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Comparing the Accuracy of Sonoelastographic Ultrasound with Biopsy in the Assessment of Breast Masses among Nigerian Women in the Lagos University Teaching Hospital, Lagos, Nigeria

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Background: Breast cancer is the commonest cause of cancer related deaths globally, particularly in Africa where late presentation is prevalent. Early diagnosis demands the evolution of non-invasive, highly sensitive and specific screening and diagnostic investigation. This study assessed the diagnostic properties of Sonoelastography ultrasonography, in classifying breast masses compared to biopsy among women receiving care at the Lagos University Teaching hospital (LUTH), Lagos.
Methods: Using a cross-sectional, analytical study design, 100 women with breast masses were recruited consecutively as they presented to a multidisciplinary breast clinic in LUTH. They were assessed by history taking, clinical examination, and sonoelastography ultrasound was done to classify the breast masses. Breast masses were also biopsied to get a histological diagnosis. The outcomes were compared in a cross tabulation and the sensitivity, specificity, positive and negative predictive values, and accuracy were calculated for sonoelastography USS to assess its diagnostic properties. These indicators were also calculated for the 3 parameters (Elastography score, Strain and Lesion ratio) of sonoelastography USS.

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Results: The mean age of the women with breast mass was 39.4 years with a standard deviation of 13.4 years. Above half of the women were overweight (53.0%) with tertiary education (58.0%), Mean weight of breast mass was 368.7±627.6mg. Histology report and sonoelastography USS classified 46.0% and 47.0% of breast masses respectively, as malignant breast masses. The sensitivity, specificity, and accuracy of sonoelastography USS in relation to histology report was 87.0% in the study. The diagnostic performance of each parameter was good but Elastogram score was best with 69.6% sensitivity, 87.0% specificity and 79.0% accuracy.

Conclusion: This study concluded that sonoelastography is useful in characterizing breast masses as either benign or malignant which can be compared to the use of histologic diagnosis in characterizing breast masses. The Elastography score was the elastography parameter that yielded the highest diagnostic accuracy, and the lesion ratio yielded the least diagnostic accuracy. More research may be needed for better standardization of the cut-off values to be applied for the elastography parameters (Elastography score, strain ratio and lesion ratio)to improve their diagnostic performance.

Keywords: Sonoelastography USS; elastogram score; strain score; lesion ratio; biopsy; diagnostic properties.

1. INTRODUCTION

Breast cancer has been defined as the commonest female malignancy worldwide, in Africa and in Nigeria [1]. It accounts for 25.1% of female cancers with approximately 1.7 million new cases reported in 2012 and causing death of about 521,907 patients. It is also the commonest cause of cancer related deaths with a prevalence of 1 in 100 deaths worldwide and 1 in 15 cancer related deaths [2]. It is estimated that 12% of all women will have breast cancer and 3.5% will die of the disease. There is a sharp increase in the incidence of breast cancers after 40 years and even after menopause. The average age of presentation of benign masses is 27.7 years and 47 years for malignant masses with an incidence of 3.89% at 70years for malignant lesions [3,4]. The burden of breast malignancy in Nigeria has been on the increase in recent years with the incidence of 54.3 cases/1000 [5].

Various breast imaging modalities have been described and used for the characterization of breast lesions. Each technique has its strengths and weaknesses. Mammography is one of the most commonly used, in investigating the breast and can also be useful in screening exercises, but it has a drawback of its inability to differentiate solid from cystic masses, limited use in dense breast and its use of ionizing radiation [6]. Magnetic resonance imaging is also being utilized for screening women for Breast cancer. It is highly sensitivity to small occult masses and very helpful in patients with implants [6]. Contrast enhanced magnetic resonance imaging and magnetic resonance elastography are advanced techniques currently in use in developed nations for further characterization of breast masses [6]. Dynamic studies with different patterns of washout is also invaluable in the diagnosis of breast tumors. Newer techniques such as breast thermography (uses tumor temperature which is elevated in malignant lesions, as they have higher metabolic rates), optical breast imaging (uses electrical Impedance), positron emission tomography (particularly useful in recurrence) are currently in use for breast imaging and mass characterization [6].

