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ORIGINAL ARTICLE

Radioguided localisation of impalpable breast lesions using 99m-Technetium macroaggregated albumin: Lessons learnt during introduction of a new technique to guide preoperative localisation

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Abstract

Introduction: Preoperative wire-guided localisation (WGL) of impalpable breast lesions is widely used but can be technically difficult. Risks include wire migration, inaccurate placement, and inadequate surgical margins. Research shows that radioguided occult lesion localisation (ROLL) is quicker, easier, and can improve surgical and cosmetic outcomes. An audited introduction of ROLL was conducted to validate the technique as a feasible alternative to WGL. **Methods:** Fifty patients with single impalpable lesions and biopsy proven malignancy or indeterminate histology underwent WGL followed by intralesional radiopharmaceutical injection of 99m-Technetium macroaggregated albumin. Postprocedural mammography was performed to demonstrate wire position, and scintigraphy to evaluate radiopharmaceutical migration. Lymphoscintigraphy and intraoperative sentinel node biopsy were performed if indicated, followed by lesion localisation and excision using a gamma probe. Specimen imaging was performed, with immediate reexcision for visibly inadequate margins. **Results:** Accurate localisation was achieved in 86% of patients with ROLL compared to 72% with WGL. All lesions were successfully removed, with clear margins in 71.8% of malignant lesions. Reexcision and intraoperative sentinel node localisation rates were equivalent to preaudit figures for WGL. ROLL was easy to perform and problems were infrequent. Inaccurate radiopharmaceutical placement necessitating WGL occurred in four patients. Minor radiopharmaceutical migration was common, but precluded using ROLL in only two cases. **Conclusions:** ROLL is effective, simple, inexpensive, and easily learnt; however, preoperative confirmation of correct radiopharmaceutical placement using mammography and the gamma probe is important to help ensure successful lesion removal. Insertion of a backup hookwire is recommended during the initial introduction of ROLL.

Introduction

Wire-guided localisation (WGL) is considered by many to be the gold standard for preoperative localisation of impalpable breast lesions. However, it can be uncomfortable, technically difficult, and carries the risk of complications such as inaccurate wire positioning or movement postplacement.[1] As the surgeon can only estimate the lesion location preoperatively, suboptimal choice of incision site may occur.

Radioguided occult lesion localisation (ROLL) is an alternative technique first described in 1998 by Luini et al.,[2] in which a small volume of a radiopharmaceutical is injected into the lesion under imaging guidance. The lesion is then located and excised intraoperatively with a gamma detecting probe, using similar principles to those of sentinel node biopsy (SNB).

ROLL is routinely used in many centres around the world. Advantages include being technically easier, quicker, higher rate of clear margins, fewer complications, and enabling surgeons to plan excision to maximise cosmetic result.[1,3,4] The one published article documenting use of ROLL in Australia[5] concluded that the technique is effective, easier, and safe. As part of our quality improvement programme, we conducted an audited introduction of ROLL with the aim of validating the technique as a feasible alternative to WGL.

Methods

Patient population

A consecutive series of patients with single impalpable lesions scheduled for wide local excision between November 2010 and July 2011 were invited to participate in a prospective audit approved by the Royal Perth Hospital Human Research Ethics Committee. All patients had imaging-guided core biopsy showing either a malignant or an indeterminate lesion requiring surgery. Pregnant patients and those with retroareolar or intraductal lesions were excluded (the latter to avoid potential radiopharmaceutical leakage into ducts). Informed consent was obtained from all participating patients.

Lesion localisation

Preoperative localisation was scheduled for the morning of surgery. To allow surgeons and radiologists to gain experience without compromising patient outcome, standard WGL was performed as a backup in case of difficulty with the ROLL procedure. After wire placement, 5 MBq of 99m-Technetium macroaggregated albumin (Draximage® MAA; Jubilant Draximage Inc, Kirkland, Quebec, Canada) in 0.2–0.3 mL was injected into the lesion centre (Fig. 1A and B), or immediately adjacent to the superficial edge if significant resistance was encountered. A 0.5 mL air bubble 'chaser' behind the radiopharmaceutical ensured the full dose was delivered. Ultrasound guidance was used wherever possible. For stereotactic localisation procedures, a radioopaque marker (Ultraclip II; Bard Biopsy Systems, Tempe, AZ) was inserted at the ROLL injection site to allow visualisation on mammography. A breast biopsy marker was used rather than radioopaque contrast as the latter tends to diffuse through adjacent tissues, making exact confirmation of the injection site difficult. Markers were not inserted for ultrasound-guided ROLL, as placement can be confirmed in real time.

