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Evaluation of changes in excision cavity volume during whole breast irradiation using secondary CT image

A.R. Nikoofar[1,2] , Z. Falahatpour[1,3*], G.H. Hoseinzadeh[2]

[1]Parsa Radiotherapy Center, Pars Hospital, Tehran, Iran
[2]Tehran University Medical Sciences, Tehran Iran
[3]Medical Radiation Engineering of Faculty of Shahid Beheshti University, Tehran, Iran

▶ ***Original article***

**** Corresponding author:***
Dr. Zahra Falahatpour,
***Fax:** +98 21 88098058*
E-mail:
mahsa_falahat@yahoo.com

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ABSTRACT

Background: The aim of this study was to evaluate the reduction in excision cavity volume (ECV) during the whole breast radiotherapy (WBRT). The delineating of reduced cavity volume on secondary CT (computed tomography) might decrease the field size of boost plan. ***Materials and Methods*:** Twenty patients were treated having breast conservative surgery. At first, primary CT simulation (CT-1) was done prior to WBRT. Treatment planning was performed by a 3D treatment planning system. A CT-2 was performed after WBRT. Then the excision cavity was contoured on CT-1 and CT-2 for each patient. Boost irradiation was planned on both ECV-1 and ECV-2. ***Results*:** In Comparison of CT-1 and CT-2: The contoured volumes for ECV-1 and ECV-2 were on average of 42.9 $cm^3$and 23.4 cm^3, respectively ($p< 0.002$). The ECV-2 was reduced in 85% of the patients. Patients with ECV-1 greater than the mean value of ECV-1 (ECV-1> 35.5 cm^3) had more reduction in ECV-2 than patient with ECV-1 smaller than the mean value ($p < 0.000$). The volume of normal breast tissue on CT-2 was decreased from the volume of CT-1 ($p< 0.03$). ***Conclusion*:** A significant reduction in excision cavity volume was shown during WBRT. This volume reduction made smaller sizes of boost field and remaining breast received lower doses. The reduction was more significant in patient with primary large ECV. The Secondary CT for boost planning is suggested for patients with larger cavities after WBRT.

Keywords: *Excision cavity volume (ECV), secondary CT, whole breast radiotherapy (WBRT).*

INTRODUCTION

The current standard treatment for early breast cancer includes conservative surgery followed by whole breast radiation over a period of 5 to 6 weeks [1, 2]. The technique of the radiotherapy (RT) consisted of two tangential beams to the whole breast with or without a boost field applied to the tumor bed. Several studies have demonstrated the addition of a boost irradiation which enhances local control [3, 4, 5] though increases morbidity and has an unfavorable cosmetic outcome [6]. Accurate contouring of the excision cavity for boost planning is necessary, because it prevents the geometric negligence of excision cavity and also reduce unnecessary radiation dose to the adjacent part of the breast [7]. The related studies have reported that 65% to 80% of breast recurrences occur after conservative surgery and radiotherapy around the primary tumor bed [4]. Contouring of the excision cavities on CT image is performed by guidance of surgical clips placed in the excision cavity, the appearance of seroma/hematoma, apparent changes of breast tissue on a CT image, observation of MRI or mammography images before surgery and clinical information obtained from pathology reports [1].

During CT-based treatment planning, after the end of whole breast RT, the boost planning starts after 4-6 weeks by means of initial CT obtained prior to the whole breast RT. The most recent studies have demonstrated that the excision cavity volume (ECV) reduces during treatment of whole breast RT [8-12]. Therefore, if then the initial CT scan is utilized to plan for boost dose in patients with a change in the ECV during the course of RT, the delineating of tumor bed might be less accurate and remaining normal breast tissues or critical organs might receive an unnecessary dose [13]. The purpose of this study is to identify the reduction volume in the ECV during whole breast irradiation and determine any factors might affect a reduction in ECV. This reduction might reduce the received dose by the critical organs (lung, heart) and remaining breast tissue.

