

Introduction

Accurate dose verification in HDR prostate brachytherapy is challenging due to steep dose gradients and the limited availability of routine internal in-vivo dosimetry. DOSEmapper™ is a modular internal dosimetry platform developed to enable high-resolution dose verification at multiple anatomical sites, providing a practical approach for treatment verification with minimal impact on clinical workflow.

Methods

A thermoluminescent dosimeter (TLD)-based system (DOSEmapper™) using micro-silica bead arrays was developed for in-situ dose measurement at tumour and organ-at-risk sites, including the bladder, rectal wall, and clinical target volume (CTV).

Development followed a six-stage engineering and translational framework:

- 1) Identifying optimal internal dosimetric parameters;
- 2) DOSEmapper™ Commissioning (Fig 1) and Phantom Validation Framework.

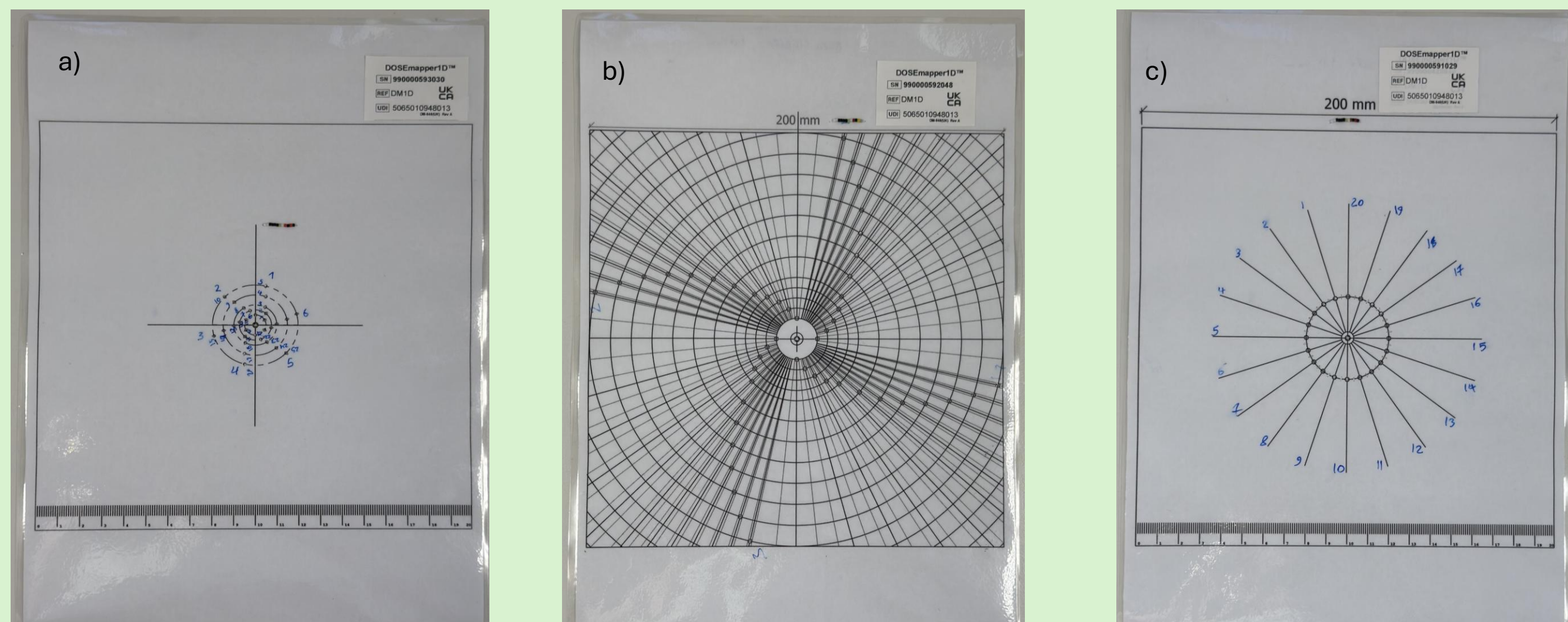


Figure 1 . Commissioning and phantom validation templates developed for characterisation of UK-manufactured, UKCA-marked 1.0 mm borosilicate micro silica bead TL detectors (OD = 1.0 mm; thickness = 1.0 mm).
a) Six – arm spiral commissioning template containing 30 1.0mm bead detectors arranged within a 2 cm radius
b) Four-arm spiral commissioning template containing 48 1.0mm bead detectors arranged within a 10 cm radius.
c) Circular commissioning template containing 20 1.0mm bead detectors arranged at a 2 cm radius for dosimetric characterisation

- 3) Establishing a practical internal in-vivo bench strategy compatible with existing treatment cycles;
- 4) Designing multiple DOSEmapper™ prototypes:

(a) 1D DOSEmapper™ in two sizes of bead : L:1.0mm and 1.6mm integrated into urinary catheters for urethral dose measurement with size range of 14 - 20Fr. Currently in clinical use (Fig 2).