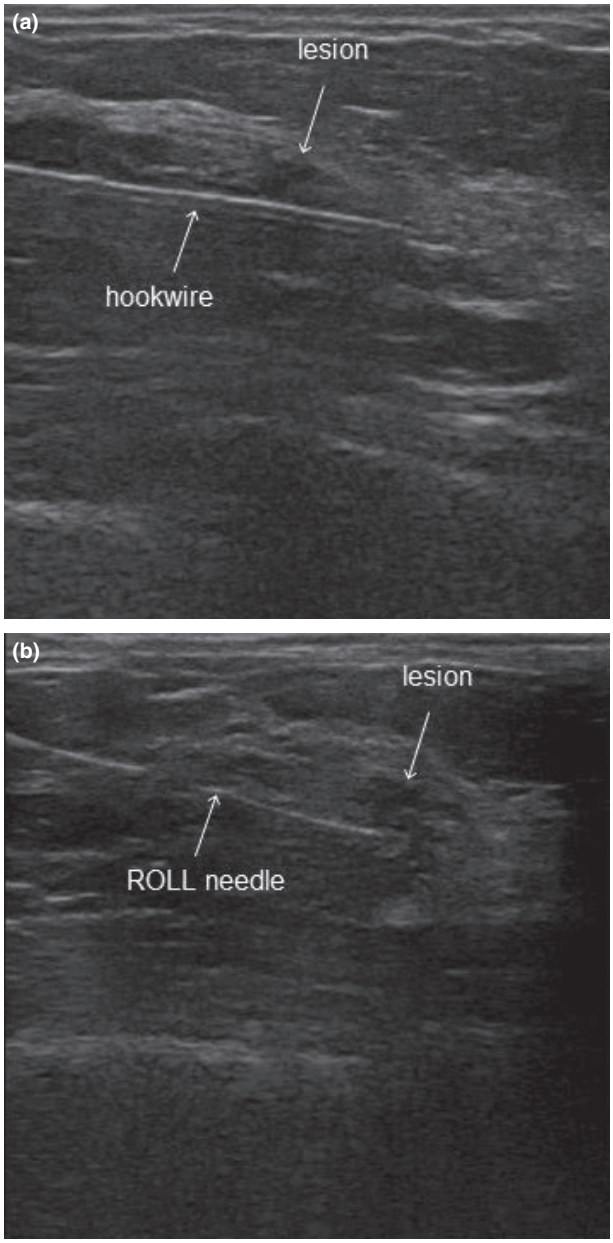

Figure 1. Images of an ill-defined hypoechoic mass during ultrasound localisation show: (A) the hookwire transversing the lesion with the tip 1 cm beyond; (B) the radioguided occult lesion localisation (ROLL) needle tip within lesion centre during injection of the radiopharmaceutical.

Accuracy of wire placement was assessed on two-view mammography by measuring the distance from the

lesion centre to the thickened segment of the wire. For stereotactic ROLL injections, accuracy was also assessed on the mammogram by measuring the distance from the lesion centre to the ROLL marker. A distance of <5 mm was regarded as satisfactory, 5–10 mm suboptimal, and >10 mm unsatisfactory. For statistical analysis, suboptimal placements were considered inaccurate and classified as unsatisfactory. Radiologists assessed the degree of difficulty of the ROLL injection technique using a 1–10 Likert scale, with 1 being easy and 10 being difficult.

Scintigraphy

Scintigraphy was performed to confirm delivery of MAA to the lesion site. Supine anterior and lateral images were obtained using a 57-Cobalt transmission source to delineate body contour, allowing approximate anatomical localisation (Fig. 2A). Images were reviewed for evidence of radiopharmaceutical mobilisation (Fig. 2C and D). Where migration was observed, regions of interest were placed around the ROLL injection site and any extralesional sites of activity. The average counts per pixel for each region were used to calculate the percentage of injected dose outside the lesion. A semiquantitative scoring scale was used to classify the degree of migration: less than 40% of MAA outside the lesion was classified as being minor, 40–60% as moderate, and greater than 60% as severe.

