Light Field Projection: Simplifying 3D-Printed Bolus Positioning in Breast Radiotherapy and Omitting re-CT

an innovative approach

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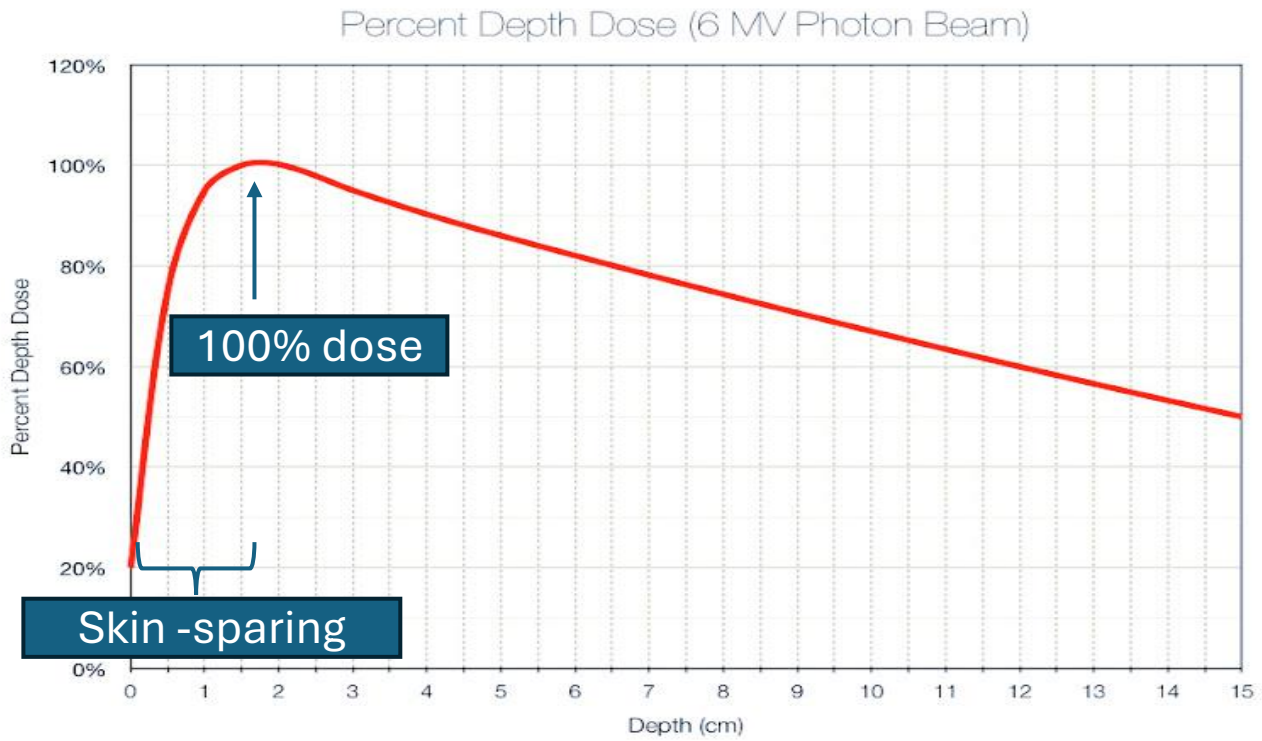
Tuen Mun Hospital

Introduction

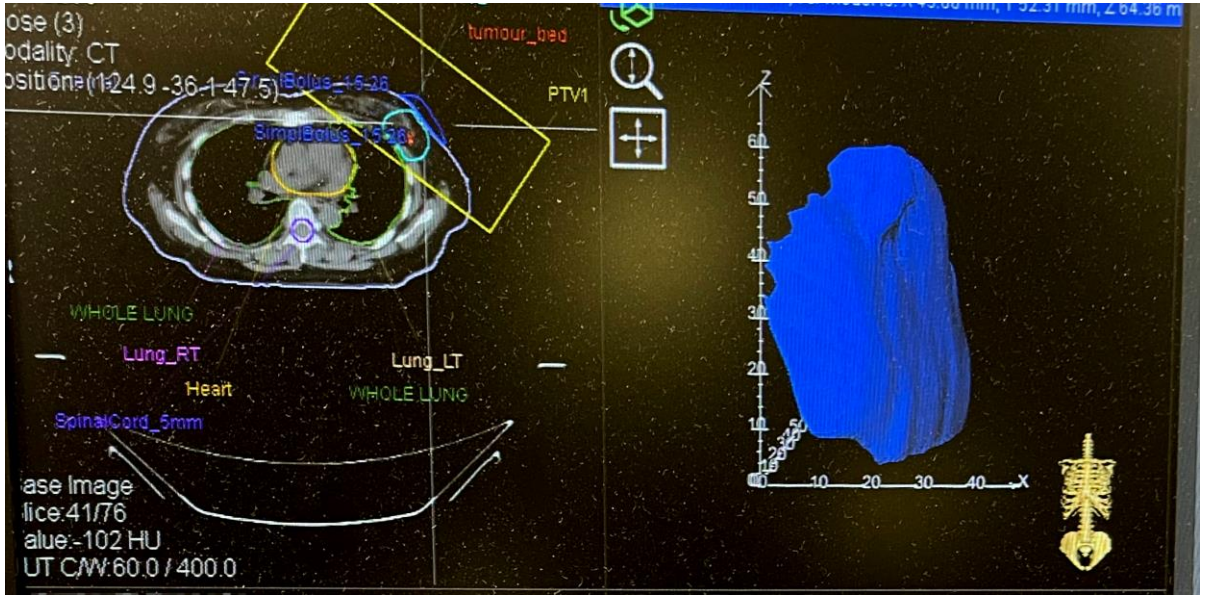
Purpose of Bolus in Radiotherapy:

