

Review article

A review of mammographic lesion localisation and work up imaging in Australia in the digital era



K. Spuur

School of Dentistry and Health Sciences, Faculty of Science, Charles Sturt University, Locked Bag 588, Building 30, Boorooma Street, Wagga Wagga, NSW, 2678, Australia

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ABSTRACT

Objectives: To investigate the use of coned compression with and without magnification in contemporary Australian digital imaging. To describe lesion localisation techniques used for mammographic work up.

Key findings: As digital breast tomosynthesis becomes mainstream, the need for coned compression imaging has reduced, however the need for coned compression with fine focus magnification for assessment of microcalcification remains. Adapting film screen lesion localisation techniques to the digital setting is limited by the need for “true size” 1:1 ratio images for ease of measurement. Both the digital ruler and a grid technique can be used as an alternate.

Conclusion: Advances in image acquisition has evidenced a change in imaging protocols for suspicions lesions within the breast with breast tomosynthesis superseding the need for non-magnified coned compression views of the breast. Adaptation of the approaches to localising these lesions in the digital setting has also been necessary.

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Introduction

The two routine projections of the breast are the craniocaudal projection (CC) and mediolateral oblique (MLO) projection. These projections are performed in both the diagnostic and screening setting using planar 2D imaging and film screen (FS), computer radiography (CR) or full field digital mammography (FFDM), or with 3D digital breast tomosynthesis (DBT). These routine images are reviewed with the aim of determining if the breast is normal or if abnormalities, including pathologies, are present. Pathological change as seen on the mammogram may present as a circular, oval, stellate or spiculated lesion, with or without microcalcification, and/or architectural distortion.¹

In 2D imaging where an abnormality is visualised, further images or work up projections may be required to establish a differential diagnosis. These images are not only used to confirm or exclude the presence of a true lesion,² but they also facilitate the decision making of the reader, justifying and increasing confidence in reporting.³ The use of 2D work up projections has been shown to directly improve reporting accuracy in the diagnostic setting.⁴ Typically work up imaging utilises coned or spot compression for lesions without microcalcification and coned or spot compression

with fine focus magnification when microcalcification is present.¹ From here on in the term coned compression (only) will be used. Women may also undergo further assessment and evaluation using DBT, ultrasound (US), magnetic resonance imaging (MRI) or a combination of all of these, depending on their specific presentation and history.

In the screening setting, a woman undergoes screening and may then be notified that she needs to return to an assessment clinic for additional imaging which may include coned compression.⁵ In the diagnostic setting, 2D work up projections including coned compression where required are undertaken directly after routine imaging and during the same appointment. The recall to assessment rate for women presenting for initial screening in Australia in 2015 was 11.8% of the total women screened; this reduced to 4.3% in subsequent screening rounds.⁶ In the diagnostic setting similar imaging protocols apply, however statistics reflecting additional imaging are not readily available.

In contemporary mammographic practice, where the routine images are initially acquired by DBT (not 2D mammography), and subsequently demonstrate an area of interest, only 2D coned compression fine focus magnification (CCFFM) projections are typically required to be progressed. This is because mass lesions and asymmetric densities have been demonstrated to be able to be adequately evaluated by DBT alone.^{7–9} This is an important change in mammographic imaging protocol and patient management.

E-mail address: kspuur@csu.edu.au.

Indeed, DBT has been reported to have made 2D coned compression mammography obsolete. Mhuircheartaigh et al. determined in their study that for both benign and malignant findings no additional diagnostic information was elicited undertaking 2D coned compression projections compared to DBT alone.^{7–9} However where DBT is not available, 2D coned compression must still be performed where indicated.

