Cureus

Flattening filter-free beams for cranial stereotactic radiosurgery: A dosimetric comparison with flattening filter beams

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Categories: Neurosurgery, Quality Improvement, Radiation Oncology
Keywords: flattening filter-free, cranial srs, intensity modulated radiosurgery, acoustic tumors

How to cite this abstract
Ravindran P B, Raj J (March 21, 2019) Flattening filter-free beams for cranial stereotactic radiosurgery: A dosimetric comparison with flattening filter beams . Cureus 11(3): a391

Abstract

Objective: The objective of the study was to evaluate the impact of the flattening filter free (FFF) beams for static conformal Stereotactic Radiosurgery (SRS) and Intensity Modulated Radiosurgery (IMRS) for acoustic tumours and compare the dosimetric parameters with the flattening filter (FF) beams. Methods: Static 3D conformal stereotactic plans using 6FF and 6FFF beams were generated on the CT data set of 15 patients treated with SRS for acoustic tumours. Clinically acceptable SRS plans were achieved for all patients with target volume receiving 11 - 12 Gy and covering isodose of 80% while the dose to the main organ at risk (OAR) viz., the brainstem, was kept to about 8 10 Gy. For the same CT data set, IMRS plans with FF and FFF beams were generated with identical plan objectives. In both the comparisons, all the plan parameters such as beam angle, couch position were kept identical, except for the type of the beam i.e. FF and FFF. For IMRS plans, the planning objective was to cover 100% of the PTV with 95% of the prescribed dose (isocenter dose). The dose calculations were performed with 2 mm grid size. For evaluation of the dosimetric data, dose volume parameters such as V80 for SRS plans, V95 for IMRS plans and, V50, V25, and maximum dose to brainstem were scored. In addition, conformity index (CI) based on the RTOG and the gradient index (GI), i.e. the ratio of V50 to V80 and V25 to V20 were derived. In the case of IMRS, the total MU for the plan was investigated as technical parameter for comparison. Results: Comparison of Static 3D conformal plans: The minimum and maximum PTV volumes were 0.493 cc and 8.135 cc respectively and the mean PTV volume was 2.815 cc. The mean PTV volume covered by 80% isodose was 95.58% (SD 1.455) with FF and 94.72% (SD 1.657) with FFF respectively. The mean maximum dose of 102.88% (1.827) to PTV using FFF beams was found to be comparable with the same using FF beam viz.,102.74 % (SD (1.77). The mean brainstem dose was 2.5% lower with FFF beams. The plans with FF beam had higher conformity index with mean RTOG CI of 1.73(SD 0.328) and that for FFF plans was 1.674 (SD 0.273). The mean high dose GI(high) i.e. V50/V80, was marginally superior for FFF compared to FF beams whereas the low dose, GI(low) i.e. V25/V50, was superior for FF. The mean total MU was not significantly different between the plans. Comparison of IMRS plans: The mean PTV volume covered by 95% isodose was nearly the same with both FF and FFF IMRS plans and were 93.78 (SD 3.05) and 94.06 (SD 2.96) for FF and FFF plans respectively. Similarly, the differences were negligible for mean of maximum dose to the PTV, brainstem and the mean of CI. As in the case of conformal plans, the mean high dose GI (high) was marginally steeper for FFF than FF, but the mean low dose GI(low) was steeper for FF plans. The mean total MU for FF and FFF plans were nearly the same i.e. 6039 (SD 1008) and 5986 (SD 927) for FF and FFF respectively. Conclusion: This study has demonstrated that the

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Published 03/21/2019

exclusive use of a linear accelerator in FFF mode is feasible for conformal SRS plans. It is possible to generate treatment plans with FFF beam with comparable quality to FF plans with both static conformal technique and with
IMRS. Since the dose rate for 6FFF is 1400 MU/minute as compared to 600 MU/minute with 6 FF, the treatment time for IMRS with FFF will be much shorter thereby reducing patient discomfort and improving throughput.