

Commissioning a New LDR Brachytherapy Dosimetry Practice

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Introduction

Background

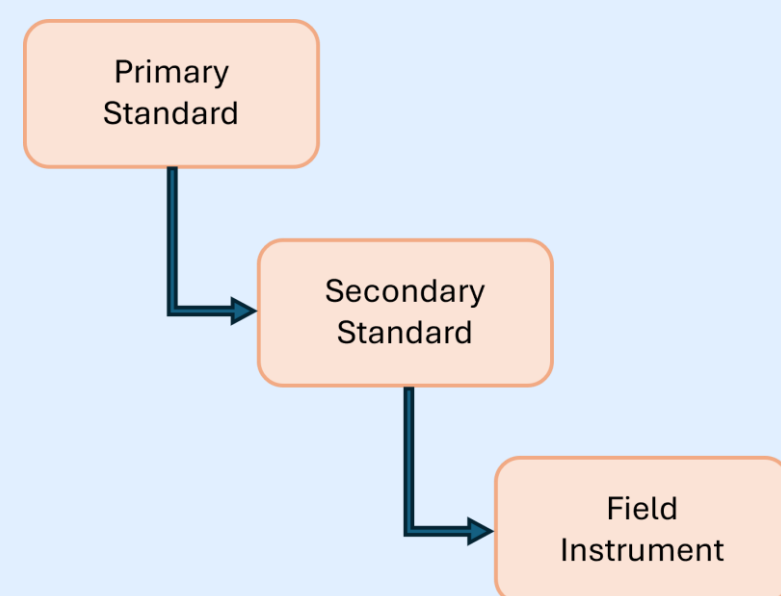
- LDR prostate brachytherapy uses I-125 seeds implanted permanently to deliver conformal dose
- Dose delivery depends on accurate source calibration and verification as inaccuracies cannot be corrected post-implant
- Department changing LDR dosimetry practice

Key Need

- Robust, traceable dosimetry and quality (QA) processes

Aim

- Review international guidance and local practice
- Develop practical recommendations for commissioning new LDR dosimetry system



Method

Literature Review

- Review of key guidance¹⁻⁸: IPEM, Royal College of Radiologists (RCR), AAPM, GEC-ESTRO
- Focused on Calibration Methods, Traceability and QA requirements

Local Process Review

- Evaluation of:
 - Current dosimetry system (flat chamber-based)
 - Proposed well chamber system and calibration chain
- Comparison of workflows and calibration approaches

Key Findings

Literature Review

- Independent end-user calibration is mandatory
- Calibration must be:
 - Traceable to a primary standard
- Well-type ionisation chambers are the preferred measurement method
- QA requirements include:
 - Regular recalibration (~2 years)
 - Constancy checks (<=6 monthly)
 - Seed sampling prior to implantation



Figure 1: PTW SourceCheck flat chamber. Source: Tornero-Lopez (2015)

Local Process Review

- Current Dosimetry System
 - Flat chamber (PTW SourceCheck)
 - Calibrated via single NPL-traceable seed
 - Measurements performed in theatre environment
 - Limitations
 - Not inherently sterile
 - Indirect calibration geometry
 - Reliance on correction factors
- Proposed Dosimetry System
 - Well-type ionisation chamber calibrated via ADCL
 - Dedicated holder for multi-strand measurement
 - Strand-specific calibration factors used
 - Advantages:
 - Improved geometry and reproducibility
 - Direct traceability
 - Alignment with international guidance



Figure 2: Standard Imaging HDR 1000 Plus well-type ionisation chamber. Source: www.standardimaging.com/brachytherapy

