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Improvement of consistency in delineating breast lumpectomy cavity using surgical clips

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ARTICLE INFO

Article history:

Received 29 January 2017

Received in revised form

12 July 2017

Accepted 21 July 2017

Keywords:

Surgical clips

Lumpectomy

Whole breast radiation

Breast cancer

Lumpectomy cavity delineation

ABSTRACT

Background: Delineation of lumpectomy cavity for whole breast radiation therapy after breast conserving surgery can be challenging because of poor visualization of the cavity. The use of surgical clips on lumpectomy cavity walls has been suggested as an effective and low-cost method to improve the accuracy and consistency of lumpectomy cavity delineation.

Materials and methods: Twenty-three eligible female breast cancer patients who were treated with lumpectomy and adjuvant radiation therapy were recruited for this study. During breast conserving surgery, four surgical clips were placed on the superior, inferior, lateral, and medial walls of the lumpectomy cavity. Patients were imaged prior and during radiation treatment. Software was developed to anonymize the image sets and digitally remove the clips from the computed tomography images. Three radiation oncologists contoured the lumpectomy cavity volume, with and without presence of clips. Contoured image sets were analyzed with regard to cavity volume, dimensions, and concordance index. Statistical analysis was performed using a paired t-test.

Results: The presence of clips significantly increased the average lumpectomy cavity volumes from 23.50 cc to 26.42 cc ($P < 0.0001$). The presence of clips also significantly increased the mean craniocaudal, anteroposterior, and mediolateral dimensions by 6.8, 2.3, and 2.9 mm, respectively (all $P < 0.01$). In addition, the presence of surgical clips improved the consistency in delineation in CC dimension by significantly decreasing the standard deviation ($P < 0.006$).

Conclusions: The presence of surgical clips improves the accuracy of lumpectomy cavity delineation. However, consistency is only improved in CC dimension.

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Introduction

The current standard of care for early stage breast cancer includes a combination of breast-conserving surgery and adjuvant whole breast external beam radiation therapy. This treatment protocol has been shown to have a similar survival

rate to mastectomy, while providing better cosmetic outcome.^{1–3} However, poor visualization of lumpectomy cavity on treatment planning computed tomography (CT) imaging and a lack of a valid guideline for defining the tumor bed results in a lack of consistency among radiation oncologists in contouring the lumpectomy cavity.^{4,5} It has been

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 0022-4804/\$ – see front matter © 2017 Elsevier Inc. All rights reserved.
<http://dx.doi.org/10.1016/j.jss.2017.07.033>

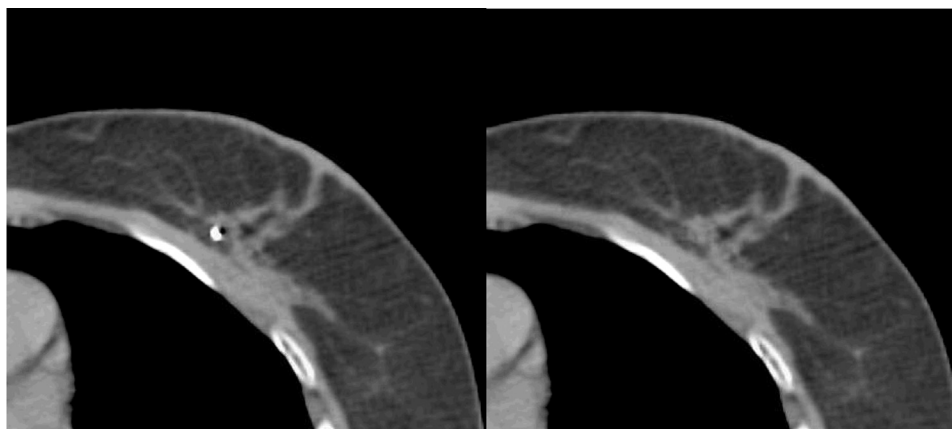


Fig. 1 – Axial CT slices showing surgical clip (left) and corresponding image after patch-based texture synthesis (right).

