A modified half-block breast irradiation technique using a CT-simulator

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Purpose. *Over the past two decades numerous approaches with varying degrees of complexity have been proposed for radiation treatment of the breast and peripheral lymphatics. In our center a single isocenter, rotating half-block technique has been used since 1982, and the recent installation of a CT-simulator and a linear accelerator with asymmetric jaws has provided an impetus to improve our treatment technique by incorporating this new technology into the treatment planning and dose delivery process.*
Materials and methods. *Our breast irradiation technique requires no couch or patient motion when switching from one field to another, and provides a smooth and reproducible junction between the tangential chest wall fields and the supraclavicular fields. Before treatment, the patient is scanned on the CT-simulator, and with the aid of virtual simulation software the optimal isocenter, common to all radiation fields, is determined and marked on the patient's skin.*
Results. *Since 1997, 17 patients have been treated with the modified breast irradiation technique. The simulation time is reduced to about 30 minutes. The patient setup on the linear accelerator is straightforward, and the dose delivery is relatively simple because all fields, despite being half-blocked, use the same isocenter. The wedged tangential fields are produced with a dynamic wedge, and the asymmetric jaws enable us to determine the optimum isocenter common to all treatment fields.*
Conclusions. *Treatment planning for our breast irradiation technique is based on virtual simulation, and dose delivery is accomplished on a 6 MV linear accelerator incorporating a rotating half-block, asymmetric jaws, dynamic wedge, and a multileaf collimator. The technique is practical, meets the requirements for adequate irradiation of the breast and peripheral lymphatics, and is easy to implement on modern linear accelerators.*

Key words: breast neoplasm-radiotherapy; radiotherapy dosage; rotating half-block, CT-simulation, beam matching

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Introduction

Since 1982 our center has used a single isocenter breast irradiation technique for treatment of the breast or chest wall and draining lymphatics. The technique as originally described,[1,2] uses a rotating half-block to achieve a match between the two tangential chest wall fields and the AP-PA fields used to treat the axilla and supraclavicular region. A single isocenter is used for all four fields, and no couch motion is required when switching from one field to another.

The acquisition in 1994 of a CT-simulator and a linear accelerator with asymmetric jaws provided an opportunity to improve the technique in terms of treatment planning and beam delivery. In this paper we describe the modified technique, which uses virtual simulation software for the determination of the optimal location of the treatment isocenter and relies upon a rotating half-block and asymmetric jaws to define the treatment fields. It has been established that the isodose distributions and matchline dosimetry that were performed for the original technique[1] have not changed for the modified technique, therefore this paper presents only the modification to the planning using the CT simulator.

Materials and methods

Numerous techniques with varying degrees of complexity have been proposed for radiation treatment of the breast and peripheral lymphatics.[3-10] Our original technique was designed around the capabilities of linear accelerators without asymmetric jaws. The isocenter of the machine was placed onto the patient's skin on the matchline between the two treatment volumes and midway between the medial and lateral limits of the anterior supraclavicular field. While this isocenter position was appropriate for the supraclavicular region, it was not always optimal for the two tangential chest wall fields, and often resulted in the isocenter for the two tangential fields being located medially with respect to the position which would be chosen for a simple set of opposed tangential chest wall fields.

In our current technique the most appropriate isocenter is chosen for the tangential fields first, and then this isocenter is also used for the supraclavicular fields in conjunction with asymmetric jaws. Both our original and current breast techniques are shown schematically in Figure 1. For the original technique the solid dot (point 1 in Figure 1a) indicates the position of the treatment isocenter at the matchline of the fields, positioned midway between the medial and lateral limits of the supraclavicular field. The analogous isocenter point in our current technique (point 2 in Figure 1b) is shown shifted laterally. The placement of the isocenter using the symmetric jaws (point 1) was on the patient's skin, while typically point 2 will be positioned subcutaneously. The line CC′ runs through point 2 along the coronal aspect of the patient.

