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EFFECT OF LUMPECTOMY CAVITY VOLUME CHANGE ON THE CLINICAL TARGET VOLUME FOR ACCELERATED PARTIAL BREAST IRRADIATION: A DEFORMABLE REGISTRATION STUDY

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Purpose: Previous studies have shown that lumpectomy cavity volumes can change significantly in the weeks following surgery. The effect of this volume change on the surrounding tissue that constitutes the clinical target volume (CTV) for accelerated partial breast irradiation and boost treatment after whole breast irradiation has not been previously studied. In the present study, we used deformable registration to estimate the effect of lumpectomy cavity volume changes on the CTV for accelerated partial breast irradiation and discuss the implications for target construction.

Methods and Materials: The data from 13 accelerated partial breast irradiation patients were retrospectively analyzed. Deformable registration was used to propagate contours from the initial planning computed tomography scan to a later computed tomography scan acquired at the start of treatment. The changes in cavity volume and CTV, distance between cavity and CTV contours (*i.e.,* CTV margin), and CTV localization error after cavity registration were determined.

Results: The mean ± standard deviation change in cavity volume and CTV between the two computed tomography scans was −35% ± 23% and −14% ± 12%, respectively. An increase in the cavity-to-CTV margin of 2 ± 2 mm was required to encompass the CTV, and this increase correlated with the cavity volume change. Because changes in the cavity and CTV were not identical, a localization error of 2–3 mm in the CTV center of mass occurred when the cavity was used as the reference for image guidance.

Conclusion: Deformable registration suggested that CTV margins do not remain constant as the cavity volume changes. This finding has implications for planning target volume and CTV construction. © 2010 Elsevier Inc.

Partial breast irradiation, boost irradiation, clinical target volume, lumpectomy cavity, image guidance.

INTRODUCTION

The lumpectomy cavity is used as the basis for the clinical target volume (CTV) in external beam accelerated partial breast irradiation (APBI) and boosts after whole breast irradiation. During CTV definition, a uniform margin is generally applied to the cavity. The same margin is typically used even when a patient has undergone repeat simulation and a new CTV has been defined. Numerous recent studies have shown that the lumpectomy cavity volumes can change significantly in the weeks after surgery when radiotherapy planning and treatment normally occur (1–17). In most cases, the cavity has been observed to shrink. Therefore, repeat simulation without changing the CTV margin would be expected to result in a smaller treatment volume, which is desirable and an argument for late or repeat simulation (1–2, 4, 8, 10, 11, 13, 16, 17).

However, with the exception of a few balloon brachytherapy studies (18, 19), the effect of cavity changes on the volume of the surrounding tissue constituting the CTV has not been evaluated. In particular, the appropriateness of using the same CTV margin at different times for a given patient has not been validated. In the present study, we used deformable registration to estimate the change in the CTV between planning and the start of treatment for APBI patients, related these changes to the observed cavity changes, and considered the implications for CTV definition and image guidance.

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Conflict of interest: none.

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METHODS AND MATERIALS

The data from 13 APBI patients with two computed tomography (CT) scans each were retrospectively analyzed. For each patient, the earlier CT scan, acquired a median of 30 days (range, 4–98) after lumpectomy, had been used for treatment planning and contained contours for the breast, cavity, and CTV. Cavity contours were manually drawn by a physician. The CTV contours were generated by uniformly expanding the cavity contour, except at the limits of the chest wall and 5 mm from the skin surface (Fig. 1A). The cavity-to-CTV expansion was 10 mm for 4 patients and 15 mm for 9. Breast contours were created according to the definition established by Section 2.0 of Appendix F of the National Surgical Adjuvant Breast and Bowel Project B-39/Radiation Therapy Oncology Group 0413 protocol (20).

For each patient, a second CT scan had been acquired on the first day of treatment, a mean of 22 ± 8 days after the initial CT scan. An in-house, grayscale-based deformable registration program was used to propagate the contours to this CT scan from the initial planning CT scan (Fig. 1B). The propagated CTV contour obtained using deformable registration will be referred to as the ''variable-margin CTV.'' An additional, alternative CTV was generated on the later CT scan using the same procedure used in the original plan (*i.e.,* uniform expansion of the cavity by 10 or 15 mm except as limited by the chest wall and 5 mm from the skin surface; Fig. 1C). This structure will be referred to as the ''fixed-margin CTV,'' because the same margin was used, independent of time. The paired Wilcoxon signed rank test was used to determine whether the volumes of the variable-margin and fixed-margin CTVs were significantly different from each other. The amount of cavity margin required to cover >99% of the variable-margin CTV was also determined. We chose 99% coverage, rather than 100%, to moderate the effect of the relatively greater ''noise'' in the variable-margin CTV boundary (Fig. 1B) created by the deformable registration program. Otherwise, for example, even no net change in the position of a CTV boundary could result in an apparent margin increase, because of the contour's increased jaggedness, if 100% coverage were used as the standard for margin definition.