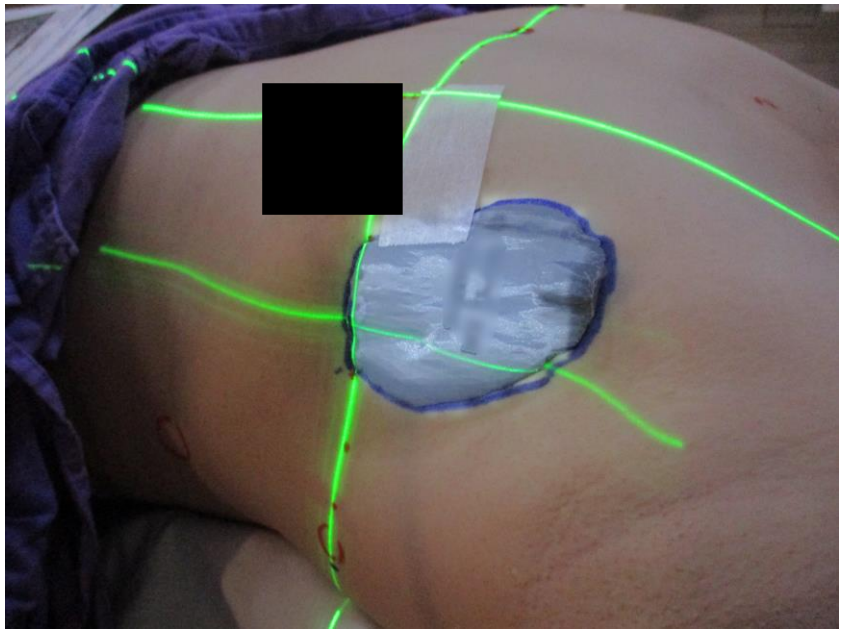
- Mitigates skin-sparing effect of high-energy photon treatments.



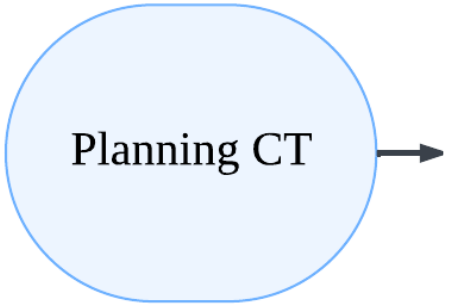
Introduction

- Since 2022, our department has been using 3D-printing technology to create patient-specific boluses for breast cancer radiation therapy.





Traditional Workflow



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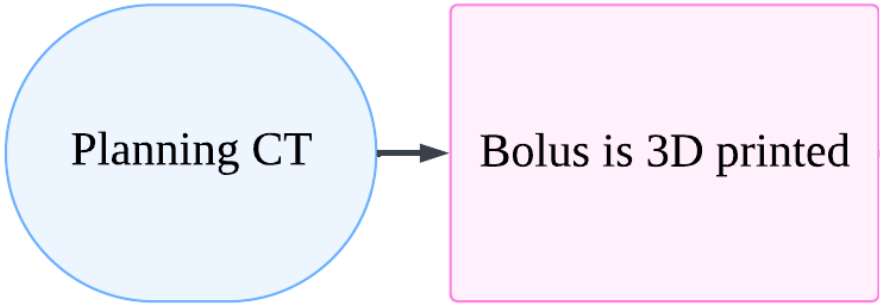

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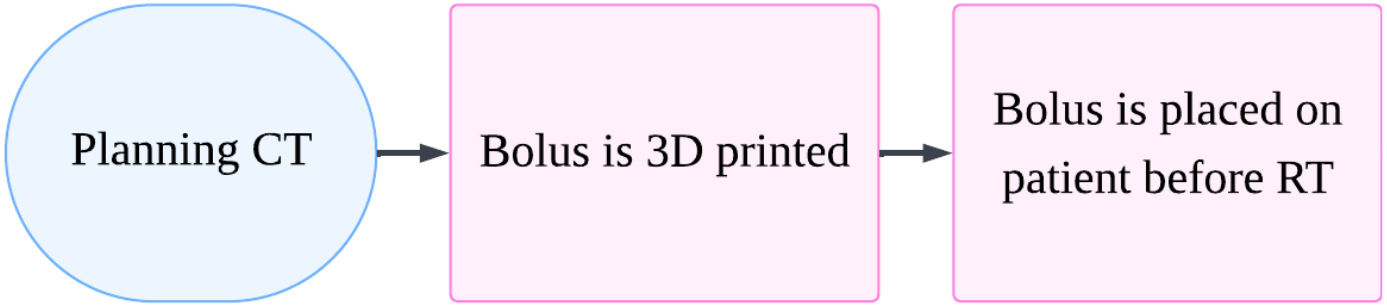

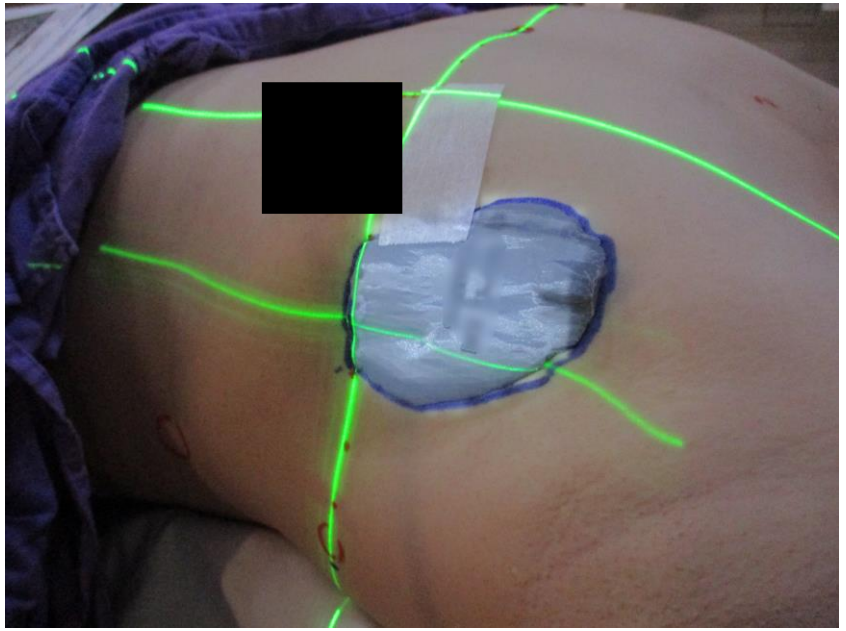

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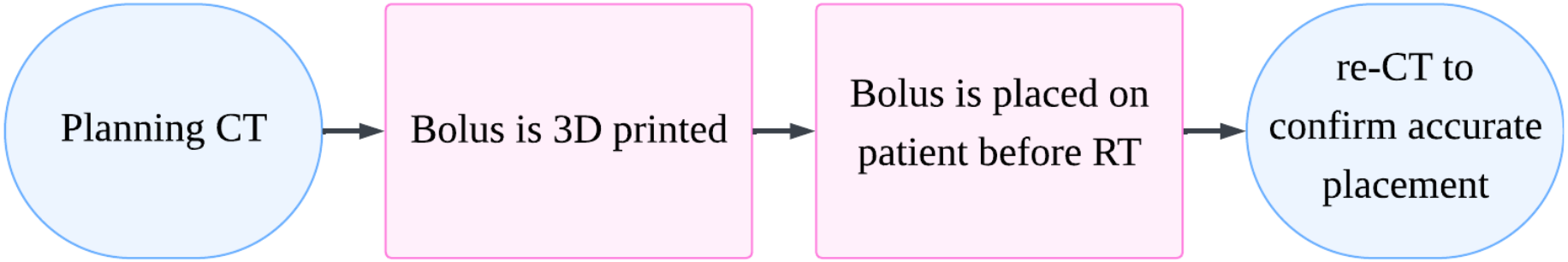

