Design and fabrication of training models for brachytherapy

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Disclosures

The authors have no financial interests or relationships with any of the manufacturers or vendors of equipment described in this presentation, nor with any of the commercial supporters of the EPSM Conference. The final slide includes a plug for a text-book co-edited and co-authored by authors of this abstract.

Consumables associated with this study were provided through the Herston Biofabrication Institute Cancer Care Services research program and the University of Queensland.

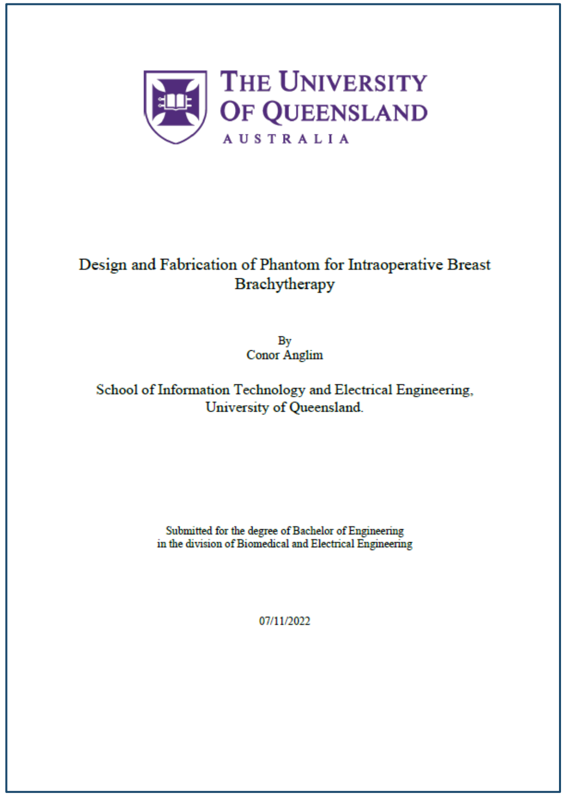
Educational models

The decreased utilisation and availability of brachytherapy as a treatment modality presents a challenge to training of new specialists, as not everyone is fortunate enough rotated through a department with brachytherapy.

Training models or phantoms may have a role to play in training new specialists.

The design and production of educational models is also an interesting topic for students studying biomedical engineering wanting a research project.

Sounds like synergy!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Design and Fabrication of Phantom for Intraoperative Breast Brachytherapy

By
Conor Anglim

School of Information Technology and Electrical Engineering, University of Queensland.

Submitted for the degree of Bachelor of Engineering
in the division of Biomedical and Electrical Engineering

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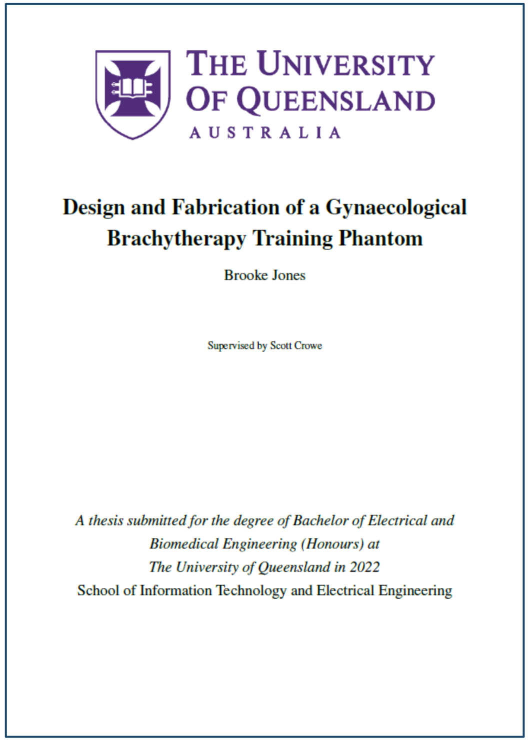
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Design and Fabrication of a Gynaecological Brachytherapy Training Phantom

