

Research on new generation of safer mesh implants

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Introduction

The current mesh implants (Fig. 1) are composed of polypropylene (PP), polyethylene terephthalate (PET), expanded polytetrafluoroethylene (ePTFE) and polyvinylidene fluoride (PVDF).¹ Mesh implants have been widely used, but given the number of complications associated with mesh insertion, and the recent media coverage relating to the lawsuit against the National Health Service (NHS) in UK for the current use of polypropylene mesh inserts (<http://bbc.in/2oHu7zT>), pursuing research for the development of a new generation of mesh inserts is now of the utmost

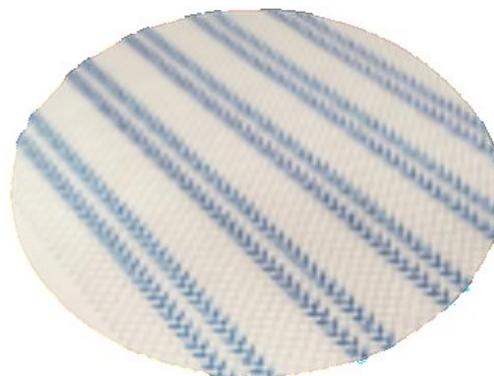


Figure 1. An example of a polypropylene mesh.

importance for the future of patient care and recovery. Potential mesh-related complications include chronic infections, chronic pain and mesh rupture. There is a need to have a mesh implant that is softer with characteristics that resemble native muscles, and on the same time reduce the risk of infection, with bespoke production for cost reduction. The mechanical properties of the mesh and the compatibility between the materials and the tissues are critical in healing; tissue incorporation is a key goal, which is dependent on the material, density, compliance and electric charge of the mesh.² This is especially important if the risk of graft failure is high and complications due to infection are experienced. These limitations stimulate research into new methods of fabrication (e.g. 3D printing and high-speed rotary spinning), and by incorporating biomaterials and drug encapsulation in these mesh matrices.³

Electrospun Nanofiber Mesh

Electrospun nanofibers (Fig. 2) offer advantages for a wide range of applications in a variety of fields, including biomedicine and biotechnology.⁴ An important advantage of Electrospun fibres over many other types of polymeric fibres is their high surface over volume ratio and very high and tuneable porosity, which generates a large and easily accessible surface.⁵ The challenge facing doctors using scaffolds in tissue engineering applications lies in controlling the way the fibres being used physically morph and interact with the host body's normal physiological function.

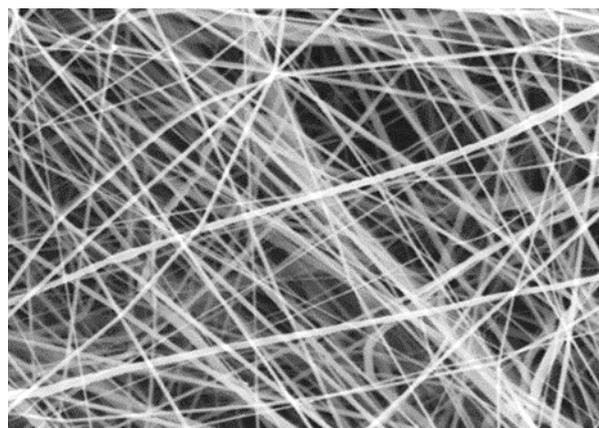


Figure 2. An example of Electrospun Nanofibers.

Although, tissue scaffolds commonly contain antibiotic drugs to inhibit bacterial infection, increasing complications resulting from the use of widely-used mesh implants to repair damaged or weakened tissue in the abdomens of some women have been documented in recent years. The number of complications associated with mesh insertions and recent media coverage relating to the lawsuit

continued

against hospitals for the current use of polypropylene mesh inserts has made the development of a new generation of mesh inserts more urgent. The most common complications of mesh repair are: seroma, infection (~16% of the operations), chronic pain, recurrence, fistula, and degradation. In a recent research we have shown that antibiotic-loaded FDA approved biocompatible-polymeric fibres have the potential to be developed further as a possible medical device and reducing the complications of current mesh implants.³

In our lab we are formulating mesh implants by electrospinning (makes fibers oriented) and Food and Drug Administration (FDA) approved biodegradable materials (e.g. Collagen) that commonly used in biomedical applications for controlled release. Bespoke fabrication and fibers orientation helps in reduction of cutting and therefore pain. Moreover, Antibacterial agents (e.g. irlgasan), have been loaded in these systems for sustained and controlled release. Through bridging chemical, mechanical and biological studies, their behaviours can be fully interpreted. We have formulated a system which is mechanically stable, softer (hardening causes the tissue to tighten, which is painful), and with more advances than existed commercial mesh products (e.g. cheaper, softer, easier to be operated and prepared for each patient's individual needs). Moreover, preliminary cell experiments have shown that Cells are grown on these mesh implants following the fibre alignment (Fig. 3) which is very important for reconstruction of the surgical area in order for the body to feel that this object (mesh implant) is not a foreign material; this will reduce the cause of pain dramatically.

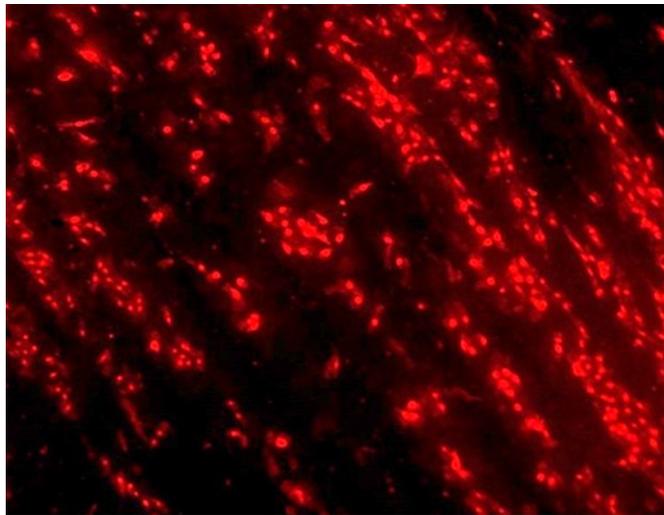


Figure 3. An example of Cells grown following fibre alignment.

Conclusions

Mesh implants prepared using electrospinning and FDA approved biodegradable materials can successfully modify tissue scaffolds and this modification may be useful in the compatibility and utilisation of tissue engineered structures within the human body. By using new technologies (e.g. electrospinning and 3D printing) we can now produce a system which is easier to be operated, have the same (and better) mechanical properties than existed systems, safer, and is loaded with antibacterial agents for a sustained/controlled release. In the future, the doctors will be able by scanning the area (using commercial scanners or Medical Devices) to request (or produce) each time an accurate mesh implant that could be potentially prepared in hospitals by trained staff (e.g. Medical Engineers) with the intention to have a bespoke production that is patient focused in the hospital / locally.

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