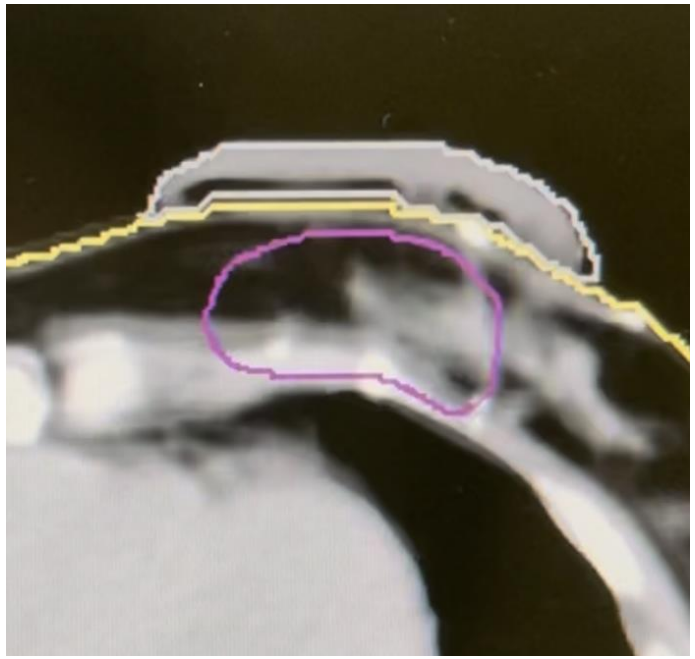

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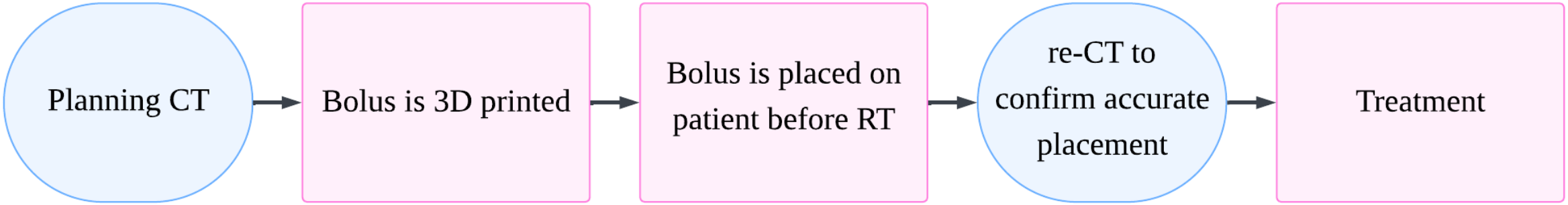

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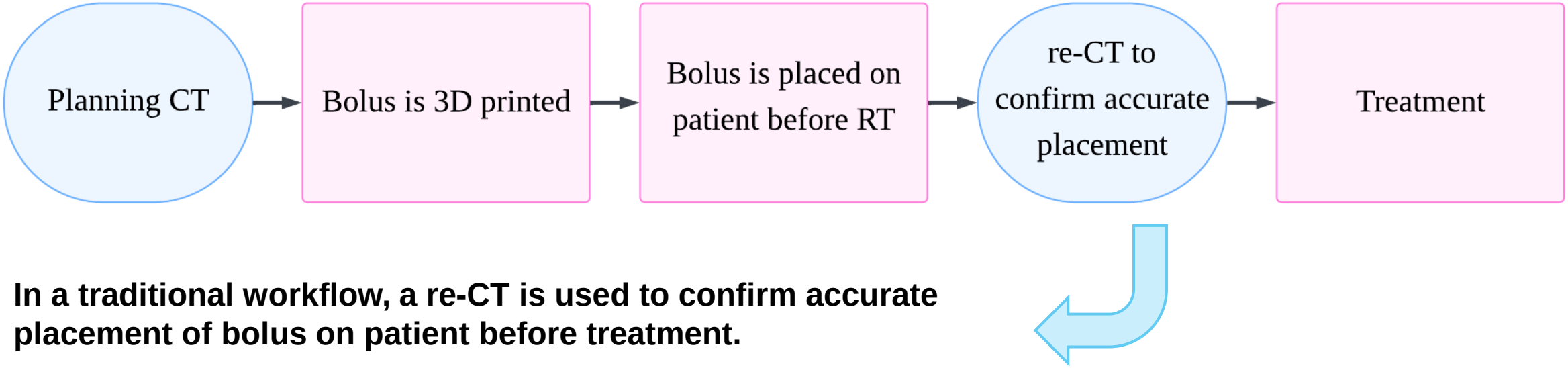

In a traditional workflow, a re-CT is used to confirm accurate placement of bolus on patient before treatment.

Cons:

- Increases workload
- Strains CT resources
- Prolongs treatment
- Additional patient radiation exposure.

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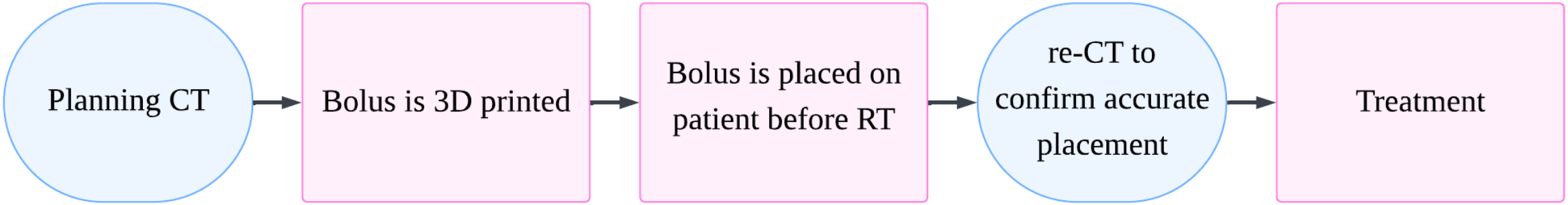

