Phantom positioning variation in the Gamma Knife® Perfexion dosimetry

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Abstract: The use of small volume ionization chamber has become required for the dosimetry of equipments that use small radiation fields. A pinpoint ionization chamber is ideal for the dosimetry of a Gamma Knife® Perfexion (GKP) unit. In this work, this chamber was inserted into the phantom, and measurements were performed with the phantom in different positions, in order to verify if the change in the phantom positioning affects the dosimetry of the GKP. Three different phantom positions were performed. The variation in the result is within the range allowed for the dosimetry of a GKP equipment.

Keywords: gamma knife; pinpoint ionization chamber; dosimetry

1. INTRODUCTION

The Gamma Knife® Perfexion (GKP) unit, introduced in 2006, is a fully automated unit for the stereotactic radiosurgery and the stereotactic radiotherapy of the brain lesions including also certain extra-cranial lesions [1].

It has 192 sealed sources of ^{60}Co arranged on eight movable sectors such that each sector contains 24 sources. The collimator system consists of a single large tungsten ring with collimator holes of three different sizes of 4, 8 and 16 mm [2].

When a patient treatment is initiated, all eight sectors with their 24 sources each quickly move out from their shielded home position at the extreme rear of the radiation cavity and slide over the tungsten ring and past the 8 mm collimators to park in the "off position" in shielded space between the 8 and 4 mm collimators. During this time, no beam is turned on and the treatment does not start to count. Depending on the size of the beam desired from a particular sector, the sources on that sector are aligned with the desired collimator size. The beams from a sector may also remain "blocked" if the sources in that sector remain parked in the off-position [1].

2. MATERIALS AND METHODS

A dose-rate calibration of a GKP unit is performed using the largest size collimator (16 mm, shown in Figure 1) and an ionization chamber with small volume positioned at the geometric center of the phantom. In this study, a pinpoint ionization chamber from PTW-Freiburg with 0.016 cm^3 of volume was used. Figure 2 shows the pinpoint ionization chamber. The pinpoint ionization chamber is inserted into the phantom, so that its sensitive volume is positioned in the center of the phantom.

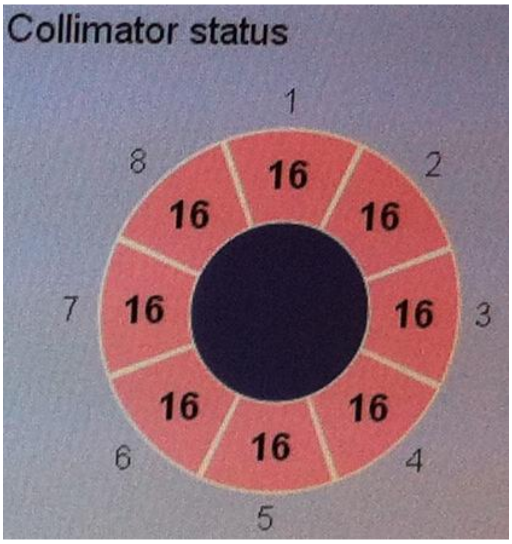

Figure 1: Size collimator used for calibration. All sectors are opened

Figure 2: Pinpoint ionization chamber

The calibration of a GKP is performed using a spherical polystyrene phantom 16 cm in diameter, which is provided by the manufacturer. It consists of two hemispheres with each hemisphere having 130 mm wide and 5 mm deep slot in the central area across the diameter of the hemisphere. The two hemispheres are held together with the help of two small Lucite pegs and corresponding holes for the pegs in the peripheral area of the hemispheres. The slot in the central area of phantom is used to accommodate a 130 x 160 x 10 mm^3 flat plate, made of ABS plastic. The plate is rounded off on two ends so that the surface of the plate is flush with the spherical surface of the phantom[3]. This phantom is held in irradiation position by a C-shaped aluminum adaptor, which has stainless steel side-fixation screws. This side-fixation screws have been proved to attenuate the beam in up to 4.6% [2]. Figure 3 shows the setup of the phantom mounted with the ionization chamber inserted in it.

