The Role of Imaging Modalities in the Diagnosis of Parkinson's disease

Aziz Makandar
Professor
Akkamahadevi Women's University, Vijayapura

Rashmi Somshekhar
Research Scholar
Akkamahadevi Women's University, Vijayapura

ABSTRACT
The Parkinson's disease (PD) is the second most common neurodegenerative disease. It is characterized by the progressive loss of dopamine neurons in the substantia nigral which helps in managing all the body movements. There are four important symptoms of PD includes slow movement (bradykinesia), muscle stiffness (rigidity), postural instability and shaking (tremor) [1]. An increases amount of research is being done to detect the Parkinson disease at the early stages for early diagnoses and for proper treatment plan. There are many medical imaging modalities used to diagnosis PD like magnetic resonance imaging (MRI), functional imaging – which includes positron emission tomography (PET), single photon emission computed tomography (SPECT), and transcranial sonography. Each of these modalities provide a specific and unique aspect in detecting or identifying the disease. This review paper mainly focuses on the Brain functional imaging in the evaluation of Disease, current development of medical imaging modalities and its application in the diagnosis of PD.

General Terms
Imaging Modalities, Parkinson disease.

Keywords
Parkinson disease (PD), magnetic resonance imaging (MRI), Positron emission tomography (PET), single photon emission computed tomography (SPECT), and transcranial sonography.

1. INTRODUCTION
The Parkinson's disease (PD) is a disease pertaining to central nervous System. It is a degenerative disorder that impairs speech, motor skills and other functions of the human who suffers from it [2]. The main cause of Parkinson's disease is actually unknown. It has been researched that the combination of environmental and genetic factors plays an important role in causing PD [3]. Parkinson's disease (PD) is a chronic and progressive neurodegenerative disorder which is characterized by loss of dopaminergic neurons in the substantia nigra pars compacta (SNpc) and the formation of intracytoplasmic Lewy inclusion bodies [4]. PD can be imitated by many other syndromes, such as essential and dystonic tremors, multiple system atrophy (MSA), progressive supranuclear palsy (PSP), corticobasal degeneration (CBD) and vascular Parkinsonism. To date, up to 20% of the cases thought to be idiopathic PD turn out to be other diseases, despite strict diagnostic criteria being used [5]. In considering this situation, the precise grasping of the altered nigral structure or striatal dopamine terminal function can help to increase diagnostic accuracy for idiopathic PD and rationalize the use of dopaminergic replacement strategies. Conversely, it is also difficult to discriminate atypical Parkinsonian syndromes from idiopathic PD in their initial stages. Only when the full picture of the syndromes become evident does the diagnostic accuracy of atypical Parkinsonian syndromes improve. These conditions tend to have a dissatisfied prognosis as well as poor response to levodopa (it's a drug). Imaging modalities provide useful tools for detecting striatal pathology, which helps to differentiate them from true idiopathic PD. The below figure 1 shows the dopamine activity in normal and PD affected person.

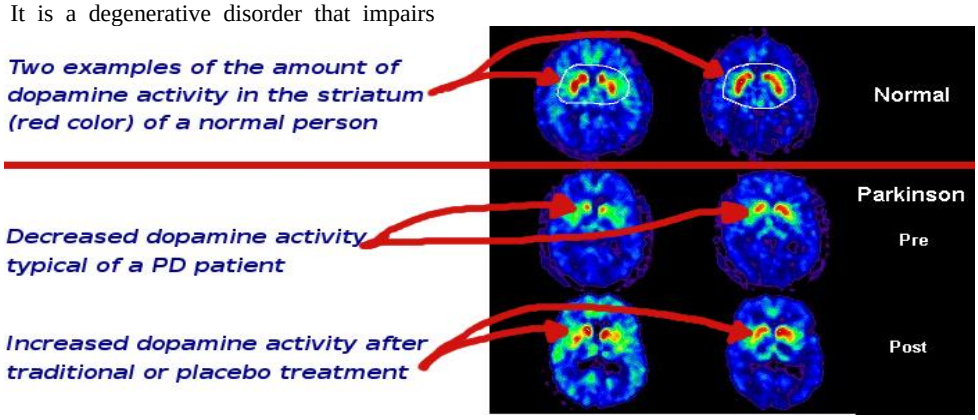

Fig 1: Shows the normal brain and the personaffectedwith the PD.

