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Original Report

Clinical evaluation of interfractional variations for whole breast radiotherapy using 3-dimensional surface imaging

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Abstract

Purpose: To evaluate the impact of 3-dimensional (3D) surface imaging on daily patient setup for breast radiotherapy.

Materials and Methods: Fifty patients undergoing treatment for whole breast radiotherapy were setup daily using an AlignRT system (VisionRT, London, UK) for 3D surface-based alignment. Daily alignments were performed against a reference surface topogram and shifts from skin marks were recorded daily. This investigation evaluated the following: (1) the performance of the surface-based imaging system for daily breast alignment; (2) the absolute displacements between setup with skin marks and setup with the surface-based imaging system; and (3) the dosimetric effect of daily alignments with skin marks versus surface-based alignments.

Results: Displacements from 1258 treatment fractions were analyzed. Sixty percent of those fractions (749) were reviewed against MV portal imaging in order to assess the performance of the AlignRT system. Daily setup errors were given as absolute displacements, comparing setup marks against shifts determined using the surface-based imaging system. Averaged over all patients, the mean displacements were 4.1 ± 2.6 mm, 2.7 ± 1.4 mm, and 2.6 ± 1.2 mm in the anteroposterior (AP), superoinferior (S/I), and left-right (L/R) directions, respectively. Furthermore, the standard deviation of the random error (σ) was 3.2 mm, 2.2 mm, and 2.2 mm in the A/P, S/I, and L/R directions, respectively.

Conclusions: Daily alignment with 3D surface imaging was found to be valuable for reducing setup errors when comparing with patient alignment from skin marks. The result of the surface-based alignments specifically showed that alignment with skin marks was noticeably poor in the anteroposterior directions. The overall dosimetric effect of the interfractional variations was small, but these variations showed a potential for increased dose deposition to both the heart and lung tissues. Although these interfractional variations would not negatively affect the quality of patient care for whole breast radiotherapy, it may require an increase in PTV margin, especially in cases of partial breast irradiation.

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Conflicts of interest: None.

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Introduction

With an increasing number of studies comparing standard fractionation versus hypofractionated whole breast (WBRT) radiotherapy techniques,[1-3] increasing focus has been placed on image-guided radiation therapy (IGRT) to account for interfraction motion in patients treated for breast cancer. In comparison with the numerous IGRT techniques used in partial breast irradiation (PBI), the historical standard for patient setup with WBRT has been alignment with lasers and skin marks and weekly electronic portal image verifications.[4,5] Our study aims to evaluate whether standard-fractionated WBRT could be improved with better alignment techniques or are our current conventional alignment techniques sufficient for whole breast radiotherapy. With respect to standard-fractionated WBRT, treatment of the target volume is less sensitive to small errors in patient alignment in comparison with PBI, where the target volume is limited to the lumpectomy resection site plus an appropriate margin.[1,6] However, with WBRT, alignment errors still should be reduced to avoid toxicity from excessive irradiation primarily to normal lung and cardiac tissues.[2]

The need for greater accuracy with WBRT and PBI has contributed to technological advances in reducing interfractional variations with patient setup for breast radiotherapy. Numerous investigations have reported on various methods for 3D surface imaging in radiation therapy.[7-10] This investigation focuses on one of those IGRT advancements, 3D surface-based imaging with the AlignRT system (VisionRT, London, UK). The details of this system have been previously described in greater depths.[6,11-14] More specifically, several publications have reported on the use of the AlignRT system for partial breast irradiation.[6,9,12,14,15] Bert et al[12] conducted one of the early investigations on the clinical performance of the AlignRT system for 9 PBI patients over 53 fractions. Our investigation is similar to the study by Bert et al in that we evaluate the patient alignment procedure with surface imaging against lasers and skin marks. Gierga et al[6] further quantified the performance of 3D surface imaging for PBI through evaluations of target registration errors on 12 patients using implanted breast clips as their "ground truth" for patient alignment. More recently, Chang et al[14] evaluated surface alignments on 23 PBI patients using kV X-rays and the centroid of implanted clips as their reference standard. In order to measure the interfraction motion and understand the dosimetric effects on our conventional technique for WBRT patient alignment at our institution, this investigation reviewed alignments with WBRT patients using 3D surface imaging versus our current technique of alignment with lasers and skin marks and megavoltage (MV) portal imaging. We examined daily impact of 3D surface-based imaging by using clinician review of MV portal imaging after surface-based alignments as our "ground truth" for 1258 treatment fractions. The aim of this investigation was to evaluate the following: (1) the daily clinical performance of the AlignRT system for breast alignment; (2) the absolute displacements between setup with lasers and skin marks and setup with the 3D surface-based imaging system; and (3) the dosimetric effect of daily alignments with skin marks versus 3D surface-based alignments for WBRT patients.

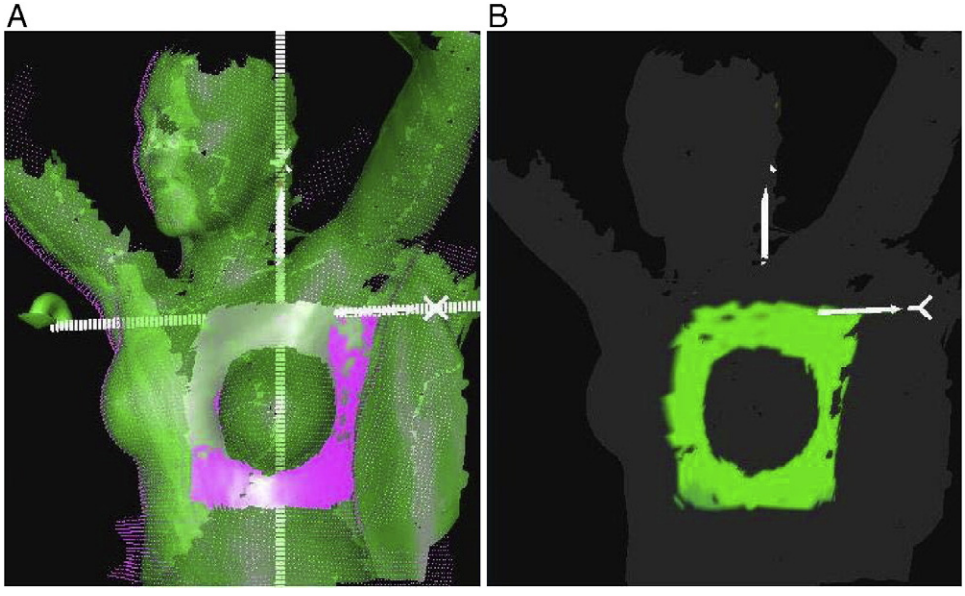

Figure 1 Examples of AlignRT reference and verification surface images: (A) reference (pink) and verification surface (green) daily registration and (B) the registered region of interest within 2 mm of the reference surface after registration.