Coned compression

The primary aim of coned compression is to demonstrate if a lesion is “real” or a product of summation, and to evaluate and characterise masses more accurately, by determining the nature of the borders of the lesion (well or ill defined).^{2,3,10,11} Coned compression projections increase focused compression onto an abnormality to provide a more detailed image by bringing the object (potential lesion) closer to the image receptor and by dispersing overlying structures; thereby (theoretically) making it more visible.¹² They may be performed in any position.^{13,14} Typically however, coned compression is undertaken in the same projection as the abnormality is originally identified. To maximise the tissue spreading and reduction of breast thickness on compression and the benefit of the coned compression technique, “maximum tolerable” compression is desirable and is usually achievable if the woman has been well informed as to its necessity.^{2,10}

Magnification

Most commonly magnification techniques are used to evaluate microcalcification, however they are also used to evaluate certain other lesions.¹⁵ Magnification is undertaken with the aim of adding information about an area of abnormality and to more accurately determine if there is a suspicion of malignancy.^{10,15} Magnification of the breast is used to improve the resolution of the region of interest and to identify the number and characteristics of the microcalcification present.

Magnification is preferably used in conjunction with a coned compression paddle where it is of a sufficient size to cover the area of interest. The importance of CCFM was emphasised in a study by Maden et al., who demonstrated a 58% decrease in biopsy rate comparing 2D mammography and CCFM with 2D mammography images alone; an important consideration for patient management.¹⁵ It is also used in specimen radiography to assist mammographic excisional correlation.¹⁶

Contemporary FFDM image acquisition allows for two approaches to magnification of the breast. True magnification (TM) involves additional imaging and is achieved through the application of simple geometric factors, increasing the distance of the breast to the image receptor using a magnification stand.¹⁷ TM has the disadvantage of additional imaging correlating to additional dose, however it has been shown to have superior contrast detail to the alternate option of electronic magnification (EM).¹⁷ EM utilises image processing to electronically zoom the region of interest. The advantage of this approach is reduced patient dose as no additional imaging is required, however EM has the disadvantage of increased noise.¹⁷

Compression paddles

Coned compression with or without magnification is undertaken utilising specialised compression paddles. Typically there are two distinct types of paddles: small round paddles (7.5 cm) and larger quadrant paddles which may be square (10 cm) or rectangular (15 cm).¹² Smaller paddles allow for a more focused application of

compression.^{3,10} Larger paddles are typically used where lesion size or distribution (as in the case of multifocal lesions or dispersed pathology) is greater than the coverage of the smaller round compression paddle.¹⁰ Use of larger paddles can be beneficial in reducing dose by limiting the number of work up projections undertaken with increased field coverage.¹² Limitations of the use of the larger paddles include decreased focal compression over lesions which may decrease the value of the additional projections due to decreased image quality and failure to adequately resolve summation effect.

In Australia, work up imaging is the responsibility of radiographers and mammographic technologists. There is however little instruction in the literature concerning lesion localisation techniques for the work up of mammographically detected lesions. Most information contained in educational and accreditation texts focuses on positioning of the routine and supplementary projections (extended CC, mediolateral, lateromedial, axillary tail, tangential, twin projection, rolled, tangential and Cleopatra projection etc.),¹⁰ and are primarily aligned with FS image acquisition (Table 1).

Localisation

Localisation of a lesion for coned compression can be exceptionally easy with a palpable mass within a small breast, but is noted as technically difficult in a large breast.³ The key to the latter issue is planning, the ability to replicate the original positioning, good communication, a marking pen for marking the breast, and patience. In contemporary Australian clinical practice there are three key approaches to localising non palpable lesions for work up imaging. These methods are using the fingers, a software ruler and a grid technique.

Localisation techniques

Localisation of “true size” images with the fingers

The traditional FS methodology for localising a mammographically detected lesion is to reference from the nipple using the fingers for positioning accuracy against a “true size” image.¹⁴ This is a technique aligned to FS acquisition, but can also be used in the digital setting where images are configured in a ratio of 1:1. Measurements are made on the image relative to the nipple as being posterior to the nipple and medial or lateral to the nipple in the CC projections and in the MLO projections as posterior to the nipple (parallel to the pectoral muscle) and superior or inferior to the nipple^{14,21} (see Figs. 1,2). This technique is only useful where the images under review are “true size”. That is where images are genuinely representative of the true size of the breast and not scaled down (or up) as is the case for most digital images and digital hard copies.

Once the required measurements are determined, the radiographer then repositions the breast and uses the acquired measurements to localise the lesion. Ideally, the point of reference is marked and the breast manoeuvred in the same plane to place the marked lesion directly under the coned compression paddle. Some texts suggest applying compression to the breast to mimic the original compression whilst localising the lesion,^{13,19,20} however the validity of this method is not known to be proven.