2. IMAGING MODALITIES
Imaging modalities are used to create visual representation of the interior of the body for clinical analysis, medical interpretations and for identification of the diseases. They are many imaging modalities toidentify the PD like, MRI,CT,PET,SPECT etc. The detail review of the imaging modalities is given below.

2.1 Magnetic resonance imaging:
Magnetic resonance imagingis a medical imaging technology that uses radio waves and a magnetic field to create detailed images of organs and tissues.The Structural resonance imaging (MRI) iscomprised of MRI- based volumetric, diffusion- weighted (DWI) and diffuse tensor (DTI) imaging. Basic MRI shows a standard nigral structure in disorder

metallic element and then isn't diagnostically useful. It is additionally tough in applyingVolumetric T1- weighted MRI to discover volume in metallic element owing to its poor accuracy in distinguishing the border of the nigra compacta [4].Diffusion weighted imaging (DWI) or diffusion tensor imaging (DTI) may be a MRI- based technique providing quantified diffusion info on the random movement of the water molecules that flow on the fiber tracts within the central nervous system [6]. This diffusion info will be delineated as property. The latter represents a scenario that the diffusion depends upon directions and is quantified as an evident diffusion constant (ADC) by applying thefield gradients of various degrees of diffusionsensitization [7]. Neurodegenerative disorders get obviate restraints in water molecule movement, leading to reducing property whereas increasing the ADCs and then proving the disruption of neural tracts. This theoretical analysis provides for the potential utility of DWI and DTI within the diagnosing of disorder metallic element by police work altered property and ADCs in basal ganglia. In Vaillancourt's study, fragmental property and therefore the apparent diffusion constant within the nucleus nigra was measured in fourteenearly- stage metallic element patients and 14 age- matched healthy volunteers [8]. Lower fragmental property values were found all told metallic element patients within the region of interest,compared with the management cluster. The reduction incaudal SN, moreover, is bigger than that within the rostral region of interest, that is in agreement with postmortem studies. A sensitivity and specificity of 100 percent was nonheritable in distinguished metallic element patients with the healthy controls on the idea of their fragmental property. Additionally, the worth of DTI approaches in differentiating between disorder Parkinson's sickness and atypical brain disease are mentioned in many studies. Boelmans et al. showed thatDTI parameters within the tract will be wont todifferentiate corticobasal degeneration from disorder metallic element [9]. Nicoletti et al. showed that the apparent diffusion constant values of the superior neural structure peduncle might be wont to discriminate patients with PSP from disorder metallic element similarly because the Parkinsonian variant of multiple system atrophy (MSA- P) [10]. Within the future, newer techniques supported MRI could be increasinglyintegrated into the diagnosis of thedisorder. The below figuresshow the MRI brain image.

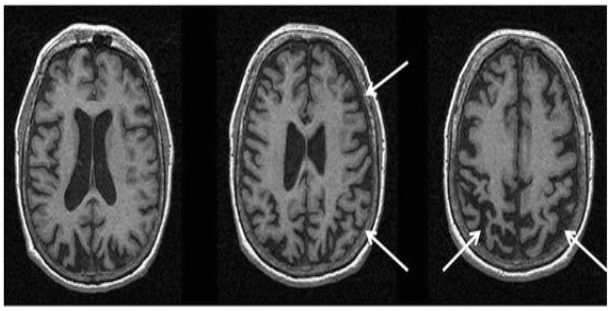

Fig 2. Shows the MRI of the brain imaging.

