Clinical Indications, Use, and Accuracy of Patient-Specific 3D Milled Foam Immobilization Devices

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I. Introduction

Radiation therapy workflow encounters challenges in daily patient repositioning. Foam immobilization molds were a developed solution in collaboration with .decimal™ (Sanford, FL) at our facility. This addressed a variety of treatment modalities including proton therapy, MRI guided therapy, SBRT as well as clinical indications for routinely difficult setups such as extremity treatment. It was also used to exact patient treatment positions to PET scan positions for better targeting of metastases. This poster details the clinical indications for this device, its use, and its accuracy.

II. Methods

To date, foam immobilizers have been applied to 15 different cases. First, a patient body contour from volumetric imaging was transferred to .decimal™ for foam manufacture. For each device, 3D volumetric scans of the patient with and without the foam molds were compared for fit to patient anatomy as determined by rotational corrections from image fusion using Eclipse treatment planning system (Varian Palo Alto, CA). For fractionated treatment courses, the daily setup standard deviations were evaluated to check interfraction setup variations using the foam immobilization device.

III. Foam Immobilization Setup

The patient-specific 3D immobilization device is created from exporting a patient scan to .decimal™ (Sanford, FL), upon which a milling machine file is created to the negative of the body contour, representing the patient surface. The device is usually milled in several sections, and when created takes the appearance of a blue foam. Indications for use of this immobilization device include diagnostic scan-based planning treatment alignment, accommodation of proton portals, and creation of patient anatomy separation. The left side of the following setup variability table displays the rotational corrections necessary to register the planning CT to the foam immobilization CT (either another simulation or alignment). The correlating day to day patient setup variability using these foam molds may be seen on the right side. High setup variability may be indicative of additional difficulty in the radiation therapist workflow when using these immobilization devices.

IV. Clinical Indications and Experience

Patient	Site	Treatment	Clinical Reasoning
1	Lower Extremity	Tomo	Foam was designed with modification to form an opening to spare genitalia.
2	Abdomen	Tomo	Added support for patient setup.
3	SBRT Rib	VMAT	Improvement of fusion between the PET study and simulation CT to target with SBRT.
4	Liver	Protons	Effecting a cut-out beam path for lateral beams where this wasn't possible with a vacuum cast.
5	Pelvis	3D	Severe patient discomfort in the prone simulation position warranted a cast to be made from a diagnostic PET/CT so that the patient could be treated supine.
6	Lower Extremity	Tomo	Patient started treatment with a vacuum cast but setup reproducibility was poor. Foam was designed to extend through the entire knee and mid-calf for better setup.
7	Pediatric Pelvis	Tomo Protons	Foam was designed to help in positioning and stabilize patient during treatment.
8	Pediatric arm	3D	Vacuum cast was not fitting well to immobilize the arm/hand. The foam cast was designed to position the arm without rotations.
9	Lower Extremity	MRI-RT	Patient started treatment with a vacuum cast but setup reproducibility was poor. Foam device was designed to reproduce patient setup position within the MRI coil.
10	Gynecological pelvis	VMAT (1fx)	Patient was planned on PET/CT for emergent single fraction treatment for bleeding. Foam device was employed to replicate PET/CT position and eliminate the need for simulation (COVID restriction on visits)
11	Liver	Protons	Foam was designed to with a cut-out beam path for lateral proton beams, not possible with vacuum casts.
12	L-Spine	2D	PET/CT was used as simulation scan due to COVID or pain complications. Foam immobilization, treatment plan, and treatment setup were based off the PET/CT.
13	Esophagus	Protons Photons	Foam device was designed based on the PET/CT to help with image fusion for planning.
14	Sacrum	VMAT (1fx)	Based on video consultation, the patient was prescribed single fraction radiation therapy for palliation. Foam device was designed based on PET/CT, and the patient planned on PET/CT to eliminate simulation.
15	SBRT T-Spine, L and R Ribs	VMAT	Foam device was designed from the PET/CT to aid with the fusion of PET scan bone mets for SBRT planning.

V. Setup Variability

Treatment		Planning Variability			Day to Day Setup Variability					
					Std. Deviation (mm)			Std. Deviation (°)		
Pt#	n	X (°)	Y (°)	Z (°)	Lateral	Vertical	Longitudinal	Pitch	Yaw	Roll
1	29	-0.3	-0.6	0.3	1.7	3.4	3.5	-	-	0.6
2	18	0.5	1.4	0.2	2.6	3.0	2.5	-	-	0.3
3	5	-2.4	-0.8	-0.3	2.9	4.0	6.4	1.3	0.3	0.7
4	25	1.0	2.6	-2.1	-	-	-	-	-	-
5	3	1.1	0.6	1.0	1.4	2.8	0.0	-	-	-
6	25	-4.2	0.5	-1.8	6.2	14.3	5.5	-	-	1.1
7	28	2.2	-0.6	-4.5	2.3	4.3	2.9	-	-	3.5
8	28	-	-	-	4.7	2.7	1.8	0.0	0.2	0.0
9	-	0.2	3.1	2.9	-	-	-	-	-	-
10	1	2.3	-1.1	1.9	-	-	-	-	-	-
11	14	1.2	2.7	1.1	3.8	3.9	13.4	0.6	0.9	0.5
12	2	-3.6	1.8	-0.8	7.6	0.0	3.4	0.0	0.0	0.0
13	23	-1.4	0.1	0.2	3.2	5.8	3.8	0.1	0.2	0.2
14	1	0.5	-0.2	0.0	-	-	-	-	-	-
15	3	0.3	0.0	0.0	0.7	0.9	4.9	0.8	0.1	0.5

VI. Results

The .decimal™ foam immobilizers provided excellent fit, with low average pitch (1.06° ± 1.23°), yaw (0.81° ± 0.98°), and roll (0.86° ± 1.19°). There was consistent day to day setup variability, with low rectangular shift deviations in the lateral (1.99 mm ± 2.20 mm), vertical (2.25 mm ± 3.33 mm), and longitudinal (2.40 mm ± 3.27 mm) directions. Angular shift deviations were also observed to be low. The average day to day setup variabilities among patients were pitch (0.14° ± 0.35°), yaw (0.09° ± 0.21°), and roll (0.37° ± 0.77°).

VII. Conclusion

We have developed a method for creating patient specific foam immobilization that can be used to replicate the patient diagnostic scan position or can be used to immobilize patients in configurations that are not possible with conventional vacuum casts. This process was used on several cases and can be implemented to any treatment site or treatment modality.