Int J Clin Exp Med 2014;7(3):515-522
www.ijcem.com /ISSN:1940-5901/IJCEM1401017

Original Article

An MRI study of age-related changes in the dimensions related temporal lobe

Ismail Salk[1], Mehmet Haydar Atalar[1], Ferhat Sezer[1], Hulusi Egilmez[1], Ali Cetin[2], Mubeccel Arslan[1]

Departments of [1]Radiology, [2]Obstetrics and Gynecology, Cumhuriyet University Faculty of Medicine, 58140 Sivas, Turkey

Received January 8, 2014; Accepted February 11, 2014; Epub March 15, 2014; Published March 30, 2014

Abstract: The aim of this study was to determine the effect age-related changes on the MRI-based parameters related to several measurement of temporal lobe in the lifespan of adult persons. MRI scans of head (n=236) were reviewed retrospectively to identify abnormalities of temporal lobe, third ventricle, and temporal horn of lateral ventricle. Patients were divided into 3 study groups according to their age. Using axial and coronal views of the cerebral hemispheres, interuncal distance, thickness of temporal lobe, Evans' ratio, and the width of third ventricle, height of hippocampus, width of choroid fissure, and width of the temporal horn were measured. The mean age of study group was 44.2±17.7 (18 to 86). The gender ratio (F/M) of study group was 129/107. There is mild-moderate significant correlation between age and Evans' ratio ($r=0.35$, $p<0.05$). There is mild significant correlation between age and interuncal distances ($r=0.24$, $p<0.05$). There was no correlation between age and third ventricle widths, temporal lobe widths, and temporal horn widths of left and right sides of brain ($p>0.05$). A mild and significant correlation was present between these variables ($r=0.14$ and $r=0.17$, respectively; $p<0.05$). There was a mild and significant correlation between these variables. ($r=-0.14$ and $r=-0.19$, respectively; $p<0.05$). Although several parameters including our measurements were developed for the assessment of size and structure of temporal lobe. It is not ease to determine MRI-based markers for the prediction, diagnosis, and follow-up of mild cognitive impairment and Alzheimer's disease in the elderly.

Keywords: MRI, age-related changes, temporal lobe

Introduction

Temporal lobe as one of the four lobes of brain is located beneath the lateral fissure on both cerebral hemispheres of the mammalian brain and is composed of approximately 17% of the volume of the human cerebral cortex [1]. In the temporal lobe, there are functional areas involved with the auditory, olfactory, vestibular, and linguistic functions. The medial side of the temporal lobe includes regions involved in olfaction as the uncus and nearby cortex and semantic memory as the hippocampal formation. The uncus is a small projection and found on the medial surface of the anterior end of the parahippocampal gyrus. The hippocampal formation is located on the medial side of the temporal lobe and includes the parahippocampal gyrus, subiculum, hippocampus, dentate gyrus [2].

In neuroimaging practice, cerebral atrophy is one of the nonspecific findings developed related to head trauma or degenerative processes and it can occur normally in ageing. Pattern and location of atrophic changes differ according to the behavior of the disease processes [3-6]. There is a continuing research related to MRI findings obtained with measurement of several cerebral structures and distances among them in patients with several neurologic diseases such as epilepsy, mild cognitive impairment (MCI), and Alzheimer's disease (AD) [7-10].

In the literature, although there are studies investigated the place of measurement of several brain structures and distances among them, according to our knowledge, there was no study investigated a population from 18 years old to 80 plus years. There is still no consensus on the clinical application of MRI biomarkers for the differential diagnosis of MCI and AD. The

