Investigation of the effect of fixation devices on dose delivery in radiation therapy of head tumors

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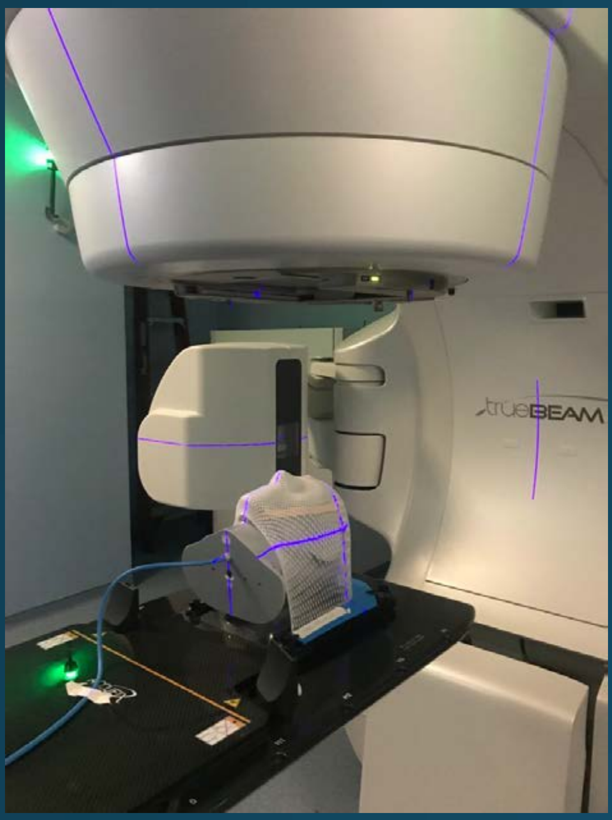
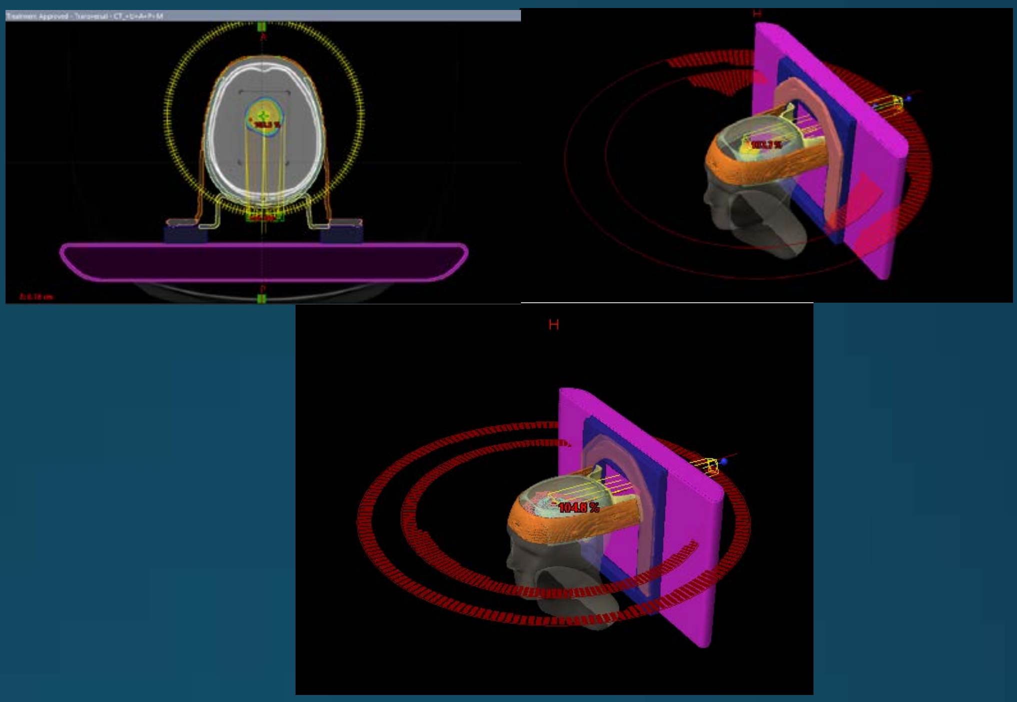
The main goal of radiation therapy is to irradiate the target with a given dose while maximizing the protection of healthy tissues and organs. According to the theoretical data from radiobiology and the ICRU recommendations, to achieve the maximum results of radiation therapy, dose delivery with an accuracy of 3-5% is required [1]. The dosimetric effect of devices external to the patient is a complex combination: an increase in the dose to the skin, a decrease in the dose in a tumor, and a change in the dose distribution [2]. Despite the fact that the use of dosimetry protocols (TRS-398, TRS-483) and modern dose calculation algorithms can significantly reduce the uncertainty in dose delivery, the presence of immobilization devices is usually overlooked in treatment planning.