Ultrasonography is presently used as an adjunct imaging modality to compliment X-ray mammography. Sonography is useful in patients with dense breast and has the ability to differentiate cystic from solid masses, thereby better characterizing breast masses when compared to mammography [6]. In recent years, with newer technologies and the use of Doppler sonography and Sonoelastography, breast lesions can now be characterized as benign and malignant easily and with more certainty without an invasive procedure like core fine needle biopsy. The parameters assessed are the vascularity of the breast lesion and the lesion elasticity using Young’s modulus respectively [6,7]. The sonoelastography has been helpful in better characterizing breast masses. It is particularly beneficial in characterizing BIRADS 3 and 4a lesions, which are intermediate masses [7].

Sonoelastography is a new technology that has been in use since 2005 [8]. It can be used in human subjects to differentiate benign from malignant masses. Two types of sonoelastography are currently in use; Strain and

Shear wave elastography. The efficacy of strain and shear wave elastography in giving a diagnosis of malignant as against benign lesions have been proven to be equal in a study carried out by Youk et al in 2014 [9].

Strain elastography which was first described for breast imaging has become particularly useful in assessing breast masses [8]. The strain elastography produces its stress by manual application of pressure or from respiratory or cardiovascular movements [10]. This method utilizes an external pressure/stress produced by the operator gently compressing on the lesion or by internal breathing or cardiac motions and the induced strain is recorded. This method is a qualitative method as the induced stress cannot be measured and the Young's modulus cannot be quantitatively analyzed [10] The region of interest is usually critically selected to include a region of normal breast parenchymal that will be used in the calculation of the Strain ratio and for Tsukuba scoring. A good gray scale image must be obtained in order to get a good elastogram map in this method [10].

The shear wave elastography a subtype of acoustic radiation force that is currently in use for the evaluation and characterization of masses [11]. Shear wave elastography can be performed by applying acoustic radiation force/stress produced from the transducer. This measures the Young modulus from the tissue stress and strain [10,11]. This method uses the acoustic pressure in form of transverse waves generated by the ultrasound transducer, and gives results of the strain pattern in quantitative terms (kpa) or m/s [12]. This method uses the Young modulus formula where (E) = STRESS/STRAIN to derive its quantitation in accordance to Hook's law [12]. The result analysis for this method analyses the amount of strain that was induced in the breast lesion. Breast masses having a strain range of 0 to 180 kpa. The region of interest in this method is key as the results are gotten by averaging the strain pattern within the set region of interest [11,12].

The Tsukuba University score/UENO score, the Lesion ratio and the Strain ratio are assessed while performing Sonoelastography. The Tsukuba score was developed by Itoh et al. [13] in 2006 while researching in Tsukuba University, Japan. In this scoring system, 5 parameters based on visualized uniformity of the color of the sonogram and ranging from 1 – 5, closely mimicking the BIRADS score are assessed. The Strain ratio or Fat-lesion ratio is also assessed. In this method, the strain of the mass is compared with the strain of the surrounding fat at the same depth and a ratio is obtained [10,13]. The cutoff point of 4.52 may be used in differentiating benign masses from malignant lesions [14]. However, most authors do not agree to a standardized value. Studies have also shown that either the Tsukuba score or the strain ratio can be used with none being more sensitive than the other [15].

The strain elastography and the shear wave elastography described above have their strengths and limitations. The strain elastography has been criticized for being extremely operator dependent and the results being highly dependent on the amount of strain applied to the tissue, which cannot be the same in two operators [16]. It can also not be quantitatively analyzed as the stress factor is unknown [16]. Another major drawback is that it cannot be used confidently in imaging deeper lesions, its mainly used for superficial lesions like the thyroid and breast [16]. The shear wave elastography, being a quantitative method seems to eliminate the problem of strain by using acoustic transverse waves generated by the ultrasound machine and this is more reproducible [16].

Breast cancer is a major epidemic both in Africa and worldwide [1,2]. The old methods of imaging the breasts were not sufficient with various drawbacks. Breast sonography was borne out of the desperate need to get a single imaging modality to compliment the previously used methods with increased specificity [17]. It is also extremely useful not only in diagnosing breast cancers but also in confidently diagnosing benign breast lesions. This invariably reduces benign breast biopsies reducing cost and patient discomfort [12,14]. It can also be confidently used to downgrade a grey scale BIRADS 3 lesion with soft elastographic features or lesion ratio <1 to BIRADS 2, thereby reducing unnecessary follow ups, as well as downgrade a BIRADS 4a lesion to BIRADS 3 reducing unnecessary biopsies. An intermediate gray scale BIRADS 3 lesions with hard elastographic features or lesion ratio>1 can also be upgraded to BIRADS 4a lesion, which should be biopsied for accurate diagnosis [12,18]. Breast elastography is also particularly useful in making the diagnosis and characterizing breast lesions that are not yet palpable and not yet visible with the B mode imaging. Isoechoic lesions that are difficult to diagnose with only B mode can be diagnosed with elastography when combined with Bmode [17]. Complex cysts are also well diagnosed with elastography, especially those that are difficult with B mode as cysts have a typical layering appearance on elastogram with the three colors appearing in layers giving a BGR sign (Blue, green, red) [17].

