

CHECKING MULTI-MET LESIONS WITH IMAGING VARIATION METHOD FOR BRAIN STEREOTACTIC RADIOSURGERY (SRS)

Corbin Helis¹, Joon Han¹, E. Ismael Parsai¹, Jeremy Karlin¹, Charlton Smith², Vivek Verma³, Cengize Aygun³, Edward Kiggundu³, James Littles⁴, Kimberly Creach⁵, Nian Mayr⁶, Enmin Wang⁷, Simon Lo⁸, William Yuh⁸
 1.A.T.Augusta Military Medical Center, 2 Walter Reed National Military Medical Center, 3 GensisCare, 4.Mon Health Cancer Center, 5. Mercy Cancer Center, 6. Michigan Sate University, 7, BNCT Hospital, 8.University of Washington

Introduction

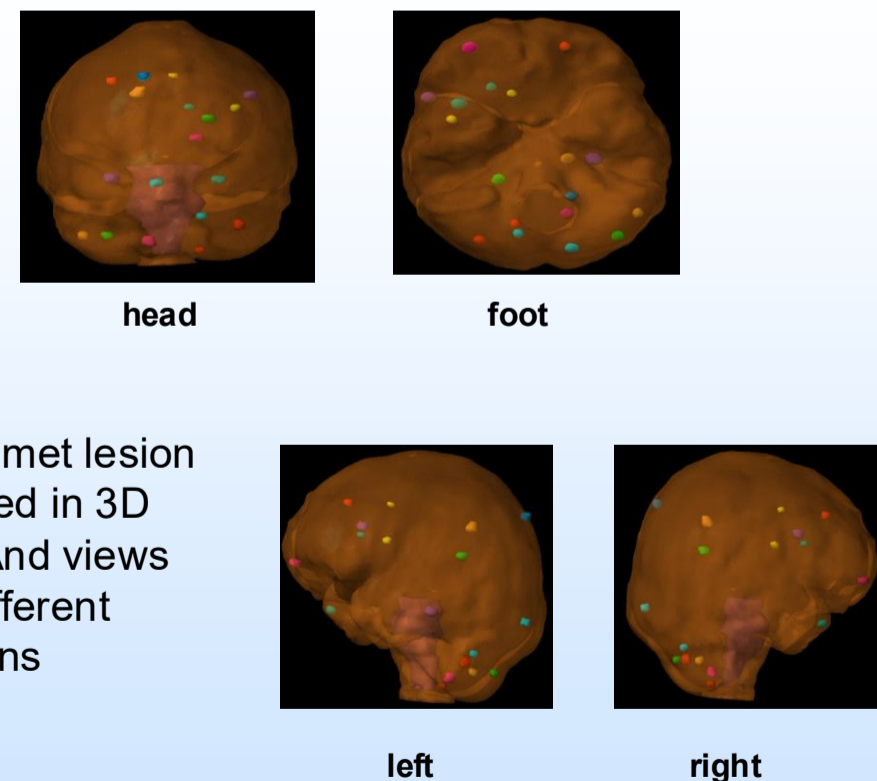
Outcome prediction is an expectation with following up imaging and different information in different temporal points [1]. There are several methods such as visual review, imaging target variation[2], volume check[3] and so on. In this analysis, an image perturbation method[4] was employed to analyze and distinguish the stereotactic radiosurgery effect for a multi-met lesion.

Reference

1. Glenn Lesser, Kathryn Weaver and Christina K. Cramer, et al., "Hypo fractionated radiotherapy vs single fraction radiosurgery for brain metastasis patients on immunotherapy (hypogryphe)", WF-2201, Wake Forest NCORP Research Base, 2022
2. Nina Mayr, et al., Longitudinal Changes in Tumor Perfusion Pattern during the Radiation Therapy Course and its Clinical Impact in Cervical Cancer, September 2009 International Journal of Radiation Oncology*Biolog*Physics 77(2):502-8
3. Jian Z Wang, et al. Sequential magnetic resonance imaging of cervical cancer: the predictive value of absolute tumor volume and regression ratio measured before, during, and after radiation therapy. Cancer. 2010 Nov 1;116(21): 5093-101
4. Kaile Li, Variance Perturbation Method in Analysis of Multiple Imaging Modalities for Cerebellum Radiosurgery, Sci Set J of Med Cli Case Stu 3(2) 01-04 2024

