Next generation of 3D-printed drug-eluting meshes for tissue engineering applications

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INTRODUCTION
Surgical vaginal meshes suffer from several limitations (e.g. infections, chronic immune reactions, pain, limited customisability1,2 and inadequate biomechanical behaviour3). Also, they are now subjected to tight regulations and have been banned in many countries1,2. Therefore, there is a strong call for the use of emerging technologies (3D Printing), new material and drug-based approaches for the production of these devices.

Aim: Evaluate the potential of 3D printing for the manufacturing of novel vaginal meshes

MATERIALS AND METHODS
Polycaprolactone (PCL, Polyscience, 50KDa) and Elastollan® Thermoplastic polyurethane (TPU, Distrupol Ltd, shore hardness 70A) meshes were printed using the 3D Bioplotter (EnvisionTEC) with two different designs (45° and 90°) (Figure 1, Table 1). Meshes were characterised via SEM (accelerating voltage of 40kV and distance of 40mm) and μCT (40 kV). Uniaxial tensile test was performed on each sample type (n=5, stretch rate of 5 mm/s) to investigate the mechanical properties.

RESULTS

Figure 2: SEM images and μCT reconstruction of A)-B) PCL 45° and C)-D) TPU 70° 45° meshes.

Among all the tested samples:
- PCL meshes exhibited a more defined structure, characterised by bigger pores (Figure 2).
- PCL 45° meshes had intermediate biomechanical properties, closer to the one of the native tissue (Figure 3, Table 2).
- TPU 70A meshes showed the highest elasticity (much more elastic than the vaginal tissue) (Figure 3, Table 2)

Table 2: Biomechanical properties of the human healthy vaginal tissue.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Healthy tissue</th>
<th>PCL 90°</th>
<th>PCL 45°</th>
<th>TPU 90°</th>
<th>TPU 45°</th>
</tr>
</thead>
<tbody>
<tr>
<td>E [MPa]</td>
<td>6.65±1.48</td>
<td>10.26±1.10</td>
<td>6.48±1.05</td>
<td>0.79±0.05</td>
<td>0.42±0.03</td>
</tr>
<tr>
<td>UTS [MPa]</td>
<td>1.68±0.11</td>
<td>4.02±0.25</td>
<td>2.02±0.25</td>
<td>0.32±0.05</td>
<td>1.37±0.04</td>
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<tr>
<td>Max Elongation</td>
<td></td>
<td>7.68±0.25</td>
<td>3.02±0.25</td>
<td>3.02±0.25</td>
<td>1.47±0.04</td>
</tr>
</tbody>
</table>

Figure 3: Evaluated elastic modulus (E), ultimate tensile strength (UTS) and maximum elongation for the 3D printed meshes.

CONCLUSIONS
Meshes were successfully printed via 3D printing. Among all the printed samples, PCL 45° meshes showed the most promising behaviour in terms of pore geometry and mechanical properties and could be selected for future works, such as the development of drug-loaded antibacterial vaginal implants.