ORIGINAL RESEARCH PAPER

Volume-8 | Issue-7 | July - 2019 | PRINT ISSN No. 2277 - 8179

INTERNATIONAL JOURNAL OF SCIENTIFIC RESEARCH

FIBRE DISSECTION TECHNIQUE OF BRAIN TO DEMONSTRATE THREE DIMENSIONAL ARCHITECTURE OF DEEP CEREBRAL STRUCTURES: A CADAVERIC STUDY

Anatomy

Dr. Mrinalini P. Wakchaure* Assistant Professor, Department of Anatomy, Topiwala National Medical College, Mumbai *Corresponding Author

Dr. Shraddha S. Bhadarge Senior Resident, Department of Anatomy, AIIMS, Mangalagiri

ABSTRACT

Introduction: Undergraduate medical students usually find it difficult to correlate neuroanatomical texts with spatial relations of white and grey matters in different areas of brain. Today in spite of newer imaging techniques for accurate localization of brain lesions, for medical undergraduates traditional method of dissection still remains as greatest tool to learn neuroanatomy.

Aim: To dissect insula, corona radiata, external and internal capsule &major deep subcortical structures.

Material & methods: Ten formalin fixed adult human cerebral hemispheres were dissected by fibre dissection from superolateral surface to medial surface using conventional dissecting instruments. Step by step description is mentioned everytime.

Results: Creation of three dimensional brain specimens which reveal the intimate relations of brain structures with each other and fibre pattern of fasciculi.

Conclusion: Brain specimens showing fasciculi and important deep structures can be dissected in routine formalin fixed brains using this cost effective method.

KEYWORDS

dissection, fibre, brain, neuroanatomy

INTRODUCTION:

The anatomy of white matter of the brain is important for medical undergraduates and also for neuroradiologists & neurosurgeons. Though the gross anatomy of the brain has been studied mainly by anatomists and clinicians, the intrinsic 3-dimensional microsurgical anatomical study of the complex fibers of the white matter in some aspects is ignored. A technique of well-defined preservation and dissection was developed by Professor Josef Klingler (1888–1963) at the University of Basel in the 1935 [1]. It was used to isolate complete fibre pathways by removing parts of the cortex and underlying white matter of formalin-fixed brains.

The newer imaging MRI techniques, DTI tractography and High definition fibre tractography (HDFT) are excellent for the clinical and surgical understanding [2,3]. For further development in microneurosurgical field, knowledge of this 3-dimensional micrcosurgical anatomy of the internal capsule and other white fiber tracts of brain is essential for management of various intrinsic vascular, neoplastic and other pathological brain lesions which produce clinical symptoms and signs by involving the parts of the internal capsule or by pressure over it[4]. The neurosurgeons and radiologists have already been using MR navigation, fiber tracking for intra & perioperative evaluation and management of brain tumors [5].

However for first year undergraduate medical students it is always difficult to correlate neuroanatomy textbooks with actual three dimensional architecture of brain. Fibre dissection of brain specimens is necessary since it gives the students first visual impact. These types of fibre dissection cadaveric studies are very few in literature [4]. White matter damage has been seen in many of neurological and psychiatric diseases.

Though radiological and neurosurgical techniques are becoming increasingly precise, knowledge of the 3-dimensional structural architecture of the internal capsule and other white fiber tracts of brain is essential for management of neurosurgical cases.

The knowledge and experience gained from this technique can be applied to micro-neurosurgical procedures. Three dimensional models of brain architecture will help undergraduates, postgraduates, neuroradiologists and neurosurgeons.

MATERIALS AND METHOD:

Instruments used in the study- B.P Handle, Surgical blade, Plain forceps, Toothed forceps, Scissors, Camera.

Sample size-10 Formalin fixed adult human cerebral hemispheres and one complete cerebrum with cerebellum in the department of Anatomy routinely in use for undergraduate dissection and teaching were dissected and studied.(n=10)

Duration of study- One month

Inclusion criteria- Brains of unknown sex from formalin embalmed cadavers which are preserved again in formalin for atleast 6 to 8 weeks after removal from cadavers in the department of Anatomy.

Exclusion criteria- Any injured or dried brains were excluded.

