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Technical note

# Comparison of set-up errors by breast size on wing board by portal imaging☆

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ABSTRACT

*Aim:* To quantify and compare setup errors between small and large breast patients undergoing intact breast radiotherapy.

*Methods:* 20 patients were inducted. 10 small/moderate size breast in arm I and 10 large breast in arm II. Two orthogonal and one lateral tangent portal images (PIs) were obtained and analyzed for systematic ($\Sigma$) and random ($\sigma$) errors. Effect of no action level (NAL) was also evaluated retrospectively.

*Results:* 142 PIs were analyzed. $\Sigma$(mm) was 3.2 versus 6.7 ($p = 0.41$) in the mediolateral (ML) direction, 2.1 versus 2.9 ($p = 0.06$) in the craniocaudal (CC) and 2.2 versus 3.6 ($p = 0.08$) in the anteroposterior (AP) direction in small and large breast, respectively. $\sigma$(mm) was 3.0, 3.3 and 3.3 for small breast and 4.1, 3.7 and 3.2 for large breast in the ML, CC and AP direction ($p = 0.07$, 0.86, 0.37), respectively. 3 D $\Sigma$(mm) was 2.7 versus 4.2 ($p = 0.01$) and $\sigma$(mm) was 2.5 versus 3.2 ($p = 0.14$) in arm I and II, respectively. The standard deviation (SD) of variations (mm) in breast contour depicted by central lung distance (CLD) was 5.9 versus 7.4 ($p < 0.001$), central flash distance (CFD) 6.6 versus 10.5 ($p = 0.002$), inferior central margin (ICM) 4 versus 4.9 ($p < 0.001$) in arm I and II, respectively. NAL showed a significant reduction of systematic error in large breast in the mediolateral direction only.

*Conclusion:* Wing board can be used in a busy radiotherapy department for setting up breast patients with a margin of 1.1 cm, 0.76 cm and 0.71 cm for small breasts and 1.96 cm, 1.12 cm and 0.98 cm for large breast in the ML, AP and CC directions, respectively. The large PTV margin in the mediolateral direction in large breast can be reduced using NAL. Further research is needed to optimize positioning of large breasted women.



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## 1. Introduction

Setup errors, though undesirable are an inherent part of radiation delivery. Coverage of target volume is a direct function of setup margins. Use of portal imaging to measure setup errors is an accepted standard practice. It is recommended that every institution should generate data on its set-up accuracy without blindly adopting published margin recipes. Radiotherapy in pendulous breasts is an area of concern as the breast tends to wrap around the chest wall resulting in increased dose to the adjacent normal tissues such as the ribs, heart and lung. These patients have been studied by breast immobilization using cast, tape, rings or a breast bridge to reduce its mobility by pushing it upright.[1,2] These methods are still an area of active research. Treating patients with pendulous breast in prone position reduces lung, cardiac and contralateral breast doses by enabling the breast to fall away from the chest wall and allows a more even dose distribution throughout the breast.[2,3] But it adds to the difficulties for the patient in mounting on the treatment table, the discomfort of lying prone on a hard surface and the inability to add an electron boost with plan summation. Also tumours near the chest wall, towards the medial or lateral side or with nodal irradiation are a relative contraindication for prone positioning. In patients presenting in locally advanced stage comprehensive loco regional irradiation is mandatory and the target volume in conserved breast usually touches the chest wall.[4]

The standard practise for intact breast radiotherapy by tangential beams on breast board is to keep a 2 cm margin for central flash distance, 1 cm for inferior central distance and less than 2 cm for central lung distance. For irradiation of tumour bed by boost, a CTV to PTV margin of 1 cm is recommended. Positioning of patients on a breast board is time consuming. It is in this context that this prospective study was planned in our department to estimate and compare set-up errors in small and large breasts on a wing board.

### 1.1. *Aims and objectives*

The aim of this study was to compare relocation of chest and the breast silhouette between small and large breast patients as determined by PIs and to derive margins and evaluate the effect of NAL.

