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ORIGINAL ARTICLE

Radiofrequency-assisted intact specimen biopsy of breast tumors: critical evaluation according to the IDEAL recommendations

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Abstract

Radiofrequency-assisted intact specimen biopsy (RFIB) has been introduced for percutaneous biopsy or removal of breast tumors. Using radiofrequency cutting, the system enables the radiologist to obtain an intact sample of the target lesion. According to the IDEAL recommendations, we performed a critical evaluation of our initial experience with RFIB. Between June and November 2010, radiography-guided RFIB was performed in 19 female patients. All patients presented with suspicious microcalcifications (BI-RADS III-V) on mammography. Biopsy specimen integrity, thermal damage and histologic diagnosis were assessed by an expert breast pathologist. Data on technical success, diagnostic and therapeutic accuracy and periprocedural complications were collected and analyzed. The median age of the patients was 59 years. Median lesion diameter on mammography was 8 mm (range 2–76 mm). The procedure was successful in 16/19 (84%) patients and unsuccessful in 3/19 (16%) patients (2 non-representative samples, 1 sample with extensive thermal damage). Histologic analysis of the RFIB specimen revealed 12/19 (63%) benign lesions and 7/19 (37%) malignancies (4 ductal carcinoma in situ (DCIS) lesions and 3 invasive ductal carcinomas). In 1 patient, a DCIS lesion was completely removed with RFIB. Overall, 3 periprocedural complications occurred (1 wound leakage, 1 arterial hemorrhage and 1 infection requiring oral antibiotics). Tissue sampling of suspicious breast lesions can be performed successfully with RFIB. In 1 patient DCIS was radically excised with RFIB, which illustrates its potential as a minimally invasive therapeutic procedure for removal of small breast tumors. This is an interesting focus for further research when larger probe sizes become available.

Keywords: *Breast cancer; breast biopsy; stereotactic; percutaneous excision; thermal artifact.*

Introduction

Image-guided large core-needle biopsy (LCNB) or vacuum-assisted core-needle biopsy (VACNB) are accurate and safe methods to obtain a preoperative diagnosis of non-palpable breast lesions[1]. In 2003, a new intervention was added to the spectrum of percutaneous biopsy techniques: radiofrequency-assisted intact specimen biopsy (RFIB).

RFIB uses radiofrequency cutting and enables the radiologist to obtain an intact sample of the target lesion. Because tissue integrity is maintained and a larger sample is harvested from the target region, RFIB is expected to yield a better diagnostic performance

compared with core-needle biopsy, by reducing underestimation rates of ductal carcinoma in situ (DCIS) and atypical ductal hyperplasia. In addition, RFIB theoretically allows complete removal of small breast lesions. The first series has shown promising results, with DCIS underestimation rates varying from 3.2 to 21%[2–4] and complete excision rates for malignant lesions of 33–66%[2,5].

Evaluation of newly introduced complex interventions, such as RFIB, is challenging, due to uncertain factors such as the learning curve, unknown complications and technical failure. In 2009, a 5-stage model for the evaluation of innovative interventional procedures was introduced by members of the Balliol Collaboration, in order to achieve safe and effective innovation: the IDEAL recommendations[6]. These recommendations describe 5 distinct phases that have to be completed when introducing a new interventional procedure: Idea, Development, Exploration, Assessment and Long-term study. The authors propagate detailed reporting of early results to enable optimal technical development of a new interventional procedure.

For RFIB, the pitfalls and learning curve in the introductory period have not yet been well described. In line with the IDEAL recommendations, we have evaluated the technical feasibility and periprocedural complications of RFIB for tissue sampling of non-palpable suspicious breast lesions in clinical practice.

Methods

This study includes the first 19 patients who underwent RFIB of the breast at our institution between June and November 2010. Female patients with a suspicious mammographic lesion presenting as microcalcifications and classified as Breast Imaging Reporting and Data System[7] (BI-RADS) category III, IV or V were selected. Patients with an implanted electronic device, a distance between the lesion and skin or chest wall smaller than 6 mm under compression, or a total compression thickness of the breast smaller than 30 mm were not eligible for the procedure.