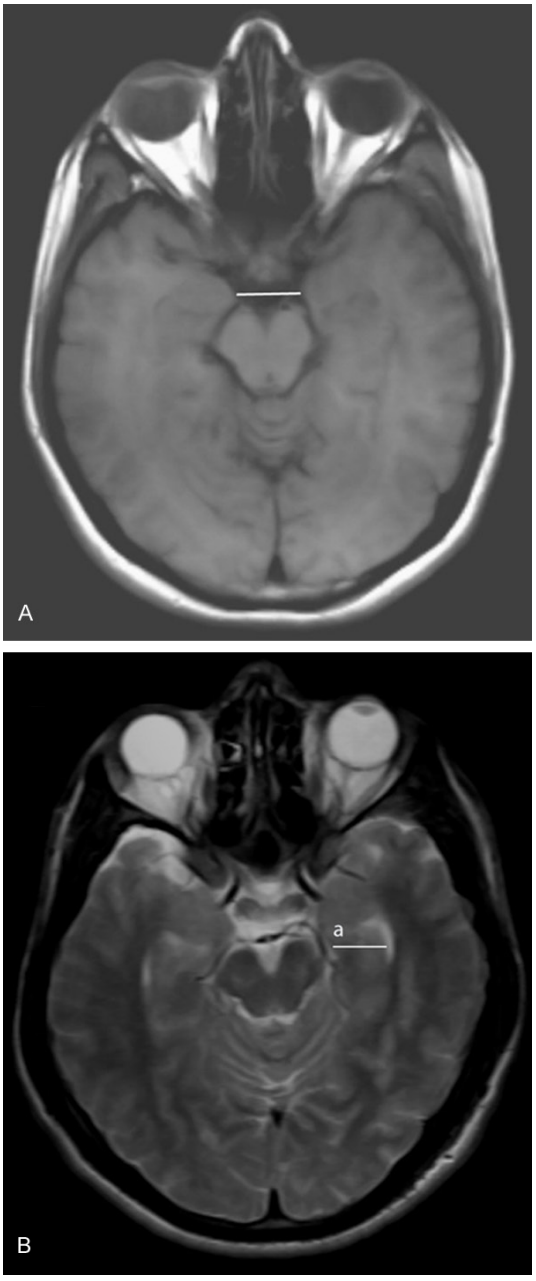

Figure 1. Representative images including measurements of interuncal distance and thickness of temporal lobe (A and B, respectively).

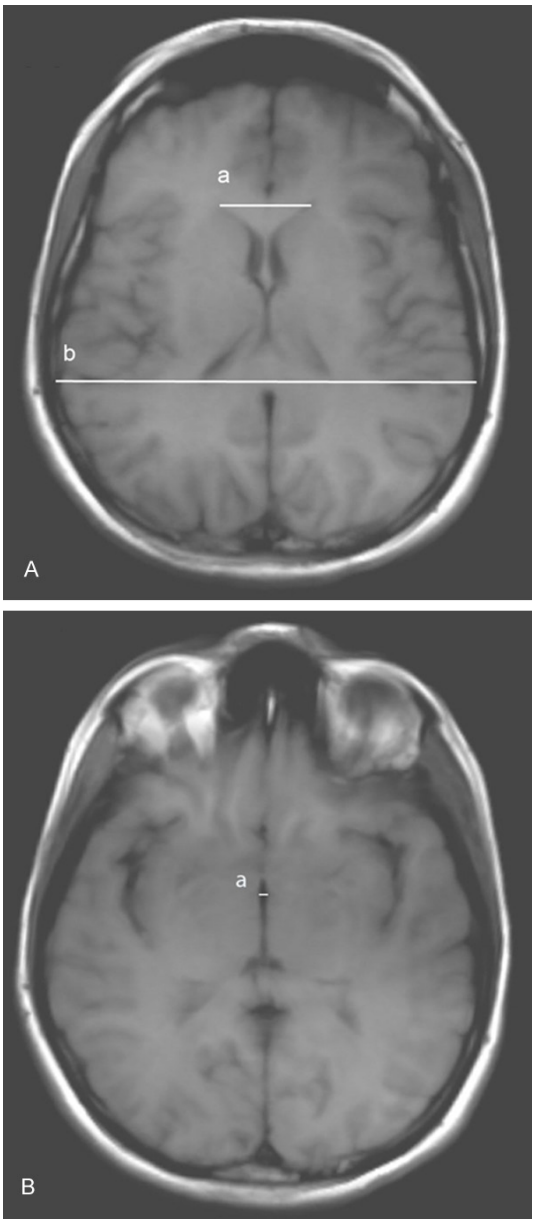

Figure 2. Representative images including measurements of Evans' ratio and width of third ventricle (A and B, respectively).

aim of this study was to investigate the age-related changes in the dimensions of temporal lobe with the measurements of interuncal distance, thickness of temporal lobe, Evans' ratio, and the width of third ventricle, using axial views of the cerebral hemispheres; and with the measurements of height of hippocampus, width of choroid fissure, and width of the temporal horn, using coronal views of the cerebral hemispheres in patients aged from 18 to 80 plus years.

