Ann Med Res 2021;28(11):1999-2004

Annals of Medical Research
DOI: 10.5455/annalsmedres.2021.01.100

Original Article

A understanding of the three dimensional microsurgical anatomical architecture of the temporal lobe with its functions

Murat Atar[1], Ceren Kizmazoglu[2], Inan Uzunoglu[3], Ilker Deniz Cingoz[4], Gokhan Gurkan[3], Ismail Kaya[4], Gulden Sozer[5], Ahmet Ozdilmac[1], Nurullah Yuceer[3]

[1]Department of Neurosurgery, Sultan Abdülhamid Han Training and Research Hospital, Istanbul, Turkey
[2]Department of Neurosurgery, Faculty of Medicine, Dokuz Eylul University, Izmir, Turkey
[3]Department of Neurosurgery, Katip Celebi University Ataturk Training and Research Hospital, Izmir, Turkey
[4]Department of Neuroseurgery, Dumlupinar University Kutahya Evliya Celebi Training and Research Hospital, Kutahya, Turkey
[5]Department of Pathology, Forensic Medicine Institution, Izmir, Turkey

Abstract

Aim: This study aimed to evaluate the human brain temporal lobe white matter pathways with respect to microsurgical anatomy, reveal the relationship between these white matter pathways, evaluate their functions, which are already known in the literature, and contribute to the literature to establish safe temporal region surgical interventions.

Material and Methods: 10 specimens of postmortem human brain hemispheres were fixed in accordance with Klingler's method. Subsequently, dissection of the temporal lobe white matter pathways was performed under a surgical microscope. Each stage of dissection was achieved using the technique of merging multiple focus images in high-quality three-dimensional images.

Results: The data obtained in lateral-to-medial and medial-to-lateral dissections were compatible with the literature. Moreover, microsurgical three-dimensional architectural structure of temporal lobe white matter pathways has been clearly revealed. The horizontal and vertical segments of superior longitudinal fasciculus were detected. The limbic system, connection of central cores with the temporal lobe, temporal stems region, and relationship with other fiber systems have been shown in this study. The importance of the temporal stem and Meyer's loop for safe interventions on temporal lobe has been noted.

Conclusion: Temporal region white matter pathways should be handled in a multimodal system, and anatomical knowledge of these white matter pathways should be mastered before performing temporal surgical interventions. Furthermore, the surgical strategy and preoperative planning should be discussed considering the relationship between the lesion and white matter pathways, thereby reducing neurosurgical morbidity and mortality.

Keywords: Cerebrum; fiber dissection; temporal lobe; white matter functions; white matter pathways

INTRODUCTION

The information on the structure and functions of the human brain is insufficient. Both the organization and management of the cerebral cortex are still being examined, and new information is emerging. Moreover, three-dimensional examination of brain parenchyma architecture and macroscopic display of white matter pathways are of great importance for current studies. The ability of neurosurgeons to master the functional architecture of the brain in a 3D macroscopic manner facilitated the development of safe surgical techniques. In the 1800s, in demonstrating the white matter fiber system, researchers used gross dissection and then myelin dyeing materials and degeneration methods in clinical cases. Because of these studies, a specific major association of fiber bundles, such as the cingulum and uncinate fasciculus, were identified and named. Approximately 80 years ago, Klingler published a new method that has attracted considerable attention from researchers (1). The dramatic improvement in skull base surgery was achieved because of cadaver dissection (2). A 3D examination of the brain parenchyma structure in microneurosurgical laboratories of neurosurgeons allowed the development of safe surgical techniques. Macroscopic exposure of white matter pathways played an important role in revealing the functions and roles of the brain (3,4). Furthermore, imaging methods are of considerable importance in the development of neuroscience and brain research.

