Optimisation of GYN brachytherapy by 3D printing of personalized applicators

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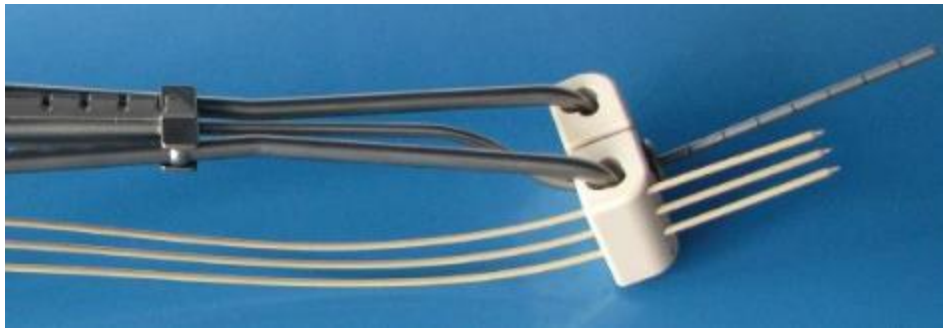
Project background: team

- Britt Haanen *Research Associate*
- Dr. ir. Celine van Beveren *Medical Physicist, Project Leader*
- Dr. Nienke Kuijsters *Radiation Oncologist*
- Dr. Ludy Lutgens *Radiation Oncologist*
- Dr. ir. Erik Roelofs *Medical Physicist, Medical Technology Supervisor*
- Robert Voncken *Brachytherapy Technician*

- Prof. Dr. ir. Frank Verhaegen *Head of Physics Research Department*
- Dr. Gabriel Paiva Fonseca *Assistant Professor Physics Research Department*

Project background: cervix procedure

- Brachytherapy Centre of Excellence
  - *+/- 200 brachy treatments per year*
  - *Cervix: 50 treatments per year (25 patients)*
  - *Use combined IC/IS technique:*
    - *Varian Fletcher applicator with interstitial ovoids*
    - *Varian Interstitial Cylinder*



Fletcher applicator with interstitial ovoids [1]

Interstitial cylinder [1]

[1] Varian Medical Systems Inc. Brachytherapy Catalogue Applicators & Accessories. Retrieved from https://varian.widen.net/s/wwyx9dru1f/brachy_catalog_rad10536a_september2019 (16/05/2023). 2019

Project background

‘We can do better’

Standard needle configurations not satisfactory

- *Combination oblique and straight*
- *New applicator forms*
- *Personalisation*

3D printing opens up a lot of possibilities

Project background

Aim of the project is two-fold

Use 3D printing to…

(1) Develop a set of ‘new standard’ templates based on our clinical experience *Focus for clinical implementation*

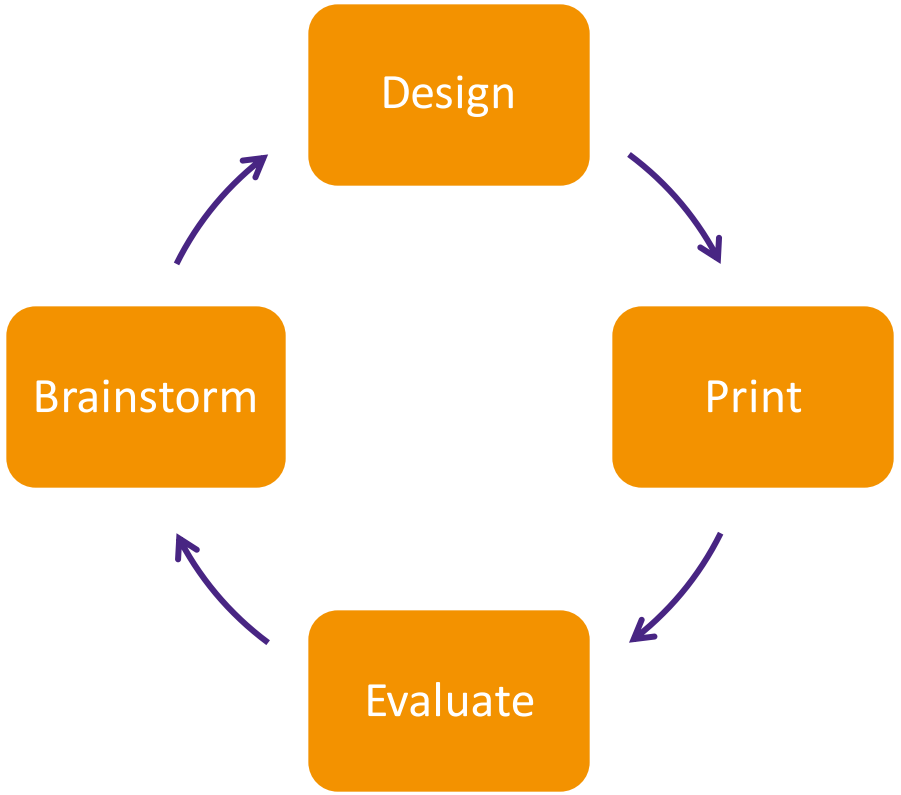
(2) Develop a method for full personalization of a template based on a pre-plan *Research phase*

