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Variance Perturbation Method in Analysis of Multiple Imaging Modalities for Cerebellum Stereotactic Radiosurgery

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Abstract

Purpose: *Neuro function and structure of Cerebellum are still lack of enough knowledge to be described due to limitation of different resources such as imaging modalities availability, direct clinical data, and qualified researchers. Most of current studies was utilized Magnetic Resonance Imaging (MRI) and diagnostic Computer Tomography (CT) with contrast agents. Modern Linear accelerator X-ray for stereotactic radiosurgery (SRS) usually equipped with onboard Cone Beam Computed Tomography (CBCT) imaging system, which is used for target localization before dose delivery. In this study, the sensitivity of on-board CBCT imaging was evaluated through comparing with MRI and CT-images for cerebellum stereotactic radiosurgery (SRS) with volumetric perturbation methodology.*

Method and Materials: *A cerebellum SRS case was selected for this study. During the patient care procedure, several imaging modalities was utilized. These imaging modalities include MR, CT and CBCT. And these images were taken by Siemens MR Scanner, GE LightSpeed^{RT} System, and On-board- imager (OBI) on Truebeam Linear accelerator from Varian Medical System. The volumetric perturbations were generated by the percentage of prescription dose for the treatment. The percentages range from 120%, 100%, 80%, 60%, 40% and 20%. The collected images information include volume, minimum Hounsfield Unit (HU), maximum HU, mean HU, standard deviation of HU in selected volumes. The second order standard deviation method was applied to compare the sensitivity of among these imaging modalities for these volumes of interest.*

Results: *In this study, based on the selection volumes, which were 24.37cc, 34.01cc, 45.72cc, 67.79cc, 132.19cc and 383.73cc, the corresponding differences of second order standard deviation for CT to MR were 119.01, 91.67, -34.42, -133.08, -237.01, and -256.05: for CBCT to CT were-17.22 -40.38. -54.24. -75.72, -98.51, and -92.90; for CBCT to MR were 101.797, 51.29, -88.664, -208.795, -335.518, and -348.95.*

Conclusions: *Modern Linac system for SRS provided OBI for CBCT imaging for evaluation cerebellum patient under SRS procedure. And the procedure could embed an instantly post treatment CBCT imaging for cerebellum response evaluation. Further development could apply selecting spectrum of imaging system for precise analysis of microscopic structure of cerebellum.*

Keywords: Perturbation, Neuro Function, CBCT, MRI, CT, Radiosurgery

Introduction

Neuro function and structure of Cerebellum are still lack of enough knowledge to be described due to limitation of different resources such as imaging modalities availability, direct clinical data, and qualified researchers. Most of current studies was utilized Magnetic Resonance Imaging (MRI) and diagnostic computer tomography (CT) with contrast agents. Modern Linear accelerator X-ray for stereotactic radiosurgery usually equipped with onboard Cone Beam Computed Tomography (CBCT) imaging system, which is used for target localization before dose. And small lesions cerebellum lesion and temporal imaging analysis have been proposed in previous investigation [1, 2]. In this study, the sensitivity of on-board CBCT imaging was evaluated through comparing with MRI and CT images for cerebellum stereotactic radiosurgery (SRS) with volumetric perturbation methodology.

Materials and Method

A cerebellum SRS case was selected for this study. During the patient care procedure, several imaging modalities was utilized. These imaging modalities include MR, CT and CBCT. And these images were taken by Siemens MR Scanner, GE LightSpeedRT System, and On-board-imager (OBI) on Truebeam Linear accelerator from Varian Medical System. The volumetric perturbations were generated by the percentage of prescription dose for the treatment. The percentages range from 120%, 100%, 80%, 60%, 40% and 20%. The collected images information include volume, minimum Hounsfield Unit (HU), maximum HU, mean HU, standard deviation of HU in selected volumes. The second order standard deviation method was applied to compare the sensitivity of among these imaging modalities for these volumes of interest. The computation method is shown at the following.

A relative percentage difference method, which was defined to be the ratio between the differences of Standard Deviation (SD) and mean SD divided by the mean SD to separate the technical variation from imaging procedure. The formula below shows this estimation procedure.

$$\begin{pmatrix} HSD_{V_1} \\ \vdots \\ HSD_{V_N} \end{pmatrix} = \begin{pmatrix} \sqrt{\dfrac{\sum_{i=1}^{N_{V_1 p}} \left(H_{V_1 P_i} - \overline{H_{V_1}}\right)^2}{\left(N_{V_1 p} - 1\right)}} \\ \vdots \\ \sqrt{\dfrac{\sum_{i=1}^{N_{V_N p}} \left(H_{V_N P_i} - \overline{H_{V_N}}\right)^2}{\left(N_{V_N p} - 1\right)}} \end{pmatrix}$$

$$SD_{HSD} = \sqrt{\dfrac{\sum_{i=1}^{N_{HSD}} \left(HSD_{V_i} - \overline{HSD_V}\right)^2}{\left(N_{HSD} - 1\right)}}$$

