The ACPSEM Medical Image Registration Special Interest Group (MIRSIG) Online Webinars

The **current seminar** (1200, Tue 1st September 2020) is chaired by Ben Archibald-Heeren.

- Talk 1: **Dose Accumulation Clinical workflow**

Presented by David Stewart(RT)

Webinar activities!!

-Use the "Q&A" to ask questions!

Live Poll!

Poll information will be used to confirm CPD, so it is important to participate!

Post webinar survey!

Please answer survey when email is sent

Seminar material available online!

Please see https://www.acpsem.org.au/About-the-College/Special-Interest-Groups/MIRSIG

Be more involved!

1. MIRSIG welcomes professions from all disciplines, including radiation therapists and radiation oncologists
2. Sign up to the MIRSIG mailing list (https://www.acpsem.org.au/Home , click myACPSEM, click speciality groups, tick MIRSIG)
3. Join MIRSIG as a member, email mirsig@acpsem.org.au

Practical methods to account for previous treatment

DAVID STEWART

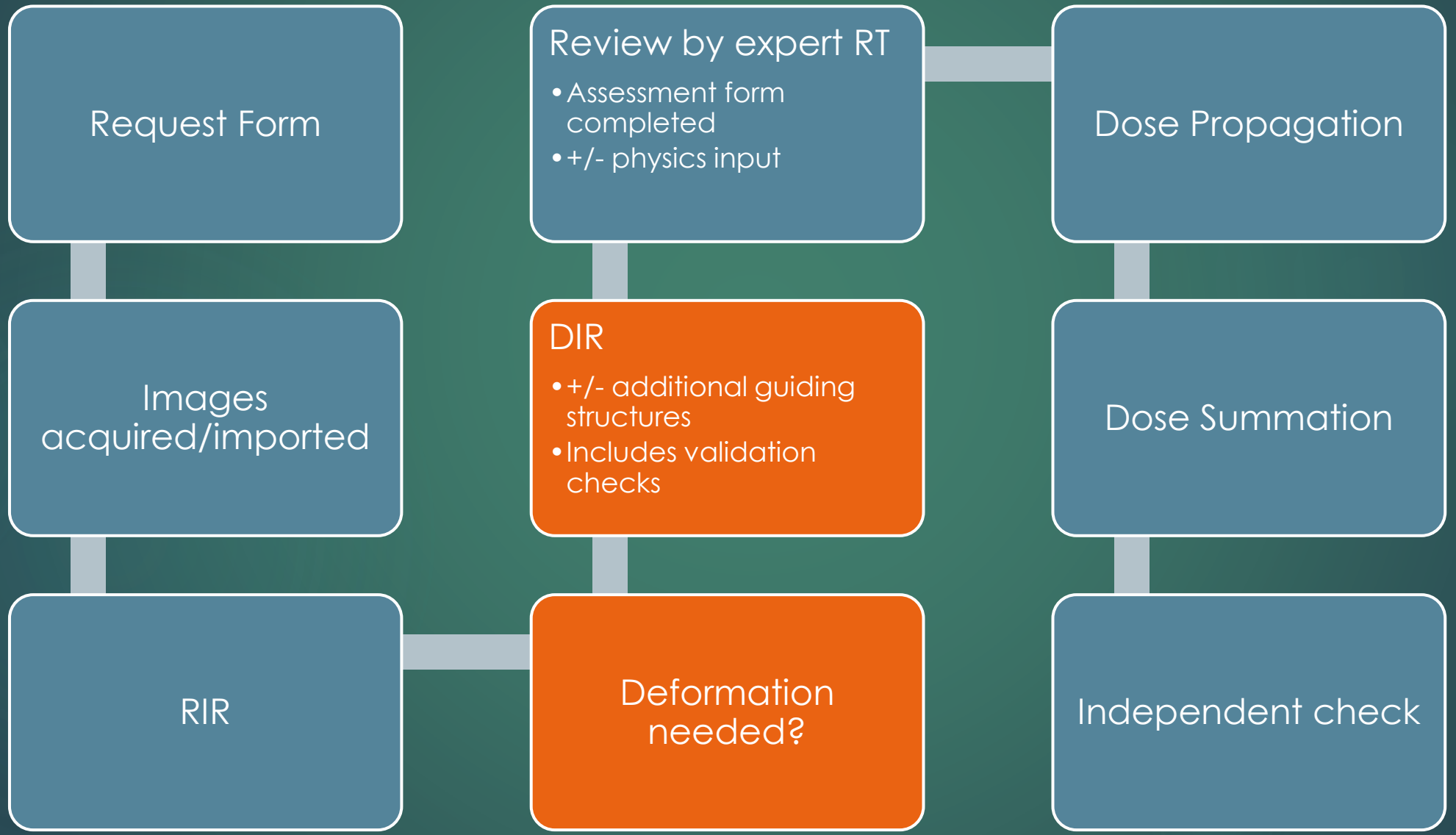
RADIATION THERAPIST, NELUNE COMPREHENSIVE CANCER CENTRE

Learning Outcomes

- Understanding dose accumulation processes and methods
- Appropriately identify use cases for sliding interfaces
- Understanding how volume changes can be handled
- Recognise challenges in deforming dose distributions