## 2. Material and methods

20 patients suitable for intact breast radiotherapy, registered in our department between November 2009 and September 2011, were inducted in this study after obtaining clearance from the institute's ethical committee. They were allocated into two arms based on the following selection criteria: Arm I: small or moderate size breast and, Arm II: large breast. Breasts with infra-mammary fold of more than or equal to 2 cm or falling laterally beyond the mid-axillary line, brassiere size larger than or equal to 40, cup size larger than or equal to D, tangential separation of more than or equal to 21 cm and or weight of woman bigger than or equal to 80 kg were included in Arm II.[5]

### 2.1. *RT technique*

Immobilization and simulation: Patients were positioned supine on a wing board on a comfortable neck rest (Fig. 1). The clinically evident palpable breast tissue after BCS (i.e. the Clinical Target Volume) and the incision mark were marked with a copper wire prior to the acquisition of a non contrast enhanced radiation treatment planning CT scan (RTP scan) with a slice thickness of 3 mm. Anterior and lateral reference marks were tattooed at the level of xiphisternum. 4D-CT was not acquired due to the lack of this facility and we did not intend to evaluate voluntary breath-hold at this stage.

### 2.2. *Treatment planning and virtual simulation*

The ipsilateral and contralateral breast, boost volume, heart, lungs and trachea were delineated. Treatment planning was done with 6 MV X-ray photons to a dose of 50 Gy in 25 fractions in 5 weeks to the whole breast which was followed by a sequential boost to the tumour bed to a dose of 16 Gy in 8 fractions. Treatment was delivered on a linear accelerator (Clinac CL600C). In both groups, a single isocentric technique was used to irradiate the supraclavicular region (SCF) and or axilla with a direct anterior field (depending on risk factors) and the intact breast with medial and lateral tangents fields. The isocentre was placed at the level of clavicle (T3 vertebra) with required *X* and *Z* movements which enabled a suitable tangent angle to encompass the CTV. The 3D conformal treatment plan was performed in consistency with the ICRU

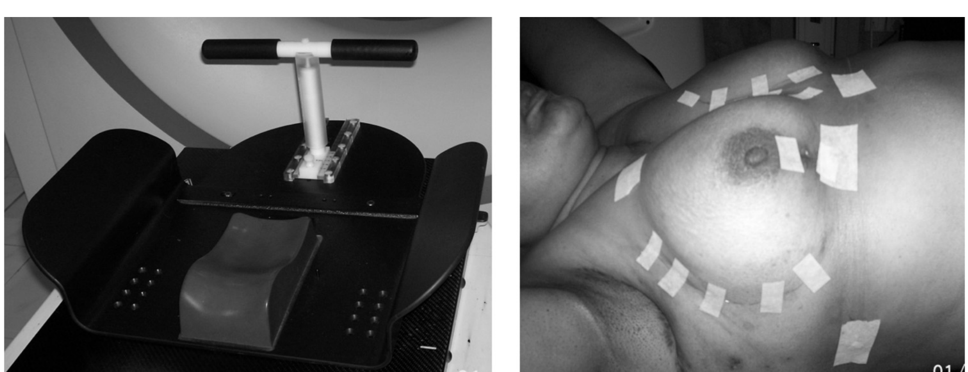

**Fig. 1 – Wing board (left) and placement of makers before RTP CT scan (right).**

(International Committee of Radiation Units and measurements) 50 and ICRU 62 guidelines.[6,7] A DRR was generated for anterior, lateral and tangential fields.

### 2.3. Portal imaging

PIs were obtained using an amorphous silicon electronic portal imaging device (EPID aSi-500-II) at a distance of 50 cm from the isocentre on the 1st, 3rd, 5th, 10th, 15th, 20th and 24th fraction. Radiographers were not aware of the arm in which patients were inducted. Reference bony landmarks used for the comparison of the PI were as follows:

AP image: Vertebral body, spinous process, pedicles and other visible bony structures.
Lateral image: Vertebral body, sternum and other visible bony structures.
Tangential image: Central lung distance (CLD), Central flash distance (CFD) and Inferior central margin (ICM)

