BEFORE THE INK DRIES
IMPLEMENTING A TATTOOLESS WORKFLOW

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Presentation content

Clinical audit

- Pre-audit
- Clinical study
- Results
- Findings

Post-audit

- Clinical wins
- Continuous development of SGRT workflows
- Case studies

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Towards tattooless

Test Name	Maximum/Threshold	Error Read	PASS/FAIL
Relative Shift Accuracy Test LNG + 10 mm	LNG error < 1.0 mm	0.00 ± 0.04 mm	PASS

Test Name	Maximum/Threshold	Error Read	PASS/FAIL
Relative Shift Accuracy Test LAT + 10 mm	LAT error < 1.0 mm	0.24 ± 0.11 mm	PASS

Test Name	Maximum/Threshold	Error Read	PASS/FAIL
Relative Shift Accuracy Test VRT + 10 mm	VRT error < 1.0 mm	0.07 ± 0.05 mm	PASS

PH1 super user training
30th – 31st Oct 2023

- Introduction
- Patient workflows
- System use

Initial acceptance & Commissioning
5th Jan 2024

- AAPM TG 147 (2012) & 302 (2022)
- End-to-end testing (test patient)
- SGRT daily QA

Online training modules and practical sessions with App specialist

- Physics and RTs competency records ✓
- User and workflow training

SGRT Go-live !
24th Jan 2024

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Clinical Audit Objective

- To validate the accuracy of SGRT setups in comparison to tattoo setups

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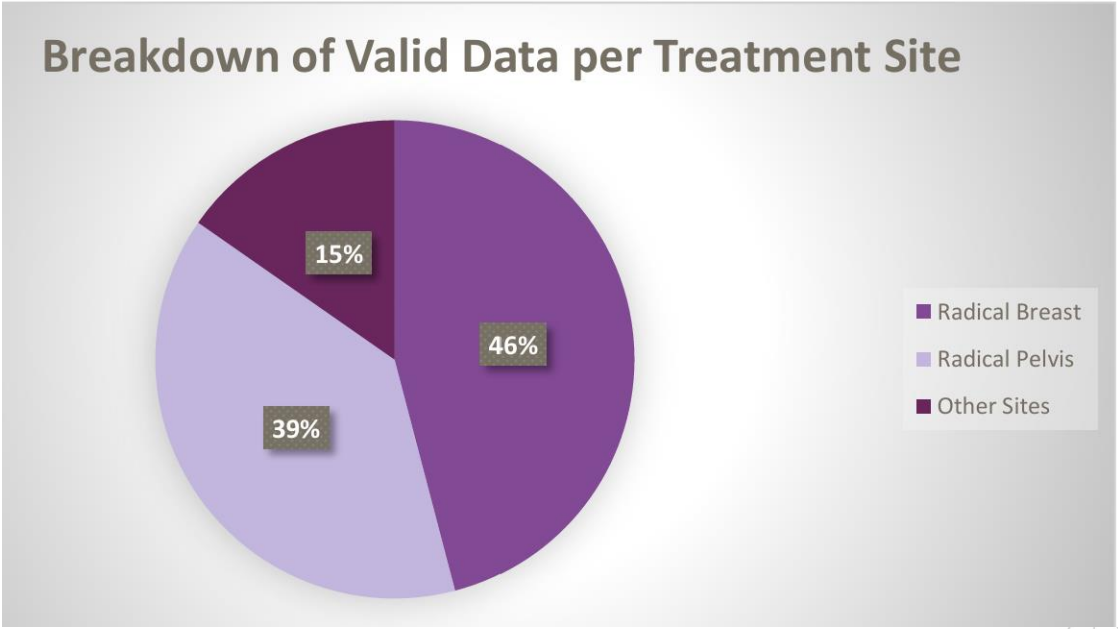
Study design

- 100 treatment sessions
- Only pelvis (39) and FB breast cases (41) were included in the analysis
- Other sites consisted of palliative and abdomen cases



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Data acquisition

- Patient aligned using tattoos and then planned shifts to isocentre were applied as per departmental policy
- Postural video -> RTDs recorded (positioning errors from tattoos)

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Data acquisition

- Postural video was then used to adjust for any residual corrections
- RTD values recorded (positioning errors from AlignRT)

IGRT:

- Patient's position verified with CBCT
- Post-CBCT shifts recorded

*(only translational values used in audit)

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Analysis

- Tattoo = Tattoo RTDs + Imaging shifts (VRT, LAT, LNG)
- AlignRT = AlignRT RTDs + Imaging shifts (VRT, LAT, LNG)
- 3D vector shifts / MAG