Limitations of this approach include needing to use more than four fingers at a time, maintaining the larger breast in position during localisation, and managing to replicate the initial position of a mobile breast. Image replication can be extremely difficult if radiographer technique has wide variation within a service or facility.

If a “true size” image is not available and the lesion is not palpable, the alternative methods of localisation are as follows:

Table 1
Educational text and accreditation bodies' instruction on localisation and work up imaging.

Source and Technique	Instruction
Rickard ¹⁴ Measurement using fingers; two data points	“The area of interest is identified on the original contact mammogram and measured from the nipple, using your fingers as the unit of measure. With the contact mammogram on a view box, measure the distance (i.e. depth) from the nipple to the lesion, with your fingers placed parallel to the chest wall. Measure the second distance from the nipple to the lesion, with your fingers placed at right angles to the chest wall. Now you need to mark the position of the lesion on the breast surface. Position the breast in the required projection (i.e. the same as the contact mammogram). Place your fingers adjacent to the nipple and parallel to the chest wall. Mark the skin surface with a line at the appropriate depth, as measured from the contact mammogram. With your fingers adjacent to the nipple and at right angles to the chest wall, mark the skin surface with a line at the appropriate depth, as measured from the contact mammogram. The area of interest will be at the intersection of the two lines. Position the breast until the area of interest is centred under the cone (spot) compression plate.... Apply compression vigorously ... ”
Lee et al. ¹⁰ Three data points; measurement method not stated	<p><u>“Accurate localisation of the area of interest.</u></p> <p>The radiographer should: examine the original mammogram, measure and note down:</p> <ol style="list-style-type: none"> the depth of the lesion from the nipple back towards the chest wall, the distance of the lesion above or below the nipple level (or medial/lateral to) the distance from the skin surface to the lesion. <p><u>Positioning</u></p> <ol style="list-style-type: none"> Position the woman mimicking, as closely as possible, the positioning on the original mammogram Referring to the noted coordinates, move the woman until the appropriate portion of breast tissue lies over the automatic exposure device (AEC), and centred under the small paddle. Remember: make allowances for the fact that your measurements are taken from a fully compressed breast. Begin to apply compression Once the breast is held in position, but not fully compressed, check the co-ordinates. If you are satisfied that the area of interest is beneath the paddle: <ol style="list-style-type: none"> mark the centring point on the skin surface, apply compression vigorously. If not adjust the woman's position until you are satisfied.”
Dronkers ¹⁸ Three data points; measurement method not stated	<p>“For a non-palpable lesion, the area of interest is determined on the original mammogram. On the films of the preceding mammogram, the technologist measures.</p> <ul style="list-style-type: none"> • The depth of the lesion by drawing a line from the nipple back towards the chest wall; • the distance of the lesion above or below that line (or mediolateral to that line); • the distance from the lesion to the skin surface. <p>The measurements are transferred to the breast and the location of the lesion is marked on the skin. This mark is in position under the centre of the spot compression device”.</p>
Long ¹³ Three data points; measurement method not stated Simulated compression	<p>“Three measurements are made on the image, regardless of the projection that will be used.</p> <ol style="list-style-type: none"> How far posteriorly to the nipple the area of concern is, using the PNL as your reference. Note for posterior lesions in very large breasts, it is easier to measure how far anterior the area of concern is from the chest wall using the PNL as your reference. The next measurement will be made from the CC, MLO or LM/ML as follows: CC: how far medial or lateral the area of concern is from the nipple. MLO or LM/ML: How far superior or inferior the area of concern is from the PNL. The last measurement is made by extending the above line ... measuring from the area of concern to the skin.... Before transferring the measurements from the image to the patient for spot compression views, the technologies must simulate compression of the breast, using your hand. This will provide greater accuracy in locating the lesion since the original measurements were taken from an image in which the breast was well compressed”.
RANZCR & ACR ^{19,20} Three data points; measurement method not stated Simulated compression.	<p>“To determine the location of the lesion, measure</p> <ol style="list-style-type: none"> (1) the depth relative to a line drawn directly posteriorly from the nipple, (2) the distance from that line to the lesion in the superior to inferior or medial to lateral direction, and (3) the distance from the lesion to the skin surface. Then reposition the patient using your hand to simulate compression. Transfer the three measurements to the breast and use a marker to identify the location of the lesion. Reposition to centre the spot compression device over the lesion”.
Kopans ²¹ Two to three data points; measurement using fingers. Simulated compression	<p>“Most technologies use their fingers as a measuring tool. They measure the number of finger widths back from the nipple in its axis and then the number over to the lesion. Some technologies suggest getting a third measurement from the lesion to the skin to better triangulate the target. These measurements are transposed from the mammogram to the patient as her breast is held against the detector in simulated compression, the way the film from which the measurement had been derived (so that the measurements are more accurate) was obtained. The spot compression paddle is then used”.</p>
Cardenosa ³ Measurement method not stated	<p>“Effective techniques can be employed (e.g. referencing the lesion back to the nipple with measurements) so that the paddle is positioned accurately in most patients. In more challenging situations marking the position of the compression paddle on the initial images can help direct the re positioning of the paddle if additional views are required.”</p>
Andolina, Tucker and Heywang-Köbrunner ^{12,22,23}	Nil localisation technique mentioned in the text