Received: 26.01.2021 **Accepted:** 29.03.2021 **Available online:** 22.11.2021
Corresponding Author: Gokhan Gurkan, Department of Neurosurgery, Katip Celebi University Ataturk Training and Research Hospital, Izmir, Turkey **E-mail:** gokhangurkan88@gmail.com

Moreover, improvements in magnetic resonance imaging techniques since the mid-1980s and development of diffusion tensor MRI technique have facilitated the in vivo definition of major white matter pathways. With developments in magnetic resonance tractography and diffusion spectrum imaging techniques, major steps have been taken in the in vivo presentation of white matter fiber bundles (5). In this study, a macroscopic demonstration of the relationship between temporal white matter pathways and other brain regions is shown, their algorithmic classification was established, and their role and functions within the framework of macroscopic anatomy was evaluated, contributing to modern neurosurgical techniques by revealing safe surgical areas.

MATERIALS and METHODS

In this study, 10 specimens of postmortem brain hemispheres were included. The cause of death in donors of these specimens was not brain pathology. The mean postmortem period of brain fixation with formalin was 16.50 ± 4.05 (10–25) h. Based on Klingler's method; these specimens were stored in 10% formalin solution for at least 2 months. Subsequently, the arachnoid, pia mater, and vascular structures were removed using an operating microscope. The specimens were then washed under running water for several hours to remove the formalin and frozen in the refrigerator freezer (−20°C) for at least 2 weeks. Then, dissection was performed under a surgical microscope. A professional photograph studio was created such that high-quality 3D images of each stage of dissection were obtained by combining multiple-focus images using Canon EOS 550 D (Tokyo, Japan). The cerebral cortex was decorticated using an aspirator and spatula. Lateral-to-medial and medial-to-lateral dissections of the specimens were obtained. Short association fibers (U fibers) were removed, and long major association fibers were accessed on the lateral and medial faces of the specimens. Moreover, each stage was observed under the Leica M620 microscope (Leica Microsystems GmbH, Wetzlar, Germany). The primary major connections of the temporal lobe with the parietal, frontal, occipital, and central cores were examined. The importance of the temporal stem region, which provides the central core connection of the temporal lobe and is greatly important in temporal surgery, was emphasized. The fiber systems forming the temporal stems, i.e., anterior commissure, amygdala fugal fibers, inferior fronto-occipital fasciculus, uncinate fascicle, corpus callosum, and Meyer's loop, and the relationship among them were examined.

Our research study has received review and approval was obtained from the Ethics Committee of Izmir Katip Celebi University Non-Interventional Clinical Research Institutional Review Board (26 November 2015; approval no.221).

RESULTS

Hemispheres were examined first by lateral and then medial dissection. Dissections were then performed in a systematically gradual manner using a certain algorithm. The gradual dissections and the anatomical formations observed were then explained in detail by images. The relation of the temporal lobe with the other lobes was then systematically examined.

Connection between Temporal Lobe and Frontal–Parietal Lobe

At this stage, the arcuate fasciculus was examined using the horizontal and vertical segment of the superior longitudinal fasciculus, which is the primary pathway. Figure 1 shows that this connection.

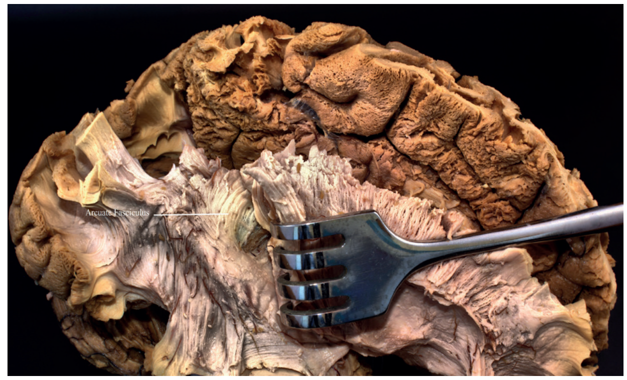

Figure 1. After decortication and gradual dissection, the arcuate fasciculus, which is the vertical segment of SLF, was reached. The insula was clearly exposed with removal of the temporal, frontal, and parietal operculum

Connection between Temporal and Parietal Lobes

At this stage, the middle longitudinal fasciculus, which was the primary pathway, was examined. Although the tractography studies in the literature identified that it was more superficial than the inferior fronto-occipital fasciculus and extended from temporal pole to the angular gyrus towards the parietal lobe, it was not clear in our dissection study.

