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Original Article

ESTRO–ACROP guidelines in postmastectomy radiation after immediate reconstruction: Dosimetric Comparison of 3D–CRT versus VMAT planning

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Abstract

Purpose: To evaluate target volume coverage and organs at risk (OARs) sparing comparing 3D–Conformal Radiation (3D–CRT) vs. Volumetric Arc Treatment (VMAT) planning based on contouring guidelines of European Society for Therapeutic Radiology and Oncology Advisory Committee in Radiation Oncology Practice (ESTRO–ACROP) for implant sparing and target volume delineation in post–mastectomy radiation therapy (PMRT) after immediate breast reconstruction (IBR).

Materials and Methods: Ten eligible patients were identified via a retrospective chart review. The CT–simulation scans were used to contour target volumes applying ESTRO–ACROP guidelines and OARs. For each case, 3D–CRT and VMAT plans were generated to evaluate the best achievement of target volume coverage and minimal dose to OARs.

Results: There was a significant difference towards VMAT for PTV coverage by 90% and 95% isodose line. The VMAT, compared to 3D–CRT, showed a lower mean (PTV–105%) (8.1 vs. 17.8), (p–value 0.000034). The OARs sparing showed a significant difference in favor of VMAT for ipsilateral lateral lung V20 (p–value 0.007048), both lungs' mean dose (p–value 0.019021), and heart mean dose (p–value 0.000076). The 3D–CRT plan showed lower thyroid mean dose (19.27 vs 23cc), (p–value 0.0235), and contralateral breast Dmax, D5 and D10, p–values (0.04088, < 0.00001 and< 0.00001), respectively. In the implant doses, there was no statistical difference between Dmax (54.59Gy vs. 54.14Gy), while there was a statistically significantly lower mean implant dose for VMAT (43.83Gy) vs. 3D–CRT (50.81Gy), (p–value < 0.00001).

Conclusion: Our study showed an advantage of VMAT compared to 3D–CRT following ESTRO–ACROP consensus for implant sparing in PMRT.

Introduction:

Breast cancer is the second most common cancer worldwide and the most common cancer in women [1]. Increased awareness of breast cancer and developments of genetic screening programs not only increased the early diagnosis and treatment of breast cancer but also increased the prophylactic surgeries in a genetically predisposed high–risk population [2]. With these developments, the trend of breast surgeries shifted more towards breast conservation and breast reconstructions, which gave relatively safe treatment options with similar long–term overall survival (OS) with good quality of life (QoL) [3,4].

Since then, an upsurge has been seen in the rate of breast reconstructions, both with immediate breast reconstruction (IBR) and delayed breast reconstruction (DBR). The reconstruction rate increased from (8%) in 1995 to (41%) in 2013 [5]. The latest IBR rates have been reported to be as high as 54% for invasive cancer and 63% for ductal carcinoma in situ cases [6].

Recently, there has been an increasing trend in breast reconstruction towards implant–based procedures with silicon–based implants in 2006 with proven long–term safety reports by the Food and Drug Administration (FDA) [7].

Implant–based reconstructions became a standard practice in 2002, due to their aesthetical benefits, availability in a wide range of shapes and sizes,

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improvement in adjunctive procedures like use of acellular dermal matrices (ADMs), fat pad augmentations with simplicity of procedure with less complications, and approval of insurance coverage [8,9].

Breast reconstruction after mastectomy radiation was previously thought to be a relative contraindication for post–mastectomy radiation (PMRT), but recently large population–based data supported the benefits and value of the use of breast reconstruction in patients deemed to receive adjuvant RT [10].

Some studies also reported improved QoL among irradiated patients who were undergoing immediate reconstruction compared with delayed breast reconstruction [11].

The rising popularity of implant–based reconstructions in the setting of PMRT has led to many studies to define the best radiation technique to limit implant failure rates. To overcome this problem, a consensus randomized trial by the Danish breast cancer group(DBCG), for patients who require PMRT with IBR necessitates the development of guidelines for target volume delineation [12]. An international group of experts from breast surgeons, plastic surgeons, radiation, and clinical oncologists was incorporated through, the European Society of Radiation& Oncology (ESTRO)'s Fellowship in Anatomic Delineation and Contouring (FALCON). Later in a meeting at ESTRO 37, a draft of contouring guidelines was released, which were endorsed by a global multidisciplinary group of breast cancer experts [12].