$$MAG = \sqrt{(\Delta VRT)^2 + (\Delta \mathrm{LAT})^2 + (\Delta LNG)^2}$$

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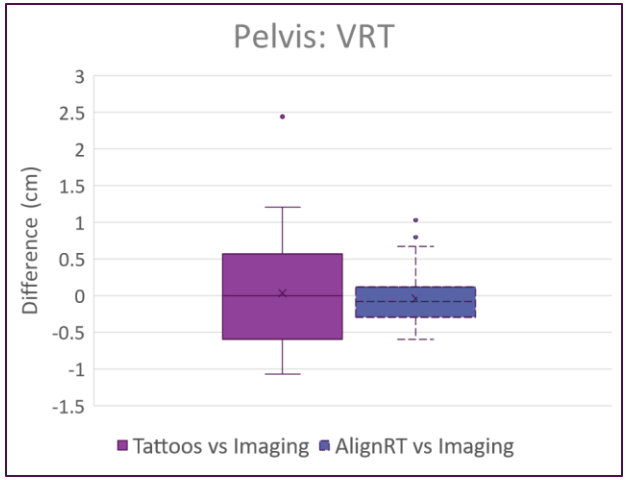
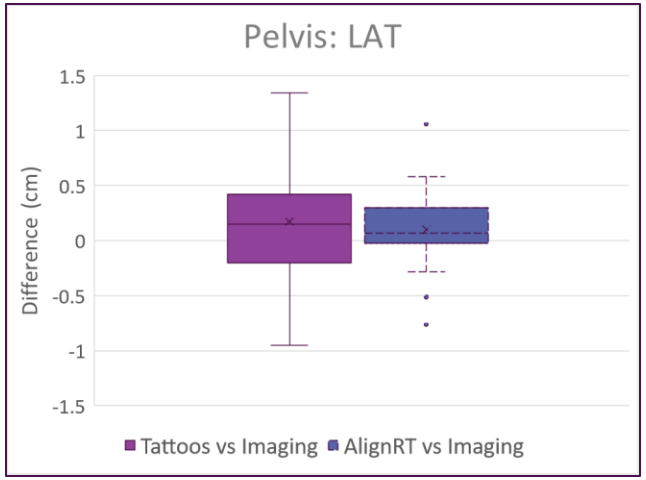
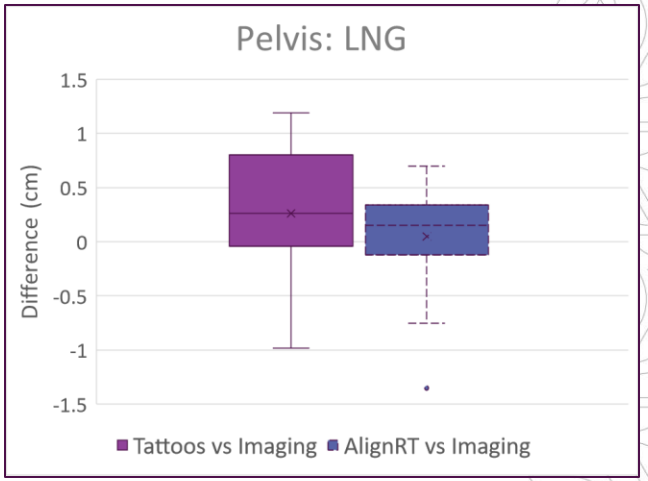
Results: Pelvis







	VRT	LAT	LNG
Tattoo	0.03 +/- 0.8 cm	0.2 +/- 0.6 cm	0.3 +/- 0.5 cm
AlignRT	-0.04 +/- 0.4 cm	0.1 +/- 0.4 cm	0.05 +/- 0.3 cm
P-value	>0.05	>0.05	<0.05

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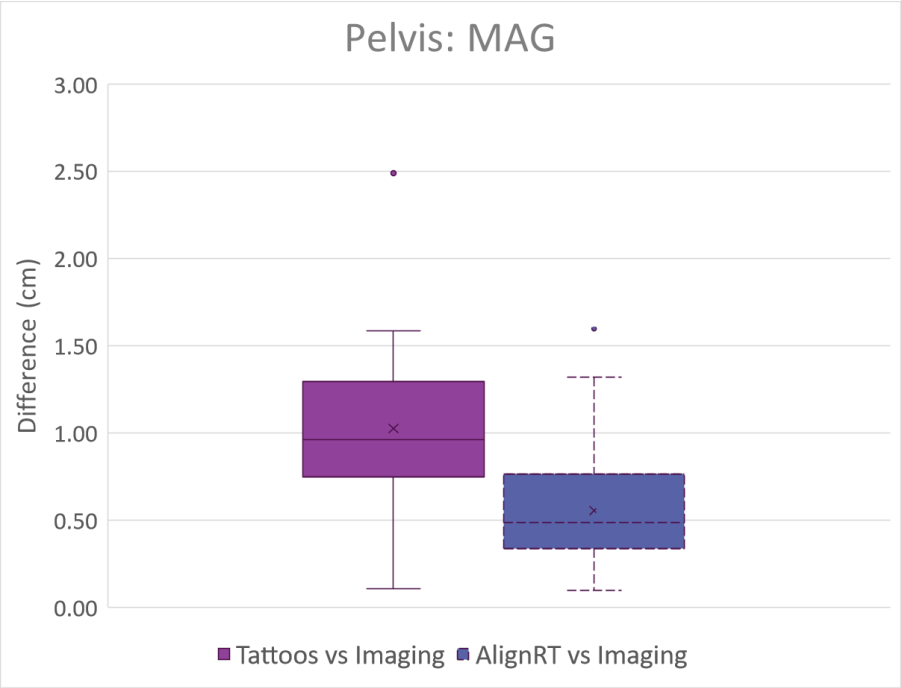
Results: Pelvis



