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Influence of 3D Printing Parameters on Surface Finish of Ceramic Hip Prostheses Fixed by Means of Osteointegration

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Abstract : In recent years, use of ceramic prostheses as an implant in some parts of body has become common. In the present study, research has focused on replacement of the acetabulum bone, which is a part of the pelvis bone. Metallic prostheses have shown some problems such as release of metal ions into patient's blood. In addition, fracture of liners and squeezing between surface of femoral head and inner surface of acetabulum have been reported. Ceramic prostheses have the advantage of low debris and high strength, although they are more difficult to be manufactured than metallic ones. Specifically, new designs try to attempt an acetabulum in which the outer surface will be porous for proliferation of cells and fixation of the prostheses by means of osteointegration, while inner surface must be smooth enough to assure that the movement between femoral head and inner surface will be carried out with on feasibility. In the present study, 3D printing technologies are used for manufacturing ceramic prostheses. In Fused Deposition Modelling (FDM) process, 3D printed plastic prostheses are obtained by means of melting of a plastic filament and subsequent deposition on a glass surface. A similar process is applied to ceramics in which ceramic powders need to be mixed with a liquid polymer before depositing them. After 3D printing, parts are subjected to a sintering process in an oven so that they can achieve final strength. In the present paper, influence of printing parameters on surface roughness 3D printed ceramic parts are presented. Three parameter full factorial design of experiments was used. Selected variables were layer height, infill and nozzle diameter. Responses were average roughness Ra and mean roughness depth Rz. Regression analysis was applied to responses in order to obtain mathematical models for responses. Results showed that surface roughness depends mainly on layer height and nozzle diameter employed, while infill was found not to be significant. In order to get low surface roughness, low layer height and low infill should be selected. As a conclusion, layer height and infill are important parameters for obtaining good surface finish in ceramic 3D printed prostheses. However, use of too low infill could lead to prostheses with low mechanical strength. Such prostheses could not be able to bear the static and dynamic charges to which they are subjected once they are implanted in the body. This issue will be addressed in further research.

Keywords : ceramic, hip prostheses, surface roughness, 3D printing
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