ORIGINAL RESEARCH PAPER
Volume - 11 | Issue - 10 | October - 2022 | PRINT ISSN No. 2277 - 8179 | DOI : 10.36106/ijsr
INTERNATIONAL JOURNAL OF SCIENTIFIC RESEARCH

ROLE OF CONVENTIONAL MRI AND DIFFUSION TENSOR IMAGING AND TRACTOGRAPHY IN EVALUATION OF STROKE

Radiology

Dr. Saiteja Namala* Senior Resident, Department of Radiodiagnosis, Sapthagiri Institute of Medical Sciences and Research Centre, Bengaluru, Karnataka. *Corresponding Author

Dr. Mallikarjunappa B Professor and HOD, Department of Radiodiagnosis, Sapthagiri Institute of Medical Sciences and Research Centre, Bengaluru, Karnataka.

ABSTRACT

Background: Stroke is considered to be a rapidly developing sign of global or focal disturbance of cerebral function. Diffusion tensor imaging permits the quantitative evaluation of white matter pathology using measures of diffusion anisotropy. Fiber tractography based on DTI can reveal three dimensional white matter connectivity of human brain. A potential application for DTI in stroke is using directionally encoded colour anisotropy images and fiber tractography to delineate the location of functionally important white matter pathways in relation to stroke. This research aims study to accurate diagnosis of stroke in definitive management. **Methodology:** The present study was 8 months prospective follow-up study of patients coming to Sapthagiri Institute of Medical Sciences and Research Centre in Bengaluru, Karnataka. The baseline data was analyzed using descriptive statistics, and Chi-square test was used to test the association of various complications with selected variables of interest. **Results:** In study, 74% participant was male. The maximum number of participants was in the51-60 years age group (28%). Males had a maximum of the disrupted fiber (n=24). On contrast in females disrupted, non-disrupted and reduced caliber was almost similar in number. A significant association was observed between the gender and the fibers affected. Male had large sized infarcts (82.35% vs 17.65%). An FA value in the affected side of 0.29±0.17 was reported for large size infarcts,0.25±0.18 was reported for medium sized infarcts, and 0.32±0.17 was reported for small sized infarcts. A statistically significant correlation was found between the infarct size and the fractional anisotropy (FA) value on the normal side with the size of the infarct. The maximum of the study participants who had a disrupted fiber was in the51-60years and 61-70 years age group. Maximum people who were in the 51-60years age group had a non-disrupted fiber. Only in 10 people, reduced caliber fiber was found commonly in the age group 41years to 80years. **Conclusion And Interpretation:** DTI tractography is a trustable technique that can provide valid information regarding the white matter fibers and its microstructural changes. Besides, this technique also provides information about the virtual reconstruction of fiber tracts. The Fractional anisotropy value of the affected, as well as the normal side, can be proved to help understand the nature of the stroke.

KEYWORDS

Stroke, MR brain, diffusion tensor imaging , MR tractography, fractional anisotropy

INTRODUCTION:

Stroke is one of the important causes of premature death and disability in low-income countries such as India. According to the Global Burden of Diseases (GBD) study,85% of the global stroke burden is borne by the middle and low-income countries[1]. The World Health Organization defined stroke as a rapidly developing sign of global or focal disturbance of cerebral function[2]. In general, stroke is classified in to two main categories: Ischemic stroke and hemorrhagic stroke[3]. Depending on the location of the hemorrhage hemorrhagic stroke can be further classified into two types: subarachnoid hemorrhage (SAH) and intracerebral hemorrhage (ICH)[4].

There are various factors that can be identified as the potential risk factors for stroke. Among these factors, some are modifiable risk factors and are more common such as diabetes, hypertension, and smoking. Non-modifiable risk factors include gender, age and geneticfactors[4]. Various imaging modalities have been used extensively for proper diagnosis of the stroke such as diffusion tensor imaging, magnetic resonance imaging, positron emission tomography (PET), and computed tomography (CT). All these techniques detect the presence of injured tissues commonly known as ischemic penumbra[5]. Positron emission tomography (PET) has been considered to be a gold standard in detecting the early stroke Pathophysiology and also it provides quantitative or semi-quantitative hemodynamic data[6].