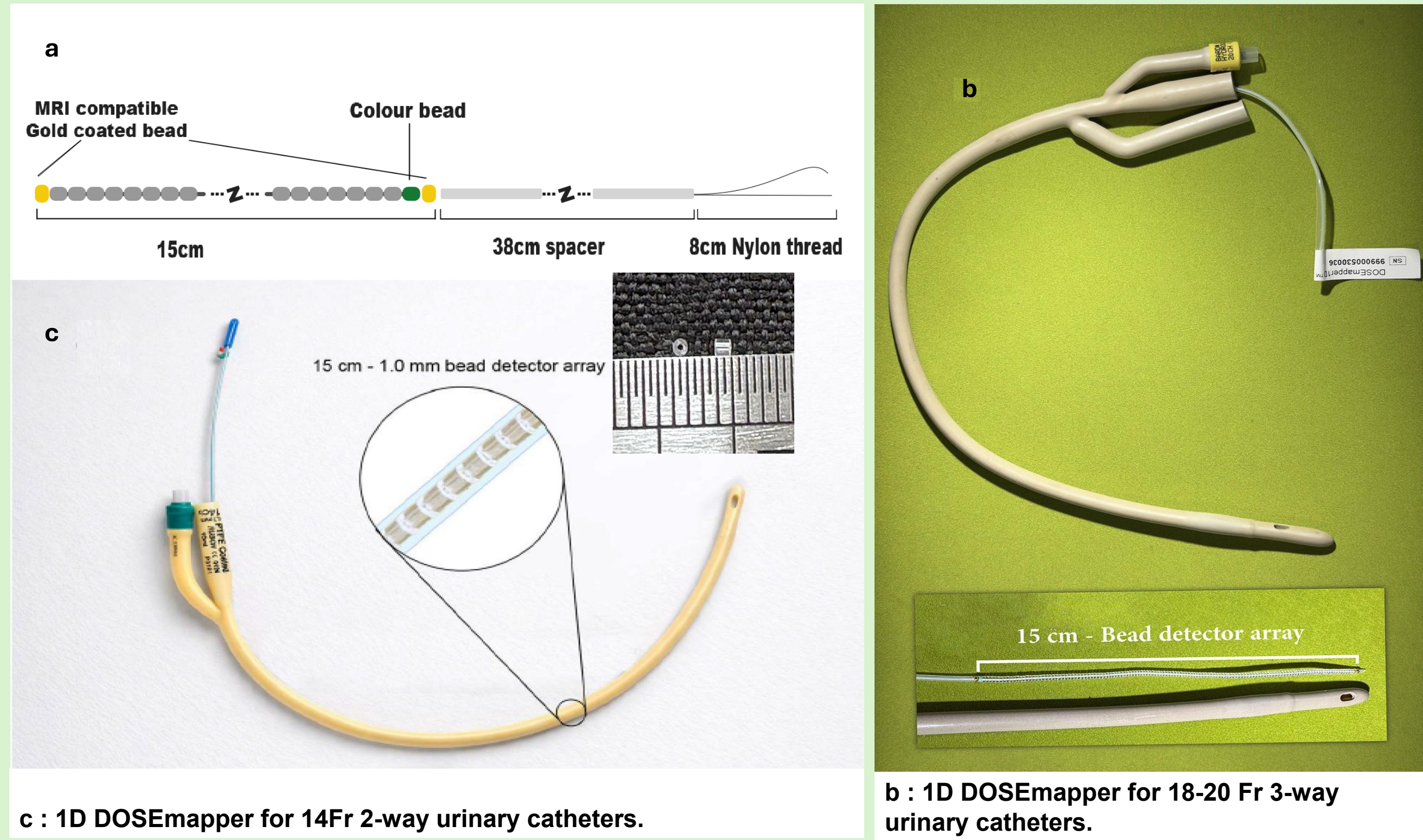


Figure 2 . 1D DOSEmapper™ designed for insertion in urinary catheters.

b)1D DOSEmapper™ integrated into interstitial needles for intra-prostatic dose verification, with successful clinical use (Fig 3).

