Journal of Radiotherapy in Practice

Journal of Radiotherapy in Practice 2001
2, 117–123

Original Article

Tangential breast irradiation – Optimising the technique

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Abstract

Patients receiving tangential breast irradiation represent a significant proportion of the workload in a radiotherapy department. This paper describes the optimisation of an existing technique for tangential breast irradiation. Simulator sessions have been made more efficient by adopting a systematic approach to the simulation process, and set up times on treatment have been reduced and accuracy increased by improving the reliability of the patient set-up. There has been an overall reduction in both the problems and the time taken to both simulate and treat patients.

Patient position variation has been minimised by the use of vac-fix bags and the choice of reference tattoo placement on the patient's skin. The single simulation session for planning treatment has been organised into three parts: definition of target volume, calculation of treatment and field parameters and simulation of treatment fields. The improvement in patient set-up on treatment has been confirmed by a reduction in the variability of FSDs measured during treatment.

Keywords

breast radiotherapy, simulation, patient set up

INTRODUCTION

Breast cancer is the most common form of cancer among women in Europe and its incidence appears to be increasing. The current European annual incidence is quoted at 180,000;[1] this compares with a figure of 135,000 in the early 1990s.[2] The UK has one of the highest rates of incidence or breast cancer, at approximately 25,000 cases per year for a population of 60 million. The recent Royal College of Radiologists (RCR) guidelines[3] recommend that at least 90% of patients receiving conservative breast surgery should receive post-operative radiotherapy; however a recent UK audit found that only 60% of relevant patients were receiving radiotherapy. The RCR guidelines also state that radiotherapy to the chest wall reduces local rate of recurrence in high-risk mastectomy patients. Patients with breast cancer represent a significant proportion of patients treated in radiotherapy departments, and if the RCR recommendations regarding breast radiotherapy are met there will be a significant increase in breast radiotherapy treatments. It is very important therefore that the planning and treatment of breast radiotherapy is efficient and effective, as problems in implementing a breast treatment technique can have significant resource implications.

The recommended technique (EORTC) for breast irradiation is the use of two tangential opposing beams angled to align the dorsal beam edges to minimise the dose to the lung.[4] This technique has been used with many variations for at least 20 years. The specification of the treatment volume is complex for the following reasons; the target volume is inclined at an angle to the horizontal if the patient lies directly on the treatment couch, the dorsal beam edges must be aligned to minimise lung and cardiac doses, the cranial edges

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https://doi.org/10.1017/S1460396900000200 Published online by Cambridge University Press

of the tangential fields must be aligned to produce a clearly defined edge to the treated volume to allow subsequent matching of superior nodal fields, the transverse patient contour can have considerable variation.

Some centres simplify the treatment volume geometry by positioning the patient on an angled breast board so that the sternum and hence the target volume is horizontal. Dorsal and cranial non-divergent beam edges can be obtained by a combination of choice of gantry angle, collimator and table angles, the use of asymmetric fields or blocking.[5,6] The technique used in this department is to treat the patient lying flat on the couch top using symmetric beams with no blocking, but using appropriate geometrical relationships between gantry, collimator and table angles given to obtain the required alignment of beam edges.[7] Planning of tangential breast irradiation is most commonly done in a single simulator session. This single session of simulation has to define the treatment volume, establish the position of the isocentre and define and confirm the treatment beams, resulting in a simulation process that is complex and time consuming. The lengthy simulator session is uncomfortable for the patient who can have difficulty in maintaining the desired position for the required length of time.

It is important that the patient position be reproducible, especially with the advent of techniques to improve dose homogeneity using breast compensators.[8,9] However the nature of the set-up of the tangential fields and the mobility of the skin and tissues in the breast region can result in a significant number of problems in reproducing the patient set up daily on the treatment machine. Assessing the accuracy of set up is complicated by the fact that the position of the target volume cannot be defined accurately by the position of the isocentre, which is in a region of mobile tissue, but must be defined by the medial, lateral and cranial beam edges. It is therefore necessary to have a satisfactory means of defining these beam edges.

This paper describes an optimisation of an existing technique by structuring and streamlining the simulation process, improving patient immobilisation and using reliable skin reference marks to improve the reproducibility of patient positioning and allow CT planning. These improvements result in treatment that is both more efficient and more effective and less stressful for both patients and staff.