Currently, these are the recommendations for the PMRT, volume delineation to be used with caution in lack of information about the precise clinical, pathological stage where standard technique is used.

A study that used this contouring guideline for implant–sparing target volumes in IBR patients has shown similar results to standard planning volumes in terms of recurrence and survival even though there was a minimal decrease in target coverage with this approach [13].

Latest inverse planning techniques are also subsequently studied in comparison with the traditional conventional Radiation techniques, which not only improved the target coverage but also has shown better sparing of organs at risk (OAR) dosimetrically [14].

Currently, we are seeing more patients with IBR that are requiring PMRT. Traditionally until today, we still include the implant in our target, which leads to an increased dose of OAR and potentially increases the rate of implant failure without any clear benefits from coving the implant within our target volume.

The primary aim of this study is to conduct a dosimetric evaluation for target volume coverage and organ at risk (OAR) sparing comparing 3D–conformal radiation (3D–CRT) planning vs. volumetric Arc treatment (VMAT) planning based on ESTRO–ACROP consensus guideline for implant sparing and target volume delineation in post–mastectomy radiation therapy (PMRT) after immediate breast reconstruction (IBR).

Material & Methods:

Study design:

This study is a retrospective study design that includes chart review and a prospective dosimetric analysis.

Inclusion criteria:

1. All female patients presenting in Radiotherapy clinics of King Abdullah Medical City (KAMC) from September 2018 to December 2019, with breast cancer post–mastectomy with immediate breast reconstruction with indications for PMRT.
2. Breast cancer patients with well–documented demographic data, clinical/operative details, and clear histopathology reports are reviewed at our center.

Exclusion criteria:

1. Male breast cancers.
2. Female breast cancer patients of age less than 18 years.

Study Procedure:

1. Eligible patients who present with histologically confirmed epithelial breast cancer with implant–based reconstruction with standard indications for adjuvant radiotherapy were identified through a retrospective review of medical records.
2. After the collection of eligible patients' medical records, the CT–simulation scans were used by radiation oncologist to contour the target volumes using the ESTRO–ACROP consensus contouring guidelines for p implant sparing and OARs (Organs at risks) [12].
3. The dosimetrist and medical physicist planned each case with two plans, one with 3–D CRT and the other with VMAT technique.
4. The plans were reviewed by radiation oncologists concerning the best achievement of target volume coverage (following ICRU) and minimal doses to the organs at risk. (following QUANTEC models)

Results:

Ten eligible breast cancer patients who had IBR followed by PMRT were identified and planned with two separate plans, with 3D–CRT and VMAT techniques. The dose–volume histogram (DVH) of the two plans was used to evaluate the best achievement of target volume coverage and the minimal dose to the organs at risk.

The average age of our population (43.2 years), and all patients had silicone implants. All patients had planned with a dose of (50Gy in 25 fractions). The mean planning target volume (PTV) was (1022cc). There was a significant difference in favor of the VMAT technique in terms of PTV coverage by 90% and 95% isodose line with p–values (0 .035088) and (0 .024136), respectively. The VMAT, compared to 3D–CRT, showed a lower mean (PTV–105%) (8.1 vs. 17.8), which was statistically significant (p–value 0 .000034). The doses to the OARs showed a significant difference in favor of VMAT in terms of ipsilateral lateral lung V20 (p–value 0.007048), both lungs mean dose (p–value 0 .019021), and heart mean dose (p–value 0.000076). No statistical difference in maximum dose to spinal cords was identified between the two plans. The 3D–CRT plan was better in terms of lower thyroid mean dose (19.27 vs 23cc) with (p–value 0.0235) and lower contralateral breast Dmax, D5, and D10 with p–values (0.04088, < 0.00001 and< 0.00001), respectively. In terms of implant doses, there was no statistical difference between the mean Dmax of the two plans (54.59Gy vs. 54.14Gy) with (p–value 0.10), while there was a lower mean implant dose for VMAT (43.83Gy) vs. 3D–CRT (50.81Gy) which was statistically significant (p–value < 0.00001) (figure 1,2).