Connection between Temporal Lobe and Occipital Lobe

At this stage, the inferior longitudinal fasciculus, which is the primary fiber pathway connecting the temporal region to the occipital lobe, was examined. Figure 2 shows that this connection.

Figure 2. Representation of the arcuate fasciculus, which is the vertical segment of the superior longitudinal fasciculus on the surface and whose orientation to the temporal lobe has been clearly revealed and, at a deeper level, the representation of the inferior longitudinal fasciculus parallel to the level of inferior temporal gyrus in the temporal lobe

Connection between Temporal Lobe and Limbic System

In this stage, the connections of cingulum, fornix, hippocampus, mammillary body, and thalamus were examined. Figure 3 shows that limbic system.

Figure 3. Representation of the fornix, mamillary body, and mammillothalamic tract

Figure 4. Anterior commissure fibers connecting both temporal lobes and the relationship between the deeper optic nerve and chiasma

Figure 5. Anterior commissure and the Meyer's loop that is located deeper

Connection between Temporal Lobe and Central Core

At this stage, insula dissection was performed at the central core. In particular, the temporal stem region, comprising six different fiber systems and intersecting the main fiber paths connecting the temporal lobe to the central core, was observed.

Figure 4,5 shows that these connections. These major fibers are as follows: anterior commissure, amygdala fugal fibers, inferior fronto-occipital fasciculus, uncinate fasciculus, corpus callosum, and Meyer's loop.

DISCUSSION

In our study, the relationship between temporal region white matter pathways and other lobes was algorithmically classified and systematically evaluated in this context. The connections of the temporal region are examined under five main topics. These topics include frontal lobe, parietal lobe, occipital lobe, limbic system, and central core connections. Catani et al. described the superficial anterior segment in humans using diffusion tensor imaging (DTI) tractography (6,7). In their studies, Fernandez-Miranda et al. and Martino et al. described (i) the superficial anterior segment, (ii) superficial posterior segment, and (iii) deep and long tract that classically represents the arcuate fasciculus (8,9). In addition to these studies, Thiebaut de Schotten et al. demonstrated that the caudal connection of this fiber ended in the inferior parietal lobe. DTI tractography and anatomical examinations in their study reported that the posterior connection of this tract was to the supramarginal gyrus and posterior part of the superior temporal gyrus (10). Kaplan et al. reported that the tract is connected to the ventral part of the precentral gyrus in the frontal lobe, while Ingham et al. revealed that the tract is divided into two groups: anterior region, which is the Broadmann area 6 (ventral premotor cortex), and posterior region, which is the Broadmann area 4 responsible for the somatotropic representation of the tongue, lip, and pharynx. They reported that both areas were responsible for the last step of producing speech (11,12). Duffau et al. induced repeatable spelling disorders (dysarthria or anarthria) by intraoperative electrical stimulation of this pathway on the left side. Based on this observation, Duffau designed this fiber as a "dorsal phonological pathway" and suggested that there might be a network between the spelling loop and verbal working memory (13). Clearly, the studies revealed that the superficial posterior segment of the SLF connects the posterior temporal lobe and angular gyrus (6-9). Consequently, the connections of the inferior parietal lobe have been clearly indicated: the anterior part of the perisylvian SLF is connected to the supramarginal gyrus, while its posterior part is projected into the angular gyrus. This anatomical distinction of the SLF demonstrates the rostro-caudal organization of the function of the dominant inferior parietal lobe. Duffau et al. reported that the connection of the supramarginal gyrus to the anterior component of the SLF plays a role in speech articulation, while Parker et al. revealed that the connection of the angular gyrus to the posterior component functions plays a role in language perception (13,14). Martino et al. and Bernal et al. reported that there is an extended direct link between the temporal and frontal lobes of the arcuate fasciculus and that this tract is connected to the precentral gyrus and posterior part of the inferior and middle frontal gyri in the frontal lobe (9,15). Catani et al. , Martino et al. , and Glasser et al. revealed that the tract is connected to the posterior part of the middle and inferior temporal gyri in the temporal lobe (6,9,16).