3D printing: methods & results

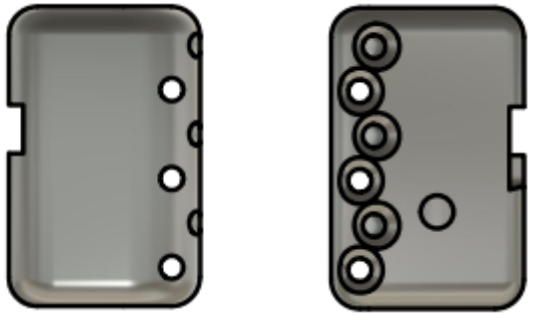
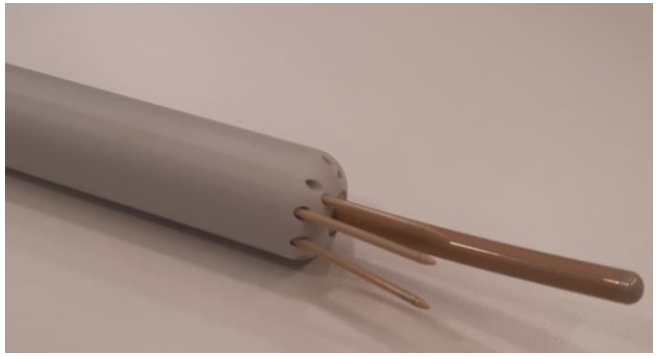
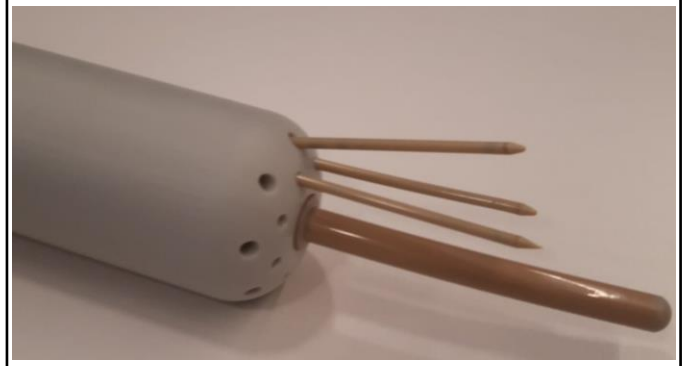
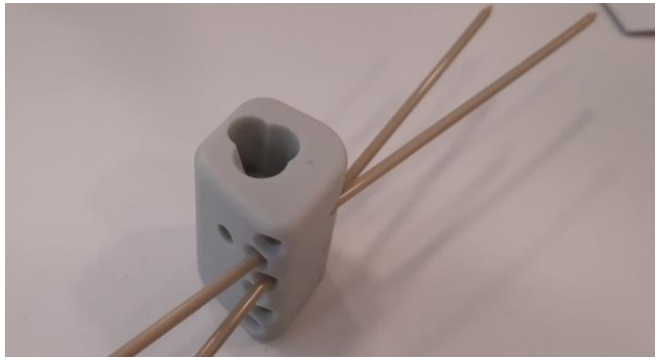
‘New standard’ designs: methods

