Annals of R.S.C.B., ISSN:1583-6258, Vol. 25, Issue 3, 2021, Pages. 3356 - 3367
Received 16 February 2021; Accepted 08 March 2021.

Role of Arfi (Acoustic Radiation Force Impulse Imaging) in Differentiating Benign and Malignant Breast Lesions

J. Jayapriya, M. Prabakaran*

Department of Radio diagnosis, Sree Balaji Medical College & Hospital Affiliated to Bharath Institute of Higher Education and Research, Chennai, Tamil Nadu, India

Corresponding author e-mail id: prabakaran.m@bharathuniv.ac.in

ABSTRACT

To differentiate benign breast lesions from malignant breast lesions non-invasively using ARFI elastography technique. To establish tissue stiffness (TS) index values to differentiate benign and malignant lesions.To derive sensitivity and specificity, positive and negative predictive values of ARFI in identifying benign and malignant lesions. Hence routine ultrasound with ARFI correlation enhances the imaging diagnostic accuracy in categorising benign and malignant breast lesions.

Key words: ARFI, elastography, benign, malignant, b-mode

1. INTRODUCTION

A lump in the breast is a cause of great concern. High frequency, high-resolution ultrasound helps in its evaluation. This is exemplified in women with dense breast tissue where ultrasound (US) is useful in detecting small breast cancers that are not seen on mammography.[1] The highest quality breast sonograms are achieved with 5 -10- MHz linear transducers, imaging the lesion within the transducer focal zone, and relatively steep time-gain compensation curves.

On sonograms, the fat in normal breast parenchyma is hypoechoic, fibrous tissue is echogenic, and glandular tissue is intermediate in echogenicity. Cysts have an anechoic interior, sharp margins, and posterior acoustic enhancement. Benign solid lesions are usually hypoechoic but variable in US appearance, which can overlap with that of complicated cysts. The classic US appearance of breast carcinoma is a hypoechoic mass with inhomogeneous internal echoes, irregular margins, and variable acoustic shadowing, although carcinoma can appear well circumscribed or have posterior acoustic shadowing in some cases.[2,3] The most important function of breast US is differentiating a cyst from a solid lesion. US is also useful for evaluating a palpable mass in either young patients (< 30 years old) or those with dense breasts and

Annals of R.S.C.B., ISSN:1583-6258, Vol. 25, Issue 3, 2021, Pages. 3356 - 3367
Received 16 February 2021; Accepted 08 March 2021.

negative mammographic results.

Elastography is a promising way to assess tissue differences regarding stiffness or elasticity which has been historically assessed manually by palpation. Combined with conventional imaging modalities, elastography can potentially evaluate the stiffness of a breast lesion and consequently help to detect malignant breast tumor from benign ones.[4]The recent introduction of elastography has increased the specificity of USG and enabled earlier diagnosis of breast cancer. The use of quantitative elastography with shear wave elastography (SE) improves diagnostic accuracy in cases with equivocal Stavros criteria (stages 3 and 4 BI- RADS).Shear wave elastography (SE) differentiates between benign and malignant lesions on the basis of their elasticity: benign lesions have an elasticity similar to the surrounding tissue, while malignant lesions are harder than adjacent tissue.[5]The purpose of this study was to assess the role of SE in the diagnosis of breast lesions. Malignant tumours havereduced elasticity and also display larger dimensions on elastography due to the accompanying desmoplastic reaction.[6] Benign lesions appear similar to the adjacent tissues and have a smaller diameter than on B-mode USG images.[7,8]

2. METHODOLOGY

STUDY DESIGN: Prospective study.

STUDY POPULATION: 50patients.

SUBJECTS OFTHESTUDY-All Patients with breast lesions-both solid andcystic.

INCLUSION CRITERIA

1. Patient attending breast clinic with solitary or multiple breast lesions will be included

2. Patients who fall under BIRADS-0, 2, 3, 4 and 5 will be subjected for the study-(BREAST IMAGING REPORTING AND DATA SYSTEM- Benign, possibly benign, possibly malignant, and malignant and lesions needing additional imaging modality to categorise.)

EXCLUSION CRITERIA

Patients with prior biopsy proved benign or malignant lesions

Methods used for data collection

In this prospective study, patients having focal lesions (either cystic or solid) were assessed with conventional B - mode USG followed by shear wave elastography /ARFI. Study was done

Annals of R.S.C.B., ISSN:1583-6258, Vol. 25, Issue 3, 2021, Pages. 3356 - 3367
Received 16 February 2021; Accepted 08 March 2021.

using siemens ACUSON S 2000 ultrasound system (Siemens Medical Solutions, Mountain view, CA, USA).

