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Editorial

Nanoparticle-based Monitoring of Stem Cell Therapy

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Abstract

This theme issue provides a timely overview on the current status of stem cell tracking with the nanoparticle-based contrast agents.

Exogenous stem cell-based therapies hold promise and potential to revolutionize medicine by restoring tissue and organ function [1, 2]. To develop effective therapy, the location, distribution, persistence, and functions of transplanted cells have to be evaluated [3]. Nanoparticle (NP)-based imaging technologies have the potential for qualitatively and quantitatively monitoring transplanted cells, which will facilitate prediction of treatment efficacy and reveal optimal transplantation conditions [4, 5]. In comparison to the traditional probes, NPs possess tunable sizes, shapes and compositions which yield desirable physical properties (*i.e.* electronic, magnetic, optical, and thermal properties). In addition, NPs possess an array of properties including magnetic and optical scattering, absorption or luminescence that can be readily measured with existing imaging modalities.

This special issue provides a sampling of the preparation and use of novel NP-based probes to track and study stem cells. First, Gu, Wu and their colleagues from Sichuan University examined this field from a perspective of materials chemistry [6]. They discussed the synthesis, surface coating/chemistry of NPs (especially magnetic NPs) that have been investigated for stem cell labeling for magnetic resonance imaging (MRI) tracking. Then Zhao and co-workers from the University of California-Irvine specifically summarized *in vivo* sensors that not only are able to track stem cells but also potentially report their dynamic functions in the body [7]. These *in vivo* sensors therefore hold the potential to revolutionize our understanding of basic biology and our treatment of disease using stem cells. In their review, they highlighted recent advances in the fields of *in vivo* electrochemical, optical, and MRI biosensors especially those using NPs (*e.g.*, gold NPs, carbon nanotubes, and quantum dots). Song *et al.* from Cardiff University then focused on the translational aspect of the topic [8]. After a brief recollection of the history of stem cell therapy and a concise comparison of the major imaging modalities in clinics, they focused on the clinically-preferred magnetic NPs and examined the major steps in the labeling and tracking of stem cells with magnetic NPs for the treatment of neurologic diseases. Then Mathiasen and Kastrup from Copenhagen University Hospital assessed this field from the clinical point-of-view [9]. By taking the coronary artery disease as an example, they summarized the latest efforts in the clinic, where radionuclides, MRI, and reporter genes have been used to help understand and monitor the fate of transplanted stem cells. Once the labeling and tracking protocol is standardized, contrast agents are expected to be produced and distributed through industrial partners. Therefore, the perspectives from the industry is vital.

To that end, Wang *et al.* from the Hybrid Silica Technologies reviewed existing commercial NPs for three commonly used imaging modalities including fluorescence imaging, MRI, and photoacoustic imaging [10]. Besides the scientific discussion about the technologies for preparing and utilizing NPs, they further listed challenges and expectations from industry for the development of new NP products for stem cell labeling and tracking. Finally, with the knowledge of success and limitations of NPs for stem cell labeling and tracking, Xia group (Georgia Institute of Technology) and Wang group (Washington University in St. Louis) presented exciting gold nanocage-based contrast agents combined with two-photon microscopy and photoacoustic microscopy for the tracking of human mesenchymal stem cells [11].

In summary, the synergy between size, structure and physical properties of NPs makes them key players in revealing the fate and performance of stem cell therapy. Although there are several hurdles that still need to be addressed and solved before implementing these platforms in the clinic, the successes and the clear promises provided in the above contributions indicate that these platforms will advance our understanding of the fate of transplanted stem cells and enhance our ability to utilize them for helping the suffering patients. Clearly NPs have much to offer in stem cell research and therapy.

Competing Interests

The authors have declared that no competing interest exists.

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