

METHODOLOGY OF QUALITY CONTROL FOR BRACHYTHERAPY'S ^{125}I SEEDS.

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ABSTRACT

This paper presents the methodology of quality control of ^{125}I seeds used for brachytherapy. The ^{125}I seeds are millimeter titanium capsules widely used in permanent implants of prostate cancer, allowing a high dose within the tumour and a low dose on the surrounding tissues, with very low harm to the other tissues. Besides, with this procedure, the patients have a low impotence rate and a small incidence of urinary incontinence. To meet the medical standards, an efficient quality control is necessary, showing values with the minimum uncertainty possible, concerning the seeds dimensions and their respective activities. The medical needles are used to insert the seeds inside the prostate. The needles used in brachytherapy have an internal diameter of 1.0 mm, so it is necessary ^{125}I seeds with an external maximum diameter of 0.85 mm. For the seeds and the spacer positioning on the planning sheet, the seeds must have a length between 4.5 and 5.0 mm. The activities must not vary more than 5% in each batch of ^{125}I seeds. For this methodology, we used two ionization chamber detectors and one caliper. In this paper, the methodology using one control batch with 75 seeds manufactured by GE Healthcare Ltd is presented.

Key Words: Brachytherapy, Iodine 125, Quality Control.

1. INTRODUCTION

Brachytherapy is a treatment where the radioactive sources are placed directly into, or immediately adjacent to the tumour. Its major advantage is to allow a high dose within the tumor and low dose on the surrounding tissues. The word brachytherapy is derived from Greek word *brachys* and *therapy* meaning, short and treatment, respectively. The brachytherapy is also known as *sealed source radiotherapy*. The main types of brachytherapy are: interstitial, intracavitary and surface applicator or moulds.

In the interstitial brachytherapy, sources of a small diameter, to allow penetration into tissue are introduced by implants or catheters. The intracavitary brachytherapy is more used in gynecological malignances. Surface applicators are used for those superficial lung tumors, in particularly sensitive normal tissues. The clinical efficacy of ^{125}I seeds derives from the interaction of the emitted ionizing radiation with the tissue being treated. The Iodine 125 has a half live of 59.43 days and decays by electron capture with the emission of characteristic photons and electrons has a low energy emission with 29 keV of average energy that allows its photons to have a small penetration power, [1,2,3].

In the implant, the seeds are put inside the prostate by needles. The number of seeds for each implant varies from 80 to 120 units. The implants are procedures of low impact, allowing most patients to return to their normal activities between one or three days after the intervention, with a small or no pain. The other important benefits for the patients are the low impotence rates and few incidents of urinary incontinence [1].

In this study, the methodology control of quality control was developed and applied to a batch of 75 seeds, manufactured by GE Healthcare Ltd. For each seeds the following parameters were measured: lengths, external diameter and apparent activity. With these values, some uncertainties and possible problems with the seeds were verified.

2. MATERIALS AND METHODS

2.0. Materials

2.0.1. ^{125}I sources

The ^{125}I seeds were manufactured by Amershan - GE Healthcare Ltd, model 6711. The batch contains 75 seeds and 1 calibrated seed for dosimetric parameters. The activity of batch was 2.58 GBq (69.750 mCi) in the reference date July 04, 2006.

The ^{125}I is absorbed onto a silver rod and encapsulated in a welded titanium capsule. The silver rod acts as an X-ray maker. ^{125}I seeds are available with air kerma strength values between 0.243 and 7.92 $\mu\text{Gym}^2/h$ or apparent activity values between 7.067 MBq (0.19 mCi) and 230.880 MBq (6.24 mCi). Seeds are also available, by special request, with air kerma strength values between 7.92 and 50.8 $\mu\text{Gym}^2/h$ or apparent activity values between 230.88 MBq (6.24 mCi) and 1480 MBq (40 mCi). ^{125}I seeds are designed to fit into an 18-gauge needle or catheter with an internal diameter of 1 mm. The silver rod are contained in a 4.5 mm long titanium capsule with external diameter of 0.8 mm and a wall thickness of 0.05 mm. Figure 1 shows the seed with its dimensions [4].

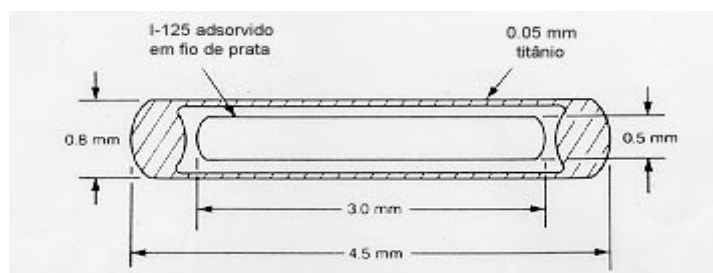


Figure 1. ^{125}I seed with its dimensions.

