MAGNETIC RESONANCE IMAGING OF SUBTHALAMIC NUCLEUS IN ADULT HUMAN CADAVERIC BRAIN- A MORPHOMETRIC STUDY

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Abstract - The Subthalamic nucleus is a lens shaped collection of neurons which is considered to be the central pacemaker of the Basal Ganglia and receives direct inputs from the cerebral cortex. It is involved in the pathophysiology of Huntington's disease, Parkinson's disease and obsessive compulsive disorder. The present study is a cross-sectional observational study conducted in the Department of Radio Diagnosis, Dr RML Hospital and Post Graduate Institute of Medical Education & Research (PGIMER), New Delhi on 30 magnetic resonance images (MRIs) of brain of patients of different age groups, that aims to study the morphometry of subthalamic nucleus in different age groups by using magnetic resonance imaging. In this study, it was observed that there was no statistically significant difference between the dimensions of right and left hemisphere. There was no statistically significant difference between the dimensions in Group A & B, Group B & C and Group A & C. The study will give an insight into the various dimensions in different age groups and will prove to be of great value to radiologists and neurosurgeons for various neurological procedures.

Keywords - Magnetic Resonance Imaging, Morphometry, Neurosurgeon, Subthalamic Nucleus

I. INTRODUCTION

The Subthalamic nucleus is a lens shaped collection of neurons located ventral to Thalamus. It is considered to be a derivative of dorsocaudal part of the hypothalamic cell column and is rudimentary in carnivores but well developed in primates and humans. In humans the nucleus is estimated to contain approximately 5,50,000 projection neurons which include large multipolar neurons, fusiform cells and small interneurons [1]. The involvement of the subthalamic nucleus in the pathophysiology of Huntington's disease has been reported[2]. It is also involved in the pathophysiology of Parkinson's disease and obsessive compulsive disorder. Parkinson's disease is the second most common neurodegenerative disorder that affects approximately 1% of the population above the age of 60 years [3].

The knowledge of the morphometry of the subthalamic nucleus is essential as it is the target site for the neurosurgical procedure, Deep Brain Stimulation. DBS is a procedure in which a device called neuro-stimulator delivers tiny electrical signals to specific parts of the brain. The hyperactivity of the neurons of the subthalamic nucleus plays an important role in the pathophysiology of symptoms of Parkinson's disease. Presently the nucleus is targeted based on coordinates derived from standard stereotactic atlases like the Schaltenbrand and Wahren atlas which do not account for the individual variability in the position of the nucleus [4]. It has been demonstrated by various researchers that the degree of clinical improvement in a Parkinson's patient following DBS is highly dependent on the accuracy of the lead placement [5]. Also the adverse effects following the procedure like apathy, hallucinations, cognitive dysfunction, depression etc. are found to be due to the incorrect placement of the stimulator. The STN has also emerged recently as a preferred target site for DBS in Obsessive Compulsive Disorder as well [6]. Thus knowledge of the morphometry of the subthalamic nucleus is essential for accurate targeting of the nucleus during Deep Brain Stimulation.

The present study aims to study the morphometry of subthalamic nucleus in different age groups by using magnetic resonance imaging. It will give an insight into the variation in dimensions in different age groups and will prove to be of great value to radiologists and neurosurgeons.

II. MATERIALS AND METHODS

The present study is a cross-sectional observational study conducted in the Department of Radio Diagnosis, Dr RML Hospital and Post Graduate Institute of Medical Education & Research (PGIMER), New Delhi on 30 magnetic resonance images (MRIs) of brain of patients of different age groups obtained from the Department of Radio-diagnosis, Dr. Ram Manohar Lohia Hospital and PGIMER. The patients with neurological lesions and subthalamic nucleus disorders were excluded from the study. The study was done after following the standard protocol for ethical clearance and informed consent from patients. The magnetic resonance images were categorized into 3 age groups: Group A: 20-35 years, Group B: 35-50 years and Group C: above 50 years. The imaging was done using 1.5 Tesla T2 weighted section at transverse level 4mm

ventral to the Anterior Commissure- Posterior Commissure (AC-PC) plane was taken. The AC- PC length was recorded (Figure 1). Also, the STN was located and the length and width were recorded by the radiologist in both the cerebral hemispheres (Figure 2). The various dimensions obtained were compared between the cerebral hemispheres and also between the three age groups – Group A, B and C. The mean, Standard deviation (SD), standard error of mean(SEM) and p values were calculated and analysed using Microsoft Excel 2007 and Epi info softwares.

III. OBSERVATIONS

The mean length of the subthalamic nucleus in group A was observed to be 7.3+/-1.33 mm on the right side and 7.27+/-1.23mm on the left side. The mean width of the nucleus was recorded as 4.13+/-0.68mm on the right side and 4.16+/-0.63mm on the left side. The mean AC-PC length was 25.49+/-3.63mm.

