STANDARDIZING SURGICAL MESHES POROSITY ASSESSMENT WITH A NOVEL IMAGE ANALYSIS PROTOCOL

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Introduction

Since the introduction of surgical meshes for the treatment of abdominal wall hernia, these devices have proved to be more reliable than direct suture repair [1,2]. Nevertheless, many questions still arise on how the properties of surgical meshes influence the outcome of the surgical procedure. Among them, morphological properties (i.e. pore size and porosity) play a crucial role in the processes of host integration and mesh encapsulation [3,4]. Several methods have attempted to calculate these parameters, however, computational techniques appear hopeful as they are non-destructive and do not deform meshes during measurements, despite computing a 2D porosity [5].

By presenting a precise and reproducible image analysis protocol, this work aims to standardize the computation of textile and effective porosity of surgical meshes.

Methods

An experimental set-up was designed to acquire images with a sufficient quality for the subsequent postprocessing step (Figure 1). A holder and a bubble level maintain the camera perpendicular to the mesh; a ring light allows constant lighting conditions; a calibration column is used to calibrate the system and a mesh support distances the mesh from the background to enhance the contrast. The last two components were 3D printed for ease of reproducibility.

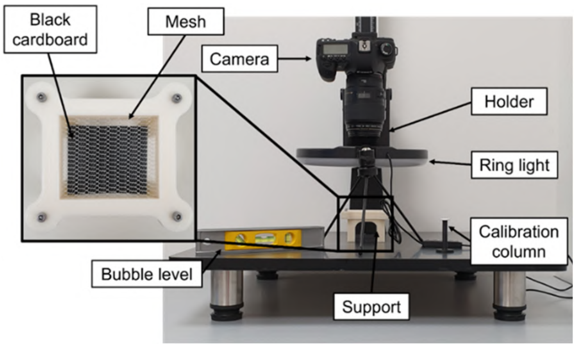
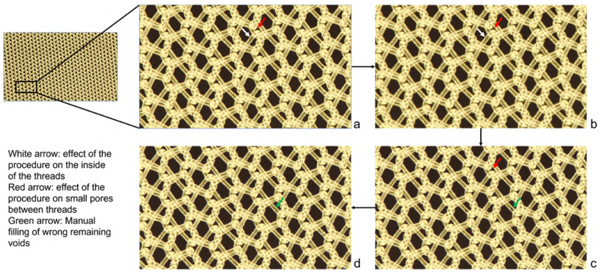


Figure 1 Experimental set-up for image acquisition.

The algorithm for subsequent postprocessing was coded on MATLAB (version R2021b) and includes four phases: (1) calibration, (2) image binarization (Figure 2a) and optimization (sequence of dilatation and erosion functions, Figures 2b and 2c), (3) manual cropping and mask correction (Figure 2d), (4) textile (ratio between the area occupied by pores and the total area of the mesh) and effective (considers only those pores with Feret diameter greater than 1 mm as effective in reducing scar formation) porosity computation. The algorithm was embedded in a free to use software (*poreScanner*) and tested on meshes from different manufacturers. The computing parameters were tuned using one heavy mesh and one light mesh, because of the different exposure conditions between the two mesh types. Seven samples were finally acquired from 22 different surgical meshes (7 heavy, 6 medium, 9 light) and the intrasubject coefficients of variation (CVs) were computed.



White arrow: effect of the procedure on the inside of the threads
Red arrow: effect of the procedure on small pores between threads
Green arrow: Manual filling of wrong remaining voids

Figure 2 Binarization of the image (a) and processes of dilatation (b), erosion (c) and manual correction (d).

Results

The intrasubject CVs computed on 22 meshes of different grammage varied between 0.23% and 6.44%, with a median of 1.16%, confirming the protocol repeatability. Additionally, a usability test was conducted on the *poreScanner* software by selecting five individuals who were instructed to read the manual and calculate the porosities of two specific images. The intersubject CV ranged from 0.52% to 1.75%.

Discussion

The lack of international standards and shared protocols among researchers presents a major challenge in studying surgical meshes. Therefore, it is crucial to establish new methodologies that are easy to replicate, enabling research groups to compare their results effectively. This work aims to meet this need by proposing a reproducible protocol for textile and effective porosity assessment, supported by a MATLAB-based software that is available for free.

References

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