	MAG
Tattoo	1 +/- 0.4 cm
AlignRT	0.6 +/- 0.3 cm
P-value	<0.05

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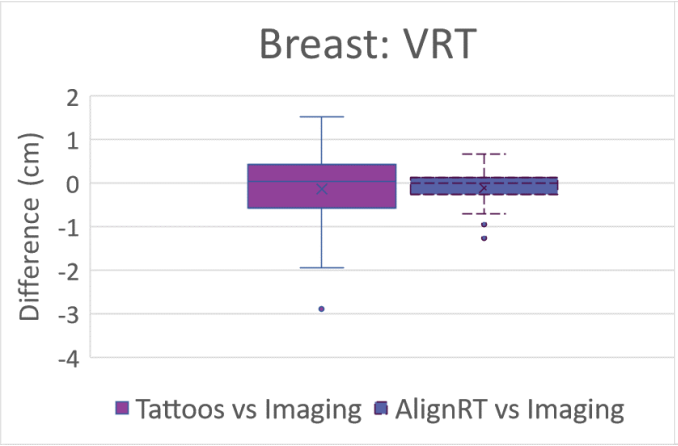
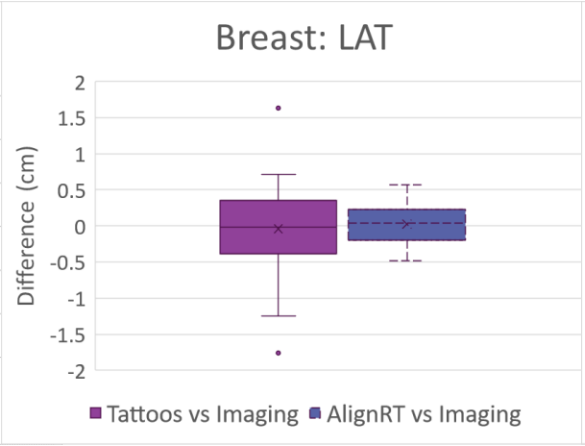
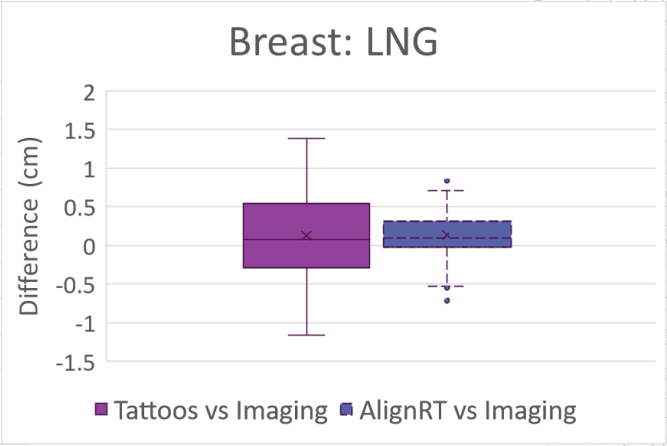
Results: Breast







	VRT	LAT	LNG
Tattoo	-0.2 +/- 0.9 cm	0.13 +/- 0.6 cm	-0.3 +/- 0.6 cm
AlignRT	-0.1 +/- 0.4 cm	0.15 +/- 0.3 cm	0.3 +/- 0.3 cm
P-value	>0.05		

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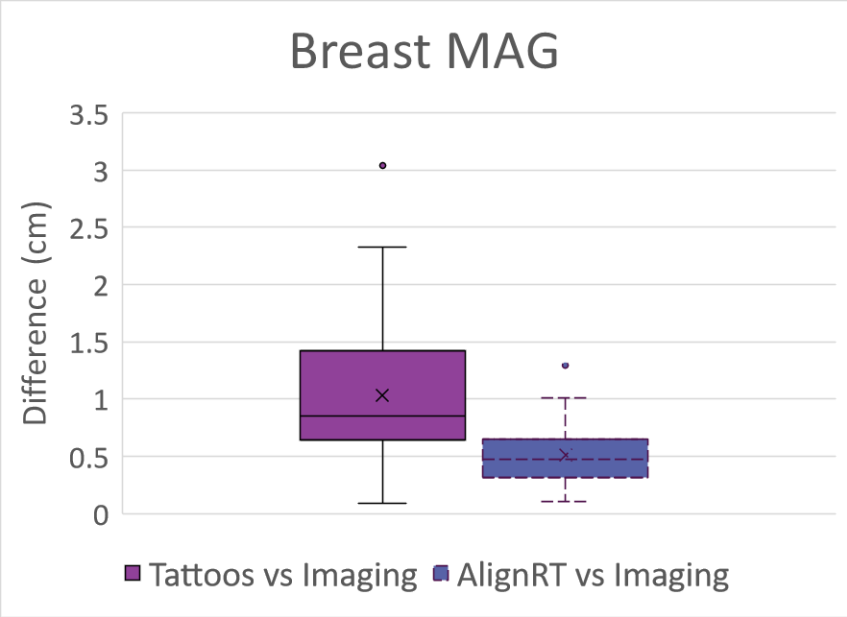
Results: Breast