Diagnostic mammograms were assessed by an experienced breast radiologist to determine BI-RADS classification, lesion size and breast tissue density. Breast tissue density was categorized according to the 4-point scale of the BI-RADS classification (1, almost entirely fatty; 2, scattered fibroglandular densities; 3, heterogeneously dense; 4, extremely dense).

As advocated in the IDEAL recommendations, the technical aspects of each RFIB procedure were analyzed in detail by studying patient records in close collaboration with the radiologists who performed the procedure. RFIB was performed using the Intact™ Breast Lesion Excision System (BLES) (Intact Medical Corporation, Natick, MA, USA). RFIB comprises the removal of an intact breast tissue sample using a high-frequency electrosurgical cutting device. The Intact™ BLES device consists of a disposable biopsy probe connected to a controller with a radiofrequency (RF) power source and motor control unit. The probe contains an extendable basket that consists of 5 wire electrodes stretched between 5 expanding capture blades. During the extension process, the wires cut the breast tissue with an electrosurgical cutting current of approximately 350 kHz and purse down to close the distal end of the basket, thus capturing a tissue sample (Fig. 1). Depending on the size of the breast, the size of the lesion and its location within the breast, disposable biopsy probes of 15 or 20 mm were used, with basket dimensions of 15×21 mm and 20×25 mm, respectively.

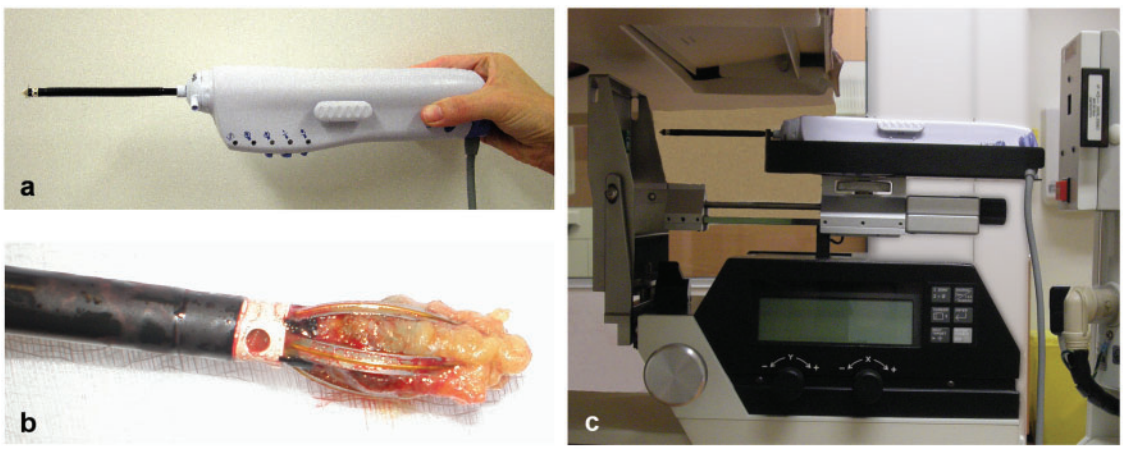

Figure 1 **The Intact™ Breast Lesion Excision System consists of a disposable biopsy probe connected to a controller with a radiofrequency (RF) power source and motor control unit (a). The probe contains an extendable basket with an RF wire that excises and captures the tissue sample (b). The biopsy system can be attached to a standard stereotactic table with a handle mount (c).**

