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SGRT for Paediatrics

Reducing Paediatric Radiotherapy-Associated Trauma, Positional Challenges and Additional Imaging Dose Through the Introduction of SGRT Technology

Molly Bamber
Lead Paediatric/TYA Therapeutic Radiographer,
Nottingham Radiotherapy Centre, UK

Samantha Stevens
Advanced Practitioner for Image Guided Radiotherapy,
Nottingham Radiotherapy Centre, UK

Our Department

- 2 Canon CT scanners
- 6 Elekta linacs
- 2 linacs with ExacTrac Dynamic and 6-DoF capabilities (and a 3rd being commissioned)
- 2 linacs with AlignRT – rolled out SGRT for 2-field breast successfully in March 2024, followed by limbs and any tricky patient setups.
- AlignRT used for both adult and paediatric treatment

Our Paediatric Photon Service

- 2 paediatric Clinical Oncologists
- 2 paediatric & TYA Therapeutic Radiographers
- Majority of radical patients referred for PBT
- Predominantly palliative workload since UK PBT centres opened but still treating radically for those non-eligible for PBT, patients/families who prefer to stay in Nottingham and expected benefits from PBT are minimal
- Joined forces with Birmingham around 2022/2023 [1]

The Midlands Paediatric Radiotherapy Service

References:
[1] NHS England. (2023). *SCHEDULE 2 -THE SERVICES Service Specifications*. https://www.england.nhs.uk/wp-content/uploads/2023/06/230601-paediatric-photon-radiotherapy-service-specification.pdf

Why introduce SGRT for paediatrics?

- Facilitates tattoo-less radiotherapy reducing overall trauma for patients and families
- Additional confidence using open-face masks
- Positioning tools should speed up set-up process
- Identifies risk of error and/or contour change that may affect dosimetry
- Potentially less need for GA due to no tattoos, faster appointments and continuous patient position monitoring
- Significant rotational issues and contour change seen on CBCTs with younger patients causing high re-imaging frequency

Patient	Dose/#	Re-images/issues
ATRT1 - GA	54Gy/30 #	3 (moved to daily)
DIPG1	39Gy/13 #	0 (++rotations and required SSE increase from 0.3cm – 0.5cm)
DIPG2 - GA	39Gy/13 #	0 (++rotations)
DIPG3 - GA	39Gy/13 #	2
DIPG4 - GA	39Gy/13 #	1 (++rotations)
DIPG5 - GA	39Gy/13 #	3 (moved to daily and trialled SGRT)
DIPG6	39Gy/13 #	5 (moved to daily, trialled SGRT & ++ facial swelling)

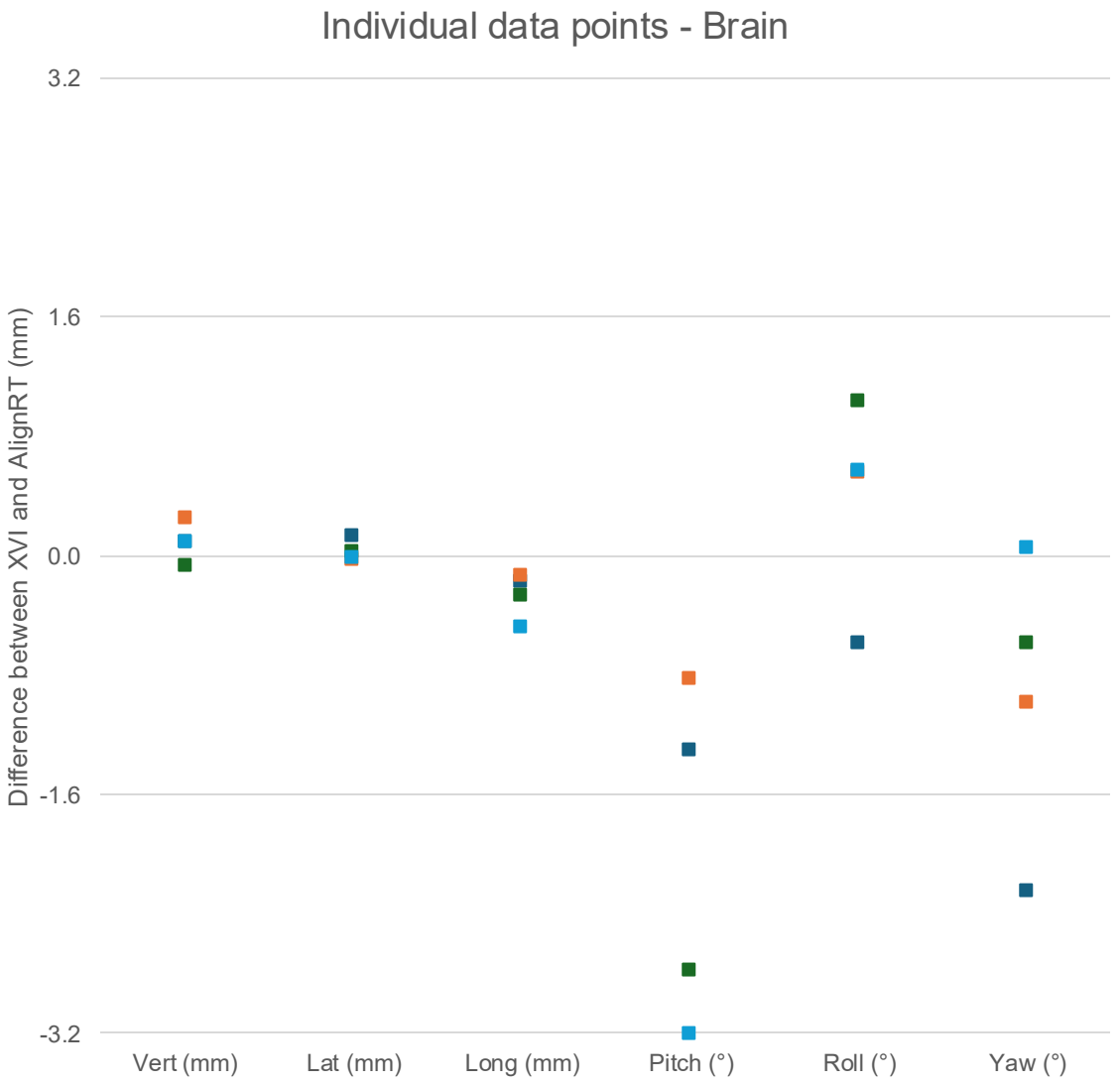
Phase 1 audit

- AlignRT vs 3D CBCT
- Translations and rotations from both systems recorded and analysed:
  - 4 body (upper abdomen, whole abdomen, whole lungs and pelvis)
  - 4 brain
- Body patients → Setup using standard tattoos
- Brain patients → Setup using reference marks (open face masks)

