

Bio-Mechano-Compatible Electrospun Scaffold as External Support to Prevent Autograft Dilatation in the Ross Procedure

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Introduction

The Ross procedure is a surgical intervention that replaces a diseased aortic valve with the patient's own pulmonary valve [1]. Despite its advantages, associated with the adaptative growth and biocompatibility, the dilatation of the autograft due to high systemic pressure remains a concern [1]. This study aims at producing a scaffold to prevent autograft dilatation combining mechanical resilience and controlled biodegradability with bioactive cues to improve biocompatibility, avoiding the low-porosity and stiffness of the current solutions.

Materials and Methods

Tubular scaffolds of 2.5 mm inner diameter were electrospun using PCL ($M_n \approx 81.6$ kg/mol), bovine elastin, and porcine aortic decellularized extracellular matrix (dECM) (19:0.5:0.5 w/v% ratio) (Fig. 1A). The results were compared to PCL and PCL:Elastin without dECM. Characterization included scanning electron microscopy (SEM) morphology, tensile testing, swelling, and accelerated hydrolytic degradation (0.2M NaOH). Cytocompatibility was assessed via conditioned medium and direct human dermal fibroblast (hDF) seeding on the tube lumen. Metabolic activity and DNA were quantified, while cellular morphology and attachment were visualized using SEM and 4',6-diamidino-2-phenylindole (DAPI) staining.

Results

The incorporation of elastin and dECM into the scaffold provided consistent fibers ($1 - 2 \mu m$) (Fig. 1B) leading to a reduction in the stiffness, as compared to pure PCL. Under physiological pressures, The tri-blend scaffold withstood failure, exhibiting supraphysiological burst pressures (Fig. 1C). Physicochemical analysis showed minimal swelling after 24h ($3 \pm 3\%$) and controlled weight loss, demonstrating superior structural stability compared to the faster degradation of PCL and PCL:elastin (Fig. 1D). *In vitro*, live/dead staining showed no harmful byproducts released by the tri-blend scaffolds, with hDFs maintaining a healthy phenotype (Fig. 1E), confirmed by cytocompatibility levels over 95% after 72h (Fig. 1F). Direct contact studies demonstrated successful scaffold colonization, with the tri-blend supporting robust hDF adhesion, viability, and proliferation over 14 days (Fig. 1G).

Conclusion

PCL:Elastin:dECM electrospun scaffolds balanced mechanical reinforcement with biological functionality, avoiding the excessive rigidity of pure synthetic polymers. The blend promoted robust hDF adhesion and proliferation on the tube lumen. Since fibroblasts dominate the aortic adventitial layer, the interface for external supports, this bioactive scaffold offers a promising strategy for reinforcing pulmonary autografts in the Ross procedure.

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References

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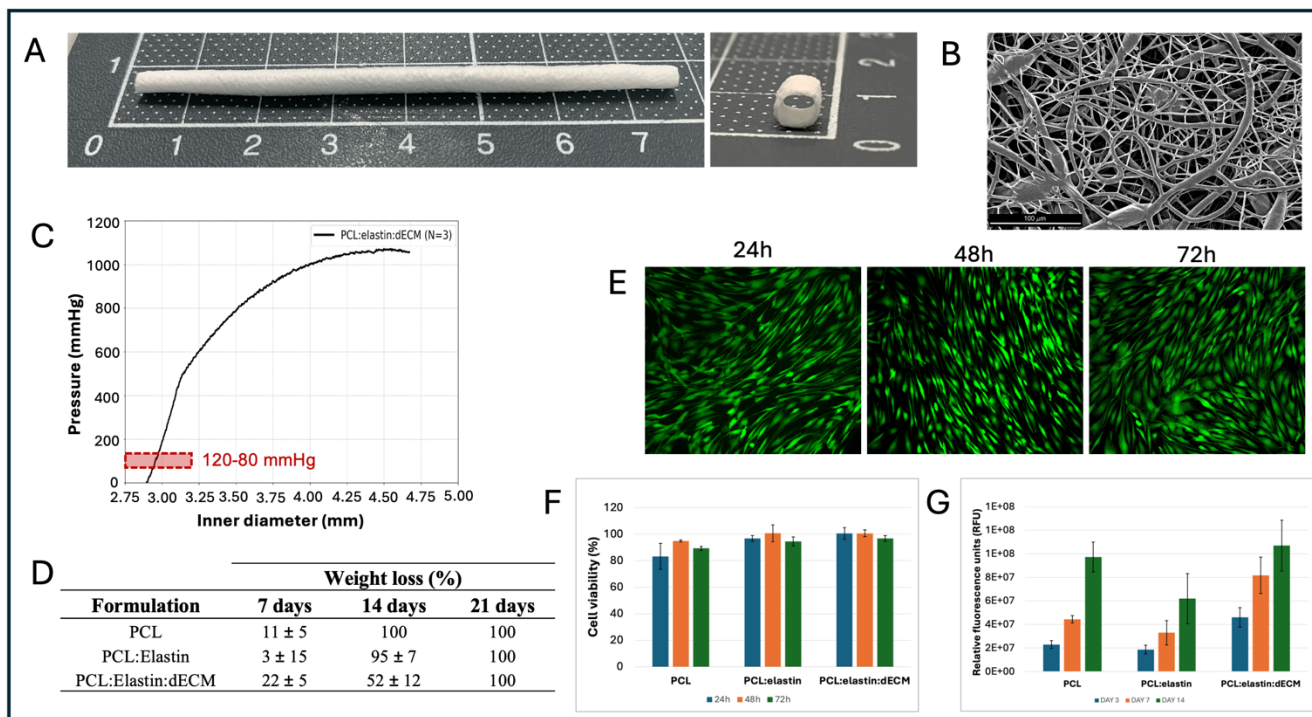


Figure 1 – A. Electrospun tubular structure; B. SEM micrograph of the inner surface of the PCL:Elastin:dECM scaffold; C. Pressure-diameter curve of the PCL:Elastin:dECM scaffold; D. Weight loss percentage of PCL, PCL:Elastin and PCL:Elastin:dECM scaffolds during accelerated hydrolytic degradation. E. Live/Dead fluorescence microscopy of hDFs after 72h exposure to PCL:Elastin:dECM scaffold leachates; F. Cell viability of hDFs after 72h exposure to different scaffold leachates; G. Metabolic activity of hDFs seeded in the different scaffolds after 14 days of culture.