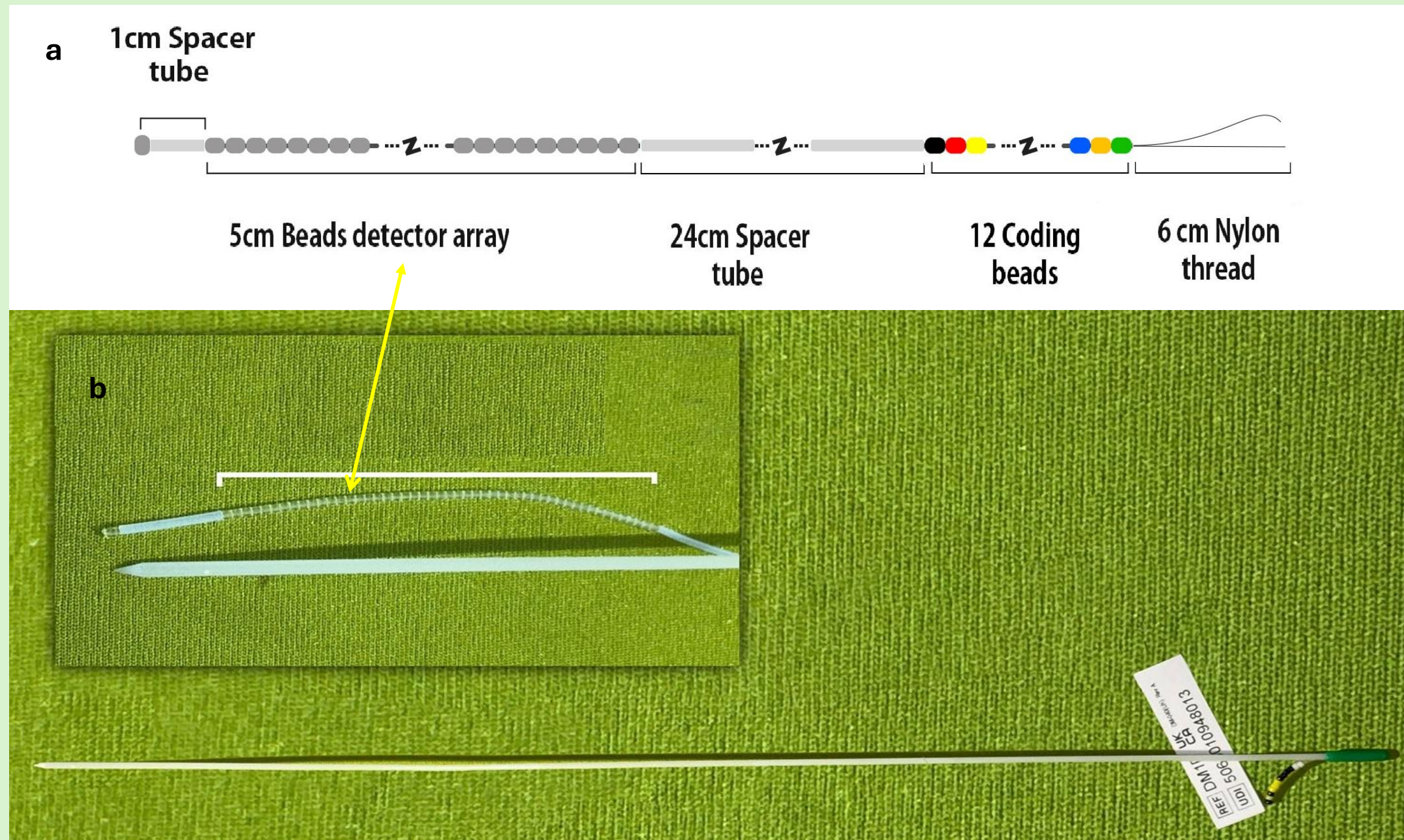


Figure 3 . Interstitial DOSEmapper™ configurations for HDR brachytherapy

a) Gynaecological DOSEmapper™ design: 32 cm catheter, 1 cm spacer and 6 cm active detector array
b) Prostate HDR DOSEmapper™: 20 cm catheter, 1 cm spacer and 5 cm detector array

(c) 3D DOSEmapper™ integrated into a 3D-printed rectal probe for spatial rectal wall dose verification. Bench testing completed; preclinical evaluation ongoing (Fig 4).