Brooke Jones

Supervised by Scott Crowe

A thesis submitted for the degree of Bachelor of Electrical and Biomedical Engineering (Honours) at The University of Queensland in 2022
School of Information Technology and Electrical Engineering

RBWH interests

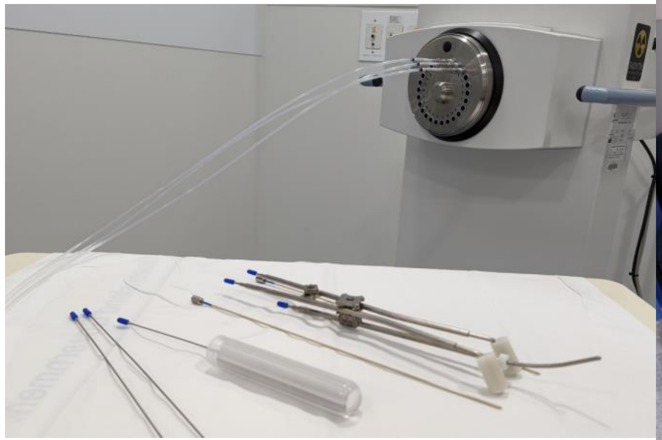
The RBWH has three brachytherapy systems:

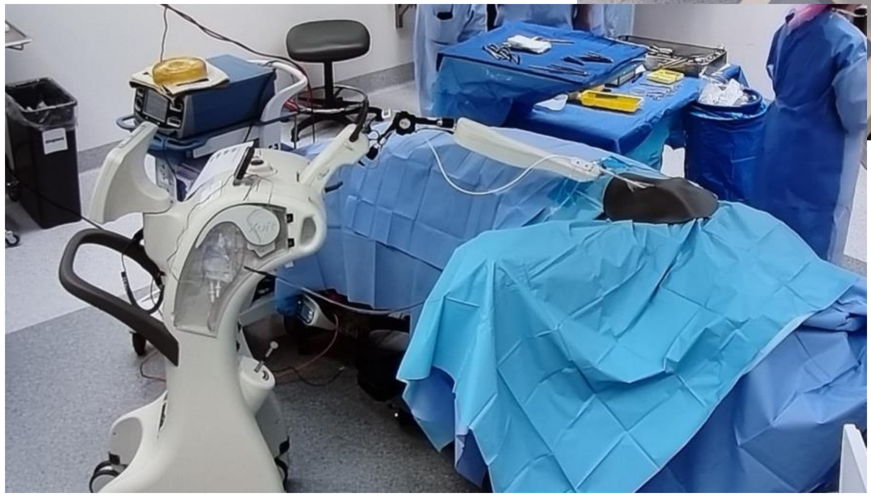
- Two Ir-192 afterloaders, used for HDR and PDR treatments. Gynaecological treatments constitute a majority of the workload, including custom-made moulds.
- One Xoft Axxent intraoperative unit, used for breast treatments.

The RBWH team also have an extensive 3D printing and fabrication program with the Herston Biofabrication Institute, partnered with UQ.

We asked two students to develop and test inexpensive anatomical models for potential use in staff training.

Design requirements included clinically realistic mechanical, geometric & imaging characteristics.





