Original Article

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Radiology Section

Role of Magnetisation Transfer Imaging in Evaluation of Tuberculoma and Neurocysticercosis

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ABSTRACT

Introduction: Precise imaging differentiation of intracranial tuberculoma and Neurocysticercosis (NCC) is essential for their effective treatment. Conventional Magnetic Resonance Imaging (MRI) is an effective modality in its evaluation. However, certain stages of both the diseases show significant simulation in their imaging features paving need for additional sequences like Magnetisation Transfer Contrast (MTC) for their precise differentiation.

Aim: To determine the Magnetisation Transfer Ratio (MTR) and its role in differentiating between intracranial tuberculoma and NCC.

Materials and Methods: A hospital based cross-sectional study was done from November 2017 to May 2019 in a tertiary care centre of Southern India, where 55 patients with imaging diagnosis of NCC or tuberculoma were subjected to Magnetisation Transfer (MT) imaging and the MTR ratio was analysed. Consistency and reliability of the measurements were confirmed by obtaining the values repeatedly. For each Region Of Interest (ROI), MTR was calculated using the formula: MTR = (Mo- Mt) x 100/ Mo Where, Mo- the mean signal intensity with saturation pulse off, Mt-the mean signal intensity with saturation pulse on. Mean MT ratios were obtained for each category with standard deviation (SD) from the Mean. The mean distribution of MTR was calculated by Kruskal-wallis test and the significance was ascertained by Mann-whitney test.

Results: MT ratio of tuberculoma ascertained by the study was 25.42±0.81 (24.62-26.22). MT ratio of vesicular stage of NCC was 10.31±1.6 (8.71-11.91). MT ratio of colloid vesicular/ granular nodular stage of NCC was 23.38±1.22 (22.18-23.58). T2 invisible tuberculomas were better visualised in MT images. Post hoc tests showed mean difference in the MTR values of the lesions as significant with a p value of 0.03.

Conclusion: MTC imaging and MT ratio aids in better detection of ambiguous lesions than the conventional MRI and is an effective noncontrast sequence for better detection of the disease load. Since its application is non-cumbersome, MTC can be effectively used as an addition sequence in the standard protocol. The mean MTR values obtained in the study were very well reproducible and were of statistical significance.

Keywords: Contrast, Magnetic resonance imaging, Magnetisation transfer ratio, Region of interest

INTRODUCTION

Ring enhancing lesions are most common lesion in children and young adults in developing countries like India, presenting with focal seizures [1]. There are multiple causes for ring enhancing lesions detected at Computed Tomography (CT) and MRI, ranging from infective to neoplastic aetiologies. Earlier, in the background of poor lifestyle and socioeconomic status, ring enhancing lesions were presumed to be tuberculoma [2,3]. However, studies conducted by Rajshekhar V et al., by stereotactic biopsy and histopathology, proved NCC as the most common aetiology in the intracranial ring enhancing lesion and tuberculoma being the next [4]. Biopsy and tissue culture from the lesion, though being the gold standard, is technically too demanding and not expedient, especially in developing countries with limited resources [5]. Most often it is a diagnostic predicament to the clinician with regard to a confident diagnosis, because both the diseases are ubiquitous and share common clinical features, forming radiological imaging cornerstone for the diagnosis [6]. Most intriguing feature of these ring enhancing lesions is their resolution within weeks of appropriate treatment without any residual neurological deficits. Thus, its effective differentiation and proper treatment becomes important. Prompt radiological differentiation and early treatment form an essential basis in reducing patient morbidity.

Plain and Contrast Enhanced (CECT) and MRI are common imaging modalities used for its diagnosis. Their appearance depends on the pathological stage. Both, caseating tuberculomas and colloidal vesicular/granular nodular NCC show ring enhancement on postcontrast studies while, caseating tuberculomas show T2 hypointense centre with iso to hyperintense rim, colloidal vesicular/ granular nodular NCC appear as cystic lesion (hyperintense to CSF) with peripheral scolex [7]. In many cases of NCCs, scolex may not be visible, and degenerative cysts can appear T2 hypointense [8]. Hence, differentiating it from caseating tuberculoma may be difficult, creating a lacuna in a confident diagnosis. MT is an un-paragoned contrast mechanism in MRI that has been developed by application of off-resonance radiofrequency pulses focusing on altercation in fundamental relaxation properties of water protons and elucidating their effects on the MRI images [9].

Many studies are done in this field to find additional sequences to quench the deficit, however most of them are pertaining to Magnetic Resonance Spectroscopy (MRS) [10,11]. Application and interpretation of spectroscopy requires high expertise. In contrary, MTC study provides a numerical value in the form of MTR which simplifies the diagnosis making it a sourceful alternative [12]. Hence more studies are required in this view, to further capitalise the benefit of the study.

