ABSTRACT

Background: Periodontitis, a highly prevalent chronic inflammatory disease, is characterized by progressive destruction of periodontal tissues. Guided Bone Regeneration (GBR) is a proven surgical technique that employs barrier membranes to facilitate bone regeneration by preventing soft tissue infiltration. However, existing membranes have significant limitations: non-resorbable membranes require a second surgery, while resorbable ones often degrade inconsistently. To address these issues, this study proposes a novel GBR membrane based on three-dimensional (3D) printed poly-L-lactic acid (PLLA), coated with polyvinyl alcohol (PVA) and silver-doped carbonated hydroxyapatite (Ag-CHA), offering antibacterial activity, biocompatibility, and controlled degradation**. Aim:** To develop and evaluate a resorbable GBR membrane incorporating 3DP PLLA, PVA, and Ag-CHA, with antibacterial and osteoconductive properties. **Methods:** This research comprised: (1) fabrication of PLLA mesh; (2) Ag-CHA synthesis; (3) PVA/Ag-CHA coating process; and (4) in vitro assessments and preliminary study of organ-on-a-chip (OOAC) prototype. Assessment included physicochemical, mechanical, biodegradability and bioactivity tests. Antibacterial testing targeted five periodontal pathogens, while biocompatibility was evaluated using MC3T3-E1 cells. A preliminary characterization of OOAC protoype was performed. **Results:** The concentration of Ag-CHA significantly influenced the membrane's overall performance. Among the tested formulations, the 3DP PLLA/PVA/Ag-CHA2 membrane demonstrated an effective balance between antibacterial efficacy against key periodontal pathogens and in vitro biocompatibility with MC3T3-E1 pre-osteoblast cells. **Conclusion:** Leveraging a hybrid fabrication strategy, the developed membrane demonstrates substantial potential as a next-generation GBR material, attributable to its combined antibacterial efficacy and in vitro biocompatibility. Furthermore, the OOAC prototype developed herein presents a promising platform for advanced dynamic bioactivity evaluations.

Keywords: Periodontitis; bone tissue engineering; carbonated hydroxyapatite; three-dimensional printing; organ-on-a-chip