Letter to the Editor

Response to "Comment on 'Update of AAPM Task Group No. 43 Report: A revised AAPM protocol for brachytherapy dose calculations' " [Med. Phys. 31, 633–674 (2004)]

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To the Editor,

We appreciate the interest of Meigooni *et al.*[1] in the Update of AAPM Task Group No. 43 Report (TG-43U1),[2] and would like to address here their concern regarding the proposed method for calculation of the effective length, L_{eff}, as used in the protocol for brachytherapy dosimetry calculations. Of particular concern to Meigooni *et al.*[1] is Eq. (5) in TG-43U1

$$L_{\mathrm{eff}} = \Delta S \times N, \tag{5}$$

which requires two parameters for specification of L_{eff}: the nominal pellet center-to-center spacing, ΔS, and the number of discrete pellets, N, contained in the source. Equation (5), which was initially proposed by Williamson,[3] assumes a static linear array of uniform-strength, equi-spaced pellets. In particular, two questions are raised by Meigooni *et al.*,

(i) How is the number of pellets determined, particularly when a combination of active and inactive pellets is used?
(ii) How should the equation be applied when the active pellet spacing is nonuniform?

Before we address the specific questions raised by Meigooni *et al.*, we would like to make some general comments on the role of L_{eff} and the geometry function in the TG-43 dose-calculation protocol. The purpose of the geometry function is to represent an approximation of the particle streaming distribution (dose distribution in the absence of any absorbing or scattering media). However, this approximation does not have to be very accurate because the geometry function merely serves as an interpolation function, improving the accuracy with which the TG-43 formalism calculates dose values between and outside of the tabulated radial dose and anisotropy function data entries. In fact, any reasonable choice of line-source or other type geometry function will always reproduce exactly the dose rates at the locations corresponding to the radial dose and anisotropy function table entries, provided that the user's treatment planning system employs the same geometry function as was used to prepare the dose ratio tables. In this sense, L_{eff} is a "dummy" parameter like the exposure-rate constant in the pre-TG-43 era, in that it is much more important that we all use the same value rather than the right value. Even relatively crude approximations to the particle streaming distribution can significantly reduce interpolation errors. These issues regarding the role of TG-43 geometry functions and more physically accurate treatments of the particle streaming distribution have been discussed in detail by others.[4–7]

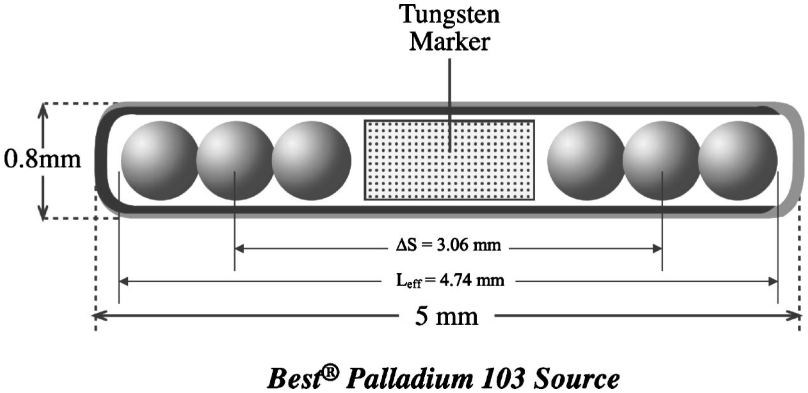

FIG. 1. The Best Medical model 2335 ^{103}Pd source with $N=2$ and derivation of $L_{\mathrm{eff}}=4.74$ mm based on Eq. (5) of AAPM TG-43U1.

