

Short-term reproducibility of apparent diffusion coefficient and intravoxel incoherent motion parameters in normal head and neck tissues: comparisons of 4b values, 4b values with cardiac gating, and 17 b values

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Purpose: Recently, intravoxel incoherent motion (IVIM) theory has been active area of research in the head and neck lesions as a non-contrast enhanced perfusion and diffusion MR imaging.^{1,2} To make IVIM model easier to apply and faster, a simplified IVIM diffusion-weighted imaging (DWI) using 4b values (0, 200, 400, 800 s/mm²) was introduced to assess perfusion related parameter (PF) and true diffusion coefficient (D) of head and neck tumors.³ However, the method cannot separate perfusion fraction (PF) and pseudodiffusion coefficient (D*). In addition, DWI is influenced by several factors, such as image noise, motion and susceptibility artifact. Especially, head and neck lesion often regains the signal from flowing blood and CSF. However, there is limited knowledge on the reproducibility of IVIM parameters in the head and neck. Therefore, the objective of this study was to prospectively evaluate short-term test-retest reproducibility of IVIM parameters and apparent diffusion coefficient (ADC) of variable tissue in the head and neck using 4b values, 4b values with cardiac gating and 17b values, respectively.

Methods: The institutional review board approved study and informed consent was obtained. Nine volunteers were scanned twice using a IVIM diffusion-weighted imaging (DWI) using 4b values (b= 0, 200, 400, 800 s/mm², acquisition time =2min 41s), IVIM DWI using 4b values with cardiac gating (b= 0, 200, 400, 800 s/mm², acquisition time =3min 46s) and IVIM DWI using 17 b values (b= 0, 10, 15, 20, 25, 30, 50, 80, 100, 120, 140, 160, 200, 300, 500, 800, 1000 s/mm², acquisition time = 7min 33s) at 1.5T. IVIM parameters (PF, D, D*) and ADC were calculated. Free-hand ROIs were drawn on the maps of IVIM parameters and ADC to cover the brain (pons, cerebellum), bilateral masticator muscles, parotid glands, submandibular glands, tonsils and 5 places of the bones. Short-term test-retest reproducibility of IVIM parameters and ADC were assessed by measuring interclass coefficient (ICC), coefficient of variation (CV), and Bland-Altman Analysis (BAA).

Results: Overall interclass agreement was excellent except D* value. The ICC values with IVIM DWI using 4b values, 4bvalues with gating, 17b values were 0.971, 0.977, 0.982 for ADC maps, 0.802, 0.837, 0.757 for PF maps, 0.959, 0.975, 0.972 for D maps, and 0.647, 0.625, 0.446 for D* maps. In the brain, muscle, parotid gland and submandibular gland, the best overall reproducibility with low CV % and narrow 95% limits of agreement was obtained with IVIM DWI using 4b values with cardiac gating rather than IVIM DWIs using 4b values without gating or 17 b values (Table 1, Table 2). CV and BAA revealed that IVIM DWI using 4b values with the shortest scan time was more reproducible in the tonsil, compared to 4b with gating or 17b. With the same way, in the bone, perfusion related parameters, PF and D* were more reproducible in IVIM DWI using 4b values with gating and the diffusion related parameters, ADC and D were more reproducible in IVIM DWI using 17 values.

Conclusion: IVIM DWI using 4bvalues with gating was the most reproducible method in the head and neck in comparison with IVIM DWIs using 4b values or 17 values.