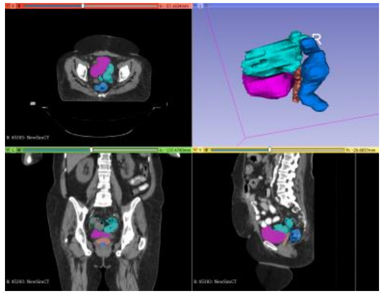
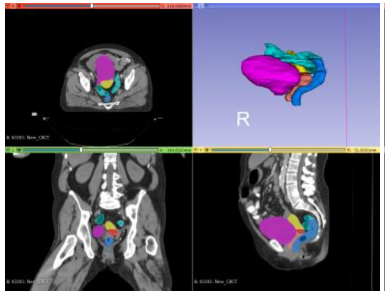
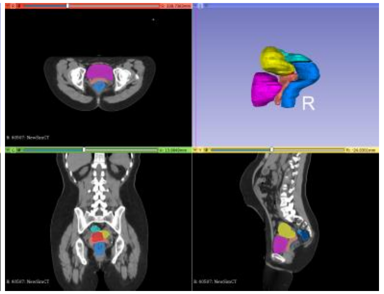
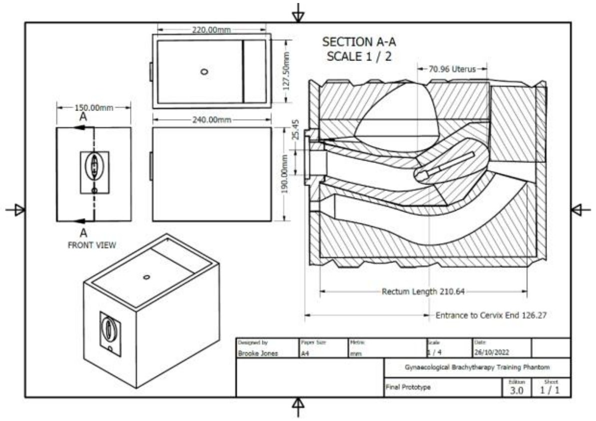
Method

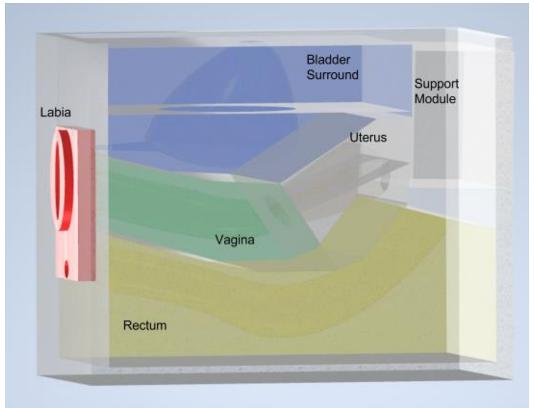
Unfortunately, 3D printable materials themselves aren't generally suitable for this purpose:

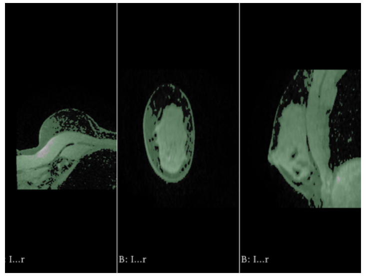
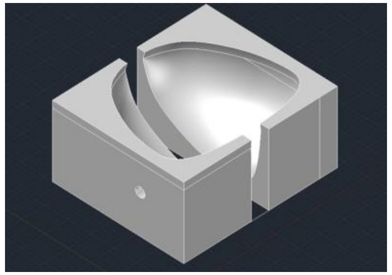
- Unsuitable for MR and ultrasound imaging.
- Mechanically different from human tissue.

Ballistic gels were explored as a potential solution. These were sourced from Humimic Medical. They are MR and ultrasound compatible, sold with different gellant concentrations to achieve tactile similarity to various tissues, are reusable, and don't expire.

