

Prospective Study of Diagnostic Techniques for Breast Cancer in Brazil: Effectiveness and Accuracy

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Abstract

Introduction: Restrictions on the resterilization or reprocessing of core needle biopsy (CNB) needles in Brazil increased concerns about cost and access, especially in public and low-resource services. This study evaluated whether fine-needle aspiration cytology (FNAC), a faster and lower-cost method, could provide reliable diagnostic performance for breast lesions suspicious for malignancy compared with CNB and final surgical histopathology.

Methods: This prospective diagnostic accuracy study included 74 punctures performed from August 2005 to February 2007 in women treated at a public Mastology Outpatient Clinic in Porto Alegre, Brazil. Eligible patients had palpable or non-palpable breast lesions suspicious for malignancy, underwent FNAC followed by CNB, and provided written informed consent. Patients without both procedures, adequate material, or sufficient comparative data were excluded. Cytopathological, biopsy, and final surgical specimens were compared. Agreement was assessed using the kappa coefficient. Sensitivity, specificity, predictive values, and accuracy were calculated.

Results: Excluding suspicious and insufficient FNAC results, sensitivity was 91.9%, specificity was 90.0%, positive predictive value was 97.1%, negative predictive value was 75.0%, and accuracy was 91.0%. The false-negative rate was 8.1% (3/37), and the false-positive rate was 10.0% (1/10). Agreement was substantial ($Kappa = 0.7$; $p = 0.000$). Among 66 cases compared with final surgical histopathology, combined FNAC and CNB showed 97.0% sensitivity, 100.0% specificity, and 96.0% accuracy; only one case had negative FNAC and CNB results but positive final surgical histopathology.

Conclusions: FNAC showed good diagnostic performance and may support the initial evaluation of breast lesions suspicious for malignancy. FNAC and CNB are complementary methods with clinical relevance in settings where cost and access limit CNB use.

Plain Language Summary

Breast cancer is often diagnosed by taking a small sample from a breast lump. This study compared two ways of collecting these samples. Fine-needle aspiration cytology, or FNAC, uses a thin needle to remove cells for examination under a microscope. Core needle biopsy, or CNB, uses a larger needle to remove a small piece of tissue. CNB usually gives more information for treatment planning, but it can be more expensive and less available in some public health services.

In this study, 74 breast lumps that looked suspicious of cancer were tested with FNAC and then CNB. The results were also compared with the final diagnosis after surgery when this information was available. FNAC correctly identified most cancers and had a low number of incorrect positive results. The best results were seen when FNAC and CNB were used together rather than separately.

Introduction

Breast cancer is the most frequently diagnosed cancer among women worldwide and remains a leading cause of cancer-related death in many countries. Mortality is disproportionately high in low- and middle-income countries, where breast cancer death rates have increased rapidly. In Brazil, breast cancer is one of the most common tumors among women and represents a major cause of cancer mortality [1].

For Brazil, 73,610 new cases of breast cancer were estimated for 2023, corresponding to a rate of 61.61 cases per 100,000 women. Rio Grande do Sul has one of the highest breast cancer incidence rates in the country, with 4,842 new cases estimated in 2024 and an incidence rate of 83.79 per 100,000 women. In Porto Alegre, the estimated incidence rate was 82 cases per 100,000 women in 2024, according to the State Health Department.

The Brazilian National Cancer Institute estimated 73,610 new cases of female breast cancer for each year of the 2023–2025 triennium, corresponding to an age-adjusted incidence rate of 41.89 cases per 100,000 women [1]. Breast cancer remains the leading cause of cancer death among women in Brazil, with more than 20,000 deaths annually and a substantial impact among women aged 50 to 69 years [1].

Health economic reviews in low- and middle-income countries indicate a shortage of formal cost-effectiveness studies specifically comparing fine-needle aspiration cytology (FNAC) and core needle biopsy (CNB) [2].

