Mechanical characterization of pancreatic suture threads and pancreatic tissue

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***Abstract*—Though pancreatic cancer is the fourth cause of death from cancer worldwide, there is a lack of knowledge about the mechanical properties of pancreatic tissue. Moreover, there are no surgical tools specifically developed for the pancreatic surgery but are adapted from other kind of cardiothoracic surgery. In this work, not only the mechanical properties of the physiological pancreatic tissue but also the strength of suture threads were investigated in order to find the best suture wire to use during pancreatic surgery.**

***Keywords*—pancreatic surgery, soft tissue, mechanical characterization, suture threads.**

I. Introduction

Pancreatic cancer is the fourth cause of death from cancer worldwide and surgical resection, when feasible, is the only curative treatment [1]. Pancreatic fistula, that consists of the leakage of pancreatic juice into the abdomen, is a treacherous postoperative complication with a rate of 10-20%. It is strongly related to pancreatic parenchyma consistency and structure, and it is one of the most feared complications [2]. A solution to the leakage of fluids can be handled by the development of new materials, techniques, and devices for this type of surgery, designed specifically for the pancreatic environment. For that reason it is fundamental to investigate the human pancreatic parenchyma characteristics and the evaluation of the mechanical properties of the main suture threads used during the pancreaticduodenectomy.

II. Methods

A. Suture threads

For this study four different suture materials have been tested: Prolene® 4-0 (polypropylene - Ethicon), Monocryl® 4-0 (poliglecaprone 25- Ethicon), Vicryl® 4-0 (polyglactin 910 - Ethicon), and PDSII® 5-0 (polydioxanone – Ethicon). Tensile axial tests were carried out until the rupture of the samples using the MTS Synergie 200H single-axial actuation machine (MTS System Corporation, MN, USA). Six threads of each suture material were tested in addition to the baseline, in the following fluids: saline solution, bile and pancreatic juice, at several immersion time 1, 3 and 7 days. Each sample was stored in a temperature-controlled environment at 37 °C.

B. Human pancreatic characterization

All the samples tested in this work come from human pancreas collected by the surgeons during the pancreatic resection. The sample were properly cut to obtain rectangular specimen and were tested using the UNHT^3 Bioindenter (Anton Paar, Graz, AU). To obtain a flat surface, samples were dip in 4% agarose. The micro indentation curve was obtained, and the elastic modulus (E_{Hz}) was calculated fitting the experimental curve with the Hertz model (Figure 1).

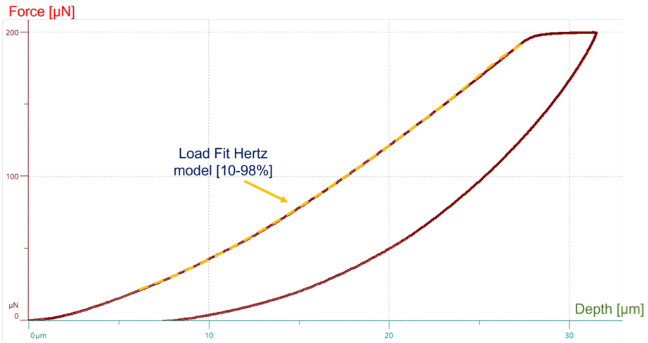

Figure 1: Characteristic test curve of a human pancreas sample in agarose.

III. Results

Maximum stress and elastic modulus at small deformation (ε=0-0.03) were obtained for all the suture threads in all the conditions. All the 4-0 threads show a reduction of the maximum stress moving from the saline solution to pancreatic juice and bile. In particular, the bile seems to be the most critical fluid for the preservation of the mechanical properties of the threads. On the other side, PDSII® 5-0 shows good stability to degradation not only in the several fluids but also at the different immersion time (E=20.6 ± 1.7 MPa), without statistically significant differences.

According to preliminary results, fresh pancreatic tissue shows small elastic modulus E_{Hz} = 37.6 ± 6.8 kPa.

IV. Discussion

Pancreas is a viscoelastic soft tissue that is complex to analysed based on the fibrous capsule surrounding it. These tests show huge difference in the mechanical proprieties of the pancreatic tissue compared the thread normally used during the surgery, even if the Monocryl® 4-0 resulted the thread with the lowest elastic modulus (E=5.85 ± 0.52 MPa) thus being close to the elastic modulus values of the pancreas. Moreover, all the threads used in the pancreatic surgery show a degradation of their mechanical properties even after only one day of immersion in biological fluids.

References

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