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STUDY OF DIFFERENT MATERIALS FOR ATTENUATION IN MEGA VOLTAGE ENERGY FOR RADIOTHERAPY IMMOBILIZATION ACCESSORIES.

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Abstract. Radiation therapy is an area of medicine that treats malignant and benign lesions. This treatment modality is performed with ionizing radiation, such as electrons, x-rays and gamma rays with function of delivering the maximum doses to lesion, minimally affecting healthy tissues. This article presents the importance of using immobilizers during radiotherapy treatment, the text is based on a bibliographic review of books and articles in the radiotherapy area. The transmission of some materials used for making accessories in radiotherapy were analyzed. Among the analyzed materials, carbon fiber presented 97%, wood 96% and acrylic 92% transmission. Therefore, carbon fiber proved to be the best material for making these accessories and, as an alternative, wood presented similar and acceptable results.

Keywords. Radiation therapy; Immobilization devices; Ionizing radiation; x-rays.

Introduction. Radiation therapy is an area of medicine that treats malignant and benign lesions. This treatment modality is performed with ionizing radiation, such as electrons, x-rays and gamma rays, with the function of delivering the maximum doses to the lesion, minimally affecting healthy tissues. (SALVAJOLI, 1999).

Before the patient starts the treatment, he/she performs a simulation tomography to identify the area to be irradiated, determine technique and prescribed dose, and then the medical physicist carries out the treatment planning to calculate the dose distribution, respecting all tissue radiation tolerance limits (INCA, 2010).

A key aspect for a successful radiotherapy treatment is proper positioning of the patient and ensuring that this positioning is reproducible between different treatment sessions, and for this, immobilization accessories are used with pre-established parameters in the simulation, according to the anatomy and mobility of each patient (CAETANO, 2014).

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Currently, there are different accessories on market that seek to meet all treatment criteria in order to obtain the necessary precision in the administration of the radiation dose.

The objective of this work is to evaluate radiation transmission through materials used in radiotherapy breast immobilizers, through tests performed in the linear accelerator.

Materials and Methods. This work is based on a detailed review of the literature in order to gather data to understand how attenuation of materials used in breast immobilization accessories in radiotherapy works. For the study, articles published on Google Scholar were selected and *Scielo* as they are within the eligibility standard. This research method made it possible to identify the materials used in the breast immobilizers accessories and the benefit of their use, but no articles were found that presented the dose of attenuation during treatment. For this purpose, publications of works and the collaboration of the company were used Oxigen Trade, Industry and Representations of Medical Equipment Ltda - EPP dedicated and focused on the health area, based on the manufacture of breast immobilizers.

The Update for Radiotherapy Technicians book, do INCA (INCA, 2010), with the purpose of instructing on the main equipment and accessories involved in radiotherapy treatment was used as a basis for the preparation of the article.

To perform the analyses, three materials were selected: wood, acrylic, and carbon fiber. These materials were selected based on those used in the breast immobilizers available on the market.

For the irradiations, a Elekta Precise linear accelerator with an 80 leaf pairs multi leaf collimator (MLC) was used. (Figure 1)

Figure 1 - Elekta Precise Linear Accelerator (Elekta AB, 2021)

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The setup used for the irradiations had a PTW Farmer type cylindrical ionization chamber of positioned 10 cm deep in an array of solid water plates (material with electron density similar to water). Under the ionization chamber, another 5 cm of solid water plate was used to ensure backscatter and the source-surface distance was 100 cm, with the field size 10 cm x 10 cm and energy of 6 MV. The studied materials were placed on this arrangement.