The deformable registration software used in the present study has been previously characterized (21). In that study, discrepancies between manually drawn and automatically generated contours in the head-and-neck region were mostly within 3 mm. Because internal breast structure has relatively low image contrast, software parameters were adjusted to narrow the image intensity ''window''

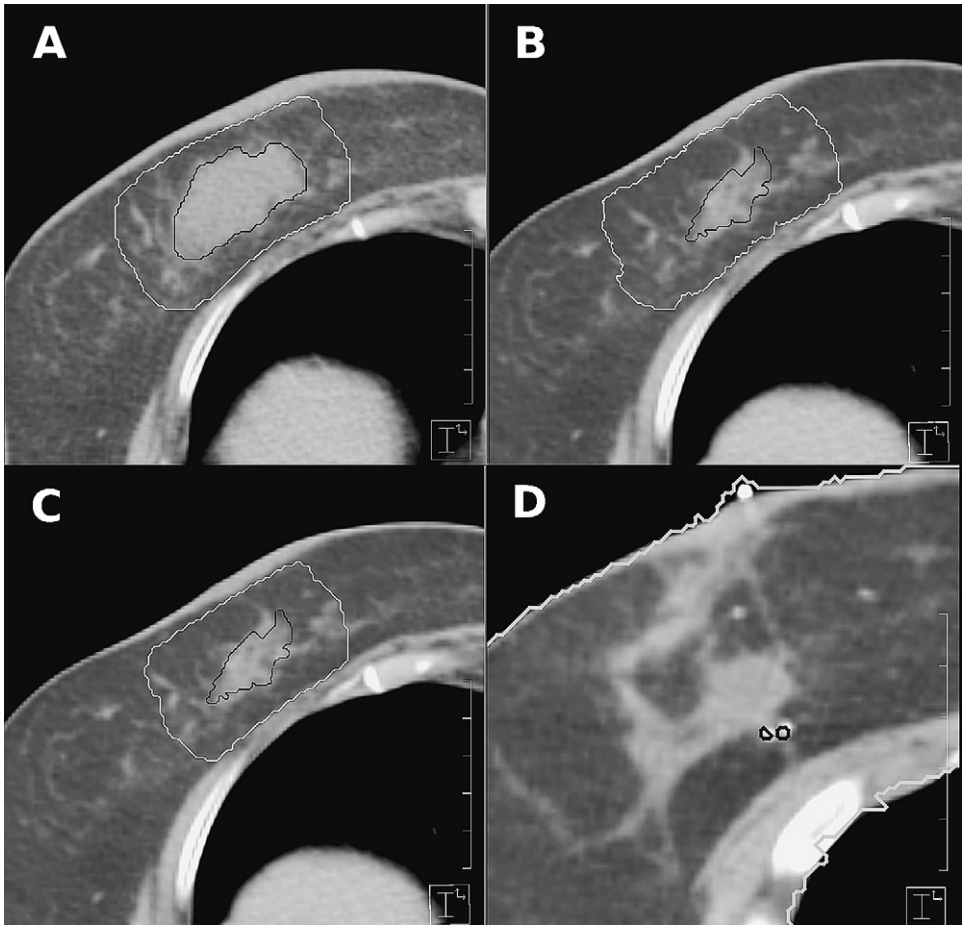

Fig. 1. (A) Initial computed tomography (CT) scan with original, clinically used contours. (B) Later CT scan with cavity and clinical target volume (CTV) contours propagated from initial CT scan using deformable registration. (C) Same, later CT scan with alternative, manually generated CTV contour created using same procedure as used in planning, with uniform expansion of cavity by 10 or 15 mm, except where limited by chest wall and 5 mm from skin surface. (D) Later CT scan from different patient showing structures used for visual evaluation of deformable registration (skin surface, chest wall, and surgical clips, when present). Visible discrepancies between contours and images were approximately 1 mm. Seroma contour and CTV contour (vis-à-vis nearby heterogeneities) were also used for these evaluations (Fig. 1A, B).