Development of novel MRI contrast agents using size-dependent magnetic properties of iron oxide nanoparticles

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Iron oxide nanoparticles have been extensively used as MRI contrast agents due to their unique magnetic property and biocompatibility. Extremely small iron oxide nanoparticles (ESIONs) smaller than 5 nm were developed as biocompatible T_1 contrast agents using their weak magnetic property. Superparamagnetic iron oxide nanoparticles (SPIONs) with sizes ranging from 5 nm to 20 nm exhibit very stable colloidal stability and moderate T_2 contrast effect. Multifunctional Fe_3O_4/TaO_x core/shell nanoparticles were prepared by a sol-gel reaction of tantalum (V) ethoxide in a microemulsion containing SPIONs. Tumor-associated vessels and tumor microenvironments were revealed after injection of the nanoparticles using CT and MRI, respectively. Ferrimagnetic iron oxide nanoparticles (FIONs) show very strong magnetization. The theoretically predicted maximum r2 relaxivity (761 $mM^{-1}s^{-1}$) of iron oxide nanoparticles was achieved by optimizing the sizes from 20 nm to 30 nm. Although r2 relaxivity of larger FIONs is smaller, they were efficiently taken up by various cells. Their efficient cellular uptake and strong magnetic property enabled highly sensitive MR imaging of single cells and pancreatic islets after transplantation.