- We currently use the RIR parts of the workflow
  - DIR is being commissioned
  - DIR will extend our capabilities to account for previous radiotherapy

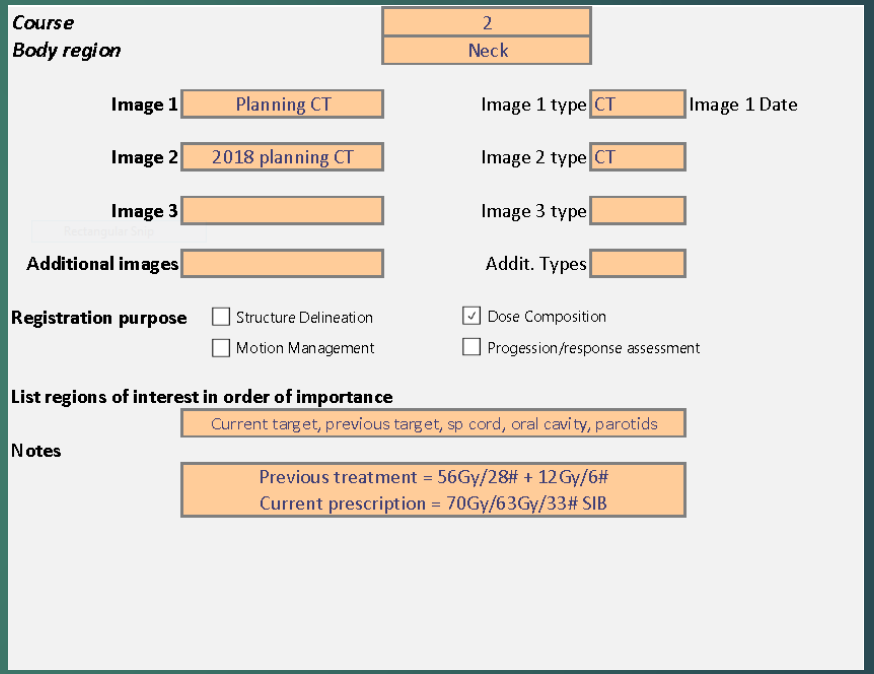
ReRT workflow



Request Form

- Part of the RT booking form in our OIS
- Completed by RO

- Practical example:
  - Mr S
  - Previously treated right tonsil and neck (2018)
  - Regional recurrence in left neck (2020)



Course 2
Body region Neck

Image 1 Planning CT — Image 1 type CT — Image 1 Date

Image 2 2018 planning CT — Image 2 type CT

Image 3 — Image 3 type

Additional images — Addit. Types

Registration purpose
☐ Structure Delineation ☑ Dose Composition
☐ Motion Management ☐ Progession/response assessment

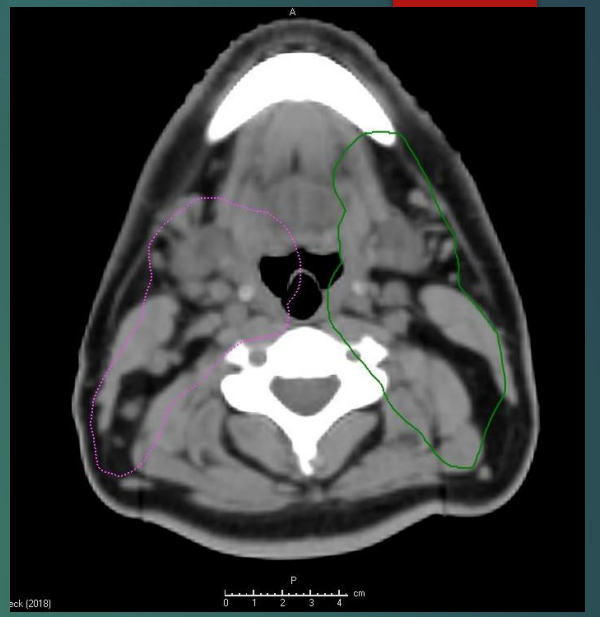
List regions of interest in order of importance
Current target, previous target, sp cord, oral cavity, parotids

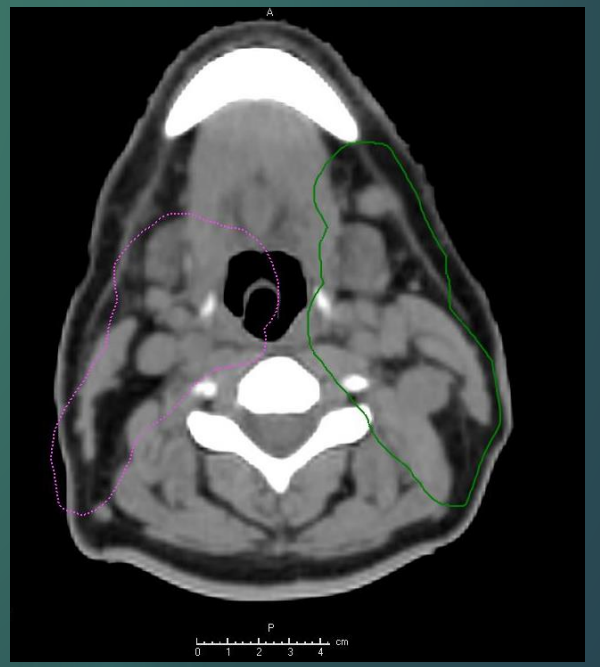
Notes
Previous treatment = 56Gy/28# + 12Gy/6#
Current prescription = 70Gy/63Gy/33# SIB

