In vitro and *in silico* mechanical characterization of surgical meshes and urogynecologic slings

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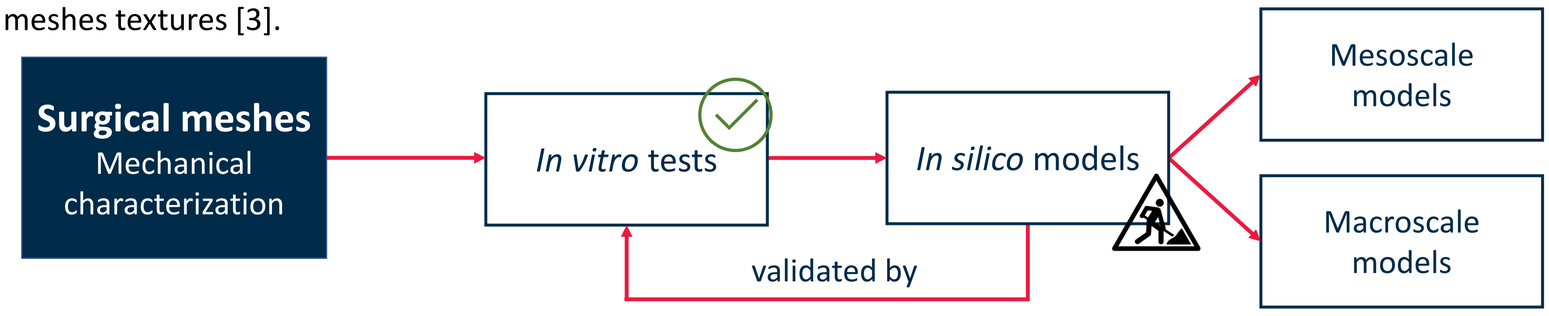
Introduction

At present, synthetic meshes are the *gold standard* for abdominal and pelvic floor repairs. The mechanical characteristics of these prostheses are often evaluated by the mean of *in vitro* tests [1]. However, the absence of specific International Standards to assess the mechanical characteristics and therefore the security of medical meshes results in a plurality of test set ups and in the lack of mechanical requirements that synthetic meshes should achieve [2]. Thus, the variability between set ups and dimensions of the specimens makes the comparison between the results burdensome.
Furthermore, the complexity of the geometry of the mesh and, consequently, of the material constitutive laws often results in macroscale *in silico* models that deeply simplify the meshes textures [3].



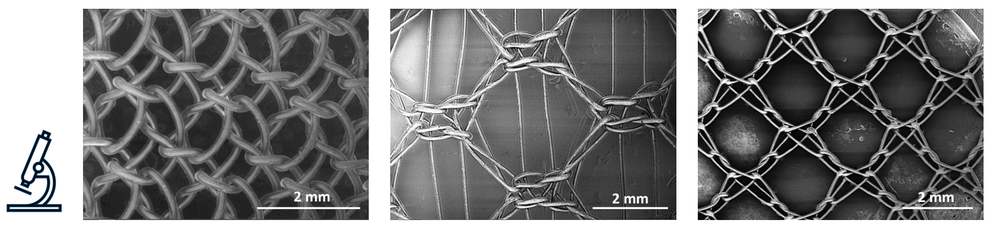
Provide a rigorous method for the complete mechanical characterization of surgical meshes by the mean of a conjunction of *in vitro* e *in silico* approaches

[1] Deeken 2011. *J. Am. Coll. Surg.* [2] Todros 2015. *J Biomed. Mater. Res.*
[3] Lubowiecka 2015. *Comput. Methods Biomech. Biomed. Engin.*

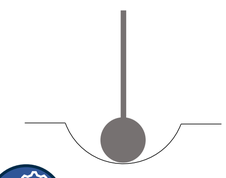
In vitro - Methods

14 polypropylene meshes with different densities
2 composite meshes
6 urogynecologic slings

For each set up an International Standard for textile fabrics is adapted in terms of specimens dimension and, consequently, strain rate.



