Cureus

Radiolucent Carbon Fiber Hardware for Oncologic Stabilization of Spinal Metastases Impacts Post-Operative Stereotactic Body Radiotherapy Dosimetry

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Abstract
Published 03/06/2024

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Categories: Medical Physics, Radiation Oncology
Keywords: stereotactic body radiotherapy dosimetry

How to cite this abstract
Swensen S N, Nguyen M H, Colbert C, et al. (March 06, 2024) Radiolucent Carbon Fiber Hardware for Oncologic Stabilization of Spinal Metastases Impacts Post-Operative Stereotactic Body Radiotherapy Dosimetry. Cureus 16(3): a1157

Abstract

Objectives:

In patients with spinal osseous metastases at risk of biomechanical instability or with epidural cord compression, hybrid therapy involving separation surgery followed by post-operative stereotactic body radiotherapy (SBRT) is considered. Traditional titanium implants introduce artifacts on post-operative imaging required for radiation planning, in addition to beam attenuation and increased uncertainty. The recent use of radiolucent carbon fiber reinforced polyetheretherketone (CFR-PEEK) hardware has been shown to provide safe and comparable surgical outcomes as compared to conventional titanium implants. We aimed to assess the dosimetric impact of carbon fiber versus traditional titanium hardware in SBRT treatment planning.

Methods:

In this single institution retrospective series, we queried the electronic medical record and radiation planning systems to identify patients with osseous metastases who received separation surgery with CFR-PEEK hardware placement followed by post-operative spine SBRT from 2019-2020. Dosimetric analysis involved comparison of the original titanium treatment plans with reoptimized plans, during which titanium hardware electronic density was replaced with that of carbon fiber. With clinical goals maintained, dose calculations were performed using RayStation treatment planning system by way of a collapsed cone algorithm.

A D'Agostino-Pearson test was used to assess data for normality. Paired Student's t-tests were utilized to compare three dosimetric outcomes in the setting of titanium and carbon fiber hardware. These included the planning target volume (PTV) coverage as represented by the volume of the PTV receiving at least the prescribed dose (%), the maximum point dose (dmax, cGy) to the spinal cord PRV (PRV, 2 mm margin), and the hot spot intensity as represented by the overall plan dmax (cGy).

Results:

Fourteen SBRT cases were selected for evaluation. All dosimetric outcomes assessed were found to be normally distributed ($p>0.05$). We found a statistically significant difference in PTV coverage between the original SBRT treatment plans with titanium hardware (mean 85.1 ± 7.9%), and the same plans reoptimized with carbon fiber hardware (mean 87.3 ± 6.6%; $p=0.002$). There was no significant difference in mean spinal cord PRV dmax between the titanium and carbon fiber plans (1846 ± 483 cGy vs. 1842 ± 495 cGy; $p>0.05$). A slight nonsignificant ($p>0.05$) increase in mean overall dmax was observed from 3932 ± 416 cGy in the titanium cohort as compared to 4111 ± 906 cGy in the carbon fiber cohort.

Conclusion(s):

Carbon fiber implants provide a slight, but statistically significant, increase in SBRT target coverage without degrading spinal cord PRV dmax. In addition to improved post-operative imaging, carbon fiber hardware may provide dosimetric advantages as compared to traditional titanium spinal implants and warrants further investigation in a larger cohort study.