Duffau et al. and Saur et al. induced reproducible phonemic paraphasia, i.e., disorders that affect the phonological structure with intraoperative electrostimulation of the arcuate fasciculus. In these studies, the transformation of the target word was provided by substitution, deletion, insertion, or displacement of one and more phonemes (17,18). Naeser et al. reported that the arcuate fasciculus functions in differentiating semantic and phonetic actions in accordance with the dual current model, while Hickok et al. reported that it is the dorsal phonological route of language function (19,20). The isotope studies in non-human primates by Schmahmann et al. and the DTI analyses in humans by Makris et al. revealed that the SLF has two non-perisylvian components that provide frontoparietal connections horizontally and called these tracts SLF-1 and SLF-2 (21,22). In our study, all SLF-related components were not clearly identified; however, the horizontal and vertical segments of the SLF have been demonstrated according to the literature.

In their human DTI tractography studies, Cabeza et al. , Makris et al. , and De Witt Hamer et al. defined the middle longitudinal fasciculus but its function was not clearly revealed. In these studies, they indicated its traject and terminations using DTI of the human brain. They described it as a thin tract deep in the arcuate fasciculus, which is connected to the superior temporal and angular gyri (23-25). The anatomical connectivity of this tract supports the hypothesis that it is involved in understanding the language in the dominant hemisphere and spatial attention and episodic (comprising episodes) memory in the nondominant hemisphere. Although the DTI tractography studies in the literature showed that it extended more superficially compared to the IFOF and from the temporal pole to the parietal lobe toward the angular gyrus, our dissection study did not clearly reveal it.

In their DTI tractography studies, Catani et al. , Epelbaum et al. , and Martino et al. demonstrated that the inferior longitudinal fasciculus (ILF) contains direct and indirect routes (26-28). The indirect path, e.g., occipital projection system, is formed by connecting the adjacent gyrus in the inferior temporal and occipital convections using U-shaped fibers; however, the direct pathway is formed by long fibers localized in the middle of the short fibers. They demonstrated that the connections of this fiber are located on the lateral surface of the temporal lobe, anterior part of the middle and inferior temporal gyri, fusiform gyrus, parahippocampal gyrus, amygdala, and hippocampus. Furthermore, there are still uncertainties regarding the ILF function. Epelbaum et al. , Catani et al. , and Fox et al. suggested that the function of the fiber is related to facial recognition, visual perception, reading, and language (27). In their study, Mandonnet et al. reported that, particularly, this tract and the UF form the indirect ventral semantic pathway in the semantic mechanism of language (29). In our study, ILF was clearly demonstrated and revealed to be the pathway connecting the temporal and occipital lobes.

The IFOF is the ventral association fiber connecting the frontal lobe to the occipital, parietal and temporal lobes. It was originally described by Curran in 1909 using postmortem fiber dissection. Using this time period, many researchers have illuminated this tract using DTI tractography and white matter dissection (29). In our study, IFOF has been clearly demonstrated, and its relationship to other fiber systems has been revealed in accordance with the literature. Particularly, its close relationship to the UF and its importance in the 3D architecture of temporal stems were emphasized.

The UF is a "C"-shaped pathway connecting the temporal anterior region and frontal lobe. The UF belonged to the limbic system; however, its functions were not clearly understood. Its functions are related to emotional processing: memory, behavioral process, social cognition, and language. Moreover, studies on neurophysiology, neuroimaging, and lesion have demonstrated that, considering that its lesions cause cognitive dysfunction and semantic dementia resulting in slight memory loss, UF is important for recombining and creating memory that is divided into sections (30). Vigneau et al. reported that the temporal pole is part of the semantic network that begins with the inferior longitudinal fasciculus (connecting the posterior temporal and occipital areas to the temporal pole) and continues with the UF (31). Duffau et al. reported only temporary language skill losses with removal of the UF in their study (32). In the studies on the long-term results of other studies on naming well-known faces, this fiber pathway is involved in gathering and creating proper, meaningful, and smooth nouns (33). In our study, the UF is shown in coherence with the literature. Its proximity and depth relations with the IFOF and Meyer's loop are particularly noteworthy, and attention should be given to this relationship in temporal lobe surgery.

