The comparison of diffusion and perfusion characteristics among the different types of uterine fibroids based on T2WIs: an intravoxel incoherent motion MRI study

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Target audience: Gynecologic radiologist and gynecologist

Introduction: Uterine leiomyoma is the most common benign tumour of the female reproductive system. There are various therapies available to relief symptom, including myomectomy, hysterectomy, uterine artery embolisation, magnetic resonance-guided focused ultrasound surgery (MRgFUS) and medical therapy such as GnRH analogue[1]. In current clinic, the prognoses both of MRgFUS[2] and GnRH[3] analogue treatment were correlated to the signal intensity of uterine leiomyoma on T2-weighted images (T2WIs) [2,3]. Intravoxel incoherent motion (IVIM) MR imaging is a preferable diffusion weighted imaging (DWI) technique that reflect both diffusion and perfusion components of tissue. Therefore, the purpose of this study was to compare the perfusion and diffusion charateristics among the different T2WI type of uterine fibroids.

Methods: *Subjects*: Twenty eight patients (35 to 54 years of age) with symptomatic uterine fibroid were included in the study. The fibroids were classified into 3 types based on the signal intensity of T2WIs as follows: type 1, low intensity as skeletal muscle; type 2, intermediate intensity, lower than myometrium but higher than skeletal muscle; and type 3, high intensity, the same as or higher than myometrium[2]. The average age of patients in each group showed in Table 1, and there was no statistical difference among three groups. *MR acquisition protocol*: The examinations were performed on a 1.5T MRI scanner (Achieva, Philips Medical System, the Netherland). Turbo field echo T2WIs were obtained as sagittal orientation with slice thickness of 4 mm, in-plane resolution of 1.2 x 1.2 mm, TR/TE 4500/130ms. The transverse echo-planar DWIs were obtained with slice thickness of 5 mm, in-plane resolution of 2.5×2.5 mm, TR/TE 3000/68ms and 10 b-factors (0,25,50,75,100,150,200,500,700,1000 s/mm^2)，excluding the 1000 s/mm^2 because of low SNR. *MR image analysis*: To examine the individual contributions of true molecular diffusion and incoherent motion of water molecules in the capillary network to the apparent diffusion changes, D (real diffusion coefficient), f (perfusion fraction), and D* (blood pseudodiffusion coefficient) were estimated using a least-square nonlinear fitting on IDL 6.3 version by fitting the DW signal decay in the ROI to the IVIM bi-compartmental model. The ROIs were measured by the software Image J. The differences in all IVIM parameters among the three groups were tested by One-Way ANOVA analysis. Statistical differences with P<0.05 were considered significant.

Table 1. Patient's number and age

T2WI	Patient number	Age (years)
type 1	10	44.0±4.14
type 2	11	43.6±6.17
type 3	7	44.4±5.56
P		0.9542

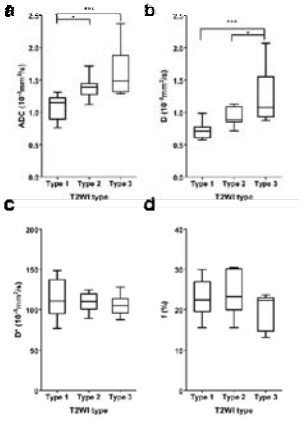

Fig 1. The distribution of ADC(a), pure diffusion D (b), Perfusion fraction f (c), and pseudodiffusion coefficient D* (d) among 3 type of uterine leiomyomas.

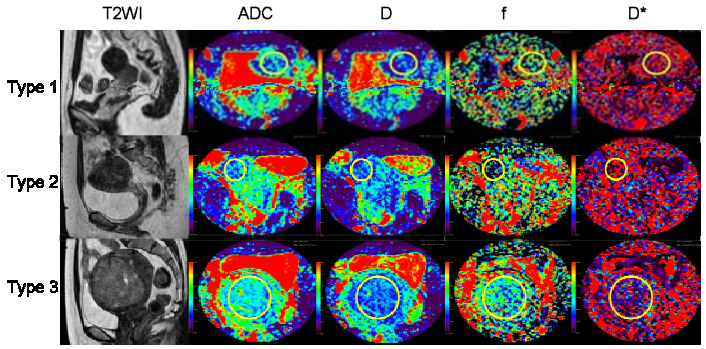

Fig 2. The color-coded IVIM parametric maps in the typical 3 T2WI types of fibroids

Table 2. The relationship between IVIM parameters and the 3 T2WI types of fibroids

IVIM-DWI parameter	D (x10^{-3}mm^2/s)	D* (x10^{-3}mm^2/s)	f (%)	ADC (x10^{-3}mm^2/s)
	mean±SD	mean±SD	mean±SD	mean±SD
type 1	0.72±0.12	113.21±23.73	22.89±4.41	1.08±0.18
type 2	0.94±0.14	109.71±10.81	23.55±5.06	1.38±0.16
type 3	1.23±0.40	106.18±12.07	20.04±3.91	1.61±0.37
P	0.0009	0.7044	0.2907	0.0006

Results: The mean IVIM parameters of three-type uterine leiomyomas were displayed in **Table2.** ADC, D and f were smaller than D*. The increase tendency of ADC and D were obtained according to signal intensity elevation of fibroids on T2WI (P<0.001 respectively). Moreover, ADC had the significant difference between Type1 and Type3, Type 1 and Type 2, but no significant difference was shown between Type 2 and Type 3. However, the true diffusion coefficient (D) in 3 type of fibroids had the significant difference between Type 1 and Type 3, Type 2 and Type3, but no significant difference existed between Type 1 and Type 2 (**Fig1**). The perfusion parameters of D* and f did not correlated with T2WI types (P>0.05). The three fibroid types were shown typically with T2WIs and color maps of ADC, D,f and D* in Fig 2**.**

Discussion and Conclusion: In current study, the characters of cellularity and vascularity in 3 types of uterine fibroids were demonstrated by IVIM parameters of D and f, D*. The difference of cellular structure and density was revealed by real diffusion coefficient, D and apparent diffusion coefficient, ADC in Fig 1. It indicated that the cellularity is tighter in Type 1 and looser in Type 3 among 3 fibroid types. These differences of cellular structure and density may be the main reason to result in the different treatment effect of MRgFUS in 3 T2WI types of fibroids, since the f and D*, perfusion parameters of IVIM, seem no differences among the 3 types of fibroids. In sum, the present results implied that IVIM technique facilitated the understanding of the tissue characteristics in uterine fibroid and proposed to guide patient selection for MRgFUS ablation.

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Reference: 1.Voogt MJ, Trillaud H, Kim YS, et al. Eur Radiol;22:411-417; 2.Funaki K, Fukunishi H, Funaki T, et al. Am J Obstet Gynecol 2007;196:184 e181-186; 3.Oguchi O, Mori A, Kobayashi Y, et al. J Obstet Gynaecol (Tokyo 1995) 1995; 21:107-117