An In-House Source Holder for Batch Assaying the Source Strength Of Model STM1251 I-125 Seed Sources

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2026 JULY 19–22 VANCOUVER, BC
JOINT AAPM | COMP MEETING

ABSTRACT

It is recommended that a significant number of seed sources for low-dose-rate permanent brachytherapy (BT) be assayed and that their source strengths be validated against the manufacturer's stated values before implantation. The absence of a requisite dosimeter system and its complementary source holder, together with concerns about compromising sterility due to inadequate design, forces the Brachytherapist to rely on the manufacturer's stated source strengths without validation. This increases the risk of treating patients with dead sources or those with misrepresented source strengths, which can adversely affect treatment outcomes. To address this, an in-house source holder, compatible with the Standard Imaging HDR 1000 Plus well-type ionisation chamber (WTIC), was designed and constructed from Perspex (PMMA) sheets. The holder was designed to hold a cartridge of model STM1251 I-125 seed sources within its well. The calibration coefficient of the dosimeter system, including the in-house source holder, was established through cross-calibration with a calibrated WTIC and a commercial source holder for an I-125 seed source borrowed from another institution. To assess the effectiveness and reliability of the in-house source holder, source strength measurements were performed using the fabricated holder with STM1251 I-125 cartridges containing different numbers of seed sources. There is a strong linear correlation between the corrected response of the HDR 1000 Plus WTIC and the number of seeds within a cartridge. The intercept of the line of best fit depends on the total air kerma strength of a cartridge. The discrepancies between the measured and the manufacturer-stated source strengths range from 0.018% to 2.631% (mean of 1.155 ± 0.854%). The in-house holder ensured the reproducibility of the setup for source strength measurements. If the holder is sterilised, it can be used to validate the source strength of every seed source before implantation.

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INTRODUCTION

Transrectal Low-Dose-Rate (LDR) Permanent Brachytherapy has gained worldwide recognition and acceptance as a treatment option for early-stage prostate cancer. The implantation of I-125 seeds is guided by rectal ultrasound, enabling needles to be inserted into the prostate gland at the required locations through the perineum. The seeds are then inserted through the needles and dropped along the needle tracks as the needles are retracted, using a specialised applicator in accordance with an approved TPS plan. This approach provides a highly conformal dose distribution, effective and convenient treatment options, excellent long-term outcomes, and minimal short-term side effects.

Notwithstanding, uncertainties in seed placement and source strength specification can significantly affect the dose distribution, thereby adversely influencing treatment outcomes. Geographical misses of implanted seeds are typically identified through post-implant dosimetry, which is performed 2–3 weeks after seed implantation. Regarding source strength verification, the AAPM TG-56 report recommends that at least 10% of the seeds intended for an implant be calibrated before clinical use, and that the measured source strengths be compared with the manufacturer/vendor values. However, the lack of an appropriate source holder for the well-type ionization chamber (WTIC), concerns about compromising seed sterility during handling, and the limited number of seeds available for each implant often preclude independent verification of source strength. Consequently, many facilities offering low-dose-rate (LDR) permanent interstitial brachytherapy rely solely on the source strengths specified by the manufacturer without performing independent verification.

This study investigates the design and construction of an in-house source holder to facilitate batch source-strength assays of STM1251 I-125 brachytherapy seed sources.

METHODS AND MATERIALS

Perspex (acrylic) sheets of varying thicknesses were machined into discs and rings of different diameters to construct two in-house source holders for the I-125 seed cartridge to be used with an HDR 1000 Plus well-type ionization chamber (WTIC) (A083262; Standard Imaging, USA). One source holder was designed to allow adjustment of the source position within the well of the WTIC. This adjustable source holder was used to determine the "sweet spot" (i.e., the optimal measurement position within the well of the WTIC) for the seed cartridge (see Fig. 1). The second source holder, intended for routine clinical use, was subsequently fabricated to position the seed cartridge reproducibly at this optimal measurement position (see Fig. 2).

The local dosimetry system, comprising a MAX 4000 electrometer, the HDR 1000 Plus WTIC, and the in-house source holder, was calibrated against an IVB 1000 well chamber (Standard Imaging, USA) using a commercial source holder (Mick® cartridge source holder) borrowed from another institution as the reference. The calibrated local dosimetry system was then used to measure the source strengths of I-125 seed cartridges containing different numbers of seeds, and the measured values were compared with the source strengths specified by the manufacturer.

Figure 1. Adjustable Source Holder Setup. **Figure 2.** Clinical source holder with cartridge.

RESULTS

There is a strong linear correlation between the response of the local dosimeter system (WTIC coupled with the in-house source holder) and the number of seeds contained within a cartridge. Graphical representation of the line of best fit demonstrates that the response-axis intercept is dependent on the total source strength of the seeds in the cartridge. This relationship can be described by a fourth-order polynomial regression equation. Furthermore, the WTIC response is independent of the rotational orientation of the in-house source holder within the chamber. Measurements of the source strength of multiple seed cartridges using the local dosimeter system showed discrepancies ranging from **0.018%** to **2.631%** relative to the manufacturer/vendor specifications, with a mean difference of **1.155 ± 0.854%**.