The distance between Meyer's loop and temporal pole is important for safe epilepsy surgery. Wang et al. reported this distance at approximately 36 mm in the South Chinese population and revealed that these values are similar to that in the Caucasian and Japanese populations (34). Meyer's loop was located deep in the middle temporal gyrus. In the temporal stem, the posterior boundary of the UF and anterior boundary of the Meyer's loop are extremely close to each other (35). The inferior occipitofrontal fasciculus is located in the temporal stem around the Meyer's loop. Optical radiation in both hemispheres laterally extends between the lateral geniculate body and occipital pole. Peltier et al. measured the distance from the front end of the Meyer's loop to the sulcus 105 mm on average. They determined the average width of optical radiation at the level of the inferior horn at 17 mm and reported an increase in the thickness of the optical radiation from the temporal lobe to the occipital lobe and width close to 23 mm (36).

The corpus callosum, divided into five anatomical zones (from front to back), is the largest pathway that connects the two cerebral hemispheres with >300 million fibers: genu, rostrum, body (anterior, middle, posterior), isthmus, and splenium (37). The corpus callosum is one of the few white matter pathways that are individually defined using conventional MRI. Demonstration of the morphology of the corpus callosum has been the aim of extensive studies to explain Tourette's syndrome, Down's syndrome, depression, schizophrenia, and dyslexia observed in HIV/AIDS (38). In our study, corpus callosum fibers were clearly revealed in coherence with those in the literature.

CONCLUSION

Significance of optical radiation and temporal stem in temporal lobe surgery

It is quite difficult to demonstrate optical radiation and Meyer's loop without damaging other fiber structures using the fiber dissection technique because of the dense network of the fibers of the UF, occipitofrontal fasciculus, anterior commissure, inferior thalamic peduncle, posterior thalamic peduncle, temporopontine fibers, occipitopontine fibers, and other fiber systems. This structure is called the sagittal stratum, and demonstration of one fiber occurs with damage to others (39).

After multiple years of studies, a temporal stem terminology has been developed. The temporal stem comprises the anterior temporal lobe, thalamus, and connections of the brain stem and frontal lobe. Moreover, the functional importance of the temporal stem in surgical approaches is because it connects the polymodal association areas in the anterior temporal lobe to the frontal lobe, basal forebrain, thalamus, and opposite temporal lobe (40).

The understanding of 3D microsurgical anatomical architecture of the human brain is indisputably important for the success of the surgical intervention. White matter pathways, their relationship with each other, localizations, and functions should be discussed in a multimodal system, and preoperative planning should be performed in accordance with this anatomical knowledge.

The temporal lobe has a rich structure in terms of function. It is necessary to have detailed anatomical knowledge before performing surgical interventions in this area because of the visual and auditory pathways located therein and their importance for speech and understanding and connection to the limbic system. In surgical approaches, the terminology of safe surgical areas is considerably important.

The functions of white matter pathways and their relationship with each other should be determined for safe surgical approaches. Moreover, morbidity and mortality will be reduced in surgeries performed in this manner.

Highlights

* *Temporal region white matter pathways and functions should be handled in a multimodel system.*

* *In safe temporal surgical approaches, the temporal stem anatomy should be known.*

* *Anatomical knowledge of these white matter pathways should be mastered before performing temporal surgical interventions.*

Acknowledgments: Preparation for publication of this article is partly supported by Turkish Neurosurgical Society. The authors acknowledge the staff of the Forensic Medicine Institution for their technical support in the completion of this study.

Competing Interests: The authors declare that they have no competing interest.

Financial Disclosure: There are no financial supports.

Ethical Approval: Our research study has received review and approval was obtained from the Ethics Committee of Izmir Katip Celebi University Non-Interventional Clinical Research Institutional Review Board (26 November 2015; approval no.221).