DATE		SGRT			XVI			ADJUSTED PATIENT POSITION? (Y/N)	DELTAS OUT OF TOLERANCE FOR TREATMENT AFTER CORRECTIVE ISO-SHIFTS APPLIED?	ADDITIONAL COMMENTS
		X Vert Yaw	Y Long Roll	Z Lat Pitch	X Lat Pitch	Y Long Roll	Z Vert Yaw			
06/11/2024	Translations	0	0.26	0.3	0.31	0.31	0.05	N	N	Deltas perfect after corrective iso-shifts applied
	Rotations	-2	0.2	1	0.1	1.1	-1.6			
08/11/2024	Translations	0.02	0.2	0.17	0.19	0.16	0.06	N	N	Deltas perfect after corrective iso-shifts applied
	Rotations	-1.2	0.7	0.3	-0.7	1	-1.5			
11/11/2024	Translations	0.29	0.5	0.16	0.18	0.35	0.14	N	N	
	Rotations	0.4	1.2	3.7	1.5	1.1	-0.2			
12/11/2024	Translations	0.3	0.45	0.07	0.04	0.27	0.21	N	N	
	Rotations	0.3	0.5	4.3	2.4	0.1	-0.9			
20/11/2024	Translations	0.21	0.31	0.04	0.14	0.1	0.15	N		
	Rotations	1.5	-0.7	4.4	1.8	2.2	1.1			
21/11/2024	Translations	0.32	0.28	0.08	0.22	0	0.26	N		
	Rotations	1.8	-0.7	5.4	2.1	2	1.4			
22/11/2024	Translations	0.27	0.43	0.03	0.06	0.1	0.2	N	Y- long & height	
	Rotations	0.8	-0.8	5.4	1.9	0.2	-0.1			
25/11/2024	Translations	0.4	0.4	0.2	0.2	-0.1	0.2	Y - adjusted chin position for pitch without mask on - pitch did increase again with mask on	Y - long	Pitch also OOT on AlignRT after corrective shifts
	Rotations	-0.1	0.4	4.5	0	1.8	0			
27/11/2024	Translations	0.1	0.42	0.2	0.31	-0.08	0.06	Y - set up without mask on for pitch	Long around 0.5cm	
	Rotations	0	1.2	3.2	1.1	2.8	0			
28/11/2024	Translations	0.3	0.42	0.04	0.31	0.13	0.26			
	Rotations	0.5	-0.5	5.9	2.7	2.5	-1.2			
29/11/2024	Translations	0.21	0.54	0.13	0.16	0.07	0.14	Y - adjusted chin position	Long around 0.5cm	
	Rotations	0.2	0	4.8	0.7	0.9	-0.2			
02/12/2024	Translations	0.56	0.55	0.19	0.13	-0.1	0.24	Y - dropped chin for pitch during set up	Long around 0.5cm	
	Rotations	-1	-0.8	6.6	0	-0.1	0			
04/12/2024	Translations	0.2	0.3	0.27	0.33	0.01	0.27	Y - dropped chin		
	Rotations	0.5	0.2	4.5	1.7	1.1	-0.3			

