

A Comparison of Skin Dose Delivered with MammoSite and Multicatheter Breast Brachytherapy

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ABSTRACT

Background: Accelerated partial breast irradiation via interstitial balloon brachytherapy is a fast and effective treatment method for certain early stage breast cancers however skin, chest wall and Lung doses are correlated with toxicity in patients treated with breast brachytherapy.

Objective: To investigate the percentage of the dose received by critical organ (skin), thermoluminescence detector was used in MammoSite brachytherapy and the ability to control skin dose between MammoSite and MultiCatheter brachytherapy was compared with each other.

Method: Dosimetry is carried out using a female-equivalent mathematical chest phantom and Ir-192 source for brachytherapy application.

Results: Our initial results has shown good agreement with surface doses between those calculated from the treatment planning results and those measured by the thermoluminescence detector. The mean skin dose for the experimental dosimetry in MammoSite was 2.3 Gy (56.76% of prescription dose).

Conclusion: The results show that the MultiCatheter method is associated with significantly lower mean skin and chest wall dose than is the MammoSite. The MultiCatheter technique is quite flexible and can be applied to any size of breast or lumpectomy cavity, But in MammoSite technique, verification of balloon symmetry, balloon/cavity conformance and overlying skin thickness is essential to assure target coverage and toxicity avoidance.

Keywords

Brachytherapy, MammoSite, MultiCatheter, Thermoluminescence detector, Treatment planning system, Skin Dose

Introduction

The local management of breast cancer has evolved from radical surgical therapy to a breast-conserving approach that combines both segmental mastectomy (lumpectomy) with whole breast radiotherapy. In early stage breast cancer treatment, MultiCatheter interstitial and MammoSite brachytherapy have been used as a partial breast irradiation (PBI) technique after breast surgery. Historically, construction of the breast implant in MultiCatheter was performed in the operating room and was heavily experience-dependent. This was either done at the time of lumpectomy or as a separate procedure following lumpectomy with pathologic evaluation completed and information available. Stain-

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less steel trochars are then introduced into the breast tissue at the appropriate locations. Once trochar placement is complete the trochars are replaced with button-ended flexible afterloading catheters and secured with locking collar. Implant construction has been governed by

basic breast brachytherapy principles with the goal of optimizing target coverage and dose homogeneity [1,2]. Intercatheter spacing is ideally between 1 and 1.5 cm and earlier implant construction typically comprised a two plane implant (figure1).



Figure 1: A. The trochars are replaced with the flexible catheters as shown. B. The finalized implant is shown connected to a high dose rate afterloading device [3].

Although the multicatheter interstitial technique is quite flexible and can be applied to any size of breast or lumpectomy cavity, it can be technically challenging and adds a degree of trauma with the potential for pain during the treatment process. In light of these considerations, the MammoSite brachytherapy system was developed in an attempt to simplify the PBI implantation process and to improve

the reproducibility of dosimetric target coverage [3]. The MammoSite applicator is a single catheter with an inflatable balloon at its distal end that can be placed in the lumpectomy cavity. The treatment is performed by delivering the Ir-192 high-dose-rate (HDR) source through the center lumen of the catheter by a remote after loader while the balloon is inflated in the tumor bed cavity (figure 2).

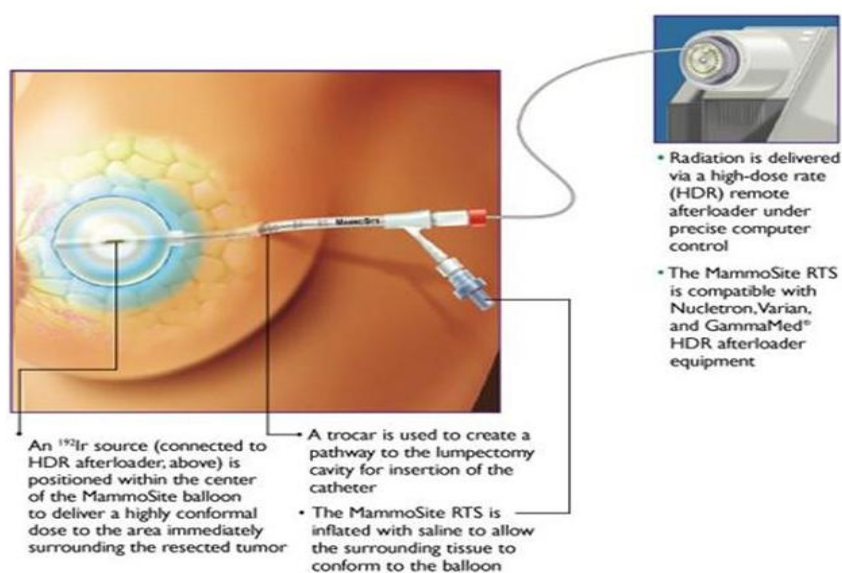


Figure 2: MammoSite brachytherapy system [4].

