Biodegradable Shape Memory Polymer for 3D-Printed Tissue and Biomedical Devices

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Biodegradable, Bioresorbable, Soft-Tissue Replacement

Soft tissue pathologies are currently treated with a wide range of materials, however, most of these lack optimal mechanical profiles, are not biodegradable, and/or do not exhibit shape memory behavior to either treat soft tissue pathologies or be used via minimally invasive surgical (MIS) treatment methods. In the simplest terms, existing technologies tend to be either too â??hardâ?• (e.g., thermoplastic polymers) or too â??softâ?• (e.g., hydrogels), with each extreme presenting its own set of problems: too hard can lead to tissue erosion or the eventual migration of the device leading to organ or vessel obstruction, while too soft can lead to implant migration and rapid resorption, which can necessitate repeat procedures.

A major challenge in the treatment of soft tissue pathologies, such as those stemming from acute injury, age-related wear, and disease, is the production of biomaterials that exhibit mechanical properties similar to those of complex soft tissues. Soft tissues display nonlinear elastic and viscoelastic mechanical properties, requiring similar behavior from potential therapeutic biomaterials enabling appropriate tissue repair within and around the pathology. In order to allow for tissue infiltration onto and within the implanted device, these materials should be biodegradable and bioresorbable, ultimately replacing the pathology with healthy tissue and removing the need for a permanent implant.

See also: 8658 Advanced Manufacturing of Biodegradable Shape Memory Polymers Increases in vivo Success

New Synthesis Reaction to Produce Novel Biomaterials for Soft Tissue Treatment

Shape memory polymers (SMPs) are a versatile family of materials developed for numerous applications including heat shrinkable tubing, smart textiles, and actuation for soft robotics. SMPs can be leveraged to treat soft tissue pathologies via MIS procedures as materials exhibiting shape memory behavior can fit in a delivery device, and ultimately â?? upon implantation and exposure to body temperature â?? expand to fit the tissue defect. Novel biomaterials developed to solve the challenge of soft tissue treatment via MIS procedures can leverage the rapidly advancing technology of 3D printing to be able to manufacture patient-specific devices.

This technology utilizes a new synthesis reaction combining a previously described (US8236350 also from Hollister) shape-memory, biodegradable, elastomeric material with photocurable chemistries used in several clinically approved applications. The use of these novel photo-crosslinkable polymers [i.e., poly(glycerol dodecanedioate), or PGD] for 3D printing applications and using direct-write nozzle-based printing and resin-based sterolithography (SLA) printing provides not only patient specificity, but also biodegradability and shape memory behavior allowing the printed polymers to fit within MIS access devices. MIS is rapidly expanding across all healthcare disciplines because of reduced costs and improved patient outcomes. In addition to accommodating design and development of patient specific anatomic devices, 3D printing these materials can accelerate development from prototyping to production for a broad range of soft tissue repair applications.

Summary Bullets

- New synthesis reaction produces novel biomaterials for soft tissue treatment combines shape memory and biodegradability with custom 3D printing for patient-specific, minimally invasive solutions
- Customizable to patient needs by varying the formulation and molecular architecture to alter the mechanical properties
- Improves safety and efficacy by providing a much-needed middle range to existing â??too hard/too softâ?• tissue repair options, while also being biodegradable and bioresorbable

Solution Advantages

- **Patient specific**: Combines shape memory and biodegradability with custom 3D printing (both direct-write methods and stereolithography approaches) to provide patient-specific, minimally invasive solutions
- **Versatile**: Varying the formulation and molecular architecture can alter the mechanical properties for further customization and patient specificity
- **Improved safety and efficacy**: Provides a much-needed middle range to existing â??too hard/too softâ?• tissue repair options, while also being biodegradable and bioresorbable

Potential Commercial Applications

- Personalized, implantable medical devices for soft tissue repair
- Cardiovascular, musculoskeletal, gastrointestinal, and other repair applications to address esophageal, diaphragmatic, craniofacial, inner ear, and other pathologies
- Research-grade, patient-specific tissue engineering models
- In-vitro biological models

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