Standardizing Metallic Port HU Overrides for Breast Tissue Expanders

Erika Bilokon, MS[1]; Neil Taunk, MD[1]; Gary Freedman, MD[1]; Emily Hubley, MSc, DABR[1]
[1]Department of Radiation Oncology, University of Pennsylvania

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ABSTRACT

Purpose: High-density metallic ports in breast tissue expanders (TE) introduce CT artifacts that cause dose calculation uncertainties for postmastectomy radiation planning. TE ports have either a titanium or stainless-steel needle guard and a very high-z magnet. Materials and dimensions vary by vendor. With no clinical standardization, HU overrides will vary depending on the planner or physicist. Our goal was to identify a repeatable and practical approach for port overrides that produce clinically acceptable dose distributions.

Methods: Six patients (two per TE type) were retrospectively selected: Allergan Natrelle 133s, Mentor Artoura, and Sientra AlloX2 TE and planned with 3D and VMAT. Using the vendor-specified dimensions and materials, three override strategies were investigated: (i) separate magnet and needle guard density overrides, (ii) combined magnet and needle guard overrides, and (iii) override the entire port to water-equivalent density. Plans were re-calculated and assessed for each method using maximum dose, skin dose, chest wall dose, heart dose, and lung dose.

Results: Dose maxima were comparable across the methods per each patient with method iii consistently marginally higher. Methods i and ii consistently displayed similar dosimetric outcomes, with colder regions around the port and 95% isodose coverage behind the port. Method iii generally produced higher hot spots, with most of the dose differences being highly localized within the saline volume. Method iii also had higher variability of dose within the chest wall and locally around the port. Skin and chest wall doses were method- and expander-dependent, with AlloX2 showing the largest variability. Across all cases, heart and lung doses remained comparable. These results were consistent for VMAT and 3D.

Conclusion: Methods i and ii demonstrated better dosimetric outcomes than iii. Method ii is recommended since it is as dosimetrically effective as Method i, while being more reproducible and less time-consuming to contour. This provides a standardized repeatable and practical approach for port HU overrides.

CONTACT

Erika Bilokon
University of Pennsylvania. Department of Radiation Oncology
Address: 3400 Civic Blvd, Philadelphia, PA 19104
Email: Erika.Bilokon@Pennmedicine.upenn.edu
Phone: 267-882-1664

INTRODUCTION

Many post-mastectomy patients will undergo breast reconstruction with the intermediate step of a temporary tissue expander (TE). These TE consist of a saline implant, a port, and a central magnet. The presence of the magnet, a high-density material, can create challenges for tissue homogeneity when trying to accurately plan and treat a patient. For post-mastectomy radiation therapy (PMRT) this high-z material is within the treatment volume and can cause an increase in the scatter dose to the surface, underdose the target due to attenuation, and causes streaking artifacts within the CT leading to potential difficulty when delineating the tumor and critical organs. These artifacts consistently make the magnet appear larger than its actual dimensions leading to inaccurate dose calculations (Figure 4). These challenges are reflected in both 3D and VMAT breast planning. A further complication in PMRT is that expanders come in many different materials, dimensions, and number of ports making it difficult to have a fixed solution that reflects the true properties of each of these TE. With no standardization of overrides for 3D or VMAT photon planning for TE we aimed to identify a best practice of overrides that was easily repeatable, not complex or time consuming, and produces a clinical acceptable dose distribution that reflects the presence of a TE. We did this through an evaluation of the dosimetric impact of various override techniques and an assessment of the minimum planning criteria required to model the TE accurately.

METHODS AND MATERIALS

Our institution mainly uses three different types of tissue expanders: Allergan Natrelle 133s, Mentor Artoura, and Sientra AlloX2 and we plan with both 3D and VMAT for these cases. We retrospectively selected six patients to evaluate: two for each expander type each planned as either 3D or VMAT so that we can determine a standard override technique that can be used for all planning. Based on our evaluation criteria, three different override techniques were assessed:

(i) contour and override the magnet and needle guard separately
(ii) contour the magnet and needle guard together and override them with the HU of the needle guard
(iii) contour and override the entire TE including the implant to be water-equivalent.

For technique i and ii the surrounding TE was overridden to be water-equivalent. The HU and material dimensions were determined based on vendor provided data (Table 1) allowing for contours to be more dimensionally accurate for the magnet and guard (Figure 4). The plans were all recalculated with no changes other than the overrides and were compared using dosimetric parameters of maximum dose, skin dose, chest wall dose, heart dose, and lung dose. An overall evaluation of hot spot and cold spot size and locations was also considered.

RESULTS

Across all TE types, maximum dose was comparable between methods, with i and ii nearly indistinguishable and iii consistently marginally higher, method iii is the right most image in Figures 1-3. Method iii also displayed greater global dose variability, with a majority of hot spots concentrated in the saline. Heart and lung doses remained comparable across all methods and TE types. Chest wall was 95-100% isodose for all TE but AlloX2 which varied with method.