### 2.4. EPI evaluation

The DRR and PIs were compared and analyzed for setup variations in terms of translations and rotations with respect to patient co-ordinate system in the ML, CC and AP directions using the offline review software module. CC displacement variation was recorded in both anterior and lateral images and mean of both observations was considered for calculations. Two observers performed the matching independently. If the difference in the measurements between the two observers was more than 3 mm, the larger measurement was taken into account. However, if the difference was more than 3 mm then the mean of the two measurements were taken.[6]

### 2.5. EPI and statistical analysis

Mean of everyday displacements was calculated for a particular patient for all sets of images. SD of mean of all the patients gave the population systematic error ($\Sigma$). Mean minus everyday displacements gave the everyday random displacements for a given patient. SD of all the random displacements for all patients resulted in population random error ($\sigma$). To cover the CTV for 90% of the patients with the 95% isodose (analytical solution), Van Herk's formula ($2.5\Sigma + 0.7\sigma$) was used to estimate margins required in the ML, CC and AP directions in both arms for thorax images.[6] From the displacements measured in each direction, 3-dimentional (3D) vector was calculated using the formula $d3D = \sqrt{d^2AP + d^2CC + d^2ML}$ where dAP, dCC and dML are the deviations in the AP, CC and ML directions. Statistical Package for Social Sciences (SPSS version 14.0) was used for data analysis. Non-parametric independent sample *t* test and Wilcoxon Signed Rank Test were used for analysis of data. Retrospectively, the effect of no action level (NAL) was evaluated with the first 3 observations of our dataset.[8] No tolerance level was set and no correction was applied.

## 3. Results

A total of 142 sets of PIs (anterior, lateral and lateral tangential fields) were available for analyses (arm I: 70, arm II: 72). Mean body mass index (BMI) was 21.4 ± 2.5 versus 29.7 ± 2.9 in small breasts versus large breasts ($p = 0.001$) (Table 1).

$\Sigma$ and $\sigma$ errors for thoracic and tangential images are shown in Table 2. Although the overall difference was greater in the thoracic images of arm II, they were not statistically significant. 3 D $\Sigma$(mm) was 2.7 versus 4.2 ($p = 0.01$) and $\sigma$(mm) was 2.5 versus 3.2 ($p = 0.14$) in arm I and II, respectively. The difference in displacement of more than 5 mm was seen in 16.7%, 28.6%, 24.3% versus 55.6%, 60%, 22.2% in the ML, CC and AP

**Table 1 – Patient's demographic profile.**

| Variables | ARM I, small breast (N = 10) | ARM II, large breast (N = 10) | *p*-Value |
|---|---|---|---|
| Age (years), mean ± SD | 41.9 ± 10.3 | 49.60 ± 8.20 | 0.063 |
| Tangent separation (cm), mean ± SD | 17.95 ± 1.20 | 22.15 ± 0.94 | 0.000 |
| Ant-post separation (cm), mean ± SD | 18.60 ± 0.97 | 20.99 ± 1.43 | 0.002 |
| Lateral separation (cm), mean ± SD | 32.01 ± 2.42 | 37.09 ± 2.64 | 0.001 |
| Laterality | 50% left breast<br>50% right breast | 70% left breast<br>30% right breast | 0.374 |
| Cup size | A (30%)<br>B (50%)<br>C (20%) | C (40%)<br>D (60%) | 0.001 |
| Tumour stage | Stage 2A (9/10) (T2N0M0)<br>Stage 2B (1/10) (T3N0M0) | Stage 2A (8/10) (T2N0M0)<br>Stage 2B (2/10) (T2N1M0) | 0.781 |
| Reactions | Grade I (1/10) (10%)<br>Grade II (7/10) (70%)<br>Grade III (2/10) (20%) | Grade I (1/10) (10%)<br>Grade II (6/10) (60%)<br>Grade III (3/10) (30%) | 0.654 |
| Body mass index (kg/m$^2$) range, mean ± SD | 17.48–25.33<br>21.4 ± 2.5 | 26.14–36.97<br>29.7 ± 2.9 | 0.000 |