References

- Kutcher *et al.*, Comprehensive QA for Radiation Oncology: Report of AAPM Radiation Therapy Committee Task Group 40. *Med Phys.* 1994; **21**(4): 581-618.
- Butler *et al.*, Third-party brachytherapy source calibrations and physicist responsibilities: report of the AAPM Low Energy Brachytherapy Source Calibration Working Group. *Med Phys* 2008; **35**(9): 3860-3865.
- The Royal College of Radiologists. Quality Assurance practice guidelines for transperineal LDR permanent seed brachytherapy of prostate cancer. London: The Royal College of Radiologists, 2012.
- Institute of Physics and Engineering in Medicine. Physics Aspects of Quality Control in Radiotherapy. IPEM Report 81, second edition. York: Institute of Physics and Engineering in Medicine, 2018.
- GEC-ESTRO, A Practical Guide to Quality Control of Brachytherapy Equipment, European Guidelines for Quality Assurance in Radiotherapy, Booklet No. 8, first edition. 2004.
- Perez-Calatayud J, Ballester F, Carlsson Tedgren A, Rijnders A, Rivard MJ, Andr  ssy M, et al. GEC-ESTRO ACROP recommendations on calibration and traceability of LE-LDR photon-emitting brachytherapy sources at the hospital level. *Radiotherapy and Oncology.* 2019;135:120–129.
- Baker M, Bass GA, Woods MJ. Calibration of the NPL secondary standard radionuclide calibrator for 125I seeds used for prostate brachytherapy. *Applied Radiation and Isotopes.* 2002;**61**:321-325
- Smith BR, DeWerd LA, Culbertson WS. On the stability of well-type ionisation chamber source strength calibration coefficients. *Medical Physics.* 2020;**47**(9):4491-4501.

Recommendations

Dosimetry Equipment

Adopt well-type ionisation chamber for LDR measurement.

Calibration & Traceability

Ensure calibration traceable to primary standards. Either: (A) chamber-based calibration, or (B) seed-based calibration. Both approaches acceptable if traceability is maintained.

Calibration Strategy

Compare calibration methods: ADCL chamber vs. NPL seed calibration to inform future calibration strategy. Assess agreement and systematic differences.

Clinical Continuity

Develop contingency plans for calibration downtime: (A) procure additional well-type ionisation chamber, (B) temporary use of HDR chamber for LDR measurements.

Field Measurement Approach

Dedicated field instrument preferred. Secondary standard may be used temporarily if required.

Seed Assay

Perform pre-implant sample measurement. Verify agreement within 3% of manufacturer value.

QA & Stability Checks

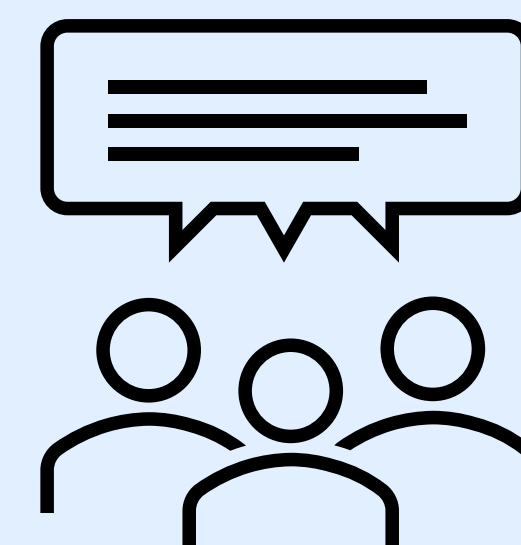
Regular constancy checks of well chamber. Frequency based on clinical usage. Verify system stability over time.

External Audit & Benchmarking

Participate in an independent audit. Collaborate with other centres. Benchmark against UK practice.

Discussion

- Literature and local findings strongly align with emphasis on traceability, verification and QA
- Current system introduces complexity in calibration and potential uncertainty
- Proposed system provides a standardised calibration pathway and an improved robustness and reliability
 - 100% seed assay due to maintained sterility
 - Day prior seed assay offers extra time to deal with error
- Key challenge:
 - Maintaining clinical service during calibration and system transition