The long term benefits to the clinicians and patients will be the provision of a cheaper, less painful, less invasive, more accessible alternative method to breast biopsies especially of BIRADS 3/4a lesions with no radiation side effects and less risk to the patient. Invasive procedures like fine needle aspiration cytology and core needle biopsy have been the predominant and accepted method for diagnosing breast cancers and are being used as the gold standard presently in giving a definitive diagnosis of breast lesions. It has been estimated that about 60% of breast biopsies are unnecessary as the results end up being benign masses [14], with some literature reporting as high as 70%. This leads to waste in human and capital resources, unnecessary prolonged follow-ups and can lead to complications from biopsies. Thus, the Sonoelastography will go a long way in alleviating the aforementioned challenges and will likely assist in reducing the burden of late detection of this deadly disease in Nigeria, as patients will likely be more willing to present for non-invasive procedures.

This study evaluated the diagnostic performance of Sonoelastography in characterization and grading of breast masses, by relating sonoelastographic findings with core biopsy reports. If the results are found to be significant, it could help in differentiating benign from malignant breast masses easily thereby reducing unnecessary and avoidable breast biopsies especially for BIRADS 3 and 4 lesions. We further compared the predictive values of sonoelastographic assessment parameters which are the Tsukuba scoring system (elastograph score), lesion ratio and strain ratio and determine the parameter with the highest predictive value for ascertaining the nature of breast masses.

2. METHODOLOGY

2.1 Study Area

The study was carried out in Lagos University teaching hospital, Lagos state. Lagos state is in the south-west region of Nigeria, and it is the largest metropolitan city in Nigeria and Africa [19].

The Lagos University Teaching hospital, Idi araba, Lagos is a leading tertiary health institution in western Nigeria. The study was carried out in Radiodiagnosis department of the hospital and patients were recruited from two busy breast outpatient clinics, a multi-disciplinary breast clinic (MDT) which is the only one available in West Africa, a busy Radio-oncology clinic and well woman clinic. These clinics run a minimum of one clinic day per week. Patients were recruited from these clinics.

2.2 Study Design

The study was a cross-sectional analytical study of female patients with breast masses who had sonoelastography done on their breast mass and the findings compared to results of histology report from biopsy of the breast mass.

2.3 Study Population

The study population comprised of women with breast masses who presented at the department of Radiodiagnosis, Lagos University teaching Hospital between August 2019 and December 2019. These patients were referred from the surgery, breast and well woman clinics. Some were self-referred on detecting a breast lump during self-examination, while others were referred from family physicians, or after an incidental discovery of a breast mass on routine ultrasound examination. Inclusion criteria for the study included patients who have a breast mass (either benign or malignant), patients who are females with age ranging from 15 to 70 years and those who freely gave consent to participate in the study. Patients who had masses with dense calcifications on mammography or ultrasonography were excluded from the study as this would give a false Positive elastogram result. Other conditions for exclusion included patients who have had previous surgeries or breast trauma in the past, patients with breast implants, patients with histologically confirmed malignancy.

2.4 Sample Size

A total of 100 participants were recruited for the study in a 3-month period of 2019. Sample size was calculated using the sample size formula for estimating a single proportion in a population shown below [20].

$$n = \frac{Z^2PQ}{d^2}$$

Where Z is the standard normal deviate at 95% confidence interval which taken as 1.96; *P* is the prevalence of disease or health event under consideration which is taken as 5.4% in this study. Awodele et al reported a prevalence of 5.4% (0.054) for breast cancer in southwest Nigeria in 2011 [21]. *Q* is the complementary proportion of *P,* given as 1 – *P* (1 – 0.054 = 0.946) and d is the level of precision in the study taken as 5% (0.05). Substitution shown below yielded a minimum sample size of 78 participants. This was corrected using an attrition rate of 15% which increased the minimum sample size by approximately 12 participants to 90 participants. This was rounded up 100 participants who took part in the study.

$$n = \frac{1.96^2 \, X \, 0.054 \, X \, 0.946}{0.05^2}$$

2.5 Sampling Technique

Patients who met the eligibility criteria for the study were consecutively recruited from the above listed clinics, until the calculated sample size of 100 was obtained.