A normal non-contrast CT imaging is usually done as a first imaging technique for stroke evaluation[7]. CT angiography (CTA) provides information about the early collateral circulation after ischemic stroke[8]. CT perfusion technique also provides information regarding the presence of vessel occlusion and stenosis in patients suffering from acute stroke[9].T1, and T2 weighted MRI been used in differentiating ischemic stroke from hemorrhagic one[10]. Diffusion tensor imaging (DTI), is another advanced technique that tracts the diffusion of the water molecules in every direction in the tissues[11].

The current research on stroke evaluation stressed that no single imaging technique could give a complete picture of completely salvageable tissues. Therefore, a multi modal approach is preferred.

OBJECTIVES:

1. To accurate diagnosis of stroke in patients with stroke.
2. To reveal three dimensional white matter connectivity of human brain by Fiber tractography using diffusion tensor imaging (DTI).
3. To delineate the location of functionally important white matter pathways in relation to stroke.

MATERIALS AND METHODS:

This hospital based prospective study was performed at Sapthagiri Institute of Medical Sciences and Research Centre, Bengaluru, Karnataka between January 2023 - august 2023. The study group consists of 50 patients coming to Radiodiagnosis department with a clinical history of weakness, slurring of speech, blurring of vision, old cerebro-vascular accident and stroke. Patients in whom MRI was contraindicated like Aneurysm clips, any metallic fragment or foreign body, Cardiac pacemaker, Implanted Cardioverter-defibrillator or Cochlear implants, restless, uncooperative patients were excluded from the study.

Magnetic Resonance Imaging was done using Siemens Magnetom Avanto MR Machine which helps to diagnose the minutest details. It was capable of acquiring T1, T2, SWI, DWI, FLARE, DTI and Tractography sequences and performing post processing on acquired data. The MRI protocol consisted of T2- weighted images, diffusion weighted images followed by DTI sequence. DTI acquisition was based on single shot spin echo echo planar imaging with the following parameters:
TR/TE3400/94, field of view of 300mm,slice thickness 5mm and 24 slices

DTI Analysis: The DTI images were analyzed with a post processing NEURO 3D software on GE. Fractional anisotropy (FA) transverse maps were generated.

Magnetom Avanto, ATim + Dot System offers leading magnet and gradient technology, in acquiring excellent image quality[12].

Data Analysis Method:

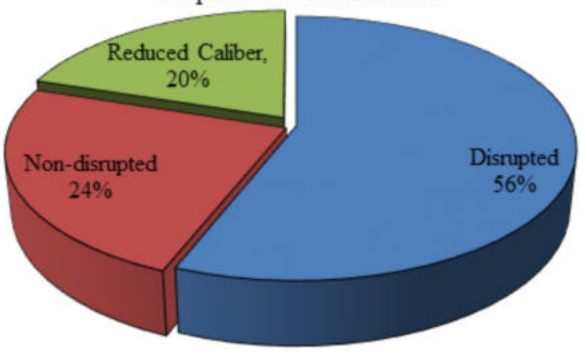
The data collected was recorded in an excel sheet and analysed by mathematical process for concluding the result to meet the research objectives. Statistical analysis was conducted by employing SPSS software version 12.0. Data was expressed as either mean ± standard

deviation or numbers and percentages. Chi-square test was used to find the significance of study. P value of < 0.05 was considered statistically significant.

RESULTS:

In the present study, 26% of the respondents were Female and 74% of the respondents were male. 28% respondents are in the age group of 51-60, 26% respondents are in the age group of 61-70 and 24% respondents are in the age group of 71-80.