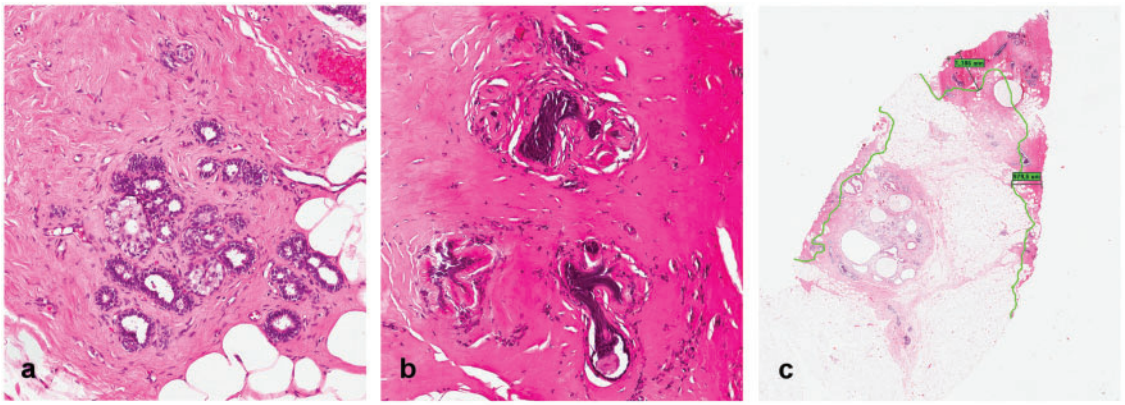

Figure 2 **Illustration of normal breast tissue (a) versus thermally damaged breast tissue (b). The latter shows blurring of the nuclei of the ductal epithelial cells and homogenization of connective tissue fibers and increased stromal eosinophilia. Thermal damage was assessed by measuring the maximum diameter of the thermal artifact zone at the equator and the poles of the biopsy specimen (c). Typically, thermal damage was more extensive towards the distal pole of the biopsy specimen, where the wire electrodes come together.**

The RFIB procedure was performed by 2 breast radiologists with at least 2 years of experience in performing radiography-guided breast biopsies and who had been trained in performing RFIB. Patients were positioned in prone position on a dedicated stereotactic table (LORAD Stereoguide, Danbury, CT, USA). After locating the breast lesion on the mammogram, the biopsy site was disinfected and a total volume of 20–30 ml lidocaine (1%) was applied subcutaneously, around the lesion in 4 quadrants, and directly posterior to the lesion. A pre-procedural scout image was obtained to check if the position of the breast lesion had changed by the local anesthetic volume and the settings of the stereotactic table were adjusted if necessary. Then a skin incision of approximately 8 mm was made. Subsequently the distal end of the biopsy probe was positioned within 5 mm of the target lesion by cold cutting through the breast tissue with the bladed tip of the probe. Correct positioning of the probe tip was verified with a scout image. Next, the RFIB device was activated to excise and capture the target lesion. An radiographic image of the biopsy specimen was obtained to check if it contained the target lesion. After the biopsy, a radiopaque marker was inserted through the biopsy canal for future localization of the biopsy site. The incision was closed using adhesive skin closure strips and covered with a sterile bandage.

The RFIB specimens were fixed in formaldehyde and routinely processed to sections that were stained with hematoxylin and eosin to establish the tissue diagnosis. A dedicated breast pathologist established the histologic diagnosis and assessed the extent of thermal damage, by measuring the maximum diameter of the thermal artifact zone in the equator of the biopsy specimen and at the poles (Fig. 2).

Table 1 Baseline patient characteristics

No. of patients	19
Age, median, years (range)	59 (37–74)
Lesion size on mammography, median, mm (range)	8 (2–76)
	n (%)
Breast tissue density on mammography	
(1) Almost entirely fatty	8 (42)
(2) Scattered fibroglandular densities	6 (32)
(3) Heterogeneously dense	4 (21)
(4) Extremely dense	1 (5)
Breast lesion classification[a]	
BI-RADS III	7 (37)
BI-RADS IV	9 (47)
BI-RADS V	3 (16)
Location of the target lesion in the breast	
Central position	2 (11)
Upper outer quadrant	6 (32)
3 o'clock position	1 (5)
Lower inner quadrant	2 (11)
6 o'clock position	2 (11)
Upper inner quadrant	2 (11)
12 o'clock position	4 (21)

[a]Categorized according to the BI-RADS lexicon[7].