MATERIALS AND METHODS

A hospital based cross-sectional study was conducted after approval from the Institutional Ethics Review Committee (No. BMC/PGs/170/2017-18). The study group consisted of 55 patients presenting to the Department of Radiodiagnosis, in a tertiary care centre of Southern India from November 2017 to May 2019. Informed and written consents were obtained from all the 55 participants.

Inclusion Criteria

- All patients suspected to have intracranial tuberculoma and NCC on conventional MRI sequences
- Patients providing informed consent for the study

Exclusion Criteria

- Patients having history of claustrophobia
- Patients having history of metallic implants insertion, cardiac pacemakers and metallic foreign body in situ
- All patients with previous history of contrast allergy
- Patients not providing informed consent for the study

Sample Size

Based upon previous study conducted by Rajapandian GD et al., [13]. Approximately, 55 patients were required, hence 55 patients were included.

All patients were followed-up to assess response for treatment which was considered gold standard for the study. The diagnosis of tuberculoma was based on the basal meningitis with enhancement, typical CSF features (cellularity and biochemistry), and response to antitubercular treatment. The diagnosis of NCC was based on the presence of scolex in a cyst in MR Images and response to antiparasitic treatment. As per the revised diagnostic criteria for NCC the presence of multiple cystic lesions with or without scolex on CT or MRI is an absolute criterion for the definitive diagnosis of NCC [14].

Imaging Techniques

MRI was performed using 1.5 Tesla Siemens MagnetomAvanto B15 machine (SIEMENS Medical Systems, Erlangen, Germany). Initial localisers were obtained and sequences were planned according to the MRI brain protocol.

Sequences Used

1. Conventional spin-echo T1-Weighted (Repetition time (TR): 1000ms; Time to echo (TE): 14 ms) non-contrast axial MR images without off-resonance saturation pulse.
2. Conventional spin-echo T1-Weighted (TR: 1000ms, TE: 14ms) non-contrast axial MR images with an off-resonance saturation pulse.
3. 3D- Constructive Interface in Steady State (CISS) sequence was obtained for the demonstration of scolex in all patients.

The off- resonance saturation pulse was obtained immediately before the 90°excitation pulse to saturate the magnetisation of protons with restricted motion. All images were obtained in axial plane with 5mm slice thickness and a base resolution of 256 x 256 matrix [15]. Pixel values were taken from the rim of the granuloma (ROI) in T1WI and MT sequences. Consistency and reliability of the measurements were confirmed by obtaining the values repeatedly. For each ROI, MTR was calculated from using the formula [13].

MTR = (Mo-Mt) x 100/ Mo

Where,

Mo-the mean SI with saturation pulse-off.

Mt-the mean SI with saturation pulse-on.

In the present study, ROI were selected from the rims of the granuloma in T1 and corresponding area on T1 MT sequences. Minimum of two values were taken from the rim of the granuloma and mean values were included for the analysis. Subsequently, MTR was calculated.

STATISTICAL ANALYSIS

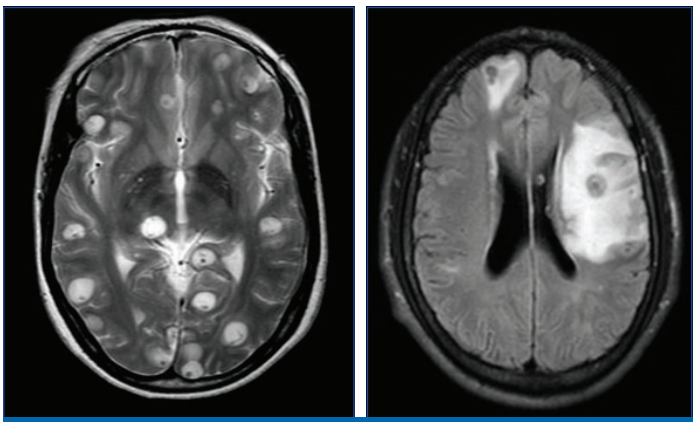
Data was entered into Microsoft excel data sheet and was analysed using Statistical Package for the Social Sciences (SPSS) 22 version software. The Mean MT ratios were obtained for each category with standard deviation (SD) from the mean. The mean distribution of MTR was calculated by Kruskal-wallis test and the significance was ascertained by Mann-whitney test.