For patients requiring SNB, sentinel lymph node mapping was performed following an intradermal periareolar injection of 5 MBq of 99m-Technetium calcium phytate colloid (COLLOID Radpharm; Radpharm Scientific, Belconnen, ACT, Australia) in 0.1 mL. Scintigraphy was

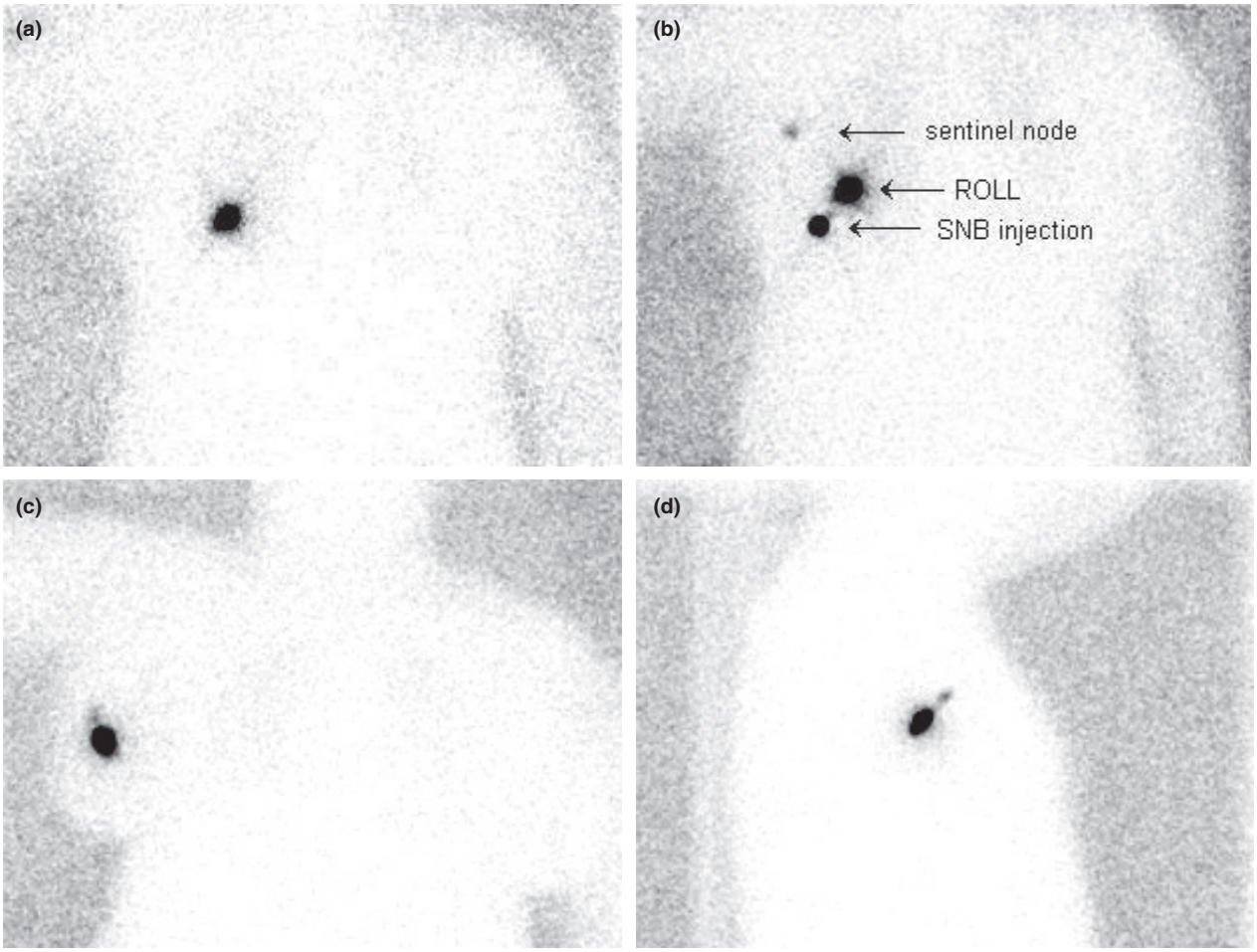

Figure 2. Scintigraphic images using a ^{57}Cobalt transmission source to delineate body contour showing: (A) a small focus of ^{99m}Tc macroaggregated albumin within the lesion following radioguided occult lesion localisation (ROLL) injection; (B) ^{99m}Tc calcium phytate colloid in a single axillary lymph node following intradermal injection for sentinel node biopsy; (C and D) radiopharmaceutical migration along the needle path following ROLL injection.

performed until the sentinel node was visualised (Fig. 2B) or the patient was required in theatre.