**Table 2 – Systematic and random errors in thorax images.**

| Displacements | Arm I ($N = 10$) | | Arm II ($N = 10$) | | $p$-Value | |
|---|---|---|---|---|---|---|
| | Systematic | Random | Systematic | Random | Systematic | Random |
| AP_ML | 3.2 | 2.9 | 6.7 | 4.1 | 0.40 | 0.06 |
| AP_CC | 2.5 | 4.1 | 3.7 | 4.5 | 0.06 | 0.68 |
| Lat_AP | 2.2 | 3.3 | 3.6 | 3.2 | 0.08 | 0.36 |
| Lat_CC | 2.1 | 3.7 | 2.5 | 5.1 | 0.01 | 0.34 |
| CLD | 5.0 | 3.4 | 6.9 | 3.4 | 0.17 | 0.73 |
| CFD | 4.9 | 3.5 | 9.9 | 5.4 | 0.40 | 0.68 |
| ICM | 3.4 | 2.4 | 4.4 | 2.7 | 0.04 | 0.73 |

AP_ML: displacement in mediolateral direction (antero-posterior image), AP_CC: displacement in cranio-caudal direction (antero-posterior image), Lat_AP: displacement in antero-posterior (lateral image), Lat_CC: displacement in cranio caudal direction (lateral image). CLD: central lung distance, CFD: central flash distance, ICM: inferior central margin.

directions in small and large breast ($p$ value: 0.001, 0.007, 0.77), respectively. The standard deviation (SD) of variations (mm) in breast contour depicted by central lung distance (CLD) was 5.9 versus 7.4 ($p < 0.001$), central flash distance (CFD) was 6.6 versus 10.5 ($p = 0.002$), inferior central margin (ICM) was 4 versus 4.9 ($p < 0.001$) in arm I and II respectively. $\Sigma$ and $\sigma$ errors for ICM were 3.4 versus 4.4 ($p = .05$) and 2.4 versus 2.7 ($p = 0.14$) in arm I and II, respectively (Table 2, Fig. 2a and b).

Based on these results, CTV to PTV margin was 10.1 mm versus 19.6 mm, 7.8 mm versus 11.2 mm and 7.6 mm versus 9.8 mm in the ML, AP and CC directions in arm I and II, respectively (Table 3). Correction by NAL would result in the reduction of systematic error from 6.7 mm to 3.2 mm in the ML direction in large breast, hence the reduction of the PTV margin from 1.96 cm to 1.21 cm (Table 4).

**Table 3 – Comparison of PTV margins.**

| Direction (mm) | Arm I ($N = 10$) PTV margin | Arm II ($N = 10$) PTV margin |
|---|---|---|
| AP_ML | 10.0 | 19.6 |
| AP_CC | 9.1 | 12.4 |
| Lat_AP | 7.7 | 11.2 |
| Lat_CC | 7.8 | 9.9 |

AP_ML: displacement in mediolateral direction (antero-posterior image), AP_CC: displacement in cranio-caudal direction (antero-posterior image), Lat_AP: displacement in antero-posterior (lateral image), Lat_CC: displacement in cranio caudal direction (lateral image).

## 4. Discussion

The majority of studies on setup errors in breast cancer comprise 20 patients or fewer, with various kinds of positioning devices,[9–12] hemibody cradles,[13,14] foam cushions,[15] cellulose casts,[16] fixed arm support[9] and breast boards.[17] The use of positioning devices has been demonstrated to improve setup reproducibility.[9,15,17,18] Creutzberg et al. compared 17 breast cancer patients immobilized with a plastic mask and 14 patients without immobilization, and demonstrated that immobilization reduced random error from 4.4 mm to 2.1 mm in the AP direction.[3] In a study comparing patients undergoing tangential breast RT positioned supine on a wedge board with