METHOD:

1) Dura, arachnoid, pia matter & blood vessels were stripped off brain surfaces (Figure 1).

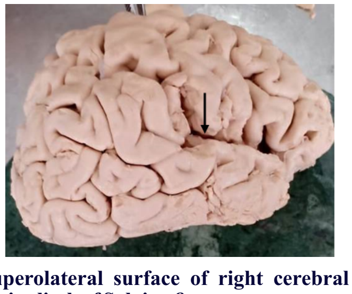

Figure 1 :Superolateral surface of right cerebral hemisphere. Arrow- posterior limb of Sylvian fissure

2) For insula external and internal capsule and corona radiata, lateral approach as described by Cunningham's manual of practical anatomy volume three [6], fibre dissection technique by Ture & MG Yasargil [7] & Klingler's fibre dissection method [1] were referred as a guide.
3) The frontal & parietal opercula were incised along the periphery of insula with a sharp cut. At the same time superior temporal gyrus was removed to have a clear view of insula, taking care not to damage the inferior horn of lateral ventricle & hippocampus. Morphology of insula was studied for the arrangement of sulci and gyri (Figure 2).

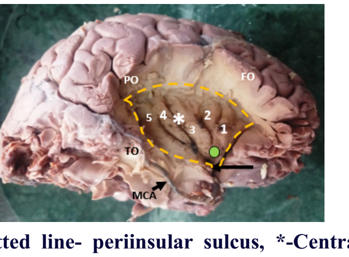

Figure 2: Dotted line- periinsular sulcus, *-Central sulcus of insula, FO- Frontal Operculum, PO- Parietal operculum, TO-

Temporal operculum, MCA- Middle cerebral artery turned away, Green dot- Pole of insula, Arrow- apex of insula, 1- anterior short gyrus, 2- middle short gyrus, 3- posterior short gyrus, separated by two sulci, 4- anterior long gyrus, 5, posterior long gyrus, separated by one sulcus

4) Grey matter of insula was scraped off with proper instruments. The extreme capsule which is deep to it was revealed. Here various association fibres like superior longitudinal, arcuate & uncinate fasciculi were seen (Figure 3 &4).

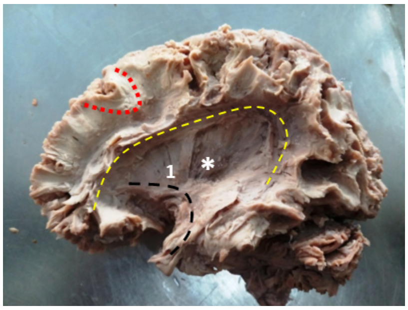

Figure 3: Yellow dotted line- Superior longitudinal fasciculus, Black dotted line- Uncinate fasciculus, Red dotted line- Small association fibres, 1- External capsule, *- Bulge of lentiform nucleus

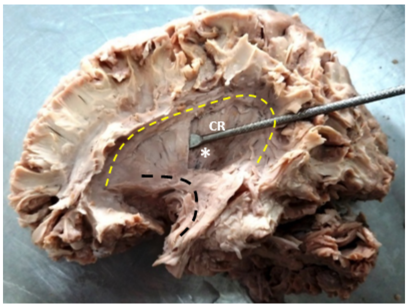

Figure 4: A probe has been passed between external capsule & lentiform nucleus, Yellow dotted line- Superior longitudinal fasciculus, Black dotted line- Uncinate fasciculus, *- Lentiform nucleus, CR- Corona radiata

5) Then an attempt was made to search for claustrum. Then the projection fibres of external capsule were revealed to surface (Figure 4). After removal of it the bulge of lentiform nucleus was disclosed. Superior longitudinal fasciculus was removed revealing the fibres of corona radiata converging towards internal capsule above the putamen.
6) The fibres of corona radiata were cut an inch above the lentiform nucleus.
7) Also outer bulge of body of lateral ventricle was cleared off the fasciculi. In retrolentiform part of internal capsule the optic radiations were defined.
8) The middle temporal gyrus was approached to expose the inferior horn of lateral ventricle, in the floor of which lies the choroid plexus & hippocampus. After removal of ependyma, the pes hippocampus and fimbria were revealed (Figure 5, 6, 7).

