**Stereotactic radiotherapy for brain metastases: Cyberknife® versus VersaHD®/ ExacTrac®**

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**Introduction :**

The objective of this study is to compare the dosimetric and geometric performances of the CyberKnife (Accuray) and VersaHD (Elekta) with the ExacTrac system (BrainLab) in stereotactic radiotherapy for brain metastases.

**Material and method :**

This study was conducted on 5 patients for a prescribed dose of 27 Gy in 3 fractions with a margin of 1 mm between CTV and PTV for the Cyberknife and 2 mm for the VersaHD in accordance with our clinical practices. The dosimetric study was also conducted with a 2 mm margin for the Cyberknife to assess the dosimetric impact of the margins.

Plans have been computed for the CyberKnife M6 v10.6 with non-isocentric multi-beams generated by inverse optimization on Multiplan v5.3 (Accuray). For the VersaHD equipped with ExacTrac v6.1 and used with the Frameless system (BrainLab), 4 non-coplanar arcs (VMAT) has been generated by inverse optimization on Pinnacle v9.10 (Philips).

The dosimetric evaluation focused on the coverage of PTV and volume of brain outside PTV receiving 23.1 Gy corresponding to the main criteria of medical approval. The volume of isodoses 6 Gy, 2.7 Gy and 1 Gy and the ratio of the volume of isodose 13.5 Gy and 27 Gy have been reported to characterize the spread of low doses and the dose gradient around the PTV.

Quality controls have been performed with radiochromic films (EBT3/Ashland) and with an ionization chamber (Pinpoint 31014 /PTW) in an anthropomorphic phantom (STEEV/CIRS). The dose measured by film has been compared to the calculated dose according to the method of the gamma index with 3% (local) / 2 mm criteria (analytical threshold : 30% of the maximum dose). The geometric difference between the measured and calculated dose distribution has been also reported.

**Results :**

Table 1 shows that validation criteria were reached for both modalities. For an equivalent PTV coverage, dose gradients obtained with the Cyberknife were greater than those obtained with the VersaHD and lower volumes of healthy tissue received doses lower than 6 Gy.

The mean differences between the dose measured by ionization chamber and the calculated dose were 2.3% and -0.5% with Cyberknife and VersaHD respectively. The mean value of the gamma index was 0.41 for the Cyberknife and 0.35 for the VersaHD. The mean geometric differences between the measured and calculated dose distributions were 0.86 mm and 0.50 mm Cyberknife to VersaHD.

**Conclusion :**

Both treatment modalities, Cyberknife and VersaHD with ExacTrac, allow compliance to dosimetric criteria in the stereotactic treatment of brain metastases. The Cyberknife provides higher dose gradients than the VersaHD and limit irradiation of healthy tissues at low doses. The agreement between calculated dose and measured dose was acceptable for both modalities with mean gamma values​​ lower than 0.5. An investigation will be performed to evaluate low margins (1 mm) with the VersaHD / ExacTrac due to the very low geometric deviations.

**Key-words**: Stereotactic radiotherapy; brain metastases; Cyberknife; VersaHD; ExacTrac

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| --- | --- | --- | --- |
|  | **Cyberknife** | **VersaHD/Exactrac** | **Criteria**  |
| **CTV → PTV margins** | **1 mm** | **2 mm** | **2 mm** |
| **V PTV (27 Gy) (%)** | 97.6 | 97.9 | 97.5 | > 95 |
| **V BRAIN OUTSIDE PTV** **(23.1 Gy) (cm3)** | 2.6 | 2.8 | 2.9 | < 7  |
| **V 13.5 Gy / V 27 Gy** | 3 | 2,8 | 3.6 | Ideal : 1 |
| **V 6 Gy (cm3)** | 51.9 | 58.7 | 88.5 | Ideal : 0 |
| **V 2.7 Gy (cm3)** | 174.1 | 210.1 | 237.9 | Ideal : 0 |
| **V 1 Gy (cm3)** | 626.5 | 679.2 | 859.2 | Ideal : 0 |

***Tab. 1 :*** *Dosimetric comparison for 5 patients between Cyberknife and VersaHD with Exactrac for stereotactic radiotherapy of brain metastases (mean values)*