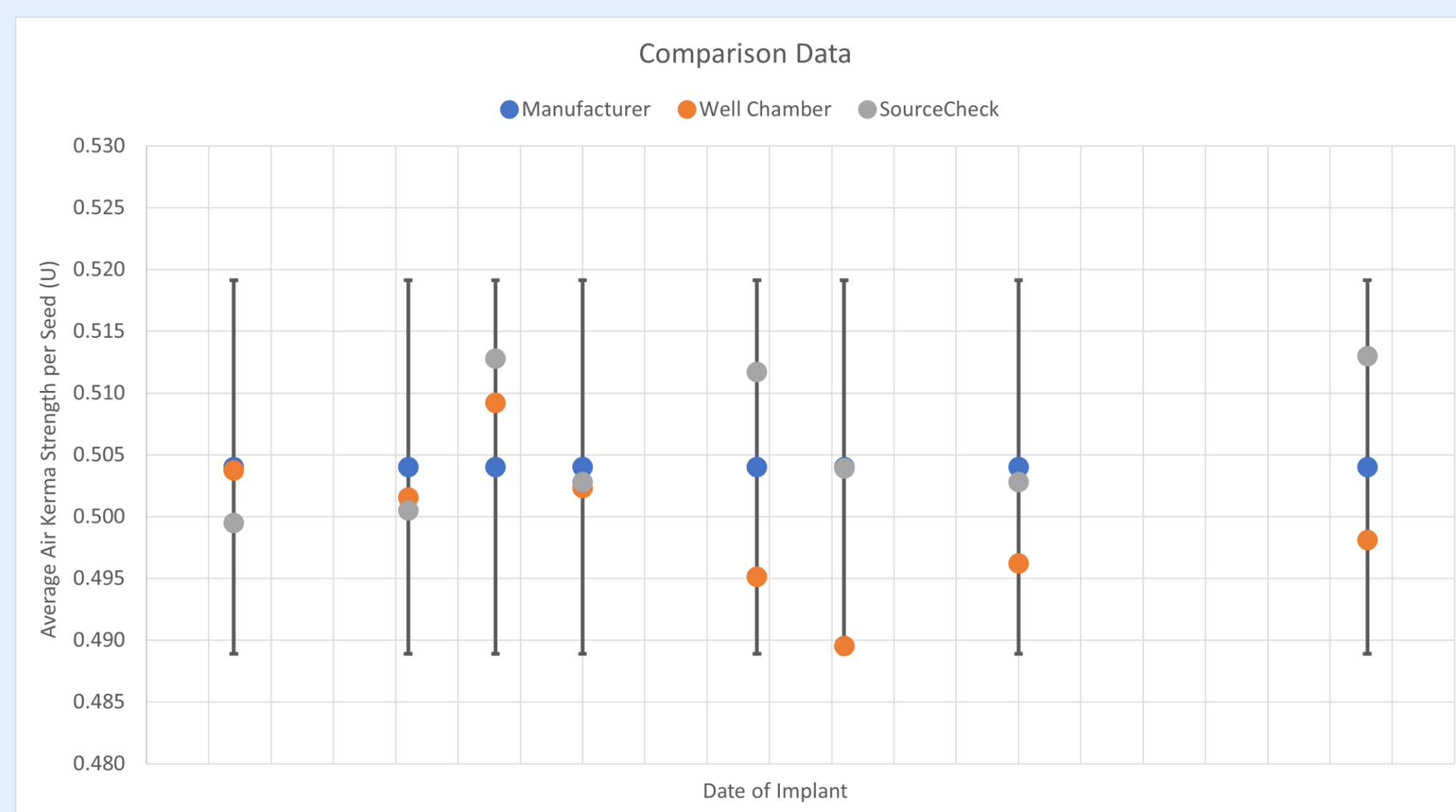


Conclusion

- Accurate, traceable calibration is critical for safe LDR brachytherapy
- Strong consensus across guidance that independent verification is essential
- Transition to a well chamber-based dosimetry system improves accuracy and reproducibility and aligns with best practice
- Further validation enhances confidence in new dosimetry system, strengthens QA framework and ultimately improves clinical safety

Future Work

- Validate new dosimetry system through ongoing comparison with flat chamber-based measurements for pre-implantation seed assay.



- Perform independent validation of ADCL calibrated well chamber with NPL calibrated seed.
- Calibrate current HDR chamber for LDR measurements and derive new strand factors.
- Create QA programme for new LDR dosimetry system, including constancy checks and cross-calibration process.
- Evaluate long term stability of calibration factors.