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Technical Note

Assessment of a source position checking tool for the quality assurance of transfer tubes used in HDR ^{192}Ir brachytherapy treatments

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ABSTRACT

PURPOSE: The determination of source positions before treatment is an essential part of the quality assurance (QA) associated with high dose rate brachytherapy treatments. The purpose of this study was to design and commission a tool to allow the quantification of source positions across multiple transfer tube types.

METHODS AND MATERIALS: A bespoke flexi-adapter jig, three transfer tube adapters, and a film piercing pointer were designed and built for source position QA across three transfer tube types—the standard, 6 French, and gynae transfer tubes. The jig was calibrated against a manufacturer source position check tool, and intratube and intertube source position variations investigated across a total of 40 transfer tubes, using strips of Gafchromic film irradiated at multiple positions 20 mm apart with a microSelectron V3 afterloader (Elekta, Holland). The performance of the jig in localizing the nominal dwell positions relative to the manufacturer check tool was assessed. Associated expanded uncertainties were quantified in line with the International Organization for Standardization Guidelines.

RESULTS: The mean expanded uncertainty associated with the use of the jig was 0.4 ± 0.0 mm ($k = 1$). The performance of the jig was 0.3 ± 0.0 mm, while the intratube and intertube source positional variations were observed to be within ± 1.0 mm across most transfer tubes.

CONCLUSIONS: A bespoke flexi-adapter jig capable of allowing source position measurements to be carried out on various transfer tube types has been designed. Measurement results highlight the need for routine QA of all transfer tubes in clinical use.

Keywords: Quality assurance; Commissioning; Source position check; High dose rate; Transfer tubes; ^{192}Ir; HDR brachytherapy treatments

1. Introduction

High dose rate (HDR) brachytherapy sources are associated with close proximity to the target, steep dose gradients, and large inverse square corrections. These factors, coupled with the small physical sizes of the sources (1), place a premium on routine quality assurance (QA) of the afterloader source positioning accuracy (2) and are recommended as a mandatory test prior to treatment (3). In this respect, many brachytherapy centers typically use commercially available source position check QA tools, which can be limited as they are generally restricted for use with a specific transfer tube type. This is particularly relevant for centers treating across multiple sites where the tube type used for QA may be different from that used for patient treatment.

A study was commissioned to design and build a bespoke jig capable of ensuring the QA of various transfer tube types used for patient treatment, in contrast to the existing QA tool—the microSelectron source position check ruler (Elekta, Veenendaal, Holland), which only allowed QA across a single tube type. The commissioning process allowed the assessment and quantification of source position variations across the tube types, thus providing an effective means for the definitive calibration of the tubes.

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Conflict of interest: The authors report no proprietary or commercial interest in any product mentioned or concept discussed in this article.

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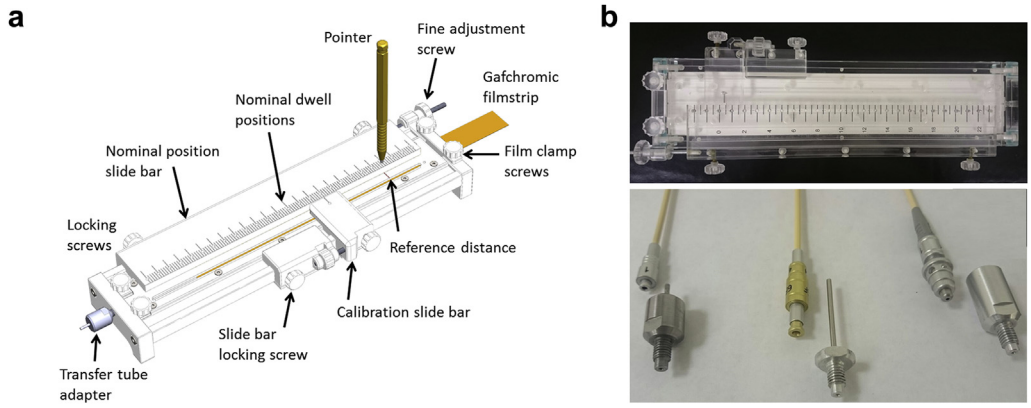

Fig. 1. (a) Illustrates the component parts of the bespoke flexi-adapter source positioning jig. (b) Top illustrates the jig in clinical use, and bottom illustrates the respective transfer tube types and associated adapters for the standard, 6 French, and gynae transfer tubes (from left to right).

2. Methods

2.1. Flexi-adapter jig design and setup

A bespoke flexi-adapter source position jig, three transfer tube adapters, and a film piercing pointer (Fig. 1) were designed such that, on setup, the most distal source position across the three transfer tube types was coincident with the reference position, the reference position being determined from the combined length of the transfer tube (Table 1), adapter, and jig dimensions.

The flexi-adapter jig was used by inserting a 2.0 × 30.0 cm RTQA2 Gafchromic filmstrip as illustrated in Figure 1a. The film was clamped into position and pierced at nominal dwell positions using a tungsten carbide−tipped pointer and then irradiated. This process replicates the microSelectron source position check ruler (for the purposes of this study called the Gold Standard), but across all three transfer tube types on connection of the appropriate adapter (Fig. 1b). Before indenting the filmstrip with the pointer, the nominal position slide bar was used to align the most distal nominal dwell position with the reference distance—1500 mm for the standard and gynae tubes and 1300 mm for the 6 French (6F) tubes.

The pointer stem had a diameter of 2 mm and was tapered to a point. The holes in the slide bar were centered on 0.5-mm wide inscribed lines to denote the nominal dwell positions. Each hole had a diameter of 2 mm but with a tolerance of 0.1 mm to allow for ease of insertion and withdrawal of the pointer. In addition, the distal end of the holes was tapered to the same dimensions as the distal end of the pointer to minimize uncertainty in marking out the positions on the film.

Table 1
Manufacturer-quoted nominal reference lengths, where the reference length refers to the distance from the face of the afterloader indexer to the proximal end of the applicator

Transfer tube type	Nominal reference length (mm)	Uncertainty (mm)
Standard	1218.0	±0.2
6F	1005.0	±0.2
Gynae	1219.5	±0.2

6F = 6 French.

2.2. Design validation

The flexi-adapter jig was validated by comparing the reference distance against the Gold Standard prediction. This was done by calibrating the jig against the check ruler and involved sending the dummy source successively to 1500 mm in the Gold Standard and to the same preprogrammed position in the jig, using the same transfer tube type and associated adapter (Fig. 2a). The calibration slide bar was then aligned with the tip of the dummy source, following which it was locked in place and the pointer used to indent a hole in the filmstrip. With the tip of the dummy source denoting the center of the nominal source position, the offset between the indentation from the calibration and the reference distance was assumed to quantify the accuracy of the jig relative to the Gold Standard.

2.3. Data collection

Data were collected for channels 1 through 18 and 1 through 17 for the standard and 6F tubes. For the gynae tubes, it was channels 1 through 3 with two sets each for channels 1 and 2. This meant that a total of 40 transfer tubes were used for this study. All the tubes were prelabeled by the manufacturer to be used with an associated afterloader indexer channel. In addition, before commencing with data collection, all the tubes were inspected for signs of obvious physical damage. No signs of damage were observed.

A measurement session consisted of setting up each transfer tube with its associated adapter and calibrated jig as previously described in Section 2.1 and irradiating the filmstrip at 12 nominal dwell positions 20 mm apart starting at the most distal nominal dwell position, using a programmed afterloader stepping size of 2.5 mm. This stepping size was selected as it was the smallest stepping size