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Abstract

Profile Comparisons of Small Dose Volumes between Three Radiosurgery Systems

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Objectives: To compare small field isocentric plan profiles, using full width at half maximum (FWHM), and penumbra in the x, y, z directions for the ZAP-X, Gamma Knife and CyberKnife radiosurgery systems. Methods: The treatment planning system (TPS), for each radiosurgery device, was used to generate an isocentric plan using the smallest collimator size available. The beams were aligned with the planes of EBT3 film. The film was placed in the axial, and the sagittal/coronal orientations to capture data in all three axes. For the Gamma Knife (GK) Perfexion (Elekta, Stockholm, Sweden) a single 4 mm shot plan was created. The plan was delivered with films placed in a spherical phantom. The first delivery was with the film in the axial orientation and the 2nd with the film in the coronal orientation. For the CyberKnife (CK) system (Accuray Inc, Sunnyvale, CA) an isocentric plan was created with the head-path using the 5 mm fixed collimator. The plan was delivered to a skull phantom with film in the axial and then sagittal orientation. Finally, an isocentric plan was created with the ZAP-X (ZAP Surgical System, San Carlos, CA) using the 4 mm collimator. The plan was delivered to the same skull phantom as that used for the CK, with films placed in the same orientations. An Epson 10000XL scanner was used to scan all the films using a 48bit color image-type and a resolution of 75 dpi. Two calibration curves were created, one using GK the other using CK. The CK curve was also used for ZAP. The optical density in the scanned films was converted to dose using these calibration curves. Dose profiles in the x, y, z direction were then plotted for each radiosurgery system. The x,y,z directions correspond to the lateral, anterior/posterior and superior/inferior directions, respectively, for a phantom placed in the head first-supine position. The FWHM and penumbra (defined as the average of the lateral width between the 80% and 20% isodose lines on either side of the central axis) were calculated. The corresponding profiles from the treatment planning systems (TPS) were extracted and compared to those measured with film. Results: The film measured FWHM in the x,y,z directions were 6.4, 6.4, 5.1 mm for GK, 7.4, 7.4, 6.6 mm for CK and 5.8, 5.5, 5.0 mm for ZAP, respectively. The film measurements showed a penumbra of 3.3, 3.3, 1.8 mm for GK, 4.6, 4.3, 3.5 mm for CK, and 2.9, 2.9, 2.2 mm for ZAP in x,y,z. By subtracting the film measurements from the TPS values the differences between planned and delivered were quantified. For the FWHM, differences of 0.3, 0.2, 0.0 mm for GK, 0.5, 0.5, 0.1 mm for CK, and 0.0, -0.2, -0.5 mm for ZAP, were seen in x,y,z. Similarly, differences

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of 0.5, 0.5, 0.2 mm for GK, 0.8, 0.5, 0.1 mm CK, and -0.3, -0.2, -0.4 mm for ZAP , were seen for the penumbra in x,y,z. Conclusions: The FWHM results show the ZAP dose volume profiles to be the smallest, followed by GK, and then CK. Acceptable agreement (FWHM < 0.6 mm, penumbra < 1.0 mm) is seen for the film measurements compared to the TPS data for all systems.