GERMAN CANCER RESEARCH CENTER IN THE HELMHOLTZ ASSOCIATION

Research for a Life without Cancer

ADAM-pelvis phantom update:

Using different dosimetry detectors to measure the dose by an end-to-end validation

Authors: Wibke Johnen[1,3], Clarissa Gillmann[1,3], Mathieu Marot[1,3], Andrea Schwahofer[1,2,3], Armin Runz,[1,3], Gernot Echner[1,3]

[1]German Cancer Research Center DKFZ, Medical Physics in Radiation Oncology, Heidelberg, Germany

[2]National Center for Radiation Research in Oncology (NCRO), Heidelberg Institute for Radiation Oncology (HIRO), Im Neuenheimer Feld 280, Heidelberg, Germany

[3]Heidelberg Institute for Radiation Oncology (HIRO), National Center for Radiation Research in Oncology (NCRO), Heidelberg, Germany

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INTRODUCTION

In radiotherapy, anthropomorphic multimodal phantoms are used to verify new treatment techniques. This work describes an end-to-end test for measuring 3D dose distributions in prostate and rectum in an anthropomorphic pelvis phantom using polymer gel (PG) and thermoluminescent detectors (TLDs).

AIM

We consider anthropomorphic phantoms to be very important in order to improve radiotherapy or to develop new procedures. In order to be used for the validation of image-guided adaptive treatment workflows, the phantoms should be anthropomorphic, multimodal and deformable. Polymer gel (PG) and thermoluminescent detectors (TLDs) are used to measure the radiation dose in the target (prostate) and adjacent organs at risk (rectum).

METHODS

An existing anthropomorphic pelvic phantom (ADAM) [REF 1 Niebuhr] was modified (figure 4). Organs as prostate and rectum were 3D printed. The prostate and its connection with the bladder was designed in a way that prostates can be exchanged in between treatment series. Furthermore, the prostate shell is printed in a special process enabling a filling with polymer gel (PG). Dose measurements in the rectum were perfomed with thermoluminescence detectors (TLD). Therefore, a holder was designed (Autodesk Inventor, Autodesk, San Rafael, SA) containing nine bags for TLDs, which are equidistant with three in a row and three in a coloumn. The holder is made of a combination of the 3D printing materials Agilus30™ and VeroClear™. It was created with the 3D printer Connex3 (Stratasys, Minnesota, US). The treatment plan was based on CT imaging. The whole irradiation process was conducted twice.

RESULTS

Several 3D printed prostate shells can be filled with PG and placed consecutively in the phantom. The connection within the phantom allows a reproducible replacing of prostate and TLD holder in only 15 minutes.
The dose in the rectum was measured successfully with TLDs with an average dose difference of 0.08 Gy (range: 0.02-0-21 Gy) between measured and calculated dose.
For a serial measurement several holders were used.

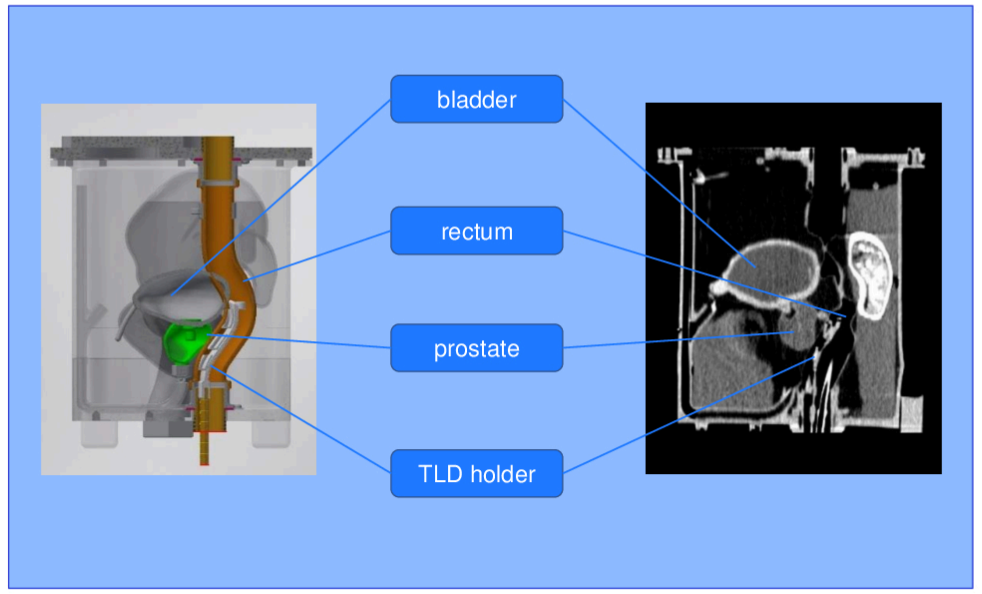

Figure 1: ADAM-prostate phantom in a technical software (left) and CT image of the real phantom (right).

