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Comparison of computed tomography and magnetic resonance imaging-based target delineation in radiotherapy planning of central nervous system tumors (High grade gliomas)

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ABSTRACT

Aim: *The study was designed to assess and analyze the difference in tumor volumes depicted on computed tomography (CT) and magnetic resonance (MR) and their effect on the treatment planning.*
Methods: *Twenty–five patients with high grade glioma who had underwent surgical resection and referred for radiation treatment were taken in the study. CT and MRI imaging were done for all the patients with 1.25 mm thickness. The CT and MRI tumor volumes were delineated, and comparison was done between them.*
Results: *The mean and median of GTV on CT scan were 70.82 and 65.55 respectively. The mean and median of GTV on MRI were 91.11 and 76.54 respectively. A linear relationship between CT and MRI volumes with correlation coefficient of r = 0.93 and MRI shows 1.19 times more volume when compared with CT volumes.*
Conclusions*: The study shows that MRI is an important imaging modality to delineate the brain tumor to avoid the geographical miss and underdosage of the tumor.*

Keywords: *High grade gliomas, computed tomography, magnetic resonance imaging*

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INTRODUCTION

Delineation of accurate target is the main aim of the radiation oncologist so that radiation therapy can be delivered to exact target for curative purpose. Radiation therapy treatment is depend upon the computed tomography (CT) based planning. Although CT provides anatomically precise information it does not give better soft tissue delineation. On the other hand, the high sensitivity of Magnetic resonance imaging (MRI) to variations in tissue proton density remain an important parameter for radiotherapy imaging in central nervous system tumors (CNS). MRI scan as an imaging modality in CNS tumors has multiple advantages in form of excellent contrast enhancement, easy multi parametric imaging and absence of artifacts. It can also provide cellular, vascular and metabolic properties of brain tumor. Being radiation free, MRI remains a good choice of investigation for frequent imaging. MRI is the imaging modality of choice for the lesions located at vertex, posterior fossa and base of skull. CT MRI fusion is the standard imaging technique for radiotherapy treatment planning for brain tumors, many tertiary care centers still use CT based target delineation which can lead missing the accurate target and hence affect the opportunity of radical treatment. This study was conducted at tertiary cancer care institute with the aim being to compare the tumor volumes as seen on CT and MRI.

METHODS

Total of 25 patients of gliomas (CNS tumors) were taken who have undergone maximal safe resection and referred for adjuvant radiation therapy based upon their histopathogical diagnosis. Thermoplastic cast was made for immobilization.

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Using the sequential scanning mode, 60-80 slices were taken for each patient. Contrast enhanced CT scan with 2.5 mm slice thickness was done. Pre-operative contrast enhanced MR imaging was taken from the patient for CT-MRI fusion-based radiotherapy planning. The CT images were transferred to the eclipse treatment planning system. Tumor target volume was delineated separately on CT and MR image datasets. After contouring the gross tumor volume (GTV) an appropriate margin was added to get the final Clinical target volume (CTV) and planning target volume (PTV) according to the institutional protocol. The CT tumor volume and MRI tumor volume were measured and compared with each other. One sample Kolmogorov-Smirnov test done for both GTV and CTV. Statistical analysis was done with SPSS software. CT and MR volume comparison was done by paired t –test.

RESULTS

The tumor volumes both Gross tumor volume and clinical target volume along with composite and overlap volumes delineated in CT and MRI is shown in table 1.

Table 1: The different volume of the target lesion delineated on CT and MRI in high grade brain tumors