For the comparative study of the attenuation of the materials, the setup was irradiated with 100 monitoring units and 2 cm of thickness of each material, except for the wood whose sample had 1.5 cm. In this case, we extrapolated to 2 cm according to the following calculation:

For 1,5 cm:

$$I = I_0\, e^{-\mu x}$$

$$11{,}27 = 11{,}8 e^{-\mu \,.0{,}015}$$

$$\frac{11{,}27}{11{,}8} = e^{-\mu \,.0{,}015}$$

$$e^{-\mu.0{,}015} = 0{,}955$$

$$-0{,}015\mu = ln\ 0{,}955$$

$$\mu = \frac{-ln\ 0{,}955}{0{,}015} = 3{,}07$$

For 2 cm:

$$I = 11{,}8\, e^{-3{,}07\ .\ 0{,}02}$$

$$I = 11{,}8\ .\ 0{,}94$$

$$\boldsymbol{I = 11{,}09}$$

Results and Discussion. Present research in scientific articles related to the subject, and studies of possible materials for the composition of accessories in radiotherapy treatments, present tests

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carried out at Unimed Bauru Hospital with different types of designated materials, applied directly to therapeutic procedure.

Currently, the most used material to make breast immobilizers is carbon fiber. This composite is under development following advancement of medicine and science.

During the development of this research through the exploratory analysis on the importance of accessories, it was analyzed that manufacture of immobilizers with other elements, being them, wood and acrylic, can provide necessary assistance for radiotherapy, since they are of extremely important in some cases.

Table 1 shows results obtained with irradiations and transmission percentages in relation to the transmission without the addition of any material (output):

Table 1: Results obtained in the transmission tests (Own Authorship).

MATERIAL	READING 1 (nC)	READING 2 (nC)	AVERAGE	TRANSMISSION (%)
OUTPUT (100 MU)	11,8	11,8	11,8	100
SOLID WATER	10,98	10,98	10,98	93
ACRYLIC	10,89	10,89	10,89	92
WOOD	11,27	11,27	11,27	96
CARBON FIBER	11,39	11,39	11,39	97

For each measurement, two readings were performed, and the value considered was the average between them. The results show that carbon fiber presents lower attenuation with 97% of transmission, therefore, from those analyzed, it is the best material for manufacture of radiotherapy immobilization accessories.

Wood is a good alternative with 96% transmission. Acrylic presented the worst result with 92% transmission for analyzed thickness. A measurement was performed with 2 cm of solid water to have a reference of attenuation value, and this showed 93% of transmission. (Figure 3)

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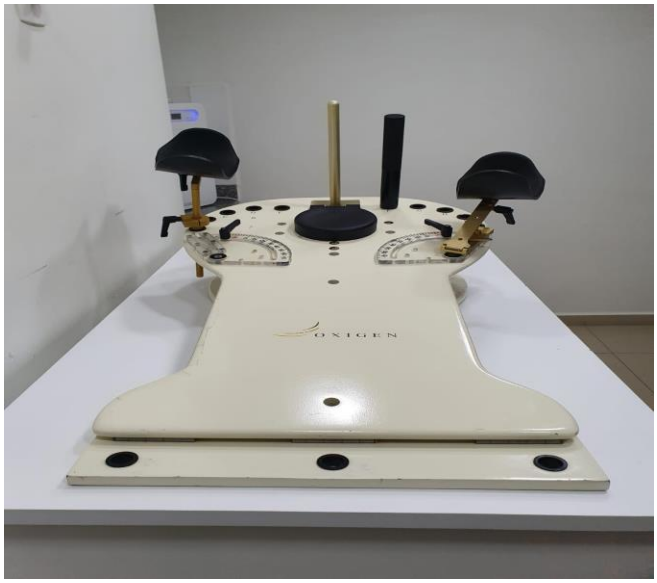

Figure 2 – Wood Breast immobilization accessory (Own authorship).

Figure 3 – Setup used to perform the measurements (Own authorship).

Final Considerations. During this work and through the performed tests, it was possible to analyze that manufacture of a radiotherapy immobilizer with appropriate material can guarantee a better dose delivery in the patient treatment.

The articles and books used as a basis for this work emphasize the importance of an adequate immobilization system to guarantee the reproducibility of the positioning throughout the treatment.

Results obtained in the tests show that among the analyzed materials, the one that presents the best results is carbon fiber. As an alternative, wood presented similar and acceptable results.

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