MATERIALS AND METHODS

Patient data

Patients data used for this study was collected at Pars Hospital, Tehran, Iran from September 2010 to December 2011. Twenty patients with early stage breast cancer underwent RT after breast conserving surgery, were enrolled in this Study. None of the patients have received chemotherapy prior to this study. Aconsent form was signed by each Patient to perform this study. The median age was 48 years (range, 26–60 years). The median body weight was 67 Kg (rang, 48-85 Kg). Two patients had pre invasive tumors (Tis), 15 had T1 tumors and 3 had T2 tumors. The clinical characteristics of the patients are listed in table 1. Patients were simulated by Siemens CT-simulator system. CT simulation of the breast was obtained in two sessions: the first CT (CT-1) was obtained 12 to 18 days after conservative surgery and before the first RT session. The second CT (CT-2) was taken after the end of RT, about 50 to 63 days after surgery. The CT slices were taken with 3 mm width. The patients were positioned supine on the breast board. Ipsilateral arm was positioned above the patient's head to be placed outside of the radiation field. Inferior and superior treatment borders were determined respectively at 1.5cm inferior to the inframammary fold and 2cm beyond the palpable breast tissue. The lateral and medial borders were determined at the midaxillary line and midsternal line [4].

Table1. Patient characteristics.

Characteristics	Number
Age (y), median (range)	48 (26-60)
Weight (kg), median	67 (48-85)
T Stage	
T*is*	2
T1	15
T2	3
Seroma/hematoma	
Yes	16
No	4
Surgical clips	
Yes	15
No	5
Passed time (d) from surgery to obtain CT-1	14(12-18)
Passed time (d) from surgery to start RT	25(21-32)
Passed time (d) from surgery to obtain CT-2	56(50-63)

The planning of ECV-1

In order to plan for whole breast RT, planning target volume (PTV) was countered on CT-1. Two tangential fields were used to cover the entire breast. The prescribed dose was 50 Gy in 25 fractions using 6MV photon beams energy. After delivering of 50 Gy to the whole breast in 5 weeks, in order to perform boost field planning, the initial excision cavity volume (ECV-1) was delineated on CT-1. Contouring was performed with the guidance of the surgical clips, the collection of fluid seroma at the tumor bed, apparent changes of breast tissue on CT scan, mammography or MRI images before surgery and clinical information obtained from pathology reports, depending on which indicated greatest volume. Fifteen patients had surgical clips, while sixteen of them had collected seroma/hematoma in their tumor bed. The ECV-1 was countered by a resident physician and confirmed by the attending radiation oncologist (figure 1). The ECV-1 was calculated by the Coreplan3D