Measure using the software measuring tool

Lesions may also be localised using the software measuring tool to determine the position of the lesion relative to the nipple (similar to the “true size” technique) by acquiring two data co-ordinates measured in millimetres (mm). These measurements are then translated to the breast using a ruler. Or alternatively by applying three measurements to additionally include directly

posterior to the nipple, the distance from that line to the lesion in the superior-to-inferior or medial-to-lateral direction, and the distance from the lesion to the closest skin surface^{18–21} (see Fig. 3). In consideration of the patient, it should be noted that taking a list of measurements into the mammography room and mapping them onto the breast can be disturbing, making them feel as though something is wrong in the breast.¹⁹ Open communication is key to avoid undue distress.

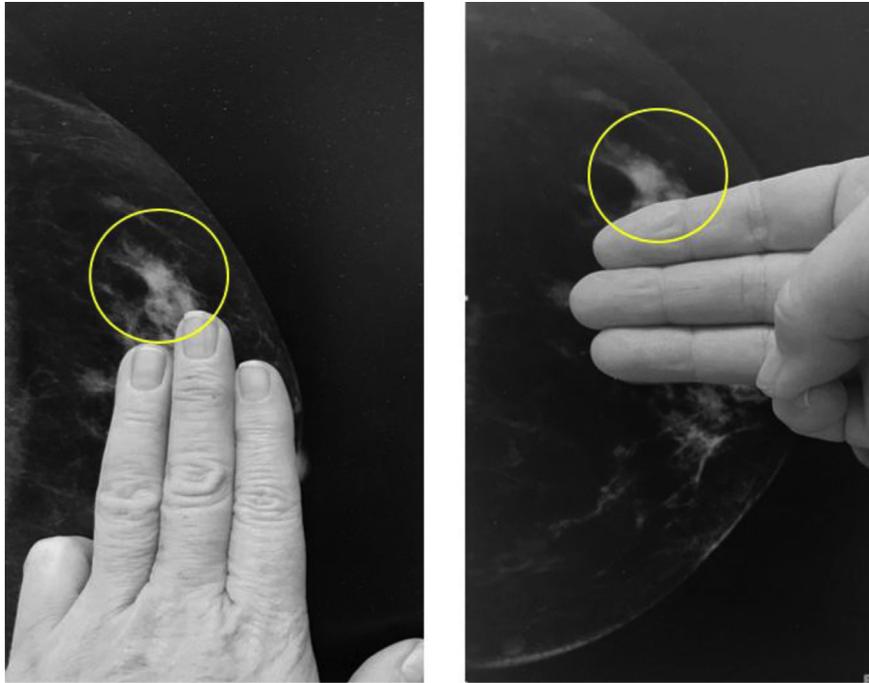


Figure 1. Demonstration of “true size” localisation in the craniocaudal (CC) projection using the fingers. In the CC projection, this lesion is measured approximately two and a half fingers posterior to the nipple and three fingers lateral to the nipple. Source: Image adapted from BreastScreen NSW.