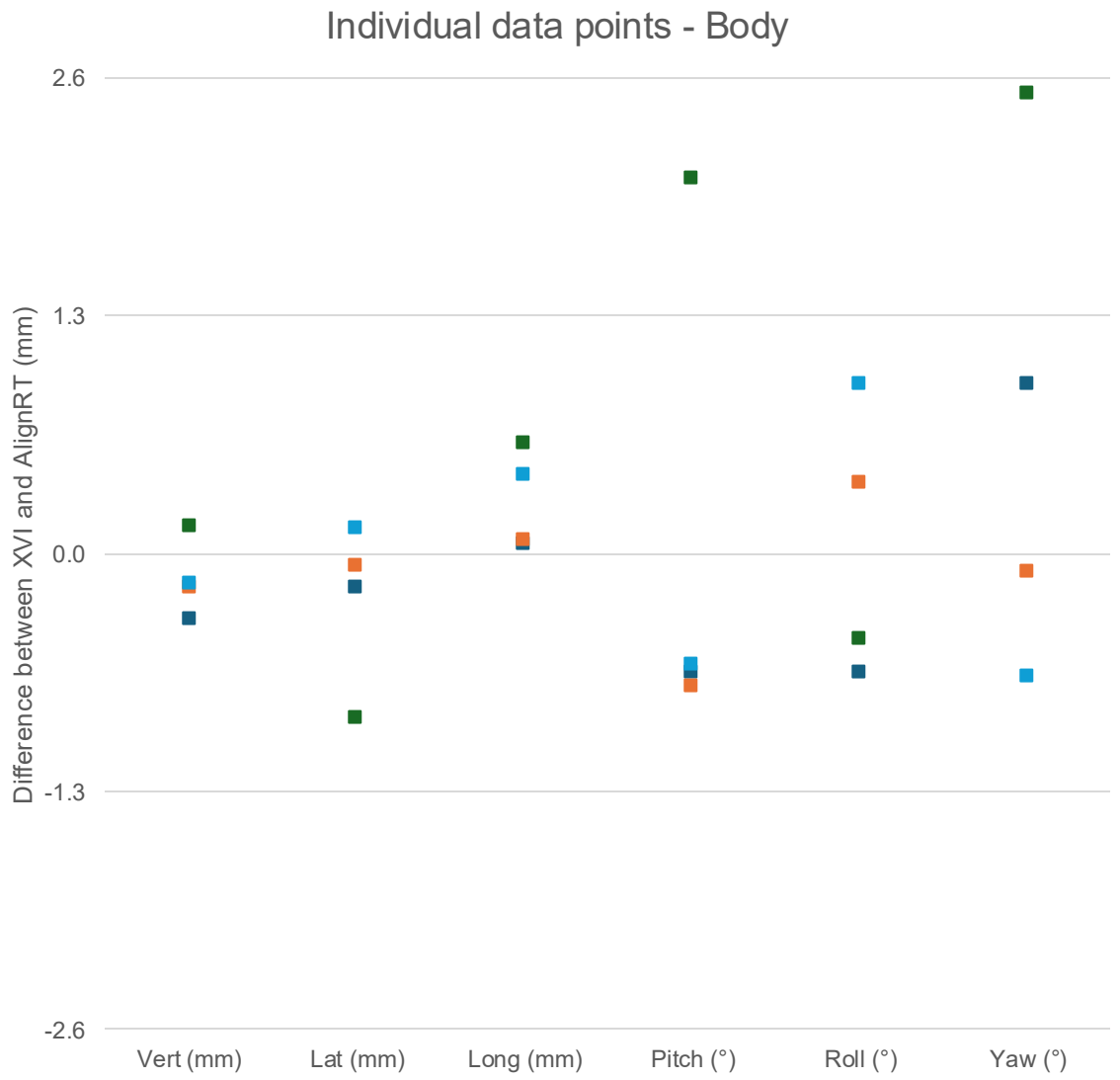
Results – Brain

- **Brain cases:** smaller, more consistent translational differences (Vert, Lat, Long)
- Showed larger pitch rotational difference:
  - likely due to facial swelling due to steroid use
  - modification of ROI/reference capture can rectify this



Results – Body

- **Body cases:** greater variability across all axes, particularly rotations
- Findings reflect increased positional complexity in paediatric body set-ups compared to brain immobilization
  - Likely due to contour change caused by weight loss/gas



Overall results

- Mean difference between 3D imaging system and AlignRT minimal (≤0.1cm and 1deg)
- Indicated **SGRT is safe to use as primary setup tool** (enabling move to phase 2 of audit)

	Difference between Xvi and AlignRT					
	Vert	Lat	Long	Pitch	Roll	Yaw
Body1	-0.3	-0.2	0.1	-0.6	-0.6	0.9
Body2	-0.2	-0.1	0.1	-0.7	0.4	-0.1
Body 3	0.2	-0.9	0.6	2.1	-0.5	2.5
Body4	-0.2	0.1	0.4	-0.6	0.9	-0.7
Brain1	0.1	0.1	-0.2	-1.3	-0.6	-2.2
Brain2	0.3	0.0	-0.1	-0.8	0.6	-1.0
Brain3	-0.1	0.0	-0.3	-2.8	1.1	-0.6
Brain4	0.1	0.0	-0.5	-3.2	0.6	0.1
Mean	0.0	-0.1	0.0	-1.0	0.2	-0.1
Standard deviation	0.2	0.3	0.3	1.5	0.6	1.3

Considerations for phase 1 of audit

- Contour change:
  - Facial swelling due to steroids
  - Gas and weight loss/weight gain
- Small sample size due to limited patient numbers
- Analysing multiple body sites
- Risk of transcription error
- ROIs – we were (and still are) learning!
- Tubing from the laryngeal mask airway (LMA) for those patients under GA may occlude cameras
- Dignity

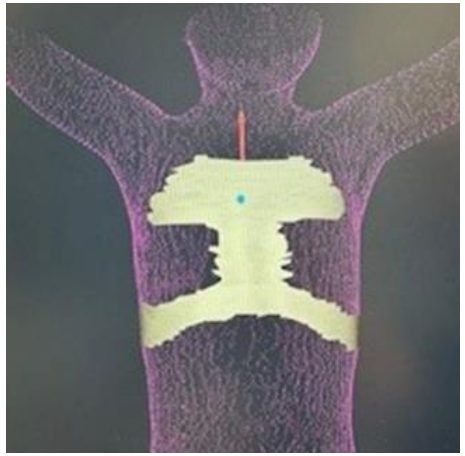
Progress since phase 1 of audit

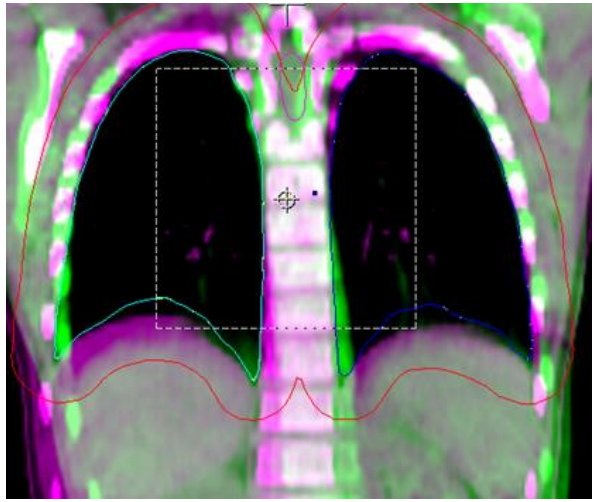
Phase 2 of audit started and currently on-going:

- Using SGRT as primary set up tool **straight to iso-centre for body** patients (still tattooing for backup)
- Using SGRT to **pre-position brain** patients prior to applying immobilisation mask to improve rotations
- Recording re-imaging frequency and reason for re-image
- Use of nasal specs (where safe to do so) for GA patients reducing risk of camera occlusion

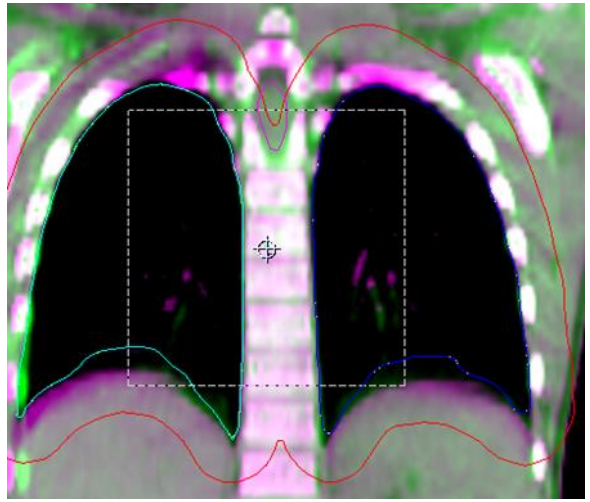
Case study – whole lungs

- 7yo girl treating whole lungs for metastatic Ewings Sarcoma - awake
- Initially part of the phase 1 stage of audit
- Repeat imaging required at start of treatment due to ++yaw on lower spine
- Moved to using AlignRT to correct for yaw each day on ph1 audit as consistent and improving positioning on images





