Plan quality and efficiency comparison for brain metastasis treatments between Gamma Knife and Versa HD linac

A. Nevelsky1, M. Yakhina2, V. Kostjuchenko2, A. Dalechina2, H. Nasrallah1, R. Bar-Deroma1
1Rambam Health Care Campus, Oncology, Haifa, Israel
2Burdenko Neurosurgery Institute, GammaKnife Center, Moscow, Russian Federation

Purpose/Objective: For stereotactic radiosurgery (SRS) of multiple brain metastases, several different systems have been used in the last decades; they include GammaKnife, Cyberknife, Tomotherapy and linear accelerators (linacs). Recently, a number of works on the comparison of different techniques have been published. However, none of these works used Elekta linacs and software. The purpose of this project was to evaluate a new single-isocenter technique for SRS of multiple brain metastases using the Elekta VersaHD linac and to compare it with the Leksell GammaKnife (LGK) based technique. This comparison was performed in terms of plan quality and plan delivery efficiency.

Materials and Methods: Fifteen patients with 2 or 4 brain metastases which were planned and treated with LGK Perfaxion were randomly selected. The plans were created using the Leksell GammaPlan v.10.1.1 with forward planning. These patients were re-planned based on the same anatomy on the Monaco TPS for the Elekta VersaHD linac. A single isocenter approach was employed with the isocenter location selected to be geometrically central to all the lesions. 4 VMAT arcs were used - 1 full coplanar and 3 partial non-coplanar. Plan quality was assessed using the following parameters: Conformity Index (CI), Gradient Index (GI), Paddik Conformity Index (PCI), Homogeneity Index (HI), Volume of the healthy brain receiving more than 12 Gy (V12) and Brain Integral Dose. For delivery efficiency assessment, beam-on time was recorded for each plan.

Results: For years, LGK has been considered the gold standard for SRS due to its mechanical accuracy and ability to produce sharp dose gradients (due to the inherently low penumbra of the collimators). The main drawback of using LGK for SRS is long treatment time. For multiple brain metastases SRS, single isocenter multiple VMAT arcs technique produced clinically equivalent plans compared to LGK. For this technique, treatment time was found to be significantly lower compared to LGK. It seems that for small targets (less than 0.5 cc) LGK-based technique can produce dosimetrically better plans.

Conclusions: Due to its similar plan quality and increased delivery efficiency, single-isocenter VMAT radiosurgery may constitute an attractive alternative to GK-based radiosurgery for patients with brain metastases. For treatment of functional disorders and benign diseases, LGK may still be preferable due to higher mechanical accuracy and sharper gradients. For specialized neurosurgical centers, LGK and Versa HD may represent complimentary solutions for the whole range of Oncological and Functional SRS treatments.

EP-1447
Feasibility of scalp dose reduction during hippocampus-sparing whole brain radiotherapy
S. Daniel1, A. Nevelsky1, R. Bar-Deroma1, H. Nasrallah1
1Rambam Medical Center, Oncology, Haifa, Israel

Purpose/Objective: Whole brain radiotherapy (WBRT) remains a mainstay in the treatment of brain metastases. However, this technique is related to several neurological and physical side effects. In order to address the problem of neurocognitive decline, WBRT with hippocampus sparing may be delivered according to the recommendations of the Radiation Therapy Oncology Group (RTOG) protocol 0933. Another distressing side effect of WBRT is hair loss. In an attempt to reduce this effect, dose to the scalp should be decreased. The purpose of this study was to evaluate the feasibility of combined hippocampal and scalp sparing in WBRT planning.

Materials and Methods: Five patients previously treated by WBRT using the classical method of two opposed lateral fields were re-planned using the Monaco treatment planning system for the Elekta Axesse linear accelerator. Delineation of the hippocampus region was done on magnetic resonance imaging (MRI) scans and copied to the computed tomography (CT) scans after a fusion and registration. Scalp was defined as the area along the hair line from the patient surface to a depth of 3mm and was delineated directly on the CT scan. The optic nerves, optic chiasm and the eyes were considered organs at risk (OAR) and were also delineated. Dose prescription was 30 Gy in 10 fractions. PTV coverage criteria and OAR constraints were per RTOG 0933 protocol. Further planning was done to minimize the scalp dose while maintaining other RTOG defined planning criteria. The plan with two opposed lateral fields was used as a reference for scalp dose estimation. Four additional treatment plans were created for each patient: 1) volumetric modulated arc therapy (VMAT) with two coplanar 6 MV beam arcs for WBRT and hippocampal sparing, 2) VMAT with two coplanar 6 MV beam arcs for WBRT, hippocampal and scalp sparing, 3) VMAT with two coplanar and two non-coplanar (couch at 90 degrees) 6 MV beam arcs for WBRT, hippocampal and scalp sparing, 4) VMAT with two coplanar 6MV arcs and two non-coplanar (couch at 90 degree) 10MV arcs for WBRT, hippocampal and scalp sparing. Mean scalp dose was evaluated for each plan.

Results: Effective hippocampal sparing can be achieved using VMAT with two coplanar arcs; if scalp is defined as OAR, this method also allows reducing the mean scalp dose from 18.9 Gy to 15.1 Gy. Further mean scalp dose reduction (to 13.7 Gy) can be obtained by adding a non-coplanar VMAT arc. The best scalp sparing in terms of mean dose reduction is realized by using a high energy beam (10MW) for the non-coplanar arcs; in this case the mean scalp dose can be decreased to 12.2 Gy.

Conclusions: We have shown that scalp dose can be reduced by about 35% during hippocampal-sparing WBRT while still fulfilling the RTOG 0933 criteria for PTV coverage and OAR constraints. Prospective studies are needed to evaluate the clinical significance of such dose reduction.

