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3D bioprinted scaffold for dermal tissue mimicry for burn treatment: physicochemical and biological characterization

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INTRODUCTION & AIM

Burns represent a major public health problem due to their high morbidity and mortality rates. Conventional treatments, such as autologous grafts, are limited by donor tissue availability and challenges in dermal tissue regeneration. Three-dimensional bioprinting has emerged as a promising strategy for fabricating customized scaffolds that mimic skin structure and function. This work proposes the development of a 3D bioprinted scaffold based on synthetic polymers and collagen-rich bioinks, incorporating growth factors and epithelial cells to promote cell adhesion, proliferation, and viability, aiming to enhance dermal regeneration in burn patients.

METHOD

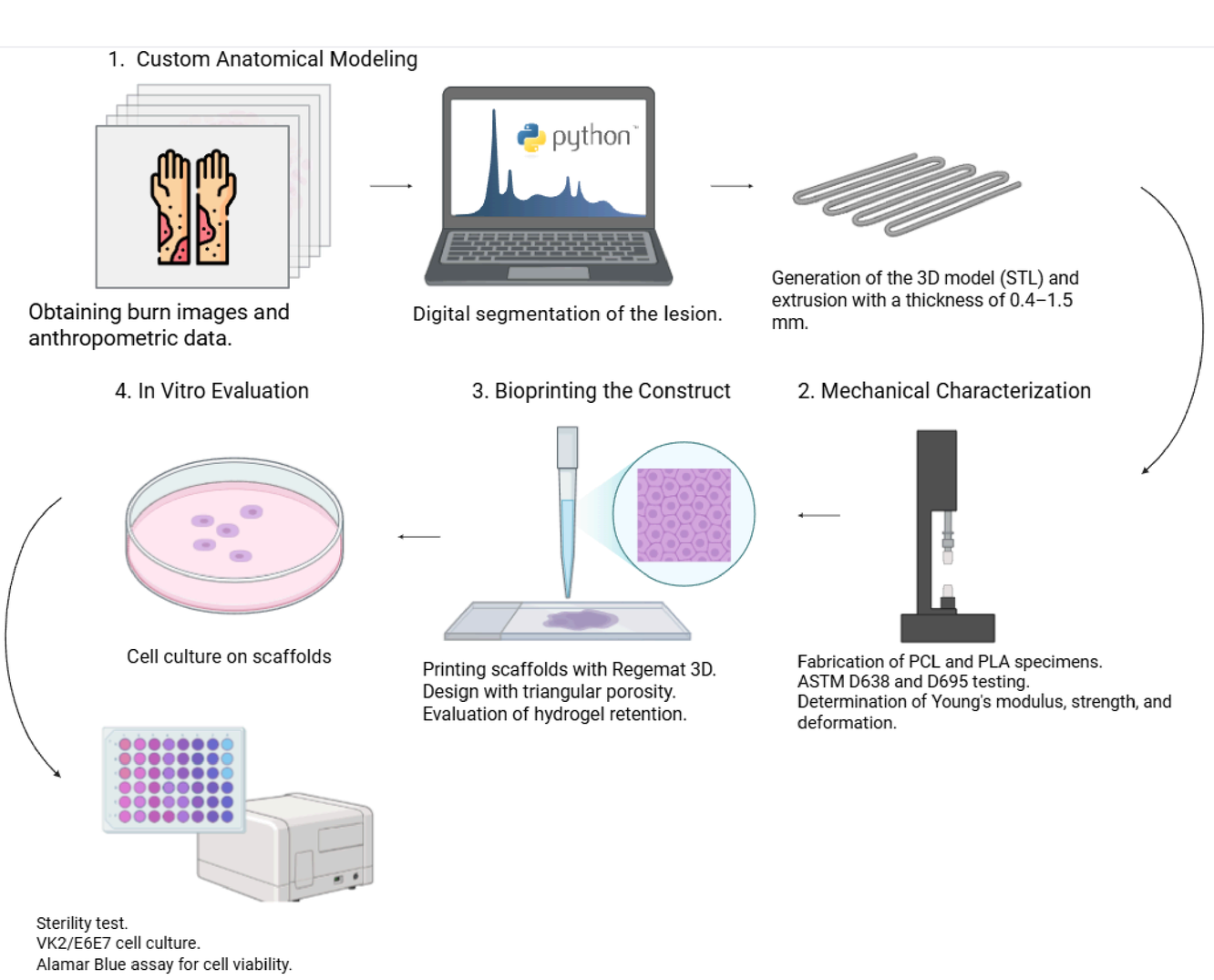

Figure 5. Anatomical modeling of burns was performed using digital segmentation and the generation of customized 3D models. PCL scaffolds with 1 mm pores were fabricated by 3D bioprinting and incorporated with type I collagen-based bioinks. Finally, their mechanical and rheological properties were characterized, and their biocompatibility was evaluated using cell cultures and in vitro viability assays.

