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DOSIMETRIC BENEFITS OF 3D PRINTED PATIENT-SPECIFIC SURFACE APPLICATOR VERSUS STANDARD FREIBURG FLAP IN HDR BRACHYTHERAPY TREATMENT OF SKIN LESIONS

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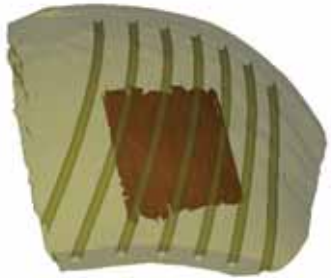

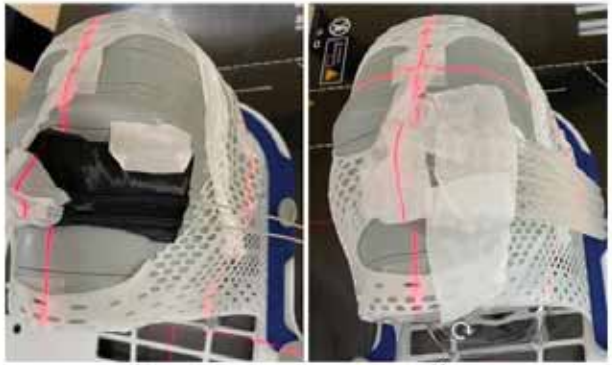

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SKIN BRACHYTHERAPY : STANDARD WORKFLOW WITH FLEIBURG FLAP

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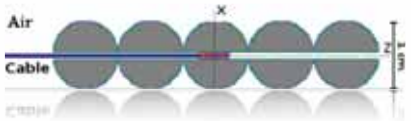
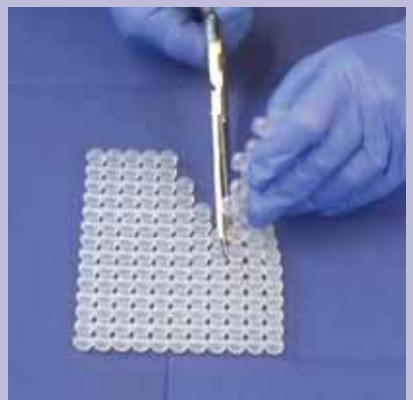
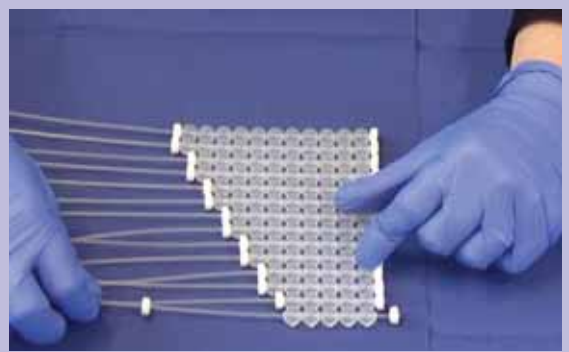
- The **Freiburg Flap** is a flexible silicone flap with embedded flexible brachytherapy catheters
- The flap with catheters can be draped over a part of the skin area in order to perform brachytherapy treatment on this surface
- It consists of many spheres (1cm diameter) that all have an open channel in the center



Target definition | **Fleiburg Implant preparation** | **Treatment planning** | **Treatment delivery**





Time consuming

Challenging for curved surface

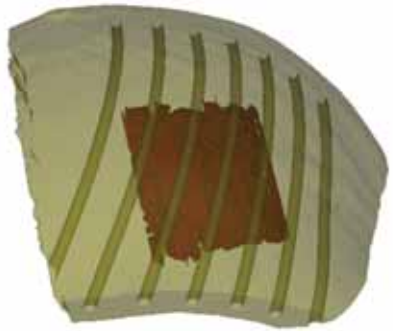
Only for experienced staff

Image courtesy of Elekta

WHY INCORPORATE 3D PRINTING INTO HDR SKIN BRACHY?

1 Dosimetric motivation

- Specify strategic catheter trajectories (better OARs sparing)
- Personalized bolus thickness to cover the target and limit maximum dose to skin surface (Dmax < 125-150% prescription dose [GEC-ESTRO])