The mean length of the subthalamic nucleus in group B was observed to be 7.27+/-0.25 mm on the right side and 7.23+/-0.41mm on the left side. The mean width of the nucleus was recorded as 4.11+/-0.65mm on the right side and 4.14+/-0.47mm on the left side. The mean AC-PC length was 25.48+/-3.07mm.

The mean length of the subthalamic nucleus in group C was observed to be 7.03+/-1.21 mm on the right side and 7.02+/-1.42mm on the left side. The mean width of the nucleus was recorded as 4.09+/-0.614mm on the right side and 4.1+/-0.61mm on the left side. The mean AC-PC length was 24.97+/-3.61mm.

It was observed that there was no statistically significant difference between the dimensions of right and left hemisphere. The length and width of the subthalamic nucleus measured in the three age groups were compared with each other and the p value calculated.

There was no statistically significant difference between the dimensions of Group A and Group B (Table 1). There was no statistically significant difference between the dimensions of Group B and Group C (Table 2). There was no statistically significant difference between the dimensions of Group A and Group C (Table 3).

The maximum length of STN was noted in a brain specimen belonging to Group A in the right hemisphere which was 9.0mm. The minimum length was observed was 6.1mm in the left hemisphere of a specimen of the C group. The maximum width of STN was recorded in the right hemisphere of group A ie.4.8mm and the minimum width was noted as 3.4mm which was observed in two hemispheres in Group C and right hemisphere of Group B.

The maximum AC-PC length was observed in the right hemisphere of Group C ie.28.1mm and minimum on the right side of Group C, which was 21.9mm. On comparing the AC-PC dimensions obtained on the right and left hemispheres of Group C it was observed that there was no significant difference between the values.

It was observed that there was no statistically significant difference between the dimensions of right and left hemisphere in all the three groups (Figure 3).

IV. DISCUSSION

In the current study, the mean length, mean width and AC-PC length of the subthalamic nucleus were measured in the right and left hemisphere using 1.5 Tesla T2 weighted section. The results obtained in our study are similar to findings of Mavridis I, Boviatsis E, Anagnostopoulou S [7]. Variability in the size of STN has been observed by Daniluk et al[8] and Danish S et al[9] although the study was done on 62 patients with advanced Parkinson's disease which is different from our study population. There was no statistically significant difference between the dimensions in Group A & B, Group B & C and Group A & C but evidence for age related shrinkage of the nucleus was provided by Mavridis I, Boviatsis E, Anagnostopoulou S. In another study by Keuken et al on age related structural changes of the subthalamic nucleus in which mean volume of the subthalamic nucleus was calculated, no significant decrease in the volume of the subthalamic nucleus was thus detected[10]. In another study by Patil P et al [11], 3T MRI is proven to be better suited to visualize the posterior part of the STN as compared to 1.5T MRI. This kind of comparison has not been done in the current study.

CONCLUSION

The MRI study did not suggest any significant variation in the dimensions of Subthalamic nucleus with laterality or with increasing age.

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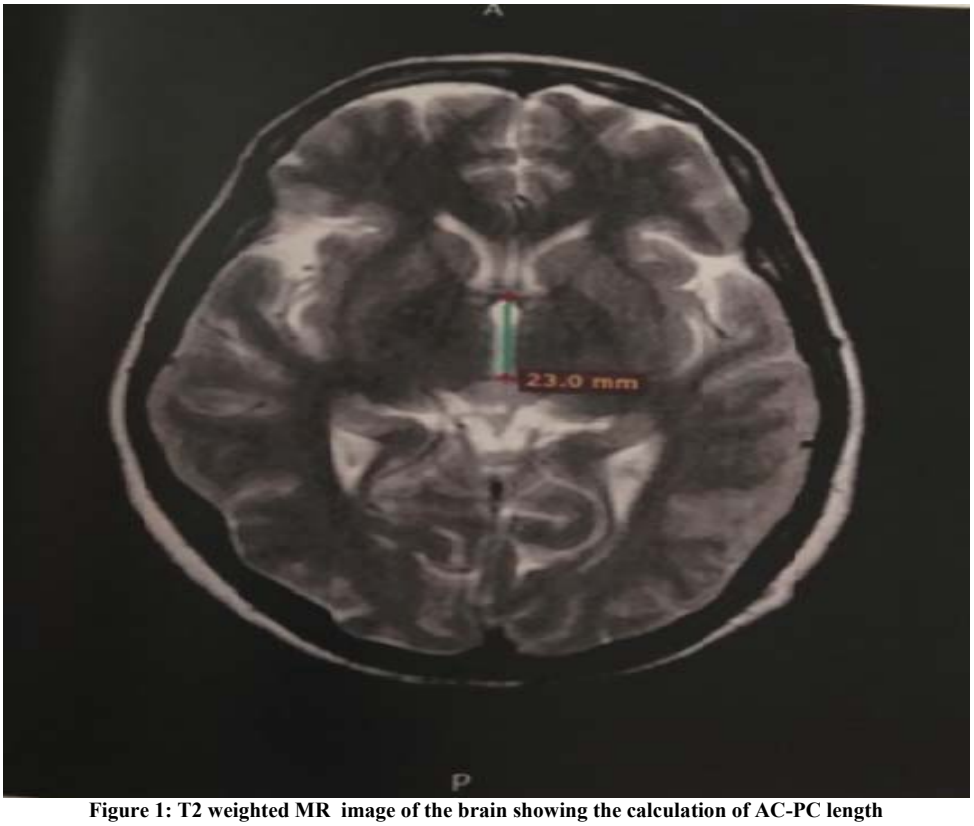