- Starting point: current clinical material
- Adapt based on clinician and technician experience/need

‘Expanding our arsenal’

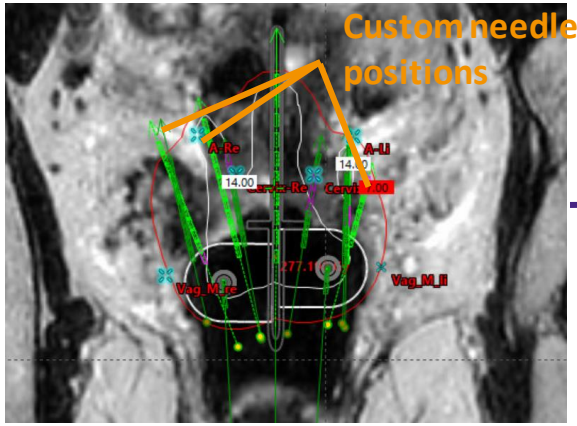


‘New standard’ designs: results

	1.) Optimised cylinder A (25 mm)	2.) Optimised cylinder B (30/35/40 mm)	3.) Optimised ovoid (mini/small/medium/large, 10 or 15 degree angle)
a.) Needle configuration			
b.) Printed design			

Personalisation: methods

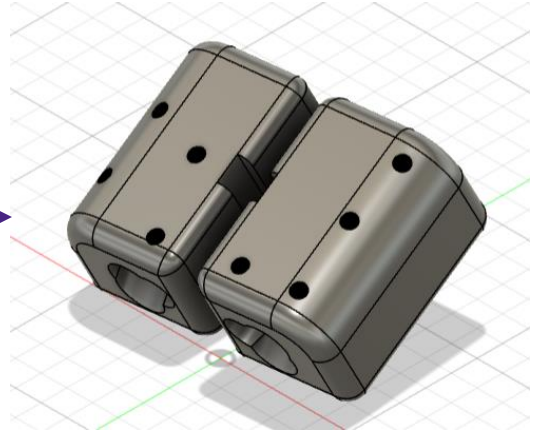
- Create a personalised design from a pre-plan
  - Export plan
  - Developed software to convert dwell positions to STL file of needle channel
  - Needle channel STLs manually fused with template design



