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Abstract

Composite poly(L-lactic acid) - ceramic structures for fully degradable cranial implants

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To surgically repair a bone defect in the skull, a cranioplasty might be necessary. This procedure currently carries a high complication rate (7-20% [1][2]). This rate is reduced to 2% [3] when using cranial implants composed of a titanium mesh and specific calcium phosphate ceramic tiles. However, unlike the ceramic, which allows for partial replacement of the implant by the patient's own bone [3], titanium is non-resorbable, interferes with follow-up imaging techniques, is a potential site for bacterial attachment, and its use in young, growing patients presupposes revision surgeries. Poly(L-lactic acid) (PLLA) is biocompatible, 3D-printable, and was evaluated as a potential resorbable material to replace the Ti structure. In this study, ceramic and PLLA composite structures were tested as a starting point for developing the best possible material for a suitable and non-harmful degradation process [4].

Samples were designed as a beam of PLLA manufactured by fused deposition modeling (FDM) on a Prusa i3 MK3S+ (Prusa Research a.s., Prague, Czech Republic), embedded in a self-setting ceramic made of β-tricalcium phosphate (Sigma-Aldrich, Missouri, USA), monocalcium phosphate monohydrate (Scharlau, Scharlab S.L., Sentmenat, Spain), and 0.5M citric acid solution. Scanning electron micrographs of cross-sections (InLens detector, 3kV accelerating voltage, Zeiss 1550 SEM, Carl Zeiss AG, Oberkochen, Germany) showed that the recesses in the polymer beam were well filled with ceramic. Retention of ceramic particles on the PLLA wall after peeling indicated that the two materials were well integrated. Mechanical tests were conducted by 4-point bending (ISO 5833, Shimadzu AGS-X, Shimadzu, Kyoto, Japan). The average bending modulus obtained was 2274±316MPa. The ceramic-only controls failed catastrophically at 115±10N, while the PLLA-ceramic composite structures remained structurally intact after an initial crack at 139±23N, and withstood the load until a final failure at 249±42N.

The results indicated signs of adhesion between the two materials as well as some structural support provided by the PLLA structure to the molded ceramic. Further studies will be carried out on the behaviour of the material when immersed in degradation media.

AUTHOR'S STATEMENT

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