a. Ball burst

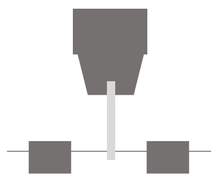


ASTM D6797-15
Specimen clamped diameter: 35 mm
Steel sphere diameter: 20 mm

b. Uniaxial tensile test

ISO 13934-1:2013
Specimen type: Dog Bone
Gauge length: 20 mm

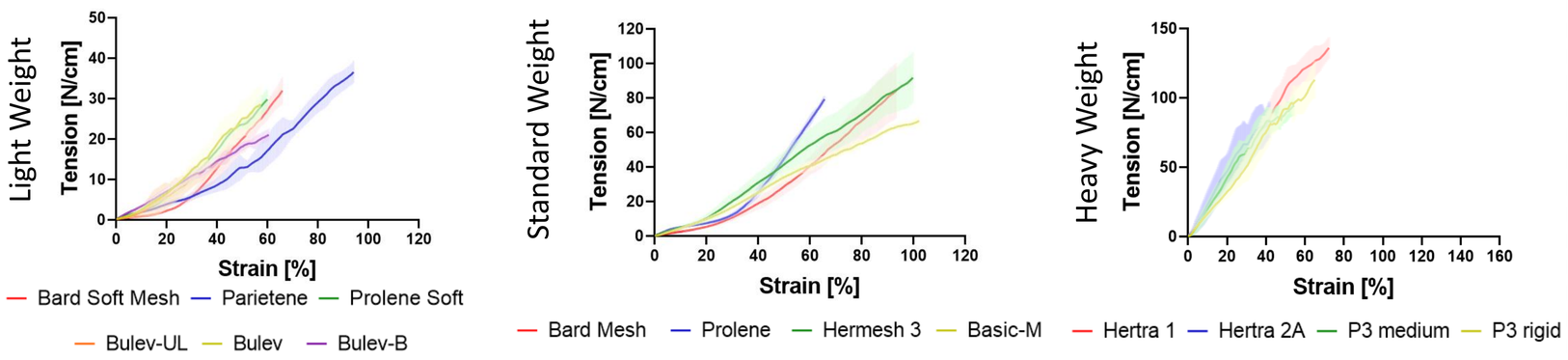
c. Suture retention test



ASTM D2261-13
Used for Suture retention strength computation

In vitro - Main Results

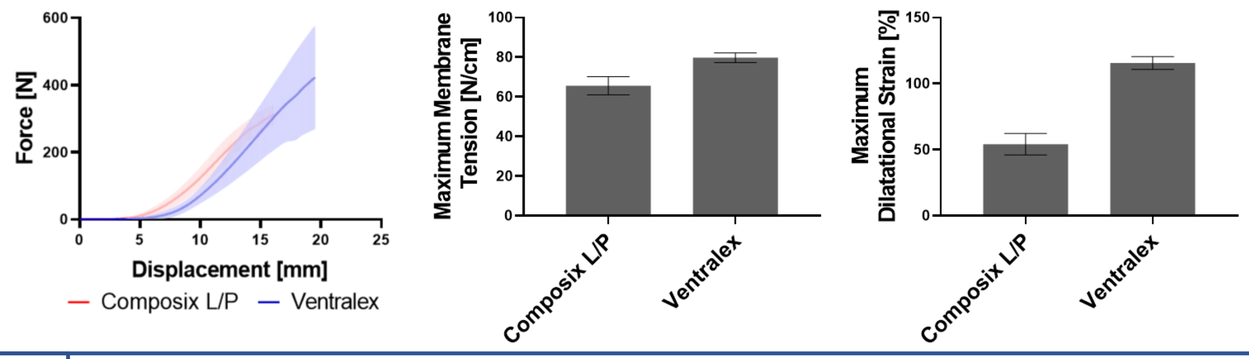
Uniaxial – Strong direction



- Dissimilar results for the different densities both in terms of peak tension and peak strain
- Medical meshes with same weight show similar trends
- Urogynecologic slings can be divided in three trends that mainly differ in terms of stiffness

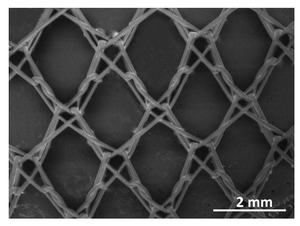
Ball Burst

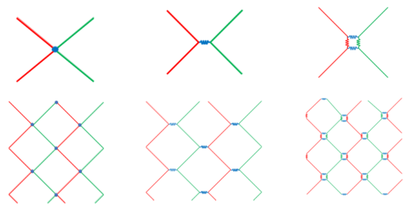
- Composite meshes exhibit similar trends but dissimilar bursting forces
- Different values are displayed in maximum membrane tension and of greater entity in the dilatational strain



In silico – Mesoscale model

Geometric reconstruction of a unit cell



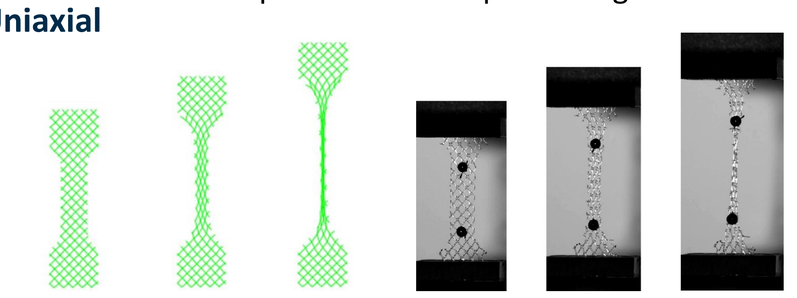


Mesh discretization → **B31**

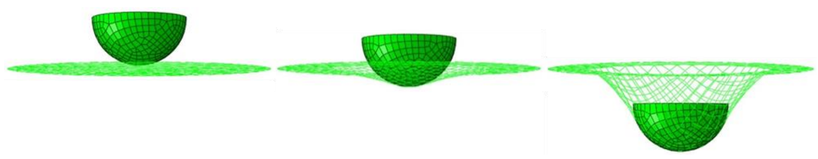
Node interaction approximation → **SpringA**

Definition of simulation parameters and processing

Uniaxial



Ball Burst



Hard Skills

Course Name [Validated hours]

Applicazioni di Sistemi Multibody [26]
To offer the basic knowledge in the fields of Multibody codes for the kinematic and dynamic study of mechanical systems

Principi di meccanica sperimentale in campo statico [16]
To provide the required knowledge to select and to use knowingly the measuring techniques of the main quantities (force, displacement, stress, strain, temperature) used in mechanical and aerospace research

Principi, materiali ed applicazioni della robotica nella biomedicina [20]
To offer to the student the basic knowledge in the fields of principles, materials and applications of robotics to surgical disciplines

Rhino3D: Beginner Level to Advanced Level [30]
To learn the fundamentals and become proficient in 3D surfacing, prototyping and rendering with Rhino 3D

Soft Skills

Course Name [Validated hours]

The Hitchhiker's Guide to the Academic Galaxy [20]
Didattica, tecnologie e ricerca educativa [30]
Public speaking [5]
Antropologia dei contesti scolastici ed educativi [30]
Pedagogia della scuola e dell'inclusione [30]

Tutors: Prof. Alberto Audenino
Dr. Mara Terzini

PhD Day 2022
25th October 2022, Dental School, Torino