RESULTS

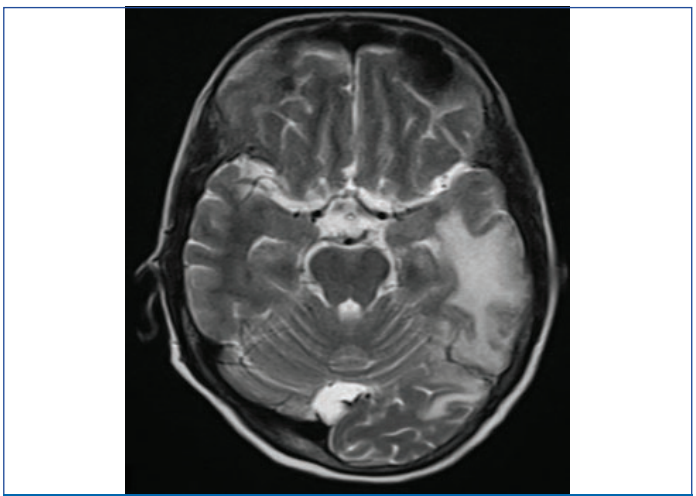
Among 55 patients, 64 granulomas were evaluated. Among the study population 27 were males and 28 were females with mean age of the population being 35.2 years.The number, location, presence of perilesional oedema, signal intensities and associated features of meningitis if present, were noted and the lesions were branded into tuberculoma, cystic NCC and degenerative NCC. In the present study, 13 granulomas were cystic NCC, 21 were degenerative NCC and 30 granulomas were tuberculomas. Nine patients had multiple NCC granulomas and 17 had multiple tuberculomas.

Characterisation of the ring enhancing lesions was made based on conventional MRI sequences.

1. Cystic NCC granulomas were hypointense on T1 (100%) and T2 hyperintense (100%) [Table/Fig-1] and showed complete inversion on FLAIR (100%).
2. Degenerative NCC lesions were T1 Isointense (76.2%)/ hypointense (23.8%), T2 hyperintense (85.7%) /hypointense (14.3%) with no complete inversion on FLAIR (100%) [Table/Fig-2].
3. Tubercular granulomas were T1 isointense (86.7%)/hypointense (13.3%), T2 hypointense (100%) [Table/Fig-3] and did not show inversion on FLAIR (100%).

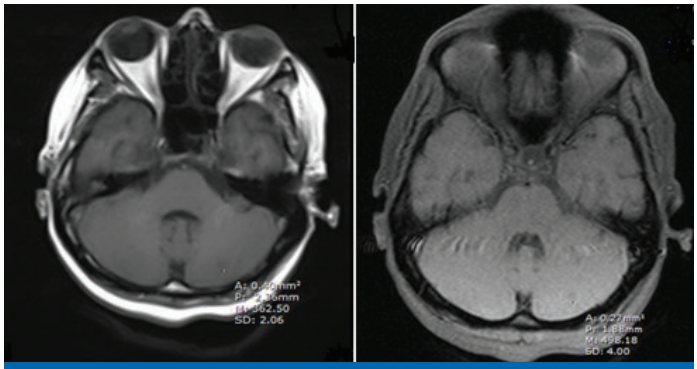


[Table/Fig-1]: T2 weighted turbo spin echo (T2TSE) image showing multiple T2 hyperintense cystic lesions in grey-white matter of bilateral frontoparietal and occipital cortex with a T2 hypointense eccentric scolex which is suggestive of vescicular stage of NCC.
[Table/Fig-2]: Fluid attenuated inversion recovery (FLAIR) image showing two isointense cystic lesions with a hypointense scolex within and surrounding perilesional oedema in right frontal and left parietal lobe suggestive of degenerative NCC.

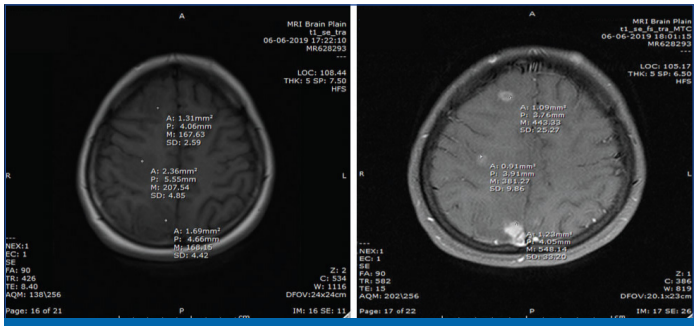


[Table/Fig-3]: T2TSE image demonstrating a T2 hypointense lesion in left posterior temporal lobe cortex with perilesionaloedema suggesting caseous tuberculoma.

T1 and MTC imaging was done with ROI values were taken from the rims of the granulomas for analysis [Table/Fig-4-8]. Subsequently, MTR was calculated. Mean MTR for 30 evaluated tuberculoma obtained by the study is 25.42±0.81. Thirteen innocuous cystic lesions representing vesicular stage of NCC showed mean MTR of 10.31±1.6. Twenty one lesions with imaging features suggestive of degenerative cysts showed MTR of 23.38±1.22 [Table/Fig-9]. When multiple comparisons are made, the mean difference between the ratio of the three groups were significant [Table/Fig-10].