For an anthropomorphic structure and shape of the phantom, DICOM data of a test person are used as basis. These data are then modified in the design software to create connections and moulds for the bladder (figure 1, left).
For a movable and expandable bladder, a mould is constructed and filled with silicone. This allows a variable bladder filling level (figure 2). The volume of the bladder can be changed from a normal level (120 ml) up to a triple amount (360 ml). The different filling states influence the position of the prostate. In addition, the position of the prostate is influenced by the rectal filling. In our phantom, this can be simulated by inflating a rectal balloon. For dosimetry measurements, the 3D printed prostate shell is filled with PG and a 9 TLDs mounted onto a specifically designed TLD holder (Figure 3) are inserted into the rectum attached to an endorectal balloon.

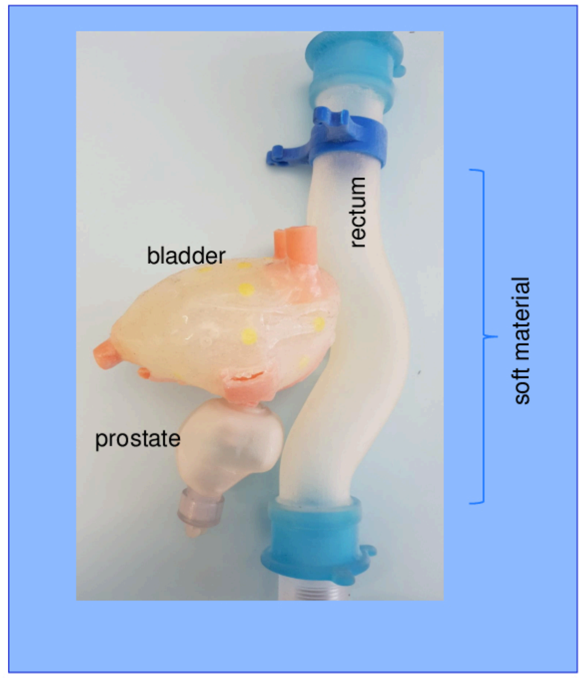

Figure 2: Silicon bladder, printed rectum and the connected prostate

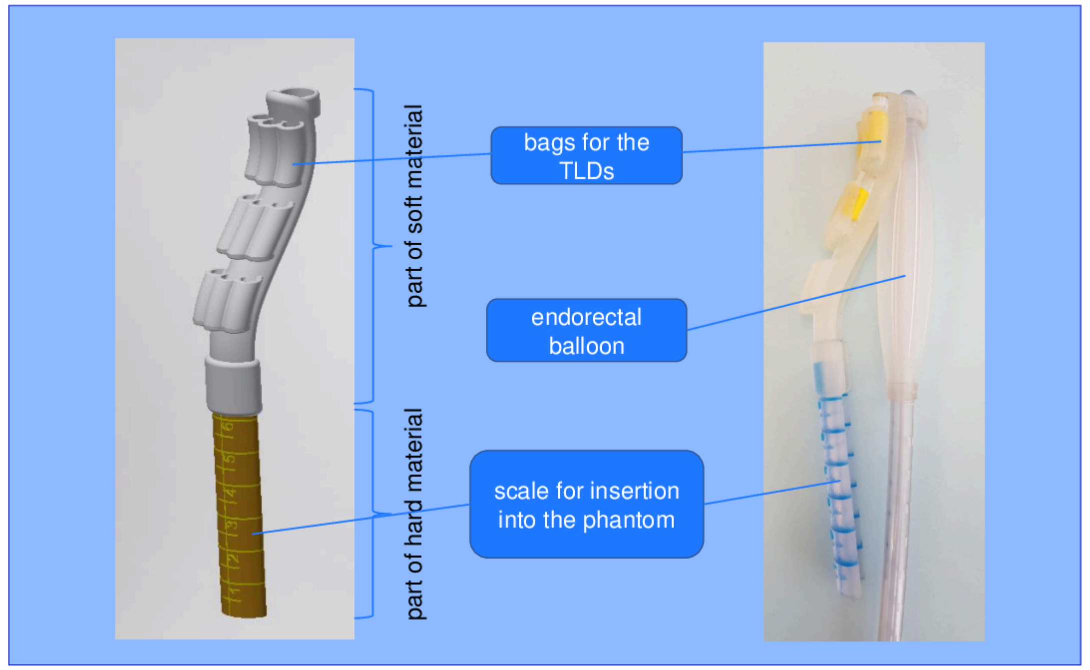

Figure 3: TLD holder in a technical software (left) and the printed TLD holder with the rectum balloon (right).

CONCLUSIONS

The redesign of the ADAM and the use of new 3D printing techniques and the construction of a specific holder for TLDs allows to integrate dosimetry detectors into anthropomorphic phantoms. It leads to a dose distribution conformal to he measurements.

MODIFIED PHANTOM

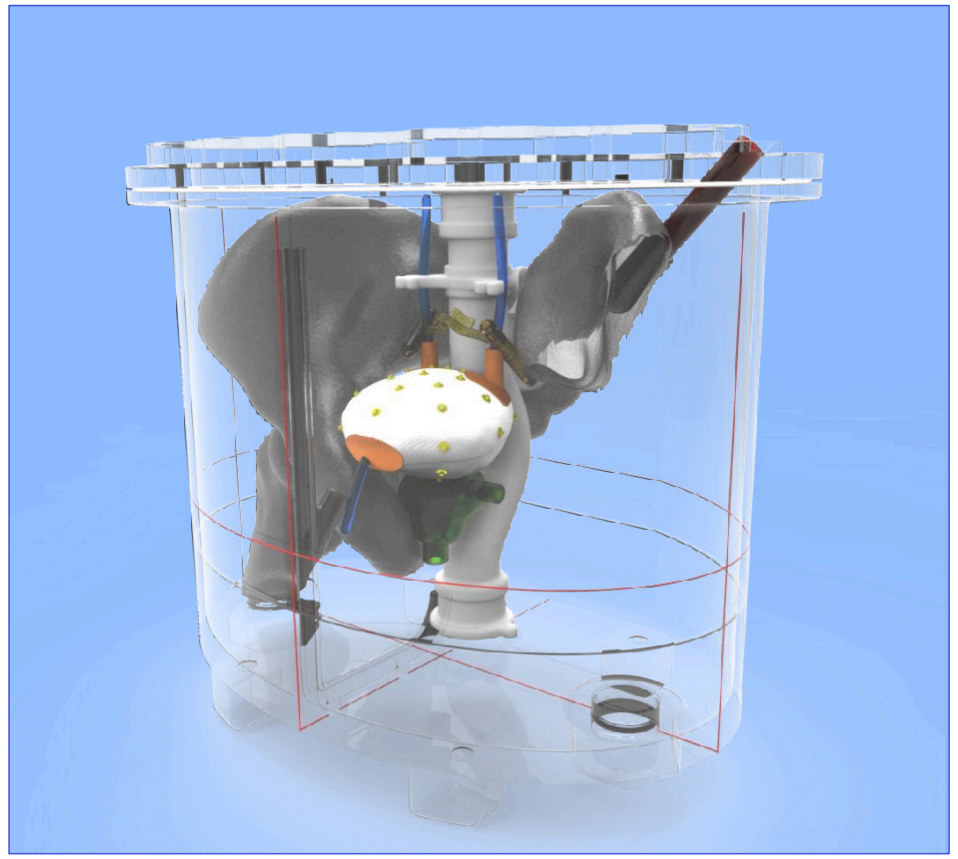

Figure 4: Rendering of the modified Adam-Peter Phantom. The hipbone was cut off to view the organs.

REFERENCES

[1] Niebuhr et al Med Phys 43(2), pp.908-16, 2016

CONTACT INFORMATION

w.johnen@dkfz-heidelberg.de (Designer)
c.gillmann@dkfz-heidelberg.de (Medical physicist)