Pre-SGRT
Yaw affecting spine



Using SGRT
Yaw eliminated – no repeat imaging after change to using AlignRT for rotations

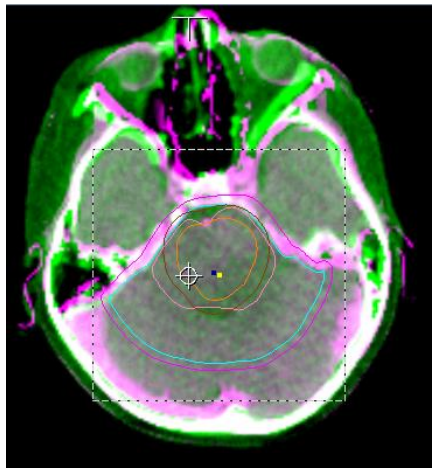
Case study – brain

- 5yo boy treating brain for DIPG *(DIPG5)* under GA with LMA
- 1st course (39Gy/13#) August 2024
- Started treatment a week before we started PH1 of audit
- Very poor, variable position ?due to some swelling
- Moved to daily imaging and followed advice from Vision RT to correct rotations with AlignRT prior to putting the mask on

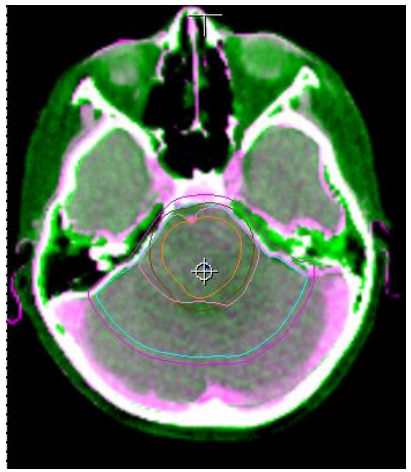
- Reirradiation (20Gy/10#) Feb 2025 (under GA with nasal specs)
- Ph2 audit pre-positioning
- Significant facial swelling due to steroids

Case study – brain (cont.)

1st course treatment Aug 2024

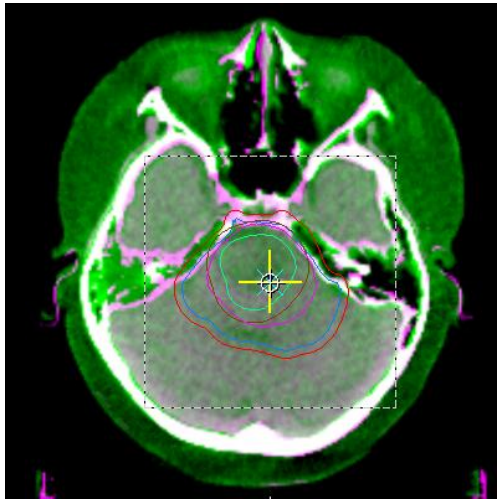


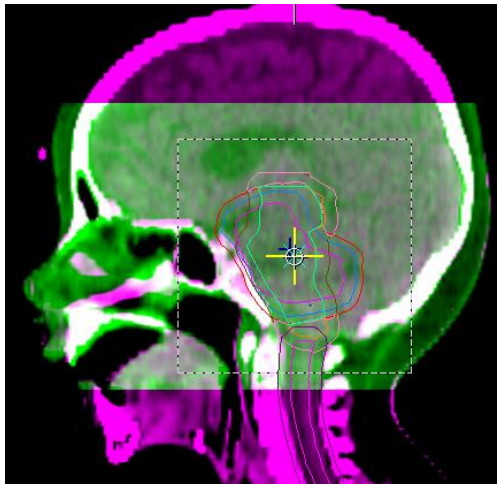
Pre-SGRT - ++roll seen on imaging



Used SGRT to pre-position eliminating roll

2nd course treatment Feb 2025

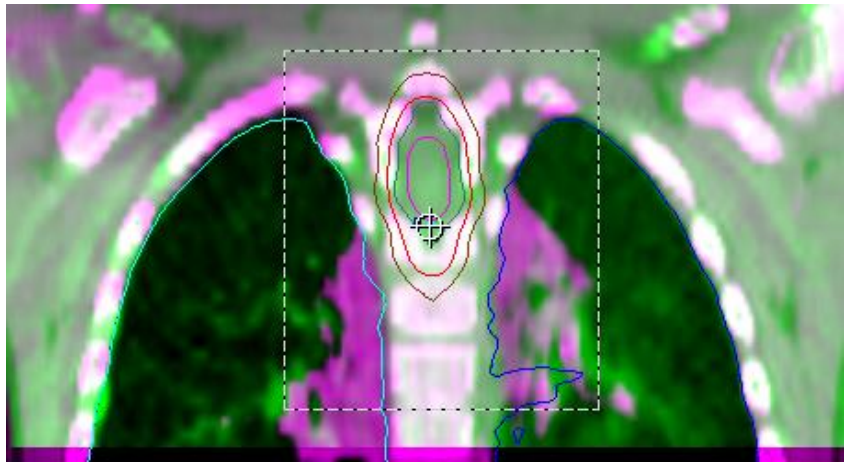


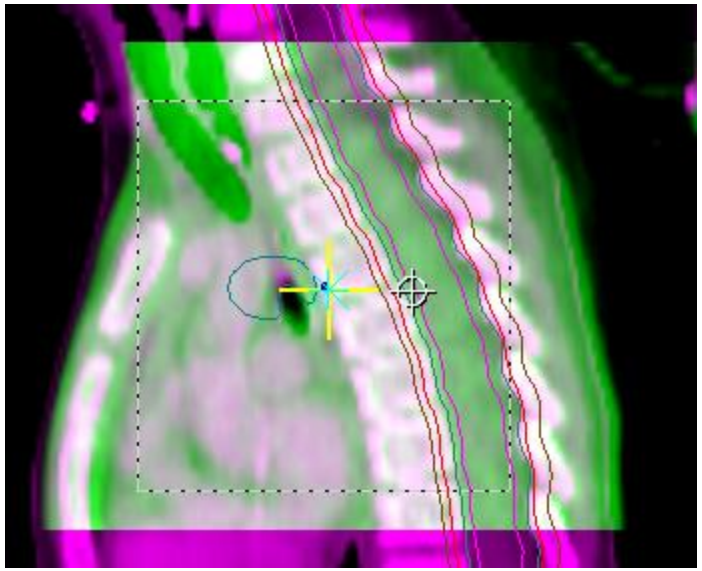


- Phase 2 of our audit had started
- Pre-positioned with AlignRT before mask
- Significant facial swelling due to steroids
- Only one re-image on final fraction due to pitch caused by swelling on cheeks – highlighted by deformation tool on AlignRT!

