

Introduction

Spine stereotactic radiosurgery (SRS) has emerged as a method to provide local control with minimal toxicity or interruption in systemic therapy to patients with spinal metastasis. Despite impressive local control, SRS has complications, the most studied of which is vertebral compression fractures (VCFs). Vertebral compression fractures following radiosurgery at the irradiated level have been reported at incidences ranging from 6-39%. Thus far, studies have evaluated the incidence and risk factors for VCF at the level of the irradiated vertebral body and not for VCF occurring in vertebral bodies adjacent to the index level. However, VCFs above and below the irradiated level have occurred. This represents the first study to our knowledge evaluating adjacent level VCFs in patients undergoing spinal SRS.

Methods

A retrospective review of 206 patients with a total of 239 lesions in the mobile spine treated with single fraction SRS to dose 24Gy from 2011 to 2014 at a single institution was performed. (**Table 1**) Clinical and pathologic factors were collected including evaluation of VCFs in adjacent levels to site of SRS. The primary outcome was development of an adjacent level VCF (which included endplate fractures and collapse deformities). Each patient had at least one documented imaging methodology for review. Cox regression univariate analysis modeling was performed with IBM SPSS software to determine any associations between clinical factors and adjacent level VCFs. The fractured endplates of all pure adjacent segment VCFs were contoured as well as sixteen non-fractured endplates, and dose volume histograms were calculated. Mean and maximum doses in Gray (Gy) were collected. A representative treatment plan is shown in **Figure 1**.

Results

Patient and tumor characteristics are summarized in **Table 1**. There were 206 patients treated to a total of 239 treatment sites with SRS to the mobile spine, and all patients were treated to dose 24Gy in 1 fraction.

There were 26 incidences of adjacent level VCFs observed in 26 patients. There were seven adjacent level VCFs without hardware or metastases present at the level of VCF. The median time to adjacent level VCF was 13.5 months post-SRS (range, 5 – 25 months). There were two lumbar, three thoracic and two cervical pure adjacent VCFs. There were three mobile spine, two junctional, and two semi-rigid locations according to spinal instability neoplastic score (SINS) criteria. Five of the seven (71.4%) pure adjacent level VCFs were associated with collapse of the irradiated vertebral body, three occurring simultaneously and two afterward. Four of the adjacent level fractures occurred at the endplate adjacent to the irradiated vertebral body, and three adjacent level fractures occurred at the opposite endplate. The mean of the mean dose to adjacent level fractured endplate immediately adjacent to the irradiated vertebral body was 22.5 Gy, and the median mean dose was 23.3 Gy. The mean of the mean dose of sixteen non-fractured endplates immediately adjacent to the SRS site was 18.8 Gy with a median mean dose of 19.1 Gy.

Cox regression analysis was performed for the seven adjacent level fractures without hardware or metastatic disease as shown in **Table 2**. This was again performed for the subset of four patients who had fractures at endplates adjacent to the irradiated vertebral body and is shown in **Table 3**. A cumulative incidence curve for the development of adjacent level VCF is shown in **Figure 2**.

Table 1

Table 1. Patient and Tumor Characteristics

Patient Characteristics	No. (%), n=206
Patient age, median (range), years	60 (20 - 84)
Patient age	
>70 years	38 (18.4%)
≤70 years	168 (81.6%)
Patient sex	
Male	161 (67.4%)
Female	78 (32.6%)
Tumor Characteristics	No. (%), n=239
Tumor location	
Cervical spine	21 (8.8%)
Thoracic spine	117 (49.0%)
Lumbar spine	101 (42.3%)
Primary tumor site	
Renal	57 (23.8%)
Lung	42 (17.6%)
Sarcoma	31 (12.9%)
Prostate	22 (9.2%)
Colorectal	21 (8.8%)
Thyroid	14 (5.9%)
Melanoma	12 (5%)
Breast	9 (3.8%)
Gynecological	7 (2.9%)
Chordoma	4 (1.7%)
Hepatobiliary	4 (1.7%)
Unknown	5 (2.1%)
Other*	11 (4.6%)

*Other (bladder, head and neck, salivary gland, pancreas, adrenal)

Table 2

Table 2. Univariate analysis of clinical factors and association with adjacent level VCFs using Cox linear regression model (7 patients).

	Hazard Ratio	95% CI	p-value
Age (continuous)	0.992	0.993 - 1.054	0.789
Sex (female vs. male)	0.302	0.036 - 2.509	0.268
Histology (carcinoma vs. other)	0.484	0.058 - 4.020	0.501

Table 3

Table 3. Univariate analysis of clinical factors and association with adjacent level VCFs which fractured at the endplate adjacent to the irradiated vertebral body using Cox linear regression model (4 patients).

	Hazard Ratio	95% CI	p-value
Sex (female vs. male)	0.627	0.065 - 6.036	0.686
Age at SRS (continuous)	1.015	0.933-1.105	0.726
Histology (carcinoma vs. other)	1.01	0.105 - 9.717	0.993

Figure 1

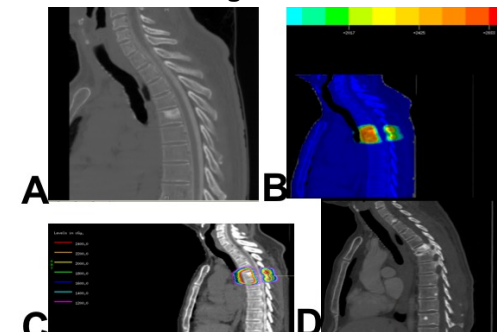


Figure 1. A.) Pre-SRS sagittal CT of the spine demonstrating metastasis at T5. **B.)** SRS plan demonstrating dose to each area in dose color wash and **C.)** isodose lines. **D.)** Post SRS adjacent level fracture at the adjacent endplate (superior endplate) of T6.

Figure 2

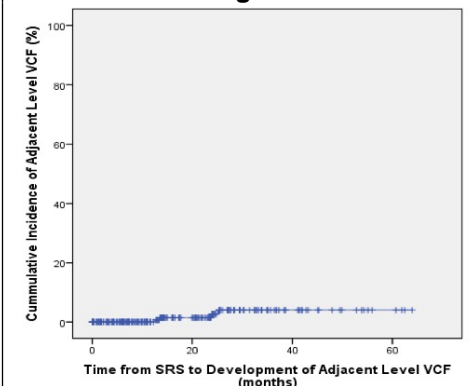


Figure 2. Cumulative incidence curve for the development of adjacent level vertebral compression fracture (VCF) at endplates adjacent to irradiated vertebral body (four patients)

Conclusion

Adjacent level VCF after spinal SRS occurs at a low rate. This is the first paper to detail such findings. Adjacent level vertebral body endplates should be further investigated as an organ at risk during SRS planning.

References

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