Results

RFIB was performed for 19 breast lesions in 19 female patients with a median age of 59 years (Table 1). Seven breast lesions (37%) were classified as BI-RADS III, 9 (47%) as BI-RADS IV and 3 (16%) as BI-RADS V. Median lesion size on mammography was 8 mm (range 2–76 mm). All lesions were visible as microcalcifications on mammography. One lesion showed a density as well. A 20-mm probe was used in 11 patients and a 15-mm probe in 8 patients. Final histologic assessment showed 11 benign lesions (63%), 4 DCIS lesions (21%) and 3 invasive ductal carcinomas (16%) (Table 2).

Sixteen RFIB procedures were executed successfully. One DCIS lesion, presenting as a 7-mm cluster of microcalcifications, was completely excised with RFIB with a 20-mm probe. The specimen appeared to contain the whole cluster of microcalcifications on the specimen radiograph, which was confirmed by the absence of microcalcifications on the post-biopsy mammogram. Among the other 3 patients with RFIB-confirmed DCIS, surgical excision confirmed the diagnosis (i.e. no underestimation of DCIS).

Technical problems were encountered in 3 procedures. In 2 cases, biopsy samples were not considered representative on specimen radiographs. Both patients subsequently underwent a VACNB procedure. Pathologic assessment revealed a DCIS lesion and microcalcifications in one RFIB sample (as well as in the subsequent VACNB samples), and normal breast tissue in the other RFIB sample; the subsequent VACNB samples showed microcalcifications and duct ectasia with signs of chronic inflammation. In a third case, the specimen contained a probably benign lesion, but a conclusive diagnosis could not be made due to extensive thermal damage. This patient underwent subsequent open breast biopsy, revealing residual sclerosing adenosis.

Table 2 Histopathologic diagnoses

	Biopsy specimen, *n* (%)	Final diagnosis (*n*)[a]
Benign	12 (63)	1
Ductal carcinoma in situ	4 (21)	3
Invasive ductal carcinoma	3 (16)	3

[a]Only diagnoses confirmed by surgical excision are listed.

Mild to moderately severe complications occurred in 3 patients (Table 3). One patient developed arterial bleeding after insertion of a radiopaque marker. The bleeding stopped after 20 min of manual compression. A second patient presented with minimal wound leakage 7 days after the RFIB procedure. No medical intervention was required. In both cases a delayed hematoma was reported. A third patient developed an infection of the biopsy site which was treated with oral antibiotics. After 7 days the infection had subsided and the patient underwent breast conserving surgery the next day.

Assessment of thermal damage revealed that the maximum thickness of the thermal artifact zone in the equator of the biopsy specimen ranged from 0.4 to 1.5 mm (median 1.1 mm). At the poles of the specimen, the thermal artifact zone could be assessed in 13/19 specimens, showing a median diameter of 1.2 mm (range 0.7–1.9 mm).

Discussion

In this study we provide a detailed report, according to the IDEAL recommendations, of our initial clinical experiences with radiography-guided RFIB. RFIB yielded an interpretable biopsy specimen containing the target lesion in 17/19 (89%) cases. Three complications (16%) occurred, which seems to exceed the complication rate reported in previous studies.

Allen et al.[5] and Seror et al.[2] both reported 1 hematoma in their prospective cohorts of 74 and 163 patients, respectively. Among the larger retrospective cohorts of Killebrew et al.[3] and Sie et al.[4], only the latter contained 1 record of an infection that resolved with oral antibiotics, although it is possible that minor complications occurred without being recorded. The lower complication rates reported in previous studies might be