3D printable skin brachy applicator model

Bolus thickness effect on skin Dmax

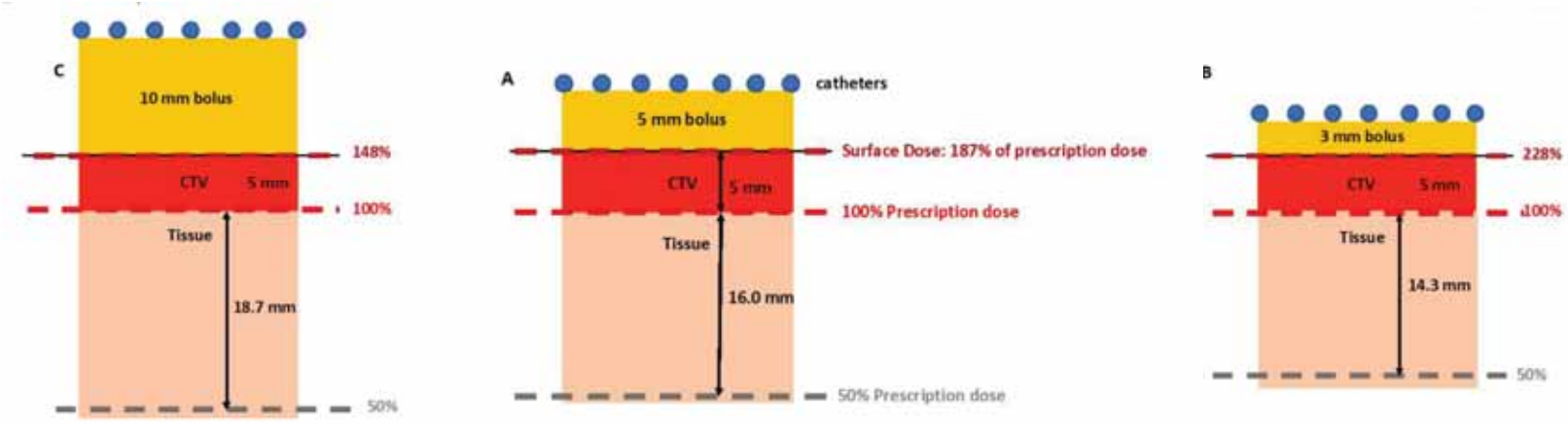


Image courtesy of V. Gonzalez-Perez, A. Rembielak, J.L. Guinot et al.

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WHY INCORPORATE 3D PRINTING INTO HDR SKIN BRACHY?

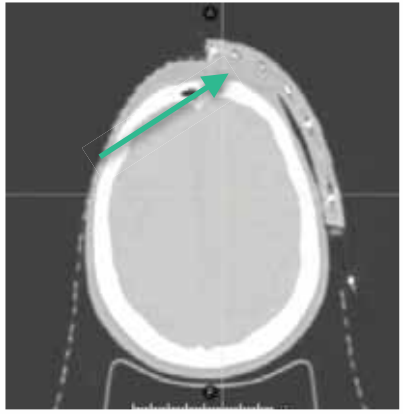
2 Patient experience and ease of use

- Enhanced fit for patient especially for curved anatomical sites
- Improved reproducibility

3 Increase process efficiency by digitizing manual steps

- Eliminate hand-fabricated mould
- Reduce manual steps (e.g. cut and attachment of Freiburg flap)

Fleiburg flap



3D printed applicator (better fit!)

3D PRINTED PATIENT SPECIFIC APPLICATORS : THE IMPLEMENTED WORKFLOW

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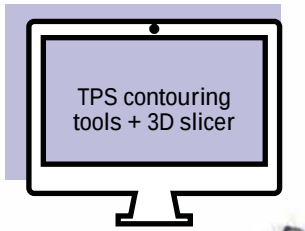
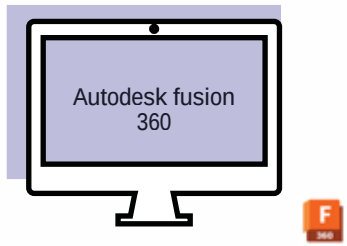
01 CT Scan of the patient