EP-1448
Inter-fractional set up correction using hexapod robotic couch for VMAT prostate treatments
M. De la Casa1, E. Ambroa Rey2, A. Seguro Fernández1, R. Garcia Marcos1, P. Samper Ots3, J.M. Jiménez González1
1Hospital Rey Juan Carlos, Radiofísica, Móstoles, Spain
2Hospital General de Catalunya, Radiofísica, Sant Cugat del Valles, Spain

Purpose/Objective: Whole brain radiotherapy (WBRT)
Materials and Methods: 15 prostate cancer patients were treated with radical rotational radiotherapy (VMAT). The robotic couch corrected the misalignments in all 6-DOF and a pre-treatment verification CBCT was then obtained. A total of 425 fractions were evaluated. For each patient the set-up corrections of the three principal axes (L/R, A/P, and C/C) and three rotational movements (pitch, roll, and yaw) were extracted from the CBCT software.

The following parameters were calculated:

- For the complete data set (15 patients, 425 fractions) a global mean (the systematic error, M) and standard deviation (σ) of the set-up corrections for each direction.
- For each individual patient the means of the set-up corrections for each direction, and the standard deviation (Σ) of these means.

Also, a Principal Components Analysis (PCA) on the correlation matrix was performed to determine the principal components.

Results: Table 1 shows the results of the parameters mentioned before.

![Rotation corrections](image)

Concerning target coverage, the use of DJ determined a slightly reduced dose homogeneity in the PTVs for both clinical scenarios. CI showed no significant differences for the three sets in the two clinical scenarios. Furthermore, worst results for DJ_2 (two paired t-test; p<0.05) were obtained by analyzing the overall mean V98% values for PTVs coverage (89%, 88% and 80% for FJ, DJ_1 and DJ_2) in the WP plans. Better results was obtained for P plans (88%, 87% and 85% for FJ, DJ_1 and DJ_2). With regard to OARs, a significant dose sparing of penile bulb was observed for WP and P scenarios when DJ was used (mean dose difference up to 12 Gy). In the WP cases, no significant increase in the other OARs exposure was detected when FJ was compared with DJ_1, as most OARs are generally located within the irradiated area. The larger FW determined a slightly reduced sparing of most OARs (Fig 1). A significant reduction in delivery duration of 60% on average could be accomplished for WP and P irradiations with DJ_2.

Conclusions: The results shown in the Table 1 suggest that the biggest systematic error is found in the Yaw direction, with the smallest standard deviation compared with the other angles. Otherwise the standard deviation on the pitch seems to be significantly higher compared with the other angles. That suggests that the biggest source of error in the set up is, in fact, in that direction. The PCA results suggest that it is not possible to make any significant reduction in the complexity of the data as the most significant component only explains 30% of the variance. Despite the fact that the robotic couch only allows rotations in the [-3, 3] degree interval, we found out that the 5% of the corrections were larger than 3 degrees in the pitch direction.

EP-1449

TomoEDGE dynamic jaws for prostate cancer: small/large field width with/without whole pelvis irradiation

G.M. Cattaneo¹, C. Sini¹, B. Longobardi¹, P. Mangili¹, R. Calandrino¹

¹San Raffaele Scientific Institute, Medical Physics Department, Milan, Italy

Purpose/Objective: The aim of this study was to evaluate the effective potentiality of TomoEDGE dynamic jaw (DJ) with small/large field width (FW) compared to the regular fixed helical tomotherapy in the treatment of prostate cancer.

Materials and Methods: Two clinical situations were chosen for comparison between fix jaw (FJ) mode with FW of 2.5 cm and DJ delivery with a FW of 2.5 cm (DJ_1) and 5.0 cm (DJ_2): prophylactic whole pelvis (WP) and small-field irradiation to the prostate and seminal vesicles (P) only. Pitch of 0.287 and modulation factor of 2.5 were used in all simulated plans. For WP plans, hypofractionated (51.8, 61.6, 65.5, 65.5, 74.2Gy-28 fr) simultaneous integrated boost was prescribed to pelvic lymphnodes, most cranial and the first third of seminal vesicles, overlap between rectum and prostate, prostate respectively. For P plans, no pelvis irradiation, keeping the same prescribed doses in WP scenario for the other 4 planning target volumes (PTVs). Six patients were selected for planning comparisons. For each patient, WP and P plans were simulated for the three different settings. For each clinical scenario the same contours, prescriptions and planning objectives were maintained. Plan quality was evaluated in terms of coverage, conformity index (CI) and homogeneity index (HI) of the prescribed dose to the PTV, maximum/minimum, mean doses and dose-volume histograms (DVH) data for organs at risk (OARs) and delivery time.

Results: Concerning target coverage, the use of DJ determined a slightly reduced dose homogeneity in the PTVs for both clinical scenarios. CI showed no significant differences for the three sets in the two clinical scenarios. Furthermore, worst results for DJ_2 (two paired t-test; p<0.05) were obtained by analyzing the overall mean V98% values for PTVs coverage (89%, 88% and 80% for FJ, DJ_1 and DJ_2) in the WP plans. Better results was obtained for P plans (88%, 87% and 85% for FJ, DJ_1 and DJ_2). With regard to OARs, a significant dose sparing of penile bulb was observed for WP and P scenarios when DJ was used (mean dose difference up to 12 Gy). In the WP cases, no significant increase in the other OARs exposure was detected when FJ was compared with DJ_1, as most OARs are generally located within the irradiated area. The larger FW determined a slightly reduced sparing of most OARs (Fig 1). A significant reduction in delivery duration of 60% on average could be accomplished for WP and P irradiations with DJ_2.