The difficulty in maintaining the breast position whilst manipulating a ruler and marker to translate the lesion position, particularly in the MLO projection, can make this approach technically unworkable without assistance. As a technique its use is really only practicable in the CC projection where the receptor maintains the position of the breast leaving the radiographer with two free hands.

Grid technique

This technique best suits digital imaging or where available images are not “true size”, and involves continually visually breaking down the image into smaller quadrants (see Fig. 4). The lesion may appear within a quadrant to be superior, anterior, posterior, or inferior, or dissected by quadrant lines. This technique is a

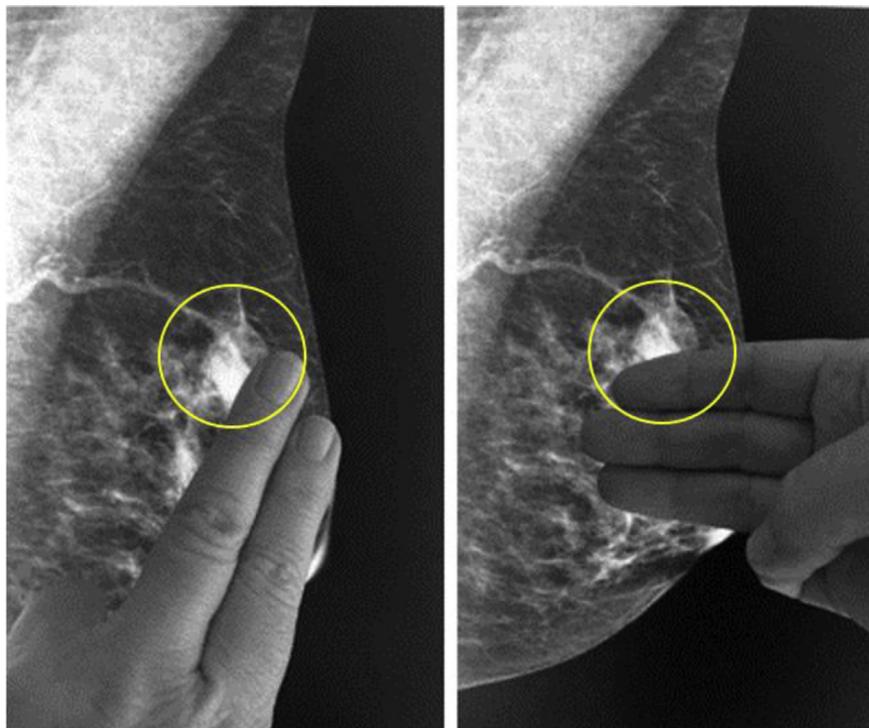


Figure 2. Demonstration of “true size” localisation in the mediolateral oblique (MLO) projection using the fingers. In the MLO projection this lesion is measured parallel to the pectoral muscle, two fingers posterior to the nipple and three fingers superior to the nipple. Source: Image adapted from BreastScreen NSW.