The combination of physical examination (PE), mammography (MMG), and fine-needle aspiration cytology (FNAC) in the diagnosis of breast lesions, known as the “triple diagnosis,” has demonstrated the effectiveness of these methods. In several studies, triple diagnosis has achieved sensitivity comparable to that of incisional biopsy alone. When these findings are discordant, histological diagnosis should be performed [2–6].

FNAC is frequently used because it is accessible; however, its higher rate of inconclusive results and inability to provide complete biomarker assessment limit its usefulness as the sole diagnostic method. CNB, although initially more expensive, tends to provide more complete histopathological information for treatment planning.

FNAC was introduced in 1930 by Martin and Ellis in New York. It was accepted in Europe three decades later and became established in North America another decade thereafter [4, 5]. Because it is easy to perform and low in cost, it was the first diagnostic procedure used to obtain information on breast lesions [6]. This method consists of obtaining material for cytopathological examination through aspiration using needles with an external diameter of up to 1 mm.

In services where FNAC is not performed or where histopathological confirmation is required, CNB—also known as fragment biopsy or *tru-cut* biopsy—has become an important diagnostic method [7]. It uses large-caliber needles to obtain tissue for histopathological examination before definitive surgical treatment [8, 9].

The present study aimed to evaluate the accuracy of FNAC and CNB in breast lesions suspicious for malignancy, calculating sensitivity, specificity, and predictive values, and comparing these findings with the final histopathological diagnosis.

We hypothesized that FNAC would show diagnostic accuracy comparable to CNB and could serve as a complementary low-cost method in the evaluation of breast lesions suspicious for malignancy.

As a secondary objective, the sample was characterized according to demographic and clinicopathological variables, including age; nodular size on PE, MMG, ultrasound (US), and final pathology; and MMG and US classification according to the Breast Imaging Reporting and Data System (BI-RADS), created by the American College of Radiology (ACR) to standardize breast imaging reports.

Methods

This was a prospective diagnostic accuracy study.

Case selection: Seventy-four breast lesions suspicious of malignancy were evaluated from August 2005 to February 2007. FNAC was performed followed by CNB for diagnostic assessment, and definitive surgery was used to obtain the final histopathological diagnosis when available.

The inclusion criteria were female patients from the Breast Clinic of Hospital Santa Rita, SCPA, with palpable or non-palpable breast lesions classified by mammography and/or ultrasound as suspicious or highly suspicious for malignancy according to BI-RADS categories 4A, 4B, 4C, or 5, who underwent FNAC followed by CNB and agreed to participate after signing the informed consent form. The exclusion criteria were male sex, previous malignant neoplasm, previous radiotherapy or surgery in the same breast, and refusal or inability to sign the informed consent form.

Cytopathological and histopathological procedures were performed after skin antisepsis. Aspiration was performed with a 10 mL syringe and 0.8 × 25 mm needles, using multiple passes, approximately 10 incursions, through the palpable lesion by freehand technique. In non-palpable lesions, FNAC was ultrasound-guided using a syringe holder and needle [10].

Three aspirations were performed for each lesion, with negative pressure applied to obtain material in the needle [2]. New material and a new slide were used for each aspiration, following the American consensus recommendations for breast aspiration, totaling three slides per lesion (1996) [11]. FNAC material was stained using the Papanicolaou technique and fixed with three drops of 70% alcohol [12].

CNB was performed immediately after FNAC. After antisepsis with alcohol and local anesthesia with 3 mL of 2% lidocaine without vasoconstrictor, an approximately 4 mm skin incision was made with a number 11 scalpel blade. A 14-gauge BARD MAGNUM needle, registered with ANVISA under number 10243720013, was manually operated, attached to the biopsy gun, and introduced into the nodule to obtain tissue material.

The biopsy needle was classified as a disposable single-use product. Its resterilization or reuse has been prohibited in Brazil since 2006, according to ANVISA Resolution RDC No. 156/2006 and Resolution RE No. 2,605/2006, as well as the instructions for use approved in the sanitary registration.

Five tissue fragments were collected from each lesion. The first fragment was taken from the center of the lesion, and the remaining four fragments were obtained from each quadrant. All samples were placed in vials containing formalin for preservation [12–15].