	MAG
Tattoo	1 +/- 0.6 cm
AlignRT	0.5 +/- 0.3 cm
P-value	<0.05

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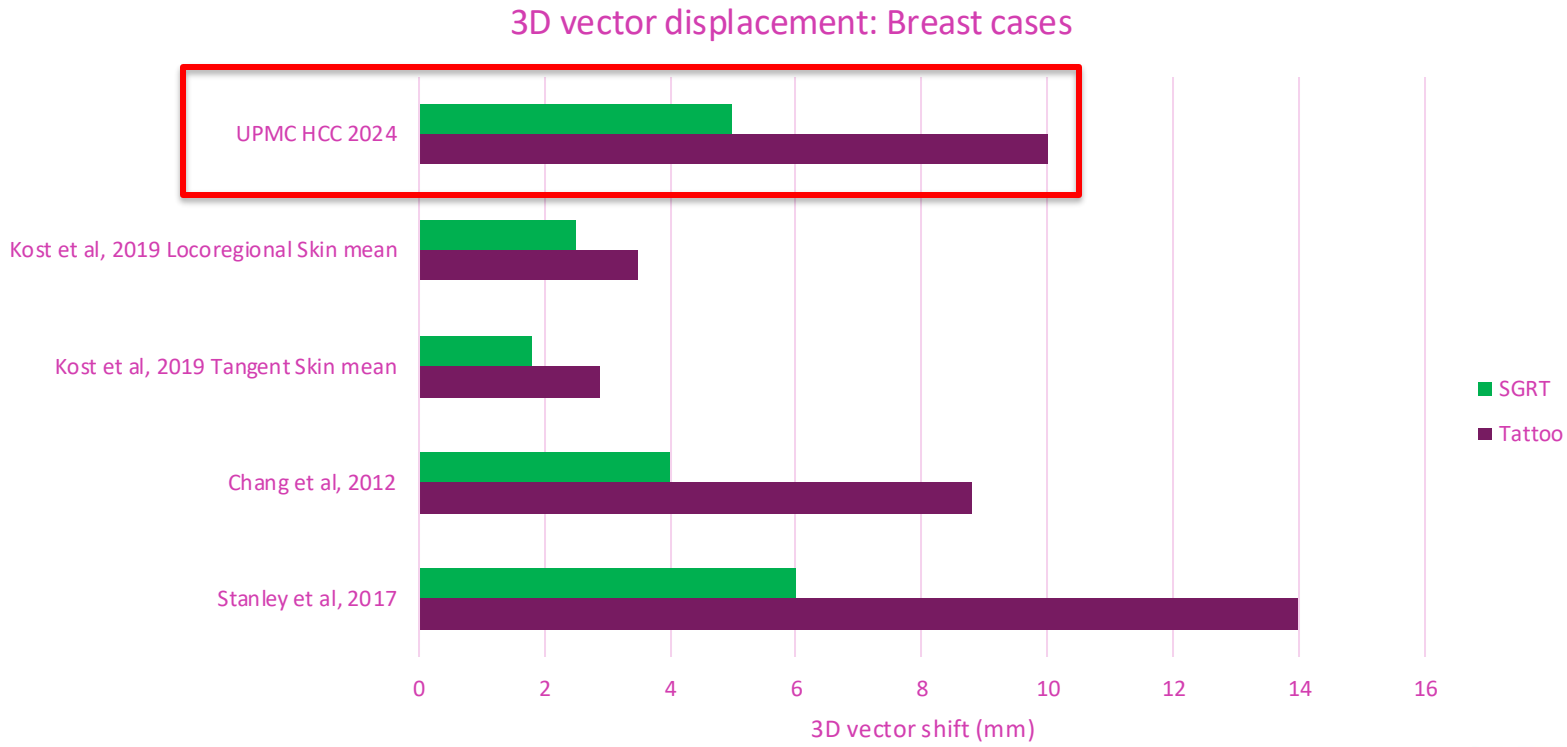
Comparison with literature



Findings

- Robustness of patient setups w SGRT for breast and pelvis cases => Tattooless!
- Less patients requiring correctional shifts
- Less patients requiring repeat imaging?
  - More than 1 cm translational shift?

	Tattoo	SGRT
Pelvis	12 (30%)	3 (8%)
Breast	14 (34%)	1 (2%)

- Staff feedback/comment on SGRT centric worflows
  - Patient setups requiring less manual handling
  - Time saving?
    - 5 min saving for DIBH treatments (breast only)

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CLINICAL WINS

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SAFE DELIVERY OF TREATMENT

REDUCED RATES OF RE-SETUP & RE-IMAGING

INCREASED TIME EFFICIENCY

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Pelvis: ROI Optimisation

Breast: DIBH Troubleshooting

Extremity: Case Study

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PELVIS: ROI Optimisation

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Continuous Development of ROIs

- Traffic light system in place to ensure ROI consistency amongst users
- Guide for training new users
- Ability to understand the system
  - What we are trying to achieve
  - How we can achieve it
  - When to take action and troubleshoot an underperforming ROI

AlignRT ROI Work Instruction

Pelvis

✗	✓	Notes
		- Wide enough centrally to provide modesty sheet. - Inferior boarder at level of scrotum. - Superior border to cover pubic symphysis: Avoid excessive superior extension to abdomen. - Posterior border to mid coronal plane. - Lateral margins to cover entire iliac crest – following inguinal canal.
		