Case study – whole lungs & boost

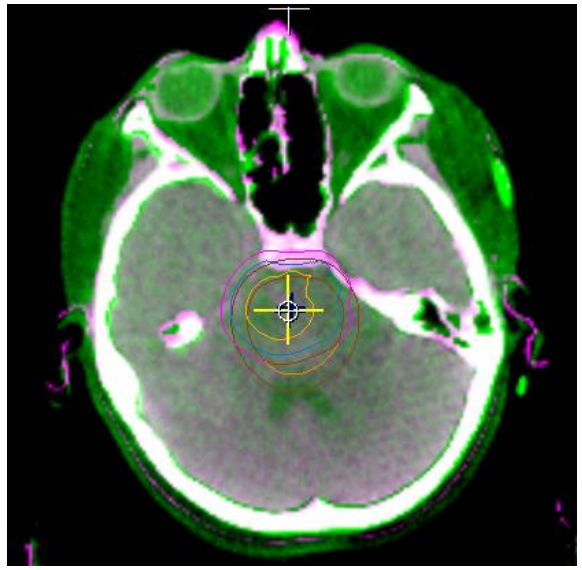
- 6yo boy
- Treating whole lungs and mediastinal boost for metastatic Wilms tumour under GA (nasal specs)
- First paediatric patient successfully treated on phase 2 of audit setting up straight to isocentre using AlignRT (ignoring tattoos)
- **No re-imaging required**

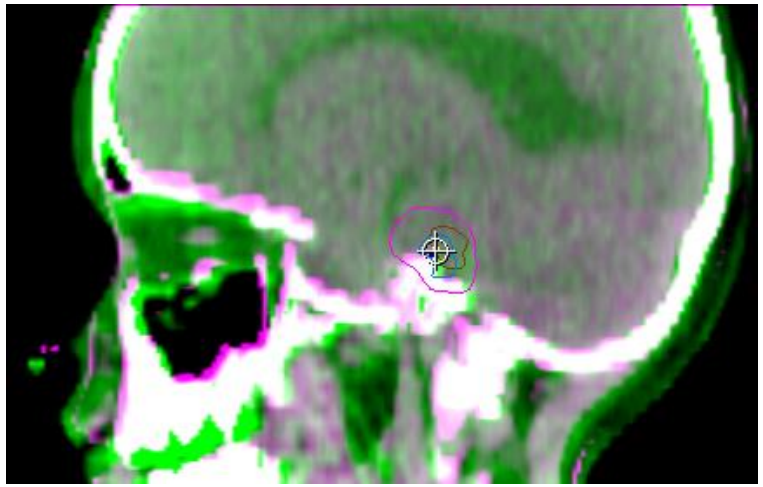




Case study – brain

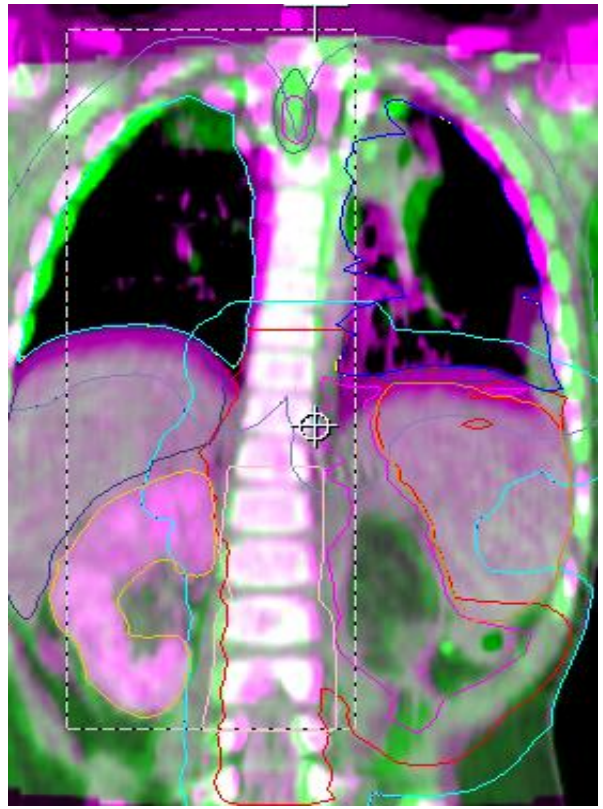
- 7yo girl
- Treating brain for DIPG under GA (nasal specs)
- Prepositioned with AlignRT on phase 2 of audit before applying immobilisation mask
- **No re-imaging required**





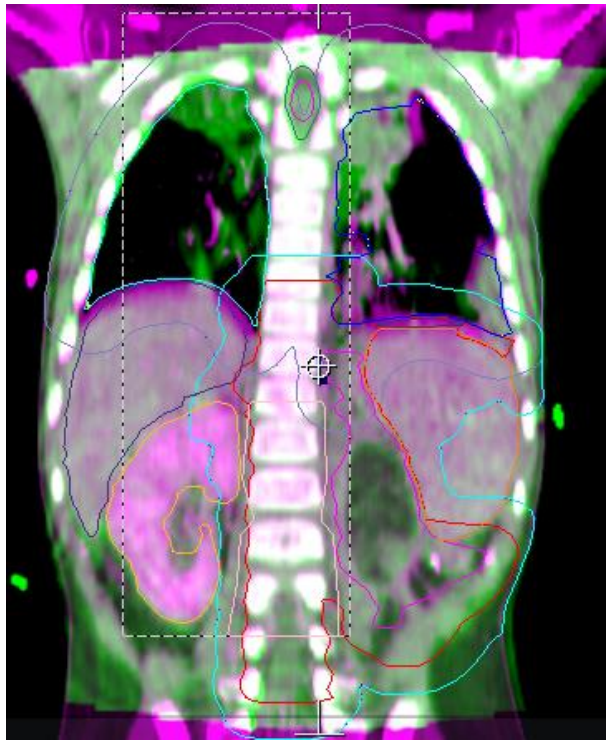
Case study – flank & whole lungs

- It isn't always perfect!
- 3yo girl under GA for treatment
- Treating flank & whole lungs for metastatic Wilms tumour – ++long volume
- On phase 2 of audit – 3 repeat images
- Patient diagnosed with C-Diff & flu after 1# - needed 1 week gap
- Contour change, illness & LMA contributed to difficulties



Case study – flank & whole lungs (cont.)