CNB specimens were processed using routine histological techniques and stained with hematoxylin and eosin.

FNAC samples were evaluated by one examiner and histological specimens by another examiner at the SCPA Pathology Laboratory, using a double-blind design [12]. Non-palpable lesions were assessed by breast ultrasound at the hospital's Breast Radiology Service.

Ultrasound-guided FNAC and CNB were performed only in cases of non-palpable lesions because of the cost of this examination and the lack of availability of an ultrasound device in the outpatient clinic.

FNAC and CNB of palpable lesions were performed by the same examiner, whereas ultrasound-guided procedures were performed by another examiner.

Cytological and histological results were paired with the final surgical histopathological diagnosis, obtained from nodulectomy, segmentectomy, or mastectomy.

FNAC results were classified into four categories: benign (C1), malignant (C2), atypical or suspicious cells (C3), and insufficient material (C4).

Cytopathology results classified as benign were considered negative for malignancy. Cytopathology was considered positive for cancer when malignancy criteria were identified, including ductal or lobular carcinoma. Results were classified as suspicious when the criteria for malignancy were not completely fulfilled. Cytopathology samples were considered insufficient when few cells, blood, or fixation difficulties on the slides were identified.

CNB and final histopathological results were classified according to the histopathological diagnosis.

The CNB histopathological diagnosis was considered the reference standard when compared with FNAC. If different histological results were obtained for the same lesion, the definitive surgical specimen was considered the reference standard.

The remaining sample characteristics were recorded on standardized research forms.

Statistical analysis

Variables were analyzed using Excel 97, Epi Info for DOS 6.0, and SPSS (*Statistical Package for the Social Sciences*) version 14.

Categorical variables were described as absolute and relative frequencies, and quantitative variables were described as mean and standard deviation.

Agreement between examinations was assessed using the kappa coefficient. Categorical variables were compared using Fisher's exact test. A significance level of 5% was adopted.

The homogeneity of cytological and histopathological analyses was assessed between two observers, both blinded to previous results, using the interobserver kappa coefficient.

Statistical analysis was based on frequency data and diagnostic accuracy assessment, including determination of sensitivity, specificity, and positive and negative predictive values for both methods.

For FNAC accuracy analysis, two calculations were performed according to National Health Service (NHS) recommendations: complete sensitivity, in which suspicious results were included as malignant and benign cases were included as insufficient; and absolute sensitivity, which included only malignant cases and excluded suspicious and insufficient cases [17].

Sensitivity ($[TP]/[TP + FN]$) established the probability of FNAC detecting breast cancer. Specificity ($[TN]/[TN + FP]$) indicated the probability of excluding breast cancer. Positive predictive value ($PPV = [TP]/[TP + FP]$), negative predictive value ($NPV = [TN]/[TN + FN]$), and accuracy ($[TP + TN]/[TP + TN + FP + FN]$) were also calculated. TP: true positive; TN: true negative; FP: false positive; FN: false negative.

Sample size was calculated considering an estimated sensitivity of 80%, specificity of 85%, maximum confidence interval of 0.15, and confidence level of 95%, resulting in a minimum sample size of 88 cases [16].

Ethical considerations

The study was submitted to the SCPA Research Ethics Committee and was approved under protocol number 1141/05.

Results

FNAC and CNB were performed in 74 patients. Five additional patients met the inclusion criteria but did not attend the scheduled ultrasound-guided FNAC and CNB procedures and were therefore excluded. Eight patients did not undergo definitive surgery for final anatomopathological evaluation because of poor clinical condition, lack of surgical clearance, diagnosis of distant metastases, absence of nodule identification on the day of surgery, likely resolution of benign disease, or clinical follow-up. Five patients underwent neoadjuvant chemotherapy to reduce the initial nodule size and retained the same initial CNB histological diagnosis, which was concordant with the final anatomopathological result.

The mean age of the study group (n = 74) was 57 years, with a standard deviation of 14 years.