Discussion:

The ESTRO–ACROP contouring guidelines for PMRT after IBR, recommend that the implant is not part of the chest wall

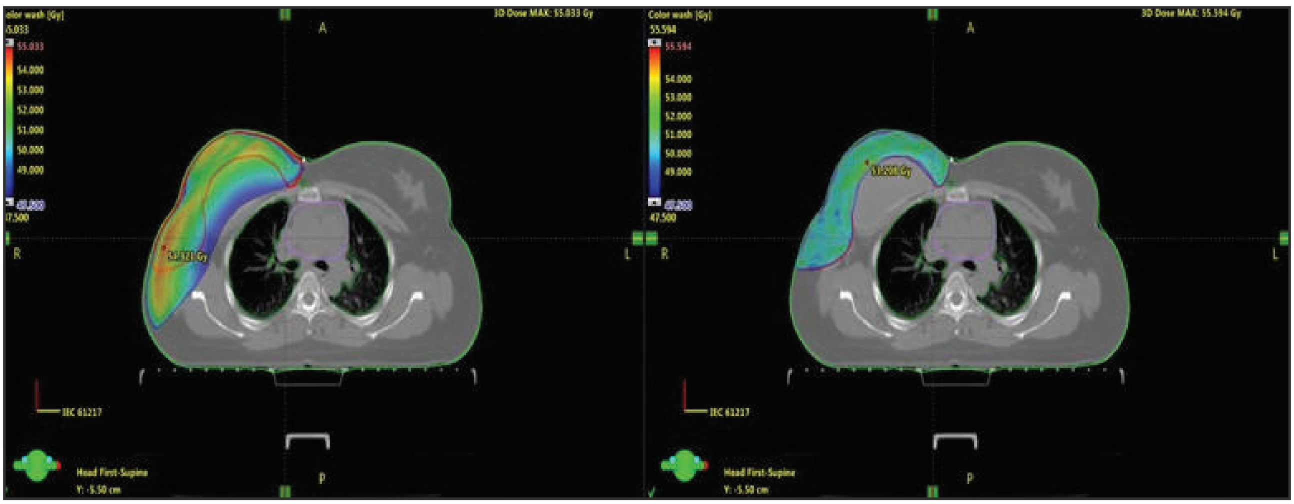

Figure 1: Dose Distributions for (3D–CRT) vs (VMAT).

