gradient of the breast when using Irregular Surface Compensators

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Introduction

- Irregular surface compensation is a planning technique available on the Eclipse treatment planning system where it utilizes dynamic multileaf collimators to compensate for irregular body surfaces, a technique useful for breast radiotherapy.
- These dynamic multileaf collimators create a fluence which can be modified to a deliver a homogeneous dose distribution.
- In determining the depth of compensation, a transmission penetration depth (TPD) is chosen by the user.
- Some institutions may use a standard TPD for every breast plan, while others may measure maximum breast size to determining the appropriate TPD.
- To choose the optimal TPD the whole breast must be taken into account, including the variation of the breast anatomy in 3-D.

Methodology

- In this retrospective study, ten breast patients treated with two tangential fields were analyzed to see the effects of the gradient changes in the breast anatomy along the superior-inferior direction.
- First part of the study involved the creation of triangular water phantoms with varying contained angles (10°-65°) to simulate varying slopes of the breast anatomy.
    - 6 MV tangential fields were optimized based on Homogeniety index (HI) and maximum hot spot within the phantoms to determine the optimal TPD value.
- As the contained angle of the triangular phantom decreased the TPD increased.
    - A graph was generated with the values found from the phantoms and points in between were interpolated.
    - The following trend was used as a guideline to choose the TPD for the ten breast patients.
- A standard TPD, chosen by best overall distribution, was used to compare with the angle based TPD.
    - Contained angles were measured for each of the tangential fields (medial and lateral) for each patient to determine the optimal TPD value at the superior, middle, and inferior sections.

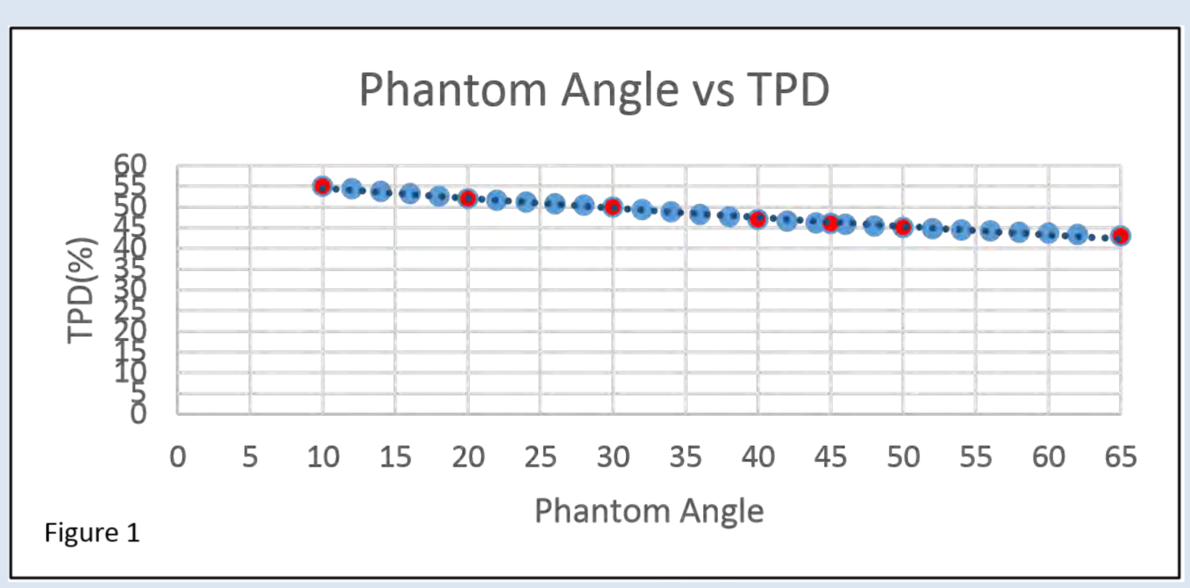

Figure 1

Figure 1 (left), shows the correlation between phantom angle and TPD. Seven phantoms were created in the Eclipse TPS with varying angles. Triangular Phantoms each with a constant base length of 15cm were created with varying angles; 10°, 20°, 30°,40°,45°,50°,65°. The optimal TPD found for each phantom were; 55%, 52%, 50%, 47%, 46%, 45%, 43% respectively. A decreasing trend line is noted, where as the angle increases the TPD decreases. The phantom points were plotted shown in red and the points in between were interpolated, shown in blue.