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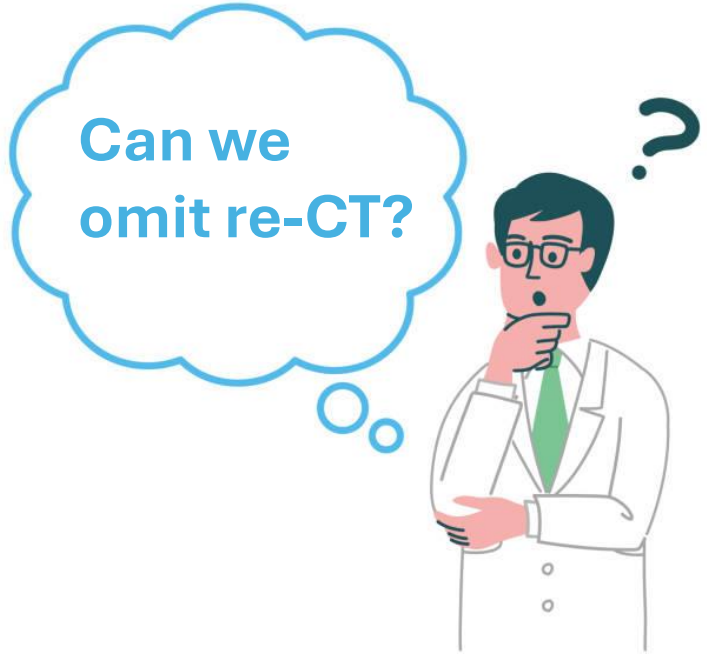

Objectives

- Evaluate accuracy of bolus placement using LINAC light field projection.
- Assess dosimetric outcomes.
- Determine feasibility of omitting re-CT from clinical workflow.

Methodology

Patient selection: Breast cancer patients undergoing adjuvant radiotherapy from May 2023 to Feb 2024.

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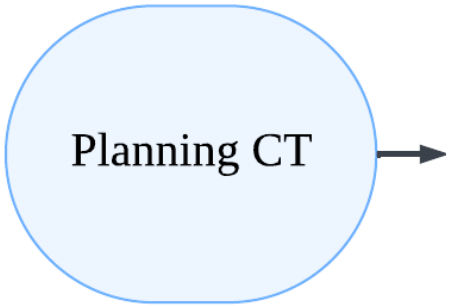

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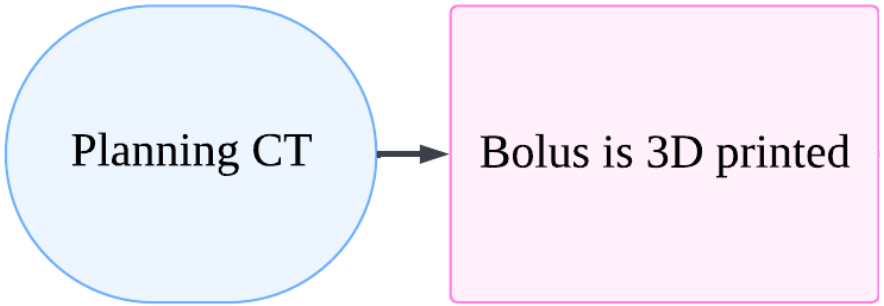

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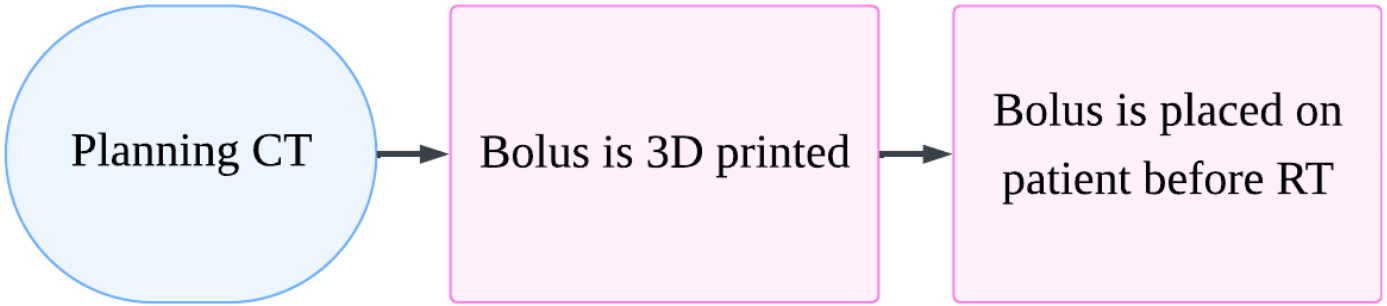

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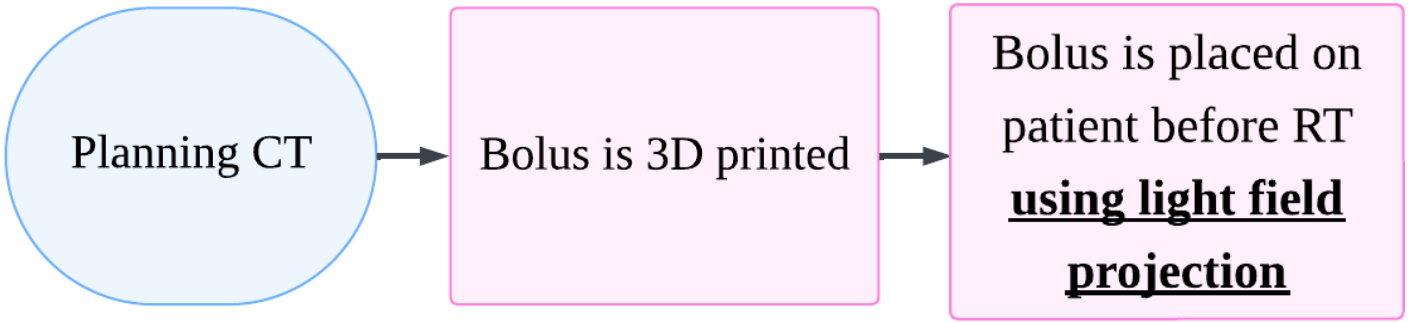

