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MELT ELECTROWRITEN PCL COG THREADS PRODUCTION AND MECHANICAL CHARACTERISATION FOR PROLAPSE REPAIR: PRELIMINARY STUDY

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1 INTRODUCTION

Pelvic organ prolapse (POP) occurs when the pelvic organs descend due to weakening pelvic floor support structures. This condition affects millions of women worldwide, and the number of cases has been increasing over the years [1].

In severe cases, surgery is often needed, using either native tissue or mesh implants to strengthen or replace weakened tissue. However, surgeries have had high failure rates, and due to the risks of mesh implants, the FDA (Food and Drug Administration) has banned their use for treating transvaginal prolapse [1]. Given the limited effective treatments for POP, technologies from cosmetic procedures, such as cog threads used in facelifts, have been explored. In facial procedures, tissue relaxation leads to the loss of support, which has led to the development of various lifting techniques. Thread lifting, a minimally invasive technique with quick recovery and positive outcomes, has shown potential in other medical fields [2]. These threads can be made from bio-absorbable polymers, such as polycaprolactone (PCL). Typically, PCL cog threads have a diameter of 630 μm, a cutting angle of 135º, a cut depth of 200 μm, and a cog spacing of 1600 μm. A recent study using PCL cog threads for POP treatment showed promising results, improving vaginal wall strength under pressure without compromising compliance[2].

This study aims to develop cog threads with varying geometries and cutting angles using 3D printing techniques like Melt Electrospinning Writing (MEW) for vaginal wall reinforcement and defect correction.

2 METHODS

During the initial phase of the work, the goal was to develop cog threads with varying cut angles, taking inspiration from those commercially available. Then, uniaxial tests were conducted on the developed cog threads to compare the resulting stress-strain values, and thus, better understand how the cut angle influences the results. Following this, the focus will shift to creating new cog threads with varying diameters and geometries. Key factors in the development process include the cuts' number, position, and depth.

To support this process, the printing parameters of the MEW device were optimised to produce fibres with 200 mm length, and approximately 600 μm diameter. Subsequently, a support and rotation tool was designed through SolidWorks® software to hold the printed fibres and enable the cutting of the cog features (Figure 1a). Two cutting tools were developed, one with a 135º cutting angle and the other with a 150º angle (Figure 1b). To perform the cog thread indentations, the tools were adapted to the Multitest 2.5-dV machine (Figure 1c), applying load to the fibre.

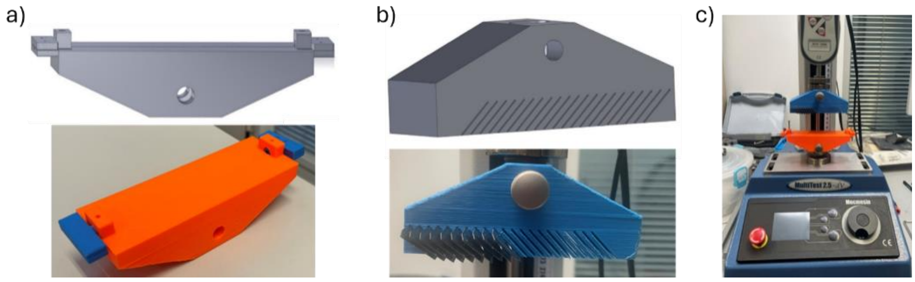

Figure 1 - a) Tool of fixation and rotation of the PCL fibres. b) Cutting tool. c) Multitest 2.5-dV machine equipped with the fixation, rotation, and cutting tools.

3 RESULTS AND DISCUSSION

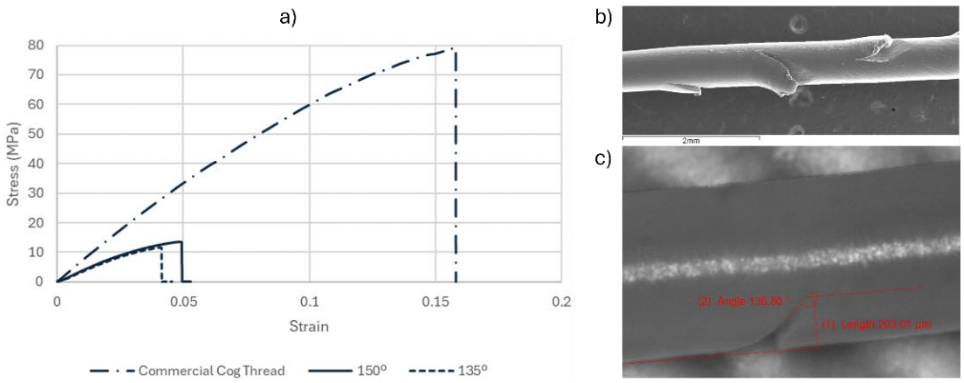

Figure 2 – a) Stress-strain values obtained from uniaxial tensile tests on both commercial and printed cog threads. b) SEM image of the commercial cog thread. c) Microscope image of the printed cog thread.

Based on the stress-strain values obtained from the uniaxial tensile test performed on both the printed and commercial cog threads, as shown in Figure 2, it can be concluded that the commercial cog thread exhibits a more rigid behaviour, capable of withstanding higher stress levels. However, this rigidity may not be ideal for application in vaginal tissue, as it increases the risk of causing tissue damage. The printed cog threads, with their less rigid behaviour more closely resembling that of vaginal tissue, could provide a better fit for reinforcing the vaginal wall.

Additionally, when comparing the two printed cog threads, the one with a 150º dentation angle shows higher stress-strain values, suggesting that the angle of dentation influences the mechanical properties. By optimising certain parameters, such as cog angle and thread diameter, cog threads could be tailored for various applications.

Cog threads promote collagen production, aiding tissue repair and early prolapse treatment while preserving future vaginal delivery. Their barbs anchor securely, reducing material use and inflammation. The procedure is customizable by adjusting thread number, material, and type.

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