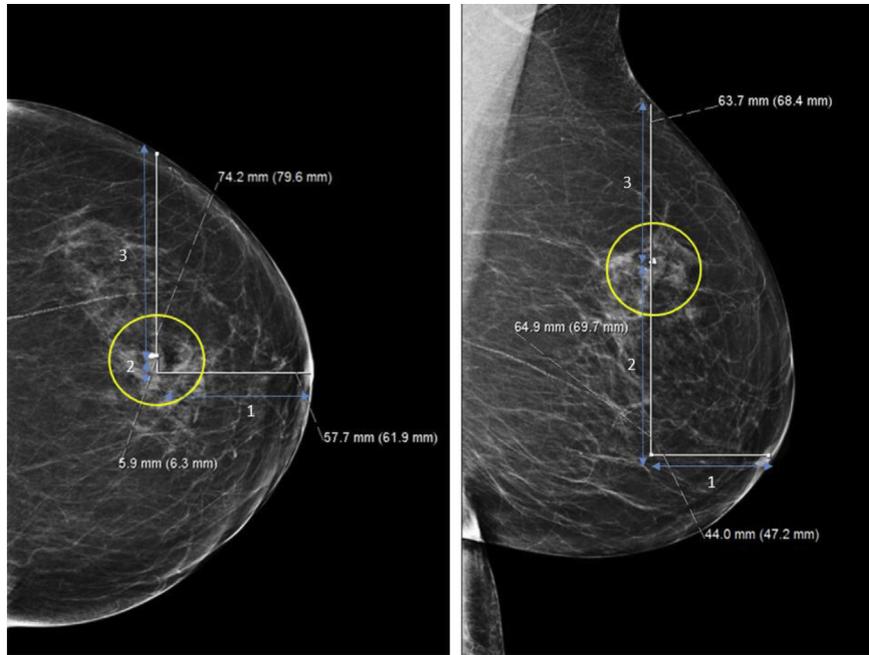


Figure 3. Localisation in the craniocaudal (CC) projection (left) and the mediolateral oblique (MLO) projection (right) using a digital ruler and three reference points. Source: Image adapted from BreastScreen NSW.

visual one and does not suit all radiographers. This technique has not previously been reported in the known literature but is acknowledged to be utilised in the clinical setting in Australia.

Discussion

Localisation techniques for work up imaging have not been well explored in the literature. Three techniques are forefront in

Australian clinical practice: fingers, digital ruler, and grid technique. This paper discusses for the first time these techniques in a contemporary FFDM context. In practice, as long as the initial positioning is replicated during localisation for work up imaging any of these techniques are potentially successful. However, it is essential to know variability between your own and fellow practitioners' positioning techniques, if any. Where a lesion cannot be localised after a limited number of attempts, a repeat mammogram

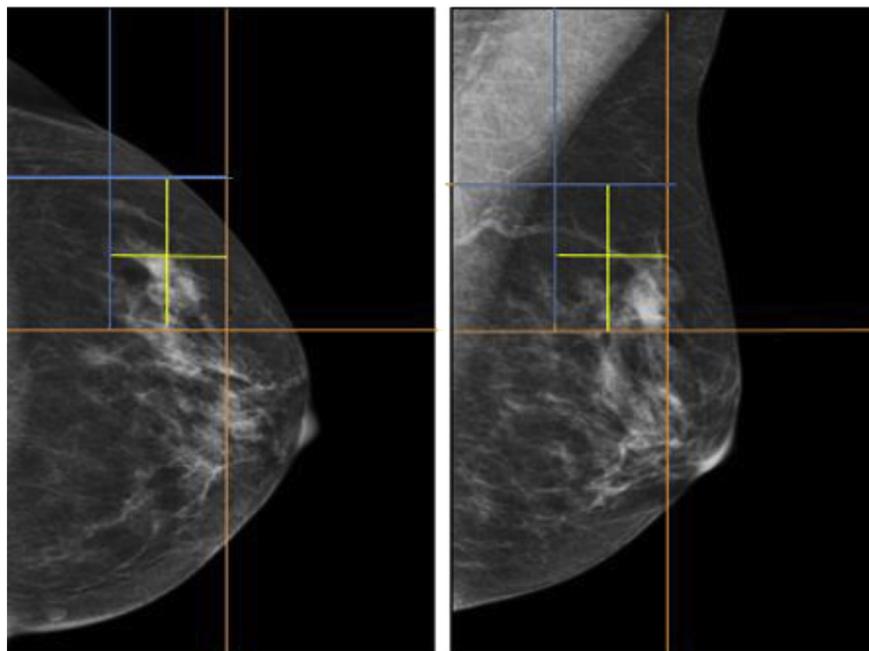


Figure 4. Localisation in the craniocaudal (CC) (left) and mediolateral oblique (MLO) (right) projection using the grid technique. Grid technique grid sequence breakdown order: orange, blue, yellow. Source: Image adapted from BreastScreen NSW. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

of the projection in question is required. Commonly, lesions may no longer appear as “real” as a result of the parenchyma altering in composition or position, or the lesion relative to the original mammogram having moved due to differences in positioning techniques between practitioners. Occasionally the lesion may have simply resolved particularly in the case of screening mammography where there is typically up to a ten day delay between the initial screening and subsequent assessment.

