Dosimetric characterization of 3D printed phantoms at different infill percentage for diagnostic x-ray energy range

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Introduction

The use of 3D printing and filaments commonly found commercially for development of phantoms has been investigated in recent years due to the cost of materials and improvements in the quality of printers. The application of this technique for radiation protection and dosimetry requires a complex study of the quality control and the interaction of printed materials with different radiation beams. The aim of this paper is to characterize 3D printed phantoms and printing set-ups for different infill percentages for diagnostic energy beams.

Methods

3D printing performance was studied using the RAISE 3D PRO2 printer from IPEN for printing with PLA (Polylactic Acid) and ABS (Acrylonitrile Butadiene Styrene) filaments. Printing characteristics such as repeatability, reproducibility, effective density by displaced water mass and porosity at 100% infill were studied. Plate samples of 8x8x1cm^3 were printed and, using the Pantak Seifert irradiator with different x-ray qualities in the diagnostic energy range, the attenuation coefficients were obtained experimentally for different percentages of plates infill.

Results

By printing three identical samples for each print mode, the 3D printing system had a repeatability better than 1.0% for masses and average of 0.7% for the dimensions of the printed objects, obtaining the highest variations in small printed parts. Little to no porosity has been found on the printed pieces with 100% infill, giving to the printed objects the same density of the chosen filament. The attenuation coefficients were determined for the different beam qualities and it was verified that the variation in the values decreases as the infill quality increases.

Conclusions

The results show that the printing system have excellent repeatability and print quality. The different printing modes characterized together with their attenuation coefficients for the x-ray beams will be studied and used in the development of new 3D printed phantoms in our institute.