Image acquisition

- Reproduce the patients position (where possible)
- Consider time between courses
- Anatomical changes
  - Weight loss
  - Other treatments
  - Breathing state
  - Organ filling

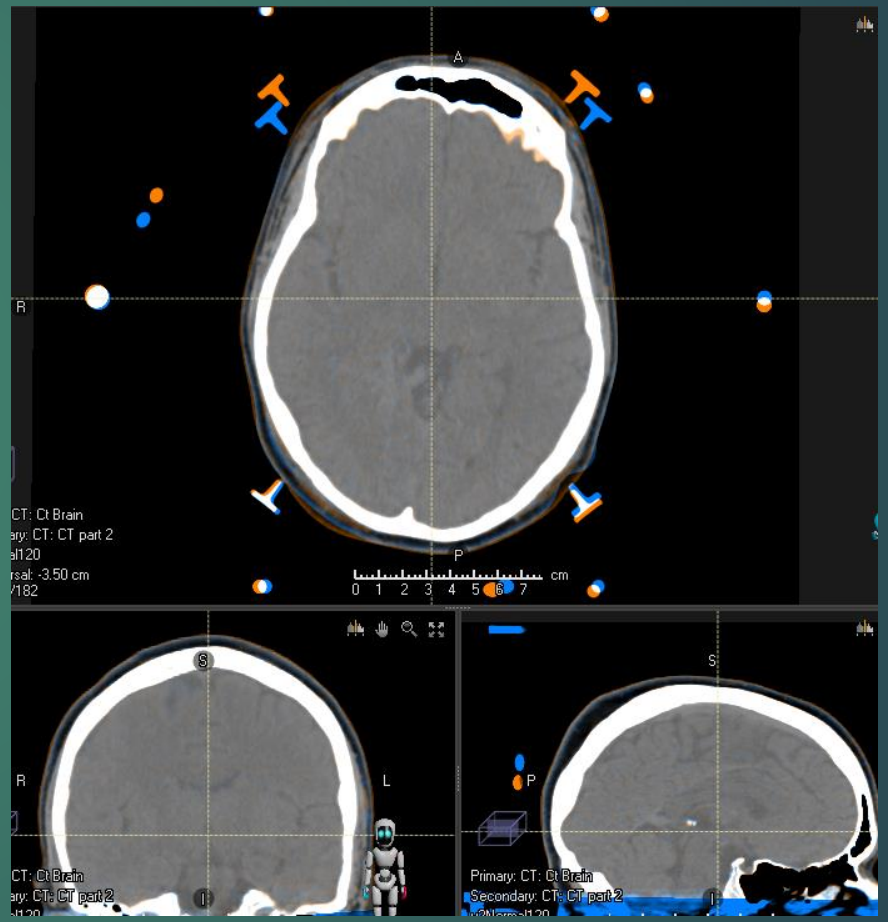
Level	Action	Registration error	Description
0	Whole scan aligned	0-2mm over whole scan	• Usually within same studyset • Stereotactic localisation
1	Locally aligned	0-2mm over primary region	• Treatment setup imaging
2	Useable with error mgmt.	2-5mm over primary region	• DIR may improve upon the RIR
3	Useable for diagnosis only	5-10mm over primary region	• Identify general region of lesion
4	Alignment not acceptable	10+ mm over primary region	• Side-by-side comparison • “Cognitive fusion”