Two transverse sections through the patient are shown for the original technique (Figure 1c) and the modified technique (Figure 1d). As indicated in Figures 1a and 1b, section AA′ is at the level of the beam matchplane and section BB′ is at a level midway through the tangential chest-wall volume. The constraints imposed by the linac with symmetric jaws required that the treatment isocenter (point 1) be placed medially, forcing the apparent isocenter (point 1′) of the tangential fields to be off mid-volume and requiring unequal beam weights to produce an optimized dose distribution. Since these two tangential beams did not meet at midplane, the medial beam often had a large air splash, while the lateral beam was tight with respect to the patient's external contour. For the current technique (Figure 1d) the center of the chest wall volume to be treated at the level of section BB′ (point 2′) is identified and then a simple calculation described in Equation (1) is carried out to determine the position of the treatment isocenter at the level of section AA′ (point 2).

Figure 2a shows the current technique in the medial oblique beam's eye view containing the line CC′ of Figure 1b and indicates the position of the rotating half-block which compensates for the collimator angle ά. The field dimensions for the current technique are indicated by the rectangle with the solid line. The treatment isocenter (point 2) is located at a depth below the matchplane and the center of the tangential treatment volume (point 2′) is located along the axis defined by the colli-

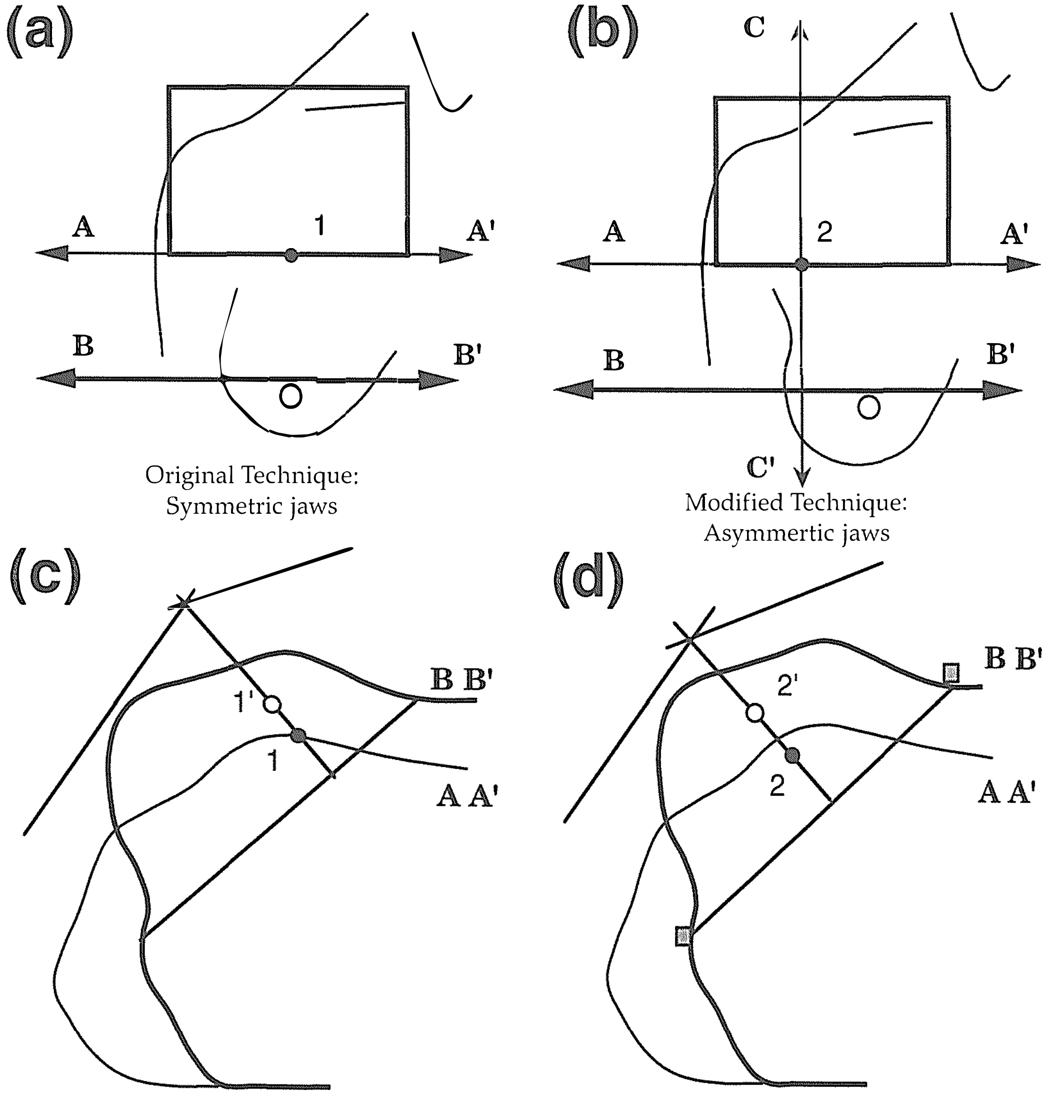

Figure 1. The original breast irradiation technique designed for use with symmetric jaws is shown on the left, the modified technique using asymmetric jaws on the right. Parts (a and b) show the coronal view, parts (c and d) two transverse sections, one at matchplane (AA′) and the other at mid-tangential plane (BB′).