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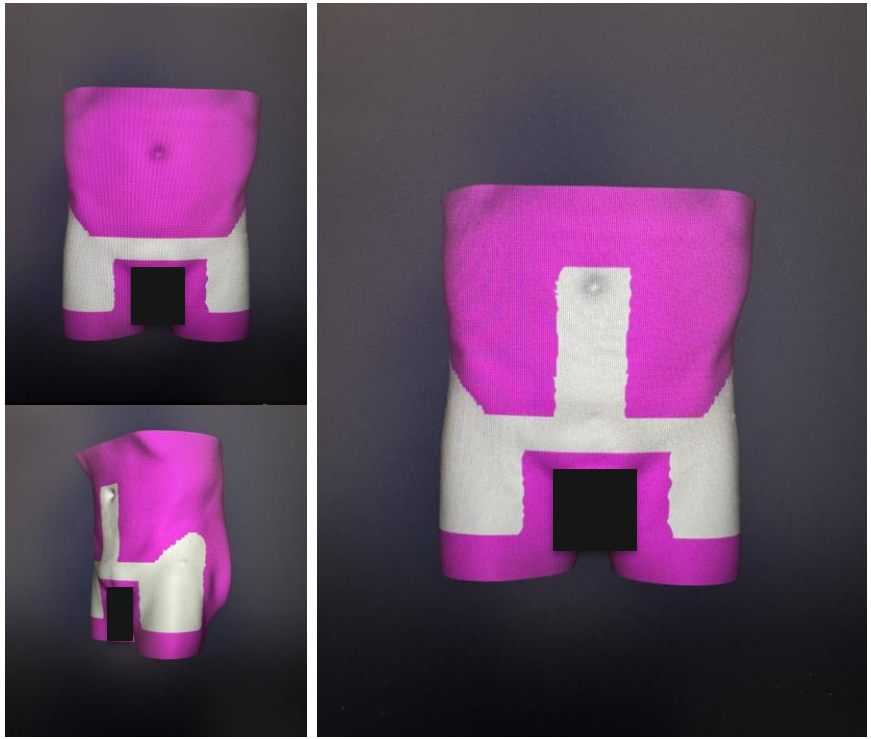
Clinical Example: Additional Umbilicus Strip



Mean Shift Values (Prior to Umbilicus strip)	Vertical	Longitudinal	Lateral
	0.5 ± 0.1	0.9 ± 0.3	0.1 ± 0.1

Mean Shift Values (Prior to Umbilicus strip)	Vertical	Longitudinal	Lateral
	0.7 ± 0.2	0.2 ± 0.2	0.12 ± 0.05

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Learnings & Recommendations

- Robust training programme for new users is instrumental to successfully implementing a tattooless workflow
- Recognising underperforming ROIs & problem solving effectively to ensure consistently accurate setups
- Ensure all users have a strong understanding of AlignRT Advance system and what the ROI/RTDs represent

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BREAST: DIBH TROUBLESHOOTING

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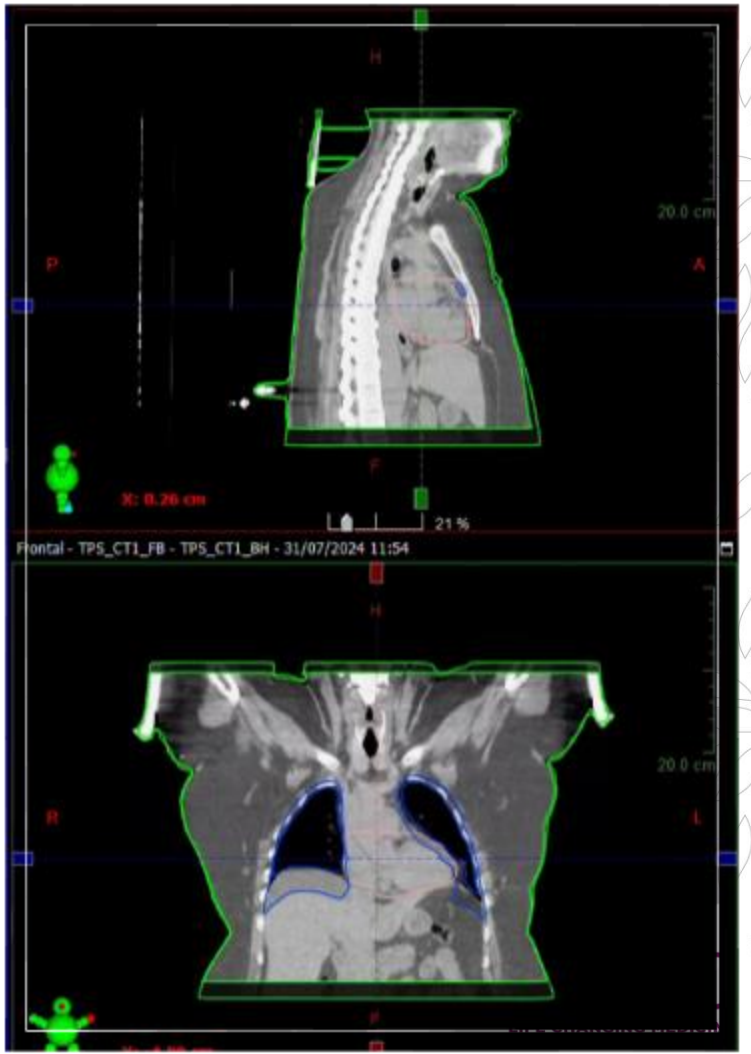
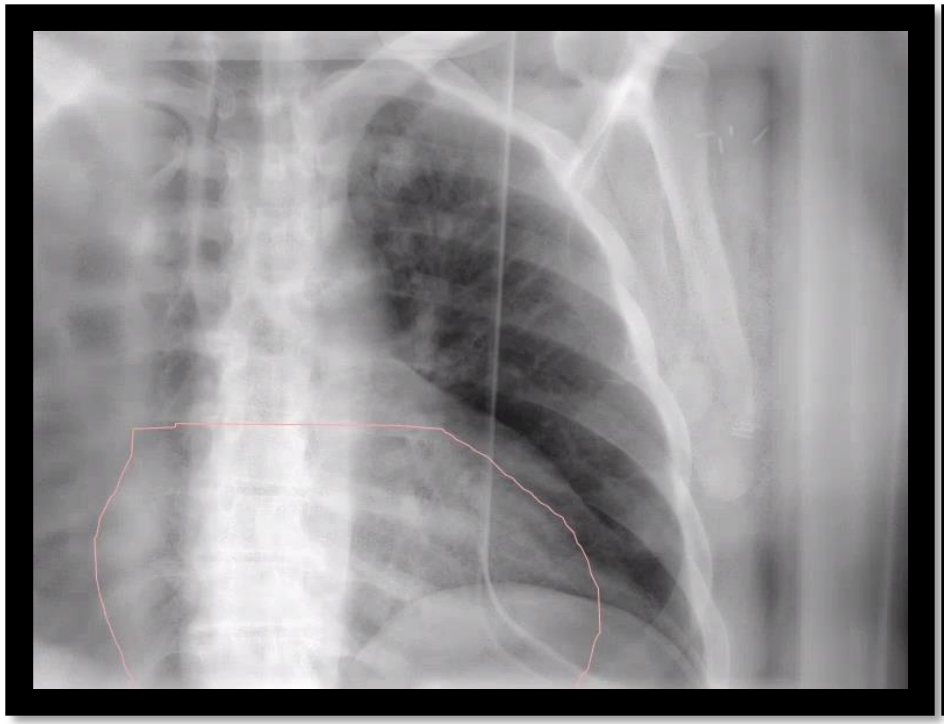
Contour vs Amplitude

