Comparison between T1-, T2- and T1 StarVibe-weighted MRI and contrast-enhanced CT based delineation of organs at risk in head and neck radiotherapy

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Purpose/Objective:
Radiation therapy planning for head and neck tumors necessitates precise delineation of target volumes (TVs) and organs at risk (OARs), traditionally performed using computed tomography (CT) imaging. Magnetic resonance imaging (MRI), with its superior soft tissue contrast, has the potential to improve the accuracy of delineating both OARs and TVs while also providing insights into physiological tumor characterization. This study aims to evaluate the added value of MRI in the delineation of OARs by comparing T1-weighted, T2-weighted, and T1 StarVibe with gadolinium-enhanced MRI to contrast-enhanced CT (ceCT). Additionally, it investigates inter-observer variability and consistency in delineation among radiation oncologists.

Material/Methods:
Sixty-two patients with head and neck carcinomas underwent simulation imaging using contrast-enhanced CT (ceCT) and 3T MRI, both performed with the same immobilization mask to ensure consistency. Ten organs at risk (OARs) were selected for analysis: the brainstem, optic chiasm, left and right optic nerves, left and right eyes, spinal cord, mandible, left and right parotid glands, left and right submandibular glands, pharyngeal constrictor muscle (PCM), and oral cavity. These OARs were independently fully manually delineated by three radiation oncologists (two mid-career and one junior) in a blinded manner to evaluate volumetric differences and inter-observer variability. To minimize bias, delineations on different imaging modalities were performed several weeks apart for each patient.

Results:
Results from the first 23 patients (Table 1) revealed no significant differences in delineation volumes between ceCT and the three MRI sequences, except for the mandible and spinal cord, which appeared significantly larger on CT ($p < 0.05$). Inter- and intra-observer variability for the MRI acquisitions was minimal. MRI, particularly T1- and T2 weighted sequences, provided superior visualization of the pharyngeal constrictor muscle (PCM), resulting in smaller delineated OARs.

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However, significant disparities were noted among radiation oncologists, likely influenced by their level of experience, with larger volumes delineated by the junior oncologist. Finally, MRI-based delineations were notably faster (~40 minutes) compared to ceCT, which required over an hour.

Table 1. ***OAR volume comparison between radiation oncologists (RO)***

OAR	T1 StarVibe gadolinium WI MRI			T1WI MRI	T2WI MRI	ceCT	ceCT
	RO1 (mean vol cc)	RO2 (mean vol cc)	RO3 (mean vol cc)	RO2 (mean vol cc)	RO2 (mean vol cc)	RO1 (mean vol cc)	RO2 (mean vol cc)
Bone_Mandible	49.03	46.51	53.46	46.40	46.06	57.32	57.52
Brainstem	22.57	23.02	23.60	25.02	24.11	24.45	25.77
Eye_L	8.01	8.17	9.12	8.25	8.61	8.05	8.01
Eye_R	8.15	8.31	9.31	8.39	8.56	8.16	8.17
Optic_Chiasm	0.49	0.30	0.92	0.42	0.37	0.51	0.36
Optic_Nerve_L	0.52	0.56	0.91	0.63	0.55	0.55	0.54
Optic_Nerve_R	0.5	0.63	0.92	0.67	0.53	0.57	0.58
Oral_Cavity	109.36	106.67	94.60	103.98	103.57	104.33	105.15
Parotid_L	28.69	28.28	32.16	29.52	29.57	27.74	28.98
Parotid_R	28.1	27.52	31.99	30.41	29.06	28.64	28.14
PCM	8.70	8.58	9.80	9.28	10.07	9.49	9.19
Spinal_Cord	9.32	7.86	10.9	8.60	7.32	10.73	9.03
Submandibular_Gland_L	9.32	8.86	10.72	9.66	9.36	9.16	8.36
Submandibular_Gland_R	8.92	8.30	10.19	9.47	9.40	8.90	8.2

Delineation was done using the guidelines from Brouwer et al.(3)

Conclusion:

Consistent with findings from previous studies (1,2), our data confirm that MRI provides superior precision in delineating the pharyngeal constrictor muscle (PCM) and spinal cord compared to ceCT, while ceCT remains more effective for mandible delineation. Ongoing work includes extending the analysis to the full patient cohort, incorporating target volume delineation. Additionally, efforts are underway to develop a fully automated solution leveraging artificial intelligence for MR-based delineation of organs at risk (OARs) and target volumes in head and neck tumors.

Keywords: MRI, head and neck, radiotherapy