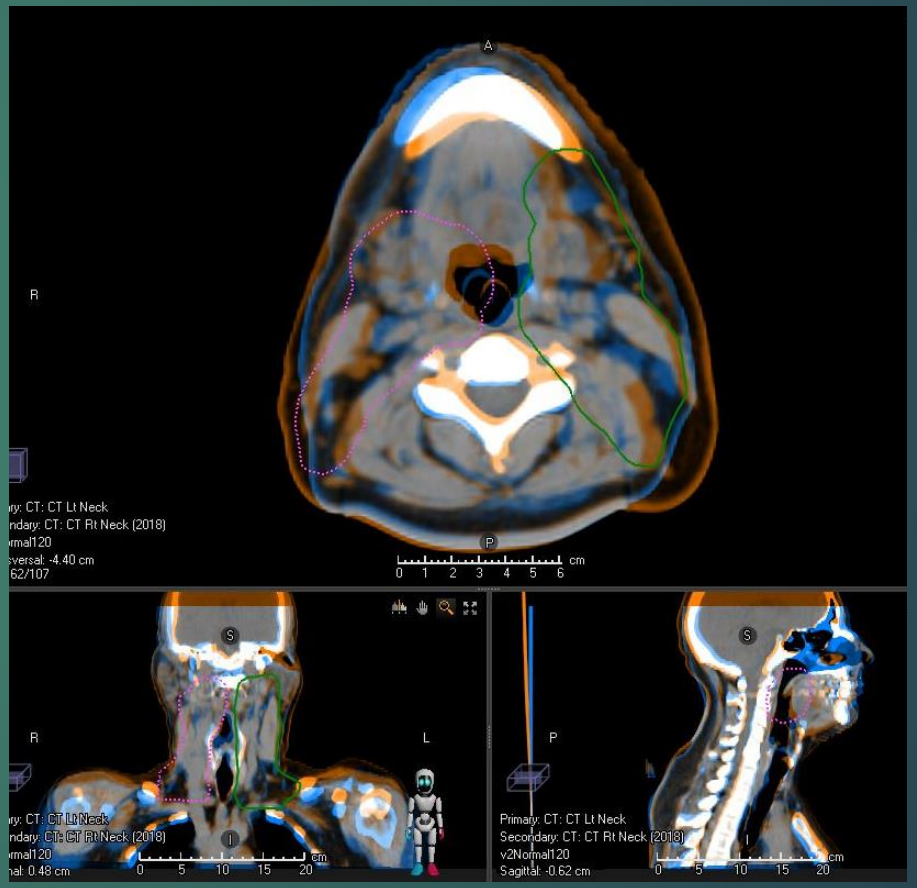
Rigid image registration

- Sometimes rigid image registration is all that is needed
- Not always possible to match entire scan
  - Best match possible of primary area of interest
  - Multiple RIRs for different areas