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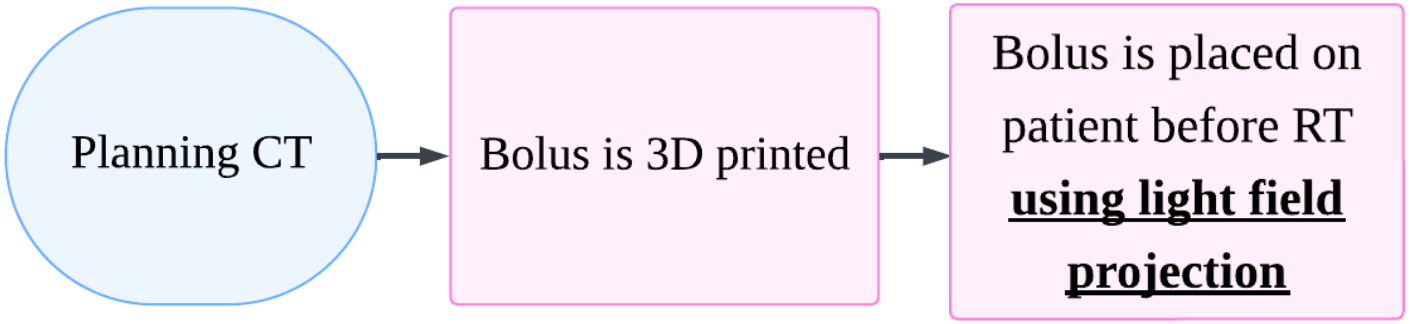
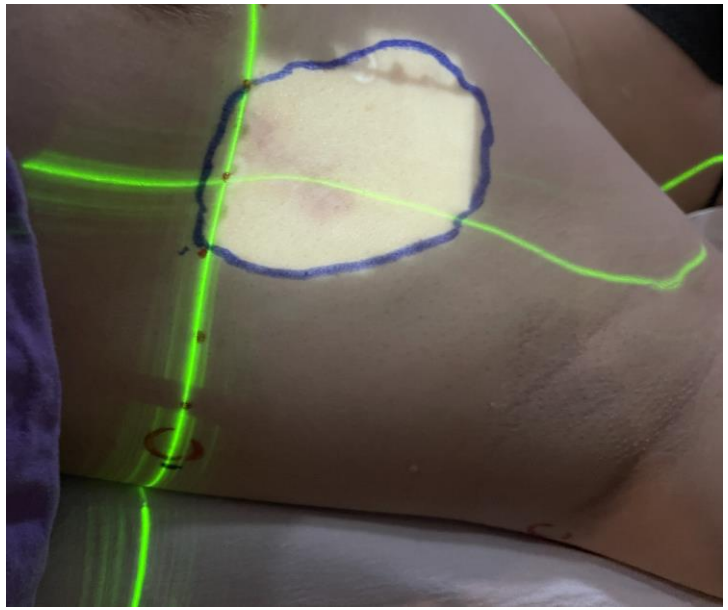
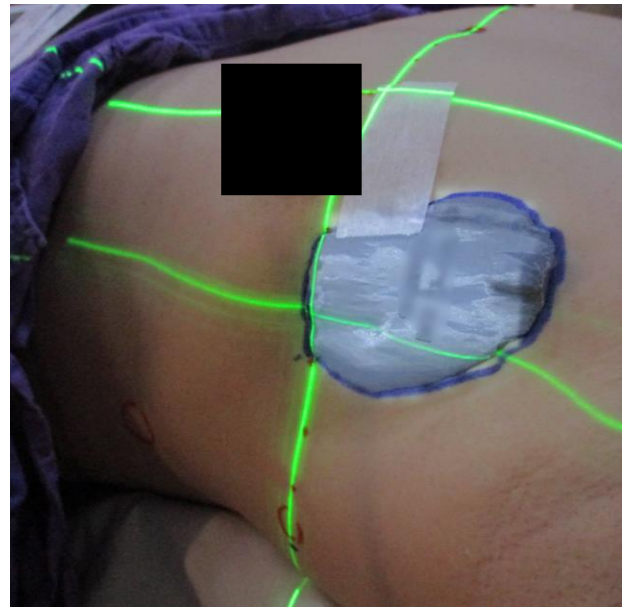


Bolus Placement by light field projection from the treatment machine (LINAC)

- Virtual bolus outline **projected onto patient's skin** using LINAC collimator.
- Radiographers **positioned 3D-printed bolus** guided by projected light field.





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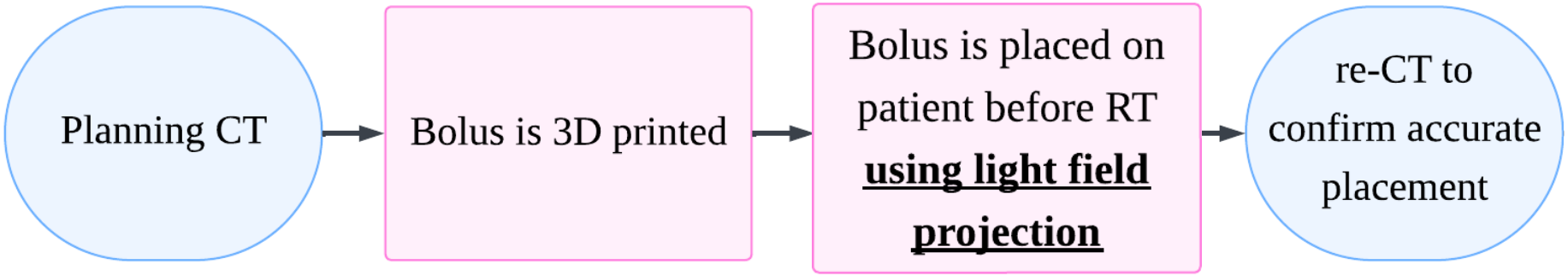
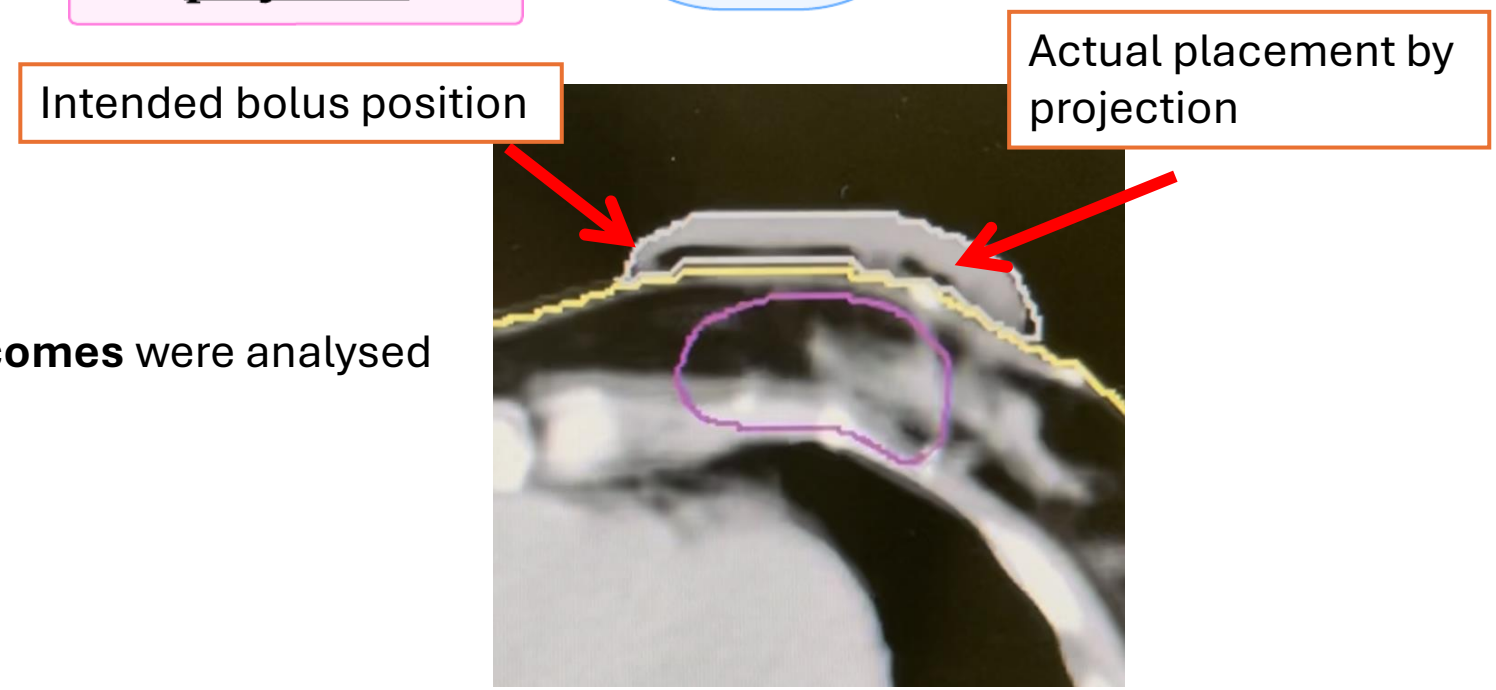