s.no	GTV CT	GTV MRI	CTV CT	CTV MRI	GTV overlap	GTV composite	CTV overlap	CTV composite
1	122.58	176.23	367.11	439.55	48.78	176.30	60.59	440.19
2	10.34	13.62	292.88	306.50	1.93	14.36	9.16	312.81
3	90.27	116.24	308.15	345.01	29.00	120.81	43.94	355.03
4	27.50	37.06	132.77	165.80	18.79	42.59	43.23	173.12
5	95.06	99.74	408.69	443.91	64.53	131.15	57.63	461.37
6	128.66	161.25	408.86	451.18	22.10	161.93	23.97	451.37
7	44.44	57.22	271.11	287.39	16.44	60.34	27.42	296.97
8	37.45	58.51	206.18	246.30	19.36	58.70	37.93	246.53
9	7.16	9.91	135.05	152.84	2.77	10.63	21.71	157.49
10	68.30	89.75	308.47	299.21	30.77	95.96	58.67	337.75
11	134.40	146.05	168.78	206.46	9.46	26.07	34.39	207.02
12	56.90	59.40	286.22	291.44	17.41	69.01	59.12	320.60
13	53.86	61.78	283.24	358.15	17.07	68.34	80.71	364.96
14	26.08	27.89	152.33	158.13	9.94	33.30	16.32	168.25
15	24.93	40.47	211.30	242.65	26.30	46.49	76.89	266.60
16	120.06	143.22	643.55	767.88	61.21	164.28	175.16	797.39
17	41.34	61.37	273.04	304.82	18.66	62.06	25.18	307.39
18	63.87	149.87	387.91	552.97	85.02	150.14	163.28	554.15
19	110.33	156.61	345.80	400.50	41.92	170.35	54.17	410.81
20	125.43	158.22	398.11	430.38	20.10	158.34	20.43	439.94
21	42.15	60.91	205.04	250.84	25.77	63.63	42.71	256.78
22	78.39	99.04	310.78	311.46	41.45	100.07	65.40	347.03
23	69.47	66.78	280.81	286.88	17.32	77.34	65.71	300.96
24	126.08	150.23	623.50	745.87	67.22	178.33	180.69	766.40
25	65.55	76.54	135.77	178.98	36.34	47.22	120.56	174.67

The mean and median of GTV on CT scan were 70.82 and 65.55 respectively. The mean and median of GTV on MRI were 91.11 and 76.54 respectively (Table 2).

Table 2: Descriptive data of gross tumor volumes delineated on CT and MRI.

	N	Mean	Std. Deviation	Minimum	Maximum	Percentiles		
						25th	50th (Median)	75th
GTV CT	25	70.824	40.24532	7.16	134.4	39.395	65.55	115.195
GTV MRI	25	91.1164	51.30386	9.91	176.23	57.865	76.54	147.96
GTV Difference	25	20.2924	19.37414	-2.69	86	6.3	18.76	25.06

Table 3: Descriptive data of Clinical target volume on CT and MRI.

	N	Mean	Std. Deviation	Minimum	Maximum	Percentiles		
						25th	50th (Median)	75th
CTV CT	25	301.818	132.25279	132.77	643.55	205.61	286.22	377.51
CTV MRI	25	345.004	160.59751	152.84	767.88	244.475	304.82	434.965
CTV Difference	25	43.186	41.5145	-9.26	165.06	14.95	35.22	50.25

A linear relationship between CT and MRI volumes with correlation coefficient of r= 0.93 and MRI shows 1.19 times more volume when compared with CT volumes. Statistical analysis using paired sample t-test for difference in CT and MRI tumor volumes was significant (p < .001). Figure 1 and 3 shows the relationship between CT and MRI volume. Figure 2, 4 shows the bland –Altman test for CT and MRI volume.

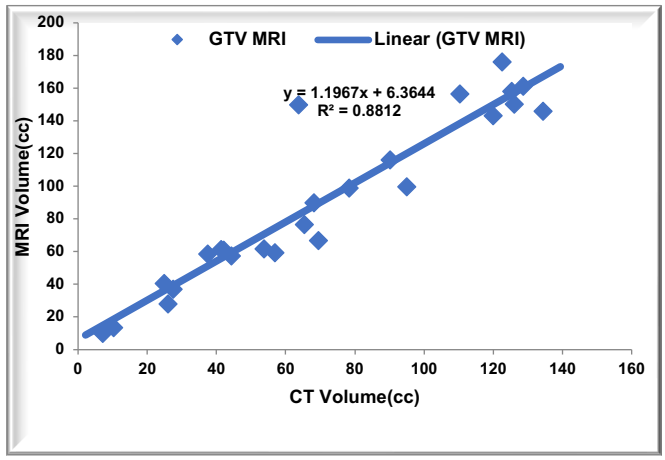

Figure 1. Relationship between CT and MRI volume.