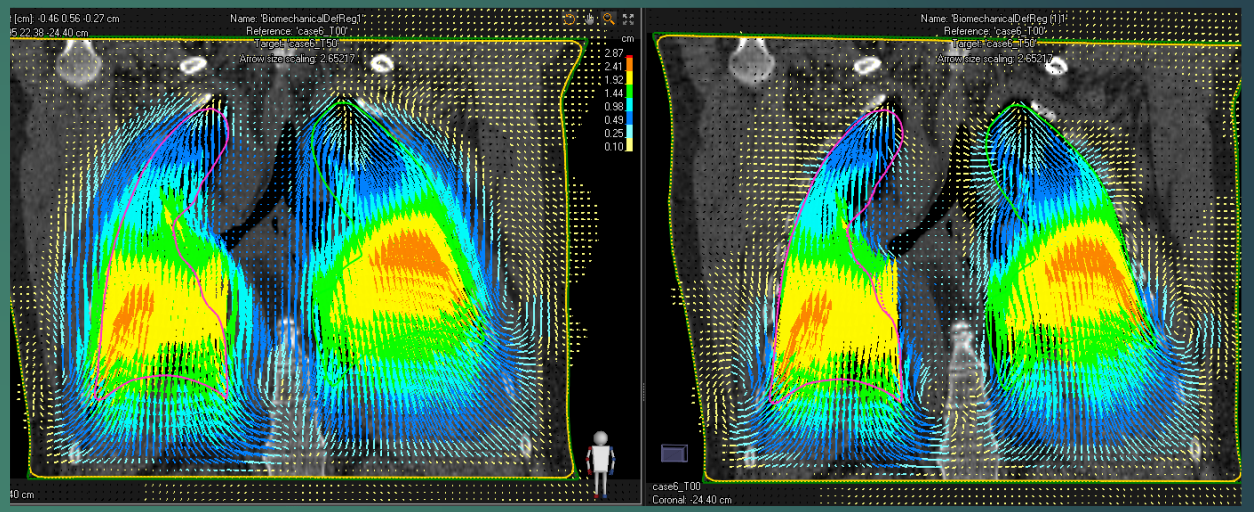
Registration strategy

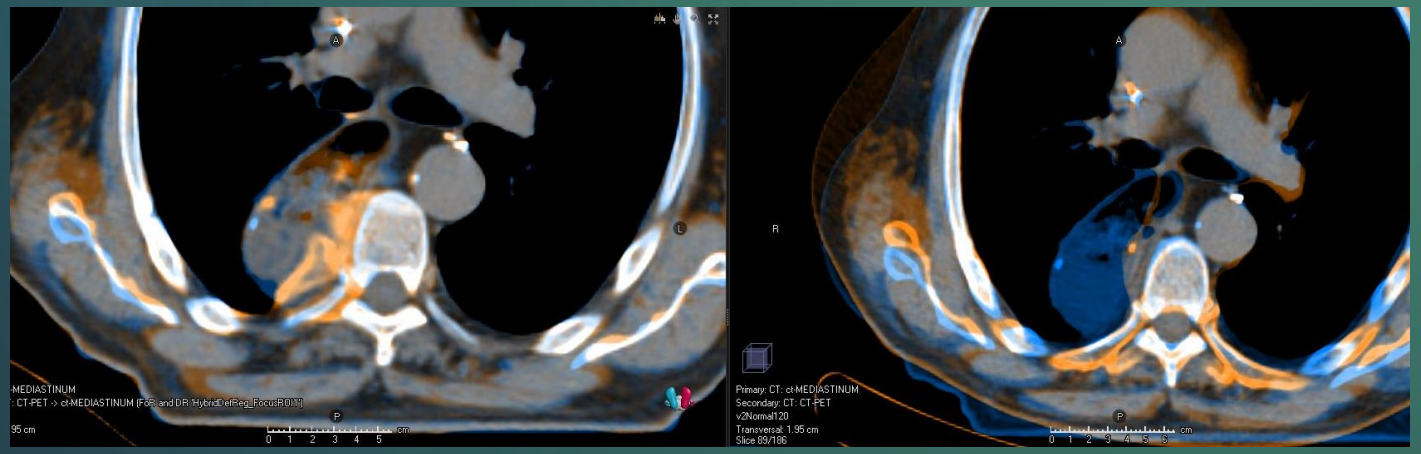
- Is RIR acceptable?
- Will DIR introduce more errors than it fixes?
- Is the internal anatomy significantly different?
  - DIBH/FB
  - Bladder filling
  - Weight loss/gain
- Mobile anatomy is hardest to match
  - Shoulders, limbs etc.

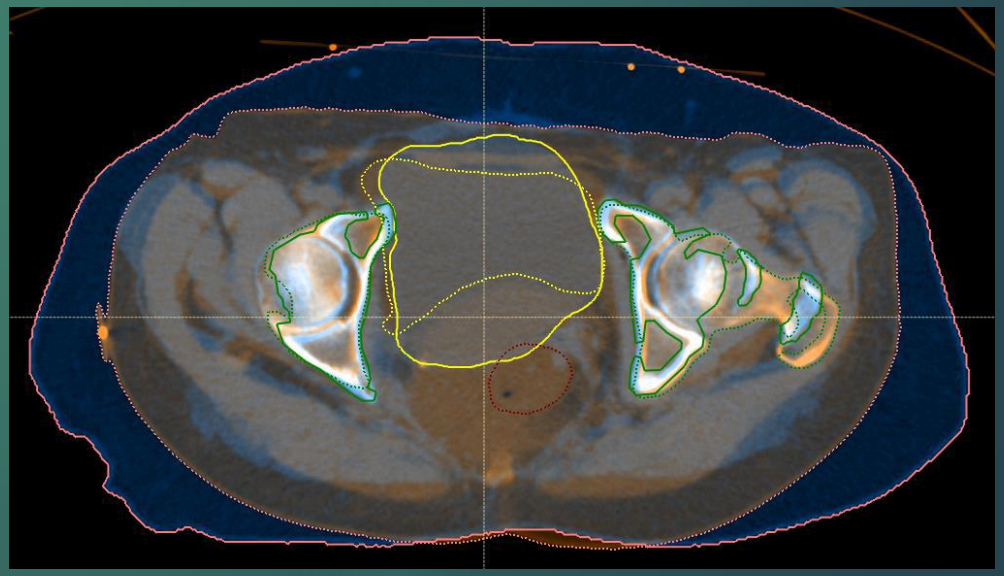


Know Your Algorithm(s)

- Compression/expansion
- Sliding interfaces
- Use or discard image information
- Guiding structures







Deformable Image Registration

- Limit extent of deformation field
  - More specific information for the optimisation algorithm to work on
- Regions of interest/organs on both scans can assist/guide deformation
  - Use autocontouring (atlas/AI) to speed process
- Include quick sanity checks:
  - Inverted elements (negative jacobian determinant)
  - Image similarity has improved (CC/MI)
  - Visual (qualitative) inspection