Materials and methods

In this study, 236 MRI scans of the head performed at our Radiology Service from September 2012 to February 2013 were reviewed retrospectively to identify structures of temporal lobe, third ventricle, and temporal horn of lateral ventricle. All MRI scans were reviewed by qualified radiologists. These MRI

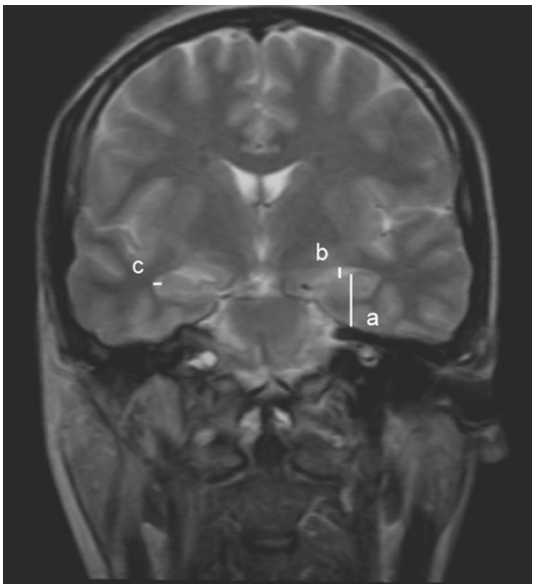

Figure 3. Representative images including measurements of hippocampal, choroid fissure, and temporal horn measurements.

scans were requested by neurologists for the differential diagnosis of headache in the adult patients. Patients with normal MRI scans were included. In the 65-plus patients, we included patients with a preliminary diagnosis of brain atrophy. They have no diagnosis of MCI and AD. Patients with a history of any type of cerebrovascular and traumatic, and structural brain abnormalities were excluded.

For each case, a detailed reviewed was conducted to confirm the absence of any cerebral or cerebrovascular pathology.

MRI assessment

MRI examinations were performed using a 1.5 T MRI machine (Excelart, Toshiba, Tokyo, Japan) using standard head coils. The MRI examination included axial and sagittal spin-echo (SE) T1-weighted [repetition time (TR) 550 ms, echo time (TE) 15 ms, flip angle 90°], axial and coronal enhanced T1-weighted (TR 550 ms, TE 15 ms, flip angle 90°), axial and coronal fast SE (FSE) T2-weighted (TR 5000 ms, TE 94 ms, flip angle 90°), axial proton-density T2-weighted (TR 2500 ms, TE 18 ms, flip angle 90°), and axial fluid-attenuated inversion recovery (FLAIR; TR 7500 ms, TE 94 ms, TI 2200, flip angle 90°) images. Mucosal swelling in paranasal sinuses is defined as sinusitis on T2-weighted MRI.

All linear measurements were performed on magnified images with the built-in distance measurement software, who was blinded to the diagnosis, age, and sex of the subject, as previously described [11-14]. Inter- and intra- observer reliabilities were determined as Kappa coefficient ranged from 0.72-0.88. Using axial views of the cerebral hemispheres, interuncal distance, thickness of temporal lobe, Evans' ratio, and the width of third ventricle were measured. Using coronal views of the cerebral hemispheres, height of hippocampus, width of choroid fissure, and width of the temporal horn were measured.

Interuncal distance

Interuncal distance was measured from the T1-weighted axial images and defined as the distance between the unci of the temporal lobes, measured on a plane parallel to the bicommissural plane at the level of the suprasellar cistern (**Figure 1**).

Thickness of temporal lobe

The minimum thickness of the medial temporal lobe, measured on a plane parallel to the temporal lobe plane, as the thickness of the medial temporal lobe considered at its narrowest point on the scan section that best represents the medial temporal lobe between its superior and inferior limits [11] (**Figure 1**).

