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Model analysis of dose distribution in a bone implant during radiation sterilization

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Relevance of this work is defined by constantly increasing need of practical medicine in plastic material for carrying out restorative surgical interventions in traumatology, orthopedics, maxillofacial, military field surgery and other fields [1]. The most important part of the process of obtaining an effective plastic material is sterilization. The innovative development of perspective radiation and combined technologies of bone implants sterilization [2] is associated with the necessity to achieve optimal radiation treatment regimes that ensure destruction of pathogens while minimizing the dose load. The latter is caused by the existence of dose-dependent changes in the structure of the bone tissue, decrease in the osteoinductive and osteoconductive characteristics of implants. It is particularly important to provide the most accurate and objective information on the value of integral absorbed dose during radiation sterilization of bone fragment as we;; as on its spatial distribution in the sample as it is associated with the specialties of bone tissue architectonics and with the existence of developed system of intraosseous spaces in it [3]. To solve this problem, in addition to computational methods and direct measurements with the use of film dosimeters, model consideration of the effect of radiation exposure on the bone fragment with the help of program software GEANT4 was applied. Parameters of the real experiment were used as the initial configuration [2]. The calculation results show that the Monte Carlo simulation with the use of the GEANT4 package allows to obtain estimates of the deep dose distribution in the bone material considering certain parameters of the radiation exposure process. These parameters include the size of the irradiated object, the geometry of the exposure process and the energy characteristics of the radiation source. Furthermore, it also allows developing practical recommendations on its optimization. A comparison of various kinds of radiation technologies demonstrates the differences in the conditions of the implementation of processing. For instance, for gamma radiation the object can be motionless but requires greater exposure time and intensity; whereas fast electron-beam is characterized by their greatest effect coming onto the surface. Therefore, it is necessary for the sample to be rotated or turned over to obtain uniform radiation. Along with technical difficulties, it is also required to consider different cost-effectiveness of these techniques. Despite the fact that sterilization using electron-beam takes the less part in the market volume, such optimization creates condition for expanding its usage in bioimplantology. This research has been supported by the Interdisciplinary Scientific and Educational School of Moscow University «Photonic and Quantum technologies. Digital medicine».

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