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Impact of new delivery methods in proton therapy on radiation protection of Compact Proton Therapy Centers (CPTC)

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In their eagerness to improve clinical results, the delivery methods in proton therapy are moving towards more precise techniques with the goal of increasing their therapeutic index. Once the primal passive scattering methods were overcome by current active scanning process, the evolution continues and news delivery methods such as arc therapy, minibeams or flash therapy, among others, are currently in several stages of development and research. For example, Proton Monoenergetic Arc Therapy (PMAT) uses isoenergetic fields from 360º degrees, with lower energies than conventional ones, but for a longer time. On the other hand, Flash-Therapy with Protons (PFT) involves irradiation for less than 500 milliseconds of a total dose greater than 5 Gy, that is, pulsed fields of high energy and intensity, above 40 Gy/s. Obviously, trials of these new methods are being carried out in existing facilities, so the big question that arises is if the current radiation protection measures of proton centers are ready for these new challenges. Consequently, the main goal of this work has been to carry out the comparative analysis, using Monte Carlo codes and experimental measurements, of the impact on the radiation protection of different proton dose delivery modes with greater projection and development. The current and new proton delivery methods compared were Intensity Modulated Proton Therapy (IMPT), PMAT and PFT. For PMAT, both experimental measurements and simulations with several Monte Carlo codes (MCNP6, PHITS and GEANT4) have been reached. For Flash, results have only been calculated with Monte Carlo simulations. The results show that with PMAT higher neutron fluences are generated, but with lower energy, therefore, its impact is greater on activation, but lower on the ambient dose equivalent, therefore, the shielding requirements could be reduced. For Flash, however, the current shields should be reviewed since the energies used are the maximum and the instantaneous doses rates (IDR) outside the barriers could overtake legal limits in some cases, depending on the country. Mitigating actions could be limiting orientation of beam and occupancies in some spaces, using special concretes in different areas, or change the design and location of treatment control room. Experimental measurements could help to achieve more precise assumptions, but neutron monitors must be able of measuring high-energy neutrons in pulsed fields. Active measurements should be supported with reliable data from passive monitors. Evenly, the impact over others relevant aspect of radioprotection, as activation or personal dosimetry should be carefully reviewed.

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