Methods

A patient with 18 lesions were selected for this study, the temporal points were 8 for about two years, and the data included Magnetic Resonance (MR) image set, simulation Computed Tomography (CT) image set, Cone Beam Computed Tomography (CBCT) image set. Through registration process, the target delineation was transferred to the new temporal point image set. The variations were expressed with target pixel Hounsfield Unit(HU) perturbation. After nondimensionalizing of this 8x18 matrix, the vertical matrix elements formed a set of numerical arrays. The similarity of these array sets was compared with ranking method.



A multi-met lesion displayed in 3D view. And views from different directions

Methods and Materials

Ranking Method

$$P = \frac{2[1 + \sum_{i=1}^n \sum_{j=1}^m \prod_{k=1}^q (r - q - n + 1) \prod_{l=1}^{q-1} (r - q - n + l)]}{|q \times |q|}$$

$|P|$ represents the number of j -part partitions of i ,
 r is the serial number of possible rank totals, 0, 1, 2, ..., r ,
 q is the number of replicates, and
 n is an integer representing the serial number of the term in the series.

$$P = \frac{2[1 + \sum_{i=1}^n (\sum_{j=1}^{r-i} \prod_{k=1}^q \Pi_{l=1}^{q-1} (r - q - n + l))]}{2q}$$

r is the serial number of the total under consideration in the series of possible totals 0, 1, 2, ..., r ,
 q is the number of pair differences.

Perturbation Method

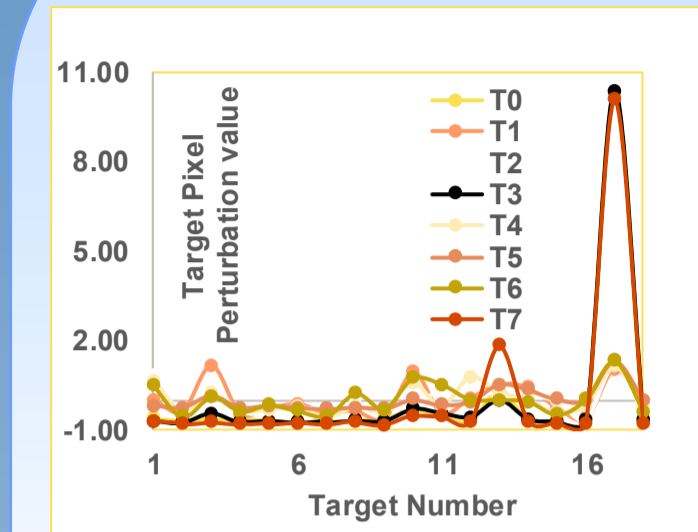
$$\begin{pmatrix} HSD_{V_1} \\ \vdots \\ HSD_{V_N} \end{pmatrix} = \begin{pmatrix} \sqrt{\frac{\sum_{i=1}^{N_{V_1}} (H_{V_1P_i} - H_{V_1})^2}{(N_{V_1P} - 1)}} \\ \vdots \\ \sqrt{\frac{\sum_{i=1}^{N_{V_N}} (H_{V_NP_i} - H_{V_N})^2}{(N_{V_NP} - 1)}} \end{pmatrix}$$

Note: HSD (HU Standard Deviation in VOI V)
 SD (Standard Deviation)
 N (number of VOIs or pixels in a VOI)
 P (Pixel in VOI)