2.6 Data Collection Tool

A self–design proforrma was used for data collection in the study. It comprised of 4 sections. Section 1 explored the sociodemographic characteristics of participants, Section 2 investigated social and clinical history of participants while Section 3 captured the findings of sonoelastography. The last section of the study proforrma recorded the biopsy report from the histopathology laboratory.

2.7 Study Procedure

The objectives, procedure, and benefit of the research was explained in details to prospective patients. The safety of Sonoelastography, the discomfort and potential risks of core biopsy were explained to the patient to allay the patient's fears. Those willing to participate were then recruited into the study by signing a written informed consent form whose content was also explained to the participants. All explanation was done in plain simple English. After the consent, participants were clerked to extract sociodemographic information like age, educational status, religion and occupation. Family, social and predisposing factors to breast malignancy were also explored. The breast was later examined, Sonoelastography USS was carried out and biopsy was taken from the breast mass. The information obtained from the history taking, clinical breast examination, Sonoelastography USS and core biopsy were entered into the data collection form, from which subsequent data analysis were done.

2.8 Sonoelastographic Technique

The Strain elastograhic technique was used in this research work. Elastography was performed after a good B mode image had been obtained using a Toshiba Xario 200 machine and a 16Hz linear high frequency transducer probe. Two orthogonal cine loop were obtained. The mass was centralized on the screen and elastography was performed three times on the same mass at the same location and depth and an average was used, while the patient temporarily holds her breath to remove intra observer variations. This was done after obtaining a good gray scale image. The probe was put parallel to the lesion before elastography after sufficient quantity of gel had been applied to increase probe to skin contact, thereby reducing pre compressions. A transducer with a large footplate was used to ensure that majority of the mass was covered and that even compressions are gotten from subsequent contractions. Heel to toe movement was avoided when performing Sonoelastography. If the lesion was greater than the probe, the probe was placed in a way that majority of the lesion will be covered by the probe. The elastographic patterns were viewed simultaneously with the B mode by splitting the ultrasound screen [22]. Every lesion was assessed thoroughly and then graded using the following scores:

1. Qualitative Method (Tsukuba Ueno Score) The Tsukuba score was assigned by making a visual assessment of the pattern of the lesion color and giving it a grade based on the patterns described by Tsukuba/Ueno. Grade 1 was taken as clearly benign, Grades 2 and 3 equivocal/intermediate (likely benign) while Grade 4 and 5 were classed as malignant.
2. Semi-quantitative Method (The Strain Ratio). This was obtained by assessing the ratio of the strain of the adjacent fat to that of the lesion at the same depth. The region of interest was set at 2mm and placed in

the hardest part of the mass, and at the adjacent fat. A fat to lesion ratio was calculated and graded as benign, or malignant. A ratio of 4.5 was set as the threshold point for this study.

3. Semi- quantitative Method (The Lesion Ratio). This was calculated by comparing the size of the mass on Elastogram to the size on gray scale and obtaining a ratio. If the mass ≥ 1 (size greater on Elastogram than B-mode imaging), it was considered more likely a malignant lesion, however, if <1(Elastogram less than or equal to B Mode size) then it is likely a benign lesion. To perform quality control checks on the Elastogram obtained, the image was frozen and the Cine loop checked for uniformity of the color map.

2.9 Core Needle Biopsy

All participants had their breast mass biopsied. A core needle biopsy was done after the ultrasound scan. Participants were in a supine position, the region of the breast to be assessed was cleaned with an antiseptic solution. A local anesthesia was applied superficially and extended inwards especially for deeper lesions, to eliminate the pain from the procedure. A core needle specimen was obtained with a biopsy gun using a 14- or 16-guage Tru-cut needle. A minimum of three core samples were collected and the specimen obtained was put in formalin for preservation and sent to the histopathology laboratory for analysis. The results were categorized as either benign or malignant.