Evans' ratio

From the T1-weighted axial images, Evans ratio was calculated by dividing the maximum width between the tips of the frontal horns of the lateral ventricles, as measured on a plane parallel to the temporal lobe plane, to the maximum transverse intracranial diameter, as the maximal distance between the inner tables of the skull on the two sides. It is assumed to reflect frontal horns ventricular enlargement (**Figure 2**).

Width of third ventricle

The maximum width of the third ventricle was obtained from the images at the level of the section where Monro's foramen was visible. It is assumed to reflect third ventricle enlargement (**Figure 2**).

Hippocampal, choroid fissure, and temporal horn measurements

The hippocampal height, measured on a plane parallel to the brain stem axis plane where the

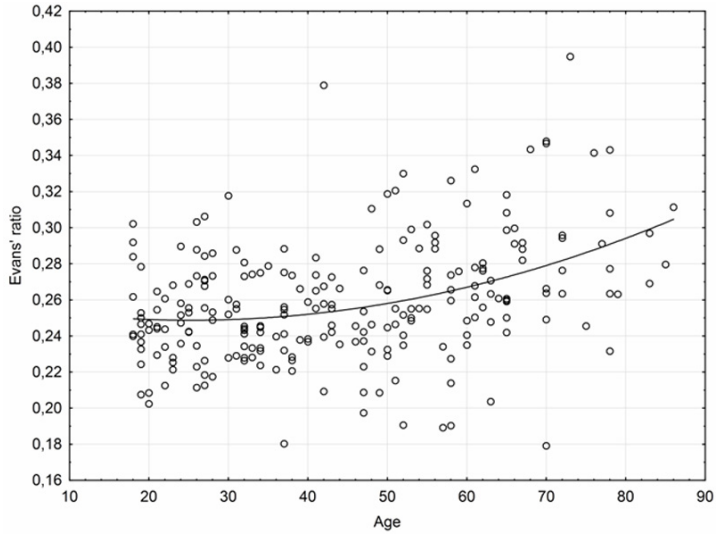

Figure 4. Correlation of age and Evans' ratio (r=0.35, p<0.05).

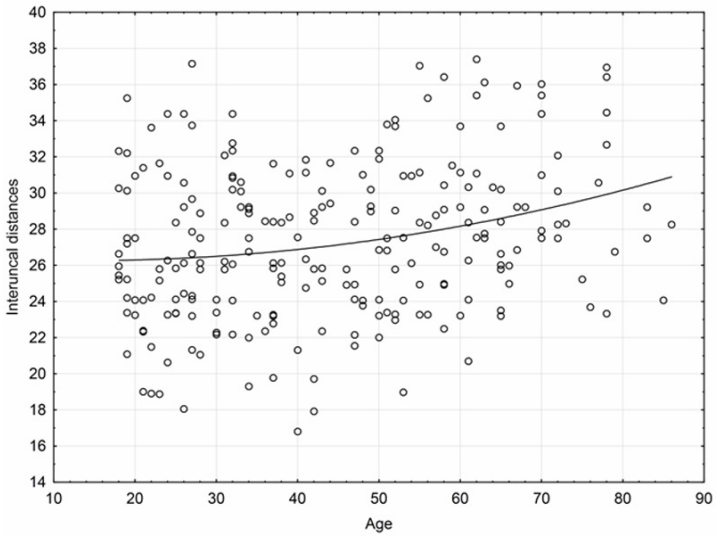

Figure 5. Correlation of age and interuncal distances (r=0.24, p<0.05).

hippocampal formation was highest, and defined as the greatest height of the hippocampal formation (dentate gyrus, hippocampus proper, and subiculum, together with the parahippocampal gyrus). The width of the choroid fissure, measured on the same plane used for hippocampal height measurement, and defined as the vertical width of the choroid fissure centered on the midpoint of the hippocampal formation. This point usually lies on the line where hippocampal height is taken. Then, the width of the temporal horn, measured on the same plane used for hippocampal height measurement [2] (**Figure 3**).

Statistical analysis

We recorded the age, sex, and cerebral measurements. Data were expressed as percentage or mean ± SD as appropriate. The data were analyzed with correlation test. Significance was determined at the p<0.05 level.

Results

The mean age of study group was 44.2±17.7 (18 to 86). The gender ratio (F/M) of study group was 129/107.