1.) Pre-plan

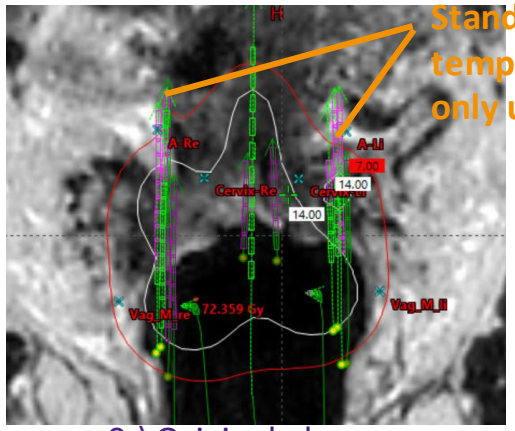

2.) STLs of needle channels


3.) Needle channels aligned with template design

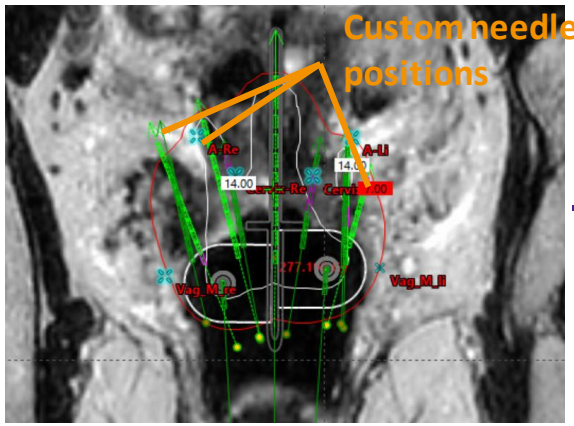

4.) After fusion: personalised design

Personalisation: results

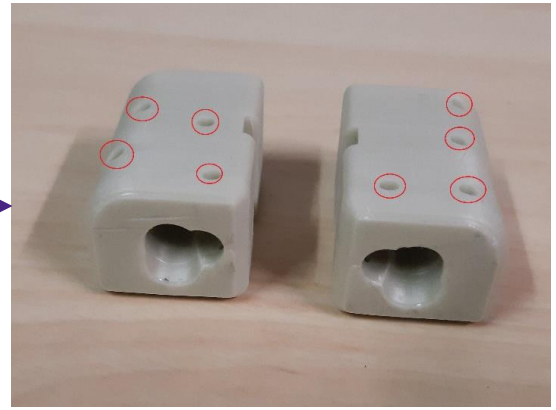
- For 2 cases, a personalized design was generated from a pre-plan



0.) Original plan



1.) Personalised pre-plan


2.) Printed personalised ovoid set

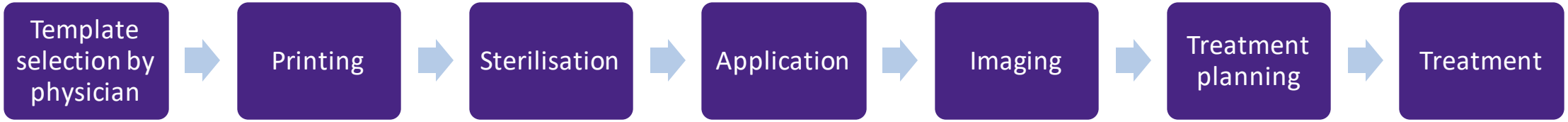
- Proof-of-concept
  - *Higher dose to tumour, higher coverage, lower dose to OAR*
  - *Further developed with applicator stl and needle coordinates → avoid manual step*
- Future development:
  - *In-house development*
  - *External: commercial software developments may also fulfil the desired functionality.*

Clinical implementation

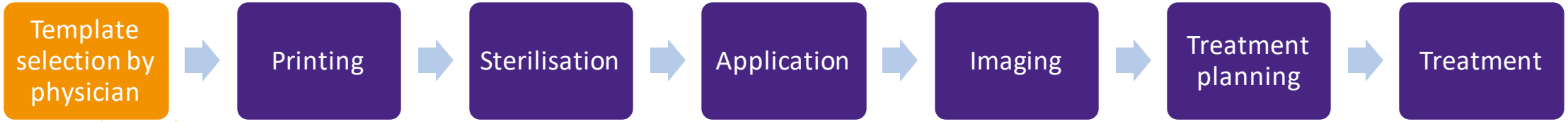
Clinical implementation: manufacturing

- Rules and regulations:
  - *MDR: accessory to medical device class IIa*
  - *ISO10993: biocompatibility endpoints for an externally communicating device with prolonged tissue contact*
- Explore outsourcing and in-house production
  - *Selected in-house SLA production with biocompatible resin*
- Manufacturing subject to Quality Management System

Clinical implementation: proposed workflow

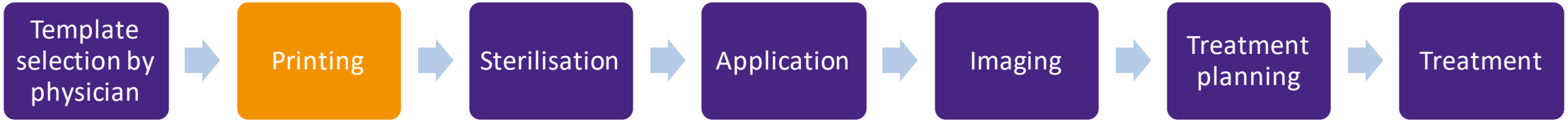


Clinical implementation: proposed workflow



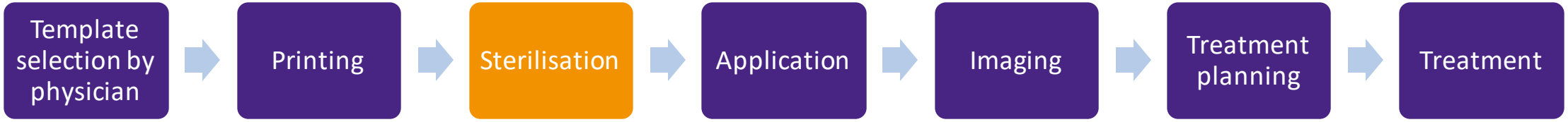
Physician selects most appropriate template
All templates must be commissioned