- We got there in the end!
- Used imaging to guide ROI delineation
- Removed sections of ROI that were occluded and added T-shape across chest to create personalised ROI
- Evidenced staff can quickly lose confidence with SGRT - tattoos would not have improved setup

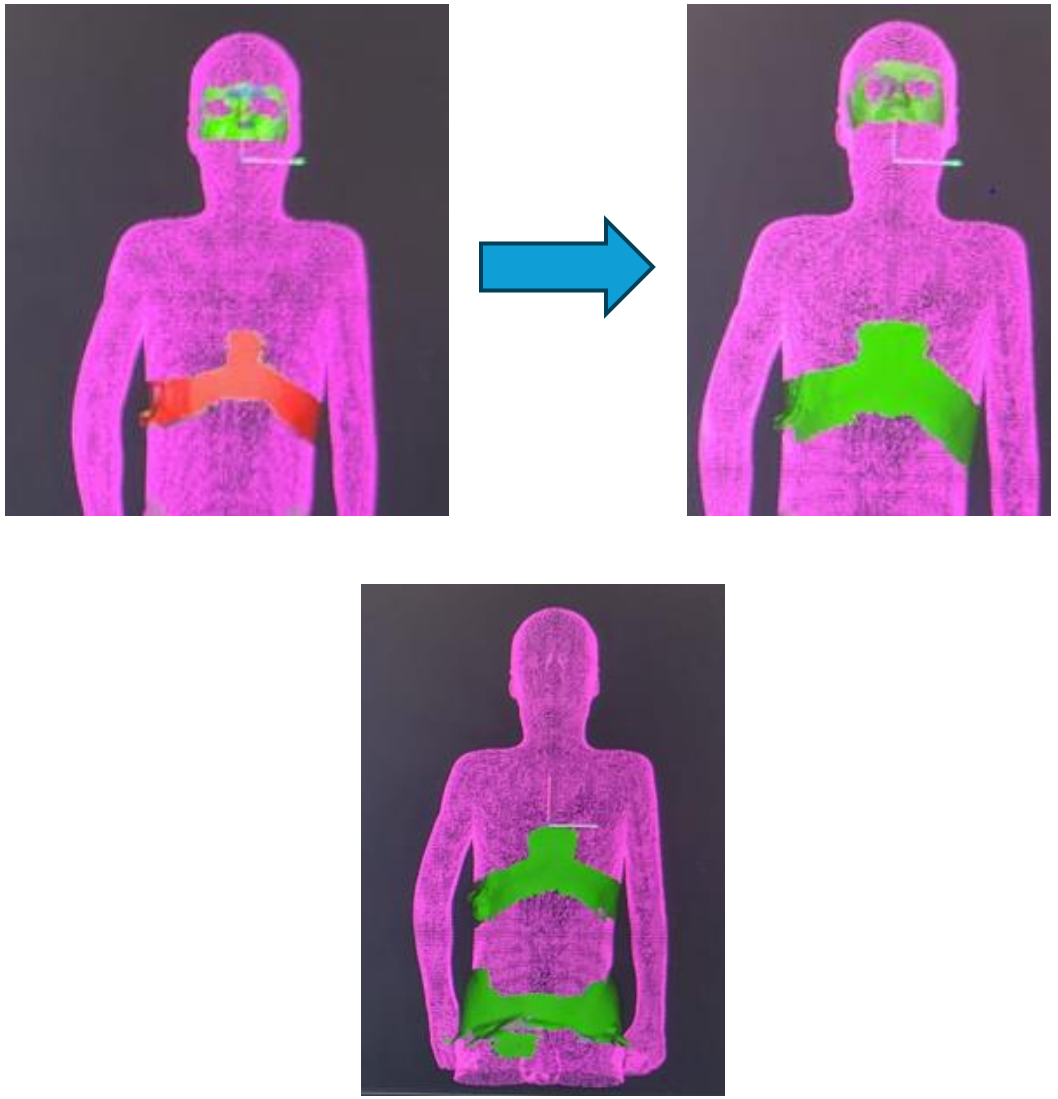


Case study – CSRT

- 14yo boy
- Treating craniospinal axis for metastatic ATRT
- 3 plans – Head, Thoracic Spine and Lumbar Spine
- 5-point immobilisation mask
- Using tattoos for setup (symph & sides with xiphi alignment) - AlignRT as setup aid
- Tricky ROI – Split or all in one?
  - Need pitch and yaw check for whole volume