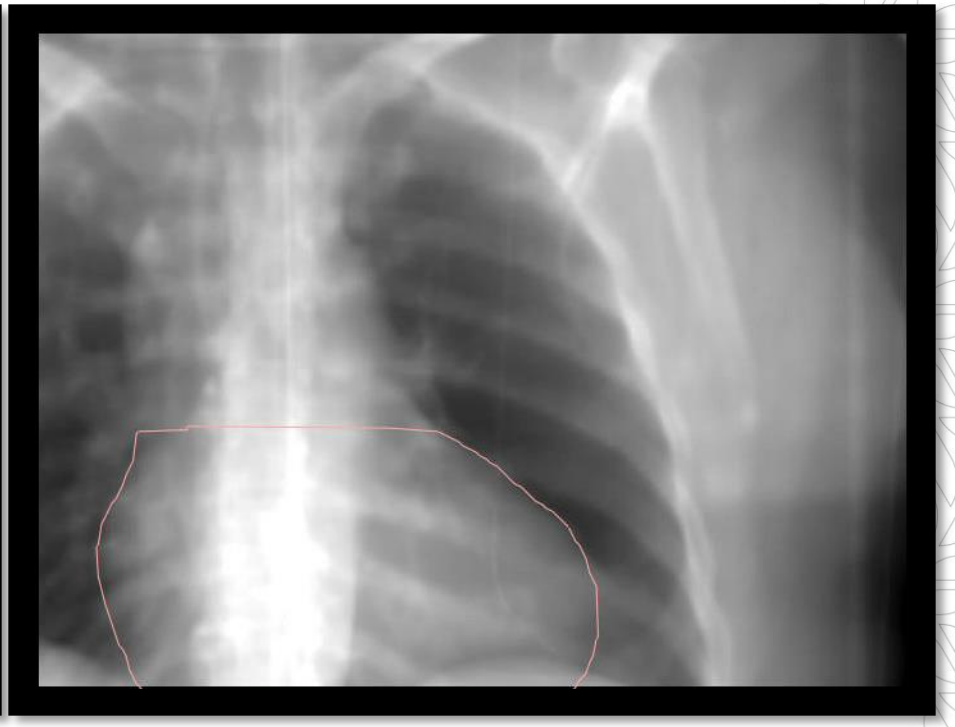
- SimRT: Patch position on upper abdomen inferred ± 0.9cm amplitude
- FB-BH image registration showed little contour change
- Patient was suitable for DIBH with positive anatomical changes (heart & lungs)
- BH plan: Optimal PTV coverage with increased heart sparing