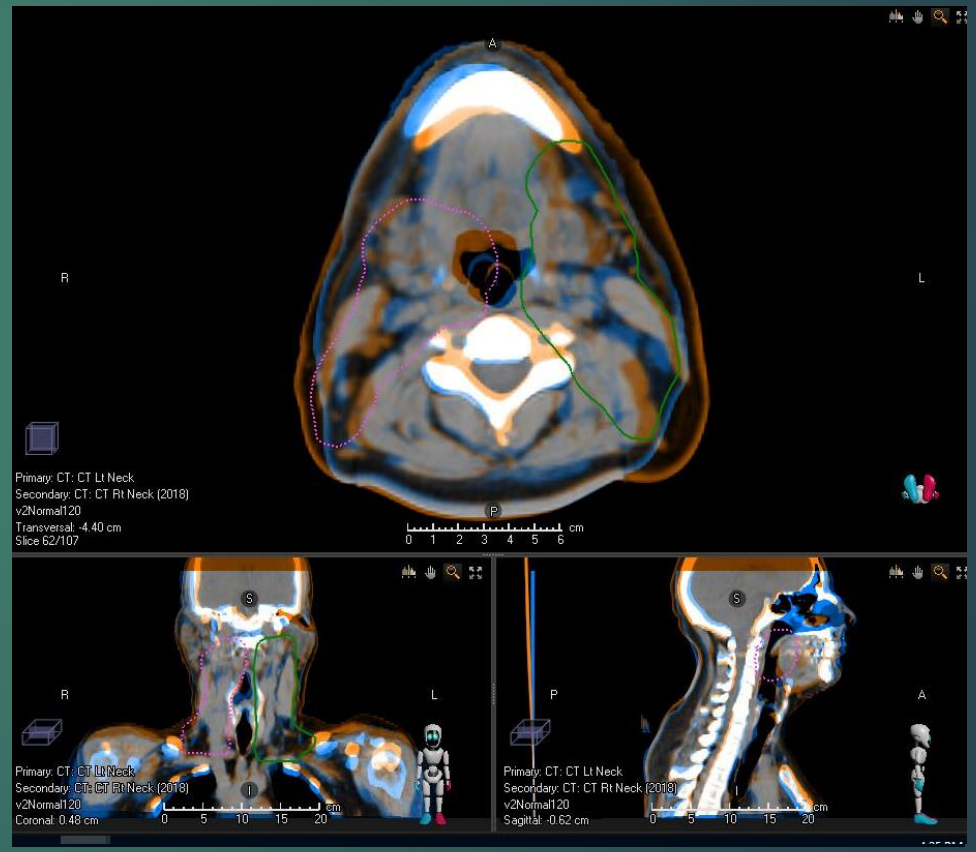


Image Registration assessment

- Performed with a second RT
  - Previously trained and experienced with DIR
- Checklist to complete in OIS
  - Records all information as well as notes
- POIs for evaluation of accuracy
  - TRE
- ROI propagation (organs included in request)
  - Visual
- Comparison of RIR and DIR

Fusion View | Deformed Grid | ROI Geometry Statistics | POI Geometry Statistics

Reference image set: CT: CT Lt Neck [30 Jul 2020, 1

Select target image set: CT: CT Rt Neck (2018) [28 Sep

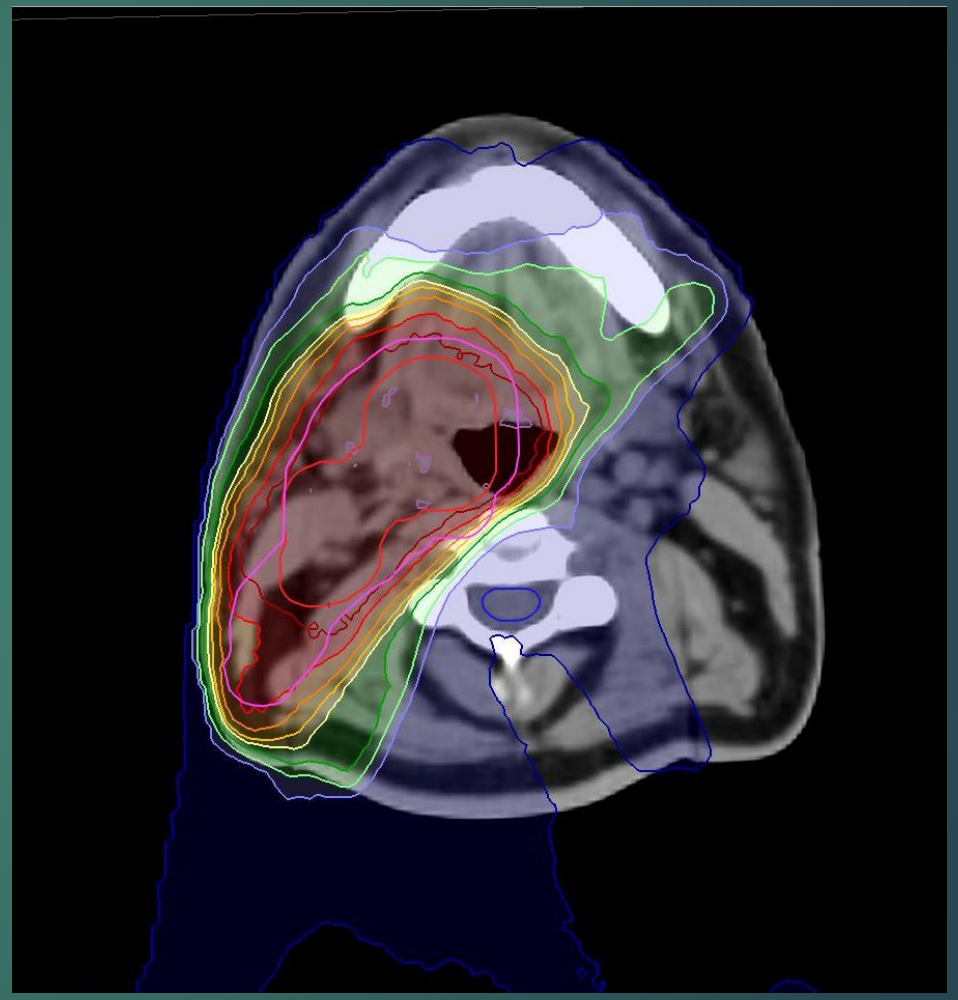
POI	Position [cm]			Distance [cm]				Displacement [cm]				Target registration error [cm]			
	R-L	I-S	P-A	R-L	I-S	P-A	Len	R-L	I-S	P-A	Len	R-L	I-S	P-A	Length
Lt mandibular foramen	4.16 4.60	0.70 0.65	3.22 2.88	0.44	-0.05	-0.33	0.55	0.49	-0.07	-0.37	0.62	0.05	0.02	0.04	0.07