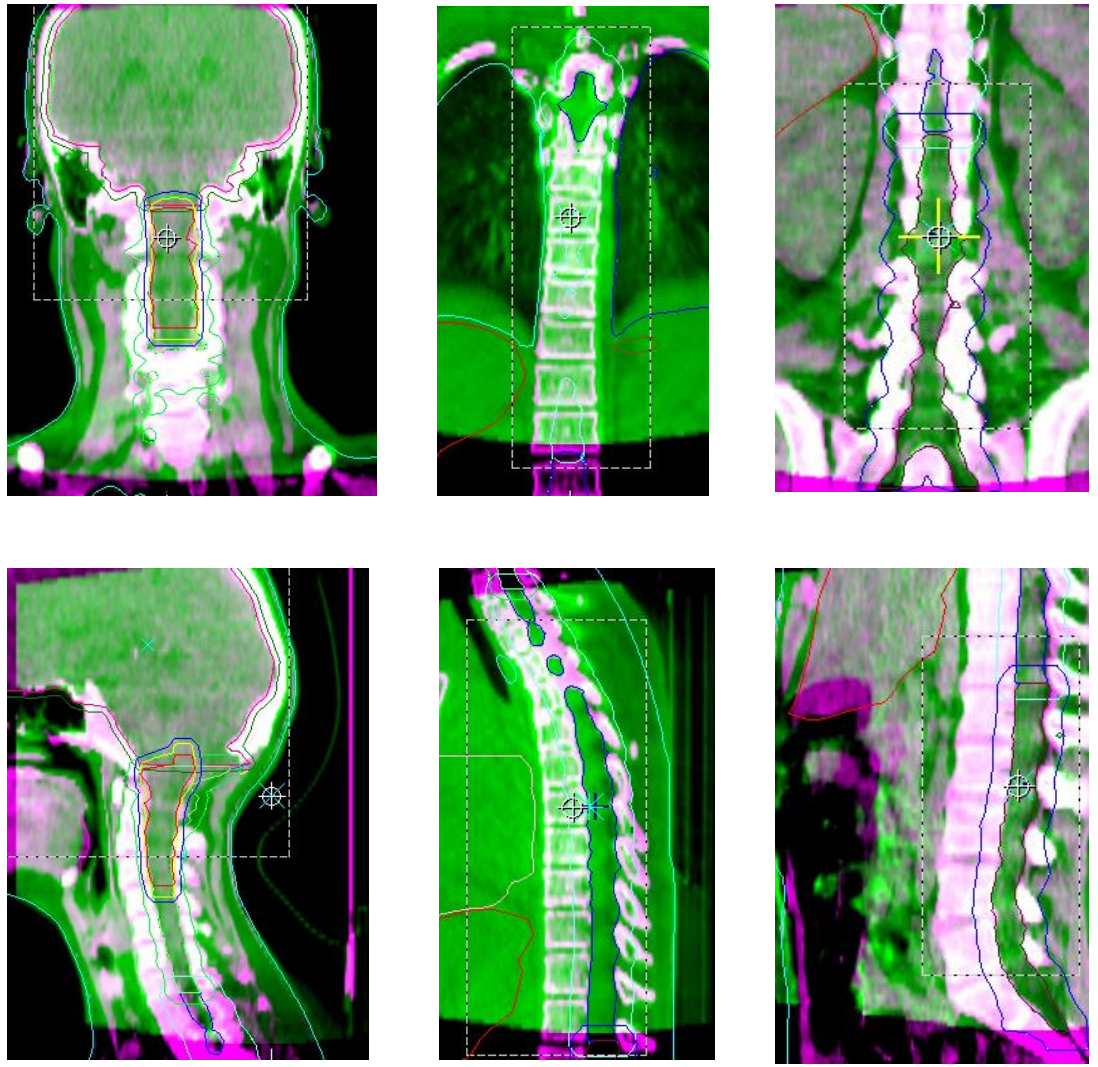
Case study – CSRT (cont.)

- Deltas struggle with the 3 ROIs
- Two ROIs together accurately showed pitch
- Cannot extend ROI superiorly due to mask
- Images showed yaw at upper T spine
- Key issue = **Patient dignity**
- No rotational or translational issues between T and L spine

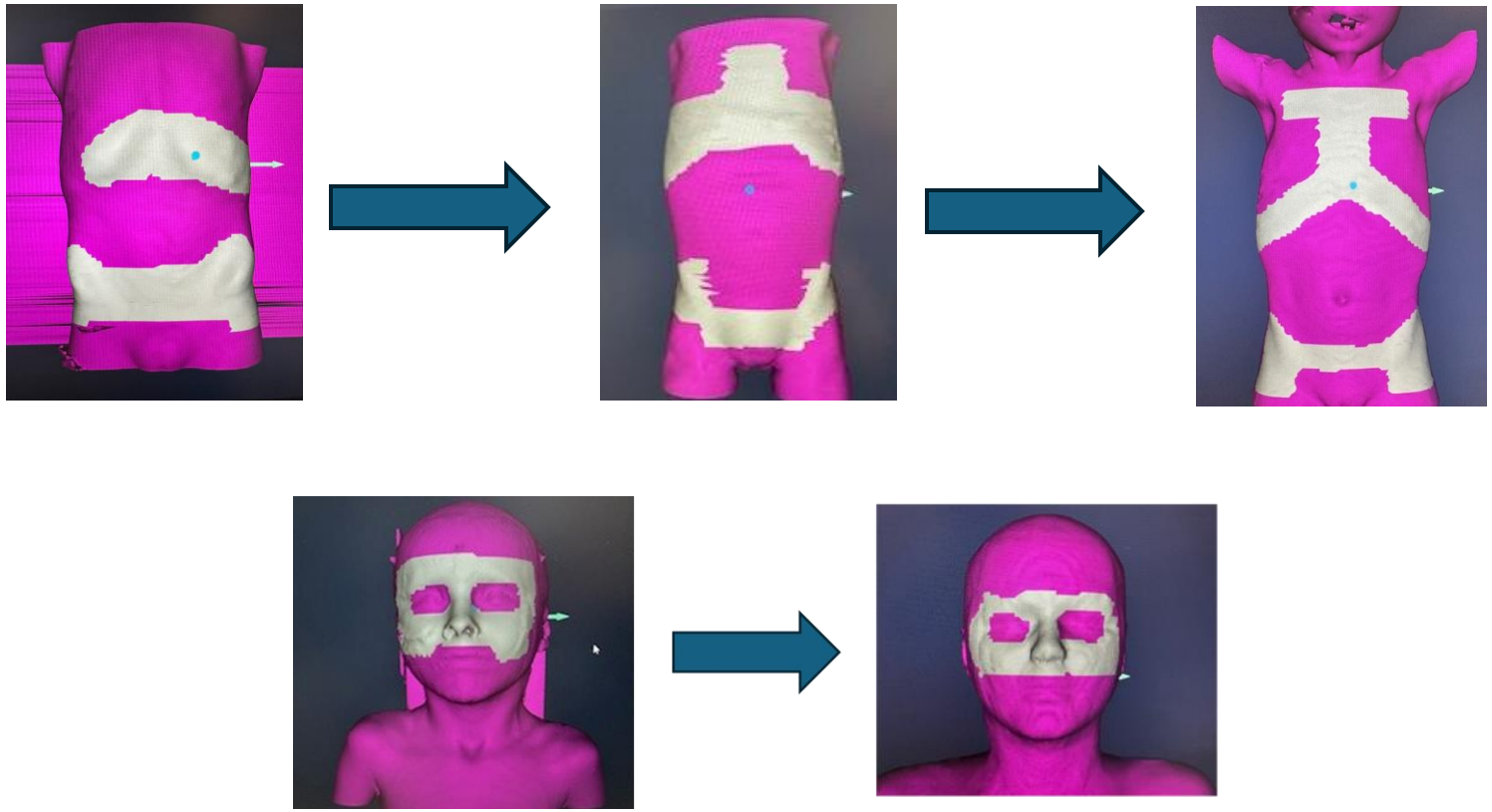


Case study – CSRT (cont.)