Figure 4 shows the correlation of age and Evans' ratio. There is mild-moderate significant correlation between age and Evans' ratio (r=0.35, p<0.05).

Figure 5 shows the correlation of age and interuncal distances. There is mild significant correlation between age and interuncal distances (r=0.24, p<0.05).

There was no correlation between age and third ventricle widths, temporal lobe widths, and temporal horn widths of left and right sides of brain (p>0.05).

Figure 6 shows the age and choroid fissure widths of left and right sides of brain. A mild and significant correlation was present between these variables (r=0.14 and r=0.17, respectively; p<0.05).

Figure 7 shows age and hippocampal heights of left and right sides of brain. There was a mild and significant correlation between these variables. (r=-0.14 and r=-0.19, respectively; p<0.05).

Discussion

In order to examine the relationship between the age and Evans' ratio, interuncal distances, third ventricle widths, temporal lobe widths, temporal horn widths, choroid fissure widths, and hippocampal heights, the age was correlated with all study parameters. Overall, minimal-mild correlations were found significant

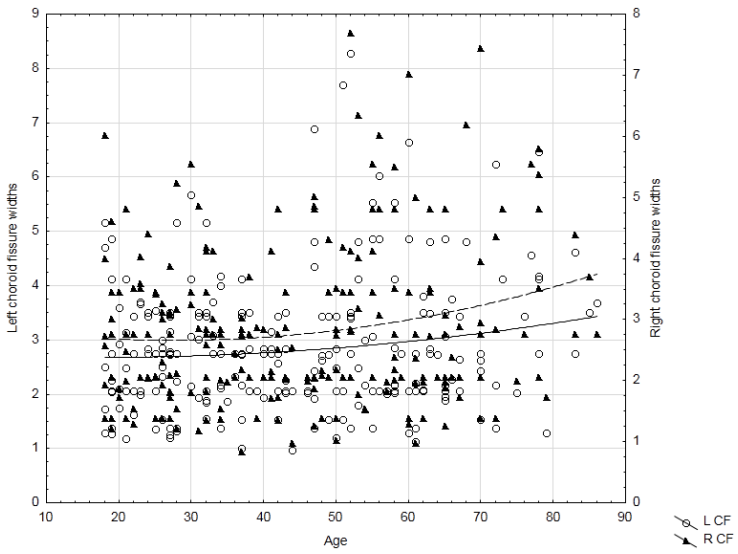

Figure 6. Correlation of age and choroid fissure widths of left (straight line) and right (dashed line) sides of brain (r=0.14 and r=0.17, respectively; p<0.05).

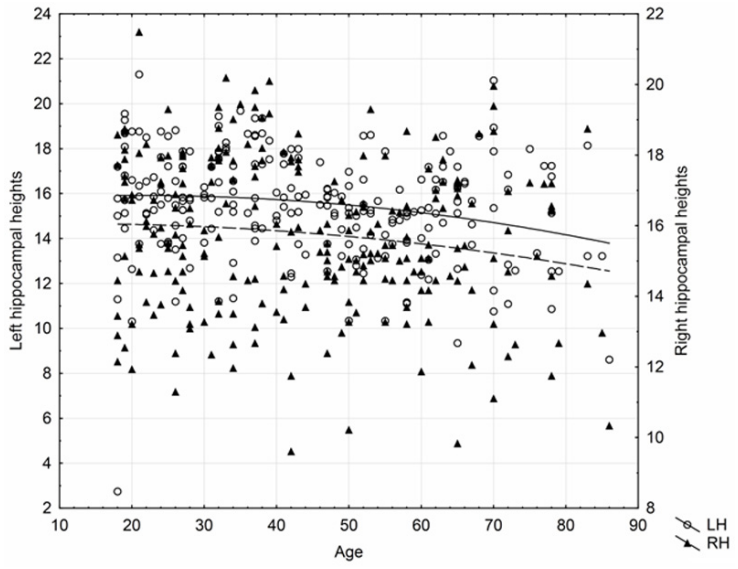

Figure 7. Correlation of age and hippocampal heights of left (straight line) and right (dashed line) sides of brain (r=-0.14 and r=-0.19, respectively; p<0.05).

between age and Evans' ratio, interuncal distances, choroid fissure widths, hippocampal heights. Small increases in the correlation coefficients of these study parameters were also observed in patients aged 50-60 plus years. No meaningful relationship was present between age and third ventricle widths, temporal lobe widths, and temporal horn widths.