Surgical procedure

All patients underwent surgery on the same day as the localisation procedures. Patients for SNB first had subareolar injection of blue dye, followed by localisation and excision biopsy of the sentinel node using a gamma probe. If macroscopic pathological analysis showed metastatic involvement of the harvested node, axillary clearance was performed during the same operation. The probe was then used to localise the lesion. The count rate of the lesion in situ and the surgical bed after excision were measured. Removal of the ROLL injection site was confirmed by significant reduction in the count rate in the surgical bed. Specimen imaging was performed to confirm the presence of the lesion and for gross margin assessment. Immediate reexcision was performed where required, based on clinical assessment of the specimen during surgery.

Surgeons assessed the degree of difficulty of the ROLL technique using the same 1–10 Likert scoring scale used by the radiologists. The extent to which the probe was used for localisation and degree of assistance received from the hookwire were also assessed using a 1–10 Likert scoring scale, with 1 indicating the surgeon was able to use the probe alone and 10 indicating complete reliance on the wire.

Statistical analysis

Means with 95% confidence intervals and percentages were used for descriptive statistics for continuous and categorical variables, respectively. For inferential statistical analysis, assessment of ease of use and degree of hookwire assistance was based on ordinal logistic regression. The method is valid if the proportional odds assumption is correct and the Brant test[6] was used for this assessment. Results show that the assumption can be assumed with the lowest *P*-value greater than 0.2. For dichotomous and categorical variables, the likelihood ratio chi-squared (χ^2) test was used. For comparison of the localisation accuracy of the two methods, the McNemar χ^2 test was used. Fisher's exact test was used for comparing intraoperative sentinel node detection rates before and after introduction of ROLL. The association between breast density and ease of use ratings used the nonparametric Spearman's rho rank-order correlation coefficient.

A *P*-value of less than 0.05 was regarded as statistically significant. All analysis was conducted using the Stata package (StataCorp 2011. Stata Statistical Software: Release 12. College Station, TX: StataCorp LP).

Results

Of the 53 eligible patients, 50 were included in the audit. Three did not complete the ROLL protocol and were excluded from the analysis: one declined ROLL following difficult and painful stereotactic wire localisation; for one patient, both stereotactic wire and MAA placement were unsatisfactory necessitating further wire localisation; and the consent form for another patient could not be located, therefore ROLL was not performed. Information regarding the participants' presentation, localisation procedures, and lesion characteristics is given in Table 1.

Table 1. Clinical and radiological characteristics of patients.

Characteristics	*n* (%)
Total number of patients	50
Mean age in years	59.0 (41–82)[1]
Mean maximum lesion size (mm)	10.9 (2.5–30)[1]
Presentation	
Screen detected	45 (90)
Symptomatic	5 (10)
Lesion location	
Upper outer quadrant	30 (60)
Upper inner quadrant	16 (32)
Central and lower quadrants	4 (8)
Radiological features	
Calcifications	19 (38)
Solitary mass	14 (28)
Stromal distortion	9 (18)
Locally increased stroma	6 (12)
Stellate opacity	2 (4)
Breast tissue density (BI-RADS[2] score)	
1	15 (30)
2	22 (44)
3	7 (14)
4	6 (12)
Lesion localisation	
ROLL	23 (46)
SNOLL	27 (54)
Guidance method	
Ultrasound	30 (60)
Stereotactic	20 (40)
Sentinel nodes identified	
^{99m}Tc-MAA	3/50 (6.0)
^{99m}Tc calcium phytate colloid	
Lymphoscintigraphy	23/27 (85.2)
Intraoperative probe	26/27 (96.3)

ROLL, radioguided occult lesion localisation; MAA, macroaggregated albumin; SNOLL, combined sentinel node and occult lesion localisation.

[1]Mean (range).

[2]Breast Imaging Reporting and Data System (BI-RADS) breast composition categories developed by the American College of Radiology: breast tissue density is rated from 1 (<25% fibroglandular density) to 4 (>75% fibroglandular density).

Lesion localisation

Ultrasound-guided localisation was performed in 30 patients. In 20 patients, the lesion was not visible sonographically and therefore required stereotactic guidance. In nine of the 20 stereotactic cases, the core biopsy marker was used to target the lesion site, with residual imaging findings used in the remaining 11 cases.

Accuracy of wire and MAA positioning was reviewed (Table 2) and showed a statistically significant difference in the proportion of cases in which satisfactory positioning was achieved, with 86% accurate ROLL placements compared to 72% of wires (McNemar test: $P = 0.035$). Suboptimal or unsatisfactory placement occurred more frequently with stereotactic guidance in both wire and radioguided localisation. Unsatisfactory positioning occurred in six cases, all using stereotactic guidance: two wire only; two ROLL only; and in two cases where both ROLL and wire placement were unsatisfactory. Wire placement was suboptimal in ten cases: seven using stereotactic guidance and three with ultrasound. Placement of the MAA injection was suboptimal in three cases, all using stereotactic guidance. In two cases of dense lesions, the MAA syringe became disconnected from the needle during the injection, resulting in radioactive spillage.