Most lesions measured between 2 and 5 cm on physical examination, imaging, and final pathology (Table 1). Most patients had palpable nodules on physical examination; only 8% had non-palpable lesions, which were evaluated using ultrasound-guided procedures. Two cases were identified as inflammatory carcinoma on physical examination, and FNAC, CNB, and skin biopsy were performed.

Table 1
Tumor size on physical examination, imaging, and final pathology. PE, physical examination; IS, imaging size; PS, pathology size; f, frequency; %, percentage.

Size (cm)	PE f (%)	IS f (%)	PS f (%)
0.5–1	2 (2.7)	8 (10.8)	2 (2.7)
1–1.5	6 (8.1)	6 (8.1)	10 (13.5)
1.5–2	13 (17.6)	18 (24.3)	11 (14.9)
2–5	36 (48.6)	28 (37.8)	33 (44.6)
> 5	9 (12.2)	3 (4.1)	4 (5.4)
Inflammatory	2 (2.7)	2 (2.7)	0 (0.0)
Non-palpable/not described/not removed	6 (8.1)	9 (12.2)	14 (18.9)
Total	74 (100.0)	74 (100.0)	74 (100.0)

FNAC cytopathology results were benign (C1) in 12 cases (16%), malignant (C2) in 35 cases (47%), suspicious or atypical (C3) in 24 cases (32%), and insufficient (C4) in 3 cases (4%).

CNB anatomopathological results were positive for cancer in 56 cases (76%), negative in 15 cases (20%), and insufficient in 3 cases (4%).

Among the 24 cases (32%) described as suspicious on FNAC, 17 (71%) were malignant on CNB histology: 9 cases of invasive ductal carcinoma and 8 cases of invasive lobular carcinoma. FNAC was unable to establish the diagnosis in 7 cases; among these, 6 (25%) were benign, including 2 cases of non-proliferative fibrocystic change, 3 cases of atypical ductal hyperplasia, 1 case of hemangioma, and 1 case with insufficient material.

Of the 3 insufficient CNB cases, 2 had invasive ductal carcinoma and 1 had non-proliferative fibrocystic change on final pathology. The histological frequencies found on CNB and final pathology are described in Table 2.

Table 2

Histological diagnosis by core needle biopsy and final pathology. CNB, core needle biopsy; f, frequency; %, percentage.

CNB diagnosis	f (%)	Final pathology	f (%)
Invasive ductal carcinoma	44 (59.5)	Invasive ductal carcinoma	49 (66.2)
Invasive lobular carcinoma	10 (13.5)	Invasive lobular carcinoma	8 (10.8)
Ductal carcinoma <i>in situ</i>	2 (2.7)	Ductal carcinoma <i>in situ</i>	2 (2.7)
Atypical ductal hyperplasia	3 (4.1)	Atypical ductal hyperplasia	1 (1.4)
Fibroadenoma	1 (1.4)	Fibroadenoma	2 (2.7)
Nonproliferative fibrocystic change	8 (10.8)	Nonproliferative fibrocystic change	2 (2.7)
Mastitis	2 (2.7)	Mastitis	1 (1.4)
Hemangioma	1 (1.4)	Angiosarcoma	1 (1.4)
Insufficient	3 (4.1)	No final pathology	8 (10.8)
Total	74 (100.0)		74 (100.0)

Of the 56 malignant CNB cases considered the gold standard, 34 were concordant with FNAC, showing malignant results. Seventeen had suspicious FNAC results, 3 FNAC results were negative, and 2 were insufficient.

The complete sensitivity of FNAC, including suspicious and insufficient results, was 91.1%, specificity was 55.6%, PPV was 86.4%, NPV was 66.7%, FN rate was 8.9% (5/56), and FP rate was 4.4% (8/18). Accuracy was 82%. The *Kappa* index was 0.5 and $p = 0.000$ (Table 3).

Table 3

Overall sensitivity of FNAC compared with the gold standard CNB.