Dementia impairs of memory and at least one other cognitive activity such as aphasia, apraxia, agnosia, executive function at a severity enough to interfere with daily function and independence [15]. MCI is an intermediate state between normal cognition and dementia [16]. AD is the most common form of dementia in the elderly, accounting for 60 to 80 percent of cases. Brain imaging, preferably with MRI, is indicated in the differential diagnosis of patients with suspected AD. According to MRI findings of studies related to AD, generalized and focal atrophy, as well as white matter lesions is found but generally not conclusive [17, 18].

Hippocampus volumetry currently is one of the best-known marker of AD obtained with neuroimaging [19]. Because hippocampal volumes decline in normal aging also, age-specific criteria are needed these measurements to be diagnostic for AD [20-22]. In neurological practice, the differential diagnosis of the early stages of mild cognitive impairment (MCI) and Alzheimer's disease (AD) is challenging. MCI has been regarded as the pre-clinical form of dementia, a high-risk condition that may precede AD, and for the prevention of AD, the reliable diagnosis of MCI is considerable important [23, 24]. Saka et al. [23] evaluated the place of interuncal distance for the differential diagnosis of MCI and AD. They concluded that interuncal distance could be used in the discrimination of MCI and AD in patients with at least one white matter lesion. Cheon et al. [25] conducted a study to assess the diagnostic value of interuncal distance measurement in patients with MCI and AD. They noted that interuncal distances of MCI and AD patients were found similar and although in AD patients, the interuncal distance is more compared to healthy controls but not to

MCI. Whitwell et al. [26] assessed dementia related changes in the brain with MRI-based measurements of hippocampal formation to determine the differences in the patterns grey matter atrophy in patients with or without a progress from MCI to AD with long follow-up. They found that MCI subjects that progress to a diagnosis of AD within 18 months has a greater degree of grey matter loss at baseline than MCI subjects that do not progress to AD within three years.

Bracco et al. [27] evaluated the cerebral dimensions obtained with brain MRI in the diagnosis and staging of AD. They measured corpus callosum width, ventricular size, right and left temporal lobe areas, interuncal distance, and assessed the degree of cortical atrophy. They suggested that these findings could be helpful in the management of AD patients. Frissoni et al. [28] studied the sensitivity of linear measures of regional frontal, medial temporal lobe (interuncal distance, minimum thickness of the medial temporal lobe), and hippocampal atrophy in the differential diagnosis of AD cases. They found that interuncal distance could discriminate patients with mild AD from control subjects with 86% sensitivity. They suggested that linear measures of hippocampal atrophy could be a useful adjunct in the routine diagnosis of AD, even in its early stages. Frisoni et al. [29] noted that although atrophic changes in the medial temporal lobe detected by neuroimaging were in the most accurate findings of AD; however, their use in routine clinical practice was limited. They found that the radial width of the temporal horn could be a useful in routine clinical practice.

The use of MRI modalities for the assessment of dementia has gaining importance since MRI broadens our understanding of the pathophysiology dementia with the evaluation of structural and functional basis of normal cognition [30-32]. Hippocampal volumetry is one of the best-known marker of AD obtained with neuroimaging [19]. Although it has a potential to be used for the diagnosis and follow-up of MCI and AD patients, according to available knowledge related to atrophy of temporal lobe obtained by neuroimaging, as stated by Teipel et al. [19], screening of cognitive dysfunction according to available MRI markers has not enough background and specification.

In conclusion, this study was conducted to contribute to the knowledge related to the use of MRI for the assessment of atrophy in the temporal lobe. Since MRI-identified hippocampal structural changes were measured in the whole lifespan of adults, we think that it may provide solid information for the researchers trying to develop new MRI markers for routine clinical use. Overall, according to our findings, there is not a strong relationship and its relevance to ageing among the several clinical parameters measured as seen from the data of this study. We think that it can considerably difficult to choose a temporal-lobe-related measurement as a MRI marker for any type of MCI and AD since this parameter is always be under the effect of ageing alone. Further research is needed to determine new MRI panels including multiple measurements for the diagnosis and management of dementia in in carefully selected patients with or without dementia.