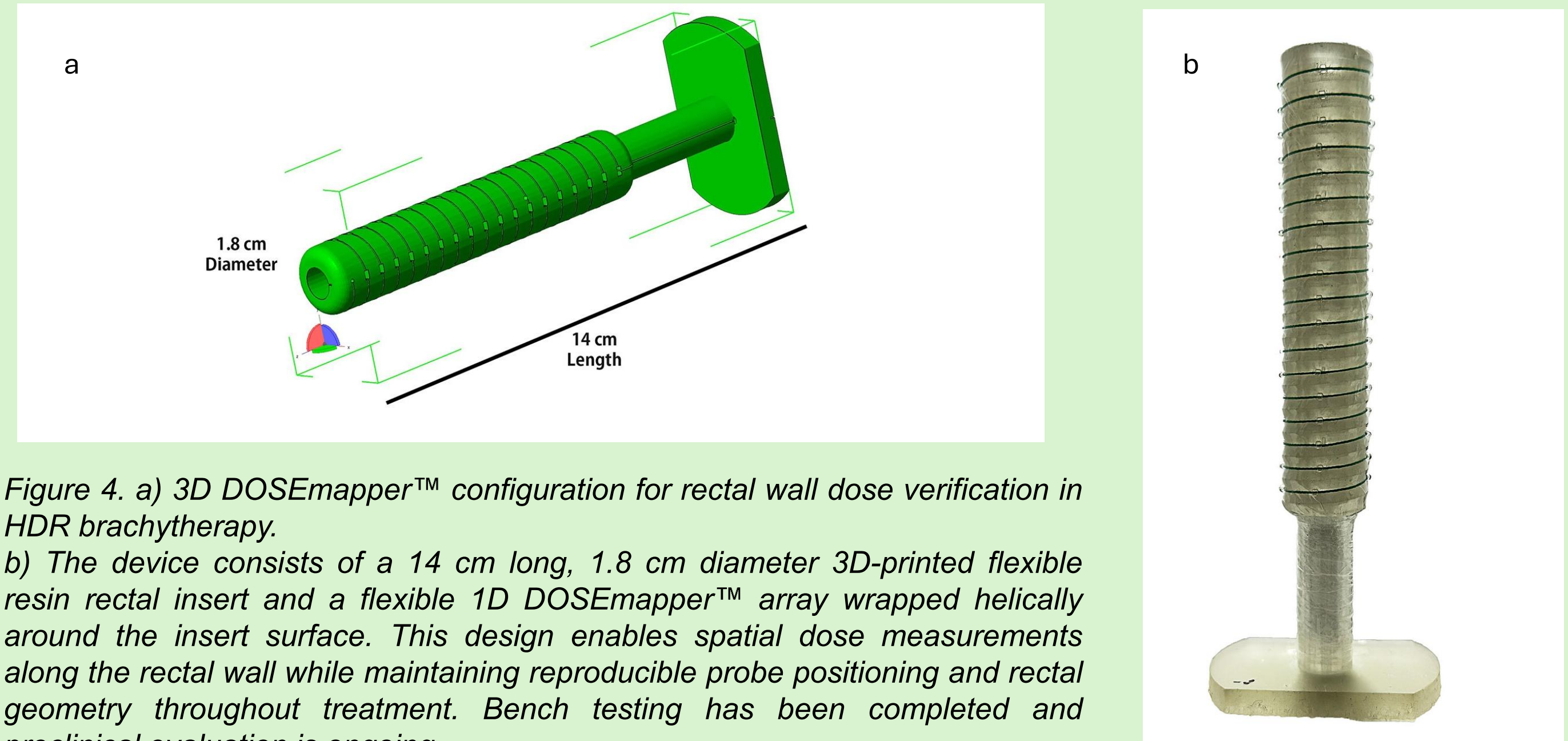


Figure 4. a) 3D DOSEmapper™ configuration for rectal wall dose verification in HDR brachytherapy.
b) The device consists of a 14 cm long, 1.8 cm diameter 3D-printed flexible resin rectal insert and a flexible 1D DOSEmapper™ array wrapped helically around the insert surface. This design enables spatial dose measurements along the rectal wall while maintaining reproducible probe positioning and rectal geometry throughout treatment. Bench testing has been completed and preclinical evaluation is ongoing.

- 5) Initial regulatory preparation completed under ISO 13485 / MDR compliance.
- 6) Clinical feasibility testing completed in twenty HDR brachytherapy patients at Mount Vernon Cancer Centre, London, UK.

Results

All DOSEmapper™ configurations demonstrated reliable mechanical integrity, reproducible geometry, and excellent dose linearity ($R^2 > 0.99$). Clinical implementation in 20 HDR prostate and gynaecological brachytherapy patients confirmed the feasibility of internal in-vivo dosimetry across multiple anatomical sites.

Key findings:

- Successful clinical deployment of urinary catheter and interstitial needle configurations (Fig 5a shows the schematic).
- Direct in-situ dose measurements achieved (Fig 5b and 5c) with minimal workflow impact (<5 min)
- No device-related adverse events were observed during clinical use.
- The interstitial configuration enabled dose verification within the target volume, extending in-vivo dosimetry beyond conventional cavity-based approaches.
- The 3D rectal probe configuration successfully completed bench testing and is currently undergoing preclinical evaluation.