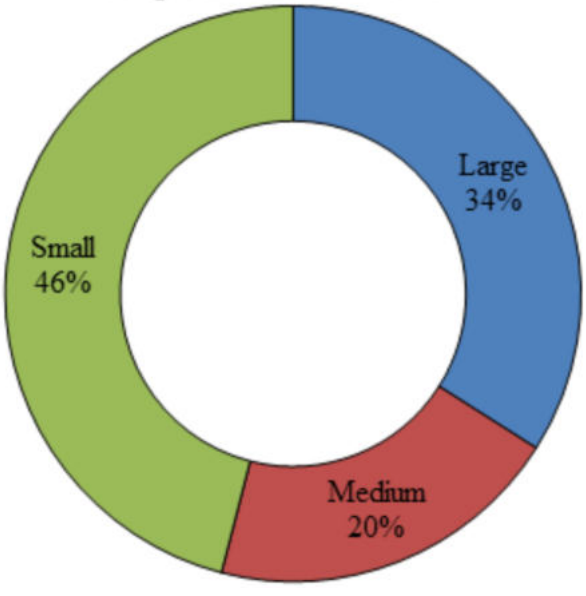
Graph 1: Fibers Affected



Fibers Affected:

56% of the respondents of the respondents who had their fibers affected were found to be disruptive in nature, 24% of the respondents of the respondents who had their fibers affected were found to be non-disruptive in nature and 20% of the respondents of the respondents who had their fibers affected were found to be reduced caliber in nature.

Graph 2: Size of Infarct



Size Of Infarct:

The above figure shows that 34% of respondents had large sized infarct, 20% of respondents had medium sized infarct and 46% of respondents had small sized infarct.

Table1: Comparison Between Age Group And Fiber At Inferior Fronto-occipital Fasciculus

Age groups	YES	Percentage	NO	Percentage	pvalue
<20years	0	0	2	5.26	0.02915
20-40 years	2	16.67	0	0	
41-60 years	1	8.33	17	44.73	
61-80 years	8	66.67	17	44.73	
> 80 years	1	8.33	2	5.26	
Total	12	24%	38	76%	

The above table shows the p-value for the result was found to be 0.02915 which is less than the threshold value of 0.05 hence the findings are significant in nature.

Table2: Comparison Of Age Group And Mean Fa Values On Affected And Normal Side

Age Group	Affected Side			Normal Side		
	Average	St. Dev.	P value	Average	St. Dev.	P value
<20years	0.46	0.15	0.664	1.23	0	0.128
21-40 years	0.09	NA		0.56	NA	
41-60 years	0.26	0.08		0.71	0.26	
61–80 years	0.32	0.21		0.81	0.25	
> 80 years	0.33	0.11		0.85	0.34	

The above table shows that on affected as well as normal side, the p-value for the result was found to be 0.664 and 0.128 and the findings are not-significant in nature.

Table3: Comparison Between Fibers Affected And Age Groups:

Age groups	Disrupted	Non-disrupted	Reduced caliber	P value
<20 years	1 (50%)	1 (50%)	0 (0%)	0. 938986
21 - 40 years	2 (100%)	0 (0%)	0 (0%)	
41 - 60 years	9 (50%)	6 (33.33%)	3 (16.67%)	
61 - 80 years	14 (56%)	4 (16%)	7 (28%)	
> 81 years	2 (66.67%)	1 (33.33%)	0 (0%)	

The above table shows that p-value for the result was found to be 0.938and the findings are non-significant in nature.

Table4: Comparison Between Age Group And Size Of Infarct

Age Groups	Large	Medium	Small	P value
<20years	0 (0%)	1 (10%)	1 (4.35%)	0.344
21-40 years	2 (11.77%)	0 (0%)	0 (0%)	
41-60 years	3 (17.65%)	3 (30%)	12 (52.17%)	
61-80 years	12(70.59%)	5 (50%)	8 (34.58%)	
> 81 Years	0 (0%)	1 (10%)	2 (8.7%)	

The above table shows the p-value for the result was found to be 0.343 and the findings are non-significant in nature.

Correlation Between Age And FA Values On Normal Side And FA Value On Affected Side:

After applying Spearman's rank correlation test correlation between age and FA values on Normal side and FA value on Affected side, p-values were 0.638 (correlation coefficient 0.07) and 0.806 (correlation coefficient -0.04) respectively and the findings are not-significant in nature.

Table 5: Comparison Between Sex And Mean FA Values On Affected Side:

Sex	Affected Side			Normal Side		
	Average	Std. Dev.	P value	Average	Std. Dev.	P value
Female	0.27	0.15	0.634	0.81	0.15	0.653
Male	0.30	0.18		0.78	0.26	

The above table shows the p-value for the result of affected as well as normal side was found to be 0.634 and 0.653 respectively and the findings are non- significant in nature.

