebri); 8, Body of basisphenoid bone; 9, Corpus geniculatum mediale (Medial geniculate body); 10, Tegmentum mesencephali (Mesencephalic tegmentum); 11, Fissura longitudinalis cerebri (Cerebral longitudinal fissure); 12, Sinus sagitalis dorsalis (Dorsal sagittal sinus).

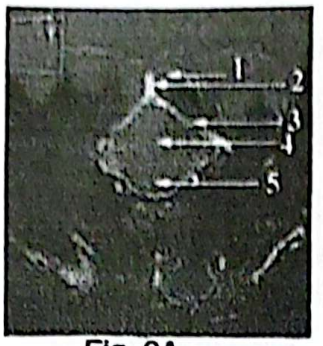

Fig. 9A

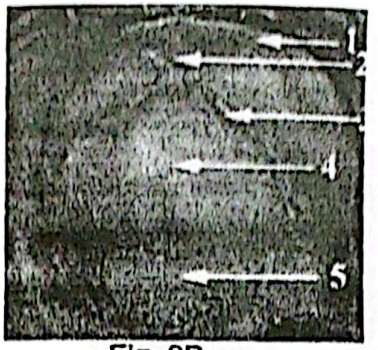

Fig. 9B

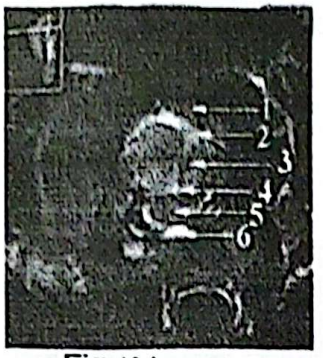

Fig.10A

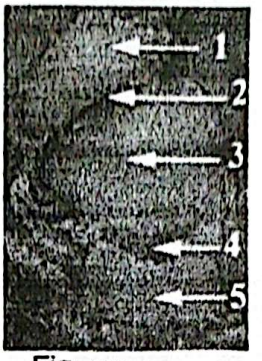

Fig. 10B

Figure 9. (A) T2-weighted transverse MR image and (B) gross cross section of the brain of fox at a level of 4.6 cm caudal to center of cribriform plate. See Fig. 2 for exact slice location. 1, Cerebral hemisphere; 2, Fissura longitudinalis cerebri (Cerebral longitudinal fissure); 3, Fissura transversa cerebri (Transverse fissure containing tentorium cerebelli); 4, Cerebellum; 5, Pons.

Figure 10. (A) T2-weighted transverse MR image and (B) gross cross section of the brain of fox at a level of 5.2 cm caudal to center of cribriform plate. See Fig. 2 for exact slice location. 1, Cerebral hemisphere (Polus occipitalis); 2, Fissura transversa cerebri (Transverse fissure); 3, Cerebellum; 4, Ventriculus Quartus (Fourth ventricle); 5, Medulla oblongata (Myelencephalon); 6, Basioccipital bone.

DISCUSSION

This article presented the first series of MRI-based anatomically labeled images of the fox brain. The present study allow for the visualization of the internal and external structures of the fox brain from the macroscopic and MR images. Different structures of the brain were observed clearly due to excellent contrast between grey and white matter, with white matter of lower intensity than grey.

The present investigation had revealed both similarities and differences between the fox brain and the brains of other carnivores (Kraft et al., 1989; Hudson et al., 1995; Kii et al., 1997). The lateral ventricles of fox are similar to that of dogs (Kraft et al., 1989) while larger than that of cats (Hudson et al., 1995).

MR images of the fox brain provided complete details of the anatomical structures of the fox brain than other imaging techniques and correlated well with corresponding gross specimens.

MRI has some advantages over computed tomography (CT), providing superior spatial resolution and great definition of soft tissue anatomic detail, especially in the caudal fossa of the cranial vault where beam-hardening artifacts obscured the nervous tissue (Komegay, 1991).

Noninvasive MR imaging could be useful in studies of lesioned animals where the extent of damage could be assessed before time-consuming and expensive behavioral trials were carried out (Thompson et al., 1993).

In conclusion, as demonstrated in this study, MR images of the normal fox brain provide excellent visualization of many anatomic structures of the brain that was labeled as a reference for MR anatomy of the fox brain.

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