The titanium wall of the seed absorbs the electrons. The main photon emissions are 27.4 and 31.4 keV X-rays, and a 35.5 keV gamma ray. The ^{125}I seed also emits 22.1 and 25.2 keV fluorescent X-rays resulting from interactions of the Iodine - 125 with the silver rod.

The dose distribution around each seed is not isotropic. This anisotropy should be included in the dose distribution calculation [2].

2.0.2. Ionization Chamber Detectors

The activities were measured using two ionization chamber detectors Capintec, model CRC 15-R. For the chamber calibration, we used radioisotopes Co-57, Ba-133 e Cs-137.

For measures, was assumed the background (Bg) with: 0.1184 ($3.2 \mu\text{Ci}$), for ionization chamber 1, and 0.0444 MBq ($1.2 \mu\text{Ci}$) for ionization chamber 2.

2.0.3. Measurement equipment

For measuring lengths and the external diameter of ^{125}I seeds, a caliper made by Mitutoyo with the resolution of 0.01 mm, was used.

2.1. Methods

This quality control was based on measuring the seeds, analyzing their activities and their dimensions to guarantee that the seeds are within the minimum uncertainty possible.

Concerning their activities, the measures could not vary 5 % from the medium values and for lengths and external diameter could not pass 5.00 mm and 1.00 mm, respectively. Their activities were measured, one by one, in the two different ionization chamber detectors and, to verify the anisotropy measured the seed in one position and then we turned the seed 180 degrees, for better linear response. For the measurements in activities we usually have a reference seed called calibrated seed. This seed will be our reference to correct the measure given by the detector. This correction is called correct factor and this factor (f_c) is obtained by the relation:

$$f_c = \frac{A_r}{A_m} \quad (1)$$

Where A_r is the activity calculated by the exponential decay, and A_m is the activity shown in the ionization chamber. All the seeds will have corrected with this factor (1), the respective correction factor is 0.810 for ionization chamber 1 and 0.818 for ionization chamber 2. These correction factors are dimensionless.

The lengths and the external diameter were measured using a caliper. Because of the dimension of the seeds, it would be difficult to use a micrometer, for this reason a caliper was used. For lengths, three measures in each seed were performed, and for external diameters, two measures were made, obtaining an average for each seed.

3. RESULTS AND DISCUSSION

The Table 1 shows the average results measured, the maximum value and the minimum value measured for the batch of seeds used in this paper.

Table 1: Comparison with the calibrators, the unit used is a multiple of Becquerel (MBq) and inside the parenthesis is the submultiple of the old unit Curie (mCi).

	Average measure	Maximum value	Minimum value
Ionization Chamber Detector 1	29.97 ± 0.07 (0.810 ± 0.002)	30.71 (0.83)	29.04 (0.785)
Ionization Chamber Detector 2	29.97 ± 0.07 (0.810 ± 0.014)	31.08 (0.84)	29.23 (0.790)

The results for activities have low minimum uncertainty. But when we turn the seed 180 degrees, we could see the measures are not the same. This event is caused by the anisotropy, this anisotropy assumed the Iodine (radioactive material distribution) is not homogenous inside the silver rod. Another event that may cause this is the imperfections in the welding, in one side; this welding was not similar to the other side. Therefore, these facts can modify this measure. For medical requests and gauge measures, the calculation for dose distribution should be included.

Figure 2 shows the results measured in the batch of 75 seeds used to present the methodology that the laboratory will use. This figure is splitted in five series, each one with 0.03 mm.