Positive FNAC	Positive CNB (n = 56)	Negative CNB (n = 18)	Total (n = 74)
	f (%)	f (%)	f (%)
	51 (91.1)	8 (44.4)	59 (79.7)
Negative FNAC	5 (8.9)	10 (55.6)	15 (20.3)
Total	56 (100.0)	18 (100.0)	74 (100.0)

The absolute sensitivity of FNAC, excluding suspicious and insufficient results, was 91.9%, specificity was 90%, PPV was 97.1%, NPV was 75%, FN rate was 8.1% (3/37), and FP rate was 10% (1/10). Accuracy was 91%. The *Kappa* index was 0.7 and $p = 0.000$ (Table 4).

Table 4
Absolute sensitivity of FNAC compared with the gold standard CNB. CP, cytopathology; H, histopathology.

Malignant CP	Malignant H (n = 37)	Benign H (n = 10)	Total (n = 47)
	f (%)	f (%)	f (%)
	34 (91.9)	1 (10.0)	35 (74.5)
Benign CP	3 (8.1)	9 (90.0)	12 (25.5)
Total	37 (100.0)	10 (100.0)	47 (100.0)

The FNAC diagnostic accuracy rate compared with CNB was 91%, corresponding to 43 concordant diagnoses: 34 positive FNAC results with malignant CNB and 9 negative FNAC results with benign CNB. Four discordant diagnoses accounted for 9%: 1 positive FNAC with benign CNB and 3 negative FNAC results with malignant CNB.

Compared with final pathology, analyses were performed using complete sensitivity, as reported in published literature [18]. FNAC showed sensitivity of 92%, specificity of 100%, PPV of 100%, and NPV of 50%. The FN rate was 8% (5/60) among final pathology cases positive for carcinoma, and the FP rate was 0% (0/5). Accuracy was 92%. The *Kappa* index was 0.6 and $p = 0.000$. Regarding imaging examinations, most patients underwent mammography and/or ultrasound at other services without BI-RADS® classification. In these cases, films and attached images were reassessed and classified when possible (shown in Fig. 1).

When mammography and/or ultrasound findings classified as suspicious for cancer were compared, FNAC results were significantly more positive for cancer than CNB results ($p < 0.001$).

CNB sensitivity compared with its gold standard, final pathology, was 87%, specificity was 100%, PPV was 100%, and NPV was 42%. There were 8 FN cases among 60 final pathology cases positive for carcinoma, and there were no FP cases. Accuracy was 88%. The *Kappa* index was 0.5 and $p = 0.000$.

When FNAC and CNB were combined and compared with final pathology, concomitant FNAC and CNB showed sensitivity of 97%, specificity of 100%, and accuracy of 96%. In only one case were both FNAC and CNB negative for carcinoma while final pathology was positive, among a total of 66 cases.

Agreement between the examinations and their gold standards is described in Tables 5 and 6. In Table 5, concordance was significant when positive cytopathology corresponded to invasive ductal carcinoma ($p = 0.04$) and when negative cytopathology corresponded to non-proliferative fibrocystic change ($p = 0.01$). In Table 6, concordance was also significant for cancer on final pathology ($p = 0.01$) and for benign final pathology results ($p = 0.06$).

Table 5
Association between FNAC and CNB according to Fisher's exact test. f, frequency; %, percentage.

	Positive FNAC (n = 59)	Negative FNAC (n = 15)	p
	f (%)	f (%)	
Positive CNB	51 (86.4)	5 (33.3)	0.04
Negative CNB	8 (13.6)	10 (66.7)	
Total	59 (100.0)	15 (100.0)	

Table 6
Association between CNB and final pathology according to Fisher's exact test. f, frequency; %, percentage.

	Positive CNB (n = 56)	Negative CNB (n = 18)	p
	f (%)	f (%)	
Malignant final pathology	49 (87.5)	8 (44.4)	0.01
Benign final pathology	7 (12.5)	10 (55.6)	
Total	56 (100.0)	18 (100.0)	

No cases of significant local hematoma or other complications occurred after either FNAC or CNB.