- Placement is **verified with re-CT scan.**
- **Positional accuracy** and **dosimetric outcomes** were analysed



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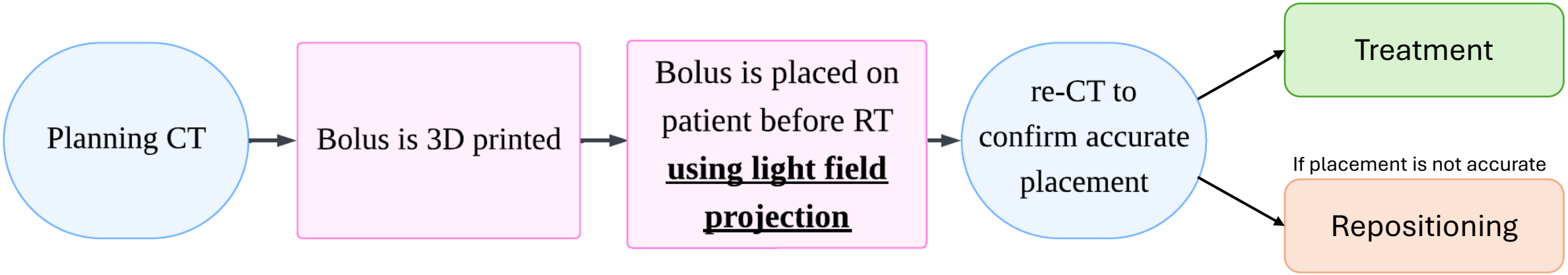

Results: Positional accuracy

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61 patients with bolus placed by light field projection

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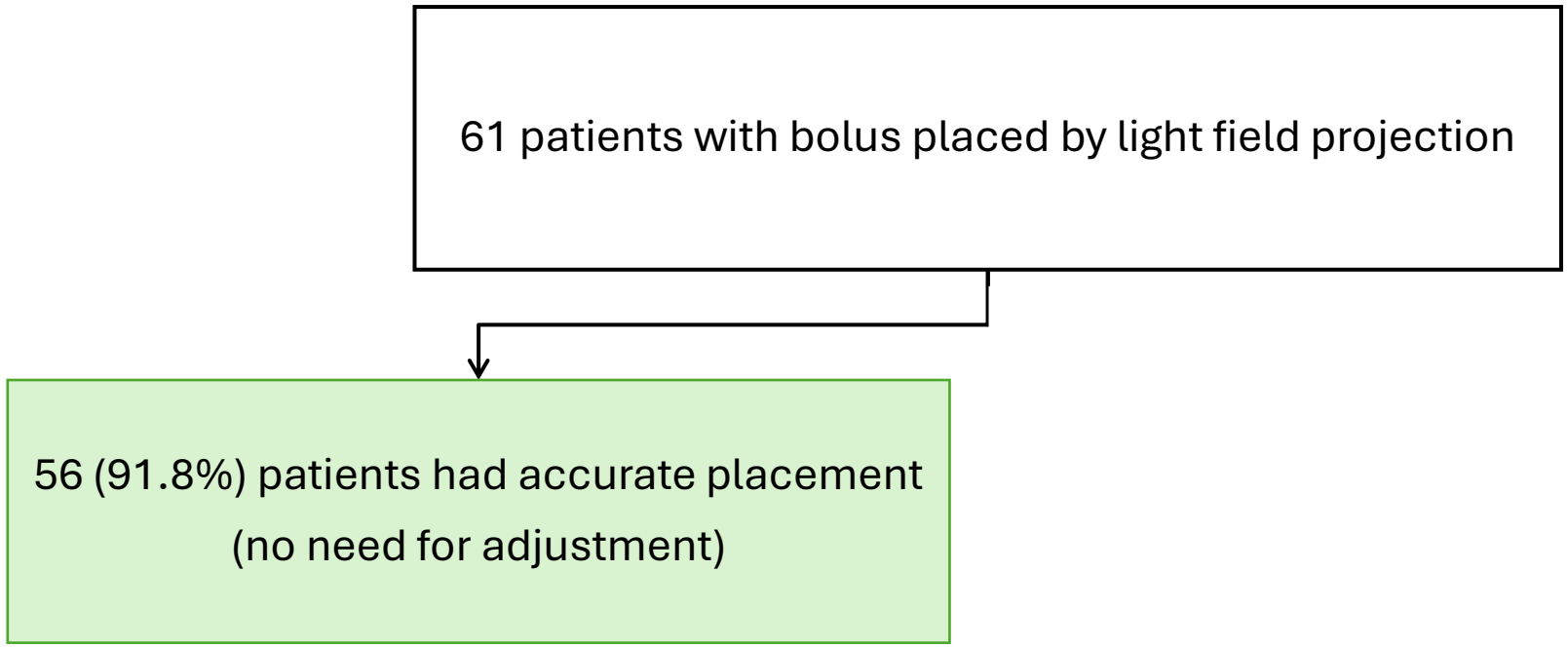