DICOM



02 Design applicator 3D model
(shape,tickness)

stl file format

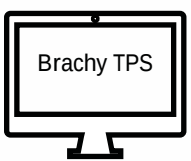


03 Catheter paths definition
(holes diameter, distance, curvature)

stl file format

04 Applicator print and QA

05 CT Scan of the patient with
the 3D printed applicator



06 Plan.QA.Treat.

FABRICATION : 3D PRINTING PROCESS

- Ultimaker 3D printer
- Print settings chosen in Ultimaker Cura software

☑ Infill factor 100% , concentric mode filament deposition

- Material : polymer

☑ TPU (thermoplastic polyurethane) filament

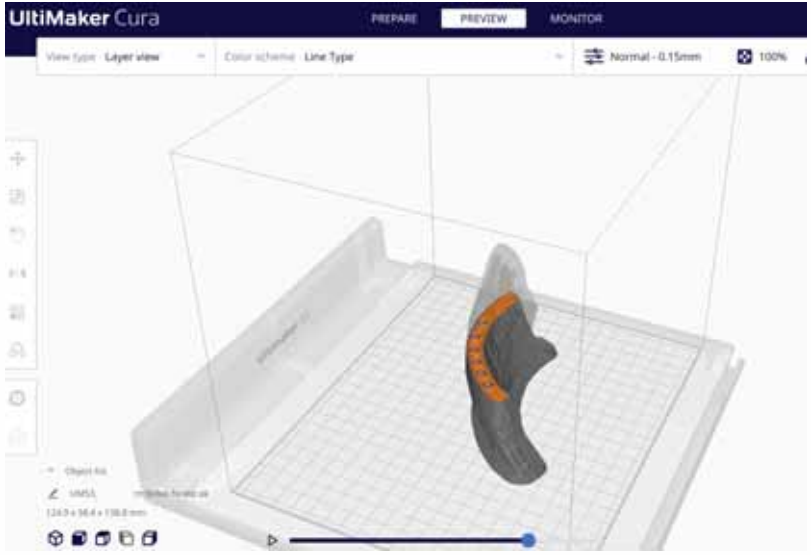
☑ Semi flexible material

☑ density : 1.19 g/cm3

☑ Extrusion temperature: 225 °C - 240 °C

☑ Skin contact : non toxic

☑ Sterilizable material



FABRICATION : 3D PRINTING TIME

- The print time ranged from 3 - 11 hours depending on applicator size and complexity

Case	Site	Applicator Thickness	Catheters number (3mm diameter)	Applicator volume	Print time
1	nose*	1 cm	2	45 cc	3 hours
2	scalp	1 cm	6	110 cc	11 hours
3	nose	1 cm	4	30 cc	4 hours
4	lips	1 cm	5	41 cc	4,5 hours

* phantom case

3D PRINTED APPLICATOR QUALITY ASSURANCE

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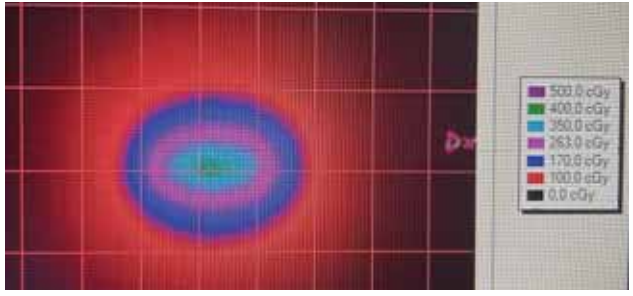
GEOMETRIC

- Visual inspection to detect layer deposition failure or unwanted air gaps
- Proper fit and dimension

DOSIMETRIC

- Catheter path testing : insert flexible tube inside the 3D printed holes and deliver a test plan for pre treatment check cable
- Dosimetric QA performed on a 3D printed test sample
- comparison of planned and delivered test plan (calibrated gaph cromic)