Scintigraphy

ROLL scintigraphy confirmed delivery of MAA to the injection site in all cases. Sentinel node uptake was observed in three patients, indicating mobilisation of MAA through lymphatic channels. The sentinel node was located in the internal mammary chain in one and in the axilla in the other two. In another patient, minor uptake of MAA could be seen in the lungs, indicating partial intravenous administration and subsequent trapping in pulmonary capillaries (Fig. 3).

Migration of MAA away from the injection site was observed in 39 patients (78%), with the degree of migration shown in Table 3. In the majority of cases this was minor. Moderate migration was observed in six cases and severe migration in three. There was no correlation between severity and the imaging guidance method used or the time elapsed since injection. However, in 82% of cases the direction of the migration corresponded to the trajectory of the hookwire and MAA needle. Migration did not affect sentinel node localisation during SNB; however, in two cases (4%) the surgeon was unable to identify a discrete signal from the lesion and the backup wire

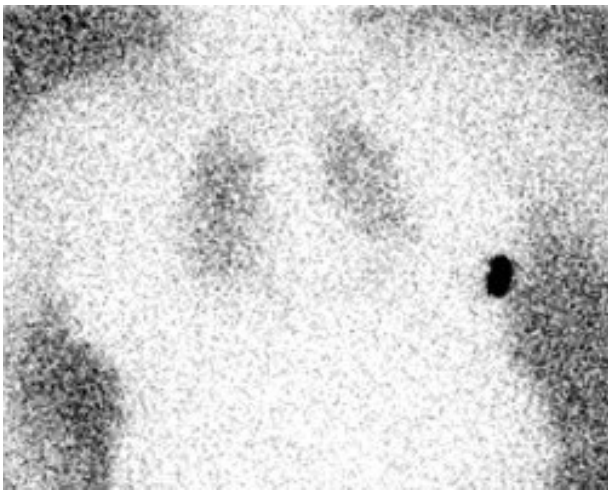

Figure 3. Minor radiopharmaceutical uptake can be seen in the lungs following ROLL injection indicating partial intravenous administration of MAA, probably into a vein adjacent the lesion. ROLL, radioguided occult lesion localisation; MAA, macroaggregated albumin.

Table 2. Comparison of the placement accuracy of ROLL and wire-guided localisation showed that accurate positioning was achieved with MAA significantly more often than with hookwire.

	MAA position		
Wire position	Satisfactory *n* (%)	Unsatisfactory *n* (%)	Total *n* (%)
Satisfactory	34 (68)	2 (4)[1]	36 (72)
Unsatisfactory	9 (18)[1]	5 (10)	14 (28)
Total	43 (86)	7 (14)	50 (100)

Positioning was considered satisfactory if the distance between the lesion centre and the wire or MAA was less than 5 mm. ROLL, radioguided occult lesion localisation; MAA, ^{99m}Tc macroaggregated albumin.

[1]McNemar test: $P = 0.035$, the test provides an assessment of the diagonal symmetry of the table by testing the equality of the discordant cells. The test shows that the difference between placement inaccuracy with MAA (4%) and hookwire (18%) is statistically significant.

Table 3. Degree of migration of radiopharmaceutical from ROLL injection site: greater than 60% of MAA found outside the lesion was classified as being severe, 40–60% as moderate, and less than 40% as minor.

	Degree of migration			
	Severe	Moderate	Minor	None
MAA remaining at injection site (%)	0–39	40–59	60–99	100
Number of patients, *n* (%)	3 (6)	6 (12)	30 (60)	11 (22)

ROLL, radioguided occult lesion localisation; MAA, macroaggregated albumin.

had to be used for successful lesion localisation and removal.

Sentinel node mapping was performed on 27 patients with scintigraphic uptake of ^{99m}Tc calcium phytate colloid observed in an axillary sentinel node in 23 cases (85.2%). The sentinel node was successfully located intraoperatively using the gamma probe in 26 cases (96.3%).

