Feasibility Study of Tantalum Markers for the Treatment of Ocular Melanoma with Cyberknife Stereotactic Radiotherapy

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Objective(s): We aim to describe our experience in the Cyberknife treatment of ocular melanoma with three different approaches for eye positioning and tracking.

Methods: From April 2014 to May 2019 34 patients suffering from ocular melanoma were treated at Cyberknife Center, Centro Diagnostico Italiano, Milan.

The Cyberknife can accurately target structures having a rigid relationship to the skull; however, skull tracking does not provide a means to track eye movement. The first 8 patients were treated using a peribulbar anesthesia, performed while the patient stared ahead to the same fixed point. The eye was then stabilized about 20 minutes before the acquisition of the simulation CT (with a standard thermoplastic mask) and before each treatment session by the same ophthalmologist. All patients underwent orbit MRI with gadolinium and the target volumes were delineated on the fused CT/MRI data set. We also performed a CT scan prior to each session, which was coregistered on the skull with the planning CT to evaluate the displacements of the lens/optic nerve insertion in all directions.

Secondly, eye immobilization was simply performed keeping the patient's eye closed while resting with a bandage on it, both during the simulation and the treatment. Also in these cases the patients were reimaged prior to every session to estimate eye position.

The PTV volume was obtained adding 2.5 mm margin in all directions to the GTV (coinciding with CTV), defined as the contrast-enhanced lesion appearing on the MRI study.

The feasibility of using some radio-opaque markers implanted to the eye was investigated to potentially reduce PTV margins. Tantalum markers are sutured to the sclera around the tumor; they are nonmagnetic, highly resistant to chemical attack and arouse very little adverse biological response.

Preliminary CT and MRI scans were performed placing the markers on anthropomorphic phantoms to assess any metallic artifact and to evaluate their detectability on the 2D image guidance X-ray images.

Results: Practicing anesthesia proved to be inappropriate, as the eyeball had the tendency to displace from its original position in an unpredictable way, verified by means of the pre-treatment CT scan. In some cases it was necessary to replan on the new CT.

In the second approach the coregistration between the simulation and the pre-treatment CT was performed to check the lesion's position and to evaluate the goodness of the

margins applied to the GTV. Rotations of the eye were detected in a small number of patients, while translations were always negligible. Starting from the x, y and z displacements of the lens/optic nerve insertion measured on all the coregistered scans and using the Van Herk margin formula, we found that our 2.5 mm in all directions was appropriate. The value of this technique was limited by the fact that the intrafraction movement of the eye wasn't monitored during treatment. The first phantom results on the use of tantalum markers as surrogate of the eye motion seem encouraging, because they produce an acceptable level of metallic artifacts and are clearly visible on the X-ray images used for IGRT. Although not strictly noninvasive, this procedure could lead to a margin reduction (estimated to about 1.3 mm), thanks to the capability of performing a real time tracking.

Conclusion(s): The use of tantalum markers for ocular melanoma radiotherapy is promising for the improvement of treatment accuracy and potential toxicity reduction.