Conclusions

- A clear correlation can be noted between the TPD and the breast angle/slope.
- For shallower breast angles, a greater TPD showed to have a better dose distribution. For all patients both the superior and inferior chest wall coverage improved. This trend can be used as a guideline during planning to get a better dose distribution.

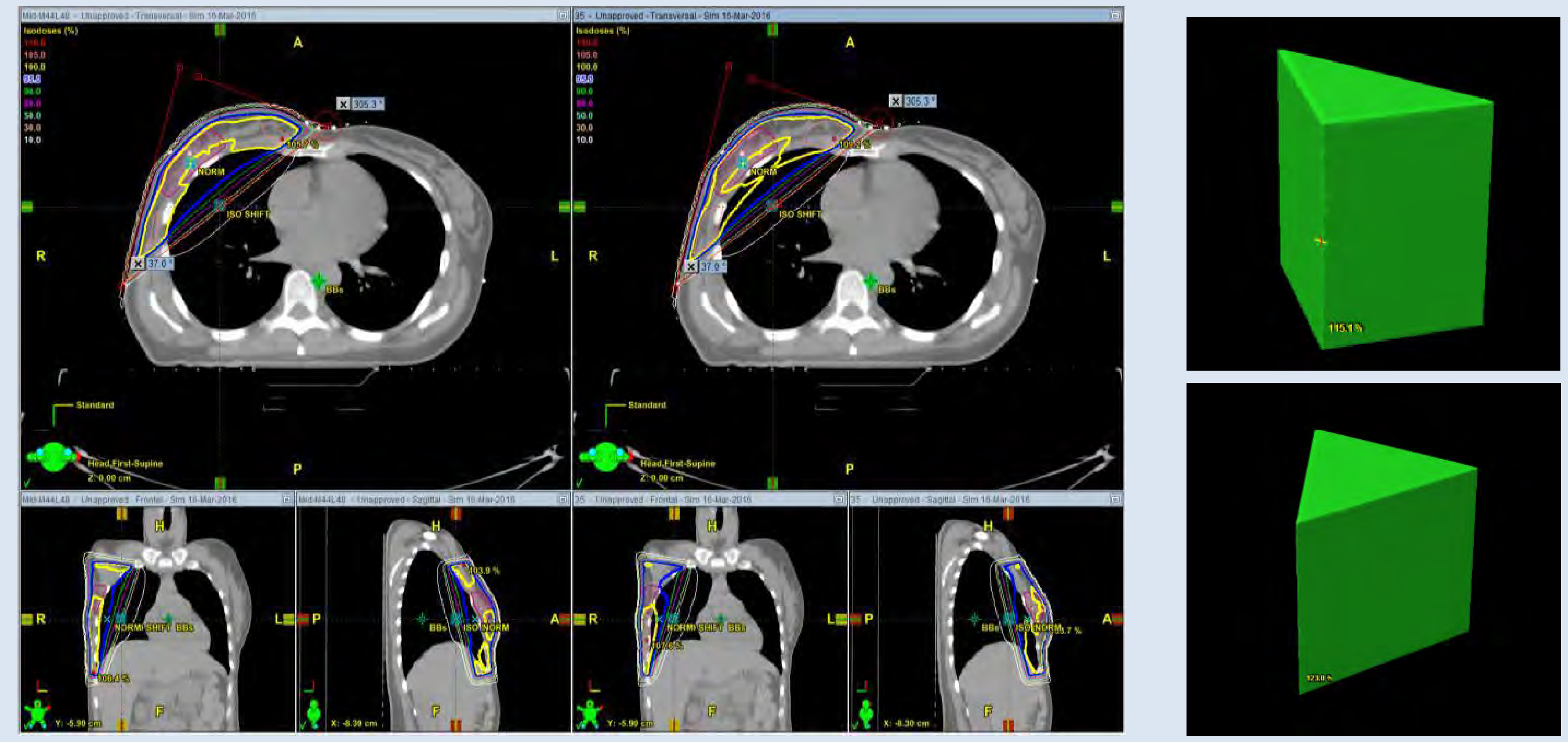

Figure 3 (above, left) is a plan evaluation between a standard and angle based TPD plan, showing how the gradient in terms of angle were measured for each the medial and lateral fields. Figure 3 (above, right) displays two of the triangular water phantoms created (45 top, 65 below).

Results

- The maximum dose for each section, dose mean and homogeneity index within the irradiated breast volume were analyzed.
- For the ten patients studied, the angle based TPD technique yielded a lower average dose maximum of 103.6% within the irradiated volume than the standard TPD technique, which gave an average dose maximum of 105.2%.
- The clinical target volume (CTV) received an average minimum and a mean dose of 95.8% and 101% respectively with the angles based technique, where as the standard technique yielded a minimum and a mean dose of 95.7% and 100.9% respectively.
- The angled based technique also yielded lower HI value of 7.6 than the standard technique (HI value of 9.5), indicating that the angle based technique provided better homogeneous plans than the standard technique.