The scoring system suggested by Itoh et al. [17] is used here. It assigns a score from 1 to 5: score 1 indicates deformability of the entire lesion; score 2, deformability of most of the lesion with some small stiff areas; score 3, deformability of the peripheral portion of the lesion with stiff tissue in the center; score 4, the entire lesion is stiff; score 5, the entire lesion and surrounding tissue are stiff. If a lesion is classified between 1 and 3 it is considered benign; if classified 4 or 5 it is considered to be malignant .

STATISTICAL ANALYSIS

All the patients were subjected to B- mode and elastography using shear wave with virtual touch imaging and virtual touch quantification and the obtained data were analyzed using the statistical package of students T test, ROC curve, sensitivity, specificity, positive and negative predictive values. The average swv for benign lesions was 2.08, which was significantly lower than that for malignant lesions (mean SR: 6.28). To calculate the sensitivity and specificity of elastography, lesions with elasticity scores 1 – 3 were classified as benign, while those with scores of 4 or

5 were classified as malignant. For assessment of the role of SE in the differential diagnosis of breast lesions, we performed a receiver operator characteristic (ROC) analysis. The statistical significant value was at $p< 0.05$.

3. RESULTS

Table : 1 Diagnostic accuracy of VTI in identifying benign lesions

Crosstab

			HPE - Benign		Total
			Positive	Negativ e	
VTI - Benign	Positive	Count	34	1	35
		% of Total	68.0%	2.0%	70.0%
	Negative	Count	1	14	15
		% of Total	2.0%	28.0%	30.0%
Total		Count	35	15	50
		% of Total	70.0%	30.0%	100.0%

Annals of R.S.C.B., ISSN:1583-6258, Vol. 25, Issue 3, 2021, Pages. 3356 - 3367
Received 16 February 2021; Accepted 08 March 2021.

Fig-1 Cystic breast lesions with no internal registrations in ARFI the value of shear wave velocity is near zero and VTI shows score 1.(Figures:1-6)