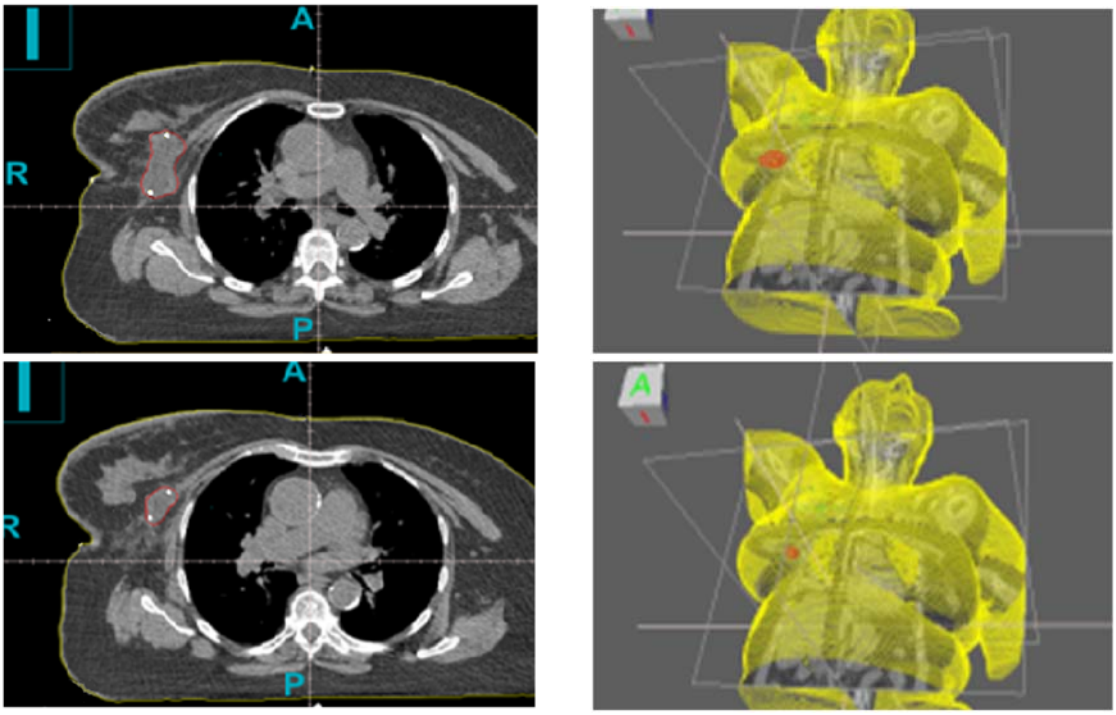

Figure 1. Delineation of the excision cavity on primary CT- scan before whole breast RT for one patient (upper figures). Delineation of the excision cavity on secondary CT- scan after whole breast RT (lower figures) for the same patient.

TPS and recorded.

The planning of ECV-2

The second CT imaging (CT-2) was performed 50–63 days after the surgery with the same setup technique for all patients. The ECV-2 on CT2 was delineated by the same resident physician and confirmed by the attending radiation oncologists who had confirmed ECV-1 (figure 1). In order to prevent bias during the time of drawing of ECV-2, the physician did not allow to refer to ECV-1 drawings.

Boost field planning

The ECVs were expanded with a 2-cm margin on both sets of plans. Then a boost field of 10 Gy using electron beam was planned on ECVs delineated based on CT-1 and CT-2. We used electron applicators with different sizes and energies. The dimensions of boost field were adjusted based on ECV-1 volume. A record of the depth from the skin surface to the anterior and posterior cavity walls in several areas was obtained to clinically determine the electron beam energy to be used. Our acceptable plans were those that covered at least 90% iso dose line of ECV. Dose-volume histograms (DVH) were generated and analyzed for adequacy of coverage for the ECV-1 and ECV-2, separately. We also used DVH to determine received dose percent by the ipsilateral lung and remaining breast volumes in both plans.

Statistical Validation

We used the Student's paired *t*-test with a two-tailed distribution to assess significant differences in the data gathered from CT-1 and CT-2. Differences were studied statistically significant at p value of ≤ 0.05.

RESULTS

The delineated ECVS on the CT-1 and CT-2 were compared for all the patients. The median volume of the ECV of using CT-1 and CT-2 were 42.9 cm^3(range, 9.8 to 103 cm3) and 23.4 cm^3 (range, 15 to 35.3 cm^3), respectively ($p < 0.002$) (figure1). There was the volume reduction in the excision cavity in 85% of patients (17/20). The median value of excision cavity decreased was 19.9 cm^3. The largest amount of change in volume was -70$cm^3$and +13 cm^3 decreasing and increasing, respectively. Patients with ECV-1 larger than the mean value of ECV-1 (ECV-1>35.5 cm^3) had more reduction in ECV-2 than patient with ECV-1 smaller than the mean value of ECV-1 (54.9% vs. 9.3%), ($p < 0.000$). The median breast volume was 1198 cm^3 (range, 345.7–3210.1 cm^3) and 1184 cm^3 (range, 336.6–3202.7 cm^3). Thus, there was no important reduction in breast volume on CT-1 and CT-2. The median time from surgery to start RT was 25 days (range, 21 to 32 days). The median time between surgery and CT-2 was 56 days (range, 50 to 63 days) (table 1).There were not significantly associated about volume reduction of the excision cavity with weight, age, T-stage and time to RT. The reduction of the ECV on CT-2 than CT-1 allowed us to use smaller sizes of boost fields; we used electron applicator 10×10 for most of the plans based on CT-1, while we utilized block to decrease size of 10×10 applicators in plans based on CT-2. The reduction of field size on CT-2 caused the ipsilateral lung receives lower dose than boost planning based on CT-1 . Also, with use of smaller sizes of boost electron field in CT-2, the volume of normal breast tissue that was being located in the electron field was decreased than CT-1 ($p<0.03$).