Surgery

Figure 4 shows the extent to which surgeons relied on the probe for localisation and the degree of hookwire assistance used. In the majority of cases surgeons relied more on the probe than the wire, with 12.8% of localisations achieved using the probe alone. All lesions were removed and histopathology is shown in Table 4. Eleven lesions were benign and 39 malignant. Acceptable margins were 5-10 mm for in situ disease and ≥10 mm for invasive cancer. Clear margins were achieved in 28/39 malignant lesions, and were inadequate requiring reexcision in 11 (28.2%). Of the 11 patients with inadequate margins, two with high-grade ductal carcinoma in situ (DCIS) proceeded to radiotherapy, two had mastectomy, two declined further surgery, and five had reexcision.

Ease of using ROLL technique

Radiologists' and surgeons' assessment of the difficulty of ROLL is shown in Figure 5. Degree of difficulty was classified using a semiquantitative scale: a Likert score ≤3 was classified as low; 4–8 as intermediate; and ≥9 classified as high. Both groups found ROLL easy to use, with low degree of difficulty in the majority of cases. The cases rated difficult by radiologists were not the same as those found difficult by surgeons. Using the Brandt test[6] the data were examined for correlation with age, preoperative histology, imaging guidance method, and whether SNB was performed. There was no significant correlation between these variables and the degree of difficulty reported by surgeons or radiologists. Possible associations between breast density (measured using the Breast Imaging Reporting and Data System [BI-RADS] classification),[7] radiologists' degree of difficulty, and surgeons' degree of dependence on the hookwire for lesion localisation were examined. There was a statistically significant positive association between a higher BI-RADS score and the radiologists' rating (Spearman's rho test: $P = 0.043$). However, when 95% confidence intervals around the line of best fit are considered (Fig. 6), the association is not convincing and this finding should be

Table 4. Lesion histopathology.

		Margins	
		Clear	Inadequate
Preoperative core biopsy			
DCIS	10 (20)		
IDC	20 (40)		
LCIS	2 (4)		
ILC	1 (2)		
Papillary carcinoma	1 (2)		
Indeterminate lesion	16 (32)		
Specimen			
Benign	11 (22)		
Malignant	39 (78)		
DCIS	10 (25.6)	2	8
DCIS + IDC	10 (25.6)	10	0
DCIS + LCIS	1 (2.6)	1	0
DCIS + IDC + LCIS	2 (5.1)	1	1
IDC	7 (17.9)	7	0
ILC	2 (5.1)	2	0
LCIS	3 (7.7)	2	1
LCIS + IDC	2 (5.1)	1	1
Papillary carcinoma	2 (5.1)	2	0
Total		28 (71.8)	11 (28.2)

The values are given as *n* (%). DCIS, ductal carcinoma in situ; LCIS, lobular carcinoma in situ; ILC, invasive lobular carcinoma; IDC, invasive ductal carcinoma.

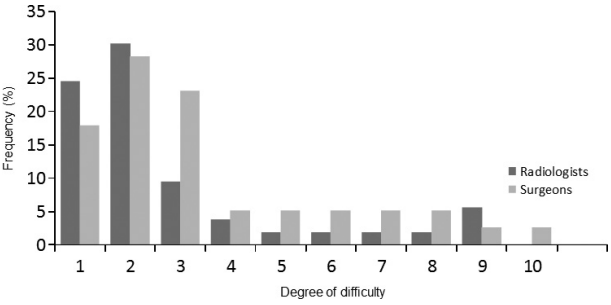

Figure 5. Ease of using radioguided occult lesion localisation (ROLL) for radiologists and surgeons assessed using a 1–10 Likert scale: easy, 1; difficult, 10.

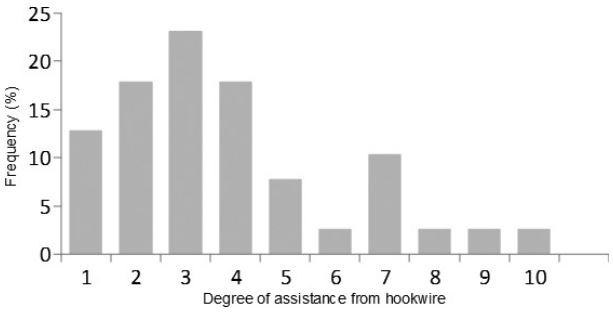

Figure 4. Degree of surgeon reliance on probe to guide intraoperative localisation assessed using Likert scores: localisation achieved with probe only, 1; localisation entirely by hookwire, 10.