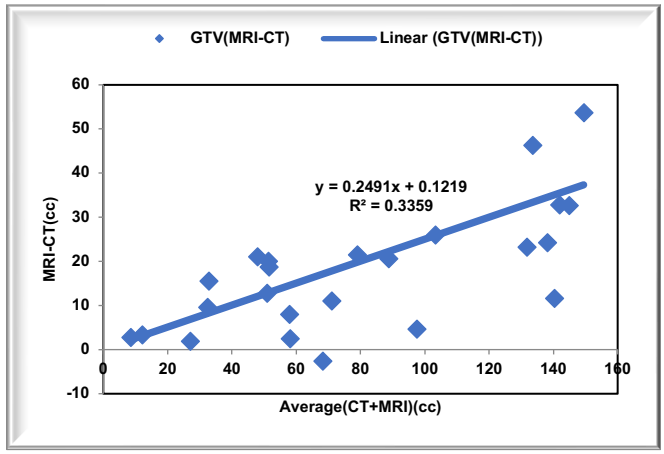

Figure 2. Bland –Altman test for CT and MRI tumor volumes.

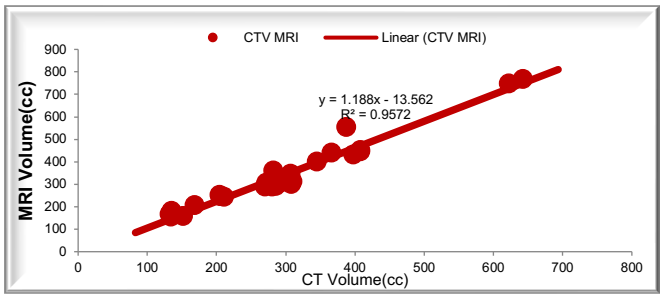

Figure 3. Relationship of CTV on CT and MRI

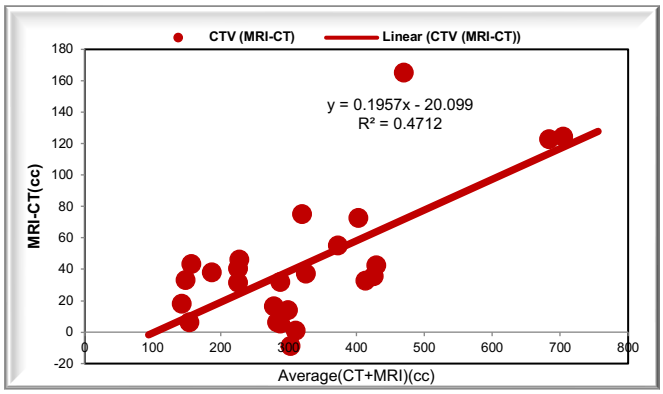

Figure 4. Bland-Altman test for CT and MRI Tumor volume

DISCUSSION

Imaging is the basis of modern radiotherapy. It plays a major role in localizing the extent of disease, improving treatment planning and guiding treatment delivery and therapy response assessment. CT scans are the most frequently obtained for treatment planning in the radiation therapy department on a dedicated CT simulator. Although CT scan provides geometrically precise scans, it gives less detailed tumor and surrounding structures anatomy and pathology.[1] MRI provides a complimentary information to CT for target delineation, particularly for treatment sites involving the central nervous system.

The tumor volume delineated on CT scan-based planning may not able to represent the actual tumor volume which further may lead to under dosage of the tumor due to geometric miss. MRI is more sensitive than CT in detecting abnormalities in the brain. This is particularly hold true in posterior fossa, where the CT image is degraded by beam hardening artifacts and for low grade astrocytoma. Under such circumstances, investigators have analyzed and contoured both CT defined and MRI defined lesions and combined the corresponding targets through image registration.[2,3] Websy G etal reported a mean reduction of 30% in the field size from purely CT defined volume.[4] Later studies shows an increased MRI defined target volume and reported a greater volume seen on MRI alone as compared to CT only.[5,6] One study shows that except in the case of meningioma in more than 44% of the patients , MRI showed more than 40% increase in the tumor volume. It shows that there may be geographic miss in small tumors especially if CT alone is used for treatment planning.[7]

CONCLUSION

The study shows that MRI is an important imaging modality to delineate the brain tumor to avoid the geographical miss and under dosage of the tumor. MRI should be made mandatory for fusion with CT scan planning for brain tumors.

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