NEXT GENERATION OF 3D-PRINTED DRUG ELUTING MESHES FOR TISSUE ENGINEERING APPLICATIONS

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Background: Surgical meshes have been widely employed since the start of 900s for the treatment of pathological conditions, including hernia and pelvic floor dysfunctions, wound healing and breast reconstruction after mastectomy.
Up to now, commercial meshes are mainly made of polypropylene (PP), with their use often associated with several side effects such as infections and pain, which in most of the cases lead to mesh removal. Moreover, stress shielding related to the employment of stiffer meshes must not be underestimated due to the subsequent erosion of the surrounding tissue that eventually could result in the device explantation.
Considering these issues, new material-based strategies should be implemented to design and develop mesh implants with better biomechanical properties and antibacterial potential. Additive manufacturing (AM), and particularly extrusion-based 3D printing, can be a powerful tool to produce safer surgical meshes, guaranteeing customisation of the final product and to allow a direct inclusion of antibacterial agents in the raw material formulation.

Methods: The purpose of the current study is to produce antibacterial loaded meshes by means of hot-melt extrusion (HME) 3D printing in order to resemble biomechanical properties of the pelvic floor and to manage infections, avoiding any future removals.
To find the most suitable mesh prototype, meshes with two different fibre patterns, made of Polycaprolactone (PCL, biodegradable) and Thermoplastic Polyurethane (TPU, non-biodegradable), were printed. Morphological and chemical characterisation were carried out using a variety of techniques (e.g. SEM, µCT, FTIR and DSC/TGA). Tensile tests were performed in order to assess the effects of the materials and of the meshes' pattern on the mechanical properties of the final product. Results were compared with data obtained from the literature to validate the findings.

Results: Two types of mesh patterns were tested, 90° and 45°. In terms of morphology, SEM and µCT analysis showed that PCL meshes had a defined and precise fibre's shape in respect to TPU. In terms of mechanical properties, results highlighted that 45° PCL meshes performed better in respect to all the others. Specifically, the values of the Young Modulus, ultimate tensile strength (UTS) and maximum strain were very close to the ones of the human vaginal tissue. Moreover, the evaluated tensile stiffness was smaller than the one of some currently used commercial meshes and very similar to the tensile stiffness of rat vagina.

Conclusions: In this study, HME 3D printing was used to produce surgical meshes for the treatment of pelvic floor dysfunctions. Among the two chosen materials and the two tested types of fibres' patterns, 45° PCL meshes, thanks to their improved mechanical properties, seem to be the most promising ones to be employed for this kind of applications.