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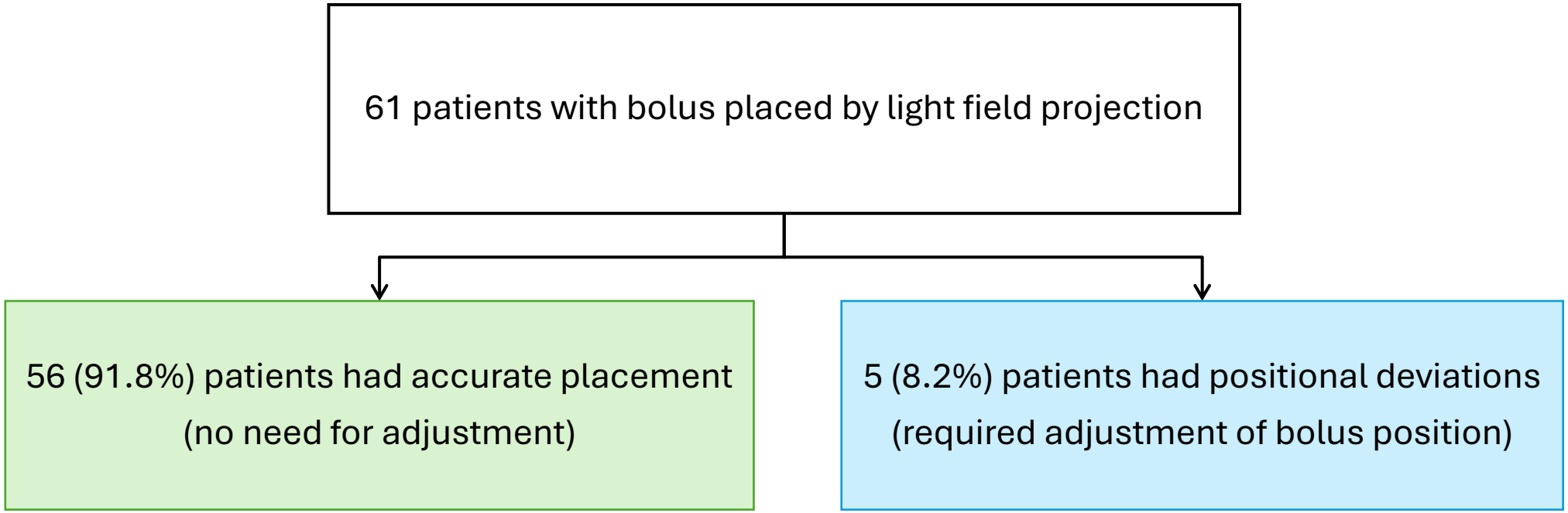
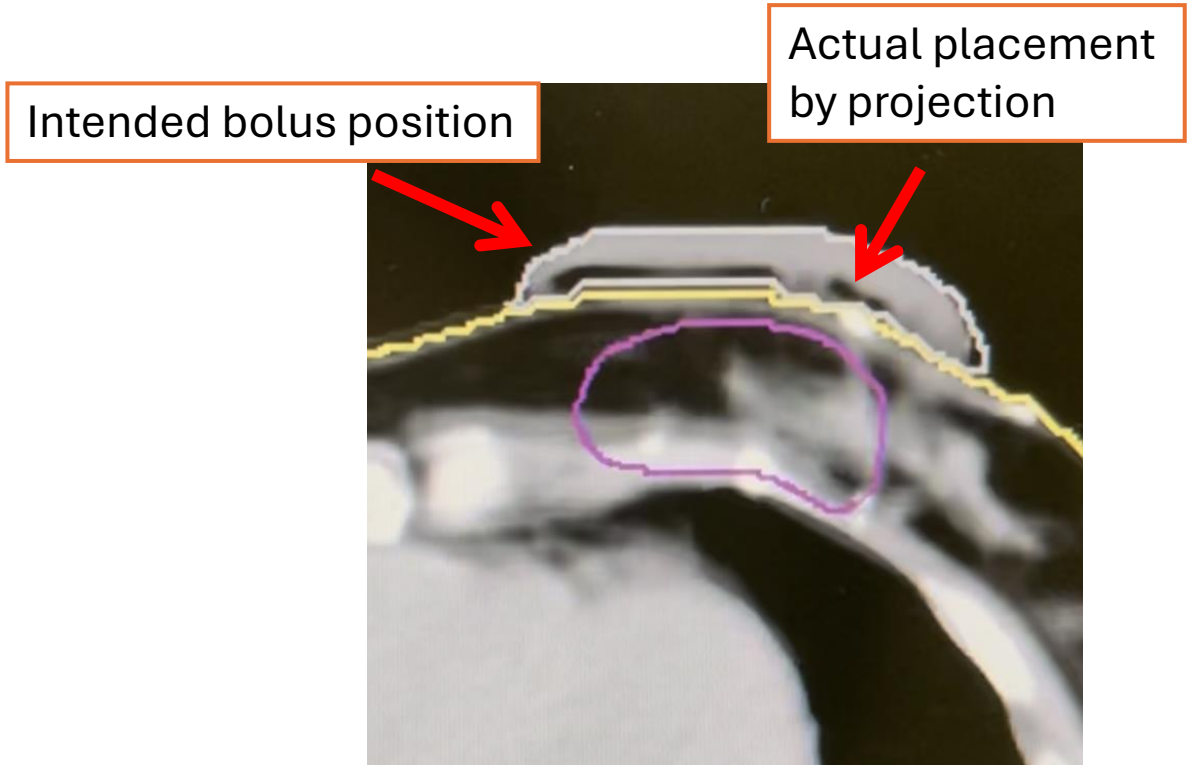
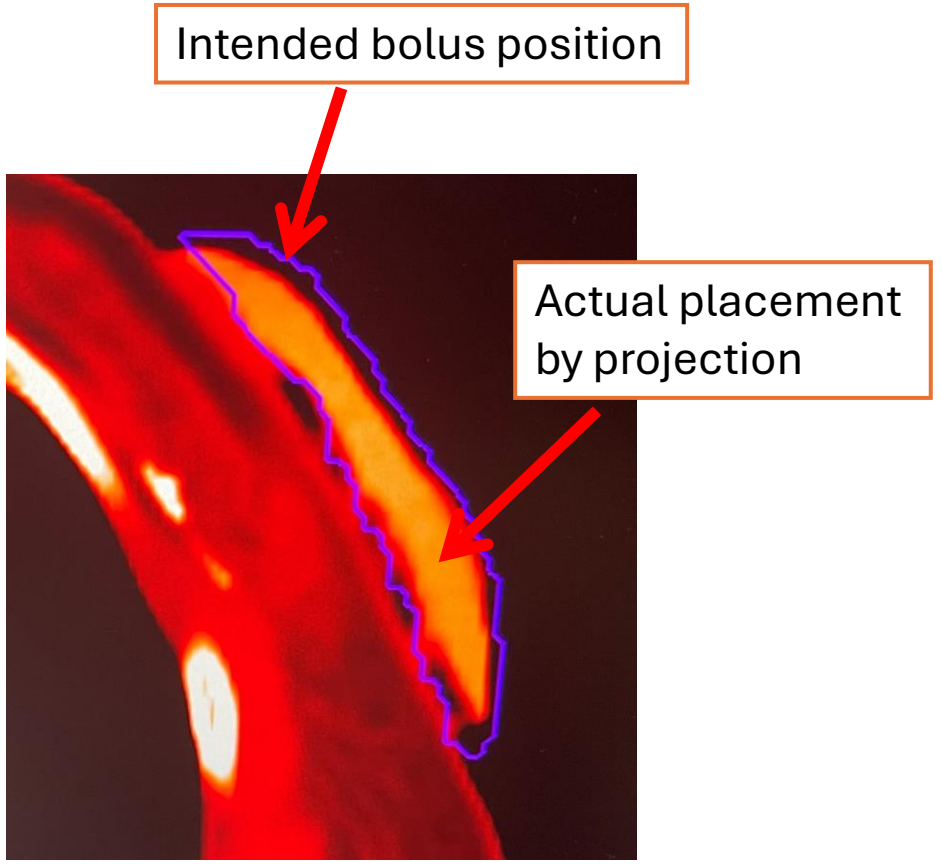