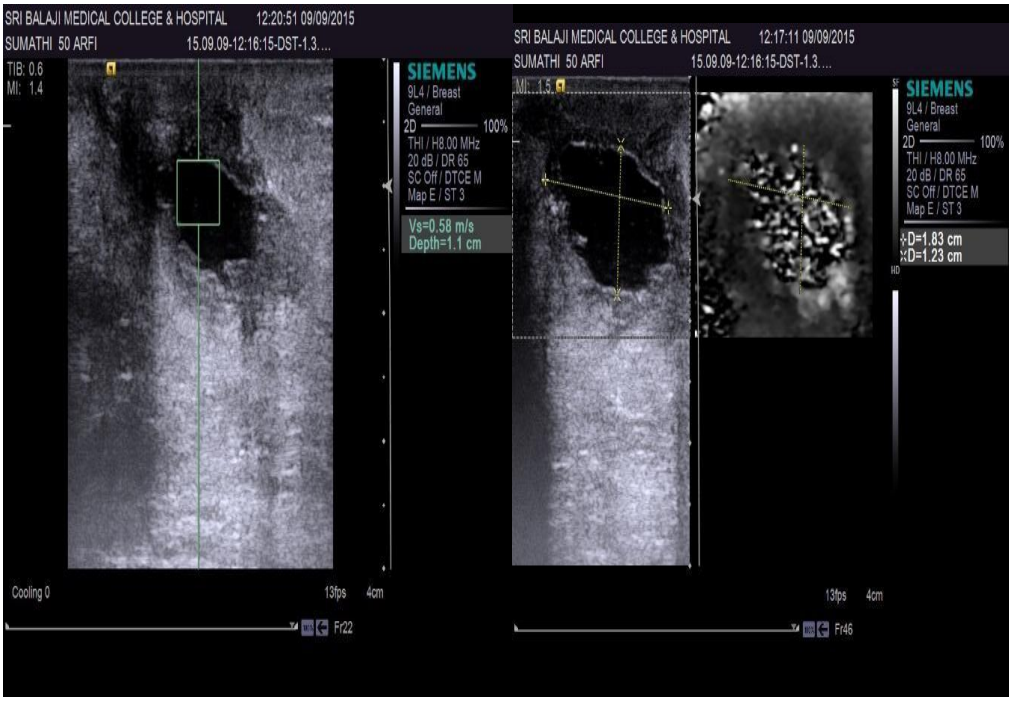
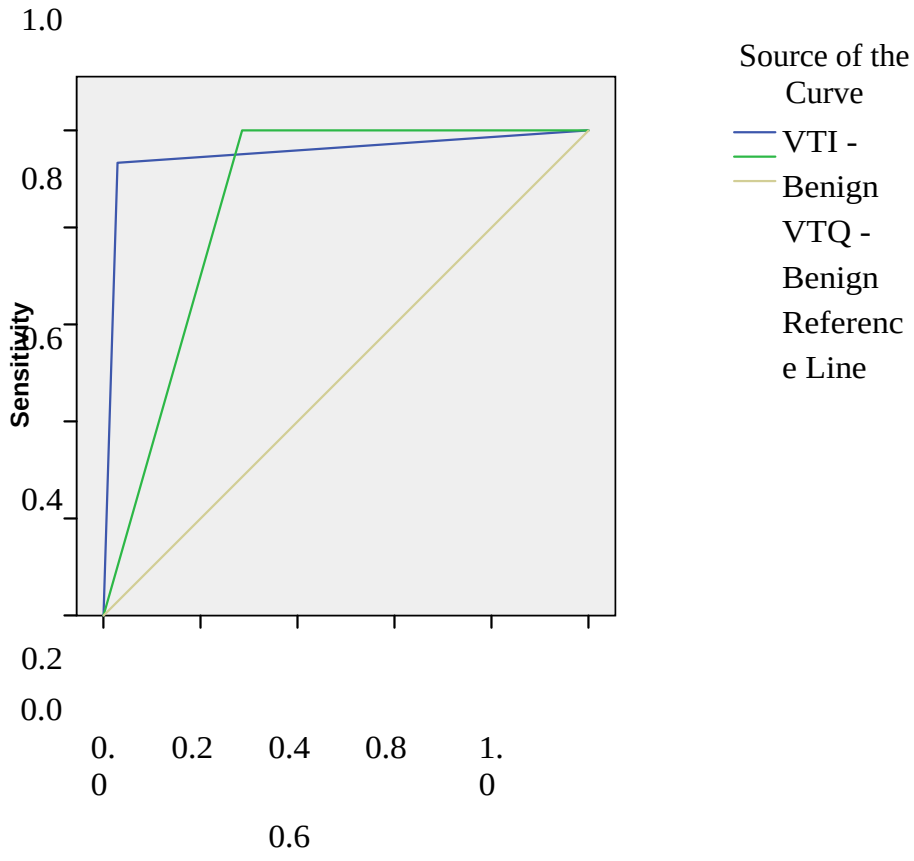


Fig.2 : Diagonal segments are produced by ties.**ROC Curve**



Annals of R.S.C.B., ISSN:1583-6258, Vol. 25, Issue 3, 2021, Pages. 1105 - 1112
Received 16 February 2021; Accepted 08 March 2021.

