measurement of T1,T2 relaxation time as assembly conditions of gold nanoparticles

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Introduction

Recently, numerous applications of nanoparticles in biomedical science had been studied because of its potential possibilities as tracers or contrast agents in MR molecular imaging, especially for the early diagnostic or therapy tool. Iron oxide and gold, silver are used in nanomedical sciences. Specially gold nano-paricles are in the limelights because which is as there isn't toxicity material oneself. Theragnosis is a new concept combined word using "Therapy" and "Diagnosis" and is a way to perform both at once and has been recently expanded centering around the nanomedical sciences[1,2].]. In other study, they studied characteristic according to size of gold nano-particles. So, this study, typical MR variables such as T1-and T2-relaxation times of the tissue-mimic phantoms which include the lab-made gold nanoparticles(GNP) were measured according to their morphological characteristics and synthesis conditions.

Materials and methods

Samples: Two morphorogical shapes, sphere and rod, of GNP were used in this study. Sphere GNP were devided into three categories according to the synthesizing chemical compounds, synthesis 1(added solutions: Chloroauric acid + CTAB + sodium borohydride), synthesis 2(+ tri-sodium solution to synthesis 1 on hot plate with stirring speed of 150, 300, 450rpm), synthesis 3(+ Chloroauric acid and sodium borohydride, tri-sodium on hot plate with stirring speed of 150, 450rpm) as shown in Table 1. And rod GNP were synthesized by adding 1.0, 0.5, 0.25, 0.125, 0.08ml of sphere 6 GNP solution. Each GNP solutions were mixed with 2% agarose gel at 1:1 ratio to make tissue-mimic MR samples.

MR Protocol: MR images of GNP samples were acquired using a clinical 1.5T MR scanner(Signa Echospeed, General Electric, Milwaukee, WI, USA) for the measurement of T1- and T2-relaxation time as shown in Figure 1. For the measurement of T1, the shortest TE(7.6ms) was fixed and various TRs, 50, 100, 200, 400, 700, 1000, 3000, 10000ms were used. For T2 measurement, TR was fixed at 2000ms and different TEs of 10, 20, 30, 40, 50, 60, 70, 80ms were applied.

Analysis: T1-recovery and T2-decaly curve fitting graph based on the intensity of MR images were obtained using self-developed software using MATLAB(Mathowrk. Co., USA). T1- and T2-relaxation times were calculated pixel by pixel using Levenberg-Marquadt curve fitting method[3]. Statistical analysis was performed by T-test and one-way ANOVA using SPSS(version 12.0 for windows, USA).

Results

Table 2 shows the measured values of T1- and T2-relaxation times(mean±SD) according to the production condition. From the T-test as shown in Table 3, there were significant differences ($p<0.001$) of T1-, and T2-relaxation times between two GNP shapes, sphere and rod. It is obvious that rod GNP has longer T1 value but shorter T2 value than sphere GNP. Sphere 2 represented comparative large T1- and T2-time. Depends on synthesis methods, T1 and T2 values were linearly decreased along rpm. Figure 2 represents one-way ANOVA test for sphere GNPs(T1 *$p<0.05$, T2 *$p<0.05$). Figure 3 shows the results of one-way ANOVA test for rod GNPs. ($p<0.05$).

Table 1. Synthesis condition of Gold nano-particles

Category	Label	Material	RPM
Synthesis 1	Sphere 1	CTAB*	N/A
Synthesis 2	Sphere 2	Sodium citrate	150
	Sphere 3	Sodium citrate	300
	Sphere 4	Sodium citrate	450
Synthesis 3	Sphere 5	CTAB+ Sodium citrate	150
	Sphere 6	CTAB+ Sodium citrate	450

Discussions and Conclusions

This study is to measure changes of MR variables(T1 and T2) as a synthesized methods and synthesis conditions of a gold nano-particles. This result would derive increase signal and optimized SNR by adjusting TR and TE along correct T1 and T2. This result would derive increase signal and optimized SNR by adjusting TR and TE along correct T1 and T2. In further study is T1, T2 change about density change of gold nano-particles.

Table 2. Measured T1 and T2 time of gold nano-particles

	T_1 (sec)	T_2 (sec)
Sphere 1 (N/A)	1.873±0.0085	0.0538±0.00035
Sphere 2 (150 rpm)	1.932±0.0320	0.0593±0.00036
Sphere 3 (300 rpm)	1.854±0.0057	0.0568±0.0041
Sphere 4 (450 rpm)	1.836±0.0125	0.0561±0.00037
Sphere 5 (150 rpm)	1.854±0.0331	0.0603±0.00046
Sphere 6 (450 rpm)	1.826±0.0299	0.0559±0.00034
Rod 1 (1ml of sphere 6)	2.147±0.1904	0.0372±0.00011
Rod 2 (0.500ml)	2.054±0.1636	0.0439±0.00040
Rod 3 (0.125ml)	2.059±0.1955	0.0379±0.00029
Rod 4 (0.100ml)	2.057±0.2048	0.0340±0.00027
Rod 5 (0.080ml)	2.072±0.2253	0.0324±0.00029
Rod 6 (0.040ml)	2.106±0.2417	0.0273±0.00030

Acknowledgement

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Reference

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Table 3. Result of t-Test

variable	Levene test		t-Test		
T_1	F	p-value	t-value	degree of freedom	p-value
	.071	.795	-10.434	10	.000
T_2	F	p-value	t-value	degree of freedom	p-value
	3.097	.109	8.871	10	.000

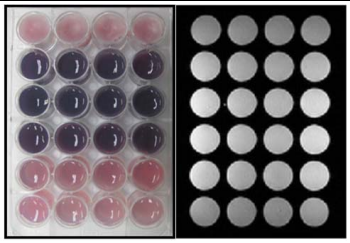

Figure 1. Phantom and MR image of gold nano-particles

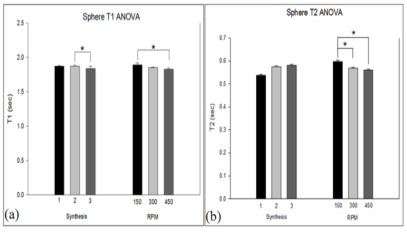

Figure 2. Results one-way ANOVA test for sphere gold nano-particles (a) T1 *$p<0.05$ (b) T2 *$p<0.05$

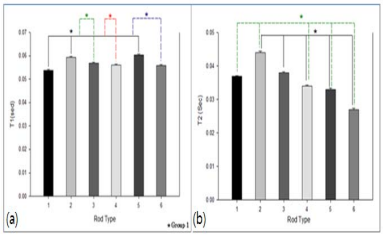

Figure 3. Results one-way ANOVA test for Rod gold nano-particles .*$p<0.05$