Rt mandibular foramen	-5.16 -4.69	0.40 0.52	2.92 2.68	0.46	0.12	-0.24	0.54	0.55	-0.12	-0.15	0.58	0.09	0.23	0.09	0.27
Superior thyroid notch	-0.07 0.04	-8.15 -8.92	3.80 3.55	0.11	-0.77	-0.25	0.82	0.24	-0.43	-0.10	0.50	0.12	0.34	0.16	0.40
Hyoid	-0.48 -0.07	-5.60 -6.42	4.31 4.24	0.41	-0.82	-0.07	0.93	0.44	-0.79	-0.08	0.90	0.02	0.04	0.01	0.05
Sternal notch	-0.21 -0.42	-16.68 -16.06	3.07 3.06	-0.21	0.62	-0.01	0.65	-0.17	0.60	0.05	0.62	0.04	0.02	0.07	0.08
C3 vertebral body	-0.07 0.08	-4.34 -4.43	-0.94 -0.88	0.16	-0.09	0.06	0.19	0.18	-0.19	0.14	0.29	0.02	0.09	0.07	0.12
C7 spinous process	-0.07 0.01	-10.70 -10.43	-8.13 -8.35	0.08	0.27	-0.22	0.36	0.12	0.16	-0.26	0.33	0.04	0.11	0.04	0.12
Epiglottis	-0.48 -0.01	-4.73 -5.30	2.56 2.52	0.47	-0.56	-0.04	0.74	0.49	-0.47	-0.14	0.69	0.01	0.10	0.10	0.14