Table 3 Adverse events

Case no.	Event	Consequence	Probe size, mm	Breast density[a]	Histologic diagnosis	Case no. for radiologist
2	Wound leakage 7 days after RFIB	ER visit, no medical intervention required, hematoma >14 days	20	2	Sclerosing fibroadenoma	1st
5	Biopsy specimen not representative based on scout image and specimen radiograph	2nd biopsy procedure (VACNB)	15	1	DCIS, poorly differentiated	3rd
6	Biopsy specimen not representative on specimen radiograph and confirmed by pathology	2nd biopsy procedure (VACNB)	20	1	Dilated ducts, minimal ductal hyperplasia[b]	4th
14	Arterial bleeding after inserting the radiopaque marker	Manual pressure needed for 20 min, hematoma >14 days	15	1	DCIS, poorly differentiated	10th
18	Infection of biopsy site	Treatment with oral antibiotics	20	4	IDC and DCIS	13th
19	Biopsy specimen not assessable due to thermal damage	Wire-guided surgical excision biopsy	20	3	Sclerosing adenosis	6th

Abbreviations: RFIB, radiofrequency-assisted intact specimen biopsy; ER, emergency room; VACNB, vacuum-assisted core-needle biopsy; DCIS, ductal carcinoma in situ; IDC, invasive ductal carcinoma.
[a]Categorized according to the BI-RADS lexicon[7].
[b]Diagnosis based on the specimens from the 2nd biopsy procedure.

