ARE MECHANICAL PARAMETERS OF SURGICAL MESHES RELATED TO STRUCTURE PROPERTIES? A MULTIPLE REGRESSION ANALYSIS

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Introduction

At present, recurrences after surgical meshes implantation for hernia treatment range from 1.4% to 26.5% [1]. The main causes of failure are often related to a foreign-body reaction and mesh shrinkage due to an incorrect tissue ingrowth during the healing process. Structure (e.g., porosity, thickness, pores dimension and orientation) and mechanical (e.g., mesh elasticity, isotropy, and strength) parameters take part in mesh *in vivo* incorporation and in patient comfort after the implantation [2]. Nonetheless, the correlation between these crucial aspects has only been theoretically analyzed [3]. This study aims to investigate the impact of structural textile characteristics on the mechanical properties of different monofilament polypropylene warp-knitted meshes. In addition, textile porosity and effective porosity are compared as independent variables for the multiple regression analysis.

Methods

Three quasi-static test methods (i.e., uniaxial tensile test, ball burst test, and suture retention test) were designed in order to extract relevant parameters for the mechanical characterization of synthetic surgical meshes. Therefore, the test protocol was executed on 14 polypropylene meshes with different weights produced by different manufactures. Meanwhile, the structure parameters of textile porosity (ratio between the area occupied by pores and the total area of the mesh) and effective porosity (considers only those pores with diameter greater than 1 mm as effective in reducing scar formation) were obtained through image processing of meshes photos (MATLAB). Additionally, the thickness of each mesh was measured through a thickness gauge (547–321, Mitutoyo). Two multiple regression analyses were conducted to investigate potential correlations between the mechanical properties and two set of structural properties: set I, composed of meshes thickness and textile porosity, and set II, composed of meshes thickness and effective porosity. Variance Inflation Factors (VIF) were also inspected in order to evaluate the severity of multicollinearity in the multiple regression analysis. VIF values greater than 10 are taken as an indication that the multicollinearity should be further investigated.

Results

The goodness of fit measure for the multiple regression analyses was evaluated through the coefficient of determination, R^2 (Table 1). A strong correlation of most mechanical parameters with the considered structure properties stands out. Lower values of R^2 are obtained in deformation-related parameters in both uniaxial and ball burst tests, with very low values for dilatational strain at 16 N/cm. The VIF values, lower than 4 in both the analyses, denote a low level of multicollinearity.

Uniaxial Tensile test

	UTR weak	UTR strong	SR weak	SR strong	k weak	k strong	alfa
I	0.69	0.88	0.13	0.19	0.48	0.85	0.15
II	0.73	0.89	0.29	0.25	0.3	0.83	0.15

Ball Burst test

	BS	MT	DS	DS16
I	0.85	0.81	0.62	0.11
II	0.88	0.69	0.79	0.05

Suture Retention test

	SRS weak	SRS strong
I	0.86	0.87
II	0.78	0.89

weak: weaker direction of the mesh
strong: stronger direction of the mesh

Table 1: R^2 coefficient computed for each mechanical parameter. UTR: uniaxial tension at rupture; SR: strain at rupture; k: secant stiffness; alfa: coefficient of anisotropy; BS: bursting strength; MT: maximum membrane tension; DS: maximum dilatational strain; DS16: dilatational strain at 16 N/cm; SRS: suture retention strength.

Discussion

The correlation of textile and effective porosity with an exhaustive selection of mechanical parameters derived from surgical meshes testing has been investigated. While previous investigations on the influence of these structure parameters *in vivo* showed that only pores sizes greater than 1000 μm are appropriate for ingrowth of soft tissue in surgical meshes [3], [4], here textile and effective porosities paired with meshes thickness showed up to be related to the mechanical parameters but without substantial differences. Further investigation regarding orientation, shape of pores and loop patterns are ongoing and will enrich the here presented analyses.

References

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