DISCUSSION

The results of numerous studies demonstrated thevalue of boost dose radiation in reducing the risk of local recurrence [3, 4, 14]. In order to achieve optimal local control, boost field should accurately cover the tumor bed. Traditionally small field boost delineating of ECV was performed based on location of surgical scars and apparent changes on the breast skin. Related studies reported that scar-guided boost plans, provide inaccurate or incomplete coverage of the excision cavity in the majority of cases [1, 13, 14]. Before starting of whole breast irradiation contouring of the excision cavity is applied. The ECVs are drawn with the aid of surgical clips, seroma, and surgical changes of breast tissue on CT, MRI or mammography images before surgery and clinical information obtained from pathology reports [1]. Then boost plan is performed on the ECV contoured on the initial CT while,the latest studies have reported that significant changes in ECV during the whole breast RT. According to our results, there is a potential for the volume reduction in the excision cavity before and after whole breast RT. From our data, by comparing of ECV-1 with ECV-2, median ECV was 42.9 $cm^3$and 23.4 cm^3on CT-1 and CT-2, respectively ($p <0.002$). There was the volume reduction in the excision cavity in 85% of patients (17/20). The several studies reported areduction in ECV from the first CT to the secondary one. Flannery *et al.* [9] reported a significant reduction in ECV before and after RT. Theresultsshow that the ECV decreased in 38 of 44 patients (86%) and the median ECV 38.2 cm^3on CT-1 decreased to 21.7 cm^3on CT-2. Tersteeg *et al.* [15] stated in their study a reduction of average ECV-1 from 78.$cm^3$to 29.7cm^3in ECV-2. Oh *et al.*[16] demonstrated the changes in ECV were 32.1 and 25.1 cc ($p < 0.000$), before and after 40 Gy of breast irradiation, respectively. Cho *et al.* [5] in their researches evaluated the mean and median volume reduction in the excision cavity after whole breast RT, 17.6 cm^3 and 16.1 cm^3, respectively ($p < 0.001$).

Our study represents there is an important association between size of the excision cavity on CT-1 and percent volume decrease on CT-2. Patients with ECV-1 larger >35.5 cm^3had more reduction in ECV-2 than patient with ECV-1 smaller than 35.5 cm^3($p < 0.000$) (figure 2). Flannery *et al.* [9] showed there was a significant correlation between initial ECV and percent decrease in volume ($p < 0.001$). They found that patients with ECVs> 30 cm^3in comparison with patients with ECV<30 cm^3were also more likely to have a volume reduction of >25%, >33%, and>50%: 92.0% vs. 21% ($p < 0.001$), 80% vs. 5% ($p < 0.001$), and 44% vs. 0 respectively ($p = 0.001$). They recommended an additional CT scan to be performed for patients with larger cavities (>30 cm^3). Tersteeg *et al.* [15] demonstrated that there was a linear correlation between the initial volume of the ECV-1 and the volume reduction. Hepel *et al.* [17] showed that excision cavity volume of >15