1 - Specificity

Figure:3 Cystic breast lesions with no internal registrations in ARFI the value

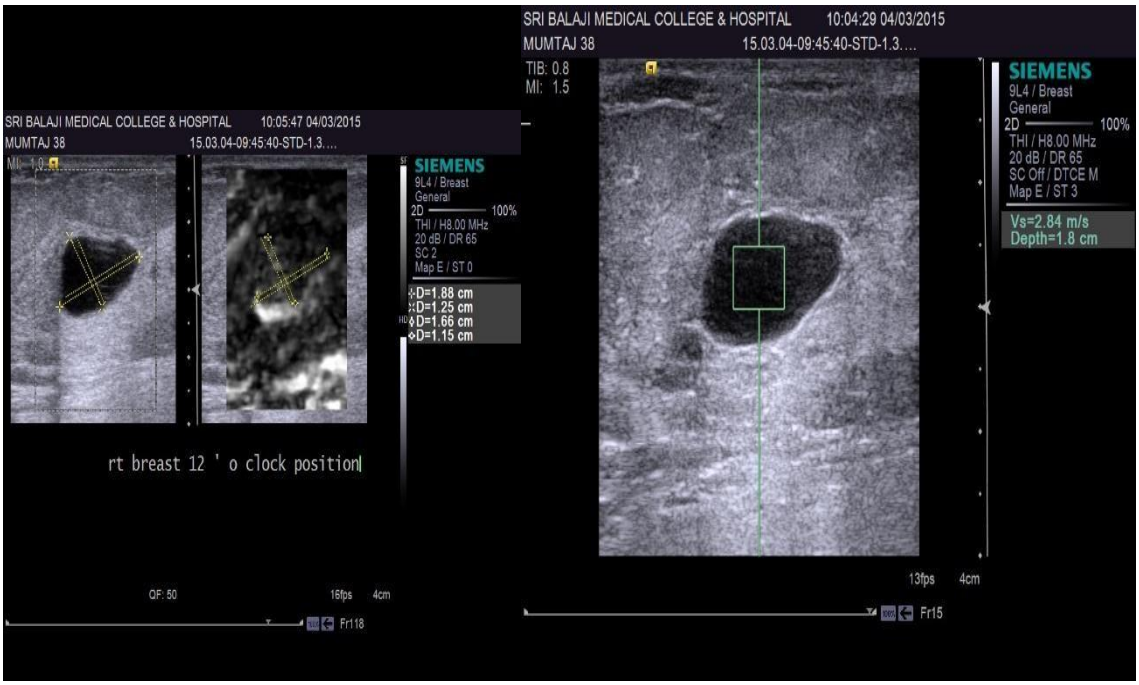


Table : 2 Diagnostic accuracy of VTI in identifying malignant lesions

Crosstab

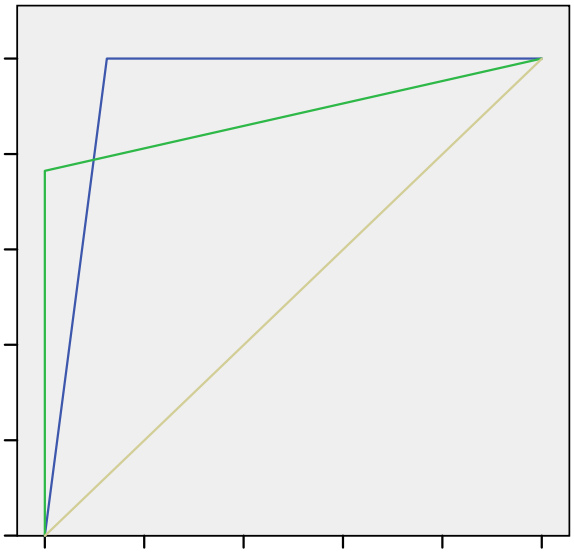
			HPE - Malignant		Total
			Positive	Negativ e	
VTQ - Malignant	Positive	Count	16	8	24
		% of Total	32.0%	16.0%	48.0%
	Negative	Count	0	26	26
		% of Total	.0%	52.0%	52.0%
Total		Count	16	34	50
		% of Total	32.0%	68.0%	100.0%

ROC Curve

Receiver operating characteristic (ROC) curve was also plotted to graphically present the results comparing the VTQ and VTI for malignant lesions

Annals of R.S.C.B., ISSN:1583-6258, Vol. 25, Issue 3, 2021, Pages. 1105 - 1112
Received 16 February 2021; Accepted 08 March 2021.

Fig 4: ROC Curvegraphically present the results comparing the VTQ and VTI for malignant lesions