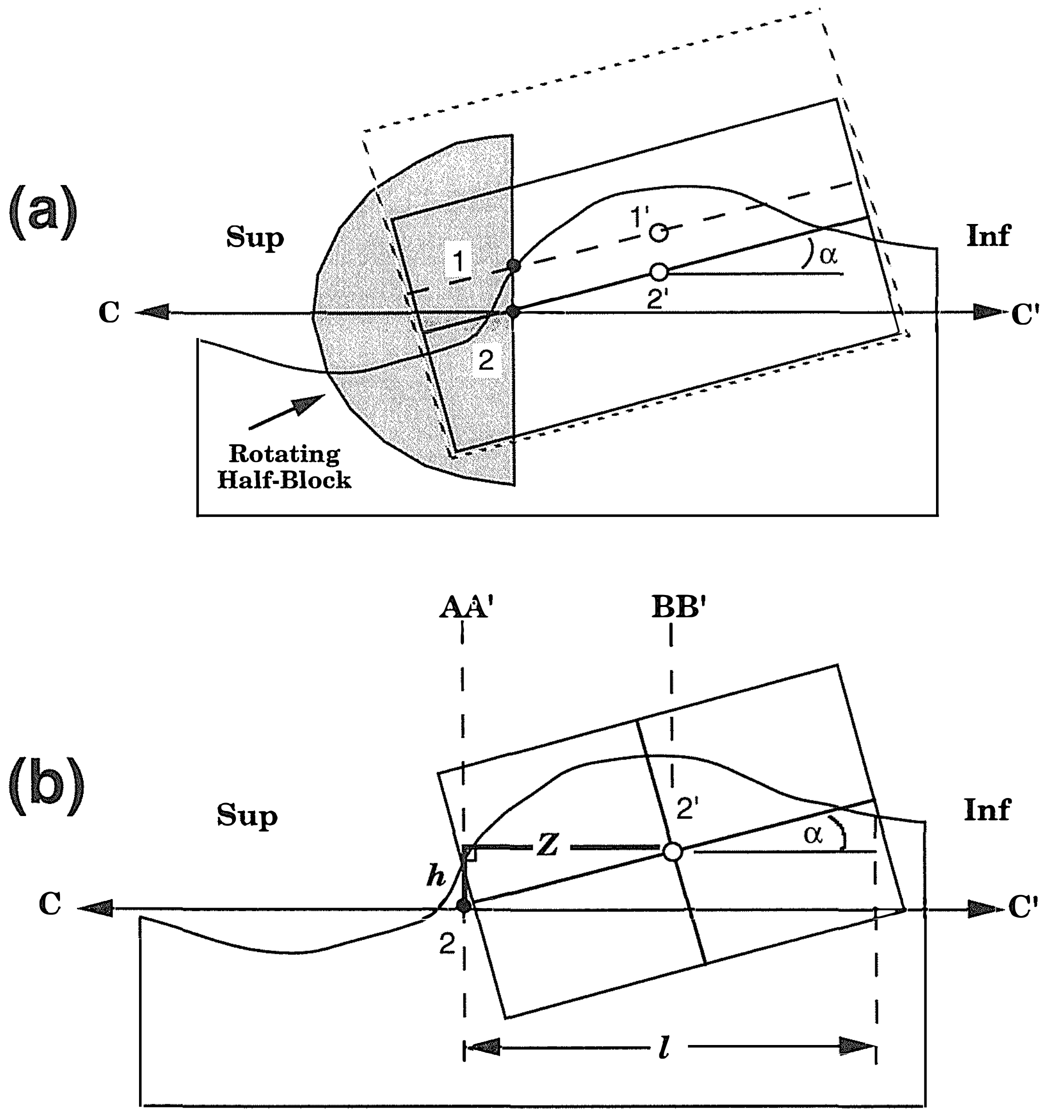

Figure 2. The medial oblique beam's eye view containing the line CC′ of Figure 1a is shown schematically . Part (a) shows the treatment isocenter and the mid-volume points for the original technique (1 and 1′ respectively) and the current technique (2 and 2′ respectively). The field dimensions for the original (dashed rectangle) and modified (solid rectangle) are also shown. Part (b) shows the geometry used to calculate the position of the isocenter (2′).

mator rotation. For comparison, the treatment isocenter for the original technique is shown on the patient's skin (point 1), with the resulting position for the apparent midvolume isocenter (point 1′). The field dimensions for the original technique are indicated by the rectangle with the dashed line.

A dedicated rotating half-block which attaches to the existing wedge slot on the linac (Clinac 2300 C/D, Varian, Palo Alto, CA) and accommodates a maximum field size of 20x40 cm^2 with a maximum collimator angle α of 25° was constructed in our machine shop. The use of the wedge slot on our particular unit precludes the use of standard static wedges, so that tangential treatments are delivered with the use of a dynamic wedge. On the anterior and posterior axilla-supraclavicular fields humeral head shielding is achieved with a 26-pair multileaf collimator (MLC) provided that the field sizes are less than 13 cm in the half-blocked direction.

Patients are planned using CT-based virtual simulation (Picker AcQSim, Cleveland, OH) by placing them into an immobilization device on the CT stretcher with the both arms extended and abducted over the head. In order for the rotating half-block accessory on the linac to comfortably clear the patient, the ipsilateral arm is positioned as close as possible to the side of the patient. The borders of the tangential fields are determined clinically and identified with