2.10 Statistical Analysis

The data collected was analyzed using Microsoft EXCEL for windows 2010 and Statistical Package for scientific solutions (SPSS) for windows, version 23. Results were summarized using frequency and proportions for categorical variables, while continuous variables were summarized using mean and standard deviation or median and range as appropriate. The categorization of breast masses by biopsy and Elastogram USS and its parameter (Elastography score, strain ratio, and a Lesion ratio) were thereafter compared to estimate the sensitivity, specificity, positive and negative predictive values and accuracy of Elastogram USS and its parameter using the formulae below.

$$Sensitivity = \frac{TP}{TP+FN} \quad (1)$$

$$Specificity = \frac{TN}{TN+FP} \quad (2)$$

$$Positive\ predictive\ Value = \frac{TP}{TP+FP} \quad (3)$$

$$Negative\ Predictive\ Value = \frac{TN}{TN+FN} \quad (4)$$

$$Accuracy = \frac{TP+TN}{TP+FN+TN+FP} \quad (5)$$

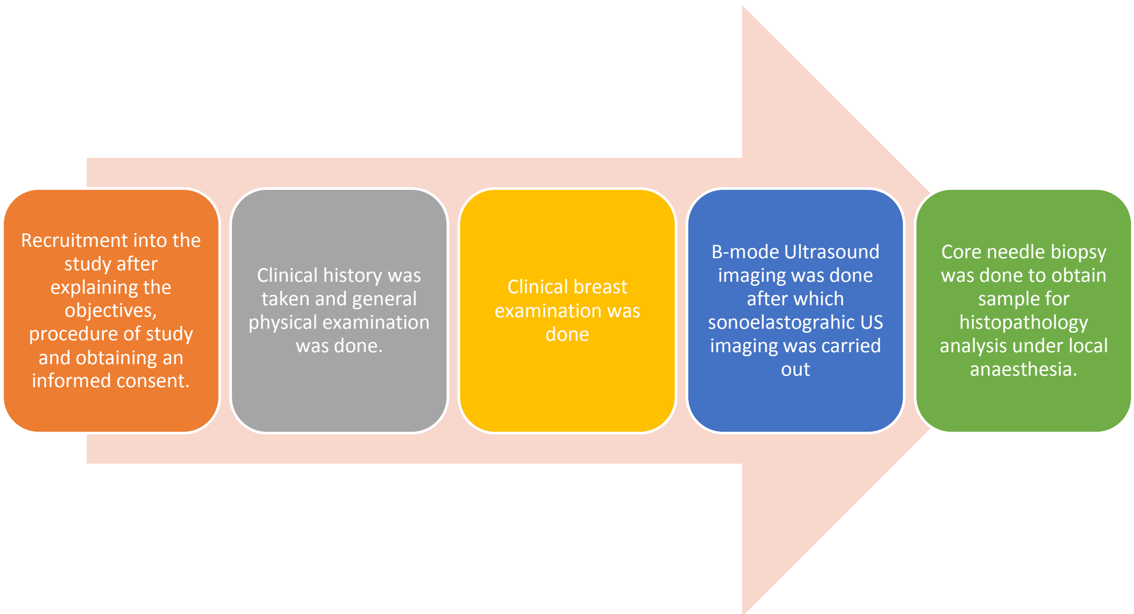

Fig. 1. Flowchart showing the different steps/procedures in the study

3. RESULTS

3.1 Sociodemographic Characteristics of Participants and Features of Breast Mass

A total of one hundred women with breast mass who presented to the health facility and gave consent for the study in the study period were recruited. Slightly above a quarter of participants were in the fourth (27.0%) and fifth (28.0%) decades of life. Mean age was 39.4 years with a standard deviation of 13,4 years (Table 2). Majority of the women were married (63.0%), with mean age of menarche at 13.3 years (SD – 1.8 years) and 2 was the median number of children. Number of children range between 0 and 8 children (Table 1). Table 1 also show that most of the women had tertiary education as the highest education attainment (58.0%) and were overweight (53.0%).

Table 2 shows that most of the breast mass were in the right breast (56.0%), and only two participants had breast mass in the two breasts (2,0%). Mean size of the breast mass in the study was 368.7milligram with a standard deviation of 627.60 milligram.