Disclosure of conflict of interest

The authors declare that there is no conflict of interest with regard to the publication of this manuscript.

Address correspondence to: Dr. Ismail Salk, Department of Radiology, Cumhuriyet University Faculty of Medicine, 58140 Sivas, Turkey. Tel: +90 346 2580000; E-mail: ismailsalk@gmail.com

References

[1] Mai JG, Paxinos G, Voss T. Atlas of the Human Brain. 3rd edition. Amsterdam, The Netherlands: Elsevier; 2008.
[2] Kiernan JA. Anatomy of the Temporal Lobe. Epilepsy Res Treat 2012; 2012: 176157.
[3] Davis PC, Mirra SS, Alazraki N. The brain in older persons with and without dementia: findings on MR, PET, and SPECT images. AJR Am J Roentgenol 1994 Jun; 162: 1267-78.
[4] Jernigan TL, Press GA, Hesselink JR. Methods for measuring brain morphologic features on magnetic resonance images. Validation and normal aging. Arch Neurol 1990 Jan; 47: 27-32.
[5] Mann DM. The topographic distribution of brain atrophy in Alzheimer's disease. Acta Neuropathol 1991; 83: 81-6.
[6] Mann DM, South PW. The topographic distribution of brain atrophy in frontal lobe dementia. Acta Neuropathol 1993; 85: 334-40.
[7] Frisoni GB, Beltramello A, Weiss C, Geroldi C, Bianchetti A, Trabucchi M. Usefulness of sim-

