Utility of a 3-Dimensional Bioabsorbable Marker in Delineating the Lumpectomy Cavity

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Abstract

Background: Advanced methods of external beam radiotherapy are not widely used to deliver post-operative treatment for breast cancer due to difficulty in defining the target region surrounding the surgical cavity. Common targeting methods utilize surgical clips and/or seroma based tissue changes. However, these methods can result in overestimation of treatment volumes resulting in undesirable radiation exposure to adjacent normal tissues. In addition, these techniques fall short of the required precision necessary to utilize newer methods of radiation delivery. In order to assess its ability to assist with identification of the surgical excision site, we evaluated a 3-dimensional tissue marker surgically placed during partial mastectomy.

Methods: A total of 36 patients were implanted with a 3-D bioabsorbable tissue marker at the time of partial mastectomy. Post-operative CT simulation studies, and treatment plans were generated and compared. The tissue marker was rated for its utility in defining the target area for treatment planning as well as day to day patient positioning between fractions. Most patients received standard whole breast irradiation with a boost to the tumor bed as treatment, however advanced techniques were used in selected cases.

Results: The marker was easy to use with standard surgical techniques. No complications were reported and it was consistently and easily visualized with clinical imaging allowing it to be readily incorporated into standard and advanced planning methods. The marker had appreciable benefits when designing optimal treatment plans, particularly when no seroma fluid remained. In these cases, the marker identified the surgical site that could not have been identified using traditional methods, and target volumes were decreased by >40% in most cases. In addition, the device assisted with image-based tracking of the lumpectomy cavity during respiratory motion (4-D CT) enabling use of IGRT.

Conclusions: The BioZorb tissue marker provided a consistent method for identifying the lumpectomy site and was a useful tool for post-operative radiotherapy and clinical followup. In addition, it provided a novel method of marking the lumpectomy cavity when using oncoplastic techniques.

Background

Clinicians involved in the multidisciplinary care of breast cancer patients recognize ongoing difficulties in precisely identifying the area of tumor resection following surgery. This seemingly simple issue is critical in defining the target area for adjuvant radiation therapy, and the literature clearly illustrates high variability among radiation oncologists in determining the target volume for post-lumpectomy radiation. Adjuvant radiation is delivered in order to reduce the risk of local recurrence, which in most cases, occurs at the original site of the excised tumor.

Common targeting methods include placement of surgical clips during lumpectomy, use of external anatomic landmarks and/or use of tissue changes such as seroma formation in the region of surgery. However, these methods are imprecise as they do not accurately define the margin that requires post-operative radiation—the surgical margin of the tumor bed.

Each of these methods has well documented limitations. For example, surgical clips are randomly placed, they act as point sources (cannot define a volume), are difficult to differentiate from vascular clips and most importantly, they can migrate to an erroneous location distant from the tumor site requiring treatment. Often, surgeons forget to place clips altogether and no identifiers are located in the tumor bed. When this occurs, radiation oncologists try to utilize tissue changes (referred to as “seroma-based methods”) within the tumor bed. However, these techniques often overestimate the planned treatment volume because the seroma can extravasate into surrounding glandular tissue. In other cases, the tumor
bed is “closed” with glandular tissue flaps or oncoplastic techniques thereby minimizing or eliminating the presence of seroma fluid making targeting with this method highly variable. The least accurate method of targeting relies on anatomic landmarks which have little correlation to the area that actually requires treatment. These issues in breast tissue targeting for adjuvant radiation treatment are important for several reasons including the following:

- Radiation treatment volumes are typically overestimated due to target uncertainty
- Inability to use RT approaches that are commonly used for other cancers
- Difficulty in patient positioning during daily treatment
- Difficulty in tracking a mobile target during radiation treatment
- Limited eligibility for existing advanced/accelerated RT protocols due to dose constraints.

Most importantly, surgeons and radiation oncologists recognize there is currently no standardized method for marking the lumpectomy cavity for post-operative identification needed for adjuvant treatment planning and long-term clinical followup. For these reasons, we evaluated a novel 3-dimensional tissue marker that is surgically placed during partial mastectomy.

