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Research Paper

Immediate postoperative changes in synthetic meshes – *In vivo* measurements

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ABSTRACT

Background and objective: Immediate post-operative structural changes in implanted synthetic meshes are believed to contribute to graft related complications. Our aim was to observe *in vivo* dimensional changes at the pore level.
Method:: Two different polyvinylidine fluoride (PVDF) meshes, CICAT and ENDOLAP (Dynamesh, FEG Textiltechnik) were implanted in 18 female Sprague Dawley ($n=9$/group). The meshes ($30\times25\ mm^2$) were overlaid on a full thickness incision ($2\times1\ cm^2$) and sutured on the abdominal wall. All animals underwent microCT imaging (res. 35 μm/px) at day 1 and 15 postsurgery. A customized procedure was developed to semi-automatically detect the pore centers from the microCT dataset. Horizontal (transverse) and vertical (cranio-caudal) inter-pore distances were then recorded. The overall mesh dimensions were also noted from 3D models generated from *in vivo* microCT datasets. Inter-pore distances and the overall dimensions from microCT images of the meshes set in agarose gel phantom were used as controls. Mann–Whitney *U* test was done to check for significant differences.
Results: Number of measurable vertical and horizontal inter-pore distances was 56.5(10.5) and 54.5(14.5) [median (IQR)] per animal. At day 1, we observed a 4.3% (CICAT) and 4.6% (ENDOLAP) increase in vertical inter-pore distance when compared to controls ($p<0.001$, $p=0.003$, respectively). Measurements fell back to phantom values by day 15 (3.7% and 4.9% decrease compared to day 1, $p<0.001$ for both). The horizontal inter-pore distances for ENDOLAP increased by 1.4% ($p=0.003$) during the two weeks period. The overall mesh dimensions did not change significantly day 1 and day 15. The *in vivo* measurement of the overall mesh dimensions demonstrated a 15.9% reduction in mesh area as compared to that in phantom controls.
Conclusion: We report for the first time, *in vivo* changes in pore dimensions of a textile implant. This study clearly demonstrates the dynamic nature of a textile implant during the tissue integration process. For studied PVDF meshes, the process of tissue integration

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leads to limited but significant reduction over time as observed at the pore level. Remarkably the extent of this reduction does not account for the change in overall mesh dimensions.

1. Introduction

The lifetime risk of undergoing surgery for prolapse by the age of 80 is 19% (Smith et al., 2010). Approximately 30% of the women operated for prolapse would require a repeat surgery within 1.5–12.5 years because of failure of the repair or recurrence of symptoms (Diez-Itza et al., 2007). Meshes are widely used to provide long term relief, especially when native tissue repair fails. However, graft related complications (GRCs) including chronic pain, exposure (often referred to as erosion), extrusion, infection, seroma and adhesion can cause significant morbidity (Bako and Dhar, 2009; Haylen et al., 2010). Contraction of the synthetic mesh has been cited as one causal factor (Feiner and Maher, 2010; Ciritsis et al., 2014). This process has been, amongst other reasons, attributed to wrinkling, folding of mesh, surgical handling and tissue integration during the healing response (Endo et al., 2013; Köhler et al., 2015; Svabík et al., 2011). "Contraction" of different mesh types has been studied and quantified extensively in animal and human models. This contraction ranges from 2.3% to 59.1%, depending on the type of mesh material, the surgical technique, the implantation site, the type of animal model and the study duration (Novitsky et al., 2007; Burger et al., 2006; Johnson et al., 2004).

Abdominal hernia models have already been used to study the relationship between mesh contraction and wound healing, for example, Zinther et al. (2010) and Ozog et al. (2011) looked at contraction on explanted meshes. However, studies in such surgical models may not necessarily reflect the actual mesh size *in vivo* because of the confounding physiological changes that happen postmortem, or prior to first measurement. Newer studies have been using Magnetic Resonance (MR) visible meshes, and analyzed *in-vivo* longitudinal changes (Ciritsis et al., 2014; Endo et al., 2013). However, these are limited to macroscale measurements, *i.e.*, overall mesh dimension. Further, both strategies generally aggregate the reduction of mesh surface due to suturing and handling during the surgery as 'shrinkage' (Svabík et al., 2011; Kuehnert et al., 2012).

Previous studies have looked at the changes in pore dimensions in dry or embedded conditions as in Maurer et al. (2014). Coda et al. (2003) also studied deformations in pore structure of several different meshes explanted (or excised) following complications of hernia surgery. However, to the best of our knowledge, *in vivo* changes in mesh pore sizes have not yet been shown. The presented study aims to study the *in vivo* change in mesh and pore dimensions using microCT.

2. Materials and methods

Poly Vinylidene Fluoride (PVDF) meshes have a higher density (specific weight = 1.8 g/cm (Bako and Dhar, 2009)) compared to the body tissue which makes them visible on microCT (Klinge et al., 2002). Such meshes are commercially available under the brand DynaMesh® Visible (FEG, Textiltechnik mbH Aachen, Germany). We used two variants with different textile structures, namely ENDOLAP and CICAT, see Fig. 1. A summary of the pre-implantation mesh characteristics is given in the Appendix. DynaMesh CICAT is clinically used for repair and prophylaxis of incisional hernias, whereas DynaMesh ENDOLAP is used for the repair of inguinal hernias. All the tested mesh material was from

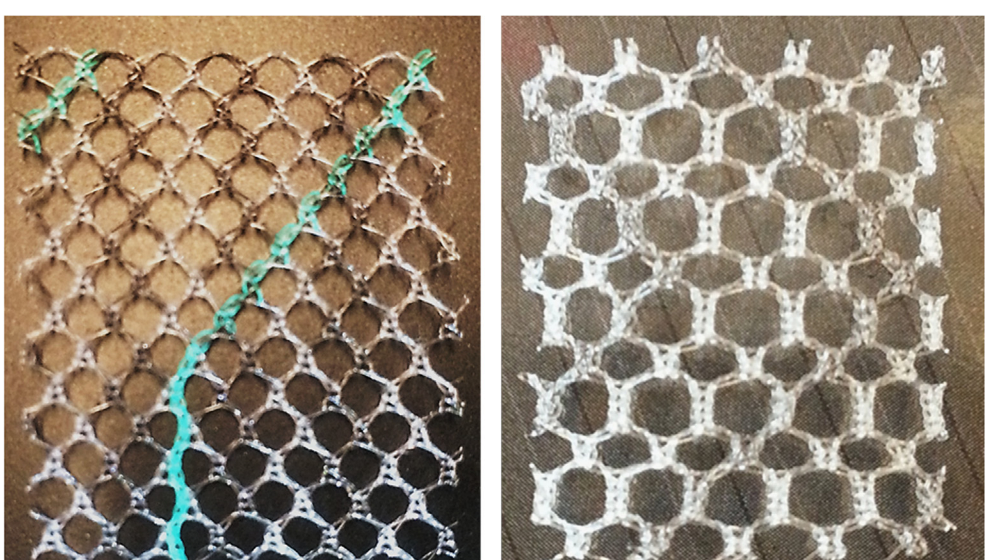

Fig. 1 – PVDF meshes DynaMesh®-ENDOLAP (Left), and the CICAT (Right).