ple measures of temporal lobe atrophy in probable Alzheimer's disease. Dementia 1996 Jan-Feb; 7: 15-22.
[8] Ishii K, Kitagaki H, Sakamoto S, Yamaji S, Kono M. [Interuncal distance measurements in normal controls and patients with dementia: MR imaging study]. Nihon Igaku Hoshasen Gakkai Zasshi 1995 Aug; 55: 646-50.
[9] Howieson J, Kaye JA, Holm L, Howieson D. Interuncal distance: marker of aging and Alzheimer disease. AJNR Am J Neuroradiol 1993 May-Jun; 14: 647-50.
[10] Doraiswamy PM, McDonald WM, Patterson L, Husain MM, Figiel GS, Boyko OB, Krishnan KR. Interuncal distance as a measure of hippocampal atrophy: normative data on axial MR imaging. AJNR Am J Neuroradiol 1993 Jan-Feb; 14: 141-3.
[11] Frisoni GB, Beltramello A, Weiss C, Geroldi C, Bianchetti A, Trabucchi M. Linear measures of atrophy in mild Alzheimer disease. AJNR Am J Neuroradiol 1996 May; 17: 913-23.
[12] Bersani G, Quartini A, Manuali G, Iannitelli A, Pucci D, Conforti F, Di Biasi C, Gualdi G. Influence of obstetric complication severity on brain morphology in schizophrenia: an MR study. Neuroradiology 2009 Jun; 51: 363-71.
[13] Bersani G, Paolemili M, Quartini A, Clemente R, Gherardelli S, Iannitelli A, Di Biasi C, Gualdi G, Pancheri P. Neurological soft signs and cerebral measurements investigated by means of MRI in schizophrenic patients. Neurosci Lett 2007 Feb 8; 413: 82-7.
[14] Frisoni GB, Beltramello A, Geroldi C, Weiss C, Bianchetti A, Trabucchi M. Brain atrophy in frontotemporal dementia. J Neurol Neurosurg Psychiatry 1996 Aug; 61: 157-65.
[15] Shadlen MF, Larson EB. Evaluation of cognitive impairment and dementia. In: UpToDate, Basow DS, Eds. UpToDate. Waltham, MA; 2013.
[16] McDade EM, Petersen RC. Mild cognitive impairment: Epidemiology, pathology, and clinical assessment. In: UpToDate, Basow DS, Eds. UpToDate. Waltham, MA; 2013.
[17] Grabowski TJ. Clinical manifestations and diagnosis of Alzheimer disease. In: UpToDate, Basow DS (Ed), UpToDate, Waltham, MA, 2013.
[18] Spulber G, Niskanen E, Macdonald S, Kivipelto M, Padilla DF, Julkunen V, Hallikainen M, Vanninen R, Wahlund LO, Soininen H. Evolution of global and local grey matter atrophy on serial MRI scans during the progression from MCI to AD. Curr Alzheimer Res 2012 May; 9: 516-24.
[19] Teipel SJ, Grothe M, Lista S, Toschi N, Garaci FG, Hampel H. Relevance of magnetic resonance imaging for early detection and diagnosis of Alzheimer disease. Med Clin North Am 2013 May; 97: 399-424.
[20] van de Pol LA, Hensel A, Barkhof F, Gertz HJ, Scheltens P, van der Flier WM. Hippocampal atrophy in Alzheimer disease: age matters. Neurology 2006 Jan 24; 66: 236-8.
[21] Barkhof F, Polvikoski TM, van Straaten EC, Kalaria RN, Sulkava R, Aronen HJ, Niinistö L, Rastas S, Oinas M, Scheltens P, Erkinjuntti T. The significance of medial temporal lobe atrophy: a postmortem MRI study in the very old. Neurology 2007 Oct 9; 69: 1521-7.
[22] Raji CA, Lopez OL, Kuller LH, Carmichael OT, Becker JT. Age, Alzheimer disease, and brain structure. Neurology 2009 Dec 1; 73: 1899-905.
[23] Saka E, Dogan EA, Topcuoglu MA, Senol U, Balkan S. Linear measures of temporal lobe atrophy on brain magnetic resonance imaging (MRI) but not visual rating of white matter changes can help discrimination of mild cognitive impairment (MCI) and Alzheimer's disease (AD). Arch Gerontol Geriatr 2007 Mar-Apr; 44: 141-51.
[24] Knopman DS, Boeve BF, Petersen RC. Essentials of the proper diagnoses of mild cognitive impairment, dementia, and major subtypes of dementia. Mayo Clin Proc 2003 Oct; 78: 1290-308.
[25] Cheon JS, Cho WY, Jeon GS, Song HR, Oh BH. Measurement of Interuncal Distance in Mild Cognitive Impairment. J Korean Geriatr Psychiatry 2004 Dec; 8: 121-126. Korean.
[26] Whitwell JL, Shiung MM, Przybelski SA, Weigand SD, Knopman DS, Boeve BF, Petersen RC, Jack CR Jr. MRI patterns of atrophy associated with progression to AD in amnestic mild cognitive impairment. Neurology 2008 Feb 12; 70: 512-20.
[27] Bracco L, Piccini C, Manfredi G, Fonda C, Falcini M, Amaducci L. Magnetic resonance measures in Alzheimer disease: their utility in early diagnosis and evaluating disease progression. Alzheimer Dis Assoc Disord 1999 Jul-Sep; 13: 157-64.
[28] Frisoni GB, Beltramello A, Weiss C, Geroldi C, Bianchetti A, Trabucchi M. Linear measures of atrophy in mild Alzheimer disease. AJNR Am J Neuroradiol 1996 May; 17: 913-23.
[29] Frisoni GB, Geroldi C, Beltramello A, Bianchetti A, Binetti G, Bordiga G, DeCarli C, Laakso MP, Soininen H, Testa C, Zanetti O, Trabucchi M. Radial width of the temporal horn: a sensitive measure in Alzheimer disease. AJNR Am J Neuroradiol 2002 Jan; 23: 35-47.
[30] Teipel SJ, Meindl T, Grinberg L, Heinsen H, Hampel H. Novel MRI techniques in the assessment of dementia. Eur J Nucl Med Mol Imaging 2008 Mar; 35 Suppl 1: S58-69.
[31] Li TQ, Wahlund LO. The search for neuroimaging biomarkers of Alzheimer's disease with advanced MRI techniques. Acta Radiol 2011 Mar 1; 52: 211-22.

[32] Fayed N, Modrego PJ, Salinas GR, Gazulla J. Magnetic resonance imaging based clinical research in Alzheimer's disease. J Alzheimers Dis 2012; 31 Suppl 3: S5-18.