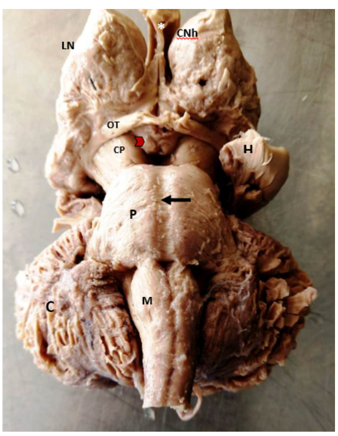

Figure 5 : Specimen from front view showing cut part of CC-Corpus callosum, SP- Septum pellucidum with its cavity, CHn-Head of caudate nucleus, LN- lentiform nucleus, CR- Corona radiata, OT- Optic tract, Red Arrow head- Mamillary body, Cp-Cerebral peduncle, P-Pons, Arrow- Basilar groove, MO- Medulla oblongata, C- Cerebellar hemisphere, H- Hippocampus

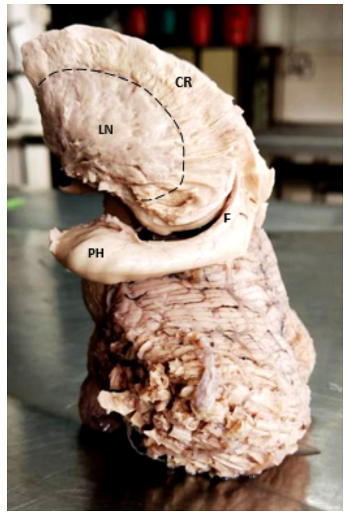

Figure 6: Lateral view of specimen showing LN- Lentiform nucleus, CR- Corona radiata, PH- Pes Hippocampus, F- Fornix, C- Cerebellar hemisphere, dotted line- Upper border of lentiform nucleus

9) The fimbria was traced as it continued into fornix, all the way upto septum pellucidum and mamillary bodies (Figure 5).

RESULTS:

From whole neocortex the projection fibres converge downwards giving them a fan shaped arrangement of fibres called corona radiata. When traced below, it is continuous with internal capsule which divides corpus striatum into lentiform nucleus on lateral side and caudate nucleus on its medial side.

Internal capsule is the main highway for input and output fibres of cerebral cortex. It is continuous above with corona radiata and below it occupies crus cerebri of midbrain. It is compact band of projection fibres having 'V' shape in horizontal section with concavity on lateral side. It is placed between lentiform nucleus laterally and caudate nucleus and thalamus medially.

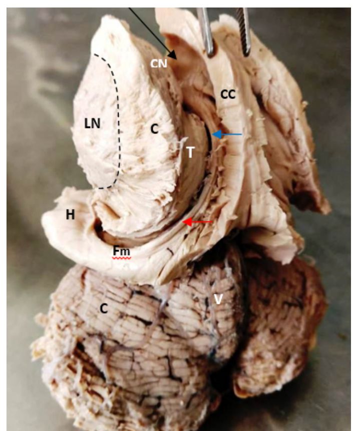

Figure 7- Postero lateral view of specimen showing LN- Lentiform nucleus, CR- Corona radiata, CN- Head of caudate nucleus, CC-Cut part of corpus callosum, T- Thalamus, H- Hippocampus, Fm-Fimbria of fornix, Red arrow- Crus of fornix, Blue arrow- Body of fornix, Black arrow- septum pellucidum, C- Cerebellar hemisphere, V- Cerebellar vermis Hippocampus is elongated prominent elevation situated in floor of inferior horn of lateral ventricle. Its anterior end is bulbous resembling paws of animal, hence called pes hippocampus. Alveus, the thin sheet of white mater covering the ventricular wall of hippocampus converges

along medial margin to form fimbria and continues as fornix.

Fornix sweeps forward below splenium of corpus callosum and pulvinar end of thalamus in the form of a pair of crura which proceed forward to form body of fornix, upper surface of which is connected in median plane to the undersurface of corpus callosum by bilaminar membrane, septum pellucidum.

For better understanding of these structures, a three dimensional specimens showing spatial architecture of corona radiata, lentiform nucleus, caudate nucleus & thalamus were made by this fibre dissection in formalin fixed brains. One specimen with above structures was dissected bilaterally keeping the part of corpus callosum and brainstem intact.