REFERENCES

1. Ludwig E, Klingler J. Atlas Cerebri Humani. Der inere Bau des Gehirns dargestellt auf Grund mackroskopischer Praparate. Boston: Brown; 1956
2. Wanibuchi M, Friedmann AH, Fukushima T. Photo atlasof skull base dissection: techniques and operative approaches. Ann R Coll Surg Engl 2010; 92:717-9.
3. Duffau H, Capelle L, Denvil D, Sichez N, et al. Usefulness of intraoperative electrical subcortical mapping during surgery for low-grade gliomas located within eloquent brain regions: functional results in a consecutive series of 103 patients. J Neurosurg 2003; 98:764-78.
4. Fernandez-Miranda JC, Rhoton AL Jr, Kakizawa Y, et al. The claustrum and its projection system in the human brain: a microsurgical and tractographic anatomical study. J Neurosurg 2008;108:764-74.
5. Catani M, Howard RJ, Pajevic S, Jones DK. Virtual in vivo interactive dissection of white matter fasciculi in the human brain. Neuroimage 2002;17:77-94.
6. Catani M, Jones DK, Ffytche DH. Perisylvian language networks of the human brain. Ann Neurol 2005;57:8-16.
7. Catani M, Mesulam M. The arcuate fasciculus and the disconnection theme in language and aphasia: History and current state. Cortex 2008;44:953-61.
8. Fernandez-Miranda JC, Rhoton AL, Jr., Alvarez-Linera J, et al. Three-dimensional microsurgical and tractographic anatomy of the white matter of the human brain. Neurosurgery 2008;62: 989-1026; discussion 1026-8.
9. Martino J, De Witt Hamer PC, Berger MS, et al. Analysis of the subcomponents and cortical terminations of the perisylvian superior longitudinal fasciculus: A fiber dissection and DTI tractography study. Brain Struct Funct 2013;218:105-21.
10. Thiebaut de Schotten M, Dell0Acqua F, Forkel SJ, et al. A lateralized brain network for visuospatial attention. Nat Neurosci 2011;14:1245-6.
11. Kaplan E, Naeser MA, Martin PI, , et al. Horizontal portion of arcuate fasciculus fibers track to pars opercularis, not pars triangularis, in right and left hemispheres: A DTI study. Neuroimage 2010;52:436-44.

