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Abstract
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Evaluate the Delivery Accuracy of Gamma Knife Trigeminal Neuralgia Radiosurgery with G-Frame Using On Board Cone-Beam CT

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Abstract

Objectives:

The on board cone-beam CT (CBCT) on the ICON model of Leksell Gamma Knife (LGK) (Elekta AB, Stockholm, Sweden) allows us to confirm the quality of frame fixation prior to treatment with accuracy. The practice of trigeminal neuralgia radiosurgery (TNRS) with LGK in our institution is to treat the posterior portion of the trigeminal nerve with a single 4-mm isocenter. Therefore, a small frame displacement between the time of frame placement and actual treatment could have effects on dose delivery quality and radiation dose on the contacting brainstem. In this study, we quantified frame displacement and dosimetry effects using CBCT.

Methods:

The data of 37 patients treated by TNRS with G-frame for head fixation from June 2019 to September 2022 were analyzed. The prescriptions were either 80Gy or 86Gy. On each patient, immediately after the frame placement, a CBCT image set was acquired and followed with MR imaging. The 1st CBCT image set was co-registered to the plan reference images in the Leksell GammaPlan (LGP) system. Right before the treatment, a 2nd CBCT image set was acquired and co-registered to the 1st CBCT images in LGP. This co-registration provided the amount of geometric translation and rotation required to minimize the position difference between the plan and treatment. Because there is no target structure in TNRS and 70Gy is the recommended minimal dose, the 70Gy isodose lines were converted to a structure and used to assess dose coverage. The LGP plan evaluation software only predicted dosimetric quantities change if the treatment was delivered without correcting the patient's position. The dose volume histogram (DVH) of the 70Gy structure were also evaluated.

Results:

Among all 37 patient the mean and standard deviation of the rotation angle (degree) in the pitch, yaw, and roll directions are: 0.2±0.2, -0.1±0.3, 0.1±0.1; and the translation (mm) in X, Y, and Z directions were respectively: 0.1±0.3, 0.0±0.2, 0±0.4, predicted by LGP plan evaluation based on co-registration of the two CBCT image sets. The mean and standard deviation of the magnitude of the translation (mm) was 0.4±0.4. This indicates overall excellent frame fixation in our institution. However, there were a couple of outliers with the magnitude of translation above 0.8mm. In those cases, the coverage of the 70Gy structure decreased by 20%, and quickly down by 47% when the magnitude of translation reached 1.2mm. Although the ICON workflow allows us to quickly apply the newly acquired CBCT right before the treatment as the new stereotactic reference to adjust the treatment plan, there was no such adjustment made in any of the cases studied.

Conclusion(s):

The position differences between the plan and actual treatment predicted by the co-registration module of LGP were within the accuracy limit in almost all the cases studied. CBCT is an accurate and efficient way to verify the integrity of the frame fixation. In TNRS, if the translation magnitude is close to 0.8mm and beyond, we may need to pay close attention to the intention of the isocenter location on the trigeminal nerve and its proximity to the brainstem. Although the ICON workflow allows us to apply newly acquired CBCT as the new stereotactic reference and re-plan on the fly, its clinical necessity and implication needs to be further evaluated.