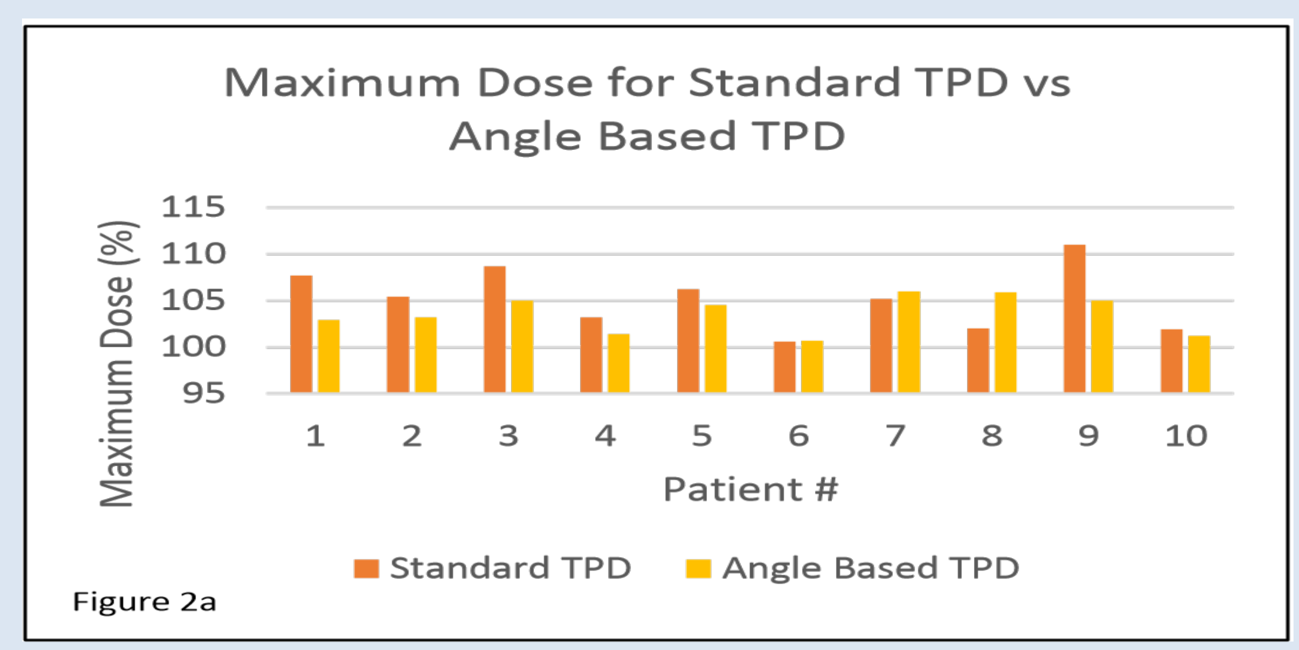

Figure 2a

Figure 2a (left), graphs the maximum dose for each the standard TPD and the angle based TPD for each of the ten patients. Nine of the ten patients showed the angle based TPD to have a lower dose maximum. The average dose maximum across the ten patients was 103.58 for the angle based TPD and 105.19% for the standard TPD. It is also important to note that the hotspots for the angle based TPD were seen at different locations for each slice, indicating a better dose distribution..

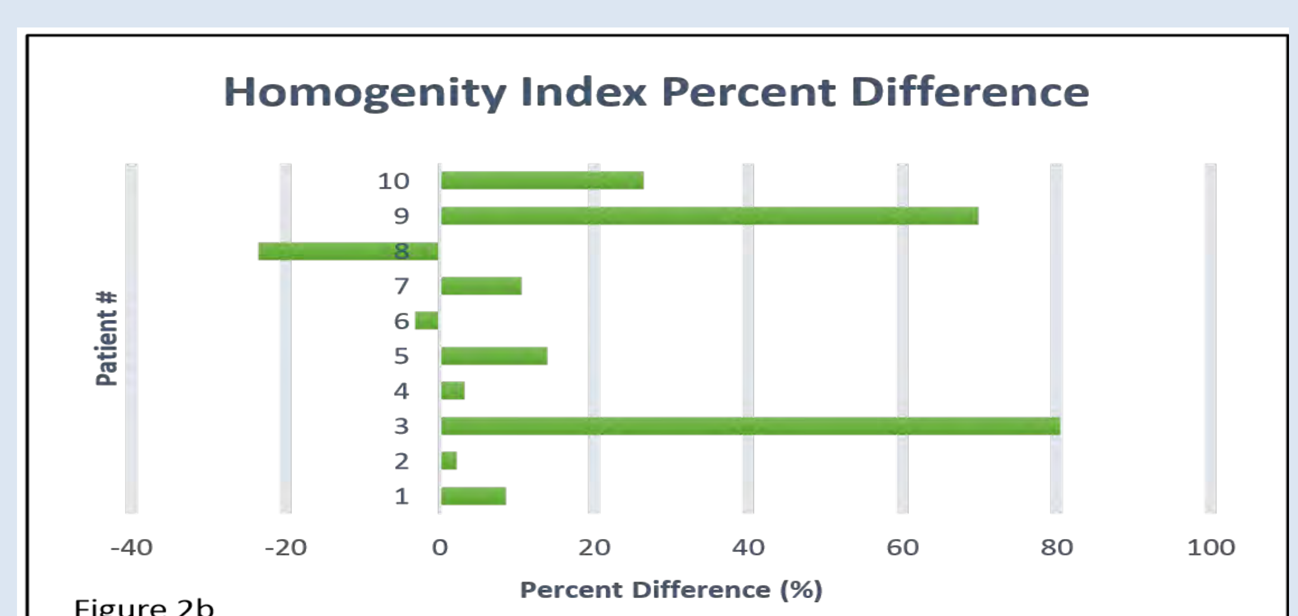

Figure 2b

Figure 2b (left), is a cluster bar graph, shows the homogeneity index percent difference between of the target structure for the standard and angle based TPD plans for each patient. Homogeneity index was used to analyze the uniformity of dose distribution in the target volume and was calculated by subtracting the dmin from the dmax and dividing by the dmax. The percent difference for standard and angle based were then calculated. Eight of the ten patients showed the angle based plan to have a more homogenous dose distribution

Summative Statement

- The optimal transmission penetration depth (TPD), when using irregular surface compensators for breast is selected by analyzing the variation of the breast anatomy in 3-D.