Discussion

FNAC has been widely used as an initial diagnostic method for breast nodules and breast cancer in many centers worldwide. This minimally invasive test is part of the so-called triple diagnosis. It is used to confirm lesions suspicious for malignancy on physical examination and diagnostic imaging, including mammography and ultrasound. Patients with FNAC confirmation of malignancy together with concordant clinical and imaging findings may avoid CNB and proceed to surgical treatment with intraoperative frozen-section examination, thereby accelerating diagnostic management [3].

The advantages of FNAC include rapid performance, good accuracy, low morbidity, low cost, safety, feasibility during the first outpatient visit, no need for anesthesia, faster results compared with CNB, and minimal discomfort [4, 6, 12]. There are no absolute contraindications to FNAC; it can be performed in anticoagulated patients, does not alter mammographic interpretation, and pneumothorax is considered a rare complication [17].

However, cytological diagnosis has inherent limitations, particularly inadequate samples and insufficient material. The examination also depends on cytologist interpretation and specific training [12]. Aspirates judged insufficiently indicate the need for repeated FNAC or another biopsy method. In the present study, the insufficient material rate was 4%, which was lower than the average reported in the literature (7.8%).

Cytologist experience, procedural technique, nodule size, and histological type influence diagnostic accuracy and may reduce cytology sensitivity. Immediate slide assessment may also improve result accuracy. Simplified protocols to streamline workflow and telepathology are currently recommended strategies.

Specificity ranges from 97.1% to 100% (mean, 99.4%), and sensitivity ranges from 53.1% to 98.9% (mean, 89.1%) [11]. Our findings were also consistent with the absolute sensitivity of 92%, specificity of 90%, and accuracy of 91%. The literature explains false-negative results by several causes, including failure of the needle to reach the nodule; diagnosis of lobular, papillary, or tubular carcinoma; small or fibrotic tumors; and large ulcerated tumors with hemorrhage and necrotic areas [11, 13, 19, 20].

The results obtained in our sample showed sensitivity, specificity, and positive predictive value consistent with the literature; however, there was a significant number of false-negative results, probably because tumor sizes were larger at initial diagnosis and were more frequently associated with necrotic areas.

In our study, no specific confounding factor was identified among FNAC cases with false-negative results. Among FNAC results described as suspicious, 8 of 10 diagnoses were described as invasive lobular carcinoma on final pathology and CNB histology. The literature describes invasive lobular carcinoma as one of the confounding factors for false-negative results. False-positive results, also consistent with the literature, are extremely uncommon and generally below 1% [6, 13].

CNB has demonstrated high accuracy, with sensitivity ranging from 85% to 100% and specificity from 50% to 100% [9]. CNB is more invasive, has a higher cost, and requires a longer time to obtain the diagnostic result. Over time, it has also become a technique used in the diagnosis of breast nodules suspicious for malignancy.

As a sampling technique, CNB also has the possibility of false-negative results as its main limitation. These may be related to cases of atypical hyperplasia or carcinoma *in situ*. These premalignant lesions may be associated with invasive carcinoma, making complete lesion removal mandatory in such diagnoses [15, 21].

The characteristics of the study population did not differ from those reported in publications that also investigated the diagnosis of lesions suspicious for malignancy. Mean age and the predominance of invasive ductal carcinoma were consistent with available data [20, 22, 23].

In Brazil, breast cancer is still diagnosed at advanced stages in primary health care outpatient clinics of the Unified Health System (SUS), because of low screening coverage, regional inequality, and delayed treatment initiation. Therefore, the mean tumor size was 2 to 5 cm, which is not consistent with global findings.

Ultrasound contributes to increased sensitivity and specificity of FNAC and CNB in diagnosis. However, it was performed in only a small number of patients in this study because of cost, which may have limited

accuracy, particularly in cases of small and poorly palpable tumors.

Difficulty in obtaining large-core biopsy needles prolonged the study period and reduced the number of patients, because the needles could no longer be resterilized after the 2006 ANVISA regulation, increasing the cost of the examination. In developing countries, needle use interferes with the cost-benefit ratio of diagnosis. A larger sample size may have been necessary to improve examination accuracy, in addition to ultrasound use in all cases.