[Table/Fig-4,5]: Precontrast T1 and T1MT images demonstrating hypointense lesion in left cerebellum hemisphere with no significant wall conspicuity on MT images.



[Table/Fig-6,7]: Demonstrating multiple T1 hypointense lesions showing hyperintense walls in pre-contrast T1 MT images portraying MT effect.

ROI	Granuloma	N	Minimum	Maximum	Mean	Std. Deviation
ROI value in T1	NCC	34	239.50	952.5	497.86	158.60
	Tuberculoma	30	529.50	1640.0	1145.1	299.51
ROI value in T1 MT	NCC	34	321.5	1211.0	607.11	203.5
	Tuberculoma	30	650.0	2011.5	1411.73	362.1

[Table/Fig-8]: Evaluation of ROI values of granulomas in T1, MTC imaging.

	N	Minimum	Maximum	Mean	Std. Deviation	Kruskal-wallis	p-value
NCC-Cystic	13	7.06	13.56	10.31	1.60	32.91	0.01*
NCC-Degenerative	21	21.18	25.98	23.38	1.22		
Tuberculoma	30	23.82	27.02	25.42	0.81		

[Table/Fig-9]: Mean distribution of MT ratio in Tuberculoma and NCC.
*significant

NCC-Cystic v/s NCC-Degenerative		NCC-Cystic v/s Tuberculoma		NCC-Degenerative v/s Tuberculoma	
Mean diff	p-value	Mean diff	p-value	Mean diff	p-value
-13.07	0.01*	-15.1	0.01*	-2.0	0.03*

[Table/Fig-10]: Post-hoc test (Mann-Whitney), Mean difference between the lesions being significant.
*significant

DISCUSSION

Present study demonstrated that pre-contrast T1 MT images were superior to conventional T2 SE images in better visibility of the tuberculomas. This visibility is because of the difference in contrast between brain parenchyma and the lesion, which is the result of the lower transfer of magnetisation in granulomas. In patients with multiple lesions, three patients showed detectability of more lesions on pre-contrast MT-SE images, which did not enhance in contrast study. This phenomenon could be explained by the lack of breach in the blood-brain barrier in some of the lesions, which is needed for contrast enhancement. Disruption of the blood-brain barrier depends on the activity of the lesion, and inactive lesions may not enhance after contrast administration. Thus, MTC imaging helps in better characterisation and detection of lesion load which were apparently not detected even on post-contrast sequences[16].

Mean MTR for 30 evaluated tuberculoma obtained by the present study is 25.42±0.81 [Table/Fig-9]. These values are nearly consistent with Rajapandian GD et al., [13]. According to their study, the tubercular lesions with a hypointense core on T2-weighted images had MT ratios of 16.6±3.7. However, these values are in contrary with Gupta R et al., study, where mean MTR for tuberculomas had MT ratios of 23.8±1.76 in the rim and 24.2±3.1 in the core [17]. In the study conducted by Vasudev MK et al., the mean MTR of the tuberculomas obtained from 33 patients were 14.09±7.41 [18]. Thirteen vesicular cystic NCC lesions showed mean MTR of 10.31±1.6. Twenty one lesions with imaging features suggestive of degenerative NCC cysts showed MTR of 23.38±1.22 [Table/Fig-9]. These values are also consistent with study by Rajapandian GD et al., where mean MTR of cystic and degenerative cysts were 10.9±2.8 and 20.8±3.5, respectively [13]. But there exists difference in the MT ratios derived by Kathuria M et al., where cystic NCC did not show any MT (MTR=5.1±1.2) whereas degenerating NCC showed MTR=26.4±2.7 [16].

Mean values obtained in the present study showed variations in the values in comparison to other studies in the same school of thought conduced by Kathuria MK et al., and Gupta R et al., [16,17]. This is attributed to several key factors of off-resonance saturation transfer techniques which alters the quantitative and qualitative aspects of MTC imaging and mean values of MTC ROI. The principle considerations thought to feign the values of different studies including base sequence, characteristics of the saturating pulse, field strength etc.,[9]. The MTmethod is a semi quantitative and an effortlessly reproducible description of anatomic and pathological characteristics of tissues thus significantly improving the specificity of MR imaging. This technique can be further applied in evaluation of demyelinating lesions, neoplasia and in Time of Flight (TOF) MR imaging for better conspicuity of the smaller vessels.

LIMITATION(S)

Histopathological diagnosis was not obtained in any of the cases which forms the major limitation of the study and further increase in the study population could narrow the confidence interval of the MTR values.

CONCLUSION(S)

MTC imaging can be used as an additional sequence in effective differentiation of the tubercular and cysticercus granulomas. T2 invisible tuberculomas are better visualised in MT images and better depicts disease load. The mean difference in the MT ratios calculated suggested that, the ascertained MTR values can be efficiently used to differentiate these lesions.

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