Method



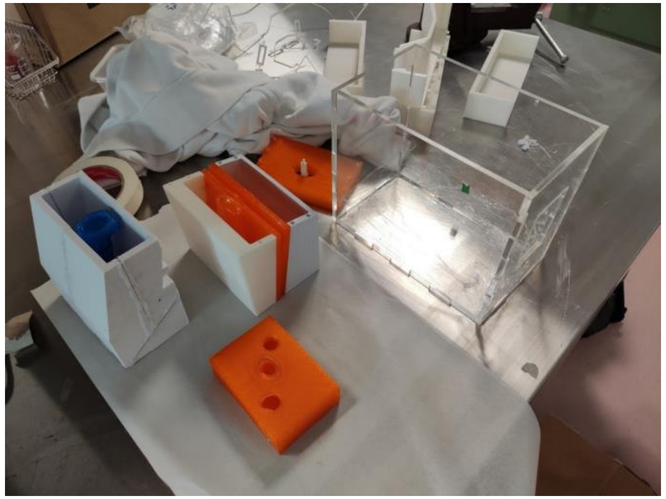



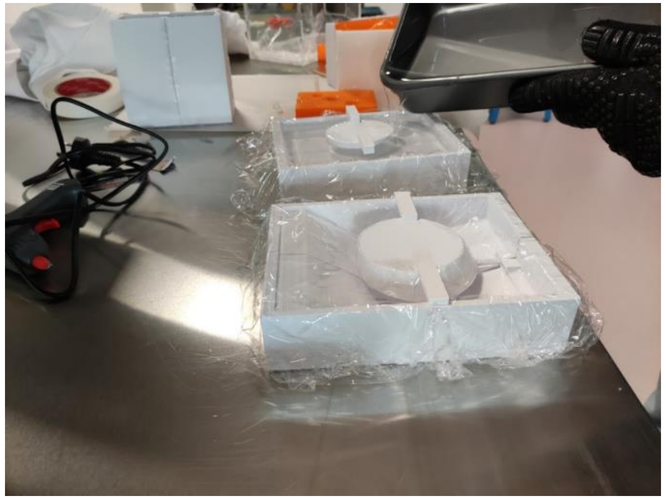

The models were designed using medical imaging data sourced from the Cancer Imaging Archive. Negatives were designed using CAD software. Feedback was sought from stakeholders during the design process.

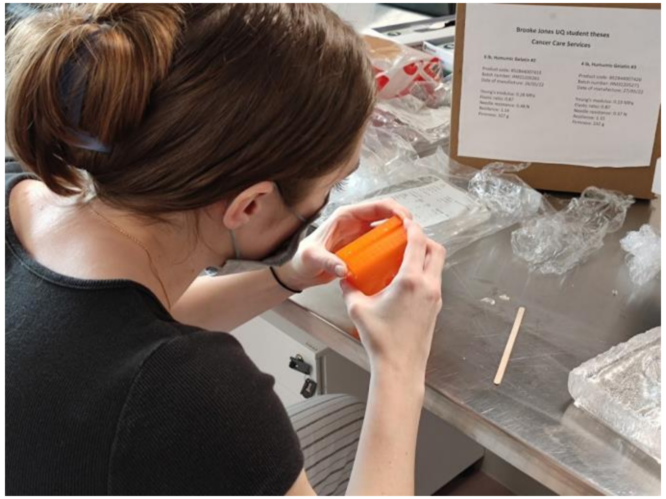
3D printing was used to produced moulds for gel pours. Cavities were added to the formed models through the use of dissolvable polyvinyl chloride (PVC) inserts.

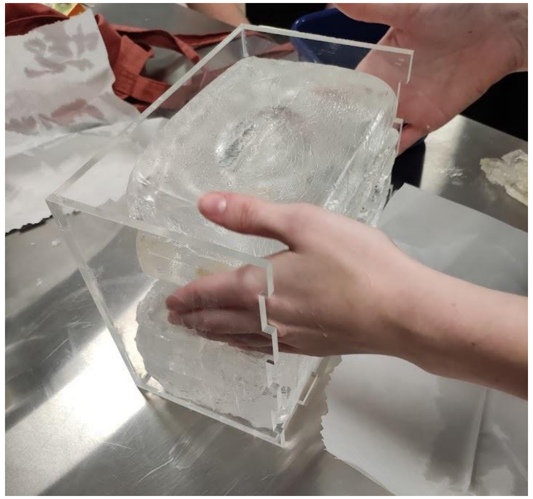
This was an iterative process, during which different post-processing techniques and mould-release solutions were explored.