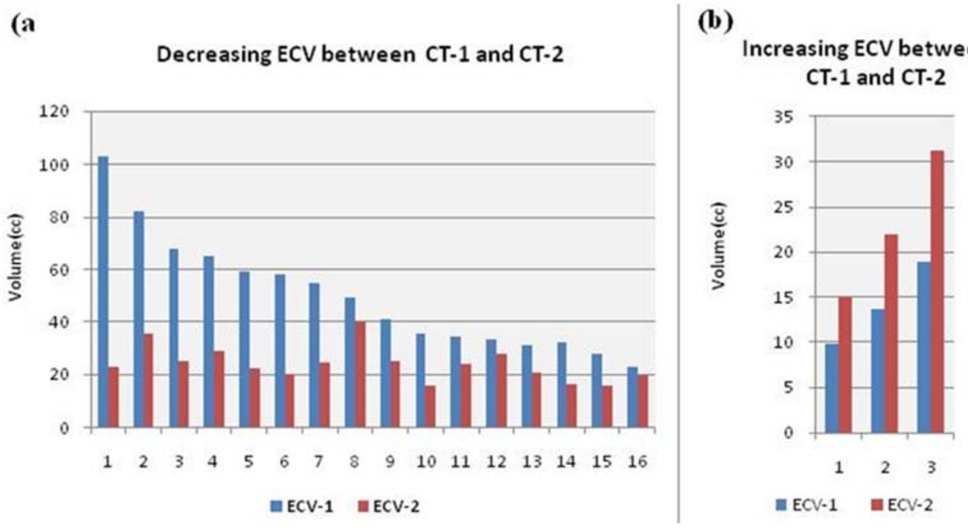

Figure 2. Comparison of change of ECV-1 (excision cavity volume- 1) primary CT-scan and ECV-2 (excision cavity volume- 2) on secondary CT- Scan for each patient: (a) decreased (b) increased.

cm3based on first CT correlated with a greater probability of a reduction in the volume. These significant reductions of the excision cavity volume explain that if the initial CT simulations are utilized for planning of boost irradiation, the remaining normal breast tissue may receive excessive doses. We could have reduced the field size of the electron boost plan in ECV based onCT-2.By means of a smaller field size, remaining normal breast tissue volume received a lower radiation dose than ECV-1 and had the less potential to create toxicity. Additionally, higher doses appear to have a negative effect cosmetic outcome on the breast skin. In some patients, the reduction in electron energy in boost plan based on ECV-2, resulted less beam penetration and the ipsilateral lung received less doses. These results emphasize that it is useful to repeat the CT simulation for patients with larger cavities.

Some studies reported correlation between time from surgery to CT-1, to start of RT, or to CT-2 and change in volume, while some others did not. Cho *et al.* [5] reported the volume reduction in the excision cavity was inversely correlated with the time from surgery to radiation therapy. Flannery *et al.* [9] found no correlation between time from surgery to first CT, to start of RT, or to second CT and change in volume. We did not find any significant correlation between time from surgery to RT and ECV reduction. Our research also explains no correlation between patient body, age, T-stage and breast volume.

CONCLUSIONS

The results of the present study showed that the patients undergoing breast conserving surgery can have a significant decrease in their ECV during the whole breast RT. This reduction is especially notable in patients with initial large ECVS. However, repeat of CT scan for boost planning might lead to increase costs, but it is suggested to consider specifically for patients with large cavities and cavities located nearby critical structures. With the use of smaller boost fields, the patients will experience better cosmetic result on the breast skin on remaining breast tissue and less lung side effects.