In the MRI of a patient with a pathological diagnosis of Corticobasal Degeneration. Serial axial T1 sequences showing right greater than left parietofrontal atrophy typical of that seen in Corticobasal Syndrome. In this case, the patient had a confirmed pathological diagnosis of Corticobasal Degeneration PD.

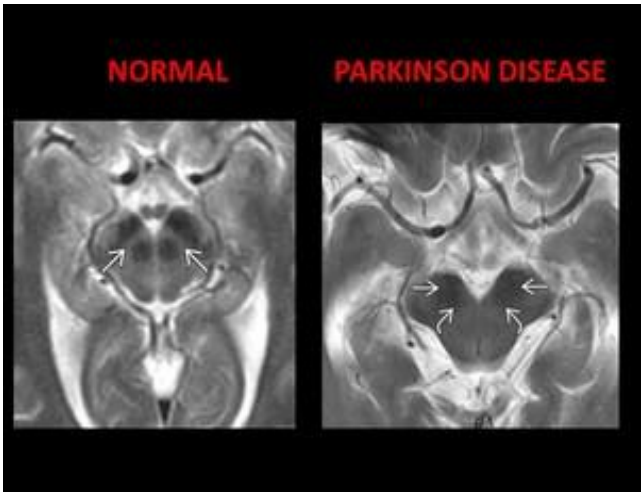

Fig. 3: Axial T2 MR images compare normal midbrain with Parkinson diseases midbrain. Second image shows blurring and thinning of pars compacta. Subsequently, the red nuclei and substantia nigra are almost touching.

2.2 Transcranial imaging (TCS).

Transcranial imaging (TCS) displays brain structures by applying Associate in Nursing ultrasound probe at the bonewindow to discover Associate in Nursing ultrasound echo regarding ninetieth of caseswith clinically outlined metallic element exhibit increased echogenicity- specifically hyper echogenicity - at the location of the substantianigra [11, 12]. Additionally, director et al. showed thattranscranial imaging detected traditional nucleus nigraechogenicity in atypical metallic element in distinction withhyper echogenicity within the neural structure of the disorder metallic elementpatient, suggesting that transcranial imaging might beused as a useful instrument for the medical diagnosisof disorder metallic element. Moreover, the hyperechogenicity of thelentiform nucleus is gift in most atypical metallic element howeverabsents in disorder metallic element [13]. traditional neural structure signal incombination with basal ganglion hyperechogenicitycan differentiate atypical from disorder metallic element with asensitivity of fifty-nine and a specificity of 100 percent. The neural structurehyperechogenicity, however, remains static over 5years despite the progression of symptoms and doesn'tcorrelate with sickness severity in metallic element [14]. As such, Brookset al. steered that the presence of neural structurehyperechogenicity might represent an attribute instead of astate marker for status to metallic element [15].

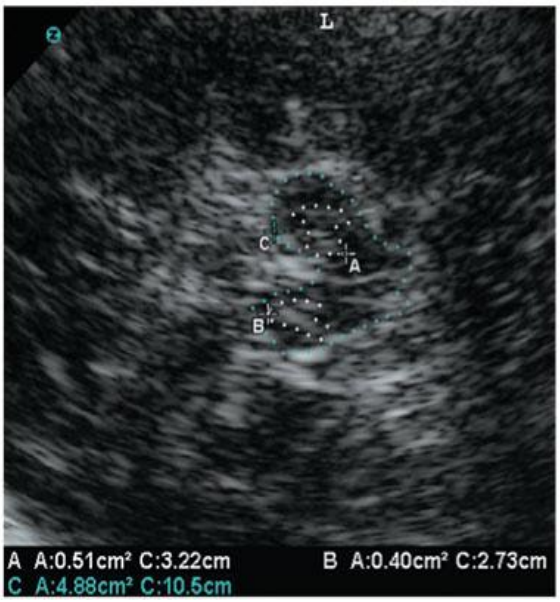

Fig 4. Transcranial sonography of a patient with the Parkinson disease. Intensehyperechogenicity can be viewed in the region of the substantia nigra of the mid brain bilaterally (A and B). The hypoechogenicmesencephalon shows a butterfly shape and is surrounded by hypercogenic basal cisterns C.