We studied the effect of immobilization devices on the dose in the skin layer and the average dose in the target during RT of head tumors. In the Eclipse treatment planning system, VMAT irradiation of target (ball of radius R = 3 cm) was simulated in the CIRS STEEV patient's head phantom with the inclusion of the following Q-fix fixation devices in the phantom model: headrest, thermoplastic mask (U-shaped mask support, thermoplastic part of the mask), base plate ACCUFIX. The PTW 3D Semiflex ionization chamber (measuring volume 0.07 cm3) for measuring the average dose in the target was positioned in the geometric center of the target. Parameters such as the speed of the accelerator gantry, the speed of movement of the multi-leaf collimator blades and their position, dose rate and beam energy remained unchanged for all dosimetric irradiation plans. The therapeutic table was taken into account in all cases; when analyzing the irradiation plans, the dose distributions were normalized to 1. The experiment on measuring the average dose in the volume of the ionization chamber was carried out on a linear medical accelerator TRUEBEAM (Varian).



Linear medical accelerator TRUEBEAM with anthropomorphic phantom head-neck CIRS STEEV, ionization chamber PTW 31021 3D Semiflex and Q-fix thermoplastic mask for radiation therapy.



Experiment geometry rendered in Eclipse planning system

mask structures not used in the calculation	Target				Skin
	D_{min}, %	D_{max}, %	D_{mean}, %	$D_{95\%V}$, %	D_{mean}, %
U, A, P, M	1,33	1,35	1,26	1,26	1,25
A, P, M	1,01	0,97	0,91	0,95	1,11
P, M	0,51	0,51	0,40	0,42	1,11
M	0,19	0,14	0,15	0,21	1,11
all fixing parts are included in the calculation	0	0	0	0	0

The errors in dose calculation in the absence of various parts of the fixing mask or headrest in the model of planning a session of radiation therapy for head tumors (U - shaped mask base, A - support Acufix, P - headrest, M - thermoplastic part of the mask).

The simulation results showed that the failure to take into account fixing devices in dosimetric planning (not including fixing devices in the patient model) can lead to an underestimation of the average, maximum, minimum dose in the target and target coverage by 1.3%, 0.8%, 1.4 % and 1.3%, respectively. The use of a 1.6 mm U-shaped thermoplastic Q-fix mask as a fixing device increases the dose in the cutaneous 1.1% (the thickness of the skin layer according to the recommendations of RTOG 1021 [3] is a layer of 5 mm from the edge of the phantom). The simulation results are in good agreement (less than 0.2%(+-0.03%) discrepancy) with the measurements of the average dose in the target. The thermoplastic part of the mask takes into account the smallest error relative to the rest of the fixing device. The results obtained show the need to take into account the immobilization device when planning radiation therapy for head tumors, since the errors caused by their absence in the model are comparable to the allowable limits.

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This research has been supported by the Interdisciplinary Scientific and Educational School of Moscow University «Photonic and Quantum technologies. Digital medicine»