METHOD

Patients are positioned supine with both arms raised above the head and with hands overlapping, supported by a vac-fix bag, which provides a head rest and also supports the arms in a defined position. This position also allows the patient to pass through the aperture of the CT scanner. Skin reference mark positions have been chosen to enable correct alignment of the patient and definition of the beam edges. Four reference marks are used; one at the superior-medial corner of the medial field and three in the central transverse plane, two at the medial and lateral field edges and the third on the contralateral side at the same height above couch top as the lateral field edge (Fig. 1c). The simulator session has been structured into three components; definition of the target volume, positioning of the isocentre and definition of field parameters, and simulation of treatment fields.

Definition of the target volume: Before asking the clinician to mark the edges of the treatment volume, the angle of the sternum to the horizontal is found. This is done using the light beam of the simulator with the gantry horizontal at 90°/270°. The collimator angle is adjusted so that the field is angled parallel to the sternum. The tilt of the collimator from the horizontal gives the angle of the treatment volume to the horizontal, M. (Fig. 1a). The clinician is then asked to mark the superior, inferior and medial borders of the treatment volume and mark the height of the lateral border in the central plane (halfway between superior and inferior borders). The couch height is adjusted so that the posterior border of the tilted light field passes through this lateral mark. The field edge is then drawn on the patient to indicate the lateral border of the treatment volume and the clinician asked to confirm the lateral border of the treatment volume especially with respect to the superior and inferior ends of the volume. With the gantry vertical at 0° and the collimator at 0°, the length of the field, L, is determined and the central plane marked. A medial reference point is marked on the central plane at the medial border (Fig. 1b). The simulator gantry is centred at the medial reference

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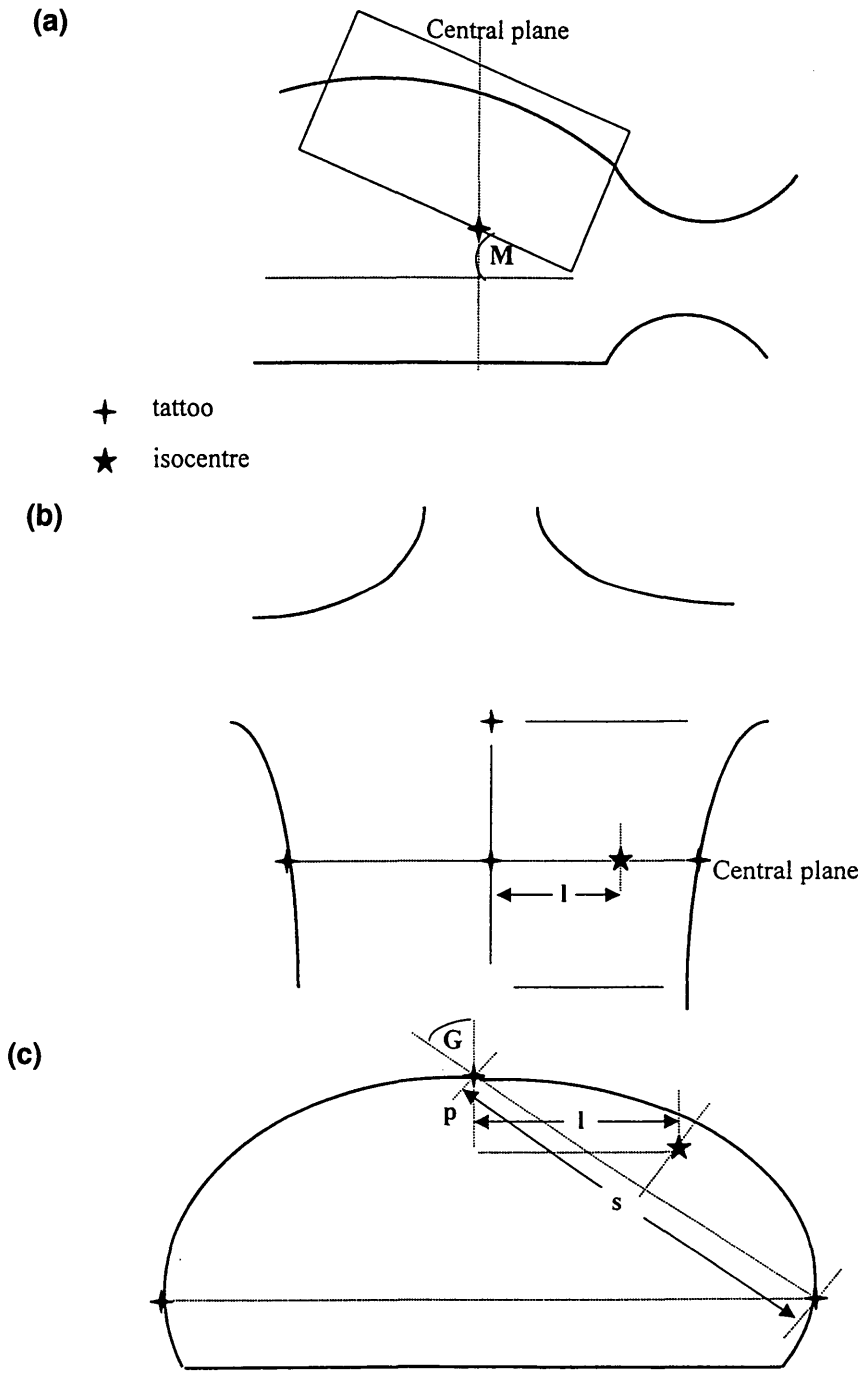