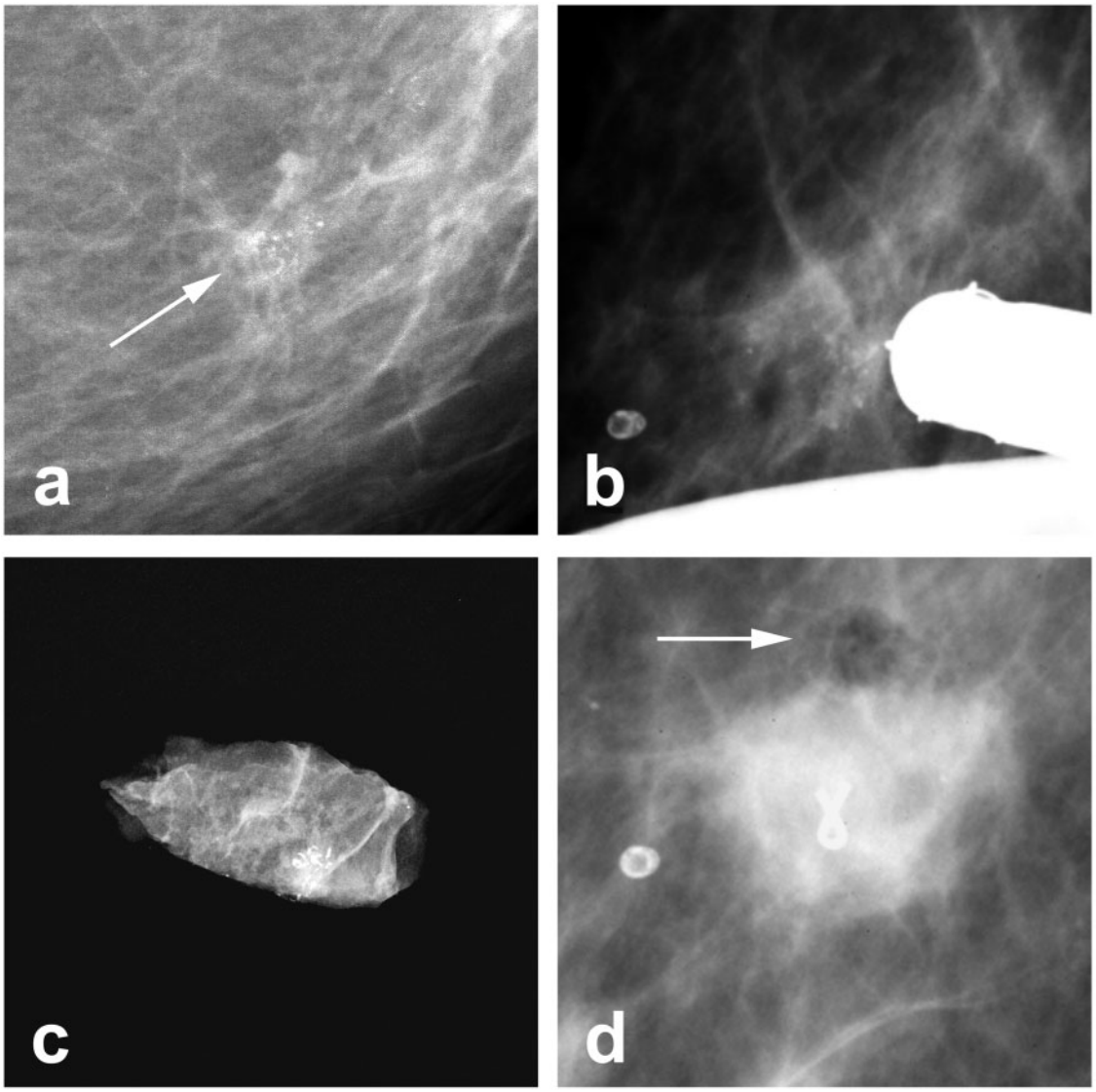

Figure 3 **Radical removal of DCIS. The lesion presented on the mammogram as a 7-mm cluster of suspicious microcalcifications (a, arrow) and was classified as BI-RADS IV. RFIB was performed after correct positioning of the biopsy probe (b), capturing the entire cluster of microcalcifications, as was confirmed by the specimen radiograph (c) and by the absence of microcalcifications on the post-biopsy scout image (d). In the post-biopsy scout image, the RFIB cavity (arrow) is visible just above the radiopaque marker.**

explained by exclusion of procedures performed during the introductory period, as mentioned by Sie et al.[4] who excluded the first 15 patients in each research site from analyses. In contrast to previous research, we followed the IDEAL recommendations[6] to assess the learning curve that precedes the implementation of RFIB in routine practice.

In contrast to previous studies, the pathology slides of our patients were reviewed for thorough assessment of thermal damage by an experienced breast pathologist. This revealed that the diameter of the thermal artifact zone in the middle of the specimen ranges from 0.4 mm to 1.5 mm (median 1.1 mm). Still, thermal damage interfered with obtaining a conclusive pathologic diagnosis in only 1 of our cases. The thermal artifact zone in the equator of this RFIB specimen was 1.0 mm, which was below the median. Because the target lesion was located at the distal pole of the specimen, where the thermal damage seems to be more extensive and the total tissue volume smaller, the specimen from that case could not be fully assessed. Allen et al.[5] reported thermal artifact zones were invariably less than 1 mm. Seror et al.[2] reported that pathologic assessment was hampered by thermal damage in 6/166 (4%) cases.

In 1 case, a DCIS lesion was excised with a clear margin with RFIB. The managing surgeon refrained from subsequent breast conserving surgery and referred the patient directly for adjuvant radiotherapy. In

addition, the patient was scheduled for mammographic follow-up. This case is illustrative of the therapeutic potential of RFIB. In our opinion, the use of RFIB as a minimally invasive procedure for percutaneous excision of small breast lesions (benign as well as malignant) should be further explored. The population of patients with a breast lesion presenting as microcalcifications on mammography might not be best suited for this, because cluster size on mammography does not correlate well with the tumor size on pathology[8]. When tumor excision with clear margins is the primary goal, perhaps patients with small (<1 cm) solid tumors without microcalcifications should preferentially be selected for RFIB[9].

All RFIB procedures in this study were performed under stereotactic guidance. With this approach, the required compression of the breast provides optimal tissue immobilization. However, a prospective study has shown that ultrasound outperforms mammography in correct estimation of lesion size[10]. In addition, ultrasound guidance provides a better three-dimensional orientation than stereotaxis, as well as real-time imaging feedback. For these reasons, we believe that ultrasound guidance should be evaluated as an alternative approach to obtain a therapeutic excision by RFIB.

In conclusion, our results show that tissue sampling of suspicious breast lesions can be performed successfully using RFIB, but technical problems and periprocedural complications can occur during the learning curve and should be evaluated at an early stage. The potential of RFIB as a minimally invasive technique for removal of small breast lesions is an interesting focus for further research.

Conflict of interest disclosure

The authors declare that they have no conflicts of interest.

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