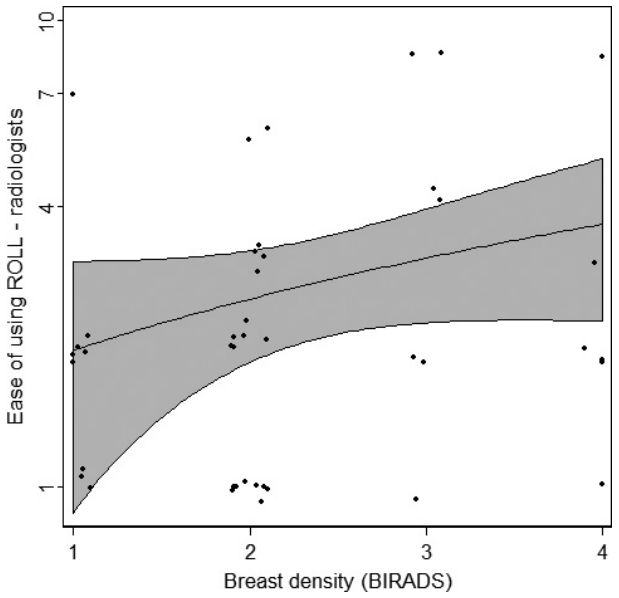

Figure 6. Graph of relationship between ease of using the procedure for radiologists and breast density (BI-RADS† score) suggests a possible association between increased breast density and higher degree of difficulty ($P = 0.043$‡). There was no significant association between BI-RADS and ease of use for surgeons ($P = 0.813$‡). †Breast Imaging Reporting and Data System: breast composition categories developed by the American College of Radiology, ‡Spearman's rho test.

regarded as preliminary. No significant association was found between breast density and the surgeons' rating of either degree of procedural difficulty ($P = 0.813$) or dependence on the hookwire for intraoperative localisation ($P = 0.802$).

Discussion

Our results indicate that ROLL can be relatively easily and successfully introduced into routine clinical practice. All lesions were successfully localised and removed. However, some significant difficulties were noted, which in some cases would have led to failed surgery had the backup hookwire not been present.

Accurate positioning of the localisation device is a key element for successful localisation of impalpable breast lesions. Although some authors consider it unnecessary to confirm accuracy of the MAA injection prior to surgery, others have injected iodinated contrast material or relied on scintigraphy to visualise the injection site. The latter methods can be unreliable. Contrast can rapidly diffuse from the injection site[8] and, with only gross anatomical landmarks, scintigraphic assessment of positioning is only approximate. Accurate injection of MAA using ultrasound is easily confirmed by direct visualisation; however, stereotactic placement is often more complex due to the effects of breast compression. Insertion of a metallic marker (as used post breast biopsy) provides a quick and easy method of confirming correct lesion labelling, with high spatial resolution and direct mammographic visualisation. Had we not checked the placement of stereotactic injection sites in this way (and in the absence of hookwire backup), surgery would have failed to remove four breast lesions. Overall, placement accuracy using ^{99m}Tc-MAA injection for lesion localisation was better than WGL. For both methods, the majority of inaccurate placements were related to stereotactic guidance, consistent with other published studies, and likely due to the 'accordion' effect noted during breast reexpansion when compression is released.[3]

A short learning curve was noted for radiologists handling the tuberculin syringes containing small volumes of liquid radioactive material. Two episodes of accidental spillage of MAA during injection occurred early in our experience when the syringe disconnected from the needle during attempted injection into the centre of dense lesions. Others have noted this and have recommended peritumoural rather than intratumoural injection in this situation.[9] We subsequently modified procedure, using Luer-lock syringes and performing perilesional injection if significant resistance was encountered. Radiopharmaceutical spills were rare, but highlighted the importance of radiation safety education and availability of spill containment kits. As the radiopharmaceutical dose used for ROLL is extremely low (~0.6% of a nuclear medicine bone scan), there is no significant radiation risk to staff from the procedure or radioisotope spillage.

Preoperative ROLL scintigraphy was performed in this audit for additional confirmation of MAA deployment and to assess radiopharmaceutical mobilisation and contamination. Our decision to use ^{99m}Tc-MAA was based on the assumption that the large particle size and clumping properties would minimise mobilisation into the lymphatic system.[10,11] Review of ROLL literature reveals variable rates of radiopharmaceutical migration and contamination within the breast, with most studies reporting low incidences or none. In past experience with sentinel node mapping of impalpable lesions post-WGL, we used a peritumoural injection of a much larger volume (1.0 mL as opposed to 0.2 mL for ROLL) and found that migration along the hookwire with leakage from the puncture site was common. Migration along the needle trajectory has been noted by others (Paredes,[12] De Cicco[11]). The incidence of migration in our audit (78%) is significantly higher than the 28.6% reported by Paredes. In our patients, the migration was a small proportion of the administered dose limited to a short distance, and could be related to mammographic compression forcing MAA along the channel created by

the presence of the hookwire. Foregoing backup WGL may eliminate migration by removing this channel. An excellent alternative to MAA would be titanium seeds containing 125-Iodine, which are not prone to migration and are visible on both mammogram and ultrasound. However, these are not as readily available as MAA and although in use in other countries, Therapeutic Goods Administration (TGA) approval for use in Australia is pending.