Most studies have not used a prospective design evaluating both methods with technical standardization **and** sequential examination use. In studies in which FNAC was superior to CNB, most included suspicious cases as positive. In addition, these studies do not present agreement data across all examinations performed.

The results show that FNAC can be accepted as a diagnostic method in our institution, as has been the case for decades in several countries. Cost reduction, especially in Brazil as a developing country, is another important factor. These findings also indicate that FNAC may be used as a complementary method, accelerating early diagnosis.

When a lesion has malignant characteristics on physical examination, is solid and palpable, and imaging examinations indicate carcinoma, in addition to a positive FNAC result for carcinoma, the patient may proceed to surgery with intraoperative frozen-section examination without previous histological confirmation [25].

FNAC is a useful method for the preoperative diagnosis of nodules suspicious for malignancy. It continues to have a role in rapid on-site assessment. It can be a complementary method and an initial screening tool, performed in primary health care units during the patient's first consultation, reducing costs and accelerating diagnosis [26].

Despite its disadvantages, a well-coordinated examiner-cytologist team can provide rapid lesion assessment and support treatment planning. Close collaboration between pathology and mastology services is essential to improve puncture technique and smear preparation, obtain adequate samples, and allow each service to assess its own case series.

Compared with CNB, FNAC has the advantage of a low false-positive rate. FNAC is a simple, low-cost, low-risk procedure with 91% accuracy and remains indispensable in the evaluation of breast lesions. Currently, the use of modern slide digitizers and artificial intelligence models may increase diagnostic accuracy.

However, only CNB can diagnose carcinoma *in situ* or tumor invasion in tissue, and it is therefore considered the gold standard for definitive diagnosis and therapeutic planning.

The combination of physical examination, imaging methods, and both diagnostic examinations increases sensitivity and accuracy compared with each method alone [27].

We believe that FNAC should not be replaced by CNB but rather combined with it, increasing the diagnostic accuracy for carcinoma in the assessment of breast lesions. FNAC remains a useful strategy in low- and middle-income countries as an initial screening method, particularly in public systems with limited resources.

These findings should be interpreted in the context of diagnostic pathways in public and resource-constrained health systems. Although CNB remains essential for histopathological characterization and treatment planning, FNAC may still have value as a rapid, low-cost, and minimally invasive method for initial assessment, especially when access to CNB is delayed or limited. In this setting, FNAC should not be viewed as a replacement for CNB, but as a complementary strategy that may help accelerate triage, support earlier referral, and reduce diagnostic delays in patients with breast lesions suspicious of malignancy.

More recent evidence suggests that FNAC retains clinical value when performed within standardized reporting systems and by experienced cytopathology teams. In the current era, its role is best understood not as a substitute for CNB, but as a rapid cytological test that may support early triage, particularly when combined with imaging and clinical assessment.

The findings of this study are therefore relevant beyond the historical context in which the data were collected. They support the concept that diagnostic pathways for breast lesions should be adapted to local resource availability, while preserving the principle that CNB remains necessary when tissue architecture, invasion status, or biomarker assessment are required for treatment planning.

Limitations

This study has limitations that should be considered when interpreting the findings. First, the final sample of 74 cases was smaller than the initially estimated minimum sample size of 88 cases, mainly because of difficulties in access to CNB needles after Brazilian regulations prohibited resterilization or reuse of single-use biopsy devices, increasing examination costs. This may have reduced the precision of diagnostic accuracy estimates. Second, this was a single-center study conducted in a public referral setting, which may limit generalizability to other health systems or regions. Third, the study period was 2005–2007; although the findings remain relevant for discussions of diagnostic access and resource-limited settings, current diagnostic pathways increasingly incorporate image-guided biopsy, biomarker assessment, and molecular testing. Fourth, ultrasound guidance was used only for non-palpable lesions because of limited availability and cost, which may have influenced sampling accuracy. Finally, not all patients underwent definitive surgery, although available follow-up and CNB findings were used to support diagnostic classification when final surgical pathology was unavailable.

