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Relating anatomical variations and patient features with dose-reconstruction accuracy of a 3D dose-reconstruction approach using CT scans of recently-treated children

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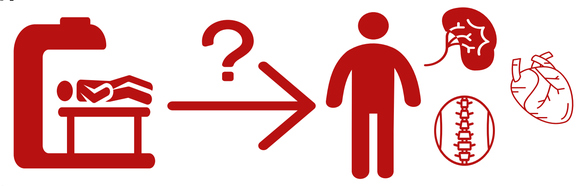
Background

- Study on relation between radiation dose and late adverse effects (LAEs) for pre-1990 childhood cancer (CC) patients is hampered due to the absence of 3D dose, because a simulator was used for 2D treatment planning in that era.
- Phantom-based dose reconstruction methods: a representative phantom for patients with matched patient features such as gender, age, height, and weight.
- We propose to use CT scans of recently-treated CC patients for plan and dose reconstruction.



? How to select a CT scan of recently-treated CC patients, to ensure an accurate dose reconstruction?

Purpose

To study the relation between dosimetric accuracy, anatomical variation, and other patient features, using CT scans of recently-treated CC patients.

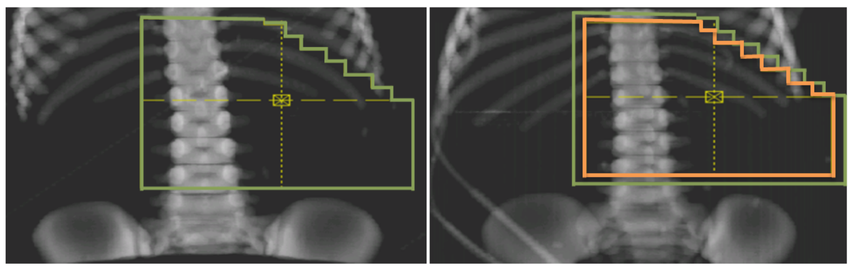
Materials & Methods

Data Collection

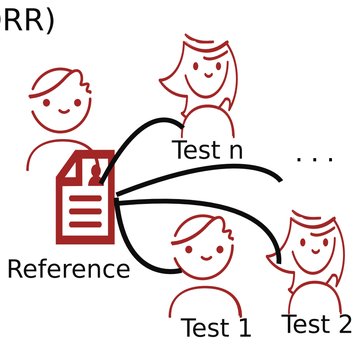
- Abdominal CT scans: 24 CC patients (age 2.5~5.3 years, n boys/girls: 12/12, treated between 2004 and 2015)
- Reference plans: three Wilms' tumor plans on left flank
- Organs at risk (OARs) delineations: right kidney, liver, spleen, and spinal cord

Dose Reconstruction Accuracy

- Re-apply RT plans to CT scans of other patients
  - Adjust RT field in digitally reconstructed radiograph (DRR)
  - Scale MUs to keep dose at isocenter the same



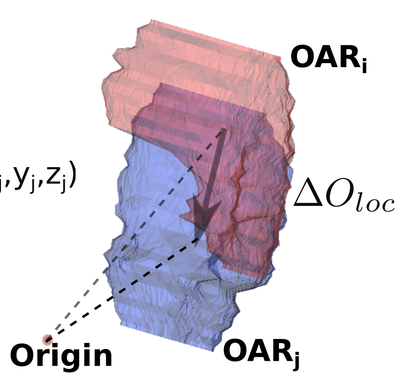
RT field (green) on reference DRR — RT field before (green) and after (orange) adjustment on test DRR



- DE_{mean} (Gy): mean organ dose difference between reconstruction and reference

Anatomical Variation

- Organ volume deviation DE_{vol}(%)
  - Relative organ volume difference between test and reference
- Organ shape deviation: Dice similarity coefficient (DSC)
  - Align test OAR_j with reference OAR_i by center of mass
  - $DSC(OAR_i, OAR_j) = \frac{2|OAR_i \cap OAR_j|}{|OAR_i| + |OAR_j|}$
- Organ location deviation (mm)
  - For each plan, set field center on each CT as origin
  - Reference OAR_i, test OAR_j center of mass: (x_i,y_i,z_i), (x_j,y_j,z_j)
  - $\Delta O_{loc} = |(x_j, y_j, z_j) - (x_i, y_i, z_i)|$
- Patient features
  - Gender, age, height, and weight



Data Analysis

- Average dose deviations and average anatomical variations
- Correlation tests on $|DE_{mean}|$ with
  - $|DE_{vol}|$, DSC, and ΔO_{loc} (Pearson)
  - Patient gender, age, height, and weight