radio-opaque markers. The medial border is usually placed at midline, the lateral border at the mid-axillary line, the inferior border at 1.2 cm below the inframammary fold and the superior border corresponds to the matchplane for the tangential and supraclavicular fields, determined by using the AP scout view. The patient is CT scanned from below the level of the inferior limit of the tangential fields to a level superior to the limit of the supraclavicular fields.

The planning begins on the transverse CT slice (BB′ of Figure 1) midway between the matchplane of the beams (AA′ of Figure 1) and the inferior limit of the tangential fields. This slice contains the two radio-opaque markers indicating the medial and lateral limits of the chest wall treatment volume. The optimal isocenter position in this CT slice is identified using a software option overlaying a rectangle in such a way that the proximal edge connects the medial and lateral radio-opaque markers, while leaving a minimum air gap of 2 cm over the breast. The virtual simulation software then computes the center of this volume, as indicated in Figure 1d by the open circle (point 2′). The shift to the treatment machine isocenter (point 2) is then calculated. The appropriate gantry angle and field size are chosen with respect to the anatomy and the radio-opaque markers as seen on the transverse CT slice (BB′ of Figure 1d). The appropriate collimator angle is then determined for the lateral tangential field using the Digitally Reconstructed Radiograph (DRR) capability of the virtual simulation software. The field length l is known, having been determined clinically at the time of the CT scout imaging. The shift from isocenter 2′ of the chest wall volume, to the treatment isocenter 2 is then decomposed into components Z and h, respectively. As shown in Figure 2b, h is simply given by:

$$h = Z \tan \acute{\alpha} \qquad (1),$$

where $Z = l / 2$.