Figure 1. Showing relevant set-up parameters and tattoo positions
(a) sagittal plane showing angle of tilt, M
(b) coronal plane showing 4 reference tattoos
(c) transverse plane showing set-up gantry angle, G, isocentre position parameters and tattoo positions in the central plane

point at an FSD of 100cm, and pieces of solder placed along the medial and lateral borders in the central plane. The gantry is then rotated to about 60° to the vertical and the patient screened. The gantry is adjusted until the two pieces of solder are coincident. The gantry angle gives the angle, G, to the vertical of the line joining the medial and lateral borders (Fig. 1c). The collimator is then adjusted to the angle, M and the width of the field set to give at least 1 cm anterior clearance of the

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treatment volume. This gives the width of the required field. The clinician is then asked to approve the amount of lung between the central axis and the chest wall. If there is found to be too much lung (>2 cm) in the field the lateral and/or medial borders are adjusted accordingly. Using the lasers in the simulator room, reference marks are placed on both sides of the patient in the transverse central plane through the medial reference mark at the height of the lateral border. The height of these lateral reference points above the couch top is measured and also the medial-lateral border separation, s (Fig. 1c).

Definition of isocentre and field parameters: The position of the isocentre and the field parameters are calculated using a simple spreadsheet program. The following data are entered into the spread sheet: length of the treatment field, L, width of the treatment field, W, set-up gantry angle, G, medial – lateral field border separation, S and sternal angle, M. The isocentre position is defined relative to the medial reference point by the pin at the medial reference point, p, and the lateral distance of the isocentre from the medial reference point, l. (Fig. 1c) These parameters are then calculated using the following equations: -

$$P = s/2 \,.\, \cos G - W/2 \,.\, \sin G$$
$$l = s/2 \,.\, \sin G + W/2 \,.\, \cos G$$

The treatment angles, G" (gantry), C (collimator), T (table) are calculated using the formulae given by Casebow.[7]

$$\cos G'' = \cos G' \,.\, \cos M \,.\, \cos \Delta - \sin M \,.\, \sin \Delta$$
$$\sin C = -(\sin \Delta \,.\, \cos G'' + \sin M) / (\Delta \,.\, \sin G'')$$
$$\sin T = (\sin M \,.\, \cos G'' + \sin \Delta \cos M \,.\, \sin G'')$$

where tan $\Delta L/200$ (for focus – isocentre distance of 100 cm) and G' is the field gantry angle required to align the dorsal field edge, which is calculated from the set-up angle G adjusted for the lateral divergence of the field.

Simulation of treatment fields: The position of the isocentre is found by setting the pin at the medial reference point and moving the table the required lateral distance. The medial treatment field is then set-up and the position of the isocentre adjusted, if necessary, to position the medial field edge at the required border. The lateral field is then set up and checked. A simulator film is taken once the isocentre position has been confirmed. The isocentre defining parameters, l and p, are then checked and also the pin setting at the isocentre. The FSDs of both fields are measured and recorded. The medial and two lateral reference points are tattooed and also the medial-superior corner of the medial field.

If the patient is to have a CT scan the simulation session ends. If a CT scan is not to be obtained an outline is obtained manually using plaster of paris. The measured parameters s, medial–lateral field edge separation and G, gantry set up angle, are used to fix the relative positions of the lateral and medial borders. The isocentre position is checked against the measured parameters.

On treatment the treatment volume is defined by the 3 tattoos in the central transverse plane and the tattoo at the superior medial corner of the medial field. The isocentre position is determined relative to the medial tattoo. If, on setting up the patient, the field edges do not match the lateral and medial tattoos, an adjustment of the isocentre height is allowed within a range of 1 cm.

FSDs are measured routinely in our department as a check on patient set up and hence they provided data for the retrospective comparison of the old and new techniques. An assessment of the reproducibility of set up on treatment was made by comparing the variability of FSD measurements for twelve patients, six using the new technique and six using the old technique. Measurements were made at the start of treatment and at weekly intervals during treatment. All measurements were made using the optical distance indicator. The FSD on the plan was the same as that taken at the simulator using the optical distance indicator.

