In Vitro Cellular Response to Surgical Mesh Materials Derived from Dermal ECM

Katherine M. Kulig[1], Xiao Luo[1,2], Eric B. Finkelstein[1], Xiang-Hong Liu[5], Joseph P. Vacanti[1,3,4], Scott Goldman[5], Cathryn A. Sundback[1,3], Craig M. Neville[1,3]

1. Center for Regenerative Medicine, Massachusetts General Hospital; 2. Tongji Hospital, Huazhong University of Science and Technology; 3. Harvard Medical School; 4. Massachusetts General Hospital for Children, Boston, MA, USA; 5. Kensey Nash Corp, Exton, PA USA

Statement of Purpose:
Surgical mesh scaffolds manufactured from donor human or animal tissue are increasingly being used to promote soft tissue repair and regeneration. The clinical product consists of the residual extracellular matrix remaining after a rigorous decellularization process. Optimally, the material provides both structural support during the repair period and cell guidance cues for effective incorporation into the regenerating tissue. Surgical mesh materials are available from several companies and are unique products manufactured by proprietary methodology. A significant need exists for a more thorough understanding of scaffold properties that impact the early steps of host cell recruitment and infiltration.

Methods:
In this study, a panel of in vitro assays was used to make direct comparisons of several similar, commercially-available materials: Alloderm (LifeCell, Branchburg, NJ), Gelfoam (Pfizer, New York, NY), Medeor Matrix (Kensey Nash, Exton, PA), Permacol (LifeCell, Branchburg, NJ), , and Strattice (Covidien, Mansfield, MA). The in vitro assays included in the panel (Table 1) were chosen to reflect basic biological processes thought to be important in soft tissue regeneration and defect repair.

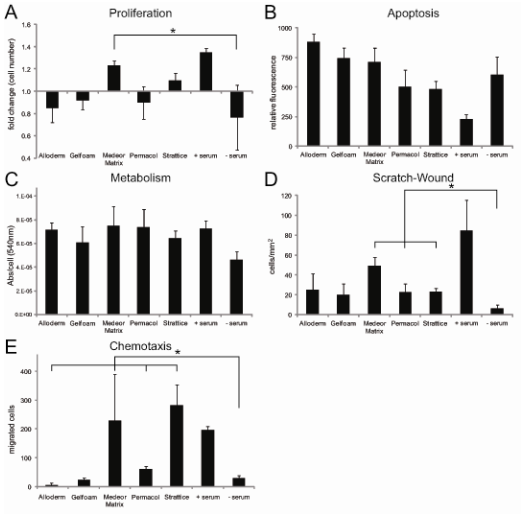
Table 1

Assay	Format	Material Interaction
Proliferation	96-well TC dish	conditioned medium
Apoptosis	96-well TC dish	conditioned medium
Metabolism	96-well TC dish	conditioned medium
Scratch-Wound	24-well TC dish	conditioned medium
Chemotaxis	Boyden chamber	conditioned medium
Cell Adhesion	96-well TC dish	attachment
Invasion	cell culture insert	chemotaxis
Choriallantoic Membrane	chick embryo	invasiveness

Specific cell types were chosen for documented sensitivity for the particular assay and resistance to confounding effects.

Results:
Differences in the materials were detected for both cell signaling and scaffold architecture-dependent cell invasion. Material-conditioned media studies found Medeor Matrix to have the greatest positive effect upon cell proliferation and induction of migration. Strattice provided the greatest chemotaxis signaling and best suppressed apoptotic induction. (Figure 1) Among assays measuring structure-dependent properties, Medeor Matrix was superior for cell attachment, followed by Permacol. Only Alloderm and Medeor Matrix supported chemotaxis-driven cell invasion beyond the most superficial zone. Medeor Matrix was the only material in the chorioallantoic membrane assay to support substantial cell invasion.

Figure 1



Conclusion:
These results indicate that both biologic and structural properties need to be carefully assessed in the considerable ongoing efforts to develop new uses and products in this important class of biomaterials. In this study, similar extracellular matrix-derived materials developed for soft tissue repair and regeneration were evaluated in a panel of in vitro assays. The present study demonstrates that commercial ECM-derived surgical mesh materials have distinct structural properties that impact cell infiltration and retain varying amounts of biologic activity. In addition to providing structural support, the large fibrous components of the extracellular matrix also reversibly bind growth factors and cytokines that can influence macrophage activity. These factors also play important roles in signaling nearby tissue during tissue regeneration, to induce mitosis and cell migration and recruitment. Certain caveats exist in interpreting this study. The in vitro assays used in the present study are unlikely to fully mimic conditions during clinical use of the materials, but they do reflect many of the general processes thought to be important for tissue regeneration. As a panel, they present a quantitative measure of biological properties that would be difficult to assess in vivo.

References:
1 Hoganson DM et al. Biomaterials. 2010;31:6730-7
2 Badylak SF et al. Biomaterials. 2007;28:3587-93.
3 Badylak SF et al. Acta biomaterialia. 2009;5:1-13.

©2013 Society For Biomaterials