11º CONGRESSO NACIONAL DE BIOMECÂNICA
A. P. G. Castro, C. Pina, P. R. Fernandes, C. Santos, J. Folgado & A. Amaro (Eds)
Sesimbra, Portugal, 21-22 de Fevereiro, 2025

DEVELOPMENT OF A VETERINARY IMPLANT MADE OF LYOPHILIZED BOVINE BONE POWDER AND PLA

Ana Sofía Macías Yi [1], Fabio Arturo Rojas Mora[1]

[1] Universidad de los Andes, Departamento de Ingeniería Mecánica - Colombia

a.maciasy@uniandes.edu.co; farojas@uniandes.edu.co

KEY WORDS: Biomaterials, Veterinary Orthopedics, Xenograft, Injection moulding

1 INTRODUCTION

In vertebrates, bone structures support, anchor, and protect organs and muscles. When injury or wear occurs, a natural regeneration process begins. Advances in medicine facilitate healing through therapeutic and surgical interventions. Fixation devices such as screws, plates, rods, and external fixators stabilize bones during surgery to ensure proper healing [1]. When additional bone tissue is needed, grafts—autografts, allografts, alloplastics, or xenografts—replace lost bone in critical defects or other clinical situations [2]. This project proposes an internal fixation device made from a composite of bovine bone and PLA, inspired by alloplastic grafts and xenografts. Designed to be absorbable by the body, it encourages new bone growth as an alternative to metal fixators. Developed under the LATEMM-GEAA project at the Department of Mechanical Engineering, Universidad de los Andes, this research builds on prior studies [3] [4]. It aims to create an absorbable implant using PLA and bone via injection molding for veterinary applications, with potential future entry into the human medical market.

2 GENERAL

The project is divided into two parts: the design of the manufacturing process and the material's design and biological characterization. The final product was achieved through the following steps. First, raw materials were pre-mixed in a double-screw extruder to prevent clumping during injection. A mix of 80% Inzea F29 HT10 PLA pellets and 20% freeze-dried medical-grade bovine bone was used. This premixed material was turned into pellets, dried, and injected into a rectangular mold, serving as a base shape for machining implants on a CNC lathe. Fine-tip lathe tools, saline lubrication, and slow machining ensured final implants without breakage or significant loss of accuracy. The resulting product met geometric and biological requirements and was ready for sterilization and testing.

Figure 1 shows the surface finish and geometric tolerances achieved during manufacturing via SEM imaging. The relatively rough surface finish is beneficial, offering more contact area with the patient's body, promoting absorption and osteogenesis by increasing the number of cells coming into direct contact and interacting with the implant. Geometrically, the design complied with proposed dimensions except at the nail tip, which deviated by over 200 µm from the plan. This deviation is unlikely to affect implant function, as nails primarily need sharp tips to penetrate, and surgical practice typically involves pre-drilling the bone.

The biocompatibility results are the most promising findings of this research. Table 1 shows cytotoxicity results for the pure material, its diluted infusions, and positive and negative controls, along with subsequent cell viability percentages. The test used L929 cells, comparing absorbance of each solution to controls per ISO 10993-5:2009 to assess viability. A successful cytotoxicity test requires a cell survival rate of at least 70%; lower rates suggest the material can damage or kill patients' cells, inhibiting healing. In Table 1, the lowest survival percentage is 92%, and the highest is 103%. Given the low standard deviation, the material is non-cytotoxic and may positively affect cell generation. This suggests the bone in the material influences cell growth and potentially osteogenesis. These results show promise for developing veterinary implants, with room for further in-vitro and clinical testing. A successful absorbable orthopedic fixation device could promote healing, reduce implant rejection risk, and be easy to mass manufacture, representing a breakthrough in biomechanics and orthopedic surgery.

3 FIGURES AND TABLES

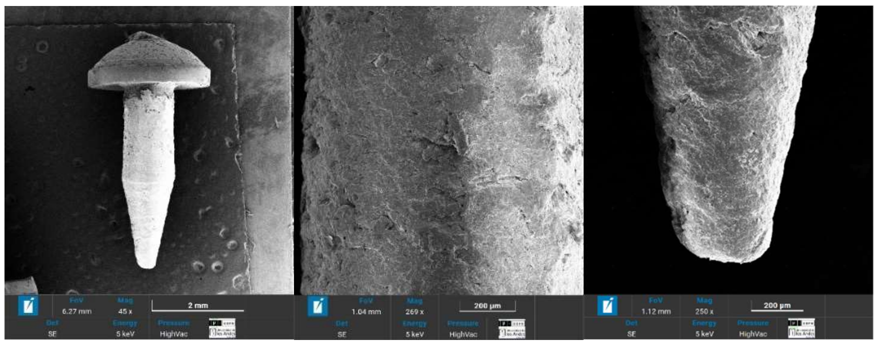

Figure 1 – General view, surface finish and detail of nail tip

Table 1 – Cytotoxicity test results

	Control +	Pure	1:2	1:4	1:8	1:16	1:32	Control -
	0,081	1,626	1,633	1,762	1,696	1,764	1,688	1,717
	0,085	1,59	1,58	1,795	1,677	1,785	1,73	1,742
	0,087	1,662	1,593	1,789	1,793	1,762	1,752	1,743
Average	0,084	1,626	1,602	1,782	1,722	1,770	1,723	1,734
Standard Deviation	0,0031	0,0360	0,0276	0,0176	0,0622	0,0127	0,0325	0,0147
Cell Viability %		**93%**	**92%**	**103%**	**99%**	**102%**	**99%**	

ACKNOWLEDGEMENTS

The author extends their gratitude to the Department of Mechanical Engineering and the Biomaterials Research Group for their support and collaboration throughout this research.

REFERENCES

[1] S. Olate, "Recuperación Ósea en Procedimientos de Reconstrucción y Colocación de Implantes," *Int. J. Morphol.,* vol. 25, no. 3, pp. 649-657, Septiembre 2007.

[2] N. Ebraheim, "Chapter 43: Orthopedic Surgery," in *Schwartz's Principles of Surgery*, 11 ed., McGraw-Hill, 2019.

[3] A. F. Tinjacá Amaya, A. Robayo Rodríguez and F. A. Rojas, "Printing and Characterization of Dental or Skeletal Implants Made of Powdered Cortical Lyophilized Bone Grafts," in *7º CONGRESSO NACIONAL DE BIOMECÂNICA*, Guimaraes, Portugal, 2017.

[4] F. A. Rojas M. and J. A. Moreno R., "Manufacturing and characterization of a veterinary bone implant by additive manufacturing of a bone compund and biopolymer," in *17th LACCEI International Multi-Conference for Engineering, Education, and Technology: "Industry, Innovation, And Infrastructure for Sustainable Cities and Communities"*, Jamaica, 2019.