RESULTS

Since adopting this technique the time spent simulating the patients has been reduced by approximately 5–10 minutes. One of the principal problems at simulation had been the definition of medial and lateral field borders that would ensure adequate coverage of breast tissue and minimal lung and cardiac irradiation. The position of these

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borders is decided when the target volume is defined so that when the treatment fields are set up no adjustments are required. In most cases the medial field sets up to the marks drawn on the patient and provides satisfactory coverage at the superior and inferior ends of the treatment volume. If there is a problem with matching the medial border of the field to the clinician's marks it is usually due to inaccuracy in setting the pin or splash on the contralateral breast. This is remedied by adjusting the isocentre height. Occasionally it is sometimes necessary to adjust the width if there is inadequate coverage at the superior or inferior ends of the volume. With experience this is becoming less frequent as adequate coverage is given at the time of screening for width. When the lateral field is set-up the posterior border of the lateral field runs along or close to the line marked at the start of the session. If this does not occur the isocentre height is adjusted and the medial field checked again. Problems experienced in setting up the fields to the marks are usually due to patient movement, in which case the fields are screened with wire on the field borders to check for coincidence. If they are not coincident it is probable that the patient has rotated in which case the lateral laser mark alignment is checked. If the patient has relaxed significantly during the simulation process it may be necessary to adjust the gantry set-up angle, G.

The variability of FSDs measured during treatment is shown in Tables 1 and 2. Table 1 gives the measurements for patients treated using the old technique and Table 2 for patients treated using the new technique. The number of measurements for each FSD is given in column 1. For each field the mean FSD and standard deviation was calculated. Column 2 shows the difference between the mean FSD and the FSD taken from the treatment plan. Column 3 shows the standard deviation. It can be seen that the mean standard deviation of the FSDs measured using the old technique is nearly double that of the new technique. The range of variability of FSD measurements has been expressed by calculating a minimum and maximum FSD, as given by the mean FSD ± the standard deviation, and thence finding the difference between the minimum FSD and plan FSD, column 4, and between the maximum FSD and plan FSD, column 5. It can be seen from Table 1 that using the old technique there are four fields where either the minimum or maximum difference falls outside the range –1.5cm – +1.5cm, representing an error at the isocentre of greater than 3%. There are no instances with the new technique, Table 2, where the minimum or maximum difference falls outside the 3% range.

DISCUSSION

The apparent simplicity of the tangential breast irradiation technique, a modified parallel pair, has resulted in the planning of the treatment being compressed into a single simulation session in which the treatment volume and fields are defined and from which a plan is produced. This is a different procedure from most radical treatment planning in which the treatment plan defining the fields required to cover a clearly defined target volume is produced prior to simulation. The major improvement in breast simulator sessions obtained with the new technique is a result of better definition of the treatment volume at the start of the process. With the old technique the treatment volume had been defined by marks placed only in the central plane of the volume. The mark defining the lateral border was insufficient to assess coverage of the target volume at the superior and inferior ends of the field because of the tilt of the lateral field to the horizontal. By drawing on an approximate lateral border at the start of the process the clinician can see that the whole of the target volume is covered sufficiently by the lateral field. If coverage is not sufficient then adjustment can be made to the angle of tilt, M, or the height of the lateral border above the couch top. Some clinicians now draw on the lateral border, parallel to the sternum by eye. If the angle of tilt, M, deviates significantly (more than 5°) from the sternal angle then it is found that the medial border is unsatisfactory at the superior and inferior ends of the volume. If M is too small then the inferior end of the medial field can splash on to the contralateral breast and the superior end of the medial border does not provide sufficient coverage. For left sided breast irradiation the choice of angle of tilt, M, can affect the amount of heart irradiated.

