Histogram analysis of apparent diffusion coefficient maps reveals differences among the different types of uterine fibroids based on T2WIs

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Target audience: Gynecologic radiologist and gynecologist

Introduction: Uterine fibroids are the most common benign tumor of the female reproductive system. Magnetic resonance-guided high-intensity focused ultrasound (MRg HIFU)ablation is currently emerging nonsurgical options in the treatment of uterine fibroids[1].The prognoses of MRg HIFUtreatment was correlated to the signal intensity of uterine fibroids onT2-weighted images (T2WIs). Apparent diffusion coefficient (ADC) histogram analyzes the ADC values of the entire volume of the tumor, which could provide quantitative information about the tissue characteristics and heterogeneity of the whole tumor, is a more objective approach than placement of regional ROIs[2]. Therefore, the aim of the study is to investigate the variation among the different T2WI typesuterine fibroids through analysis of ADC histogram, with expectation to select suitable fibroids for MRgHIFU ablation.

Table1, Patient's number and age

	type1	type2	type3	F	p
number	34	36	10		
Age(years)	43.38±4.89	42.11±3.98	44.7±5.37	1.495	0.231

Table2,ADCq, kurtosis and skewness of 3 fibroid types

Group	ADCq ($10^{-6}mm^2/s$)	Kurtosis	Skewness
type1	800.71±331.07	0.0023±0.7966	0.0670±0.3428
type2	714.86±132.17	0.3361±0.4385	0.0359±0.2214

Table3,The difference of ADCq, kurtosis and skewness among3 fibroid types ("*" : $p<0.05$)

Group	ADCq	Kurtosis	Skewness
Type1&2	0.012*	0.035*	0.667
Type1&3	0.005*	0.025*	0.631
Type2&3	0.247	0.293	0.441

Methods: *Subjects*: Eighty patients (35 to 53 years of age) with symptomatic uterine fibroid wereincluded in the study. The fibroids were divided into 3 types based on signal intensity in T2WIs: type 1, low signal compared to skeletal muscle; type 2, lower signal than the myometrium and higher than skeletal muscle; type 3, signal equal to or higher than that of myometrium. The averageage 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, PhilipsMedical System, the Netherland) with 16-channel XL torso coil. Sagittal T2WI_TSEs were obtained with slicethickness of 4 mm, in-plane resolution of 1.2 x 1.2 mm, TR/TE with 4500/130ms. The axial echo-planar DWIs were obtained with slice thickness of5 mm, in-plane resolution of 2.5×2.5 mm,TR/TE with 3000/68ms and b-factorswith0 and 700s/mm^2.*MR image analysis*: To assess the characteristics and heterogeneity of the whole fibroid, ADCq(the distance between the 25th percentile and the 75th percentile voxel in one lesion)、kurtosis(the degree of distributionpeakedness) and skewness(a measure of distribution asymmetry)derived from ADC histogram were acquired using threesoftwares: ImageJ, Excel, SPSS. The differences of ADCq, kurtosis andskewness among the three types were tested by One-Way ANOVA analysis. Statistical differences with P<0.05 were considered significant.

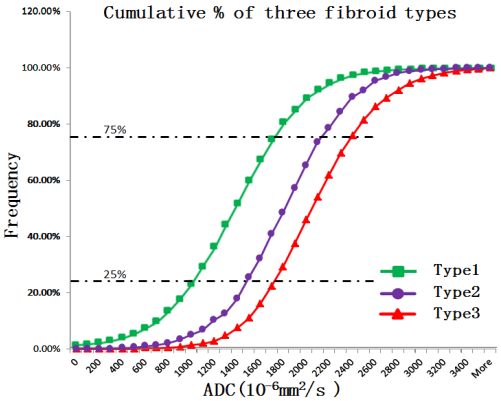

Fig 1, Cumulative histogram of 3 fibroid type. ADCq of 3 typical cases respectively: Type1,670.55; Type2,626.96; Type3,640.31($10^{-6}mm^2/s$).

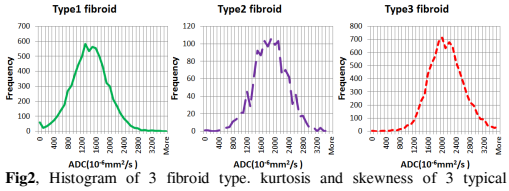

Fig2, Histogram of 3 fibroid type. kurtosis and skewness of 3 typical cases(same as Fig1): Type1, 0.2001 and 0.0094; Type2, 0.3685 and -0.0558; Type3, 0.4151 and 0.1975, respectively.

Results: The quantitative histogram parameters (ADCq, kurtosis and skewness) of each type were shown in **Table 2** as mean±standard deviation. P-value of LSD test among the three fibroid types were shown in **Table 3**.ADCq of type1 was highest than others, and there were significant difference between type 1 and type2，type1 and type3. Values of kurtosis among three type were contrary to ADCq, which of type1 was lowest than others, and there were significant difference between type 1 and type2，type1 and type3. The skewness of the three fibroid types was very close and there were no statistic differences among them. Accordingly, there was no significant difference between type2 and type3 neither on ADCq, kurtosis nor on skewness. The statistic map of ADCq in three fibroid types were typically shown by cumulative histogram in Fig 1, and histograms in Fig 2 indicate the kurtosis and skewness.

Discussion and Conclusion: To our knowledge, this was the first study to assess the characteristics and heterogeneity of the whole fibroid using ADC histogram. The compact structure of type 1 fibroids contains less smooth muscle cells, abundant collagen fibers or some hyaline degeneration, which is beneficial to the deposition of ultrasonic heat. It is the reason of the suitable choices for type1 fibroid to MRg HIFU treatment. The compact anatomy structure and low signal intensity of components in T2WIs cause the corresponding voxels with the lowest ADC values among 3 type of fibroid. Moreover, the inherent differences between collagen fiber and smooth muscle cells in type 1 fibroids lead to the highest ADCq among 3 type of fibroid. Kurtosis in type 1 were the lowest among 3 type of fibroid, with mean value of 0.0023 and very close to the Gauss distribution. Which reveal the uniformity in structure of type 1 fibroids. MRgHIFU treatment is a process of heat deposition, the effectiveness of which will be reduced if the heat transfer too fast. Probably due to blood flow taking heat away or heat transfer too fast in necrosis tissue, HIFU treatment effect are poor in type 3 and the part of type 2 fibroids. There is no significant difference between type 2 and type 3 neither on ADCq nor kurtosis, which imply the overlap of pathological components between the two types fibroid. In sum, ADCq and kurtosis can provide quantitative information to identify different fibroid types, which may be the useful screening tools to guide patients selection for MRgHIFU ablation.

Reference:1.Funaki K, Fukunishi H, Funaki T, et al. Am J ObstetGyneco l 2007;196(2):184. e1-6.
2.Kang Y, Choi SH, Kim YJ, et al. Radiology,2011;261(3):882-890.