

Review-Nanoparticle Applications in Scaffold- Based Tissue Engineering

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Abstract:

Tissue engineering is an evolving multidisciplinary field aimed at restoring or replacing damaged tissues and organs through the combined use of cells, biomaterials and bioactive molecules nevertheless, traditional scaffold materials often lack the ability to accurately reproduce the structural and functional characteristics of native tissues, which restricts their effectiveness in clinical applications. In this regard, nanotechnology gained considerable attention for its potential to overcome these limitations by enabling the fabrication of advance biomaterials with improved performance. these review presents a comprehensive evaluation of nanoparticle-based approaches in tissue engineering, highlighting key categories such as ceramic, metallic and metal oxide, carbon based and polymeric nanoparticles. Due to their nanoscale size and large surface area these materials possess distinctives physicochemical properties that enhance cellular responses including adhesion, proliferation and differentiation ,while also supporting the controlled release of therapeutic agents ceramic nanoparticles including hydroxyapatite and calcium phosphates contribute to born mimicking properties and mechanical reinforcements metallic nanoparticles such as gold, silver and iron based systems offer antimicrobial effects and multi-functional therapeutic capabilities carbon based nanomaterials improved structural strength and facilitate cell material interaction whereas polymeric nanoparticles provide adjustable degradation rates and efficient delivery of bioactive compounds .Despite their promising advantages concerns related to toxicity longterm safety and regulatory challenges continue to hinder there wide spread clinical use future research should prioritize the development of safer and more effective nanoparticle systems, along with the integration of emerging fabrication techniques. overall, nanoparticles-enabled strategies represent a powerful avenue for advancing tissue engineering and regenerative medicine.

Keywords:

Biocompaθibility, Nanoparθcle, scaffold engineering, Øssue engineering.