12. Ingham RJ, Fox PT, Ingham JC, et al. Brain correlates of stuttering and syllable production: Gender comparison and replication. J Speech Lang Hear Res 2004;47:321-41.
13. Duffau H, Gatignol P, Denvil D, et al. The articulatory loop: Study of the subcortical connectivity by electro stimulation. Neuroreport 2003;14:2005-8.
14. Parker GJ, Luzzi S, Alexander DC, et al. Lateralization of ventral and dorsal auditory-language pathways in the human brain. Neuroimage 2005;24:656-66.
15. Bernal B, Altman N. The connectivity of the superior longitudinal fasciculus: A tractography DTI study. Magn Reson Imaging 2010;28:217-25.
16. Glasser MF, Rilling JK. DTI tractography of the human brains language pathways. Cereb Cortex 2008;18:2471-82.
17. Duffau H, Capelle L, Sichez N, Denvil D, Lopes M, et al. Intraoperative mapping of the subcortical language pathways using direct stimulations. An anatomofunctional study. Brain 2002;125:199-214.
18. Saur D, Kreher BW, Schnell S, et al. Ventral and dorsal pathways for language. Proc Natl Acad Sci USA 2008;105:18035-40.
19. Naeser MA, Alexander MP, Helm-Estabrooks N, et al. Aphasia with predominantly subcortical lesion sites: Description of three capsular/putaminal aphasia syndromes. Arch Neurol 1982;39:2-14.
20. Hickok G, Poeppel D. Dorsal and ventral streams: A framework for understanding aspects of the functional anatomy of language. Cognition 2004;92:67-99.
21. Schmahmann JD, Pandya DN, Wang R, et al. Association fibre pathways of the brain: Parallel observations from diffusion spectrum imaging and autoradiography. Brain 2007;130:630-53.
22. Makris N, Kennedy DN, McInerney S, et al. Segmentation of subcomponents within the superior longitudinal fascicle in humans: A quantitative, in vivo, DT-MRI study. Cereb Cortex 2005;15:854-69
23. Cabeza R, Ciaramelli E, Olson IR, Moscovitch M. The parietal cortex and episodic memory: An attentional account. Nat Rev Neurosci 2008;9:613-25.
24. Makris N, Papadimitriou GM, Kaiser JR, et al. Delineation of the middle longitudinal fascicle in humans: A quantitative, in vivo, DT-MRI study. Cereb Cortex 2009;19:777-85.
25. De Witt Hamer PC, Moritz-Gasser S, Gatignol P, Duffau H. Is the human left middle longitudinal fascicle essential for language? A brain electrostimulation study. Hum Brain Mapp 2011;32:962-73.
26. Catani M, Jones DK, Donato R, Ffytche DH. Occipito-temporal connections in the human brain. Brain 2003;126: 2093-107.
27. Epelbaum S, Pinel P, Gaillard R, et al. Pure alexia as a disconnection syndrome: New diffusion imaging evidence for an old concept. Cortex 2008;44:962-74.
28. Martino J, De Witt Hamer PC, Vergani F, et al. Cortexsparing fiber dissection: An improved method for the study of white matter anatomy in the human brain. J Anat 2011;219:531-41.
29. Mandonnet E, Nouet A, Gatignol P, et al. Does the left inferior longitudinal fasciculus play a role in language? A brain stimulation study. Brain 2007;130:623-9.
30. Agosta F, Henry RG, Migliaccio R, et al.Language networks in semantic dementia. Brain 2010;133:286-99.
31. Vigneau M, Beaucousin V, Herve PY, et al. Meta – analyzing left hemi-sphere language areas: Phonology, semantics, and sentence processing. Neuroimage 2006;30:1414-32.
32. Duffau H, Gatignol P, Moritz-Gasser S, Mandonnet E. Is the left uncinate fasciculus essential for language? A cerebral stimu-lation study. J Neurol 2009;256:382-9.
33. Damasio H, Tranel D, Grabowski T, et al. Neural systems behind word and concept retrieval. Cognition 2004;92:179-29.
34. Wang YX, Zhu XL, Deng M, et al. The use of diffusion tensor tractography to measure the distance between the anterior tip of the Meyer loop and the temporal pole in a cohort from Southern China. J Neurosurg. 2010;113:1144-51.
35. Taoka T, Sakamoto M, Nakagawa H, et al. Diffusion tensor tractography of the Meyer loop in cases of temporal lobe resection for temporal lobe epilepsy: correlation between postsurgical visual field defect and anterior limit of Meyer loop on tractography. AJNR Am J Neuroradiol 2008;29:1329-34.
36. Peltier J, Travers N, Destrieux C, Velut S. Optic radiations: a microsurgical anatomical study. J Neurosurg 2006;105:294-300.
37. Fabri M, Pierpaoli C, Barbaresi P, Polonara G. Functional topography of the corpus callosum investigated by DTI and fMRI.World JRadiol 2014;6: 895-906.
38. Thompson PM, Narr KL, Blanton RE, Toga AW. Mapping structural alterations of the corpus callosum during brain developmentand degeneration. In: Zaidel, E., Iacoboni, M. (Eds.), The Parallel Brain: The Cognitive Neuroscience of the Corpus Callosum, 2003;93-130.
39. Yasargil MG, Ture U, Yasargil DC. Impact of temporal lobe surgery. J Neurosurg 2004;101:725-38.
40. Peuskens D, van Loon J, van Calenbergh F, et al: Anatomy of the anterior temporal lobe and the frontotemporal region demonstrated by fiber dissection. Implications for surgical approaches to the mesial temporal lobe. Neurosurgery 2004;55:1174-84.