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Linac-based radiosurgery for Parkinson tremor. Case review

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Introduction

Parkinson's disease is a neurodegenerative disorder characterized by the presence of motor symptoms, with tremor being one of the most frequent. There are multiple treatment options, the most common ones being medication, deep brain stimulation (DBS), radiofrequency ablation, and stereotactic radiosurgery (SRS). **The purpose of this paper is to report on the workflow and outcome of a patient with Parkinson's disease tremor treated with linear accelerator radiosurgery (SRS).**

Materials and Methods

A 70-year-old patient with Parkinsonian tremor of the right upper limb which had been present for 8 years, showed a poor response to medication (Levodopa 250 mg, Carbidopa 25 mg) The patient score was 73 points on the Fahn Tolosa Marin tremor scale (FTM - subjective global assessment of 75%), as shown in Figure 1. As a treatment approach, functional radiosurgery was chosen, delivering a dose of 140Gy at Dmax on the left side. High resolution MRI images were obtained using a (Siemens, 3 Tesla) and the following sequences T1, T1 CC (contrast), T2 Flair and DTI (32 directions) were used. DTI images were corrected for geometric distortion using the T1 sequence by Elements Cranial Distortion Correction (Brainlab). To identify specific brain structures and regions, Elements Anatomical Mapping and Basal Ganglia (Brainlab) were utilized to generate the brainstem, optical system, Ventral Intermediate Nucleus (VIM), Internal Capsule, Thalamus, Nucleus Ruber, Dentate Nucleus, and Precentral Gyrus. Using Elements Fibertracking (Brainlab) the left DRT tract (Dento-Ruber-Thalamic) was identified by setting specific parameters (Minimum FA: 20, Minimum length: 80 and Maximum angulation: 20), as depicted in Figure 2. This methodology, based on probabilistic tractography, allowed to obtain the fibers defining the connectivity from premotor and supplementary motor areas, and also identifying the regions of the thalamus. The patient was immobilized using an SRS thermoplastic mask (Brainlab) and a CT scan was performed with a slice thickness of 0,6 mm. CT images were fuse to MRI images. The initial isocenter was located in the VIM of the left thalamus by indirect coordinates (AC-PC) using the Trajectory application (Brainlab) based on the T1 CC sequence. The Protocol used was based on determining a point corresponding to 25% of the AC-PC distance prior to PC, lateral displacement of 11 and 2mm in cranial direction. These coordinates were verified through the anatomical atlas (Schaltenbrand and Wahren). The VIM nucleus of the thalamus is targeted using stereotactic coordinates via identification of the anterior and posterior commissures (AC and PC), and the third ventricle as major landmarks. Specifically, an x coordinate, 11.5mm lateral to wall of the third ventricle. The y coordinate, or anterior-posterior coordinate, is 25% of the AC-PC distance plus 1 mm anterior to the PC. Finally, the z coordinate, or superior-inferior coordinate, is 2.5 mm superior to the plane of the AC-PC line. It is adjusted as necessary slightly medially to avoid the internal capsule. The identification of the dentatorubrothalamic tract helps to locate the VIM nucleus. The final isocenter was defined taking into consideration the position of the left DRT fiber and left internal capsule. The distance between the initial and final isocenter was 1.1mm. A 6MV FFF beam (1400 MU/min) from a TrueBeam STx linear accelerator with 4mm conical cone system was used. The mechanical precision of the Linac was verified through Winston Lutz (WL) test using portal images, 7.5mm cone and 8 gantry and table combinations. The WL test was analyzed obtaining a maximum variation of less than 0.6mm. Elements Cones (Brainlab) was used for treatment planning using a 20-arc template of 110 degrees each. A dose of 140Gy was delivered to the isocenter, Figure 3. The patient-specific quality control consisted of an independent dose calculation and verification of collision-free treatment on the treatment mask.

Figure 1

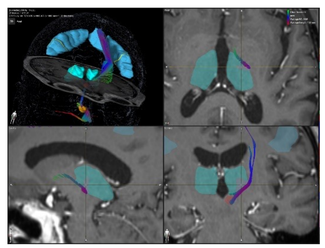

Figure 2

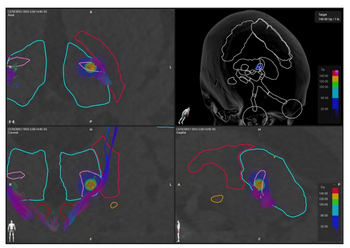

Figure 3

The patient was positioned on the treatment table using the Cranial infrared position array. The final position was defined through the ExacTrac system. This was the main image guidance system performing verification and/or position corrections if the variation between the planned and actual position exceeded 0.5mm/0.5degrees. The initial treatment position for 0 degrees couch angle was verified by a CBCT. The treatment was performed on February 24th, 2022 and the total treatment time was less than 75 minutes.

Clinical and imaging follow-up

The patient was monitored one month after treatment, showing a slight improvement in tremor. At 4 months post-treatment, the patient presents a marked improvement, on the FTM scale he obtained a value of 31 (previous 53) and a subjective global assessment of 25%. An MRI was performed, evidencing in T1 images with gadolinium a tenuous hypointense lesion of 2 mm with a hyperintense halo that together measure 5.2mm whose center coincides with the treatment isocenter. At 8 months post-treatment, Brain MRI was performed where the lesion of the same size was observed but with a marked increase in its hypo- and hyperintensity. At 16 months, complete improvement was observed, with no action tremor. A neurological evaluation was carried out with the FTM scale with a value of 11 (previous 53) and a subjective global evaluation of 0% (previous 75%), Figure 4. A control MRI was performed, observing the lesion of the same size and characteristics, Figure 5.

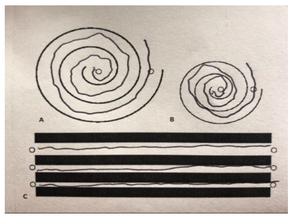

Figure 4

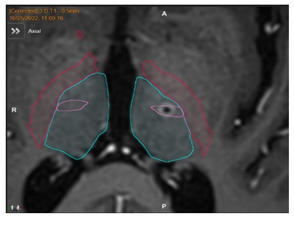

Figure 5

Conclusion

As this case report is showing, it is feasible to create focused lesions isolated to the region of interest within the thalamus using LINAC-based SRS. The evolution of this patient showed a remarkable clinical response at 16 months after treatment with a correlation between the VIM and the target.