Clinical implementation: proposed workflow



Printing according to resin instructions to ensure biocompatibility endpoints
Possibility of 'on-the-shelf'
Personalised prints in duplo

Clinical implementation: proposed workflow



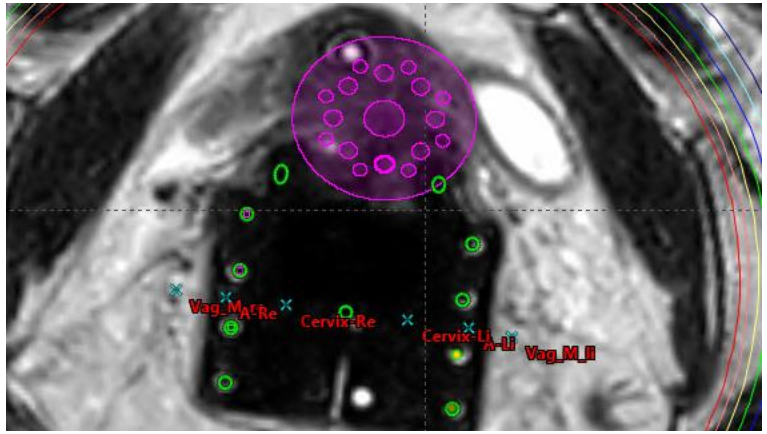
Validate sterilisation procedure for our designs

- No deformations
- Microbiological testing

These steps also in commissioning!

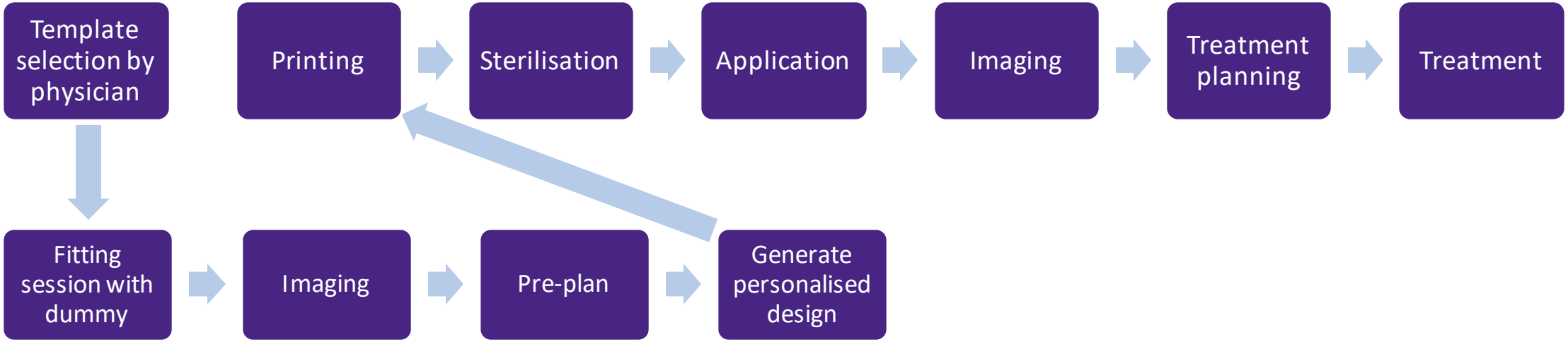
Clinical implementation: proposed workflow

Template selection by physician → Printing → Sterilisation → Application → Imaging → Treatment planning → Treatment



Template is imported as contour structure rather than ‘solid applicator’.

Clinical implementation: proposed workflow



Closing remarks

- MDR procedures and in-house validation
  →Move towards commissioning of ‘new standard’ templates late this year

- Further brachy innovations within Maastro more accessible
  - *Workflow and equipment present*
  - *MDR documentation procedure for 3D prints Collaboration with Femke Vaassen*

Thank you!

Any questions?

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