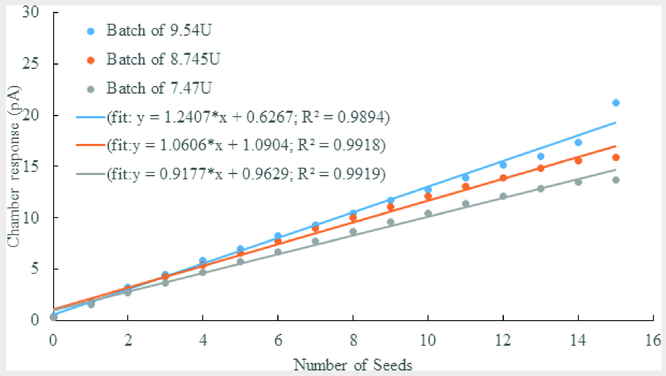

Chart 1. Chamber response as a function of the number of seeds within a cartridge.

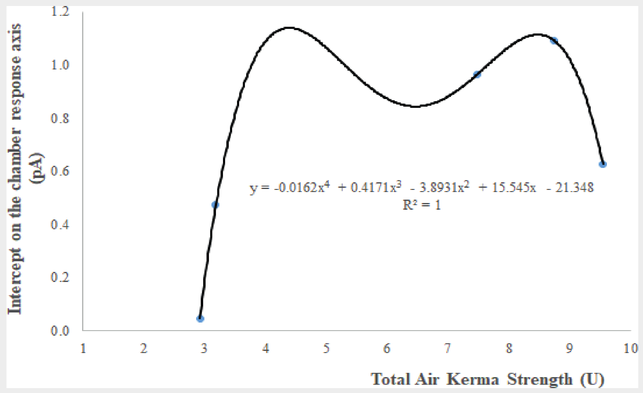

Chart 2. Response-axis intercept against the total source strength of the seed cartridge.

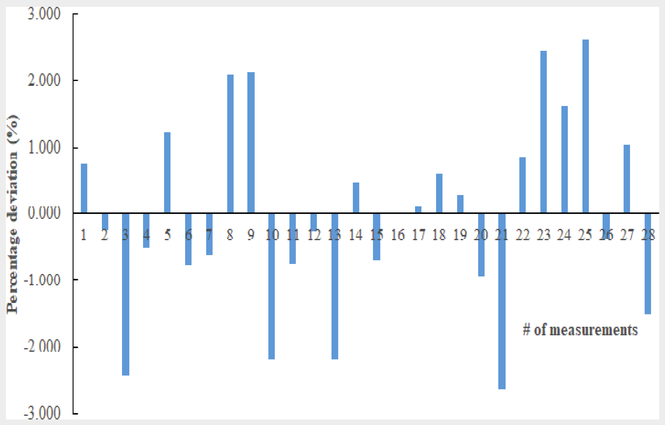

Chart 3. Comparison of source strengths of seed cartridges

DISCUSSION

Perspex was selected as the material for constructing the in-house source holder because of its ready availability, tissue-equivalent properties, and the ease with which it can be machined and assembled.

Measurements obtained with the Well-Type Ionization Chamber (WTIC) using the adjustable source holder showed a plateau in chamber response when the source holder's end was positioned between **4.5** and **6.0** cm from the mouth of the chamber. Based on these findings, the effective source position for the clinical in-house source holder was established such that the holder extends to a depth of **4.77** cm within the WTIC well. Positioning the source within this plateau region minimizes the influence of small uncertainties in source placement on the chamber response, thereby improving the reproducibility and reliability of source strength measurements.

The observed linear relationship between the response of the local dosimetry system and the number of seeds contained within a cartridge demonstrates that the clinical in-house source holder is suitable for determining the source strength of cartridges containing any number of seeds. Nevertheless, it was necessary to account for beam perturbations introduced by the combined attenuation and scattering effects of the source holder and cartridge materials. These perturbations were found to depend on the total source strength of the seeds within the cartridge. The established correlation between the intercept on the chamber response axis and the total source strength of the seed cartridge provides a practical method for correcting these perturbation effects, thereby enabling more accurate determination of cartridge source strength.

CONCLUSIONS

The Perspex in-house source holder provides a simple, reliable, and cost-effective solution for measuring the source strength of I-125 seed cartridges using a Well-Type Ionization Chamber. If the holder can be maintained under sterile conditions, it may also be used to assay the source strength of individual seeds intended for implantation. Positioning the holder within the chamber's response plateau ensures reproducible measurements with minimal sensitivity to source-positioning uncertainties. Furthermore, the observed linear response and the derived perturbation correction enable accurate source strength measurements for cartridges containing varying numbers of seeds, making the proposed method suitable for routine quality assurance in permanent seed brachytherapy.

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