It is essential that all of the area being evaluated is included under the compression paddle, and further, that the lesion itself is central to the paddle.^{10,14,19} Most facilities will cone the field of view to include an area slightly larger than that of the area of interest and the compression paddle. This is useful for confirming the location of which the compression was applied, particularly when lesions resolve or “disappear” and for orientating the reader.¹⁹

It is possible on occasion, and most commonly with larger palpable masses, that a lesion may be compressed out from under the coned compression paddle. Quite often patients will give away subtle hints that this has occurred where pain whilst they are undergoing compression suddenly reduces (commonly when imaging cysts), or they themselves feel the mass move from under the paddle and articulate the same. To prevent lesion movement, patients may be asked to press the breast tissue adjacent to the paddle with their fingers to maintain the mass underneath the compression paddle. This is not done routinely due to the fact that the fingers may themselves be in the field of view and be irradiated, which does not follow the ALARA principle.²⁴ Ideally, for every coned compression image, the lesion should be demonstrated central to the coned compression paddle and be fully covered in the field of view.

Coned compression may also be performed using larger square or rectangular compression paddles, particularly where multiple lesions are present.¹⁰ Application of compression to the retroareolar region of the breast can be both painful for the woman and difficult for the practitioner. Choosing the most suitable paddle for the individual is extremely important. On occasion with small breasts, a larger paddle is desirable to the standard coned compression paddle to manage breast retraction. Coned compression requires precise positioning and has a high risk for repeat imaging. It is also limited in that it typically only provides information concerning breast tissue directly under the paddle.²⁵ Ultimately the choice of localisation method is that of the radiographer and radiographers will use different approaches to best support accurate imaging of the differing presentation of breast lesions.

Digital breast tomosynthesis (DBT)

In facilities where DBT is available, the literature supports the use of two projection DBT imaging to replace coned compression imaging for all soft-tissue lesions requiring work up, with DBT demonstrating equivalent diagnostic accuracy.^{11,25–27} For the further mammographic assessment of microcalcification, CCFMM projections in orthogonal planes are still considered gold standard.^{11,25,27,28} Hakin et al. has gone further to state that DBT may in some cases even eliminate the need for US scanning of the breast.²⁸ Another advantage is that DBT has also been demonstrated to have a lower mean glandular dose than digital coned compression.²⁷

Marker

A permanent marker should be available in the mammography room to use for work up positioning. It should only be used with the woman's consent. Ball point pens are too harsh for the delicate skin of the breast and should not be used. Anecdotally, some

radiographers do not approve of using marking pens, preferring to rely on memory alone. However, where a lesion is localised, marked, and imaged, the radiographer is afforded the knowledge (particularly in a large breast) that any repeat images are informed ones. In addition, where a stereotactic biopsy follows, localisation of the lesion can be expedited. Sonographers anecdotally also appreciate “seeing” where the region of interest was mammographically, although breast mobility may negate its overall usefulness as a reference point during US scanning.

No matter which method of localisation is used, the distance marked posteriorly should appear in the same plane in both projections. This correlation ensures imaging of the matching lesion in both projections. Where this correlation is not present it may be indicative of the lesion not being correctly identified on both images (two different lesions or only one correctly identified) or simply that incorrect measuring has occurred. Imaging should cease until the cause is identified and the issue resolved.

Conclusion

As new technology such as DBT becomes mainstream, the need for coned compression imaging has reduced, however the need for CCFMM imaging for assessment of microcalcification remains. Adapting FS localisation techniques to the digital setting is limited by the need for “true size” images on which to base measurement. Both the digital ruler and grid technique can be used as alternatives, negating the need for 1:1 ratio display as the primary method of facilitating accurate lesion localisation. The authors trust that this paper will assist understanding this aim. Looking forward, the adaptation of even newer technologies such as coned beam breast CT²⁹ may negate the need for traditional mammographic imaging, including work up projections, altogether. However, for the present, understanding the role of coned compression with or without magnification and lesion localisation techniques is a vitally important skill for any practitioner working in the modality of mammography.

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