

News Release

Bioabsorbable Nanofiber Sheets Enable Localized and Sustained Delivery of Lipid Nanoparticles and Extracellular Vesicles for Precision Cancer Therapy

Key Points

- A bioabsorbable nanofiber sheet (BNF sheet) was developed using surgical absorbable sutures to enable localized and sustained delivery of lipid nanoparticles (LNPs) and extracellular vesicles (EVs).
- A unique retention-and-release mechanism was established, in which capillary forces during the drying process immobilize nanoparticles within the nanofiber matrix, followed by gradual release in vivo.
- The BNF sheet was fully absorbed in vivo and exhibited excellent biocompatibility without inducing inflammation or fibrosis.
- Compared with intravenous or intraperitoneal administration, the BNF sheet achieved more efficient and localized delivery of therapeutic agents to target lesion sites.
- This platform is expected to be broadly applicable to next-generation nanomedicines, including mRNA therapeutics, nucleic acid drugs, and EV-based therapies.

Summary

A research group led by Dr. Kazuhiro Suzuki (Nagoya University Hospital / currently MD Anderson Cancer Center), Dr. Akira Yokoi (Nagoya University Hospital / Institute for Advanced Research, Nagoya University), Prof. Hiroaki Kajiya (Nagoya University Graduate School of Medicine), and Prof. Takao Yasui (Nagoya University / Institute of Science Tokyo), in collaboration with researchers from Nagoya University, the University of Osaka, Tohoku University, AIST, and other institutions, has developed a bioabsorbable nanofiber (BNF) sheet platform enabling localized and sustained delivery of lipid nanoparticles (LNPs) and extracellular vesicles (EVs) for precision cancer therapy.

Although lipid nanoparticles (LNPs) are widely used as delivery systems for nucleic acids, proteins, and small molecules, their clinical use is largely dependent on systemic administration, which often results in insufficient accumulation at disease sites and off-target effects. To overcome this limitation, the researchers developed a biodegradable fibrous scaffold capable of retaining and locally releasing nanocarrier-based therapeutics.

The BNF sheets are fabricated by processing absorbable surgical sutures into nanoscale fibers, forming a porous fibrous network. When LNPs or EVs are applied, capillary forces during drying induce fiber contraction, resulting in physical entrapment of nanoparticles within the matrix. Upon exposure to physiological fluids, the structure rehydrates, enabling sustained and localized release of the loaded therapeutic vesicles.

In a murine ovarian cancer peritoneal dissemination model, BNF sheets loaded with carboplatin-encapsulated LNPs were directly applied to tumor sites. This treatment resulted in significant tumor growth suppression exclusively at the implantation site, while untreated regions showed no comparable response, demonstrating strong spatial control of therapeutic delivery.

Importantly, the BNF sheets were fully bioabsorbed over time without requiring surgical removal. Histological analyses revealed no significant inflammation or fibrotic response, and systemic toxicity markers remained within normal ranges, confirming excellent in vivo biocompatibility.

These findings demonstrate that BNF sheets provide a versatile and clinically translatable platform that bridges systemic nanomedicine and localized therapy. The system may enable more efficient, safer, and spatially controlled delivery of nanoparticle-based therapeutics.

Research Background

LNPs have become central to modern nanomedicine due to their ability to encapsulate and deliver nucleic acids, proteins, and small-molecule drugs. However, most current applications rely on systemic administration, which often leads to suboptimal accumulation at target tissues and unwanted systemic exposure.

Similarly, EVs have emerged as promising biological nanocarriers for diagnostics and therapy, but efficient and localized delivery systems remain limited.

Conventional localized delivery systems, such as hydrogels, drug-eluting implants, and patch-based formulations, are primarily designed for small-molecule drugs and rely on diffusion-based release mechanisms. These systems are often unsuitable for controlling the behavior of nanoscale therapeutic carriers such as LNPs and EVs.

Moreover, many implantable systems require surgical removal or may induce foreign-body reactions, limiting their clinical applicability. Therefore, there is a strong need for biodegradable, minimally invasive platforms capable of achieving localized and sustained delivery of nanocarrier-based therapeutics.

Bioabsorbable polymers such as polyglycolic acid, widely used in surgical sutures, provide a clinically validated and safe material foundation. However, their use as functional scaffolds for nanoparticle delivery has not been fully explored.

This study addresses this gap by developing a bioabsorbable nanofiber sheet capable of physically entrapping and locally releasing LNPs and EVs in a controlled and biodegradable manner.

Research Results

The BNF sheets were fabricated by mechanically processing absorbable surgical sutures into nanofibers, forming a porous fibrous matrix. When LNP or EV suspensions were applied, capillary forces during drying induced fiber contraction and partial pore closure, resulting in efficient physical entrapment of nanoparticles.

Structural analyses using scanning electron microscopy and porosimetry confirmed reduced pore volume after nanoparticle loading, indicating successful incorporation within the fibrous network. Upon rehydration under physiological conditions, the fiber structure reopened, enabling sustained release of the loaded nanoparticles.

In vivo studies demonstrated that the BNF sheets were gradually degraded and completely absorbed within approximately eight weeks after intraperitoneal implantation. No significant inflammatory infiltration or fibrotic changes were observed, and systemic toxicity parameters remained unchanged. Fluorescence imaging further revealed that LNPs released from BNF sheets remained localized at the implantation site for extended periods, in contrast to systemic or intraperitoneal injection, which showed rapid dispersion and lower local retention. In ovarian cancer peritoneal dissemination models, BNF sheets loaded with carboplatin-encapsulated LNPs significantly suppressed tumor growth only at the application site. Histological analysis confirmed increased apoptotic signaling and reduced proliferative activity in treated tumors.

Notably, the system was also capable of loading and delivering extracellular vesicles, demonstrating broad compatibility with diverse nanoscale therapeutic carriers.

Research Summary and Future Perspective

This study demonstrates that bioabsorbable nanofiber sheets can serve as a robust platform for localized and sustained delivery of lipid nanoparticles and extracellular vesicles.

By combining physical nanoparticle entrapment with biodegradable fibrous scaffolds, the system enables spatially controlled drug delivery without chemical modification or permanent implantation. Complete *in vivo* biodegradation further enhances clinical safety. The ability to achieve strong antitumor effects using extremely low drug doses highlights the efficiency of localized nanocarrier delivery and suggests potential for reducing systemic toxicity while maintaining therapeutic efficacy.

In the future, this platform may be extended to nucleic acid therapeutics, protein-based drugs, and extracellular vesicle-based therapies. It may also be applicable to other clinical contexts requiring localized and sustained drug delivery, including postoperative residual disease and inflammatory conditions. Further optimization of release kinetics, loading capacity, and clinical scalability will be necessary for translational development.

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