3.2 Biopsy and Sonoelastography Ultrasonographic Classification of Breast Mass

From biopsy report, sample taken from 46 participants were malignant breast mass (46.0%), meanwhile Elastogram USS classified 47 breast mass as malignant (47.0%) and 53 (53.0%) as benign. However, Elastography score, strain score and lesion ratio classified 39.0%, 27.0% and 27.0% of breast mass as malignant respectively (Table 3).

Furthermore, in Table 3, the median score (and range of score) for Elastography and Strain ratio were 3.0 (1.0 – 6.0) and 2.2 (0.0 – 51.4) respectively) while the mean Lesion ratio was 1.0 with a standard deviation of 0.3.

3.3 The Diagnostic Performance of Sonoelastography in Relation to Biopsy Findings

3.3.1 Diagnostic performance of elastogram ultrasonography

Elastogram ultrasonography identified correctly identify 40 cases (True positive) as positive cases out of the 46 so classified by biopsy, and identified 47 cases correctly as negative cases (True negative), out of the 54 classified as negative. Both the sensitivity and specificity of elastography USS were 87.0% (Tables 4 and 5).

3.3.2 Diagnostic performance of elastogram ultrasonography parameters

Elastography score among the Sonoelastography parameter identified 32 True positive cases and 47 true negative cases giving sensitivity and specificity of 69.6% and 87.0% respectively (Table 4). Both False negative cases (27 cases) and false positive cases (8 cases) were highest with the results from Lesion ratio (Table 4).

As shown in Table 5, elastography USS has a positive predictive value of 85.1%, negative predictive value of 88.7% and accuracy of 87.0%. Elastography score had the highest accurate results in relation to Biopsy (79.0%) out of the 3 parameter of Elastogram USS. The Lesion ratio and Strain ratio were most sensitive (80.4%) and most specific (94.4%) respectively among the parameters of Elastogram USS (Table 5).

4. DISCUSSION

Three elastography parameters namely the Tsukuba/Elastography score, the strain ratio and lesion ratio were evaluated to assess the diagnostic performance of Sonoelastography in characterization and grading of breast masses, by relating sonoelastographic findings with histopathological reports from examination of biopsy samples. The results of the three methods were significantly similar to Biopsy results in diagnosing breast malignancy. Tsukuba elastography score and the strain ratio were found to be the parameters with superior prediction for malignancy. Tsukuba elastography score was the best performing screening parameter of the three parameters of elastography sonography, while the lesion ratio was worst. This outcome is in line with conclusions from numerous other studies [23-27] whose results proved that elastography score was the best elastography parameter in screening for breast malignancy. Yearli et al. [25] Youk et al. [24] Mutala et al. [15] and Chung et al. [27] who studied the diagnostic properties of elastography sonography in 2011, 2014, 2016 and 2019 respectively all reported elastography score as the best performing parameter just as reported in this study. However, the work by Lee et al. [28] in 2014 reported strain ratio as the best performing parameter. The differing results may be as a result of the different algorithms used by different machines, as strain ratio is highly dependent on machine algorithms. Mutala et al. [15] in their study, concluded that the elastography score and strain ratio were equally good in differentiating breast masses with none being superior, however, this study demonstrates a slight superiority by the elastography score.

Table 1. Sociodemographic Characteristics of Participants in the study

Characteristics	Frequency (N = 100)	Percent (%)
Age of participants		
≤ 30 years	27	27.0
31 - 40 years	27	27.0
41 - 50 years	28	28.0
> 50 years	18	18.0
Mean age of participants in years (SD*)	39.4 (13.4)	
Marital status		
Single	37	37.0
Married	63	63.0
Mean age of menarche in years (SD*)	13.3 (1.8)	
Median number of children (Range)	2 (0 – 8)	
Highest educational attainment		
Primary	6	6.0
Secondary	36	36.0
Tertiary	58	58.0
Nutritional status		
Underweight	11	11.0
Normal Weight	13	13.0
Overweight	53	53.0
Obese	23	23.0
Mean body mass index in Kg/m^2 (SD*)	26.3 (4.8)	
Occupational status		
Formal Employed	31	31.0
Self Employed	43	43.0
Unemployed	26	26.0

**SD – Standard Deviation*

Table 2. Distribution of features and known risk factors of breast cancer among Study participants