By introducing the two shifts Z and h into the virtual simulator software, the position of the treatment isocenter may be displayed and verified on the central transverse slice containing the radio-opaque markers. An error in calculation or set-up becomes immediately apparent, as the beam edges will not intersect at the intended position, typically at the level of the radio-opaque markers.

Results and discussion

Once the patient is placed into the immobilization device on the CT stretcher, the CT scan of the area of interest takes approximately 15 minutes. The CT-based virtual simulation takes another 15 minutes. The position of the treatment isocenter at the matchplane for the tangential and supraclavicular fields is marked on the skin, and the patient is released from the CT-simulator. Our technique is easily adaptable to CT-simulation as there is no tilt-board required for positioning, so that the patient fits comfortably into the CT tunnel. Figure 3 shows for a typical patient the anterior CT scout view used to determine the initial patient position and to identify the matchplane between the two tangential and two supraclavicular fields, typically at the level of the posterior aspect of the 4th rib. The matchplane (AA') is identified with a radio-opaque marker, as are the medial and lateral borders (along BB') and the inferior border of the chest-wall volume.

In Figure 4a the transverse CT-slice taken at the middle of the chest-wall volume at the level of BB' in Figures. 1 and 3 is shown. The intended treatment volume is determined with a rectangle defined by the medial and lateral radio-opaque markers of Figure 3 and a minimum air gap of 2 cm over all CT slices. The corresponding DRR for the lateral field of Figure 4a is shown in Figure 4b.

The position of the treatment isocenter is determined as follows: first the gantry angle and field width are adjusted on the transverse slice BB' with respect to the planning rectangle, as shown in Figure 4a. Next, based on the