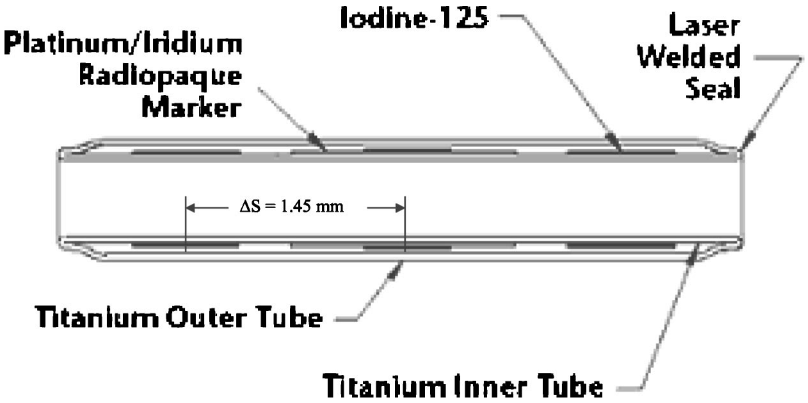

FIG. 2. The International Brachytherapy model 1251L ^{125}I source with $N=3$ and derivation of $L_{\text{eff}}=4.35$ mm based on Eq. (5) of AAPM TG-43U1.

We now return to questions by Meigooni *et al.* with the goal of establishing a reasonable convention for L_{eff}, recognizing that when a source violates the Eq. (5) assumptions, any value of L_{eff} will of necessity be an approximation. In question (*i*), two source types are presented that include both radioactive and nonradioactive pellets. The question is whether or not to include *inactive* pellets in the L_{eff} estimation, and we regret not making this point perfectly clear—only radioactive pellets, or other radioactive discrete components, should be used for calculating L_{eff}.

In question (*ii*), Meigooni *et al.* ask how to calculate L_{eff} when the radioactive pellet spacing is not uniform. In the example of the Best Medical model 2335 ^{103}Pd source, there does not appear to be a suitable geometry to calculate L_{eff}.[8–10] To illustrate the confusion further, the articles by Meigooni *et al.*[8] and by Peterson and Thomadsen[9] used effective lengths of 4.25 and 4.55 mm, respectively. This source is composed of two groups of Pd^{103} beads, each consisting of three beads, of diameter 0.56 mm, in contact with one another (Fig. 1). The two pellet groups are separated by a tungsten marker having a length of 1.19 mm. This leaves an air gap of 0.38 mm which the manufacturer indicates is uniformly distributed within the capsule. By grouping each set of three beads together to create an effective $N=2$, the effective spacing is simply the distance between the centers of the second and fifth beads (Fig. 1). With $\Delta S=3.06$ mm, the calculated effective length is 6.12 mm, which exceeds the physical length of the source capsule. Therefore, TG-43U1 recommends that the maximum distance between proximal and distal aspects of the radioactivity distribution be used as the L_{eff}, or 4.74 mm, which differs slightly from the L_{eff} values used by Meigooni *et al.* and by Peterson and Thomadsen. While the 0.38 mm air gap could have been considered to be uniformly spaced amongst the six beads and tungsten marker instead of amongst the beads only, this difference would have amounted to a change in L_{eff} of less than 0.1 mm, which is less than the combined uncertainties in the source component dimensions.

We illustrate application of these concepts to another source: the International Brachytherapy source model 1251L ^{125}I source which contains three equi-spaced annuli with unequal amounts of radioactivity (Fig. 2).[11,12] While the activity of the central annulus is not necessarily the same as that of the annuli near the seed ends, an approximate L_{eff}, giving rise to a sufficiently accurate interpolation function, can be obtained by assuming uniform source strength. In this approximation, the number of segments is three ($N=3$), and $\Delta S=1.45$ mm. Equation (5) then yields $L_{\text{eff}}=4.35$ mm.

In closing, the authors of the recently published 2004 update to the TG-43 protocol appreciate the opportunity to explain the role of effective length and active length in brachytherapy dose calculations, and to clarify application of this concept with examples of more complex radioactivity distributions.

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Mark J. Rivard
AAPM LEBD Working Group Chair,
Tufts-New England Medical Center,
Boston, Massachusetts

Wayne M. Butler
Schiffler Cancer Center, Wheeling, West Virginia

Larry A. DeWerd
University of Wisconsin, Madison, Wisconsin

M. Saiful Huq
University of Pittsburgh Cancer Institute,
Pittsburgh, Pennsylvania

Geoffrey S. Ibbott
Radiological Physics Center, Houston, Texas

Christopher S. Melhus
Tufts-New England Medical Center, Boston, Massachusetts

Michael G. Mitch
National Institute of Standards
and Technology, Gaithersburg, Maryland

Ravinder Nath
Yale University, New Haven, Connecticut

Jeffrey J. Williamson
Virginia Commonwealth University, Richmond, Virginia