Model production photos







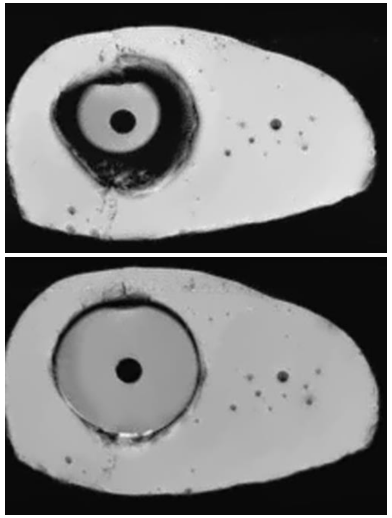


Breast phantom results

The breast phantom was able to be used to demonstrate the verification imaging of balloon applicator insertion, which is performed during the intraoperative procedure.

For example, we were able to identify poor contact between the tumour bed and the balloon applicator, and correctly measure depth of the phantom base (“chest wall”), which is done to inform OAR dose estimates during the planning process.





Results

Tandem and ovoid insertion by an RO and dome insertion by RT.

RO reported vaginal wall felt realistic and provided suggestions on revisions to geometry and material to improve ovoid placement, end-of-uterus detection and speculum use.

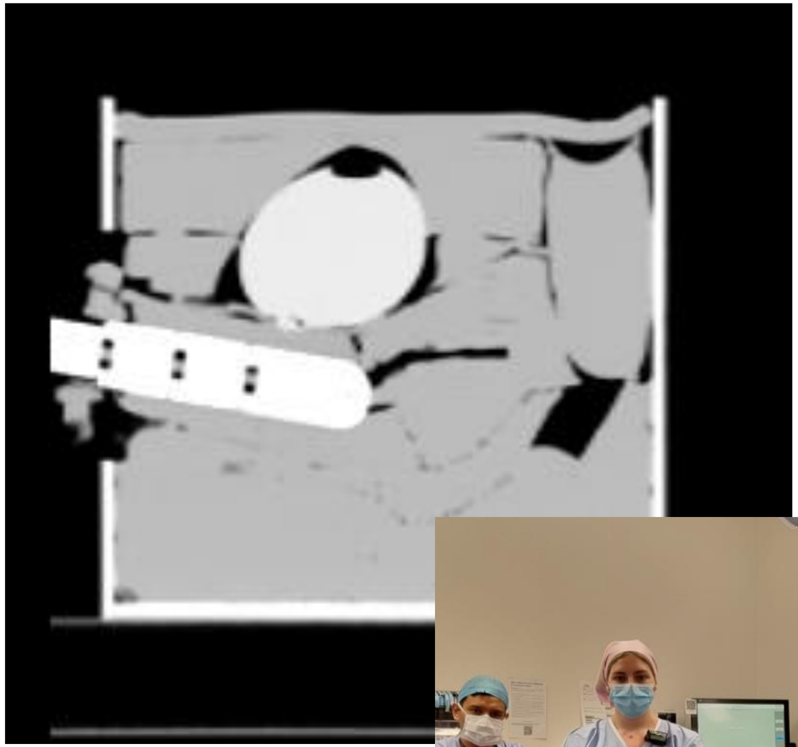
Conclusions

The gel phantoms developed in this study were found to be suitable for brachytherapy training, including the use of ultrasound to guide and verify insertion.

Assuming you already have gel stock (which is reusable), you are looking at less than $200 in consumables to produce the negatives.

We’ve since explored the use of the gel in MR visible SRS phantoms, including a failed experiment to add gadolinium as a contrast agent.

Biomedical engineering students are great!



Book plug

If you want to learn more about 3D printing in radiation therapy, consider this book!

It features chapters from many ACPSEM members, edited by Tanya, Tomas and myself!

https://store.ioppublishing.org/page/detail/3D-Printing-in-Radiation-Therapy/?K=9780750339056