It is an economical, minimally invasive, and safe diagnostic method for assessing breast lesions with a significant degree of accuracy, particularly when performed by experienced professionals [28–31].

In Brazil, delayed diagnosis of breast cancer is influenced by inequalities in access to information, socioeconomic barriers, regional differences in service availability, and difficulties in timely referral. These factors may contribute to diagnosis at more advanced stages, especially in areas with limited access to specialized breast services. In this context, diagnostic strategies that are safe, accessible, and feasible in public health settings remain relevant.

The limited availability of robust economic studies comparing FNAC and CNB in low- and middle-income countries highlights the need for future research incorporating direct costs, indirect costs, diagnostic performance, treatment delays, and patient outcomes.

For low- and middle-income countries, current evidence supports strengthening access to CNB while preserving the complementary role of FNAC where rapid, low-cost preliminary diagnosis may accelerate referral and treatment pathways.

In conclusion, FNAC demonstrated clinically useful diagnostic performance and may be used as an initial or complementary diagnostic tool for breast lesions suspicious for malignancy, particularly in settings where cost and access limit the routine use of CNB. Nevertheless, CNB remains essential for definitive histological characterization and treatment planning, and the combined use of FNAC and CNB may improve diagnostic accuracy.

Declarations

Ethics approval and consent

Approved by the SCPA Research Ethics Committee, Santa Casa de Porto Alegre, Brazil, under approval number 1141/05.

This study was conducted in accordance with the ethical principles established in the declaration on Helsinki and approved by the Research Ethics Committee of Santa Casa de Porto Alegre, under protocol number 1141/05. The Committee was founded in 1997 and is registered with the Brazilian National Commission of Ethics In research (CONEP/CNS/MS) and with U.S Department of Health and Human Services (DHHS) - IRB/office for Human Research Protections (ORPH) and IRB number IR00002509 and Federal Wide Assurance (FWA) number FWA00002949. All participants provided written informed consent prior to inclusion.

Ethics approval and consent to participate

This study protocol was reviewed and approved by the SCPA Research Ethics Committee, Santa Casa de Porto Alegre, Porto Alegre, RS, Brazil, approval number 1141/05. Written informed consent was obtained from all participants before inclusion in the study.

Consent for publication

Not applicable.

Competing interests

The authors have no conflicts of interest to declare.

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Author Contribution

DAM conceived and designed the study collected data and samples, wrote the thesis analyzed the data and conducted the final study. FAK performed all sample collections guided by ultrasound. LIB contributed to the study design and prepared terms and documents for the Ethics Committee. RL analyzed the cytology slides. CZ analyzed the pathological specimens. all authors reviewed and approved the final version.

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Availability of data and materials

The data that support the findings of this study are not publicly available due to ethical and privacy restrictions but are available from the corresponding author upon reasonable request.

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Figures

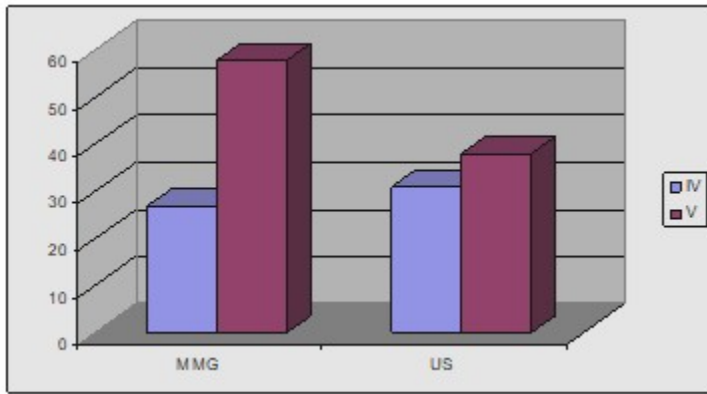


Figure 1

BI-RADS® 4 or 5 classification according to mammography and/or ultrasound findings in lesions suspicious for malignancy.