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

Results

In this study, based on the selection volumes , which were 24.37cc, 34.01cc, 45.72cc, 67.79cc, 132.19cc and 383.73cc, the corresponding differences of second order standard deviation in HU for CT to MR were 119.01, 91.67, -34.42, -133.08, -237.01, and -256.05; for CBCT to CT were -17.22, -40.38, -54.24, -75.72, -98.51, and -92.90; for CBCT to MR were 101.797, 51.29, -88.664, -208,795, -335.518, and -348.95. These computed data were also showed at Table 1, and the corresponding plot was showed in figure 4, and the x-axis was index for volumes of interest.

Figure 1: Machine modalities applied for acquiring the image sets, from left to right, Varian TrueBeam Linac, GE LightSpeed[RT] system, and Siemens MRI scanner.

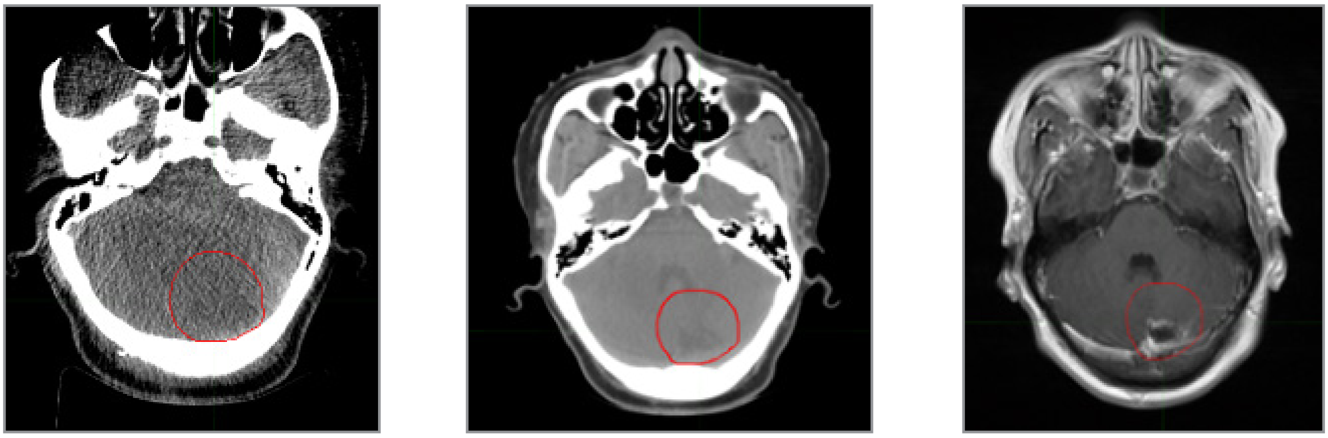

Figure 2: From left to right CBCT image, CT image and MR images attained by corresponding machines.

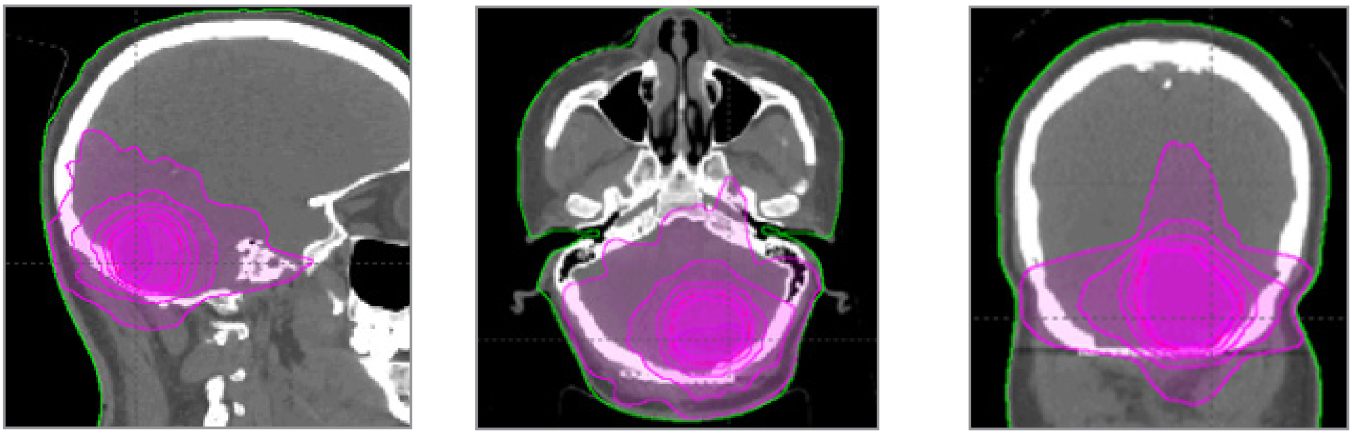

Figure 3: Selected regions of interest, from left to right, sagittal, transversal and coronal views.