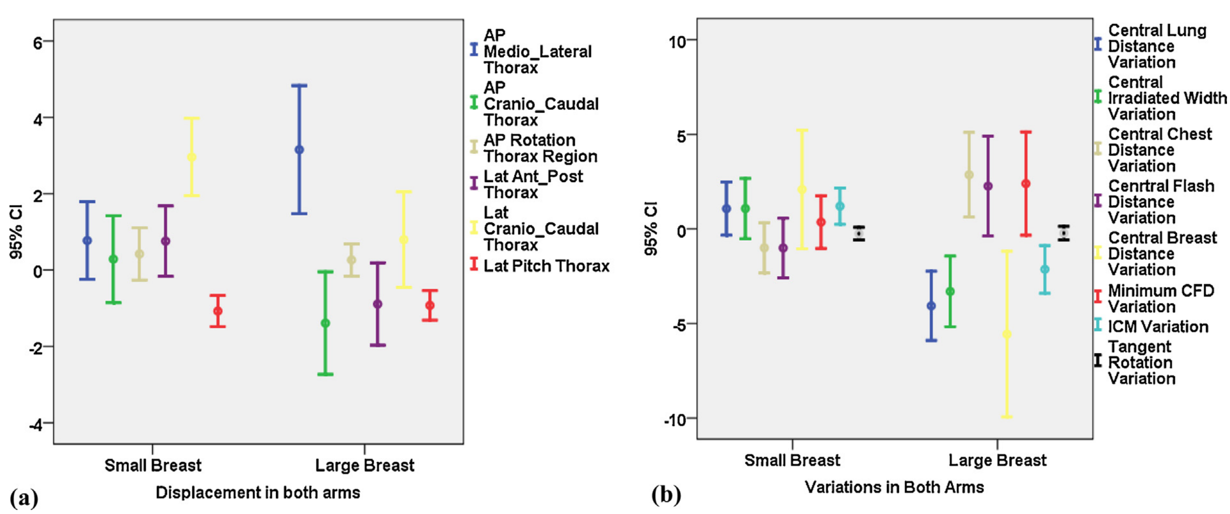


**Fig. 2 – 95% confidence interval values of displacement (mm) in orthogonal image and tangential image. (a) AP_ML: displacement in mediolateral direction (antero-posterior image), AP_CC: displacement in cranio-caudal direction (antero-posterior image), AP_R: rotation (antero-posterior image), Lat_AP: displacement in antero-posterior (lateral image), Lat_CC: displacement in cranio caudal direction (lateral image), Lat_Pitch: pitch (lateral image). (b) Displacements in CLD, CIW, CCD, CFD, CBD, ICM, rotation on tangential image.**

**Table 4 – Effect of NAL on setup errors.**

| Direction (mm) | Arm I (N = 10) | | | | Arm II (N = 10) | | | |
|---|---|---|---|---|---|---|---|---|
| | Without NAL | | With NAL | | Without NAL | | With NAL | |
| | Systematic error | Random error | Systematic error | Random error | Systematic error | Random error | Systematic error | Random error |
| AP_ML | 3.2 | 2.9 | 2.3 | 3.2 | 6.7 | 4.1 | 3.5 | 4.8 |
| AP_CC | 2.5 | 4.1 | 3.0 | 4.0 | 3.7 | 4.5 | 4.0 | 4.4 |
| Lat_AP | 2.2 | 3.3 | 3.2 | 3.0 | 3.6 | 3.2 | 3.7 | 3.0 |
| Lat_CC | 2.1 | 3.7 | 3.2 | 3.8 | 2.5 | 5.1 | 4.2 | 4.3 |

AP_ML: displacement in mediolateral direction (antero-posterior image), AP_CC: displacement in cranio-caudal direction (antero-posterior image), Lat_AP: displacement in antero-posterior (lateral image), Lat_CC: displacement in cranio caudal direction (lateral image).