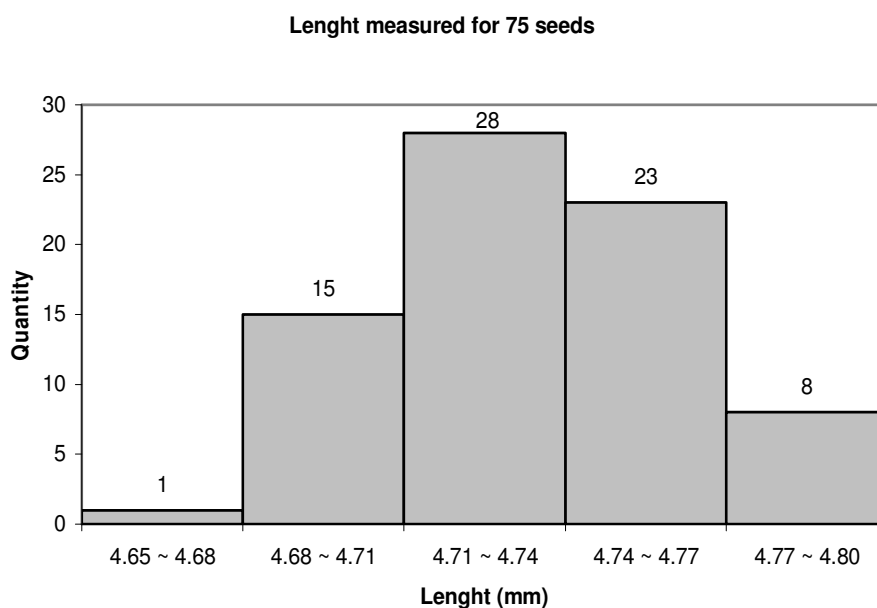


Figure 2: Batch of 75 seeds used to show the methodology used. The number above the bar is the quantity in each series used.

Some results for lengths are out of the standard measure, but the average is inside the minimum uncertainty admitted. The external diameter shows less variation than the lengths, all the values are inside the minimum uncertainty admitted. There are many explanations about these results. On the lengths, almost all the variations are caused by imperfections on the welding, a minimum imperfection may contribute for many results out the standard. It has to be considered the fact that the measurement of seeds is difficult because their position in the caliper varies during this process, leading to the necessity of more than one measurement. Three measurements in each seed, for the lengths, and two, for external diameter, can be considered suitable for our quality control. The cause for a better linear response concerning the external diameter is the fact that the Titanium capsules were made before the seeds production and only mechanical incidents, such as stresses or collision, may contribute for deformations. Table 2 shows a comparison between the standard seed with the results obtained in the experiment.

Table 2: Comparison the measures with the standard seed; the unit used is *mm* (millimetre).

Dimensions of the seed	Standard	Average measure	Maximum value	Minimum value
Lengths	4.50	4.730 ± 0.028	4.80	4.65
External diameter	0.80	0.805 ± 0.012	0.830	0.785

Figure 3 shows the results measured in the batch of 75 seeds used to present the methodology that the laboratory will use. This figure is split in five series, each one with 0.01 mm.

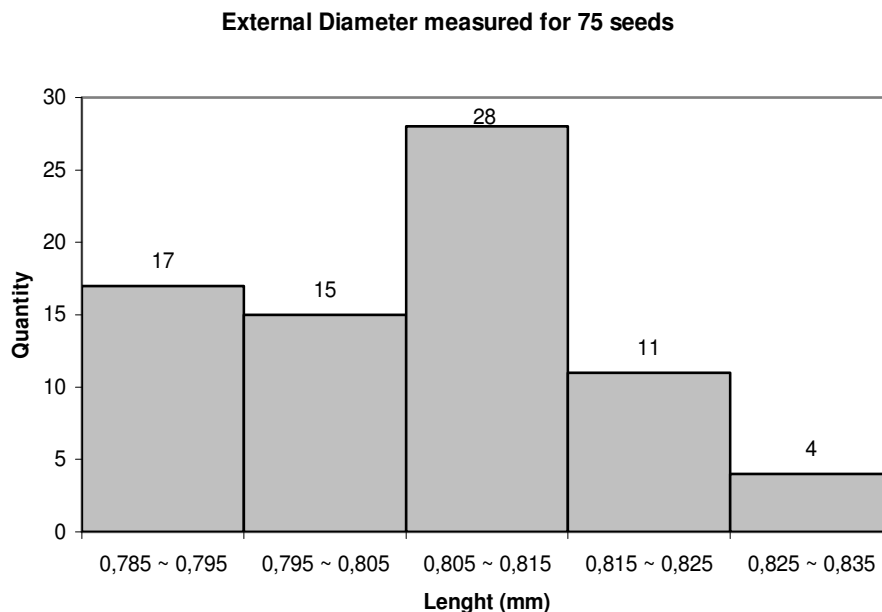


Figure 3: Batch of 75 seeds used to show the methodology used. The number above the bar is the quantity used in each series.

4. CONCLUSION

In the present study, the quality control for ^{125}I seeds found some variation in values, but the values are according with the minimum uncertainty, this methodology shows the importance of a quality control, for medical groups and the patient, with less uncertainty so that a better position and dose distribution of the seed could be planned. Further studies about dose distribution and seed immigration inside the body will improve the interstitial brachytherapy, in particular, prostate implants.

ACKNOWLEDGMENTS

We would like to thank the CTR (Centro de Tecnologia das Radiações), the IPEN/CNEN-SP and the FAPESP (Fundação de Amparo a Pesquisa do Estado de São Paulo) for technical and financial support.

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