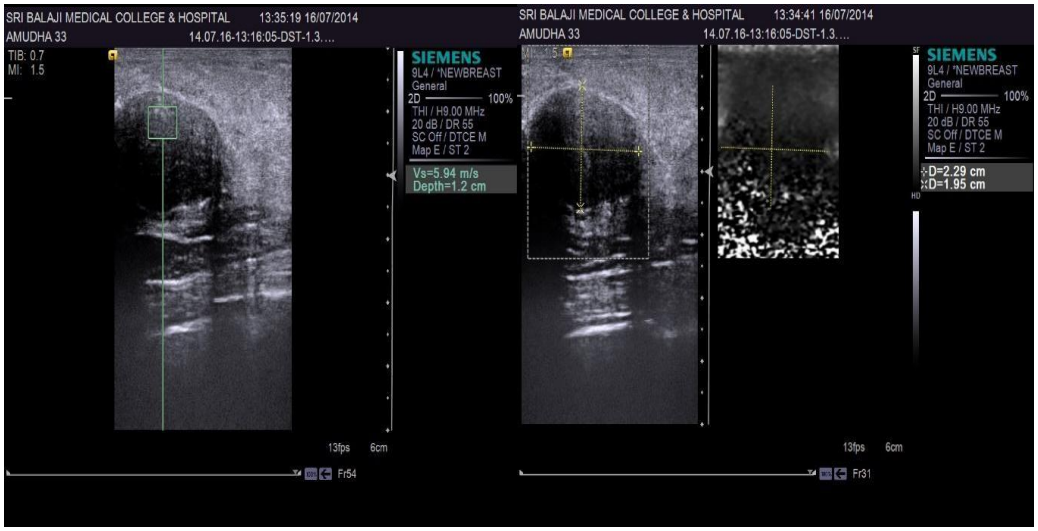


- Specificity

Diagonal segments are produced by ties.

Blue line represents VTI and green line represents VTQ.

Figure 5: Cystic breast lesions with no internal registrations in ARFI the value



Annals of R.S.C.B., ISSN:1583-6258, Vol. 25, Issue 3, 2021, Pages. 1105 - 1112
Received 16 February 2021; Accepted 08 March 2021.

Table3: Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Dev iation
AGE	50	15	71	40.56	13.958
Valid N (listwise)	50				

Figure 6: lesion larger than b mode with scores ranging from 4 to 5 in VTI.

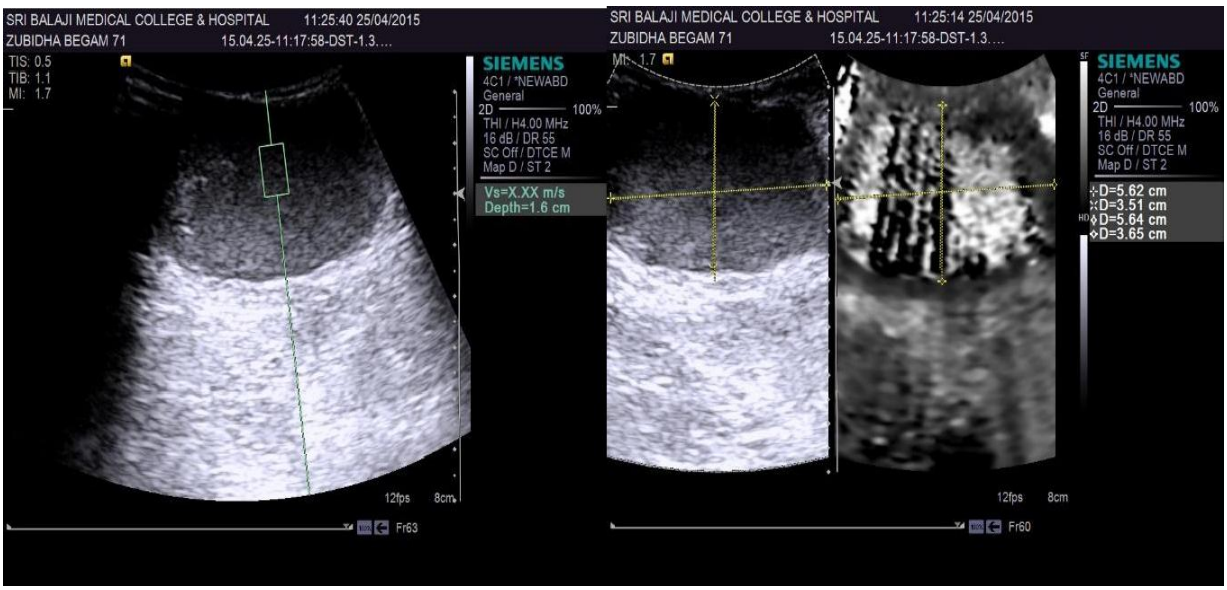


Table 4: AGE * VTQ - Malignant

Crosstab

			VTQ - Malignant		Total
			Positive	Negativ e	
AGE	>40 YEARS	Count	13	4	17
		% of Total	26.0%	8.0%	34.0%
	<=40YEARS	Count	11	22	33
		% of Total	22.0%	44.0%	66.0%
Total		Count	24	26	50
		% of Total	48.0%	52.0%	100.0%

Annals of R.S.C.B., ISSN:1583-6258, Vol. 25, Issue 3, 2021, Pages. 1105 - 1112
Received 16 February 2021; Accepted 08 March 2021.

Figure 7: lesion larger than b mode with scores ranging from 6 to 7in VTI.