In that specimen the limbic lobe was also dissected which revealed the hippocampus, fimbria, fornix, septum pellucidum. Viewing from anterior aspect, specimen showed ventral aspect of both cerebellar hemispheres, medulla oblongata, pons, middle cerebellar peduncles, ventral aspect of crus cerebri, optic chiasma, interpeduncular fossa, mamillary bodies, posterior perforated substance, caudate nucleus, thalamus, corona radiata, lentiform nucleus, hippocampus, fornix, septum pellucidum.

From posterior aspect the above specimen revealed part of the Papez circuit i.e hippocampus, fornix projecting towards mamillary bodies and other structures like pulvinar of thalamus, body of caudate nucleus, stria terminalis and superior surface of both cerebellar hemispheres & vermis.

No freezing or thawing of brains is done for this technique, although results of later are good. It was an attempt to show that even during routine dissections such three dimensional specimens can be made with meticulous dissection which will help not only medical undergraduates & post graduates but also neuroradiologists, neurologists & neurosurgeons as ready reference.

DISCUSSION:

Regardless of very new advances in radiological imaging techniques there is no satisfactory technique for describing fiber pathways. Among all this, the classic technique of cadaveric fiber dissection is still considered the best and gold standard among tractography techniques and is considered as best for neurosurgeons [8] .The fiber dissection techniques are evolved from time to time. Many anatomists have dissected white fibers and demonstrated tracts and fascicles of brain. Andreas Vesalius (1514 - 1564) was the first who described the white matter and grey matter on the basis of color and texture. The 17th century anatomist Marcello Malpighi (1628–1686) used the technique of boiling brains in water while Thomas Willis (1621–1675) developed a scraping technique for demonstration of the arrangement of bundles and fibers in the white matter[8]. Raymond Vieussens (1641–1715) used the scraping method of Willis, as well as the boiling technique of Malpighi but improved the technique by boiling nervous tissue in oil and described the dissection technique along with his own anatomical findings and demonstration of continuity of white matter through the corona radiata, internal capsule and pyramidal tract in his work “Neurographia Universalis”. Félix Vicqd'Azyr (1748–1794) used technique of hardening the brain in an alcohol solution. Josef Klingler (1888–1963) revolutionized brain study by technique of freezing and thawing previously fixed brains. Though his studies were very impressive, this technique not used widely [1,7,10]. Yasargil used technique of combination of histological techniques with fiber dissection for better understanding and he used this it for all of his routine microsurgical procedures [4,11, 12,13]. Herbert Mayo in 1927 demonstrated superior and inferior cerebellar peduncles, fasciculus uncinatus, fasciculus longitudinalis superior, outer surface of lentiform nucleus, corona radiata, internal capsule, tapetum, mamillothalamic tract and anterior commissure[4,7].

In routine anatomy teaching of medical undergraduates the traditional method of teaching neuroanatomy is through various types of brain sections [14]. It is difficult for students to imagine the spatial relation of a particular part of brain by this sectional method. Relations of deep structures of brain like corona radiata& internal capsule to lentiform nucleus, caudate nucleus & thalamus are often difficult to understand. Several horizontal, coronal & oblique brain sections may help to imagine their relation. But the specimens made by this fibre dissection method in routine dissection can help understanding the exact architecture & relation of above structures with each other. Likewise tracing the hippocampus to fimbria, crus, body & termination of fornix can be made easier.

The internal capsule, other white fibers and Papez circuit may be affected by various pathologies, like degenerative, demyelinating, deficiency or metabolic deficiency, vascular, hypoxia, intrinsic neoplastic, infection and trauma [4]. For neurosurgeons it is of immense importance to know the three dimensional architecture of brain to perform various difficult neurosurgical procedures. Surgical intervention is mostly done in neoplastic, vascular, intractable epileptic and some intractable psychiatric conditions by newer techniques like Diffusion tension imaging tractography & neuronavigation which gives excellent results but its cost and technical issues limits their use [6].