Characteristics	Frequency (N = 100)	Percent (%)
Features		
Breast affected		
Right Breast	56	56.0
Left Breast	42	42.0
Both Breasts	2	2.0
Quadrant of breast affected		
First Quadrant	27	27.0
Second Quadrant	15	15.0
Third Quadrant	36	36.0
Fourth Quadrant	22	22.0
Shape of breast mass		
Round	17	17.0
Oval	49	49.0
Irregular	34	34.0
Breast mass size Mean (SD*) in milligram	368.7 (627.60)	

Table 3. Biopsy and elastographic classification of breast masses of participants

Characteristics	Frequency	Percent (%)
Biopsy		
Benign	54	54.0%
Malignant	46	46.0%
Elastogram USS		
Benign	53	53.0%
Malignant	47	47.0%
Elastographic parameter		
Elastography score		
1 – 3	61	61.0
4 – 5	39	39.0
Median Score (Range)	3.0 (1.0 – 6.0)	
Strain ratio value		
< 4.5	73	73.0
≥ 4.5	27	27.0
Median value (Range)	2.2 (0.0 – 51.4)	
Lesion ratio		
< 1	35	35.0
≥ 1	65	65.0
Mean value (Standard deviation)	1.0 (0.3)	

Table 4. Cross tabulation of elastographic USS against biopsy findings

Radiological Screening tests	Biopsy		Total
	Malignancy N = 46 (%)	Benign N = 54 (%)	N = 100 (%)
Elastogram USS			
Malignancy	40 (87.0)	7 (13.0)	47 (47.0)
Benign	6 (13.0)	47 (87.0)	53 (53.0)
Elastogram USS parameter			
Elastography score			
Malignancy (4 – 5)	32 (69.6)	7 (13.0)	39 (39.0)
Benign (1 – 3)	14 (30.4)	47 (87.0)	61 (61.0)
Strain ratio value			
Malignancy (≥ 4.5)	24 (52.2)	3 (5.6)	27 (27.0)
Benign (< 4.5)	22 (47.8)	51 (94.4)	73 (73.0)
Lesion ratio			
Malignancy (>1)	19 (41.3)	8 (14.8)	27 (27.0)
Benign (≤ 1)	27 (58.7)	46 (85.2)	73 (73.0)

Table 5. Diagnostic properties of elastographic USS and its diagnostic parameters

Radiological test characteristics	Diagnostic properties of screening tests in percent (%)				
	Sensitivity	Specificity	PPV	NPV	Accuracy
Screening tests					
Elastogram	87.0	87.0	85.1	88.7	87.0
Elastographic parameters					
Elastography Score	69.6	87.0	82.1	77.0	79.0
Strain Ratio	52.2	94.4	88.9	69.9	75.0
Lesion Ratio	80.4	48.1	56.9	74.3	63.0

The lesion ratio which was found to be the least predictive value in this study did not agree with the work by Barr et al. [12]. They proposed the lesion ratio as the most predictive parameter which was not in keeping with previously published works. Most malignant masses in our work were found to have a borderline ratio of 1, with few having values greater than 1. The greater size of masses found on the elastogram of malignant masses has been attributed to the desmoplastic reactions which they elicit. This has a direct relationship with the histological type of the mass, [29] and the results of this method will be highly dependent on the sub type of malignancy encountered. This may have contributed to the disparity in both study as they were performed in different locations that have different predominant malignant subtypes, it may also be due to operator expertise.

The major drawback with lesion ratio is with the method of measurement. Extreme care must be taken to avoid over measurements on the B mode image which could occur especially in patients with dense breast where the boundaries of the mass and the glandular breast are not distinct. It is also noteworthy that on review of literature, lesion ratio is the least parameter that has been evaluated of the three methods and is most likely the newest of them all. This therefore calls for more study to evaluate the performance of lesion ratio in evaluating masses. The lesion ratio was measured by obtaining the lesion diameter on the elastogram and comparing it with that on the B-mode. The cutoff point was found to be 0.98 which approximates to a whole number of 1, below which it was benign, and above which it was malignant.

Analysis of the various performance of the final elastography category demonstrated that it had a sensitivity, specificity, and accuracy of 87%. The work of Chung et al. [27] showed a sensitivity of 86.5% and specificity of 89.9% similar to this study. The individual parameters were also individually analyzed to ascertain their performance, and the parameter with the best sensitivity was the lesion ratio, however it had the poorest specificity and accuracy. Strain ratio showed the best specificity followed closely by the elastography scores, but each showed a lower specificity when compared with what was obtained with the lesion ratio. This being said, elastography score still demonstrated the best accuracy of all the three parameters. These results show that to get the best of results in categorizing breast masses, it would be a better practice to use a combination of the three parameters.