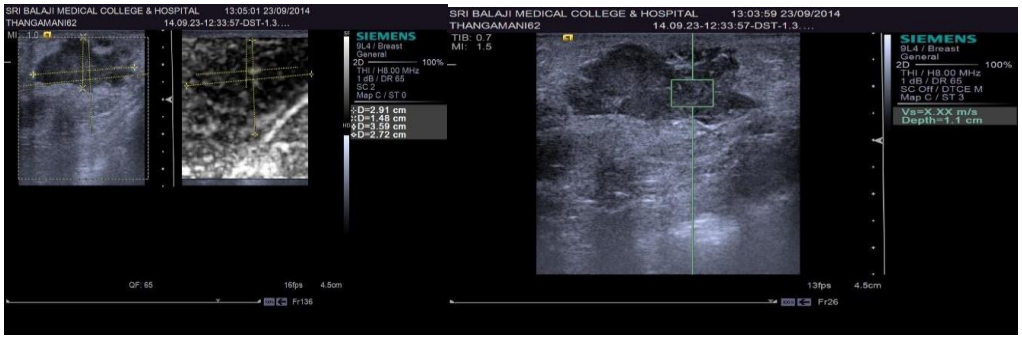
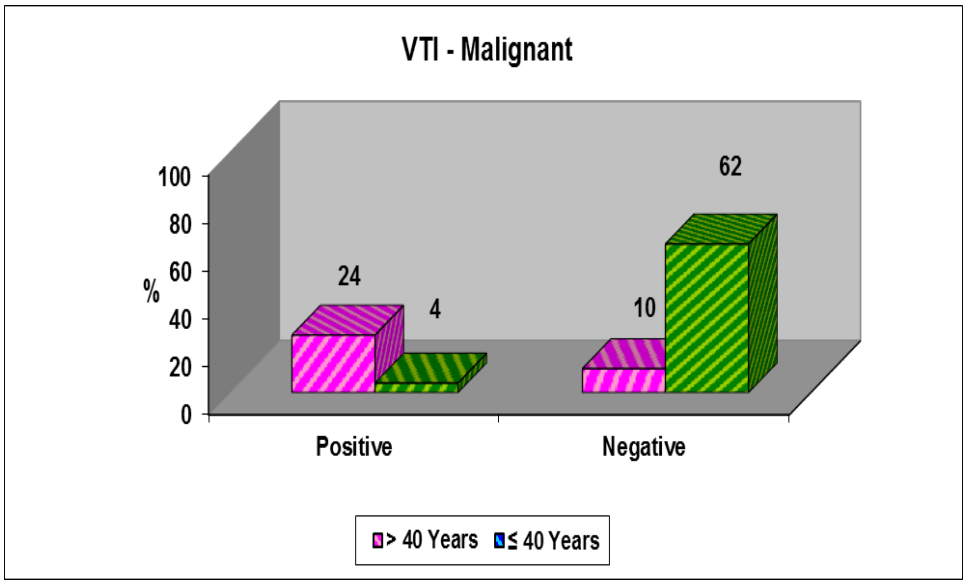


Figure 8:VTI- Malignant for 40 years age groups



	Positive	Negative
>40Years	24	10
≤40Years	4	62

In our study group of 50 patients 34 were benign and 16 were malignant. Out of which 31 cases were below 40 years and 19 cases were above 40 years. Below 40 years had predominantly benign lesions (28 benign and 3 malignant) and above 40 years had predominantly malignant lesions(14 malignant and 5 benign). VTI showed sensitivity of 97% and specificity of 93% with PPV of 97% for benign lesions. VTI showed sensitivity of 87.5 % and specificity of 100% with PPV of 100% for malignant lesions. VTQ showed sensitivity of 71.4 % and specificity of 100% with PPV of 100% for benign lesions. VTQ showed sensitivity of 100 % and specificity of

Annals of R.S.C.B., ISSN:1583-6258, Vol. 25, Issue 3, 2021, Pages. 1105 - 1112
Received 16 February 2021; Accepted 08 March 2021.

100 % with PPV of 76.6% for malignant lesions.