In dissection technique described by Klinger, after freezing the formalin expands in between nerve fibers and it separates these fibers and facilitates the dissection of white fibers. The alternate freezing and thawing allows easier separation during dissection of the white matter of brain and distinction of the fascicles and tracts. In present study we did not use the freeze-thaw method. The specimens were dissected after fixing the brains in formalin for 6-8 weeks. There were several limitations for this study like the clear cut demarcation between the crossing fibres of various fasciculi, corpus callosum & corona radiata could not be done. The fibres are very delicate so care needed to be taken during dissection not to damage the major and delicate structures.

CONCLUSION:

The described cost-effective and easily reproducible technique by Klinger should be routinely incorporated to give detailed knowledge of white matter fiber of brain.The technique can be used without freeze thaw method to create good quality neuroanatomy models for undergraduate as well as postgraduate teaching & as a ready reference for neurosurgeons.

REFERENCES:

1] Klingler J. (1935). Erleichterung der makroskopischen Praeparationdes Gehirnsdurch den Gefrierprozess. Schweiz Arch Neurol Psychiatr, 36:247-256.

2] Kei YAMADA, Koji S AKAI, Kentaro AKAZAWA, Sachiko YUEN, Tsunehiko NISHIMURA. (2009). MR Tractography: A Review of its clinical applications. Magn Reson Med Sci, Vol. 8, No. 4, pp.165–174.

3] Juan C. Fernandez-Miranda, Sudhir Pathak, Johnathan Engh, Kevin Jarbo, Timothy Verstynen, Fang-Cheng Yeh, Yibao Wang, Arlan Mintz, Fernando Boada, Walter Schneider, Robert Friedlander. (AUGUST 2012).High-Definition Fiber Tractography of the Human Brain: Neuroanatomical Validation and Neurosurgical Applications. www.neurosurgery-online.com. VOLUME 71 | NUMBER 2.

4] Forhad Chowdhury, Mohammod Haque.(2010). White Fiber Dissection of Brain; the Internal Capsule: A Cadaveric Study. Turkish Neurosurgery, Vol: 20, No: 3, 314-322.

5] Haytham Elhawary, Haiying Liu, Pratik Patel, Isaiah Norton, Laura Rigolo, Xenophon Papademetris, Nobuhiko Hata, Alexandra J. Golby. (2011 February). Intra-operative Real-time Querying of White Matter Tracts during Frameless Stereotactic Neuronavigation. Neurosurgery, 68(2):506-516. doi:10.1227/ NEU. 0b013e 3182036282.

6] Koshi R. (2018). Cunningham's manual of practical anatomy Vol 3: Head, Neck and Brain. (16th edition). Oxford.

7] Ture U, Yasargil MG, Friedman AH, Al-Mefty O. (2000). Fiber dissection technique: Lateral aspect of the brain. Neurosurgery, 47:417–426.

8] Marcos Devanir Silva DA COSTA, Vinícius Lopes BRAGA. (2018). A Technical Guide For Fiber Tract Dissection Of The Internal Capsule. Turk Neurosurg, 28(6):934-939.

9] Vergani F, Morris CM, Mitchell P, Duffau H. (2012). Raymond deVieussens and his contribution to the study of white matter anatomy: Historical vignette. J Neurosurg, 117:1070-1075.

10] Klingler J, Gloor P. (1960).The connections of the amygdala and of the anterior temporal cortex in the human brain. J Comp Neurol, 115:333-369.

11] Yasargil MG: Microneurosurgery vol III A: AVM of the brain -history, embryology, pathological considerations, hemodynamics, diagnostic studies, microsurgical anatomy.Stuttgart: Georg Thieme, 1987

12] Yasargil MG. (1994). Microneurosurgery vol IV A: CNS tumorsurgical anatomy, neuropathology, neuroradiology, neurophisiology, clinical considerations, operability, treatment options. Stuttgart: Georg Thieme.

13] Yasargil MG. (1984). Microneurosurgery vol I Microsurgical anatomy of the basal cisterns and vessels of the brain. Stuttgart: Georg Thieme,

14] Maureen E. Estevez, Kristen A. Lindgren, Peter R. Bergethon. (2010). A Novel Three-Dimensional Tool for teaching Human Neuroanatomy. Anat Sci Educ, 3(6): 309–317. doi:10.1002/ase.186.