**Materials & Methods**

A total of 36 consecutive patients were selected for implantation with the 3-D tissue marker (BioZorb™-Focal Therapeutics, Portola Valley, CA) at the time of partial mastectomy (PM/BCS/lumpectomy). All patients received pre-operative workup including mammography, MRI and ultrasound examination, and intra-operative nodal assessment was routinely performed at the time of surgery. Once excision of the tumor and surrounding margin was completed, the surgical area was irrigated with antibiotic solution (Bacitracin). At least three to four sutures of 3-0 monocryl were placed into the surrounding tissue flaps (the margins of the lumpectomy cavity) and these were held in place until a tissue marker of appropriate size was selected (Figure 1) and implanted directly into the tumor bed (Figure 2). The sutures were then individually secured to the marker following implantation, which helped to close the walls of the lumpectomy cavity, and secure the position of the tissue marker. The breasts were immobilized in a light compression dressing following surgery. A single dose of intra-operative IV antibiotics was routinely administered, as well as oral antibiotics for the one week postoperative period.

**Results**

As of this presentation, 36 patients were implanted with the 3-D tissue marker at the time of partial mastectomy. 78% of patients at our center that underwent BCS in a one year time period received the implantable 3-D marker. Of the 36 patients, 25 have completed adjuvant radiotherapy. No complications were observed in this group. Patient demographics and intra-operative information regarding the use of the 3-D marker is shown in Table 1.

One patient required re-excision for a positive margin. At the time of her second surgery, the original 3-D marker (2cm x 3cm) was replaced with a larger sized version (3cm x 3cm) in the lumpectomy cavity. The majority of patients (76%) received whole breast irradiation (WBI), where the marker was used to assist with target delineation during the boost phase of treatment. Where specifically tracked, it was found that the utility of the marker was rated to be very useful for boost planning in 80% of the cases. Moreover, the increased targeting confidence enabled by the 3-D marker led our radiation oncology team to begin employing and referring advanced and accelerated treatment methods (e.g. VMAT, 3-D conformal, interstitial brachytherapy) in 14% of our 3-D marker patients. Also, in a small random subgroup (n=5) where cavity volumes were compared with and without 3-D marker guidance, marker guidance led to >40% reduction (47%) in planned cavity treatment volume.
Table 1. Patient demographics and intraoperative information regarding the use of the 3-D tissue marker.

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<tr>
<td>Total implanted</td>
<td>37 markers</td>
<td>36 patients</td>
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<tr>
<td>Age (yrs)</td>
<td>45–83 range</td>
<td>62.8 mean</td>
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<tr>
<td>Diagnosis</td>
<td>81% IDC</td>
<td>19% DCIS</td>
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<tr>
<td>3-D marker diameter</td>
<td>49% 2 cm</td>
<td>40% 3 cm</td>
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<tr>
<td></td>
<td>09% 4 cm</td>
<td></td>
</tr>
<tr>
<td>Nodal status</td>
<td>83% negative</td>
<td>14% positive (1+)</td>
</tr>
<tr>
<td></td>
<td>03% unknown</td>
<td></td>
</tr>
<tr>
<td>Margin status</td>
<td>92% negative</td>
<td>08% positive/close</td>
</tr>
<tr>
<td>RT method (25% completed)</td>
<td>76% WBI</td>
<td>16% advanced XBRT</td>
</tr>
<tr>
<td></td>
<td>08% interstitial brachytherapy</td>
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In the treatment delivery phase, the device assisted with patient setup as various surrogates such as bony landmarks and surgical scars were effectively replaced by a marker that provided image-based tracking of the lumpectomy cavity site. The 3-D volume that delineated the lumpectomy cavity site could be tracked as needed, thus enabling the use of IGRT during treatment delivery and assisting with efficiency in daily patient positioning.

Figure 3. The 3-D tissue marker provides a standardized array of clips that are easily identified on CT scan, to assist with treatment planning and daily patient positioning. By eliminating target uncertainty, planned treatment volumes can be markedly decreased.

Figure 4 & 5. 8 month follow up of two patients following BCS, whole breast irradiation + boost (A frontal, B lateral views). Arrows indicate surgical incision and show minimal scarring as breast shape and contour are preserved.

Conclusions

We have found that the use of this new 3-dimensional tissue marker allows a standardized method for delineating the surgical bed of the lumpectomy cavity, and effectively acted as a 3-D or “volumetric” marker. In this report, the marker was used in 78% of our patients that presented consecutively for partial mastectomy. The marker minimized the uncertainties commonly encountered when using current methods for planning post-operative radiation therapy. It also provided an easy and effective method for daily patient positioning during treatment and for long term clinical follow up.

Our multidisciplinary team integrated this new tool into our routine without difficulty, and found it to be useful in improving efficiency and accuracy in the care of our patients. Furthermore, the marker enabled the use of advanced radiation treatment protocols such as accelerated partial breast and IGRT in selected patients. Future studies may help determine additional potential benefits such as cost savings that might be secondary to improved efficiencies during adjuvant radiation treatments.

References