Conclusions

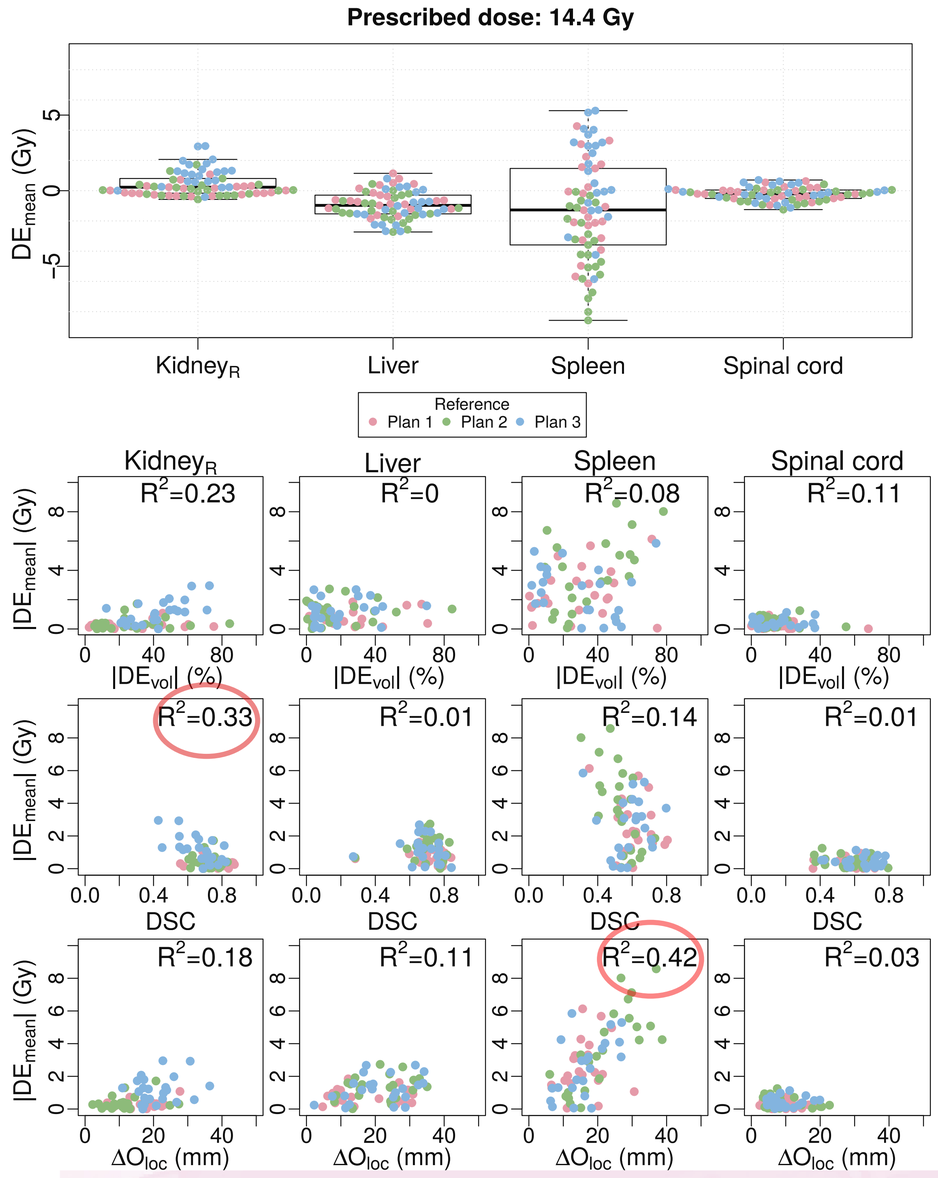
Dose-reconstruction accuracy of the approach based on CT scans of recently-treated children is primarily related to similarity in **internal anatomy, not** to patient features like **height and weight**.

Results

- Average values of the deviation measurements

OARs	$\lvert DE_{mean}\rvert$ (Gy)	$\lvert DE_{vol}\rvert$ (%)	DSC	ΔO_{loc} (mm)
Right Kidney	0.61	34	0.72	16
Liver	1.09	23	0.70	20
Spleen	2.95	32	0.58	18
Spinal cord	0.39	15	0.61	10

- Graphical summary of statistics and correlations



- No correlation found between $|DE_{mean}|$ and gender, age, height, and weight

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