Radiation-Therapy Effects On Bone Hydroxyapatite Structure

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ABSTRACT

Radiotherapy is associated with radiographically detected osteoporosis. The precise pathophysiology is not completely known yet. Hydroxyapatite (Hap, $Ca_{10}(PO_4)_6(OH)_2$) is the mineral component of the bone, and it can form chemical and mechanical bondsdirectly with living tissues, and with bone-implant interfaces as well. The aim of this research was to study the influence of external radiotherapy in the Hap ultrastructure. The experimental study was carried out on a section of bone from a human humerus, extracted from a male donor (50 years old). The bone tissue sample was irradiated with a telecobalt therapy equipment (Phoenix 2000), applying 35 fractions of 2 Gray each from Monday to Friday, until completing 70 Gray. The energy of the radiation and time of exposure used in this work was the same that it is used in common radiotherapy sessions. The calculations to determine the radiation dose were performed using the three-dimensional planner Eclipse 8.0 software. To evaluate the changes in the crystal structure of the Hydroxyapatite after each irradiation, an X-ray diffractogram was carried out on the bone sample using an X-ray diffractometer (Bruker D8) equipped with the copper anode (K-alpha=1.5406 A) and a detection scan of 5-80°. There are no differences between the diffractograms; thus, with the radiation-gamma, the same that it is used in common radiotherapy sessions, there are no appreciable changes in the crystal structure (ultrastructure) of Hap present in the bone. Radiotherapy is associated with radiographically

detected osteoporosis and investigations have shown reduced bone mineral density and increased fragility after irradiation; however, the precise pathophysiology is not completely known yet . A significant part of stereotactic radiotherapy (for peripheral non-small cell lung cancer) with tumors near the thoracic wall shows fractures of ribs in the follow-up, even in the areas of the thoracic wall that received a lower dose The primary effect of radiation on bone is atrophy, which involves a reduction in the number of functional structural components without a reduction in size. There are several primary factors to be considered in the pathogenesis of radiation-induced alterations in bone: vascular changes, cellular changes and changes in the bone matrix collagen; nonetheless, few researches have focused on changes in the bone's mineral component, and the few that have done so have not focused on the effects at the ultra structural level.

Hydroxyapatite (Hap, $Ca_{10}(PO_4)_6(OH)_2$) is the mineral component of the bone, and it can form chemical and mechanical bondsdirectly with living tissues, and with boneimplant interfaces as well Irradiated bone has demonstrated the decreased capacity to heal. These effects are largely associated with the impact of radiotherapy on the existing vascular microarchitecture and the physiological processes of angiogenesis. Radiation directly impacts the existing microvasculature causing structural disruptions, decreased overall vascular density and obliteration of small blood vessels; however, it takes time for these changes to

happen. The almost instantaneous decline in bone architecture after radiation exposure cannot be attributed only to cellular processes (resorption) because the cellular population of the bone is heavily low the early days post-radiation; thus, the quick bone loss caused by irradiation must be a product of increased osteoclast activity and also physicochemical erosion by damage to the Hap. The aim of this research was to study the influence of external radiotherapy in the Hap ultrastructure.

Keywords: Radiotherapy; Osteoporosis; Bone; Hydroxyapatite; Human