Table6: Comparison Between Fibers Affected And Sex

Gender	Disrupted	Non-Disrupted	Reduced Caliber	P value
Female	4 (30.77%)	5 (38.46%)	4 (30.77%)	0.092
Male	24 (64.86%)	7 (18.92%)	6 (16.22%)	

The above table shows that the p-value for the result was 0.092 and the findings are non-significant in nature.

Table7: Comparison Between Sex And Size Of Infarct:

Sex	Large	Medium	Small	P value
Female	3 (17.65%)	2 (20%)	8 (34.78%)	0.496
Male	14 (82.35%)	8 (80%)	15 (65.22%)	

The above table shows that the p-value for the result was found to be 0.496 and the findings are non-significant in nature.

DISCUSSION:

Stroke is one of the serious health care concerns that have a high mortality and disability ratio. However, to date, the diagnosis of stroke is a critical concern. Various imaging modalities have been used extensively for proper diagnosis of the stroke such as diffusion tensor imaging, magnetic resonance imaging, positron emission tomography

(PET), and computed tomography (CT). All these techniques detect the presence of injured tissues commonly known as ischemic penumbra [13].

In this study total of 50 patients were included. Among these study patients, 74% of the patients were male showing a male predominance. The male predominance was also reported in the study by ***Farahat et al (2018).*** In the study, ***Farahat et al*** have shown that among the study patients who were reported to have a cerebral stroke 92% of people were male. This study also reported a mean age of 64.1± 6.77years among the patients[14].

In the present study, the maximum number of patients was in the 51-60 years age group (28%), followed by 61-70 (26%) years and 71-80 years (24%). Interestingly 4% of the participants were below 20 years of age group. In the maximum of the cases, the participants had disrupted fiber (56%). 34% of respondents had large-sized infarct,20% of respondents had medium-sized infarct and 46% of respondents had small sized infarct.

64% of respondents were found to have Fiber at Short Range Association Fibers while in 36% of respondents there was no Fiber at Short Range Association Fibers. 64% of participants were found to have defected Short Range Association Fibers,30% has a defect in Superior Fronto Occipital Fasciuluic fiber, 18% have a defect in Superior Region of Corona Radiata, 8% had a defect in Posterior Thalamic Radiation,and10%had Posterior Limb of Internal Capsule. The association of age of the participants and fiber at inferior frontal occipital fasciculus was found to be statistically significant (P-value<0.5).

The fractional anisotropy value in a given voxel is the main parameter that gets measured in the DTI. Studies have shown that this parameter is helpful in the examination of tissue micro structure. It also enables mapping of the white matter tracts and thus provides excellent details of the brain structure[15].

Fractional anisotropy (FA) represents the amount of diffusion asymmetry in a voxel and is calculated by dividing the square root of the sum of squares of the diffusivity differences by the SRSS of the diffusivities. It is the most commonly used DTI scalar. A value of 0 represents infinite isotropy and 1represents infinite anisotropy [16].

In this study, we have also measured FA values for the identification of affected sections of the brain. In the present cohort, it was observed that the correlation of FA values on the affected side with fiber at arcuate fasciculus showed a highly significant association. This result proves that FA values can significantly predict the defect in the fiber functionality.

No statistical association was found between the age of the participants and fractional anisotropy value on the affected side. Similarly, no association was found between the fractional anisotropy values (FA) on the normal side with the age group of the study participants. Males had a maximum of the disrupted fiber (n=24). On contrast in females disrupted, non-disrupted and reduced caliber was almost similar in number. On statistical analysis, a significant association was observed between the gender of the study participants and the fibers affected.

Large sized infarcts were mostly found in participants who were male. In male patients,14 (82.35%) had large size infarcts compared to the female participants where only 3 people (17.65%) had large size infarcts. Most of the disrupted fiber patients were detected with large sized infarcts (n=16, 94.12%).In non-disrupted fibers, no large size infarcts were observed. This finding was also found to be statistically significant. Patients who had detected with large sized infarcts were in the age group of 61.94±14.52 years, patients with medium sized infarcts were found in patients with a mean age of 62.8±19.21 years and patients with small sized infarcts had a mean age of 60.13±15.18years.