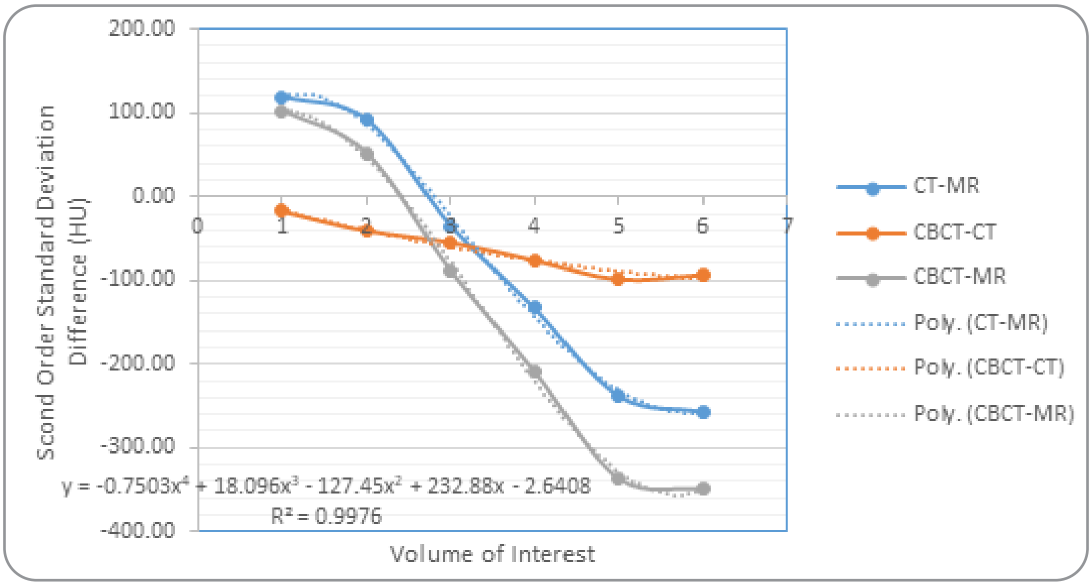

Figure 4: The HU SD variation at between CT-MR, CT-CBCT, CBCT-MR.

Table 1: Computed Difference of HU Standard Deviation between imaging Modalities.

No.	ROI Name	Volume (cc)	Diameter(cm)	CT-MR	CBCT-CT	CBCT-MR
1	Dose 120%	24.37	3.60	119.01	-17.22	101.797
2	Dose 100%	34.01	4.02	91.67	-40.38	51.29
3	Dose 080%	45.72	4.44	-34.42	-54.24	-88.664
4	Dose 060%	67.79	5.06	-133.08	-75.72	-208.795
5	Dose 040%	132.19	6.32	-237.01	-98.51	-335.518
6	Dose 020%	383.73	9.02	-256.05	-92.9	-348.95

Discussion

Modern Linac system for SRS provided OBI for CBCT imaging for evaluation cerebellum patient under SRS procedure. And the procedure could embed an instantly post treatment CBCT imaging for cerebellum response evaluation. Moreover, some non-linear algorithms could be employed for similarity analysis [3]. And further development could apply selecting spectrum of imaging system for precise analysis of microscopic structure of cerebellum with the ongoing nanoscale analysis techniques [4].

Conflict of Interest

None

Reference

1. Li, K. (2020). Perturbation in magnetic resonance images (MRIs) from cerebellum target stereotactic radiosurgery (SRS). SRCA Congress, Taiwan.
2. Wang, J. Z., Mayr, N. A., Zhang, D., Li, K., Grecula, J. C., et al. (2010). Sequential magnetic resonance imaging of cervical cancer. Cancer, 116(21), 5093–5101. https://doi.org/10.1002/cncr.25380
3. Li, K., Able, A., Mariados, N., Cornell, D., Jung, E., et al. (2018). Analysis of low dose rate (LDR) brachytherapy for prostate with similarity matrix. Brachytherapy, 17(4, Suppl.), S131–S132. https://doi.org/10.1016/j.brachy.2018.04.125
4. Pradhan, A. K., Nahar, S. N., Montenegro, M., Chowdhury, E. A., Li, K., et al. (2010). Multi-disciplinary role of atomic astrophysics: From stellar interior to cancer research via nanotechnology. In Astrophysics and Space Science Proceedings (pp. 123–138). Springer-Verlag. https://doi.org/10.1007/978-3-642-13687-2_8