- AlignRT worked well
- ++ gas causing contour change
  - AlignRT struggled with vertical delta
- Consistent day 2 - this and future sessions reference capture used
- Translational and rotational parameters (excluding vertical delta for the thoracic and lumbar spine) demonstrate strong concordance between XVI and AlignRT



ROI Learning



Impact so far

- Very difficult to compare pre-SGRT patients to phase 2 audit patients
- Daily imaging with SGRT so slight increase overall concomitant imaging dose
- **However** already seeing decrease in number of repeat images required across patient sites:
  - Pre AlignRT **14%** of treatment fractions for brain patients had repeat imaging due to positional problems
  - Post AlignRT **only 2%** of treatment fractions for brain patients had repeat imaging due to positional problems
- Patients are therefore on the treatment couch for shorter time frame so reducing overall trauma

Next steps

- Move to a completely tattoo-less workflow (Tegaderm for backup due to limited machines with AlignRT)
- Build staff confidence surrounding paediatric SGRT use (including clinicians)
- Time audit
- Audit immobilisation – ?need wider opening on open-face masks
- Apply learning to adult cohort - open face mask project
- Discussions needed with VisionRT for future CSRT treatments

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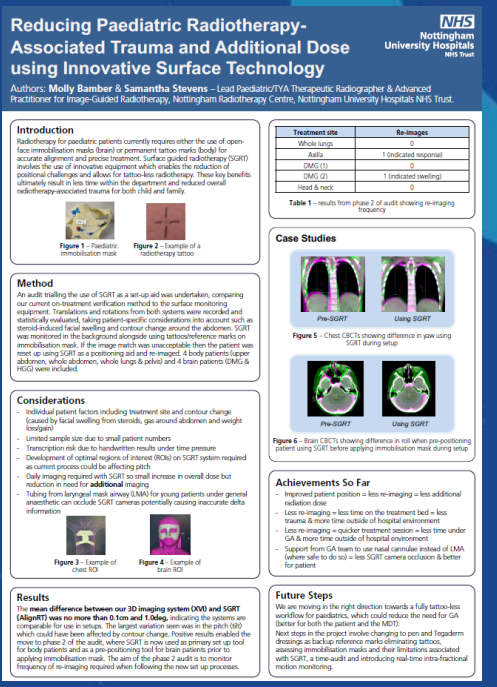
Thank you for listening!

Any questions?

molly.bamber@nhs.net
samantha.stevens19@nhs.net
jonathan.allred2@nhs.net



Reducing Paediatric Radiotherapy-Associated Trauma and Additional Dose using Innovative Surface Technology

NHS Nottingham University Hospitals NHS Trust

Authors: **Molly Bamber** & **Samantha Stevens** – Lead Paediatric/TYA Therapeutic Radiographer & Advanced Practitioner for Image-Guided Radiotherapy, Nottingham Radiotherapy Centre, Nottingham University Hospitals NHS Trust.

Introduction

Radiotherapy for paediatric patients currently requires either the use of open-face immobilisation masks (brain) or permanent tattoo marks (body) for accurate alignment and precise treatment. Surface guided radiotherapy (SGRT) involves the use of innovative equipment which enables the reduction of positional challenges and allows for tattoo-less radiotherapy. These key benefits ultimately result in less time within the department and reduced overall radiotherapy-associated trauma for both child and family.

Figure 1 – Paediatric immobilisation mask

Figure 2 – Example of a radiotherapy tattoo

Method

An audit trialling the use of SGRT as a set-up aid was undertaken, comparing our current on-treatment verification method to the surface monitoring equipment. Translations and rotations from both systems were recorded and statistically evaluated, taking patient-specific considerations into account such as steroid-induced facial swelling and contour change around the abdomen. SGRT was monitored in the background alongside using tattoos/reference marks on immobilisation mask. If the image match was unacceptable then the patient was reset up using SGRT as a positioning aid and re-imaged. 4 body patients (upper abdomen, whole abdomen, whole lungs & pelvis) and 4 brain patients (DMG & HGG) were included.

Considerations

- Individual patient factors including treatment site and contour change (caused by facial swelling from steroids, gas around abdomen and weight loss/gain)
- Limited sample size due to small patient numbers
- Transcription risk due to handwritten results under time pressure
- Development of optimal regions of interest (ROIs) on SGRT system required as current process could be affecting pitch
- Daily imaging required with SGRT so small increase in overall dose but reduction in need for **additional** imaging
- Tubing from laryngeal mask airway (LMA) for young patients under general anaesthetic can occlude SGRT cameras potentially causing inaccurate delta information

Figure 3 – Example of chest ROI

Figure 4 – Example of brain ROI

Results

The **mean difference between our 3D imaging system (VXI) and SGRT (AlignRT) was no more than 0.1cm and 1.0deg**, indicating the systems are comparable for use in setups. The largest variation seen was in the pitch (tilt) which could have been affected by contour change. Positive results enabled the move to phase 2 of the audit, where SGRT is now used as primary set up tool for body patients and as a pre-positioning tool for brain patients prior to applying immobilisation mask. The aim of the phase 2 audit is to monitor frequency of re-imaging required when following the new set up processes.

Treatment site	Re-images
Whole lungs	0
Axilla	1 (indicated response)
DMG (1)	0
DMG (2)	1 (indicated swelling)
Head & neck	0

Table 1 – results from phase 2 of audit showing re-imaging frequency

Case Studies

Pre-SGRT Using SGRT

Figure 5 – Chest CBCTs showing difference in yaw using SGRT during setup

Pre-SGRT Using SGRT

Figure 6 – Brain CBCTs showing difference in roll when pre-positioning patient using SGRT before applying immobilisation mask during setup

Achievements So Far

- Improved patient position = less re-imaging = less additional radiation dose
- Less re-imaging = less time on the treatment bed = less trauma & more time outside of hospital environment
- Less re-imaging = quicker treatment session = less time under GA & more time outside of hospital environment
- Support from GA team to use nasal cannulae instead of LMA (where safe to do so) = less SGRT camera occlusion & better for patient

Future Steps

We are moving in the right direction towards a fully tattoo-less workflow for paediatrics, which could reduce the need for GA (better for both the patient and the MDT).

Next steps in the project involve changing to pen and Tegaderm dressings as backup reference marks eliminating tattoos, assessing immobilisation masks and their limitations associated with SGRT, a time-audit and introducing real-time intra-fractional motion monitoring.