	Allergan Natrelle 133s (type II)	Sientra AlloX2	Mentor Artoura
Needle Guard Material	Titanium HU = 4450	Titanium HU = 4450	Titanium HU = 4450
Magnet Material	Samarium Cobalt HU = 9300	Neodymium HU = 9600	Neodymium HU = 9600
Needle Guard Dimensions	Diameter=3.6cm Thickness=0.06cm	Diameter=29.7mm Thickness=10.3mm	—
Magnet Dimensions	Diameter=1.76cm Thickness=0.25cm	Diameter=25.8mm Thickness=2.5mm	—
Number of Ports	Single	Dual	—

Table 1: Material and Dimensions

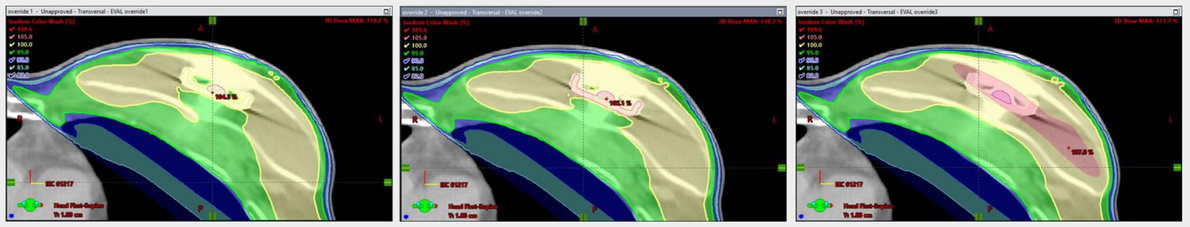


Figure1: Allergan Natrelle 133s (type II)

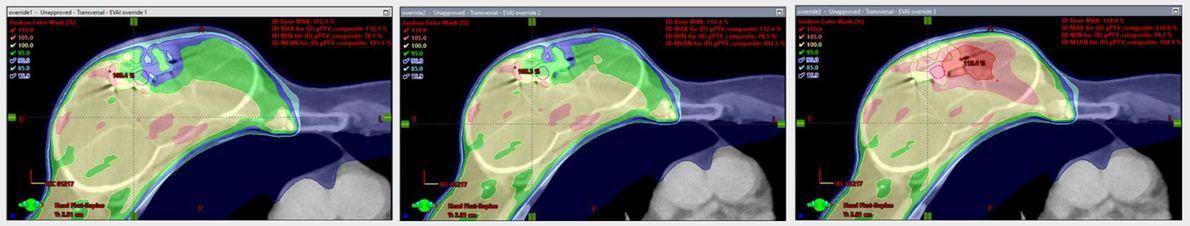


Figure 2: Mentor Artoura

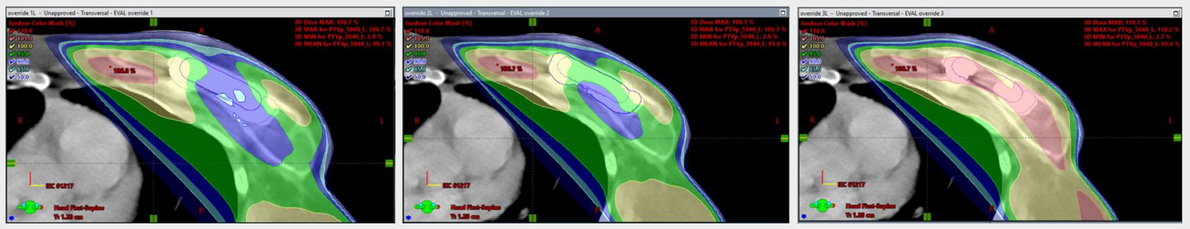


Figure 3: Sientra AlloX2

Natrelle 133s (Figure1):
- Method i & ii drop of coverage posterior to the guard
- Method iii no lose of coverage but large 105% hot spot

Mentor Artoura (Figure 2):
- Method i 90% coverage in all directions around magnet
- Method ii 90% coverage anterior of magnet
- Method iii 100% coverage throughout implant and tissue with 110% hotspots

AlloX2 (Figure 3):
- Method i coolest of all plans with 90% reaching chest wall
- Method ii 90% isodose posterior to magnet
- Method iii higher chest wall, skin, and implant dose

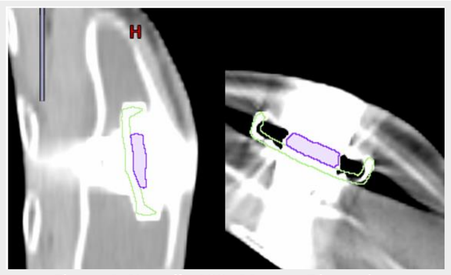


Figure 4: Natrelle 133s Magnet Dimensions

DISCUSSION

Across the TE types methods i and ii produced more consistent dose distributions, characterized by reduced hot spots within the saline and cooler dose regions near the port compared to method iii. These findings suggest that modeling TE with material-specific HU overrides yields superior dosimetric accuracy compared to a water-equivalent override. The parameters of skin and chest wall dose was the most dependent on method and TE type, with the AlloX2 having the largest method dependent changes. The lack of variation in lung and heart dose concludes the override should be based on dose accuracy near TE. Based on this and our intent to find a standardized override standard, method ii was selected and implemented due to its simplified contouring and comparable dosimetric results to the more realistic override in method i.

CONCLUSIONS

Methods i and ii produced better dosimetric accuracy than method iii across all expander types, while method iii consistently overestimated dose homogeneity near the port. We have since implemented this strategy into our clinic by providing the material and dimensions table to our dosimetry team to be used for TE specific overrides using method ii.

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