DIBH when using the Real Time Coach



DIBH without using the Real Time Couch



Left or Right? Incorrect laterality introduces positional accuracy

Problem Faced

Solution

Future Management

Implementation to be assessed on a case-by-case basis

Starting amplitudes should be monitored to detect deviation in breath

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Learnings & Recommendations

- Consider contour direction change (Vertical/Longitudinal) when using RTC to achieve reproducible inhalation
- Consideration of contralateral ROIs to achieve & maintain DIBH amplitude when imaging DIBH chestwall patients
- Ensure starting amplitudes (Vrt RTD) is recorded before beginning IGRT/treatment to ensure consistent breath in the absence of a baseline

EXTREMITY: CASE STUDY

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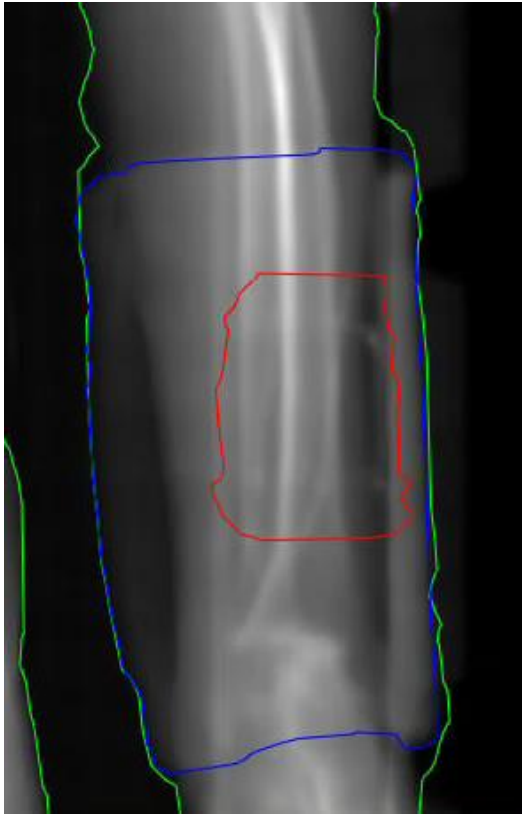
Initial Setup

- Scanned HFS & arms by side (left arm akimbo)
- Use of VacBag to aid immobilisation
- Scanned with 1cm bolus placed



Camera FOV limitation

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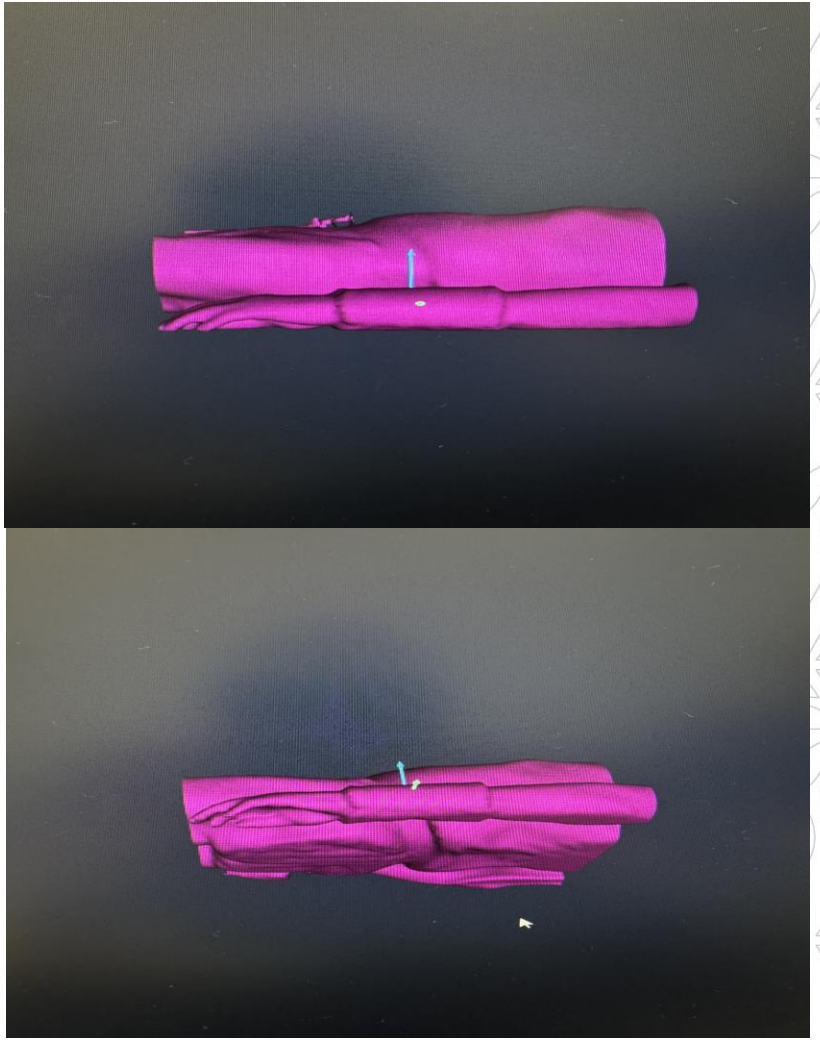
Rescan Position

- Scanned HFS & arms by side (left arm akimbo)
- VacBag not used
- Scanned with 1cm bolus placed (QIP)