2.3 Functional imaging--positron emission tomography (PET) / Single gauge boson emission tomography (SPECT).

Functional imaging determines the functional status of the brain which includes thePET/SPECT. The Positron emission tomography (PET) is an imaging technique that produces a three-dimensional image of a part of the body reflecting functional processes within the area of interest. Single-photon emission computed tomography (SPECT) is a nuclear medicine technique thatconstructs three-dimensional images from scintigraphic data, in a similar way that CT constructs three-dimensional images from transmitted radiographs.The below review shows the four-differentstudy of functional imaging.

2.3.1 Pre-synaptic monoamine neurotransmitter terminal performs Pre-synaptic dopaminergic perform will typically be evaluated by 3 completely different approaches [16]: (1) the availability of pre-synaptic monoamine neurotransmitter transporters (DAT) in charge of the high-affinity uptake of monoamine neurotransmitter from the conjugation cleft with 99mTc-TRODAT SPECT or 123IFP- CIT SPECT; (2) the aromatic aminoalkanoic acid enzyme (AADC) activity of dopaminergic neurons with 18F-dopa PET; (3) the density of sac aminoalkane transporter type a pair of (VMAT2) placed within the sac membrane, which is accountable for transporting monoamine neurotransmitter from the cytoplasm into body fluid vesicles, with 18F-dihydrotetrabenazine (18F -DTBZ) PET. Striatal audiotape binding reduction in metallic element is characterized by affecting the posterior over the Associate in Nursingterior in an asymmetric pattern, that has been found in over ninetieth of clinically probable metallic element cases [17]. This binding, however, is traditional in tremor patients or tube-shaped structure parkinsonism. A multicenter study of monoamine neurotransmitter transport imaging compared clinical diagnostic parkinsonism with tremor patients by applying 123I-FP-CIT SPECT. Their results showed a high 2 Int. j. integer. med., 2013, Vol. 1, 11:2013 WWW.intechopen.com sensitivity and specificity in differentiating brain disease with non-Parkinsonism (a sensitivity of ninety-eight and a specificity of 83%) [18]. In another study, 99mTc- TRODAT SPECT might distinguish metallic element from tube-shaped structure parkinsonism. This proof, therefore, indicates that DAT imaging might be a valuable suggests that of supporting or rejecting a diagnosing of brain disease related to striatal monoamine neurotransmitter deficiency. many studies have examined the role of audiotape imaging for determinant whether unsure Parkinsonian cases are related to striatal monoamine neurotransmitter deficiency. in a very little prospective study of fifteen subjects with clinically unclear Parkinsonian syndromes, thirteen with probable Parkinson's sickness, and 13 healthy volunteers evaluated by victimization 99mTc-TRODAT SPECT, there was eightieth agreement in scrutiny the baseline SPECTdiagnosing with the gold commonplace clinical diagnosis of metallic element at a pair of years' follow- up, and 100percent sensitivity [19], implying its potential use within the diagnosing of patients with clinically unsure Parkinsonian syndromes. Detecting pre-synaptic dopaminergic terminal integrity with either striatal 18F-dopa uptake or a DAT SPECT. Marker, however, exhibits poor effectiveness in discriminating atypical Parkinsonian syndromes from typical atomic number 46 [20, 21]. the standard gradient of loss of dopaminergic operate in atomic number 46, however, is additionally found in some cases of multiple system atrophy [22, 23, 24].