The study shows significant difference between the two parameters of ARFI imaging (VTI and VTQ) in differentiating benign and malignant lesions of the breast (P value < 0.001 derived from Table 13). VTI more rel iable as diagnostic tool compared to VTQ in benign lesions and both are equally reliable in identifying malignant lesions and hence ARFI plays a significant role as an adjuvant diagnostic tool to B mode imaging for assessing breast lesions .Hence routine ultrasound with ARFI correlation enhances the imaging diagnostic accuracy in categorising benign and malignant breast lesions

4. DISCUSSION

Breast cancer is one of the most frequently diagnosed cancers globally and also the main cause of cancer-related death among women. AFRI, as a new US-based elastography provides quantitative and semi-quantitative measurements without invasiveness or radiation. In this study the performance of ARFI in the differentiation of breast lesions was evaluated. The results indicated that ARFI elastography has a high sensitivity and specificity for the diagnosis of malignant and benign breast lesions.[9]

Some studies shows that the biopsy rate could be reduced in case of BIRADS 3 -4a benign lesions in women with a high risk of breast cancer [7]. Elasticity combined with B-mode imaging improved the specificity and sensitivity for differentiating the benign and malignant lesions. However all the lesions were correlated with HPE which is the gold standard. Both VTQ and VTI increased confidence in the diagnosis of a malignant lesion. Elasticity evaluation is a fast non-invasive procedure which is easy to perform in a routine examination. Nevertheless, false negatives were also there. Typical false negative lesions were “soft” lesions such as mucinous carcinoma, cystic carcinoma or inflammatory cancer [10,15]. Thus, B-mode features are usually suspicious enough to categorize these lesions as BI-RADS 4b or 5. False positives can occur in fibrous lesions such as “old” fibro adenoma.

Breast elastography is very useful in differentiating benign echogenic cysts from homogeneous solid lesions such as fibroadenoma. In these cases, too many Fine Needle Aspirations (FNA) are performed. Cystic features are usually specific on elasticity imaging with internal register(ARFI/ SE). In VTI the lesion is seen as bright echoes. If typical cystic features on elasticity modes are combined with benign features on B-Mode imaging, FNA could be avoided.[11-14]

Our study is limited by the fact that the sample size was relatively small. Larger studies including multiple observers would be favorable.The size of region of interest (ROI) is fixed so very

Annals of R.S.C.B., ISSN:1583-6258, Vol. 25, Issue 3, 2021, Pages. 1105 - 1112
Received 16 February 2021; Accepted 08 March 2021.

small lesions could not be assessed separately as the surrounding breast parenchyma was also included altering the VTQ values.[15]

The main limitation of this study is that ARFI VTQ is a relatively new technology. Therefore, limited data is available about the impact of the tumor size, the optimal measurement point within the lesion, the influence of the density of the surrounding tissue or the distance from the skin on the measurement, and the variance of SWV when repeatedly measuring the same region. Furthermore, precompression seems to have a significant effect on the measurements, and a major bias may result if different degrees of precompression are applied to the tissue.[16,17]

The method of ARFI VTQ is technically not fully developed, as measurements above 9.10 m/s cannot be performed. As shown by our results, SWV frequently exceeds this limit, especially in malignant masses. Therefore, our results concerning mean SWV are impaired by this limitation, and replacing X.XX m/s with 9.10 m/s gives only a rough approximation of the actual SWV, although this approach has been reported before. Further technical advances may overcome this limitation in the future.

CONCLUSION

Breast elastography is now an adjunct tool in breast ultrasonography. It is easily performed in clinical practice, adding only a small amount of time to a normal breast ultrasound.Sonoelastography with strain imaging, to some extent is operator dependent, as it is based on image interpretation. The technique of ARFI VTQ may have the potential to overcome this limitation, as it provides independent measurements of physical tissue properties.Both score systems were insensitive to the volume of the breast as well as the depth and the diameter of the lesions. They are accurate and reproducible but they should always be integrated with US examination or mammography.ARFI VTQ is a feasible method that indicates malignant tissue with an elevated SWV or even, a SWV that exceeds the upper limit of possible measurement. In summary, our study demonstrated that ARFI VTQ is able to differentiatebetween normal adjacent breast parenchyma and benign or malignant masses, by obtaining a SWV.Elastography has a significant role in the management of nodules <10 mm which are visible on the US image, but not on mammography, in which reduced deformability may lead to biopsy rather than monitoring as required by the current guidelines.False positives can occur in fibrous lesions such as “old” fibroadenoma. In general, ARFI elastography seems to be a good method for differentiation between benign and malignant breast lesions. VTI seems to be more reliable and repeatable than VTQ.

Annals of R.S.C.B., ISSN:1583-6258, Vol. 25, Issue 3, 2021, Pages. 1105 - 1112
Received 16 February 2021; Accepted 08 March 2021.