The most commonly used dose schemes for Multicatheter and MammoSite monotherapy is 34Gy delivered in 10 fractions at 1.0 cm from the balloon surface with a minimum of 6 hours between fractions on the same day over a 1-week period [4,5].

Accelerated partial breast irradiation (APBI) via interstitial or balloon brachytherapy is a fast and effective treatment method for certain early stage breast cancers but skin, chest wall and Lung doses are correlated with toxicity in patients treated with breast brachytherapy.

The purpose of this study was to investigate the percentage of the dose received by critical organ using thermoluminescent detector in MammoSite brachytherapy and compared the ability to control skin dose between MammoSite and MultiCatheter brachytherapy results [6].

Material And Methods

To investigate the percentage of the dose received by skin using thermoluminescent detector in MammoSite brachytherapy the mathematical phantom was used. The phantom represents half of a female chest and is composed of organs based on the dimensions of an average female human being. The dimensions of the organs were obtained from Scutt an anthropomorphic chest phantom [7].

In this phantom, breast was made from a half sphere of Plexiglas material and MammoSite applicator was inserted into the cavity inside the breast part of the phantom and inflated to diameter of 5 cm with 65 ml of sterile saline and the lung had the composition given by International Commission on Radiological Protection Publication 23 with a density of 0.297 g cm^{-3} . The chest wall thickness was 2 cm and the hemi-thorax dimensions were $28 \times 30 \times 30$ cm in the x, y and z directions, respectively [8].

In this study, we used square shape of TLD-100 chips (Harshaw Chemical Co.) with size of $3.2 \times 3.2 \times 0.9$ mm for dosimetry. TL dosim-

etry was performed within the Plexiglas layers with 1 mm thickness in balloon surface, planning target volume (PTV) and skin surface. Square shaped location of TLD was prepared to match with the dimensions of TLD size for each specific layer which were placed in the balloon surface and its 10 mm margin to investigate dose coverage in PTV. They also were placed in skin surface to determine the percentage of received dose by this critical organ.

Three dimensional planning was done on computed tomography (CT) images of the phantom with FlexiPlan software (Nucletron Co.) to deliver prescribed dose to the reference points (PTV and skin surface). CT images were obtained to determine the volume of the balloon, balloon-to-skin distance, maximal point skin dose per fraction, percent of the volume that received 100% of the prescription dose, V_{100} , percentage of the volume that received 150% of the prescription dose, V_{150} , and percentage of the volume that received 200% of the prescription dose, V_{200} . Also, the track length (TL) was determined in CT. The TL is the length of catheter located beneath the skin of the phantom's breast.

After three dimensional planning of dose delivery to reference points (e.g. MammoSite balloon surface plus 1 cm margin) within the phantom a comparison was made between experimental and treatment planning results.

Ideal dosimetric goals of MammoSite[®] brachytherapy include 90% coverage of PTV by at least 90% prescribed dose (PD). The maximum skin dose should be reduced to as low as achievable and it has not been exceeded from 145% of the PD at any point. The volume of breast tissue receiving 150% (V_{150}) of the PD had to be reduced to as low as achievable and designed not exceed 50 ml. The volume of breast tissue receiving 200% (V_{200}) of the PD has to be reduced to as low as possible and not larger than 10 ml [9].

Results

Our initial results had shown good agreement for surface doses between those calculated from the treatment planning system results and those measured from the experimental dosimetry via thermoluminescent detector. The normalized dose rate was obtained at 1 cm from balloon surface by treatment planning results.

Figure 3 shows that PTV dose coverage was 100% of prescribed dose in treatment planning system (TPS) and 101.76% of prescribed dose in experimental dosimetry also the percentage of the received dose by skin surface was 70.4% of prescribed dose in TPS and 73.52% in experimental dosimetry. The mean skin dose for the experimental dosimetry in MammoSite after averaging all TLD results was 2.5 Gy (73.52% of prescription dose).

Treatment planning result shows that, V_{150} and V_{200} were obtained 39.19 ml and 6.41 ml in PTV, respectively. Also, 94.7% of target volume received 100% of prescribed dose and 50% of prescribed dose was received by 34.3% of the total breast volume.

Multicatheter brachytherapy is the APBI technique associated with the longest follow-up and outcome data. With 10-year follow-up data from some institutions as well as results from a European randomized trial now available, this technique is associated with actuarial local recurrence rates of less than 5% in carefully selected patients. As Laurie et al showed the mean maximum skin dose for the MultiCatheter was 2.3 Gy that was 67% of prescription dose [6].

The difference between skin dose in MammoSite and MultiCatheter brachytherapy was shown in figure 4.