demonstrated by several retrospective studies that most local recurrences after whole breast irradiation occur at or adjacent to the tumor bed.^{2,6-10} It has also been shown in two randomized trials that a radiotherapy boost to the tumor bed after whole breast radiation significantly reduces the risk of local recurrences.^{11,12} Evidently, an accurate localization of the tumor bed is essential to minimize the chances of local recurrence and to spare uninvolved surrounding tissues. Placement of surgical clips on the lumpectomy cavity walls at the time of surgery is a low-cost and quick procedure that could potentially improve the accuracy of radiation treatment planning. The purpose of our study was to investigate the effects of intraoperatively placed surgical clips on the accuracy and interobserver consistency of lumpectomy cavity delineation using the complete CT image set from each individual participant, with and without the appearance of the surgical clips. Multiple studies have examined the effects of the placement of surgical clips in lumpectomy cavity delineation^{5,13-20}; however, our study is distinguished by the fact that the delineation of the lumpectomy cavity is performed in the presence and absence of the clips on the same CT image

series. This provides a novel and direct examination of the effects of surgical clip placement in contouring the tumor bed.

Materials and methods

For the purpose of this study, 23 patients with breast cancer who underwent lumpectomy were recruited from July 2010 to December 2011. All patients received the standard treatment except for the addition of surgical clips placement and an extra CT scan during the whole breast radiation treatment. All patients had the same follow-up as in the standard treatment protocol. All participants signed an informed consent form after meeting with the principal investigator and reviewing the details of the study. The study was approved by the Capital Health District Authority Ethics Committee to meet the criteria for clinical research. Patients who had undergone chemotherapy before radiation, had a body mass index >35 kg/m², or had experienced significant postoperative complications, such as infection, were excluded from the study.

All participating patients underwent a lumpectomy procedure with medium titanium surgical clips (Teleflex, PA) placed on the lateral, superior, inferior, and medial walls of the cavity by two participating surgeons. All patients also underwent two CT imaging sessions; the first CT was performed before the whole breast radiation therapy and the second CT simulation was performed between the 11th and the 13th fraction of radiation therapy. By performing a second CT simulation, we were able to double the size of our image sets and also observe any changes in seroma size over time. All CT images were then anonymized, and the regions of interest on the images were restricted to the affected breast, to remove any patient identifiable anatomical indications. An in-house developed software package was then used to digitally remove all four clips from each CT image set using a patch-based texture synthesis.²¹ This method allowed the clips to be removed without distorting the CT images or leaving conspicuous artifacts. All image processing was performed by a single operator, and all the images were reviewed by the principal investigator to ensure that no remnants of the clips or artifacts were recognizable on the images. Figure 1 depicts an example of axial CT image before and after removal of clip.

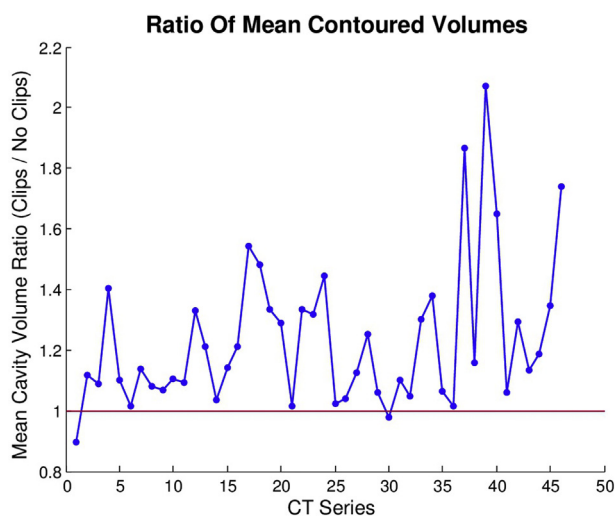


Fig. 2 – Ratio of mean cavity volumes for each CT series. (Color version of figure is available online.)

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