- Median deviation is 7mm (range 5-12mm)
- Medial-lateral displacement > superior-inferior: Mean 10.2mm vs 1.4mm

Examples



Example of patient with accurate placement (adjustment is not needed)



Example of patient with minor positional deviation (adjustment performed after re-CT)

Results: Dosimetric Analysis (for patients with deviations)

- Additional dosimetric analysis performed for **5 patients** with positional deviations.
- Analysis assumed **no repositioning** after initial placement guided by light field alone.
- Clinical Target Volume (**CTV**) coverage remained adequate:

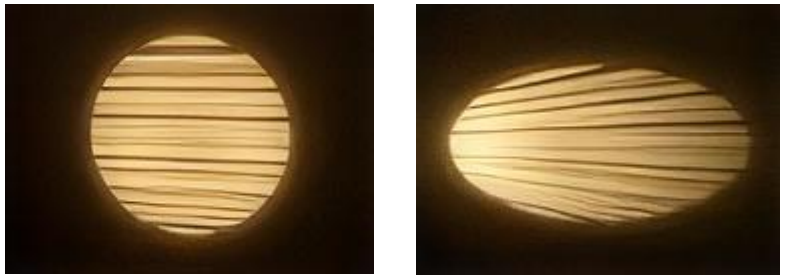
Patient	CTV Coverage (V100%)
Patient 1	100%
Patient 2	99.8%
Patient 3	100%
Patient 4	98.6%
Patient 5	97.7%

Caveat of using light field projection

- **Keystone Effect**:
  - Distortion of projected light field on angled surfaces.
  - Projection onto a very angled surface may result in distorted light field and affect accuracy of bolus placement

- **Phantom Analysis**
  Very accurate bolus positioning using light field projection, if located within:
  - **Left-sided tumours**: 0° – 60°
  - **Right-sided tumours**: 0° – 300°

•For **very lateralized tumours**, re-CT verification remains necessary to ensure accurate bolus placement.

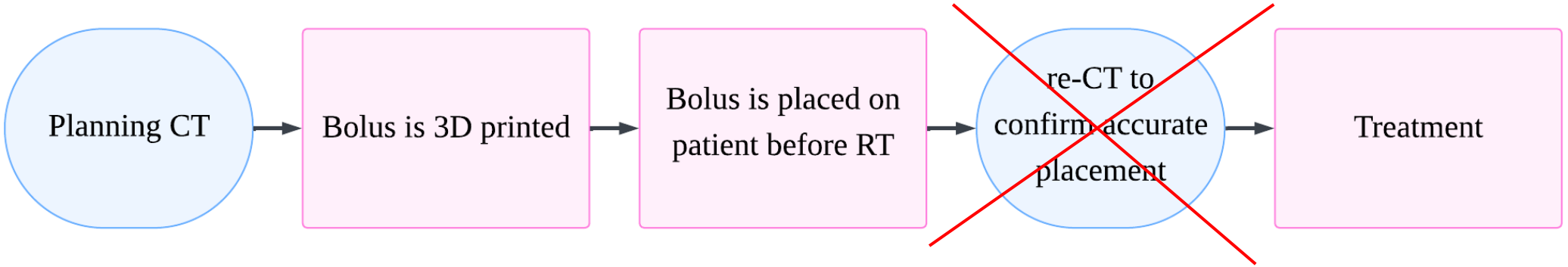


Conclusion

- The first report showing that re-CT **for bolus position verification can be safely omitted.**
- Bolus placement by light field projection is **highly accurate.**
- Even in cases of positional deviation, the **dosimetric outcome was not compromised.**

Clinical impacts: change in practice

- **New Workflow Implemented**:
  - Standard practice to omitted re-CT for majority of breast cancer adjuvant radiotherapy patients.



**Exception: Patients with very lateralized tumours*

Clinical impacts: benefits

👍 Improvements efficiency

- Re-CT time: ~30 minutes ➜ Reduce to <5 minutes with light-field projection.

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Clinical impacts: benefits

Improvements efficiency

- Re-CT time: ~30 minutes ➜ Reduce to <5 minutes with light-field projection.

Reduce staff workload and CT machine availability

Improve patient outcomes

- Reduce treatment time
- Reduce unnecessary radiation exposure

Acknowledgement

Thank you!

Our team: TMH Oncology 3D-printed Bolus Workgroup