and without a fixed arm support, Mitine et al. reported no differences in setup errors in the AP direction but overall setup errors as large as 15.5 mm in the CC direction were reduced to 5.5 mm with the fixed arm support.[9] In another study of 17 patients who underwent half of their tangential breast RT fractions using a breast board positioning device and the other half using a vacuum moulded device, Nalder et al. reported that 80% of random error were 3 mm and 80% of systematic error in the AP direction were 4 mm with both techniques. However, 80% of systematic error in the CC direction was reduced from 5 mm using the breast board to 2.7 mm with the vacuum moulded device.[19] There are few data reporting setup errors for patients with intact breast undergoing comprehensive locoregional irradiation using a single isocentre technique positioned using a breast board. Truong evaluated 46 patients irradiated to the breast or chest wall along with axilla and supraclavicular lymph nodes (SCN) on customized vacuum moulded devices to provide support under the neck, shoulders and arms. In this study, the random error ranged from 2.3 mm to 3.9 mm for the SCN treatments and systematic error was 2.6 mm and 4.3 mm in the CC and ML directions for the SCN field.[10] Lozano reported CTV-PTV margin of 11.8 mm, 14.1 mm and 8.8 mm in the ML, CC and AP directions, respectively.[20] Since the difference in setup errors between a vac fix and routine positioning device is not large and positioning of patients on a vac-fix or alpha cradle either in isolation or in conjunction with a wing/breast board is limited by cost in our country where patients have to bear the expenses, we embarked on the usage of a wing board. A wing board allows relaxation and fixation of arms on a flat board with side wings and a neck support to rest the head and the time required for setup is shorter. The advantage of avoidance of collimation with a breast board can be overcome by placing multileaf collimators and blocking excessive lung and heart. Setup errors for small breast in our study are consistent with those in the literature. Comparison of setup errors for small and large breast patients yielded different reproducibility between the two arms, for the thoracic as well as the breast silhouette parameters. Although it is intuitive that large breasts will fare worse than small breasts in setup, such a prospective comparison has not been reported earlier. A subset analysis by McGee et al. does reveal that large breasts fared worse.[21] Large breast patients fared worse but statistical significance for systematic and random errors could not be reached, which may be due to a small patient number. The CTV to PTV margin derived in our study is comparable to the literature for small breast.[20] An optimal setup image matching position in 2D orthogonal KV images was investigated by Laaksomaa et al.[22] Residual errors in the treatment field images were determined by matching the orthogonal setup images to the vertebrae, sternum, ribs and their compromises. The best general image matching position was the compromise of the vertebrae, ribs and sternum and the worst was vertebra alone. The setup margins required for the chest wall varied from 4.3 mm to 5.5 mm in the AP direction while in the superior–inferior (SI) direction the margins varied from 5.1 mm to 7.6 mm.

Offline setup correction protocols are used to reduce the systematic displacement of the patient during radiotherapy treatment, allowing smaller CTV-PTV margins to be used. Application of the NAL protocol would result in reduction in systematic setup error in the mediolateral direction for large breast which would significantly reduce large PTV margin in the mediolateral direction. Although the NAL protocol is simple and time-efficient, it is less effective for patients with time trends or sudden transitions in setup, as well as for patients with large day-to-day variations. Since a large percentage of patients had displacements of more than 5 mm, probably e-NAL would be more appropriate to correct the errors, especially in large breast patients.[23] Setup errors in large breast can be reduced by positioning on a breast board as the breast tissue moves forward with the slant of the board and higher arm elevation, allowing for less inclusion of tissues deep to the chestwall.[24] This also reduces the mean cardiac dose by 60% in comparison to treatment with flat positioning and collimation.[25]

Since breast is a non-rigid structure, setup errors for intact breast may not replicate that of lumpectomy cavity and, hence, the displacement of surgical clips (in the margins of lumpectomy cavity) during radiotherapy on a KV image or CBCT should be evaluated for boost treatment and this is the drawback of our study.

Based on our results, we routinely position patients with the derived CTV to PTV margins. We now plan to embark on a prospective study to derive PTV margins for boost based on the displacement of clips on CBCT.

## 5. Conclusions

Based on this, we can conclude that the margin required for setup errors for intact breast patients on a wing board is 1.1 cm, 0.76 cm and 0.71 cm for small breasts and 1.96 cm, 1.12 cm and

0.98 cm for large breast in the ML, AP, and CC directions respectively. Correction by NAL can further reduce the mediolateral margin to 1.21 cm in large breast. Further work is required to test various image guidance protocols, calculate PTV margin for boost and improvise positioning of large breasted women.

## Conflict of interest

None declared.

## Financial disclosure

None declared.

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