The recommended cut-off threshold for malignancy, using the elastography score was ≥3, below this threshold a breast mass should be categorized as benign while above or equal, the mass will be malignant. This agreed with the cut off value of 4 obtained by Itoh et al. [13] and Bojanic et al. [30]. in their studies, where they each evaluated breast masses using elastography.

The strain ratio threshold point was used in this study was 4.5. below which the mass is benign and above which or equal to it is malignant. This finding was in variance with Bojanic et al. [30] who recommended a threshold of 3.5 but in keeping with that of Barr et al. [31] who suggested a cut off value of 4.8. This difference observed in the assessment methods on strain elastography may be as a result of the absence or presence of pre compressions that may be observed and are known to affect the strain ratio and may give a false result [31,32]. This factor cannot be eliminated as the scans were performed by different sonographers for the different studies. The other factor that may affect the result of strain ratio obtained by different researchers is the algorithm with which different ultrasound machines employ for calculating the strain ratios, which could lead to varying results. Another problem with the strain ratio is that unlike the 5-point Tsukuba/elastography score which is standardized, the strain ratio does not have a definite defined and acceptable cut off standard value yet [31] and as such different researchers are likely to obtain different results. In the same vein, strain ratio has a challenge with the appropriate placement of the ROI of the mass and fat at the same depth. If this is not strictly adhered too, different researchers may obtain different values due to inter-observer variability [27,33].

A limitation in this study was that the histopathology results were analyzed by different pathologists, which may lead to some loss in the accuracy of the results as there was no checks and cross checks applied to the results. The ideal would have been for two independent pathologists to evaluate the results, and if there was any disparity, a third pathologist to solve it. This effect of this limitation was reduced by ensuring that only an experienced Consultant histopathologists analyzed each of the results.

5. CONCLUSION

In conclusion, despite this limitation, the findings of this study revealed that Sonoelastography is useful in characterizing breast masses as either benign or malignant. The Elastography/Tsukuba score was the elastography parameter with the best diagnostic performance and was followed closely by the strain ratio and then the lesion ratio was the least performing. At present, no definite cut-off for strain ratio has been clearly established as a standard unlike the elastography score. Various authors use various cut off points as their standard. The lesion ratio which is relatively new, has also not been thoroughly evaluated. More research work is needed on this subject area for better standardization, as the use of elastography is a promising area in ultrasound medicine with extremely useful abilities in differentiating breast masses. This is especially importance in our content where women frown at invasive procedures like biopsy as a screening/diagnostic investigation. Sonoelastography would serve as a veritable alternative to biopsy in screening for biopsy cancer among women with breast masses and ultimately contribute to early detection and overall reduction of the leading female cancer in Nigeria.

CONSENT AND ETHICAL APPROVAL

Research approval was obtained from the Research and Ethics committee of Lagos University Teaching hospital, Lagos (Approval number: ADM/DCST/HREC/APP/2687). The following ethical issues, consent, confidentiality, beneficence, and non-maleficence were also considered. For informed consent, the purpose of the study was explained to all the participants. No participants were denied any form of service upon refusal to consent to the study or a promise of facilitation of services to coerce them into giving consent. Participants were informed of their right to withdraw from the study at any time without any effect on the care they would receive. Written Informed consent was obtained for the study and for the biopsy from the participants on an individual basis by either signing or thumb printing. Only participants who gave consent for the study were recruited. Confidentiality was ensured by keeping all information including history, physical examination findings and results obtained from the participants' biopsy strictly confidential and they were only identified by code numbers, a unique identifier on the study proforma. The participants were assured that their identity would be kept in confidence by the Investigator. Beneficence was guaranteed by ensuring that the Elastography USS and biopsy were carried out at no financial cost to the participants. The results obtained from this study also contributed to the effective management of participants and improve the quality of care of participants. Non-maleficence to all participants was ensured by causing minimal discomfort to participants. All procedures were administered by trained researchers to prevent untold harm and unnecessary anxiety and agitation to the participants. Biopsy was carried out by an experienced consultant pathologist to ensure very minimal discomfort is caused to the participants. A local anesthetic agent was also given to eliminate pain.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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