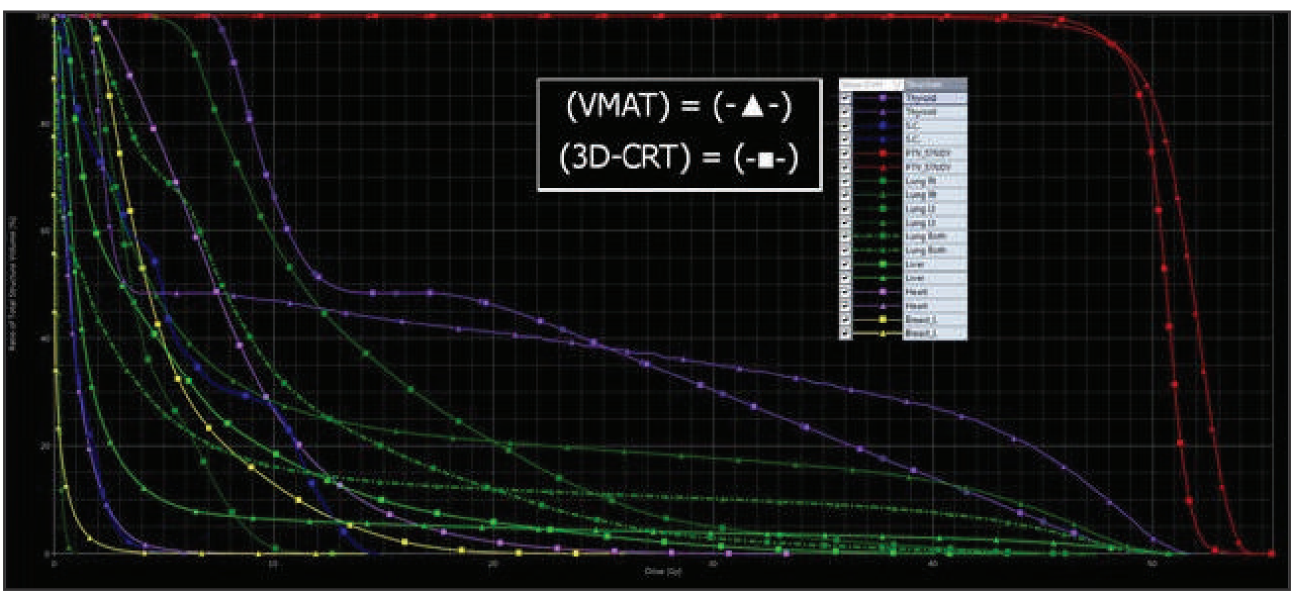

Figure 2: Dose Volume Histogram for OAR (3D–CRT) vs (VMAT).

clinical target volume (CW–CTV) [12]. In our study, we wanted first to assess the impact of these new guidelines on the planning and dosimetric outcomes for patients undergoing PMRT with IBR comparing 3D–CRT vs VMAT.

A study was done to assess the impact of the new target volume delineation based on the ESTRO–ACROP contouring guidelines for PMRT after IBR vs. conventional contouring using VMAT plans. It found a significantly smaller target volume based on the ESTRO–ACROP contouring guidelines. Although no significant difference was found in the target coverage between the two plans, the ESTRO–ACROP VMAT significantly reduced the mean heart dose, maximum (LAD) dose, and mean LAD dose compared to plans done with conventional contouring. No significant differences were found in dosimetric and delivery accuracy between both [15].

A similar study aimed to assess the impact of the new contouring guidelines on dosimetric outcomes on ten left–sided breast cancer patients who underwent PMRT after IBR. The plans were generated using VMAT and proton pencil–beam scanning (PBS) therapy. The VMAT plans using the new ESTRO–ACROP guidelines resulted in lower dose of the left anterior descending coronary artery (LAD) and ipsilateral lung, but not to the heart, with a trend of higher contralateral lung and CW doses. The PBS plans using the new guidelines resulted in further sparing of the heart, cardiac substructures, and ipsilateral lung [16].

In a study of 16 patients who underwent IBR after mastectomy, half were left–sided. The planning CT was obtained with free breathing. Retrospectively, the CTV was delineated based on the ESTRO–ACROP guidelines, and treatment plans created with helical tomotherapy (HT) and VMAT techniques. There was no statistically significant difference in target coverage in terms of PTV–D95, and homogeneity index between HT and VMAT plans. The conformity numbers were significantly higher for VMAT. Although there were significantly lower Dmax and Dmean for LAD on treatment plans with HT, there were no effects for reducing the maximum and mean dose to the heart. Although the heart volume receiving 5 Gy was significantly higher for VMAT when compared to HT, both techniques succeeded in minimizing the mean dose to implant when utilizing the ESTRO–ACROP contouring guidelines [17].

In our study, the ESTRO–ACROP contouring guidelines were generally easy to implement. However, close attention is needed to address all areas at risk for recurrence should be included within the CW–CTV.

Conclusion:

Our study showed using VMAT planning for PMRT with the utilization of ESTRO–ACROP consensus guidelines for implant sparing has the advantage over 3D–CRT of better target coverage, and lower mean doses to the implants, lung, and heart. However, this approach has potentially increased the radiation doses to the contralateral breast and thyroid gland compared to 3D–CRT.

Conflicts of Interest Statement

The authors have no conflicts of interest to declare.

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Data Availability Statement

Authors will make data available to editors, reviewers, and readers without restriction wherever possible. Further enquiries can be directed to the corresponding author.

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