Biointegrative Reticulated Elastomeric Matrix for Ventral Hernia Repair

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Introduction: The introduction of mesh technology revolutionized hernia repair by enabling tension-free repair approaches which have substantially reduced historical recurrence rates. Early heavy weight meshes resulted in complications such as loss of abdominal wall compliance, shrinkage and scarring of surrounding tissues leading to pain, discomfort and recurrence[1,2]. The use of light weight large pore meshes alleviated some shortcomings but still engender a fibrotic scarring reaction that leads to sub-optimal clinical outcomes[1-3]. In the area of ventral hernia, new developments in mesh technology have focused on composite meshes with coatings on one surface of the mesh to minimize adhesions when exposed to viscera, while the non-coated surface is intended to integrate to the abdominal wall[2]. Clinical outcomes in ventral hernia have not been satisfactory, primarily due to a lack of well-designed "dual functionality" composite meshes. A biostable and biointegrative scaffold in the form of 3-D polymeric matrix[4] that supports vascularized tissue ingrowth represents a promising solution due to superior biointegration.

This study was designed to investigate whether a novel tri-layer composite mesh consisting of a biostable and biointegrative polymer matrix[4] that acts as a scaffold for superior biointegration, a lightweight polypropylene mesh for mechanical strength, and a resorbable polymer film for anti-adhesion functionality, would provide improved outcomes in a partial thickness abdominal wall defect in a rat model.

Materials and Methods: The polymeric scaffold is a flexible biodurable, crosslinked, reticulated elastomeric polycarbonate-polyurethane-urea (RPCPU) matrix consisting of an interconnected 3-D network of cells and pores. The high void (> 95 %) reticulated morphology permits cellular proliferation and tissue ingrowth throughout the scaffold. The material is biostable.

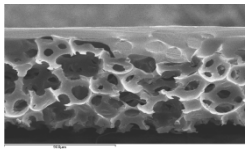

Figure 1

The ASSURE™ Surgical Mesh (Fig.1) is a conformal tri-layered structure featuring a knitted polypropylene (PP) mesh with a layer of the biointegrative RPCPU designed to facilitate rapid tissue ingrowth and improve the integration with host tissue on one side. On the other side, a resorbable anti-adhesion layer comprised of a thin polylactic-acid/polycaprolactone (PLLA/PCL) co-polymer film is designed to minimize adhesions to the underlying PP mesh. The composite mesh has a thickness of ~ 1 mm and is available in various sizes.

A partial thickness 1.0 cm x 1.0 cm resection of the abdominal wall musculature was created in Sprague-Dawley rats weighing 300-500 g. The peritoneum and transversalis fascia were left intact. The defect was repaired with test articles measuring 1.0 cm x 1.0 cm using 4-0 Prolene™ for fixation to the abdominal wall. The skin was closed using 4-0 Vicry™. ASSURE™ and PROCEED™ represented treatment and control arms, respectively. The animals were sacrificed at various time points (N=4) up to 26 weeks. Histological evaluation focused on cellular infiltration, vascularization, connective tissue formation, and presence of multinucleate giant cells (MNGC). Device shrinkage was measured at the 26 week timepoint.

Results and Discussion Macroscopic examination of the explanted test articles showed the presence of a smooth connective tissue surface across the device with no visible signs of RPCPU or PP mesh degradation or adjacent tissue necrosis at all time points. The histopathology showed robust cellular infiltrate into RPCPU, formation of connective tissue, and abundant vascularization within the first week after surgery, which continued during successive time periods with progressive maturation and strong integration into the surrounding host tissue. A well-defined fibrous connective tissue layer was present across the resorbable anti-adhesion polymer film layer at week 1; the polymer film effectively prevented cellular infiltration across this layer up to 16 weeks *in-vivo*. Complete cellular infiltration throughout the device was observed at week 26 following fractionation of the anti-adhesion film and full tissues access to the biointegrative matrix. Neotissue formation within the test articles elicited a strong angiogenic response and the deposition of extracellular matrix. A low-grade foreign body response was observed through 26 weeks, which was limited to a thin area directly associated with the polymeric struts. Test samples showed minimal device shrinkage of 7.0±5.0% along the cranial-caudal axes within the first 26 weeks following surgery, compared to a higher shrinkage of 17.5±5.0% for the control arm.

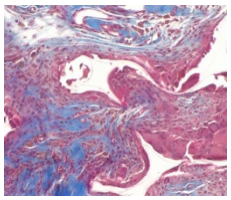

Figure 2

Conclusions: ASSURE™ showed an effective anti-adhesion functionality for up to 16 weeks. At 26 weeks, it demonstrated well-tolerated, long term response in the rat partial thickness abdominal wall model, characterized by well-organized, vascularized connective tissue ingrowth, excellent biointegration with the surrounding host tissue, and minimal device shrinkage.

References:

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