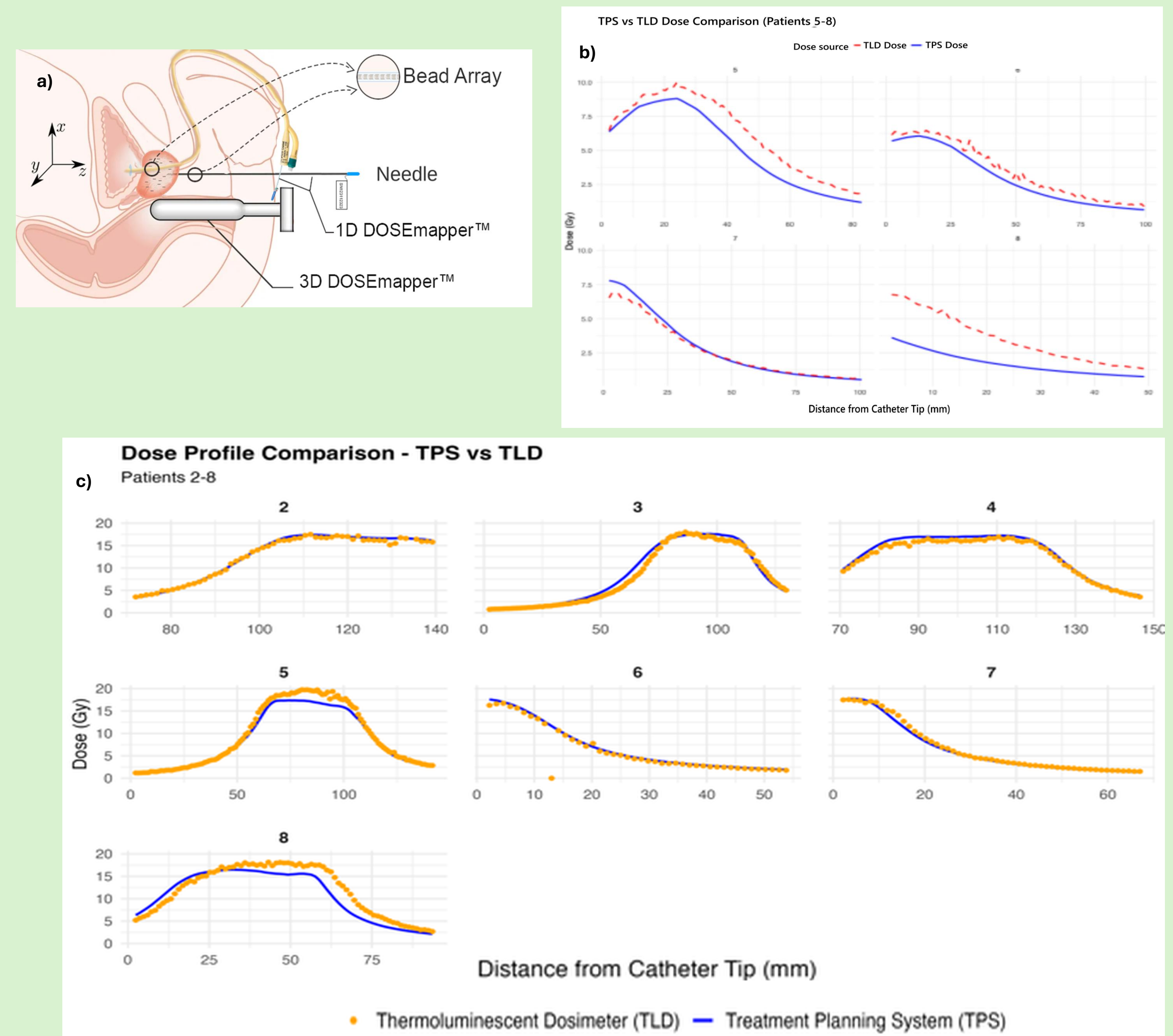


Figure 5.

- a) Schematic illustration of 1D and 3D DOSEmapper placement for in vivo dose measurement during prostate brachytherapy.
- b) Per-patient dose profile comparison between treatment planning system (TPS) and measured (TLD) readings from rectal catheters dosimetry
- c) Per-patient urethral dose profiles comparing measured (TLD) and calculated (TPS) readings

Conclusion

This study demonstrates the clinical implementation of a multi-configurational internal in-vivo dosimetry platform for HDR brachytherapy. Integration across catheter-based, interstitial, and rectal systems enables comprehensive in-situ dose verification, supporting improved treatment accuracy and quality assurance.

This approach provides a practical pathway toward routine internal dose verification in prostate brachytherapy and supports future multi-centre validation.

Acknowledgements

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