Funding: No funding sources

Ethical approval: The study was approved by the Institutional Ethics Committee

CONFLICT OF INTEREST

The authors declare no conflict of interest.

ACKNOWLEDGMENTS

The encouragement and support from Bharath University, Chennai is gratefully acknowledged. For provided the laboratory facilities to carry out the research work.

BIBLIOGRAPHY

1. Goodia ,Bonardi M, Alessi S, Breast Elastography : A literature review, Journal Of Ultrasound,2012,sep 15(3),(192 - 198), 2012 Elsevier Masson Italy
2. Balleyguier C(1), Canale S, Ben Hassen W, Vielh P, Bayou EH, Mathieu MC, Uzan C, Bourgier C, Dromain C. Breast elasticity: principles, technique, results: an update and overview of commercially available software. Eur J Radiol. 2013 Mar;82(3):427-34.
3. Li DD(1), Guo LH(1), Xu HX(1), Liu C(1), Xu JM(1), Sun LP(1), Wu J(1),Liu BJ(1),Liu LN(1), Xu XH(2). Acoustic radiation force impulse elastography for differentiation of malignantand benign breast lesions: a meta-analysis.. nt J Clin Exp Med. 2015 Apr 15;8(4):4753 -61.
4. Hiltawsky KM, Kruger M, Starke C, Heuser L, Ermert H, Jensen A. Freehand ultrasound elastography of breast lesions: clinical results. Ultrasound Med Biol. 2001;27:1461–1469.
5. Itoh A, Ueno E, Tohno E, Kamma H, Takahashi H, Shiina T, Yamakawa M, Matsumura T.Breast disease:clinical application ofUSelastography for diagnosis. Radiology. 2006;239:341–350.
6. Li G, Li DW, Fang YX, Song YJ, Deng ZJ, Gao J, Xie Y, Yin TS, Ying L, Tang KF. Performance of shear wave elastography for differentiation of benign and malignant solid breast masses. PLoS One.2013;8:e76322.
7. Sadigh G, Carlos RC, Neal CH, Dwamena BA. Accuracy of quantitative ultrasound elastography for differentiation of malignant and benign breast abnormalities: a meta-analysis. Breast Cancer Res Treat.2012;134:923–931.
8. Lyshchik A., Higashi T., Asato R., Tanaka S., Ito J., Hiraoka M. Cervical lymph node metastases: diagnosis at sonoelastography– initial experience. Radiology. 2007;243:258–267.

9. Aigner F., De Zordo T., Pallwein-Prettner L., Junker D., Schäfer G., Pichler R. Real-time sonoelastography for the evaluation of testicular lesions. Radiology. 2012;263:584– 589.
10. Nightingale K., Bentley R., Trahey G. Observations of tissue response to acoustic radiation force: opportunities for imaging. Ultrason Imaging. 2002;24:129–138.
11. Hoyt K., Parker K.J., Rubens D.J. Real-time shear velocity imaging using sonoelastographictechniques. Ultrasound Med Biol. 2007;33:1086–1097.
12. Shiina T., Nitta N., Ueno E., Bamber J.C. Real time tissue elasticity imaging using the combined autocorrelation method. J Med Ultrason. 2002;29:119–128.
13. Nightingale K., Soo M.S., Nightingale R., Bentley R., Trahey
14. G. In vivo demonstration of acoustic radiation force impulse (ARFI) imaging in the thyroid, abdomen, and breast. Ultrasonics symposium. IEEE.2001;2:1633–1638.
15. Nightingale K., Soo M.S., Nightingale R., Bentley R., Stutz D., Palmeri M. Acoustic radiation force impulse imaging: remote palpation of the mechanical properties of tissue. Ultrasonics symposium. IEEE.2002;2:1821–1830.
16. Nightingale K., Stutz D., Bentley R., Trahey G. Acoustic radiation force impulse imaging: ex vivo and in vivo demonstration of transient shear wave propagation. Biomed Imag. 2002:525–528. Conference Publications.
17. Bercoff J., Tanter M., Fink M. Supersonic shear imaging: a new technique for soft tissue elasticity mapping. IEEE Trans UltrasonFerroelectrFreq Control. 2004;51:396–409.
18. Itoh A., Ueno E., Tohno E., Kamma H., Takahashi H., Shiina
19. T. Breast disease: clinical application of US elastography for diagnosis. Radiology. 2006;239:341–350.