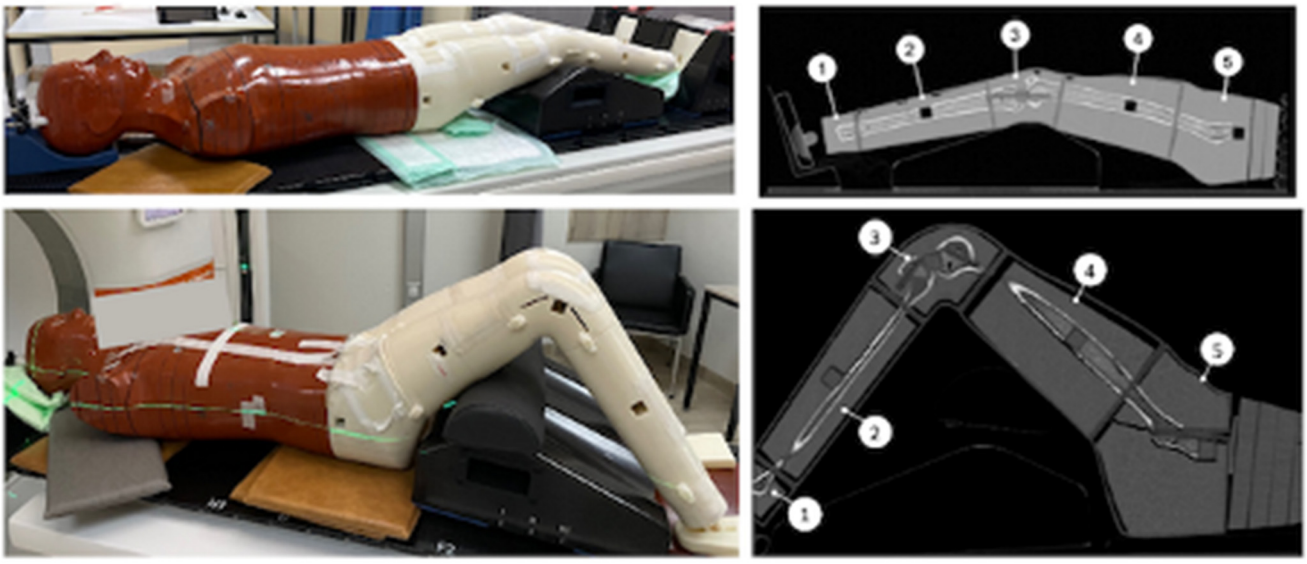

Figure 1 (abstract DIY.11): The two variant set-ups of the modular leg phantom in combination with a commercial torso phantom (left) and CT images (right). The standard modules are the foot (1), the calf (2) and the thigh (4), while the knee (3) and hip (5) are variant. Also visible are inserts for ionization chambers and radiochromic films.

anthropomorphic phantom with different leg positions facilitates plan optimization and verification at standard and extended SSDs. The purpose of this work was to develop an additive manufactured modular phantom of the leg, to be used in combination with a commercial phantom of the torso for TBI treatment plan studies.
Materials & Methods: The phantom comprises three standard (foot, calf, thigh) and two variant components (knee and hip) to simulate patient positions with straight and angled legs, respectively. Inserts for dose measurements are integrated into the knee and hip joints, as well as in the femur and fibula. We analysed several surrogate materials for mimicking soft tissue, bone marrow, and cortical bone, in order to ensure a stable and long-term usability of the phantom.
Results: We created a hollow geometry of bones and legs by means of additive manufacturing. The bones are filled with a mixture mimicking bone-marrow, which mainly consists of dipotassium hydrogen phosphate and Vaseline. A gypsum layer, applied externally, models cortical bone. Finally, the hollow legs are filled with a soft-tissue surrogate, based on an agarose-carrageenan mixture. Figure 1 shows the leg phantoms with corresponding CT images.
Summary: The modular phantom developed and manufactured in this work can be easily attached to a commercial phantom of the torso. This allows for optimization and verification of several TBI techniques, so that dose calculations can be carried out and compared with measurements at any SSD.
Appendix:

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DIY.12
DEVELOPMENT OF AN ADDITIVE MANUFACTURED ANTHROPOMORPHIC CBCT IMAGING HEAD PHANTOM

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Introduction: Increasing research in the field of adaptive radiotherapy and radiomics has enhanced the use of CBCT for imaging studies. However, systematic investigations on their reproducibility are still missing. For this purpose, durable, cost-effective phantoms, which meet specific anatomical and x-ray contrast requirements, can be produced by additive manufacturing (AM). In this work, we developed an anatomically-detailed head phantom after analysing several AM-suitable materials.
Materials & Methods: We evaluated the x-ray attenuation properties of AM filaments for fused deposition modeling (FDM), adjusting their infill pattern and density. We then investigated mixtures of silicone, silicone oil, and gypsum in several concentrations, which can be used to fill up corresponding cavities. Finally, we used a head-and-neck CT dataset [1] to segment corresponding anatomical structures and designed a first phantom prototype.
Results: By varying the infill density of white PLA between 80% and 100%, the CT numbers vary from (-40 ± 10) HU to (98 ± 15) HU. Mixtures of silicone, silicone oil, and gypsum exhibit CT numbers between (170 ± 10) HU and (800 ± 20) HU. The phantom prototype, which was manufactured with an FDM printer, can be seen in Figure 1, together with CT images and 3D model.
Summary: The use of PLA filaments and mixtures of silicone, silicone oil, and gypsum are well suited to manufacture a non-expensive, robust head phantom to systematically investigate the reproducibility of CBCT imaging features.

Appendix

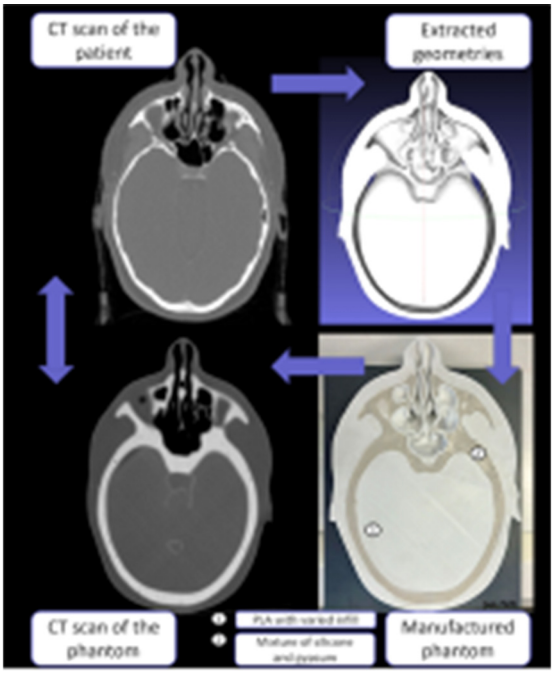

Figure 1: Manufacturing of head phantom prototype: printable structures were extracted from the patient CT scan; the phantom was manufactured using PLA filament and filled with a bone surrogate; CT image of the phantom was compared to the original one.

Reference:

[1] Podobnik G, Strojan P, Peterlin P, Ibragimov B, Vrtovec T. HaN-Seg: The head and neck organ-at-risk CT and MR segmentation dataset. *Med. Phys.* 50(3):1917–1927.

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