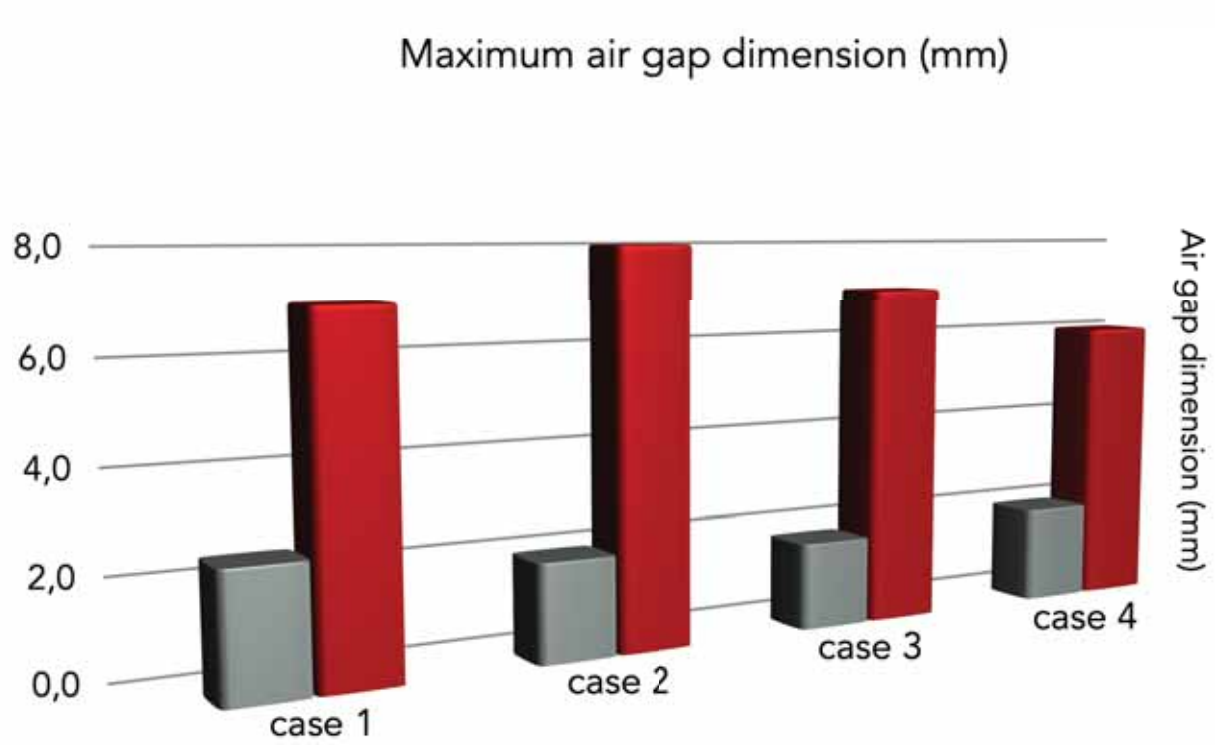


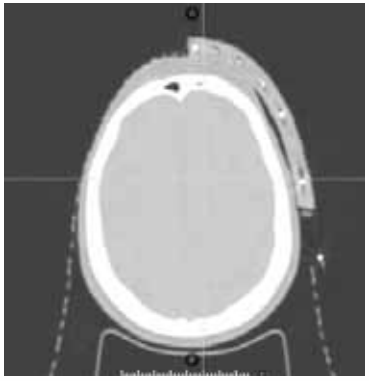
Planned vs delivered dose agreement within a local tolerance of 2.5%*

TG 43 formalism (full scatter condition) is still valid for 1cm TPU applicator with Ir-192 source if no air gaps are presents

*2D dose profile analysis

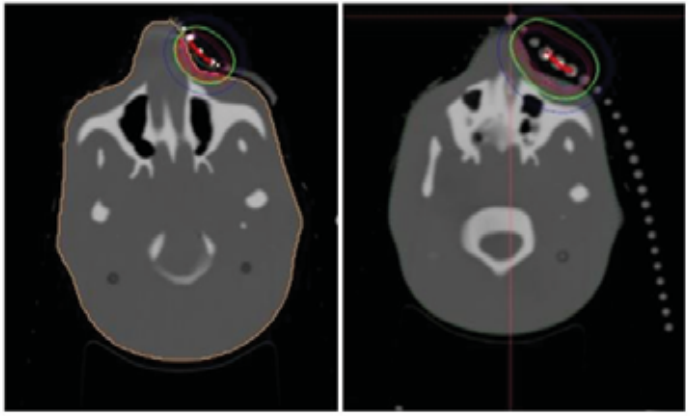
RESULTS AND FINDINGS : GEOMETRIC MEASUREMENTS

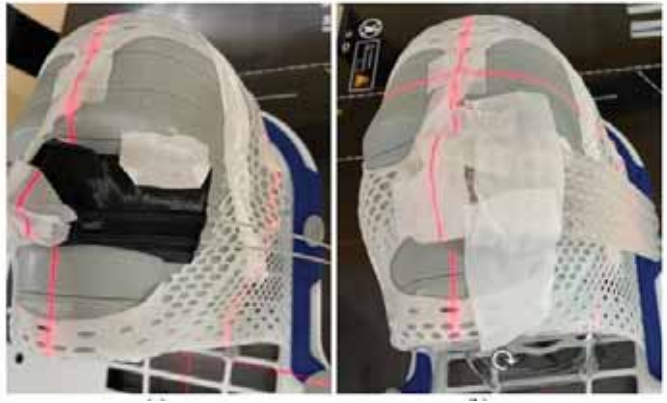




RESULTS AND FINDINGS : DOSE DISTRIBUTION PHANTOM CASE

Case	Site	Target coverage : 95% prescription (Fleiburg)	Target coverage: 95% prescription (3D printed)	OAR Dmax Fleiburg vs 3D printed
1	nose*	98%	98%	+26% (ipsi eye) +16% (ipsi lens)





CONCLUSIONS

Some evidence that 3D printed applicator are geometrically more accurate

Time saving

Highly customizable

Re-printable

Comfortable

…AND FUTURE CHALLENGES

Clinical implementation for complex cases

Optimize patient fit (fine tune post processing)

Combine applicator with real time dosimetric system for in vivo treatment verification (micro Mosfet)

Collaboration with Adaptiiv (Dalhousie University,Canada) to optimize our 3D printing workflow

THANK YOU FOR THE ATTENTION!