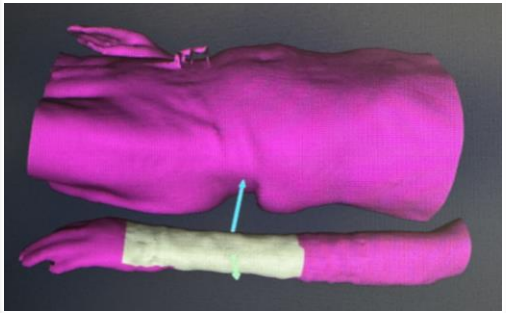
QIP: Cropping Bolus from Body

Problem Faced

Inability to accurately reproduce bony setup when bolus was scanned at CTsim

Solution

Create 'skin' contour to allow for correct bony setup prior to bolus placement and IGRT

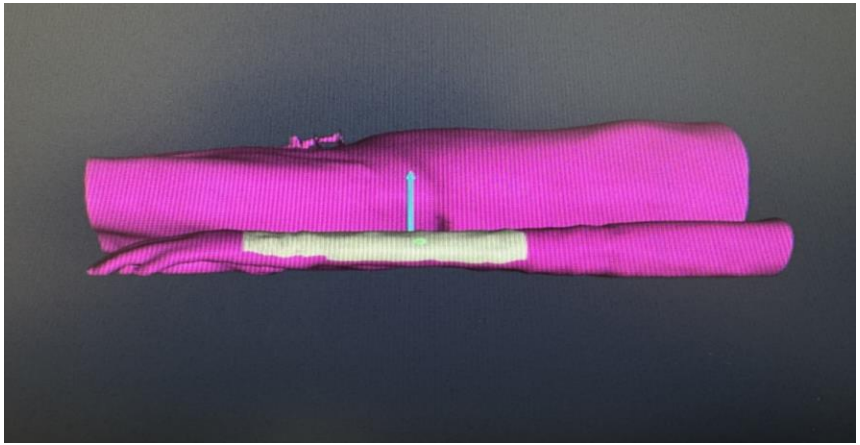


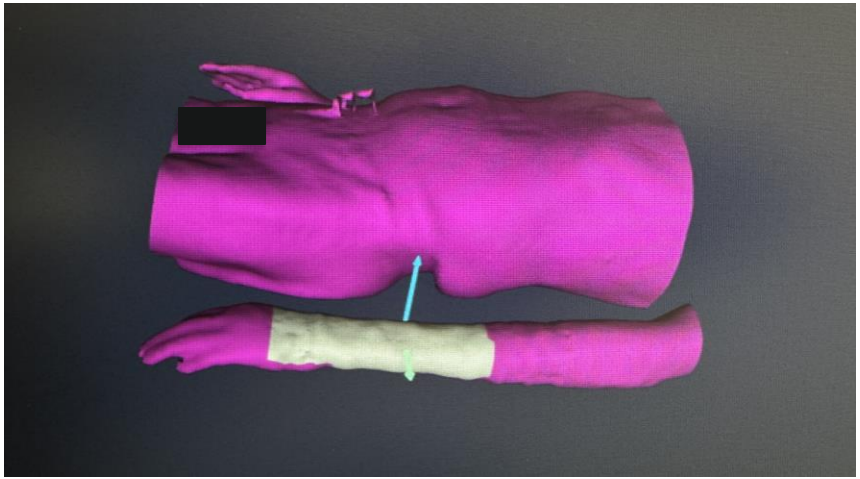
Future Management

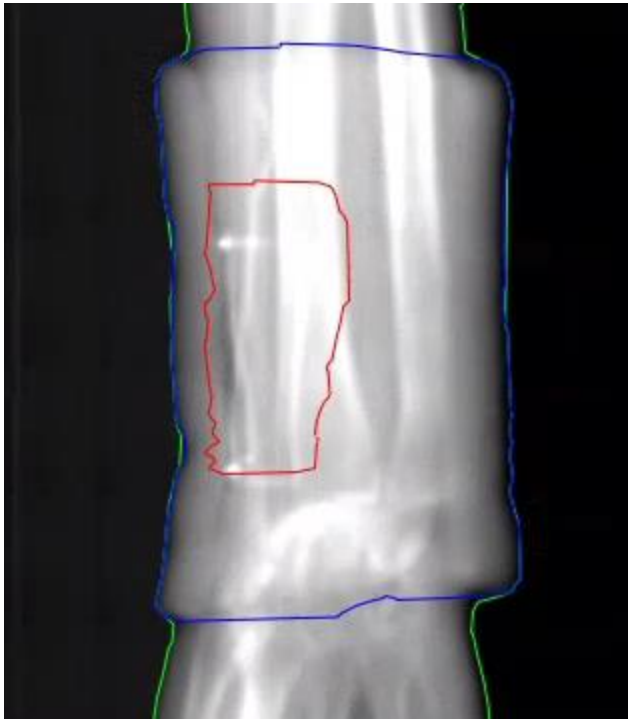
All patient scanned with bolus at CTsim should have 'skin' contour

Skin contour should only be used as a setup surface only

Once bolus is placed, switch to CTsim Body (ROI cropped from bolus)







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Learnings & Recommendations

- Simplistic setups at CTsim for more reproducible & consistent setups using AlignRT Advance
- Postural Video tool is paramount to ensure rotational accuracy in the absence of anterior alignment tattoos
- Create a ‘skin’ setup surface to ensure delta shift values represent bony anatomy prior to bolus placement

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