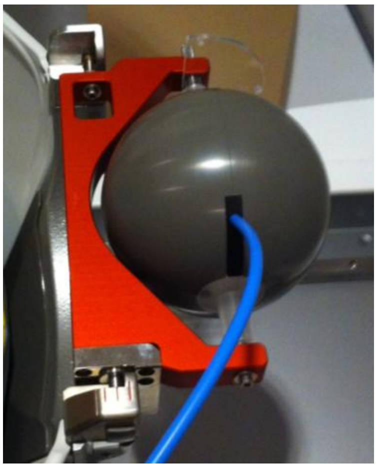

Figure 3: setup of the phantom mounted with the ionization chamber

The aim of this study was to vary the positioning of the phantom, in order to verify if there is any attenuation that might be considered during the dosimetry of the

GKP. Three different phantom positions were performed: phantom without slope, phantom with external slope and phantom with inner slope. Figure 4 shows the difference between the positioning.

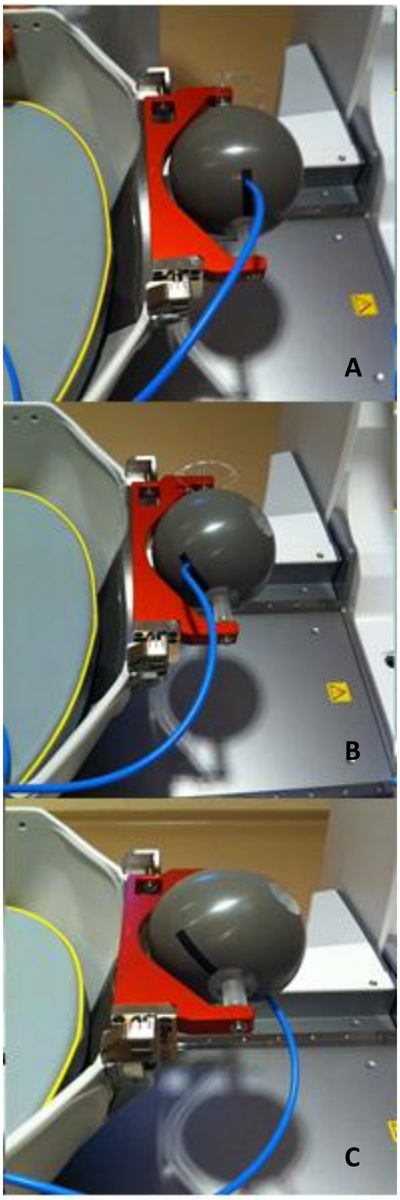

Figure 4: Phantom positions used for the measurements. In A, phantom without slope, in B phantom with external slope and in C phantom with inner slope.

Three readings of three minutes each were performed for each of the position showed above. It must be said that the manufacturer does not give any requirement related to the position that the phantom must acquire during the dosimetry of the GKP.

3. RESULTS

Results of the readings for the three different phantom positions are showed in Table 1.

Table 1: Results of the readings for the three different phantom positions

Position A: Phantom without slope (nC)	Position B: Phantom with external slope (nC)	Position C: Phantom with inner slope (nC)
3.610	3.643	3.627
3.619	3.659	3.603
3.629	3.634	3.608

The variation found for the position A, phantom without slope, was 0.53%. The variation for position B, phantom with external slope, was 0.68% and the variation for position C, phantom with inner slope, was 0.66%. Considering all the positions, the variation was 1.5% and its limit is considered to be 3% for the dosimetry of the GKP.

4. CONCLUSION

The aim of this study was to verify the variation in the readings that the GKP could show if there was a change in the position of the phantom during a dosimetry of the GKP.

Three different phantom positions were used: phantom without slope, phantom with external slope and phantom with inner slope. For all measurements, the largest size collimator (16 mm) was used.
After analyzing the data, it can be concluded that the best position to use the phantom is position A, phantom without slope, because it showed the smallest variation between the three positions analyzed.

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