Figure 1: T2 weighted MR image of the brain showing the calculation of AC-PC length



Figure 2: T2 weighted MR image of the brain showing the measurements of length and width of Subthalamic nucleus

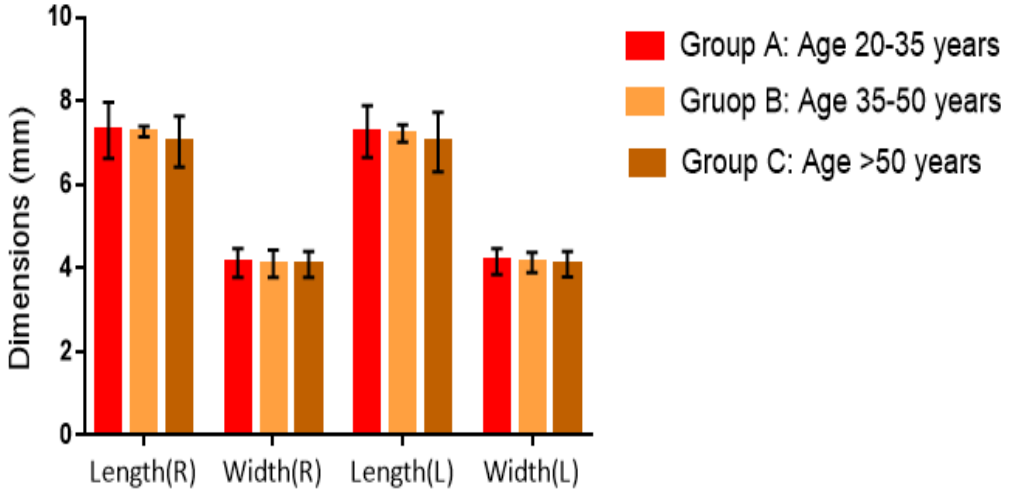


Figure 3: Box plot diagram showing the comparison of mean length and width in different age groups.

TABLE 1: COMPARISON OF THE MEAN OF DIMENSIONS OF SUBTHALAMIC NUCLEUS IN GROUP A AND GROUP B

	GROUP A			GROUP B			P VALUE
	MEAN	SD	SEM	MEAN	SD	SEM	
LENGTH(R)	7.3	0.667	0.2108	7.27	0.125	0.0396	0.8903
WIDTH(R)	4.13	0.340	0.1075	4.11	0.325	0.1027	0.8945
LENGTH (L)	7.27	0.615	0.1944	7.23	0.206	0.0651	0.875
WIDTH(L)	4.16	0.313	0.0991	4.14	0.237	0.0748	0.8738

*all dimensions in mm

TABLE 2: COMPARISON OF THE MEAN OF DIMENSIONS OF SUBTHALAMIC NUCLEUS IN GROUP B AND GROUP C

	GROUP B			GROUP C			P VALUE
	MEAN	SD	SEM	MEAN	SD	SEM	
LENGTH(R)	7.27	0.125	0.0396	7.03	0.607	0.1921	.2368
WIDTH(R)	4.11	0.325	0.1027	4.09	0.307	0.0971	0.8890
LENGTH (L)	7.23	0.206	0.0651	7.02	0.711	0.2249	0.3818
WIDTH(L)	4.14	0.237	0.0748	4.1	0.306	0.0966	0.7472

*all dimensions in mm

TABLE 3: COMPARISON OF THE MEAN OF DIMENSIONS OF SUBTHALAMIC NUCLEUS IN GROUP A AND GROUP C

	GROUP A			GROUP C			P VALUE
	MEAN	SD	SEM	MEAN	SD	SEM	
LENGTH(R)	7.3	0.667	0.2108	7.03	0.607	0.1921	0.3563
WIDTH(R)	4.13	0.340	0.1075	4.09	0.307	0.0971	0.7857
LENGTH (L)	7.27	0.615	0.1944	7.02	0.711	0.2249	0.250
WIDTH(L)	4.16	0.313	0.0991	4.1	0.306	0.0966	0.6698

★★★