RESULTS & DISCUSSION

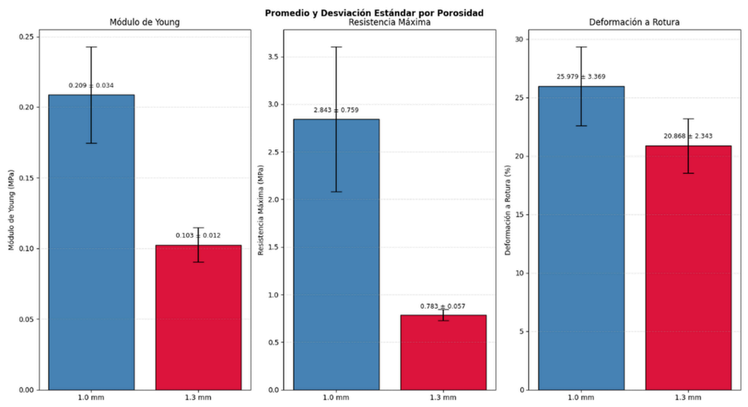

Figure 1. Average and standard deviation of Young's modulus, ultimate tensile strength, and elongation at break in PCL tensile tests according to pore size. Blue: 1.0 mm pore size. Red: 1.3 mm pore size. The 1.0 mm pore size exhibited an ultimate tensile strength of 2.84 ± 0.76 MPa, a Young's modulus of 0.209 ± 0.034 MPa, and an elongation at break of 25.98 ± 3.37%, demonstrating a balanced combination of strength and ductility.

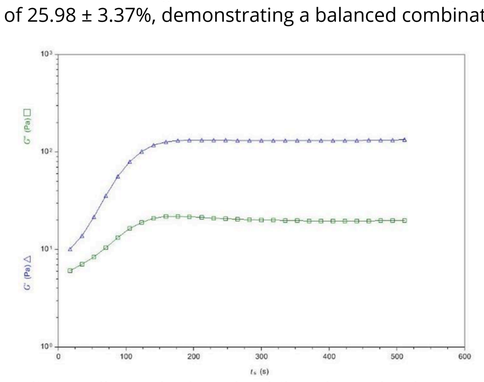

Figure 2. The bovine pericardium collagen hydrogel exhibited rapid gelation, reaching the gel point at 17.7 s and stabilizing at G' ≈ 132 Pa and G'' ≈ 19.7 Pa. The linear viscoelastic region remained stable up to 10% strain, with a yield stress of 42.5 Pa. Furthermore, the material showed predominantly elastic behavior across the evaluated frequency range (0.1–100 rad/s). Its pronounced shear-thinning behavior (n = −0.74) facilitates extrusion while preserving scaffold architecture during bioprinting.

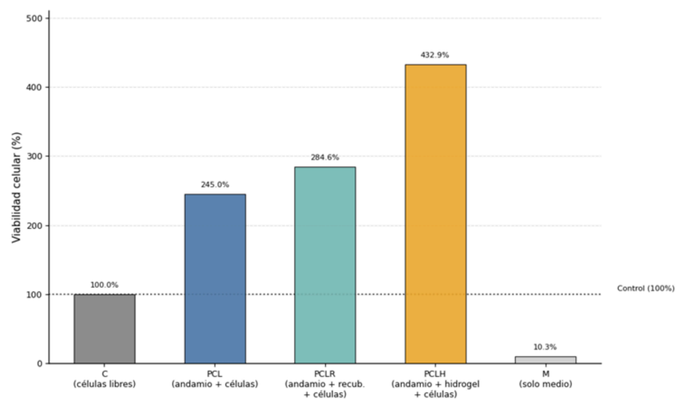

Figure 3. Relative cell viability determined using Alamar Blue. The PCL + collagen hydrogel system (PCLH) showed the highest metabolic activity (432.9%), surpassing PCL alone (245.0%) and coated PCL (284.6%), suggesting that the collagen hydrogel promotes cell adhesion and proliferation.

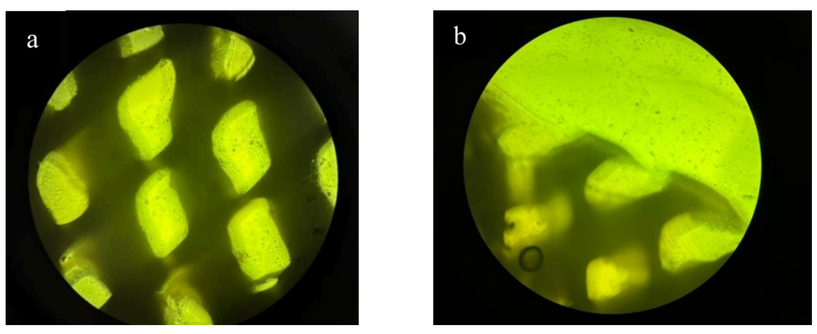

Figure 4. (a) Control group observed under an inverted microscope with a 5x objective, showing the hydrogel inside the construct's pores; (b) Problem group observed under an inverted microscope with a 5x objective, showing the coexistence of the hydrogel with the scaffold's outer perimeter. 57

CONCLUSIONS

A personalized dermal construct was developed and characterized using 3D bioprinting, demonstrating adequate dimensional fidelity, reproducibility, and fluid retention capacity. The combination of a 1 mm pore-sized PCL scaffold and a type I collagen hydrogel exhibited favorable mechanical and rheological properties for skin regeneration applications. Furthermore, *in vitro* evaluation revealed the absence of cytotoxicity and high cell viability, positioning this system as a promising platform for future studies in tissue engineering and personalized dermal regeneration.

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