Select ROIs

Name	Type	Vol ref im [cm^3	Vol tar im [cm^3	CC RIR	CC DIR	Mean Jacobian	Dice	Mean DTA	Max DTA
Mandible RegEval	Organ	65.42	66.59	0.17	0.98	1.01	0.94	0.04	0.49
Mandible	Organ	79.17	67.34	0.26	0.97	1.02	0.86	0.06	0.65
Brainstem	Organ	25.63	30.47	0.09	0.60	1.00	0.76	0.25	0.77
SpinalCord	Organ	73.10	28.52	0.56	0.97	1.01	0.55	0.28	0.86
Parotid_Left	Organ	30.26	37.56	0.13	0.79	1.08	0.84	0.19	1.00
Parotid_both	Organ	51.66	74.63	0.06	0.90	1.18	0.82	0.23	1.20
Parotid_Right	Organ	21.71	36.93	0.13	0.94	1.32	0.80	0.27	1.20

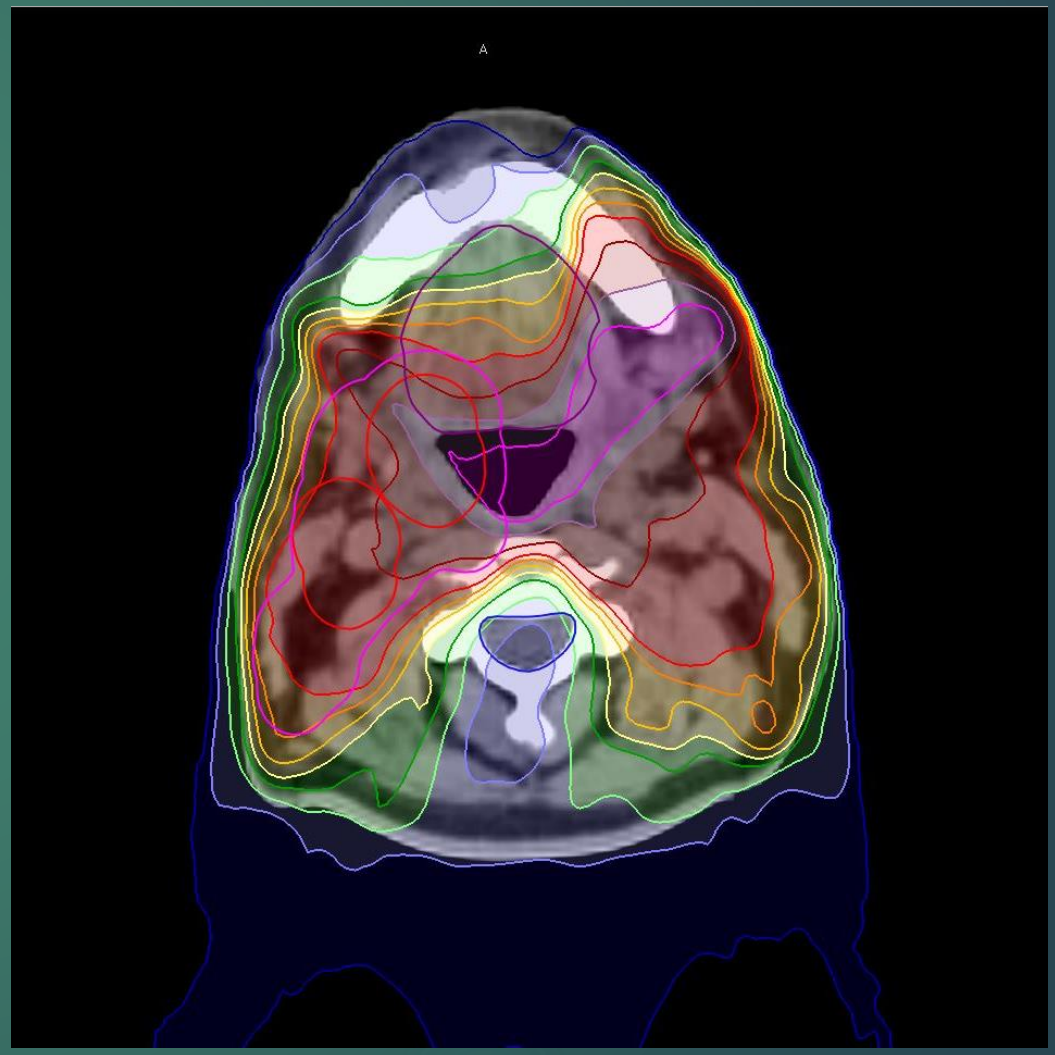
Dose Propagation

- Use best registration to transfer dose from one scan to another.
  - Rigid or Deformable
- Know the limitations before performing this step
  - **Image deformation ≠ Dose deformation**
- Registration direction is important
  - Target = image with dose
  - Reference = where dose is going to
  - For RayStation



Dose summation

- Physical dose is summed
  - Previous = 56Gy+12Gy (sequential boost)
  - Current = 70Gy/63Gy (SIB)
- Use previous dose as background/base dose during optimisation
  - Depends upon your TPS



Independent check

- Performed by a physicist
  - Checklist completed in OIS
- RIR
  - Visual assessment
- DIR
  - Are focus/guidance regions used appropriately?
  - Landmark POIS correctly positioned
  - Direction of registration
- Dose deformation/accumulation
  - Identify areas of higher uncertainty
  - Compare RIR and DIR mapping of isolines

- Qualitative
  - Side-by-side assessment of rigid vs deformable
  - Inspect deformation field for folding, twisting
  - Ensure large deformations are consistent with anatomy
  - Critique additional parameters that may improve results
- Quantitative
  - Image similarity metrics improve with DIR
  - TRE for POIs
  - Metrics for ROIs – DSC, DTA, Jacobian determinant, inverse consistency

Pass = Accept registration and dose accumulation

Fail = D/W planner to improve registration, recompute dose

Post-accumulation work

- RO reviews current plan along with accumulated dose
  - Notes from previous checks are communicated to RO
  - Adjustment made to current plan as necessary
- Normal planning workflow resumes
  - Current plan is checked as per department protocol

Time demands for ReRT

- Try to minimise additional work where possible
- Aim for clinical workflow to add about 2 hours (likely to be higher for first patients)
- Highly automated
  - Scripting APIs
  - Quantitative assessments
- Integrate within a standardised framework for all DIR applications
  - Department support for specialist staff
  - Normal timeframes adjusted for extra steps

Improvements to current prototype

- Tissue recovery/repair
  - Current assumption is 50% at 1 year
- EQD_2 corrections for non-conventional fractionations
  - SBRT is being used more in oligometastatic disease
- Examples from other institutions
  - STRIDeR project at Leeds Hospital, UK
  - ReRT-SMPC project at U Mich, USA

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Questions and Answers from the September 2020 Webinar Chaired by Ben Archibald-Heeren (Talk 1 by David Stewart)

Question 1: What anatomical sites are most prevalent in this process(ReRT)? Or is it a bit of a mix of everything?

Answers:
Our current rigid workflow is available for use across all site with the caveat that the dose is only a general representation of what is happening and should not be relied upon when the image registration is poor. Specifically, our cranial SRS cases make excellent use as we are seeing more and more re-irradiations (30+ mets across multiple courses).

We are aiming to deploy deformable registration for anything above the diaphragm. This boundary was chosen as we feel there is adequate contrast between tissues as well as minimal organ motion changes that can confound registration and dose accumulation.

In time this may expand but the definite emphasis is on getting experience and improving our turn-around times.

Question 2: how you account for decay in dose (Dose discounting)?

Answers: We do not include this in the dose accumulation within the TPS. Our radiation oncologists tend to do some form of dose discounting in their heads and may discuss it with the rest of the team.

This is one area of interest for us and it is completely possible to do so in our current workflow however there would need to be a clear request for this from the radiation oncologist and we some level of standardisation between each of the doctors.