Evaluation a Hydrogel Radiopaque Tracer for the Definition of the Target Volume for Boost or Partial Breast Radiation Therapy After Lumpectomy of Breast Cancer

Ilja Ciernik[1], Hermann Voß[2], Gunnar Lohm[1], Anton Voronin[1], Agron Bujupi[1], Fathemeh Ebrahimi[1], Maria Ganser[2] Henriette Meyer[1], und Markus Wösle[1]

[1] Radiation Oncology, City Hospital, 06847 Dessau

[2] Gynaecology and Obstetrics, City Hospital, 06847 Dessau

Introduction

After lumpectomy of a breast cancer tumor, the optimal target volume definition for external beam radiation therapy (EBRT) or the volume for partial breast irradiation (PBI) is subject to considerable inter-observer variability (1, 2). Recent data suggest, that PBI may be an appropriate time-efficient approach resulting in adequate local tumor control rates after primary surgery (3). However, while oncological final results are being awaited, late effects reported with accelerated PBI using EBRT has risen concerns regarding the cutaneous and soft tissue toxicity (4).

Materials & Methods

10mL of TraceIT® (Augmenix, Inc. Waltham, MA, USA) (Fig. 1) was installed by the surgeon after complete removal of the tumor. After wound healing, a planning CT was acquired. TraceIT® was visualized on the planning CT and expert radiation oncologists familiar with handling breast cancer target volumes were asked to contour the cavity to define the CTV, source for the PTV used for the boost.

Figure 1. TraceIT® fiducial marker (10mL).

Results

Instillation of TraceIT® during Surgery

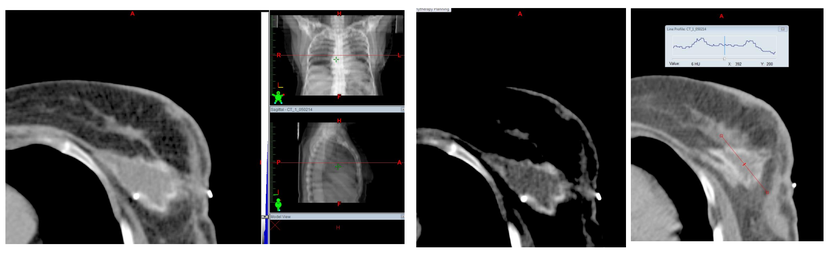


Fig. 2a *Fig. 2b* *Fig. 2c*

Figure 2. Case 1 : Instillation of 9,5 mL immediately after lumpectomy in the OR. (a) The bright spot close to the thoracic wall indicates a conventional localizer clip. (b) Gating HU = -20 to 200 highlights the tumor cavity. (c) TraceIT ® concentration is highest on the cavity boarder due to seroma foramtion after Sx.

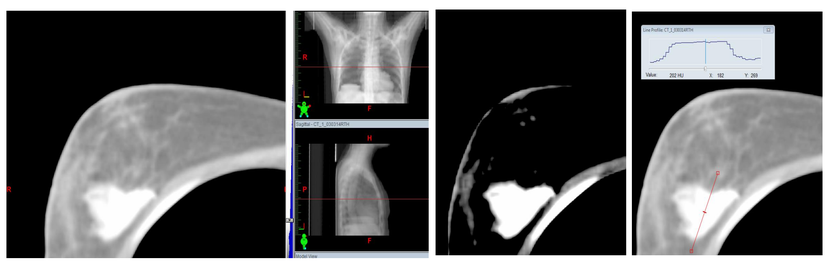


Fig. 3a *Fig. 3b* *Fig. 3c*

Figure 3. Case 2 : Instillation of 8,5 mL immediately after lumpectomy. (a) HU gating for soft tissue visualization. (b) Gating HU = -20 to 200. (c) TraceIT ® density profile.

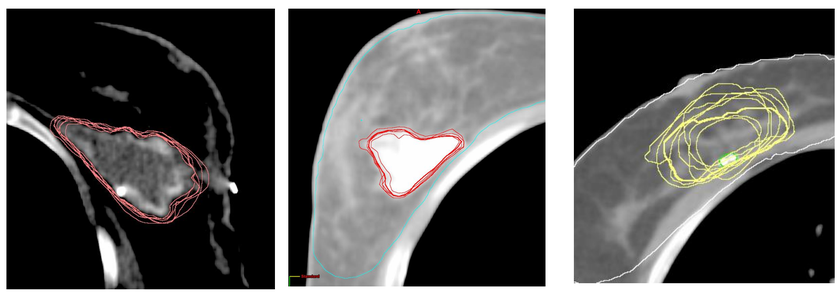
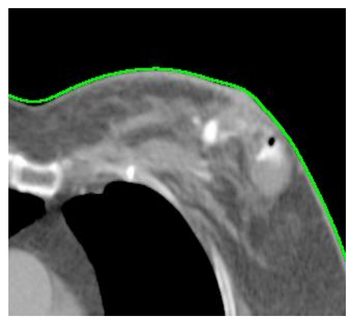


Fig. 4a *Fig. 4b* *Fig. 3c*

Figure 4. Interobserver target volume definition variability. (a) case 1, cf fig. 1 and tab. 2 (b) case 2 cf. fig. 2 and tab. 1 (c). Contouring variability without hydrogel tracer marking of the lumpectomy cavity, cf. tab 1.