The use of the simulator to calculate the required gantry angles has several advantages. It allows the width of the required field, W, to be determined and also the amount of lung in the field can be seen, so that adjustments to the medial

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Table 1. Variability of FSD measurements on 6 patients treated using the old technique

Patient	Number of measurements	Field	FSD Difference	Std Dev	Range of variability Min	Max
	(1)		(2)	(3)	(4)	(5)
1	5	med	+0.3	1.14	−0.84	+1.44
		lat	−0.7	0.38	−1.08	−0.32
2	7	med	+0.9	1.11	−0.21	+2.01
		lat	−1.4	0.35	−1.75	−1.05
3	5	med	+0.1	0.49	−0.39	+0.59
		lat	−0.1	0.43	−0.53	+0.33
4	5	med	+0.9	0.97	−0.07	+1.87
		lat	−1.6	0.37	−1.97	−1.23
5	4	med	0	0.65	−0.65	+0.65
		lat	−0.2	0.62	−0.82	+0.42
6	5	med	−0.1	1.33	−1.23	+1.43
		lat	+0.2	0.31	−0.11	+0.51
mean			0.54	0.68		

Table 2. Variability of FSD measurements on 6 patients treated using the new technique

Patient	Number of measurements	Field	FSD Difference	Std Dev	Range of variability Min	Max
	(1)		(2)	(3)	(4)	(5)
1	7	med	−0.4	0.23	−0.63	−0.17
		lat	−0.6	0.36	−0.96	−0.24
2	5	med	+0.2	0.55	−0.35	+0.75
		lat	−0.4	0.93	−1.33	+0.53
3	4	med	+0.6	0.38	+0.22	+0.98
		lat	−0.5	0.54	−1.04	+0.04
4	5	med	+0.4	0.51	−0.11	+0.91
		lat	−0.7	0.15	−0.85	−0.55
5	4	med	0	0.06	−0.06	+0.06
		lat	+0.1	0.15	−0.05	+0.25
6	5	med	−0.4	0.15	−0.55	−0.25
		lat	+0.1	0.3	−0.4	+0.2
mean			0.37	0.36		

and lateral borders can be made if required. In most cases the width chosen at this stage provides sufficient coverage at the superior and inferior ends of the field and does not require further adjustment even though the collimator angle chosen is only approximate. Thus before setting up the fields, the lateral field edge, the coverage at both superior and inferior ends of the volume and the amount of lung and heart in the field have been determined. It is these two factors that had been found to cause the clinician to adjust the fields on many occasions.

The definition of a medial reference point has two set-up advantages and has been used by other groups.[5,10] The position of the medial reference point on the sternum is less prone to movement as a result of arm positioning and by defining the isocentre with reference to the medial border, which is tattooed, both the medial border and the isocentre are precisely defined. The old technique used two tattoos on the superior border of the tangential fields, one in the sagittal plane of the isocentre and the other at the superior medial corner of the medial field. It was found that the isocentre-defining tattoo was very prone to movement as a result of arm position. This can be seen in the variation of FSDs where an increase in mean FSD on one field is usually balanced by a reduction in mean FSD for the other field, thus implying variability of the position of the isocentre. This does not have significant dosimetric consequences overall but does increase the problems of setting patients up on a daily basis. The calculation of the position of the isocentre at simulation is dependent on careful measurement

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of the medial-lateral separation with callipers. Errors in this measurement result in errors in the calculated isocentre position, which is why it is sometimes necessary to adjust the isocentre position if the field edges do not match the reference marks. The use of the two lateral tattoos in the transverse plane containing the medial tattoo reduces the rotation of the patient so enabling a more consistent set-up. The lateral tattoo also provides a reference point for the lateral border. The use of the superior-medial tattoo defines both the superior and medial borders of the treatment volume to which it may be necessary to match superior nodal fields or treatment to the contralateral breast. The definition of the field borders results in more informed decision making concerning the accuracy of field set up on treatment. It permits movement of the isocentre so as to maintain accurate medial and lateral field borders so keeping the treatment volume unchanged. This small adjustment of isocentre (less than 1cm) has been found to have an insignificant effect on the resulting dose distribution.[11]

The use of the vac-fix bag makes the treatment position more comfortable for the patient as well as providing fixed positions for the arms. The patients are found to be more relaxed at simulation so reducing variation of patient position between simulation and treatment. The old technique used a T bar placed above the patient's head to fix the position of the arm. This did not provide support for the upper arm and allowed considerable variation in the position of the arm. It was also a strain for the patient to maintain this arm position for any length of time. The important feature of the vac-fix bag is that it supports the whole arm both laterally and from underneath. In a busy department vac-fix bags may be impracticable, but there are alternative methods for supporting the upper arm as well as fixing the position of the hands above the head.

It is reported that patients are much easier to set up using the new technique, especially on the first day, and there is very little inter-treatment variation of position. The FSD measurements provided supporting evidence for the reported improvement in technique.

CONCLUSION

A systematic approach to the structure of the simulation session together with improved patient fixation and the use of suitable reference mark positions on the patient has produced a breast technique that is straightforward, effective and reliable. A significant reduction in time taken to simulate the patients has been achieved and the resulting treatment set-ups have been found to be more consistent and easier to implement so reducing the time required to treat patients.

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