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REFERENCES

1. Fisher B, Anderson S, Bryant J, Margolese RG, Deutsch M, Fisher ER, Jeong JH, Wolmark N (2002) Twenty-year f ollow-up of a randomized trial comparing total mastectomy, lumpectomy, and lumpectomy plus irradiation for the treatment of invasive breast cancer. *N Engl J Med, **347:**1233-41.*
2. vanDongen JA, Voogd AC, Fentiman IS, Legrand C, Sylvester RJ, Tong D, Schueren EVD (2000) Long-term results of a randomized trial comparing breast-conserving therapy with mastectomy: European Organization for Research and Treatment of Cancer 10801 trial. *J Natl Cancer Inst, **92:**1143–1150.*
3. Bartelink H, Horiot JC, Poortmans P (2001) Recurrence rates after treatment of breast cancer with standard radiotherapy with or without additional radiation. *N Engl J Med, **345:**1378–1387.*
4. Halperin EC, Perez CA, Brady LW (2006) *Perez and Brady's Principles and Practice of Radiation Oncology, 1248-1250.*
5. Cho H and Kim C (2011)Volumetric changes in the lumpectomy cavity during whole breast irradiation after breast conserving surgery. *Korea J RadiatOncol, **29(4):**277-282.*
6. Vrieling C, Collette L, Fourquet A (1999) The influence of the boost in breast-conserving therapy on cosmetic outcome in the EORTC ''Boost versus No Boost'' trial. *Int J Radat Oncol Biol Phys, **45:** 677–685.*
7. Benda RK, Yasuda G, Sethi A, Gabram SH, Hinerman RW, Mendenhall NP (2003) Breast boost: Are we missing the target? *Cancer, **97:** 905–909.*
8. Mohiuddin MM, Nichols EM, Marter KJ (2012) Decrease of the lumpectomy cavity volume after whole-breast irradiation affects small field boost planning. *J Med Dosim, **4:** 339-343.*
9. Flannery TW, Nichols EM, Cheston SB, Marter KJ, Naqvi SH.A, Markham KM, Ali I (2009) Repeat computed tomography simulation to assess lumpectomy cavity volume during whole-breast irradiation. *Int J Radiat Oncol Biol Phys, **75:** 751-6.*
10. Bartelink H, Horiot JC, Poortmans PM, Struikmans H, Van den Bogaert W, Fourquet A, Jager JJ (2007) Impact of a higher radiation dose on local control and survival in breast-conserving therapy of early breast cancer: 10-year results of the randomized boost versus no boost EORTC 22881-10882 trial. *J Clin Oncol, **25:** 3259-65.*
11. Hurkmans C, Admiraal M, van der Sangen M, Dijkmans I (2009) Significance of breast boost volume changes during radiotherapy in relation to current clinical inter observer variations. *Radiother Oncol, **90:** 60-65.*
12. Kader HA, Truong PT, Pai R, Panades M, Jones S, Ansbacher W, Olivotto IA (2008) When Is CT-based postoperative seroma most useful to plan partial breast radiotherapy? Evaluation of clinical factors affecting seroma volume and clarity. *Int J Radiat Oncol Biol Phys, **72:**1064–1069.*
13. Bartelink H, Horiot JC, Poortmans P, Struikmans H, Van den Bogaert W, Barillot ?(2001) Recurrence rates after treatment of breast cancer with standard radiotherapy with or without additional radiation. *N Engl J Med, **345:** 1378–1387.*
14. Romestaing P, Lehingue Y, Carrie C, Coquard R, Montbarbon X, Ardiet JM, Mamelle N, Gerard R (1997) Role of a 10-Gy boost in the conservative treatment of early breast cancer: results of a randomized clinical trial in Lyons, France. *J ClinOnco l, **15:** 963–968.*
15. Tersteeg JHA, Roesnick JM, Albregts C (2007) Changes in excision cavity volume, prediction of the reduction in absolute volume during breast irradiation (Abstr.). *Int J Radiat Oncol Biol Phys, **69:** S209–S210.*
16. Oh KS, Kong FM, Griffith KA, Pierce LJ (2006) Planning the breast tumor bed boost: Changes in the excision cavity volume and surgical scar location after breast-conserving surgery and whole-breast irradiation. *Int J Radat Oncol Biol Phys, **66:** 680–686.*
17. Hepel JT, Evans SB, Hiatt JR, Price LL, DiPetrillo T, Wazer DE, MacAusland SG (2009) Planning the breast boost: comparison of three techniques and evaluation of tumor bed during treatment. *Int J Radiat Oncol Biol Phys, **74:**458-63.*