2.3.2 Post-synaptic monoamine neurotransmitter receptor binding Post-synaptic dopaminergic operate is especially assessed by the density of monoamine neurotransmitter receptors, that area unit set in the membrane of the post-synaptic dopaminergic neurons. Generally, monoamine neurotransmitter receptors area unit divided into two families, the D1 family (D1, D5) and also the D2 family (D2, D3, D4). The monoamine neurotransmitter D1 receptor is detected by 11C-SCH23390 PET or 123I-IBZM SPECT. However, this type of imaging approach isn't wide used for there is no proof of alterations in typical atomic number 46 [25]. ^{11}Craclopride (^{11}C-RACLO) PET is used so as to estimate alterations within the D2 receptor. many studies showed that the striatal D2 monoamine neurotransmitter receptors' reduction in basal ganglion is a lot of severe in MSA patients than that in atomic number 46 cases [26, 27], suggesting that the assessment of the striatal monoamine neurotransmitter receptor could facilitate differentiate atomic number 46 from Parkinson and conditions for clinical observe.

2.3.3 Aldohexose metabolism and cerebral blood flow 18F-fluorodeoxyglucose (18F-FDG) PET is accustomed measure resting regional cerebral metabolic rates for glucose and has become a progressively in style field for the study of neurodegenerative diseases. By applying a method termed the ′scaled sub-profile model′ (SSM) - which may be a spatial variance methodology supported principal component analysis (PCA) - to assess subject-by-region effects in useful brain pictures [28], Eidelberg et al. have represented characteristic patterns of aldohexose metabolism in several neurodegenerative disorders [29, 30]. The feature of aldohexose metabolism in atomic number 46, which is called a PD-related pattern, is exaggerated metabolism in the ganglion and motor region likewise as a cerebellum with abnormal reductions in parietal- and occipital-associated regions and within the dorsolateral prefrontal cortex. What's a lot of, there also are MSA related patterns, PSP-related

patterns and corticobasal degeneration-related patterns. These patterns, therefore, make it attainable for the medical diagnosis of idiopathic atomic number 46 by using 18F-FDG PET. Eidelberg etal. showed that a high sensitivity and specificity was obtained not solely in distinguishing upset atomic number 46 patients with healthy controls (a sensitivity of 100% and a specificity of 86%), however additionally in discriminating atypical parkinsonism from upset atomic number 46 patients (a sensitivity of 96% and a specificity of 91%) by victimization 18F-FDG PET and the spatial variance methodology [31]. This promising method wants additional studies on larger patient cohorts to prove its effectiveness.

2.3.4 Viscus sympathetic denervation 123I-metaiodobenzylguanidine (123I-MIBG), that is AN analogue of guanethidine and brought up by the postganglion sympathetic neurons, is used to live the sympathetic nerve system [32]. variety of studies have shown bated heart muscle uptake in early atomic number 46 patients compared thereupon in healthy controls. Significantly lower uptake was, moreover, found in idiopathic atomic number 46 cases than that in atypical brain disease, even in terribly early stages [33,34]. Thus, 123I-MIBG myocardial scintigraphy could supply useful data in the medical diagnosis of atomic number 46 in its initial section, particularly while not clinical signs of involuntary failure. Nagayama et al., however, indicated that the high sensitivity however poor specificity of MIBG heart muscle scintigraphy in police investigation atomic number 46 (a sensitivity of eighty-seven.7% and a specificity of thirty-seven.4%, respectively) [35]. Quite half the patients while not atomic number 46 (66.5%) exhibited low MIBG uptake, that contributed to respectable overlap of the ratios between atomic number 46 and different disorders. Conversely, in another analysis up to half the patients with Hoehn and Yahr stage one will still show the traditional tracer binding [36]. Much more attention ought to be paid in victimization heart muscle scintigraphy for the identification of upset atomic number 46.

3. CONCLUSION AND FUTURE SCOPE

To detect the PD, we have different image modalities and the developments in imaging modalities have so improved the accuracy of the diagnosis of idiopathic PD.Each approach, however, has its own pitfalls that limit its utility in the diagnosis of idiopathic PD. Understanding the limitations can facilitate to form correct use of those techniques which will help in early diagnoses of Parkinson disease.Thissurvey paper is the study of different imaging modalities used in the diagnosis of PD. However, there are many regions in the brain affected by the PD. The future scope of the work would be using any one of the imaging modalities for identifying and diagnosing different regions of the brain affected by PD for the early diagnosis.

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