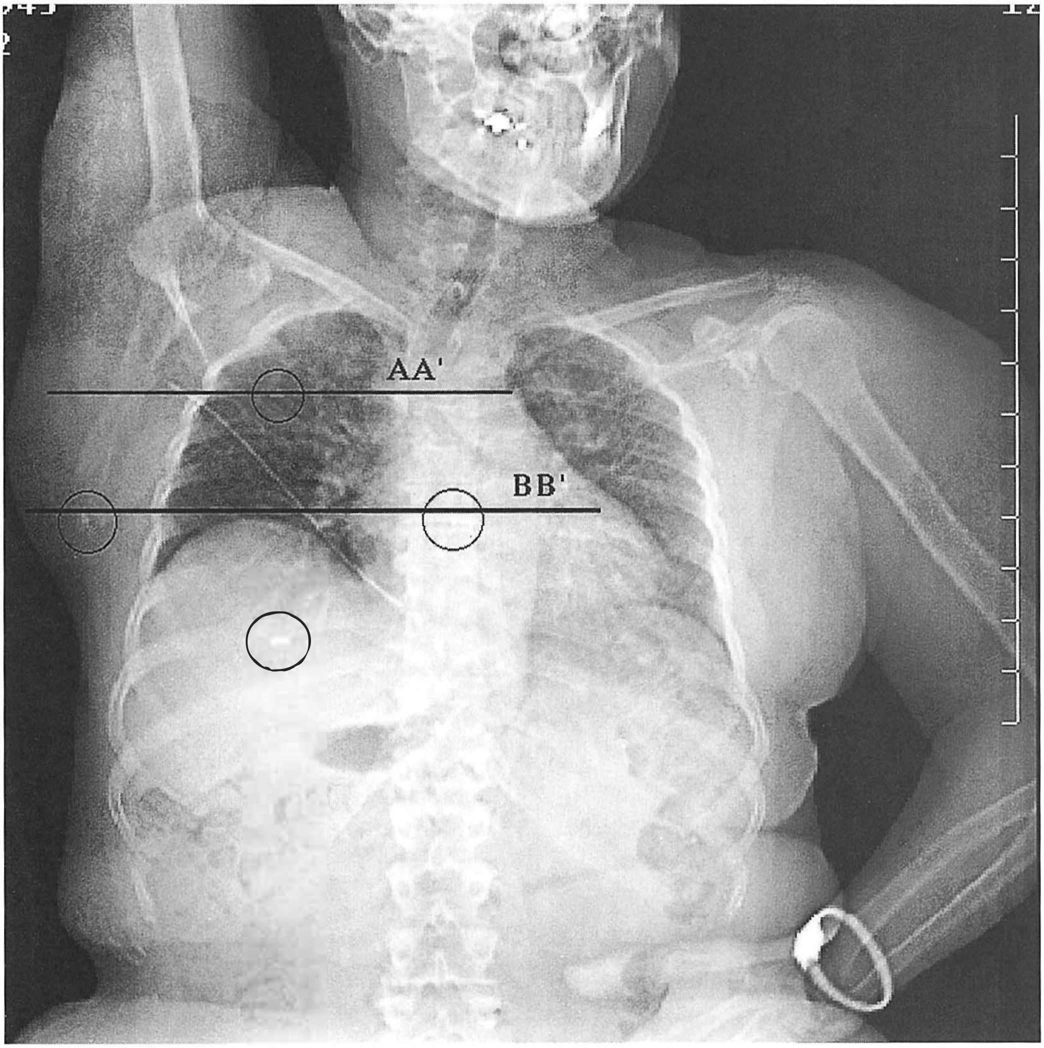

Figure 3. An AP CT scout view of the patient used to determine the matchplane (AA' of Figure 1) is shown. The location of the mid-tangential plane (BB' of Figure 1), as well the four radio-opaque markers used to identify the tangential volume are shown circled.