In two audit cases surgeons reported diffuse probe signal from the radiopharmaceutical, were unable to localise the lesion using the probe, and had to use hookwire localisation. Although scintigraphy of these patients showed the MAA confined to the injection site, it is possible that significant migration or dispersion occurred between imaging and surgery. Suboptimal probe settings (e.g., sensitivity too high) may also account for this observation, and performing probe quality control regularly prior to starting radioguided surgery is recommended. Where ROLL is used alone, satisfactory lesion marking should be confirmed preoperatively with the probe. In cases where the lesion cannot be localised, WGL should be performed before induction of anaesthesia to prevent failed surgery.

The small number of cases where MAA passed into the lymphatic system and was observed in lymph nodes is likely due to mobilisation of smaller particles (MAA particle range: 10–150 μm), and did not interfere with lesion localisation. Accidental intravenous injection of radiopharmaceutical has been reported in the literature.[13,14] Where this occurred in our audit it did not affect localisation of the lesion or sentinel node, and both were successfully removed.

An important reported advantage of ROLL over WGL is reduction in the incidence of inadequate surgical margins, likely due to the continuous three-dimensional reorientation as to the lesion centre during surgery that ROLL provides. The combined ROLL–WGL reexcision rate in our ROLL audit of 28.2% was not significantly different ($P = 0.884$) from the 26.9% noted during a previous audit in 2009, when standard WGL was used alone. This indicates that despite the difficulties experienced in a few cases, the controlled implementation of ROLL had no significant adverse effect. Overall, surgeons found lesions easier to localise with ROLL and expressed interest in pursuing radioguided localisation as a replacement for WGL.

The intraoperative sentinel node detection rate during our ROLL audit was equivalent to the rate noted in a prior audit of procedures in 2009 (Fisher's exact test $P = 0.483$). The sentinel node was successfully located with the probe in 96.3% of ROLL cases compared to 98.0% with standard WGL. The difference between the rates of scintigraphic (85.2%) and intraoperative sentinel node detection is attributed to some patients being called to theatre before the node was visualised on scintigraphy. Although our unit uses periareolar injection for SNB, others may prefer perilesional injection. Many centres routinely use a single intralesional injection of a mobile radiopharmaceutical colloid to localise both the lesion and sentinel node in a technique known as sentinel node and occult lesion localisation (SNOLL).[15]

ROLL can provide an inexpensive alternative to WGL. MAA is commonly used in nuclear medicine and is supplied in a multidose vial, the cost of which is approximately equal to a single hookwire. If multiple procedures are scheduled on the same day, cost per patient will be minimal. Facilities performing SNB will have already have access to an intraoperative probe, therefore no extra equipment needs to be purchased. As most surgeons familiar with SNB technique are already familiar with using a gamma probe, the learning curve for ROLL is short. However, before adopting ROLL as a replacement for wire localisation, it is recommended that backup WGL be provided and results audited for sufficient time to allow all members of the surgical team to become comfortable with the technique. Procedural protocols to ensure that accuracy of lesion localisation is established preoperatively are also recommended.

Conclusion

^{99m}Tc-MAA ROLL is an inexpensive, easily learnt, effective technique for preoperative breast lesion localisation preferred over WGL by radiologists and surgeons. As with WGL, the accuracy of ROLL injection must be confirmed preoperatively to help maximise the chances of an optimal surgical outcome. After stereotactic MAA injection, insertion of a breast biopsy marker is suggested to allow visualisation of the injection site. The use of Luer-lock syringes is recommended and if resistance is noted during injection into mass lesions, the needle should be withdrawn and the radiopharmaceutical injected adjacent the superficial surface of the lesion. Migration of tracer can occur, therefore confirmation of persistent satisfactory tracer concentration at the lesion site using the gamma probe prior to induction of anaesthesia is recommended. Inaccurate placement of the injection, or diffusion of the radiopharmaceutical away from the lesion site, must be rectified by hookwire insertion. ROLL using ^{99m}Tc-MAA can be successfully introduced without adverse effects on reexcision rates or intraoperative SNB.

Conflict of Interest

None declared.

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