An FA value in the affected side of 0.29±0.17 was reported for large size infarcts,0.25±0.18 was reported for medium sized infarcts, and 0.32±0.17 was reported for small sized infarcts. On further analysis, this result was found to be non-significant(P-value=0.566).

On the other hand, a statistically significant correlation was found between the infarct size and the fractional anisotropy (FA) value on the normal side with the size of the infarct. The FA values were found to be higher in the normal size compared with the affected side. For the large size infarct, the average infarct size was 0.85±0.21, for medium size infarcts the average size was 0.81±0.27, and for small size infarcts, the size was 0.74±0.24.A significant difference was observed between the FA values on the affected side and the normal side(P-value=0).

Previous studies have shown that an FA ratio nearer to the 1 signifies the health of the tract[17]. The fractional anisotropy (FA) value was calculated for disrupted, non-disrupted and reduced caliber fibers. The FA value of disrupted and non-disrupted fiber had a similar FA value (0.8). Reduced caliber fiber had an FA value of 0.74±0.18. However, this data was statistically insignificant.

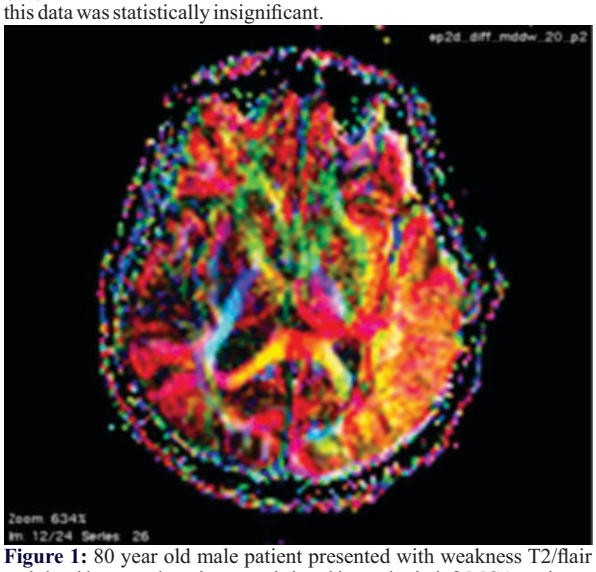


Figure 1: 80 year old male patient presented with weakness T2/flair weighted images show increased signal intensity in left MCA territory. Diffusion weighted images show restriction and reduced fa values compare to normal side colour coded FA maps shows disruption of short range of association fibers(SRAF) superior longitudinal fasciculus (SLF) inferior longitudinal fasciculus (ILF) superior and inferior fronto-occipital fasciculus.

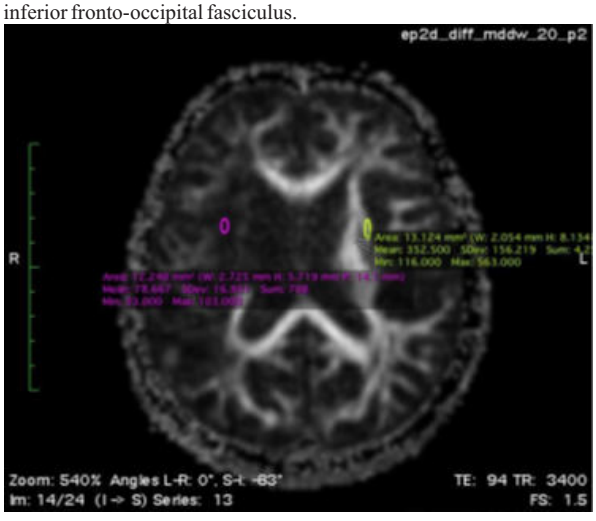


Figure 2: 62 years old male patient came with complaint of generalized weakness. T2/flair images shows gliotic changes with right MCA territory infarct diffusion weighted fa maps shows decreased fa values on affected side. Colour map shows disruption of anterior limb of internal capsule (ALIC) posterior limb of internal capsule (PLIC) superior fibers of corona radiata (SCR) superior fronto-occiptial fasciculus (SFO)

CONCLUSION:

This study has shown that DTI tractography is a trustable technique that can provide valid information regarding the white matter fibers and its microstructural changes. Besides, this technique also provides information about the virtual reconstruction of fiber tracts. The Fractional anisotropy value of the affected, as well as the normal side, can be proved to help understand the nature of the stroke. Moreover,

this study also points out the importance of MR tractography in understanding the anatomy of the brain tracts and delineation of the functions of each.