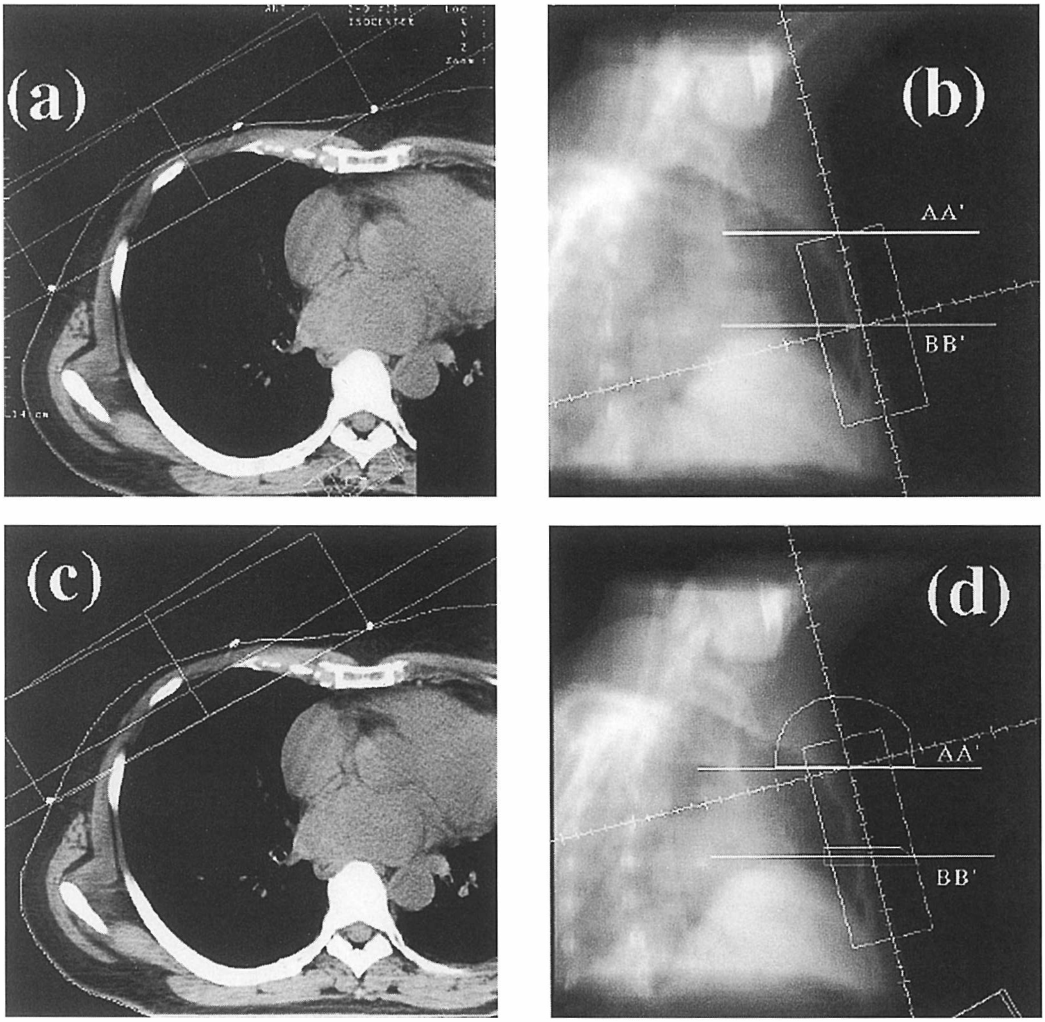

Figure 4. Part (a) shows the transverse CT section along the mid-tangential plane (BB′ of Figure 1) with the isocenter located on BB′, as well as the lateral radio-opaque markers. Part (b) shows the corresponding DRR and beam geometry. The transverse CT section along the mid-tangential plane (BB′) with the isocenter located on AA′ of Figure 1 is shown in part (c), and the corresponding DRR and beam geometry is shown in part (d).

DRR of Figure 4b, the collimator angle is then chosen with respect to the slope of the chest wall. Equation (1) is then used to determine the position of the treatment isocenter in the matchplane AA′. Figure 4c shows the transverse slice at the level of BB′ with the treatment isocenter located on the matchplane AA′. The beam covers the same volume as in Figure 4a, although the fact that this slice is now off-axis is evident, as the isocenter projects more to the medial edge of the rectangle. The accuracy of the calculations can be assessed by verifying that the medial edge of the beam is still coincident with the medial border of the planning rectangle. Figure 4d shows the DRR for the oblique beam of Figure 4c centered at the matchplane, indicating the position of the semi-circular half-block. The planning rectangle passing through BB′ off-axis is also shown.

The apex of the axilla and the supraclavicular region are typically treated with a pair of AP-PA opposed beams as shown in Figure 5. Contouring of structures such as supraclavicular and axillary lymph nodes can be done at a time convenient to the medical staff. The rotating block is lined up along the inferior border of the field on the matchplane AA' at the level of the isocenter, and the lateral borders of the field are defined with respect to the contoured structures by using the asymmetric jaws. Humeral head shielding is achieved with the use of the MLC, and the AP-PA supraclavicular beams are typically angled 5 degrees off the spinal cord. The inset in Figure 5 shows the two AP-PA beams on the transverse slice at the matchplane. The posterior supraclavicular field may be treated at a fixed SSD to avoid the possibility of patient collision, although this introduces a