Instillation of TraceIT® during Planning CT

Figure 5. Injection into the tumor cavity as visualized during planning CT. TraceIT ® is unable to indicate the dimensions of the lumpectomy cavity, probably due to seroma formation and fibrosis starting immediately after Sx.



Statistical Analysis

Table 1. CTV boost definition without TraceIT® in situ

CTV [Kürzel]	*V [cm³]*	*$CTV_x \cap CTV_{ref}$ [cm³]*	*$CTV_x \cup CTV_{ref}$ [cm³]*	*R^+ [1]*	*JI [1]*	*CN [1]*
Med1	**21,61**	**18,12**	**33,19**	**0,612**	**0,546**	**0,513**
Med2	**43,18**	**26,94**	**46,01**	**0,909**	**0,586**	**0,567**
Med5	**9,58**	**8,08**	**31,27**	**0,273**	**0,258**	**0,230**
Med3	**21,55**	**14,88**	**36,46**	**0,502**	**0,408**	**0,347**
Med6	**50,05**	**22,77**	**56,91**	**0,768**	**0,400**	**0,350**
Med4	**11,75**	**11,41**	**29,98**	**0,385**	**0,381**	**0,374**
Med7	**53,44**	**28,54**	**54,63**	**0,963**	**0,522**	**0,514**
ref	**29,63**	29,63	29,63	1,000	1,000	1,000
m	**30,17**	**18,68**	**41,21**	**0,630**	**0,443**	**0,414**
s	**18,33**	**7,77**	**11,27**	**0,262**	**0,114**	**0,121**

ref = volume of ref of a volume as defined by mean density width
m = mean without ref; **s** = SD of sample w/o ref
R+ = overlap of volume = (CTVx ∩ CTVref) / Vref
JI = Jaccard-Index = (CTVx ∩ CTVref) / (CTVx ∪ CTVref
CN = conformity index = $(CTVx \cap CTVref)^2 / (Vx \cdot Vref)$

Table 2. CTV boost definition with TraceIT® in situ

CTV [Kürzel]	*V [cm³]*	*$CTV_x \cap CTV_{ref}$ [cm³]*	*$CTV_x \cup CTV_{ref}$ [cm³]*	*R^+ [1]*	*JI [1]*	*CN [1]*
Med1	**44,83**	**36,98**	**47,79**	**0,926**	**0,774**	**0,764**
Med2	**48,26**	**35,77**	**52,53**	**0,895**	**0,681**	**0,664**
Med5	**42,00**	**36,40**	**45,49**	**0,911**	**0,800**	**0,790**
Med3	**45,95**	**37,52**	**48,37**	**0,939**	**0,776**	**0,767**
Med6	**61,92**	**39,71**	**62,08**	**0,994**	**0,640**	**0,637**
Med4	**43,87**	**36,49**	**47,33**	**0,913**	**0,771**	**0,760**
Med7	**59,36**	**39,86**	**59,38**	**0,998**	**0,671**	**0,670**
ref	**39,95**	39,95	39,95	1,000	1,000	1,000
m	**49,46**	**37,53**	**51,85**	**0,939**	**0,730**	**0,722**
s	**7,91**	**1,63**	**6,47**	**0,041**	**0,064**	**0,062**

ref = volume of ref includes voxels w/ hydrogel & signal of ≥ -5 HU
m = mean without ref; **s** = SD w/o ref
R+ = overlap of volume = (CTVx ∩ CTVref) / Vref
JI = Jaccard-Index = (CTVx ∩ CTVref) / (CTVx u CTVref
CN = conformity index = $(CTVx \cap CTVref)^2 / (Vx \cdot Vref)$

Conclusions

- Interobserver variability is low using a high contrast hydrogel for the purpose of target structure delineation.
- Standardized target volume definition may help to reduce toxicity and may improve standards in clinical trials or in daily practice.
- Reliable cavity visualization is achieved best if TraceIT® is injected immediately after lumpectomy, prior to seroma formation or fibrotic transformation.

References:

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Contact: ilja.ciernik@klinikum-dessau.de **www.klinikum-dessau.de/klinikenundinstitute/klinikfrstrahlentherapie.html**