BIO-SYNTHESISED FIBROUS-BASED MESHES FOR ABDOMINAL HERNIA WITH ENHANCED MECHANICAL AND ANTIMICROBIAL PROPERTIES

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Abstract

Abdominal hernia (AH) encompasses the most prevalent types of hernia: inguinal, umbilical and incisional. Notwithstanding current hernia complications represent a low death toll (nearly 0.001 % in developed countries), non-reducible hernias are the most severe cases, which require urgent surgical intervention due to their life-threatening nature. In a single year, at the United States of America, more than 800 thousand surgeries are performed to repair inguinal hernias. Abdominal hernia ubiquitous symptoms include pain, which may represent a mild discomfort or even an impairing morbidity. Nevertheless, some patients suffer from morbidity in the post-operative period. Recurrence was reduced when the application of a propylene mesh replaced primary suture repair more than 60 years ago. Surprisingly, currently the most prevalent hernia mesh materials are based on petrochemical plastics such as polypropylene, polyester, polystyrene and expanded

polytetrafluoroethylene. Unfortunately, despite the plethora of commercial hernia meshes, an improvement of the hernia meshes is still warranted, since petrochemical materials exhibit a deterioration over time which generate complications and recurrence. This project envisages the complete replacement of the conventional plastic-based material of hernia meshes by a fully bio-based material with superior mechanical properties: bacterial nanocellulose (BNC). BNC is synthesized by bacteria and is composed of a 3D matrix of 100 % nanofibrils of cellulose, each with a diameter ranging between 20 to 100 nm. When BNC producing bacterium are cultured in static culture, the BNC is formed as membrane (nanoporous mesh comprising pores of 100 to 300 nm in diameter) at the surface of the culture medium and adopts the shape of the available surface. Therefore, it is easy to control the membrane surface shape, as well as its thickness, which can be controlled by the incubation time (longer incubation time will result in a larger thickness). The selection of the most adequate bacterium for the production of the hernia mesh will be performed Nevertheless, for a hernia mesh to be viable it requires pores with a specific diameter to allow the permeability of leukocytes, fibroblasts, and permit the arrangement of collagen and blood vessels. Per se, the BNC mesh does not possess such large specific pores with the required diameter (> 75 μm), thus it is proposed the design and development of a template to achieve a AH mesh that meets the necessary requirements. Furthermore, due to the high complexity of hernia mesh infection, which is extremely difficult to adequately treat without removing the mesh, this project envisages the functionalization of BNC AH mesh with antimicrobial properties. Two approaches will be considered for the BNC AH mesh functionalization, namely: in situ synthesis and adsorption through filtration. NPs optimal concentration and functionalization process will be examined and tailored to obtain a BNC AH mesh with effective antimicrobial activity and negligible cytotoxicity. According the AH implantation site, three different hernia meshes classes are usually applied: low, medium and high weight, thus the optimal antimicrobial BNC meshes of each class will be patented to represent a viable commercial alternative, by displaying superior mechanical properties, biocompatibility and low infection propensity, to considerably improve AH patience overall wellbeing.

Keywords: Hernia mesh, Bacterial nanocellulose, Nanoparticles, Antimicrobial

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