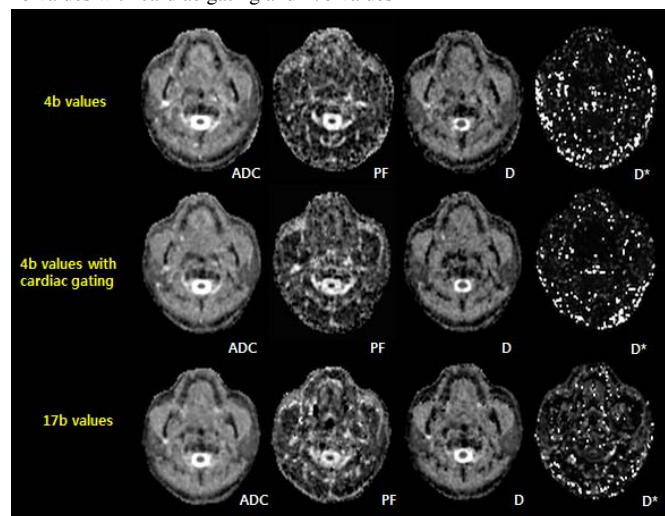
Table 1. The mean CV (%) between ADC and IVIM derived parameters on repeated IVIM DW images
Lower values indicate better measurement reproducibility (red number).

%	ADC			PF		
	4b	4b gating	17b	4b	4b gating	17b
Brain	4.44	1.21	1.25	12.7	8.62	10.57
Muscle	2.14	2.29	3.52	27.6	17.3	20.88
Parotid	3.96	2.23	2.69	16.67	6.88	14.4
SMG	4.81	4.51	4.47	19.78	12.14	26.5
Tonsil	8.92	9.08	11.28	26.09	33.37	40.37
Bone	12.72	11.99	7.95	28.77	20.09	23.13
%	D			D*		
	4b	4b gating	17b	4b	4b gating	17b
Brain	2.7	1.31	1.4	24.8	19.56	33.43
Muscle	3.29	3.24	4.25	48.03	32.28	33.68
Parotid	7.44	4.28	5.88	30.68	24.19	31.01
SMG	10.46	5.94	7.59	49.87	33.44	46.33
Tonsil	14.27	15.16	23.54	40.5	37.67	67.37
Bone	20.39	16.2	12.9	51.64	50.87	52.68

Table 2. The 95% limits of agreement between ADC and IVIM derived parameters on repeated IVIM DW images
Narrower intervals indicate better measurement reproducibility (red number).

%	ADC			PF			D			D*		
	4b	4b gating	17b	4b	4b gating	17b	4b	4b gating	17b	4b	4b gating	17b
Brain	-28, 22	-4.9, 4.4	-4.8, 3.7	-43, 53	-29, 33	-35, 37	-11, 9	-5, 4	-6, 4	-118, 124	-54, 94	-119, 117
Muscle	-9, 8	-8, 8	-15, 12	-97, 106	-59, 51	-90, 75	-14, 12	-10, 11	-18, 14	-158, 180	-135, 74	-135, 117
Parotid	-12, 17	-8, 8	-11, 11	-54, 51	-19, 26	-54, 50	-23, 28	-18, 20	-22, 26	-115, 121	-81, 78	-97, 115
SMG	-28, 28	-18, 15	-16, 2	-68, 75	-50, 39	-94, 89	-51, 47	-21, 18	-32, 29	-130, 187	-88, 117	-159, 159
Tonsil	-36, 27	-35, 3	-38, 42	-100, 86	-91, 131	-152, 109	-49, 56	-60, 38	-66, 95	-116, 164	-143, 134	-160, 248
Bone	-52, 38	-49, 47	-26, 33	-114, 81	-79, 71	-81, 87	-81, 64	-63, 55	-36, 50	-156, 194	-170, 173	-160, 182

Figure. Representative maps of ADC and IVIM parameters using 4b values, 4b values with cardiac gating and 17b values.



References

- Sumi M, Van Cauteren M, Sumi T, et al. Salivary gland tumors: use of intravoxel incoherent motion MR imaging for assessment of diffusion and perfusion for the differentiation of benign from malignant tumors. *Radiology* 2012;263:770-777
- Hauser T, Essig M, Jensen A, et al. Characterization and therapy monitoring of head and neck carcinomas using diffusion-imaging-based intravoxel incoherent motion parameters—preliminary results. *Neuroradiology* 2013;55:527-536
- Sumi M, Nakamura T. Head and neck tumors: assessment of perfusion-related parameters and diffusion coefficients based on the intravoxel incoherent motion model. *American Journal of Neuroradiology* 2013;34:410-416