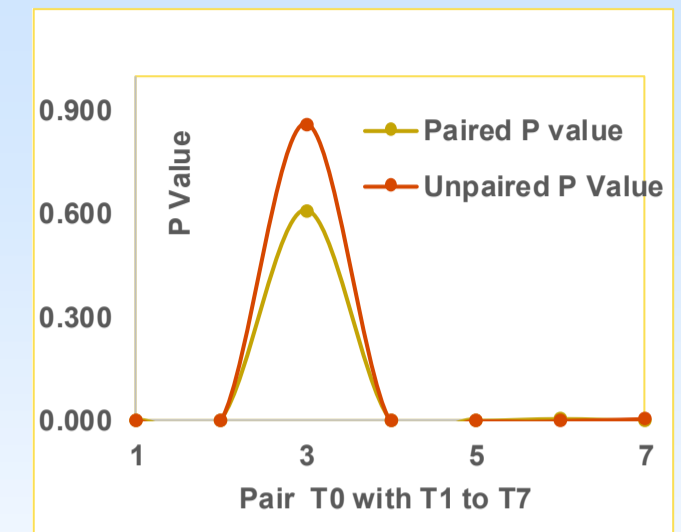
Data Collection and Computation

Table 1 Lesion imaging perturbations at different temporal points.

T0	T1	T2	T3	T4	T5	T6	T7
10/27/2023 CT	11/01/2023 MR	05/20/2025 MR	05/22/25 CT	06/09/25 MR	06/13/25 CBCT	10/02/25 MR	10/06/25 CT
SD (HU)	SD (HU)	SD (HU)	SD (HU)	SD (HU)	SD (HU)	SD (HU)	SD (HU)
-0.62	0.00	0.78	-0.73	0.62	-0.21	0.48	-0.70
-0.71	-0.36	-0.35	-0.76	-0.37	-0.27	-0.57	-0.79
-0.64	1.15	0.40	-0.47	0.22	0.13	0.09	-0.75
-0.64	-0.46	-0.35	-0.74	-0.37	-0.27	-0.39	-0.81
-0.69	-0.27	-0.43	-0.72	-0.35	-0.19	-0.17	-0.80
-0.74	-0.12	-0.27	-0.76	-0.23	-0.26	-0.37	-0.77
-0.70	-0.45	-0.29	-0.72	-0.60	-0.29	-0.57	-0.82
-0.70	-0.37	-0.14	-0.68	-0.23	-0.28	0.22	-0.74
-0.67	-0.64	-0.34	-0.70	-0.35	-0.30	-0.32	-0.84
-0.34	0.91	-0.13	-0.30	0.57	0.01	0.73	-0.52
-0.55	-0.45	0.35	-0.47	-0.19	-0.17	0.50	-0.57
-0.70	0.05	0.47	-0.58	0.77	-0.07	-0.01	-0.73
0.32	0.50	0.11	0.00	0.25	0.51	0.00	1.83
-0.70	0.40	0.12	-0.64	0.02	0.34	-0.08	-0.71
-0.70	-0.28	-0.03	-0.71	-0.43	0.02	-0.49	-0.77
-0.74	-0.62	-0.65	-0.68	-0.19	0.00	0.03	-0.78
10.23	1.02	1.17	10.34	1.10	1.30	1.30	10.06
-0.73	-0.02	-0.42	-0.67	-0.22	-0.01	-0.39	-0.79
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2.564	0.567	0.476	2.589	0.479	0.395	0.497	2.585
W paired	18	21.5	73	19	18	24	18
P	0.002	0.003	0.609	0.002	0.002	0.006	0.002
W unpaired	42.5	42.5	168	39	33	42	247.5
P	0.000	0.000	0.861	0.000	0.000	0.000	0.007



A plot of pixel perturbation value for 18 lesions at 8 temporal points in table 1



A plot of p value for 7 temporal point pairs refer to T0 with pair and unpair ranking method

Results

The initial characteristics of these lesions in average volume was 0.16cc with diameters at 0.33cm. The pixel Hounsfield Unit was 19, 156, and 44 in minimum, maximum and mean. For the standard deviation of the HU in these volumes were 22, 144, 163, 21, 185, 27, 68 and 29 at the temporal sequence for this study, and the corresponding imaging modalities were CT, MR, MR, CT, MR, CBCT, MR and CT. When referring to initial treatment data set for these lesions, the P values for these temporal points were 0.002, 0.003, 0.609, 0.002, 0.002, 0.006 and 0.002 with paired assumption.

Conclusion and Discussion

This study analyzed the local radiosurgery treatment effect with different image modalities based on pixel HU number perturbation. Further improvement of this analysis should include temporal point spans evenness, brain tissue structure with geometry location, the homogeneity of dose distribution and treatment machine mechanical limitation due to the small scales of the multi-metastases lesions.