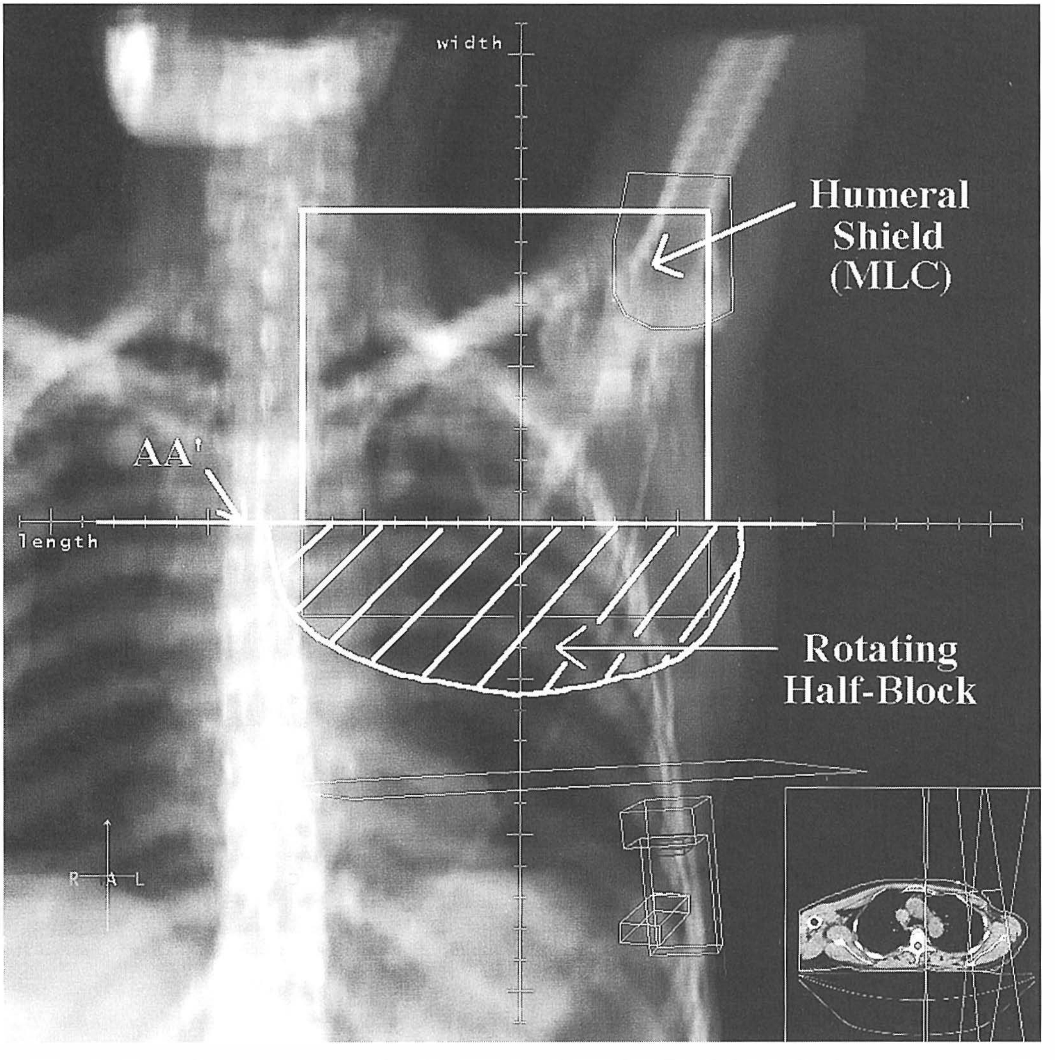

Figure 5. A typical anterior supraclavicular field is shown with the rotating block in the horizontal position. The humeral shielding is provided by an MLC. The inset shows the arrangement of both the AP and PA fields at the matchplane AA' of Figure 1.

field shift. DRRs of the supraclavicular and tangential fields are correlated with portal images obtained at the linac.

Conclusions

The CT-simulated rotating half-block breast technique is a modification of an existing technique which has been in use since 1982. To date 17 patients have been planned and treated with this modified technique since 1997. As the technique is CT planned, there is a considerable reduction in time required by the patient. Previous planning sessions using a conventional fluoroscopic simulator required upwards of one hour, whereas the time required by the patient for CT scanning, virtual simulation and skin marking is on the order of 30 minutes. The decrease in planning time is an important advantage for patients having undergone an axillary node dissection as they often have problems extending their arm for long periods of time. Additionally, the use of CT-based simulation means that information with respect to other organs such as the lung and heart are available.

The current technique improves upon our original rotating half-block technique by taking advantage of the asymmetric jaw capabilities of the linac. By doing so the optimal position for both the tangential and supraclavicular-axillary field pairs can be incorporated in a set-up with a single isocenter which requires no patient movement. The original technique has been reliably used since 1982, and this modified breast technique builds on this experience to more adequately incorporate the capabilities offered by the CT-simulator and asymmetric jaw capabilities of the linac.

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