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NANOTECHNOLOGY-BASED STRATEGIES FOR REVERSING LIVER FIBROSIS

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Abstract

Liver fibrosis is a progressive pathological condition characterized by excessive accumulation of extracellular matrix proteins, particularly collagen, resulting from chronic liver injury. Major causes include metabolic disorders, viral infections such as Hepatitis B and Hepatitis C, as well as metabolic conditions like Non-Alcoholic Fatty Liver Disease. Persistent liver injury leads to the activation of hepatic stellate cells, which play a crucial role in fibrogenesis by producing large amounts of collagen and other fibrotic components. Over time, continuous fibrotic deposition disrupts normal liver architecture and may progress to severe complications such as Cirrhosis and liver failure if left untreated.

Recent advances in Nanomedicine have introduced promising therapeutic strategies for targeted treatment and potential reversal of liver fibrosis. Nanoparticle-based drug delivery systems enable precise targeting of fibrotic liver tissue and activated hepatic stellate cells. Various nanoparticles, including lipid-based, polymeric, and inorganic nanoparticles, are being explored for their ability to transport anti-fibrotic drugs, antioxidants, and anti-inflammatory agents directly to the site of liver injury. This targeted delivery enhances therapeutic efficacy while minimizing systemic toxicity and side effects. In addition, nanoparticles can provide controlled and sustained release of therapeutic agents, improving drug stability and bioavailability. These nanocarriers can reduce oxidative stress, suppress inflammatory responses, and inhibit the activation of hepatic stellate cells, thereby limiting excessive collagen deposition and promoting the restoration of normal liver structure. Furthermore, nanoparticle-mediated delivery of protective compounds may support hepatocyte regeneration and tissue repair. Overall, nanotechnology represents a novel and promising approach for the management and potential reversal of liver fibrosis. Continued research in nanoparticle-based therapies may lead to the development of more effective and safer treatment strategies for chronic liver diseases.

Keywords: Liver Fibrosis, Nanomedicine, Targeted Drug Delivery, Hepatic Stellate Cells, Nanoparticle Therapy