Limitations Of The Present Study:

The present study has some limitations also. The following section is going to discuss those points. The main limitation of the study is the fact that the relatively large slice thickness usually increases the partial volume which eventually leads to false-positive results in the voxel-based analysis.

Secondly, because of the time constraint, we could not able to follow up patients after they were released from the hospital. Ideally, a follow-up would have provided complete information regarding the prognosis of the patients. Finally, in stroke patients FA value decreases after a few days in the perilesional area, therefore the time also has significant importance in the study.

REFERENCES:

1. Kamalakannan, S., Gudlavalleti, A. S. V., Gudlavalleti, V. S. M., Goenka, S. & Kuper, H. Incidence & prevalence of stroke in India: A systematic review. Indian J. Med. Res. 146, 175–185 (2017).
2. Donkor, E. S. Stroke in the 2 1st Century: A Snapshot of the Burden, Epidemiology, and Quality of Life. Stroke Res. Treat. 2018, 1–10 (2018).
3. Randolph, S. A. Ischemic Stroke. Workplace Health Saf. 64, 444–444 (2016).
4. Parmar, P., Sumaria, S. & Hashi, S. Stroke: classification and diagnosis. Pharm. J. 3, 200–204 (2011).
5. Wey, H.-Y., Desai, V. R. & Duong, T. Q. A review of current imaging methods used in stroke research. Neurol. Res. 35, 1092–1102 (2013).
6. Sahathevan, R. et al. Positron Emission Tomographic Imaging in Stroke. Stroke J. Cereb. Circ. 47, 113–119 (2016).
7. Patel, S. C. et al. Lack of clinical significance of early ischemic changes on computed tomography in acute stroke. Jama 286, 2830–2838 (2001).
8. Lima Fabricio O. et al. The Pattern of Leptomeningeal Collaterals on CT Angiography Is a Strong Predictor of Long-Term Functional Outcome in Stroke Patients With Large Vessel Intracranial Occlusion. Stroke 41, 2316– 2322 (2010).
9. Konstas, A. A., Wintermark, M. & Lev, M. H. CT Perfusion Imaging in Acute Stroke. Neuroimaging Clin. 21, 215–238 (2011).
10. Liebeskind David S. et al. CT and MRI Early Vessel Signs Reflect Clot Composition in Acute Stroke. Stroke 42, 1237–1243 (2011).
11. Chaudhary, N. et al. Diffusion tensor imaging in hemorrhagic stroke. Exp. Neurol. 272, 88–96 (2015).
12. Hagmann, P. et al. Understanding Diffusion MR Imaging Techniques: From Scalar Diffusion-weighted Imaging to Diffusion Tensor Imaging and Beyond. Radio Graphics 26, S205–S223 (2006).
13. Wey, H.-Y., Desai, V. R. & Duong, T. Q. A review of current imaging methods used in stroke research. Neurol. Res. 35, 1092–1102 (2013).
14. Ahmed H, F., Mervat E, L. & Hany, H. The Role of the Diffusion Tensor Imaging and the MR Tractography in the Evaluation of the Ischemic Cerebral Strokes. Int. J. Radiol. Imaging Technol. 4, (2018).
15. Souillard-Scemama, R. et al. An update on brain imaging in transient ischemic attack. J. Neuroradiol. 42, 3–11 (2015).
16. Hagmann, P. et al. Understanding Diffusion MR Imaging Techniques: From Scalar Diffusion-weighted Imaging to Diffusion Tensor Imaging and Beyond. RadioGraphics 26, S205–S223 (2006).
17. Nelles, M. et al. Diffusion tensor pyramidal tractography in patients with anterior choroidal artery infarcts. AJNR Am. J. Neuroradiol. 29, 488–493 (2008).