Short Communication

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Application of Nanotechnology and Stem Cell Therapy in Musculoskeletal Disorders: Short Commentary

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Abstract

Nanotechnology and stem cell therapy (SCT) have emerged as revolutionary approaches in musculoskeletal disorders, offering innovative solutions to complex disoders. Traditional orthopedic surgeries and pharmaceuticals often fall short in terms of long-term efficacy and recovery time. Nanotechnology and stem cell therapy present more advanced, targeted, and minimally invasive alternative approach.

Nanotechnology involves the manipulation of materials at nanoscale to create systems that can deliver correct diagnosis, and treatment of musculoskeletal disorders. Nanomaterials, such as nanoparticles, nanotubes, and nanofibers, have depicted significant improvement and enhancement in bone regeration, drug delivery, and tissue repair. small size of nanoparticles allow them to integrate better with biological system, ensuring precision in delivering therapeutic agents to specific sites in order to minimizing their side effects. Interestigly, nanoscale scaffolds have been developed to promote bone and cartilage regeneration by mimicking the extracellular matrix (ECM) and supporting the growth of new tissues.

On the other hand, SCT uses undifferentiated cells with the ability to transform in to specific types, offering significant role in the treatment of damaged tendons, cartilage and bones. These stem cells can be guided more effectively to the target areas with the combination of nanoparticles, increasing the success rate of treatments.

Keywords: Nanotechnology; Nanoparticles; stem cell therapy; SPIONs.

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Combination of nanotechnology stem cell therapy in orthopedics is an emerging field that applies nanoparticles and stem cell therapy to improve treatments for musculoskeletal conditions. It offers several potential advantages in areas like bone healing, implant durability, tissue regeneration and drug delivery. However, concerns regarding safety and cost effectiveness of nanotechnology remain ambiguous.[1] This short commentary summarises the application of nanotechnology and stem cell therapy in orthopedics.

Investigations revealed the Nanomaterials that can specifically recognize and deliver chemotherapy to malignant bones.[2] A magnetite - hydroxyapatite composite for direct bone binding, a collagen hydroxyapatite bicomposite enhanced with magnetite for bone transplantation are among mono therapies.[3,4]

Nanotechnology used for targeted drug therapy has incorporated nanoparticles (eg. Silver) into materials with nanostructured. Additionally, nanotechnology enhances accuracy and reduces the chances of bacterial infections.[5,6] Fusion oncogenes and molecular markers linked with osteosarcoma and Ewing's Sarcoma can be dysregulated using nanotechnology to suppress these molecular indicators.[7]

Nanotechnology has revolutionized therapeutics by empowering more accurate drug delivery, which has been proven beneficial for orthopedics. Animal research studies demonstrated that gold has the potential to effectively deliver iontophoresis and used to treat tendinopathy. These studies demonstrated that nanophase gold improves the efficiency of anti-inflammatory agents in certain rodents.[8,9]

Numerous studies also demonstrated that tissue engineering for the treatment of cartilage and other bone-related anomalies is one of the most important uses of nanotechnology and associated investigation in orthopedics.[10] In addition; nanotechnology has been used to monitor orthopedic therapies and guide treatment strategies. Moreover, some sensors are even enabled to detect the growth of bone.

Magnetic resonance imaging (MRI) is additional modalities that nanotechnology will improve the outcomes. Mohanty *et al.* (2019) reported that in osteosarcoma, ferumoxytol NPs able to enhance MRI and monitor macrophage reaction to CD47 mAb.[12]

Skyova *et al.* capable of monitoring cellular migration employing T2 -weighted MRI images by labelling bone marrow embryonic stem cell and mesenchymal stem cell with super paramagnetic iron oxide (SPIO) NPs (Sykova and Jandelova, 2007. They could effectively trace cell migration in models with spinal lesions and cortical lesions. This technique can identify the precise location of neural lesions suggests the probability of future site specific interventions.[13]

Another interesting connection between nanotechnology and stem cell therapy is that incorporating **SPIONs** (**Superparamagnetic iron oxide *nanoparticles* are *biodegradable components***) into cells permits contactless manipulation of cells using an external magnetic field gradient. This technique can be useful in locating or targets ting the cells at regeneration site[14,15], that's a non-invasive tool in stem cell therapy.[16,17] Importantly, this technique is used in orthopedics and applied in vascularisation of various tissues by endothelial progenitor cells. Endothelial progenitor cells are negatively charged on surface, so they are able to bind with anionic magnetic particles. These magnetic particles does not change the differentiation or proliferation capability of the cells and also membrane protein which are essential for vascularisation, remains unchanged.[18] These Nano magnetic particles are supposed to help in localised stem cell therapy as vascularisation is quite important entity for the development of several tissues. We may direct these magnetic particles with external magnetic field to areas that require vascularisation can thus promote regeneration of damaged tissues.[16]

Personalised treatments, new drugs testing, and modification of disease could be achievable with the help of stem cell therapy. Moreover, personalized treatment can be done according to assessment of the genetic machinery of an individual.[19,20]

Early clinical trials depict that stem cell-derived therapies can improve motor function in patients suffering from Parkinson's disease. Additionally, stem cells are helpful in the regulation of the immune system, potentially treating autoimmune disorders like multiple sclerosis and rheumatoid arthritis. As a matter of fact, conservative treatment for traumatic lower back pain is effective in some cases, while in recent years, stem cell therapy has been a better option for replacing orthopedic surgeries, where hardware implants fail, postoperative complications, issues of heterotopic ossification, surgical wound infection, non-union, nerve injury, malunion, etc., and even no single ideal treatment is available for complicated fractures.[21-26] Interestingly, mesenchymal cells have immunomodulatory functions and the ability to differentiate into cartilage, hence can be a better option for intervertebral disc regeneration.[27]

Contrarily, stem cell therapy also contains drawbacks, for eg. the risk of tumor formation, several ethical issues, and the risk of infection or rejection. It is quite clear that we need more clinical studies to verify the real capability of stem cell therapy.[28]

Finally, animal models of spinal cord injury (SCI) have shown that combined therapy of nanoparticles and stem cells and this combined therapy holds a better impact on neuroregeneration.

Nanotechnology can enhance the delivery and effectiveness of stem cells used to repair damaged musculoskeletal tissues. Nano biosensors may eventually help provide personalized orthopedic treatments by detecting biomarkers specific to individual patients. Further, we need more clinical trials for finding out more potent nanoparticle, which can amplify the efficacy of stem cell in regeneration of tissues.

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