Discussion

Our initial results showed acceptable agreement between experimental and treatment planning results in MammoSite brachytherapy system but as results show the mean skin dose in MultiCatheter method is significantly lower than MammoSite brachytherapy system.

Advantages of MammoSite are; Shortening of total treatment time from 6 week in external radiotherapy to 5 days and reducing

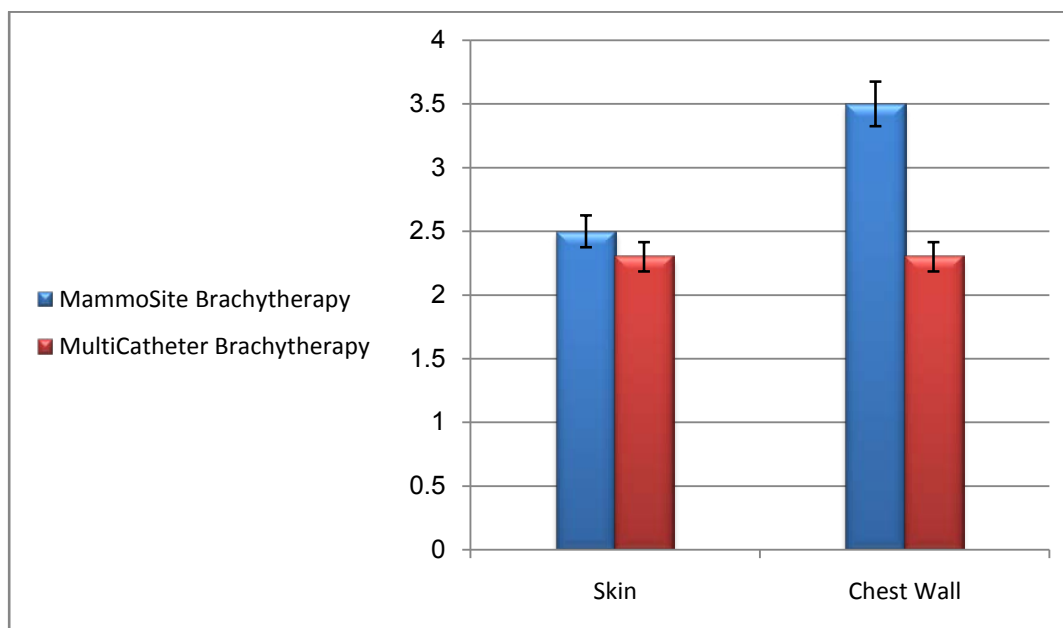


Figure 3: Treatment Planning System (TPS) and Experimental Dosimetry (TLD) Results

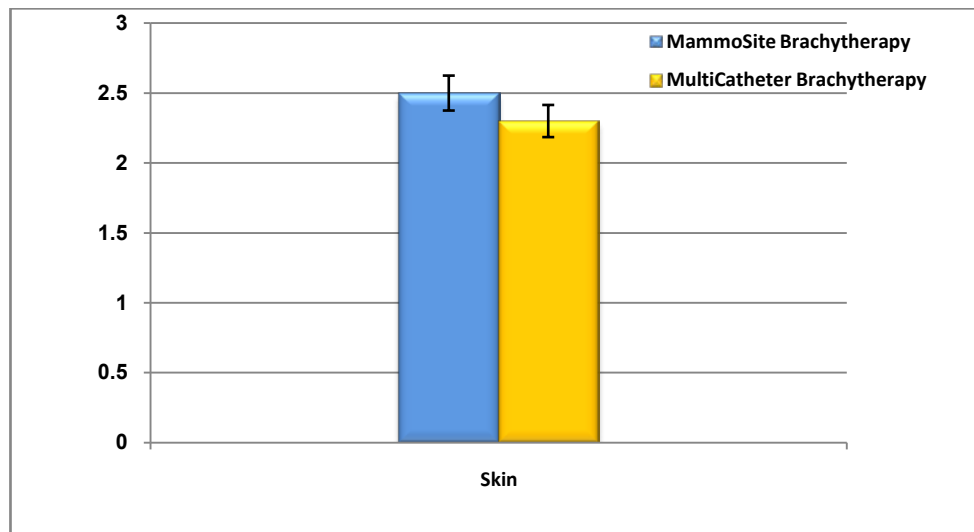


Figure 4: Comparison between MammoSite and Multicatheter skin dose results

the amount of normal tissue included in the radiation field and HDR brachytherapy using a MammoSite balloon applicator has been widely used in PBI for early-stage breast cancer patients because of its high reproducibility and stability. Although the MultiCatheter interstitial technique is quite flexible and can be applied to any size of breast or lumpectomy cavity, it can be technically challenging and adds a degree of trauma with the potential for pain during the treatment process.

Conflict of Interest

None

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