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Patient perception of meander-like versus radial breast ultrasound

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ABSTRACT

Background Radial breast ultrasound scanning (r-US) and commonly used meander-like ultrasound scanning (m-US) have recently been shown to be equally sensitive and specific with regard to the detection of breast malignancies. As patient satisfaction has a strong influence on patient compliance and thus on the quality of health care, we compare here the two US scanning techniques with regard to patient comfort during breast ultrasound (BUS) and analyze whether the patient has a preference for either scanning technique.

Materials and Methods Symptomatic and asymptomatic women underwent both m-US and r-US scanning by two different examiners. Patient comfort and preference were assessed using a visual analog scale-based (VAS) questionnaire and were compared using a Mann-Whitney U test.

Results Analysis of 422 VAS-based questionnaires showed that perceived comfort with r-US (r-VAS 8 cm, IQR [5.3, 9.1]) was significantly higher compared to m-US (m-VAS 5.6 cm, IQR [5.2, 7.4]) ($p < 0.001$). 53.8 % of patients had no preference, 44.3 % of patients clearly preferred r-US, whereas only 1.9 % of patients preferred m-US. Conclusion: Patients experience a higher level of comfort with r-US and favor r-US over m-US. As the diagnostic accuracy of r-US has been shown to be comparable to that of m-US and the time required for examination is shorter, a switch from m-US to r-US in routine clinical practice might be beneficial. R-US offers considerable potential to positively affect patient compliance but also to save examination time and thus costs.

Introduction

Many women will experience breast ultrasound imaging (BUS) during their lifetime. BUS mostly serves as an adjunct to evaluate breast masses that were detected by palpation or mammography (MG) [1, 2]. In contrast to MG, BUS is highly sensitive also in dense breast tissue [3]. Hence, BUS is used as an initial diagnostic tool in young, symptomatic women [4] and as a screening method in young women at high risk [5].

As patient satisfaction has a strong influence on patient compliance and thus on the quality of health care [6], it is of particular importance to improve patient comfort with BUS, especially if the procedure is repeated regularly.

BUS is commonly performed in a meander-like manner (m-US) [7] where the probe is moved in two orthogonal planes across the breast. In radial US (r-US), the breast is scanned in a circle around the nipple. This method is predominantly used for the examination of dilated ducts and for the visualization of intraductal papilloma [8]. With regard to breast malignancies, we recently reported a comparable sensitivity (r-US and m-US both 88.9 %) and specificity (r-US 89.4 % and m-US 86.4 %) for r-US and m-US and a false-negative rate of 5.6 % for both modalities [9]. In recent years, elastography has complemented BUS to increase diagnostic accuracy and to prevent unnecessary breast biopsies [10, 11]. In addition, artificial intelligence (AI) in BUS is emerging as a tool to improve diagnostic accuracy and thus may provide helpful guidance for further workup [12]. Accordingly, in a recent review on AI in m-US, Brunetti et al. reported a sensitivity of 84 % and a specificity of 85.7 % [13].

Women with sonomorphologically benign breast lesions [14] as well as those at high risk for BC [15] experience psychological distress. It has been shown that women with a high risk for BC and corresponding high levels of anxiety are less likely to follow surveillance methods such as regular clinical breast examinations and breast self-examination [15]. Furthermore, 50 % of women with previous BC have been shown to suffer from anxiety and depression [16], which has been associated with noncompliance [17].

It has been reported that during mammography 83 % of women experience discomfort [18]. According to Keemers-Gels et al., a high percentage of women (72.9 %) consider mammography to be painful [19]. Multiple factors such as age, ethnicity, sensitive breasts, family history of breast disease, higher education, anxiety, time span of compression, compression force, and physical contact with the breast platform have an effect on the perception of discomfort or pain during MG [19, 20]. Pain was shown to be the major factor for discontinuing MG screening [21]. In contrast, BUS as well as automated breast ultrasound was usually not considered painful [22]. Factors underlying comfort ratings for BUS have so far not been investigated, neither in general nor with regard to radial versus meander-like scanning.

In this single-center, prospective study, we investigated patient comfort during m-US and r-US and patient preference with regard to the two BUS examination techniques. Furthermore, we examined which parameters might influence patient perception of comfort and their preference for a specific scanning procedure.

Methods

We conducted a single-center, prospective study. The study protocol was approved by the local ethics committee, and informed consent was obtained from all participants prior to examination.

Among the women scheduled for a BUS at the breast center, asymptomatic women with an increased risk for BC or with dense breast tissue, as well as symptomatic women with breast pain or palpable breast lesions, including women with any type of previous breast surgery (e. g., cosmetic surgery), were consecutively recruited and enrolled in the study. Men, women younger than 18 years of age, and women already scheduled for a breast biopsy were excluded from the study in order to rule out a bias in the ultrasound examination. From the total collective of women with dual BUS examinations (i. e., r-US and m-US; n = 1948) that was analyzed with regard to diagnostic accuracy, 439 patients filled in the visual analog scale-based (VAS) questionnaire and henceforth are considered the study population.

Each woman received a physical breast examination by a trained gynecologist. Consenting women received a bilateral m-US and r-US examination conducted by two different examiners in random order on the same day. R-US was carried out by a designated research fellow specialized in gynecology and obstetrics but with limited previous BUS experience. M-US was carried out by experts or beginners under the supervision of an expert as is common in teaching hospitals.

M-US and r-US were carried out as recently described [9]. Briefly, in r-US the breast was scanned in a radial and subsequently in an anti-radial fashion. In m-US, the breast was scanned in a meander-like fashion in two perpendicular directions. Scanning of the axilla was routinely included in both examinations. In the case of voluminous breasts, women were positioned for both scanning methods in a pronounced oblique supine position with their ipsilateral arm raised to flatten the breast tissue.

Breast lesions were classified according to the US BI-RADS classification system in the BI-RADS Atlas [23] and breast density according to Madjar et al. [24]. US examination findings were entered in the electronic health patient record (Viewpoint, Version 5: GE Healthcare GmbH) and documented in a report, which was made available to the patient upon request after completion of the questionnaires. Suspicious lesions classified as BI-RADS 4 and 5, as well as BI-RADS 3 lesions in women with increased breast cancer risk were biopsied.

The duration of the examination was determined for each BUS by calculating the time between the timestamps of an image recorded before starting and after completing the respective BUS examination.

Both scanning procedures were performed with the same US equipment (EUB-7500 V 16–53 Step 3.5, Hitachi Medical Systems). For m-US, a 50 mm wideband, high-frequency (frequency range: 13–5 MHz) linear probe (EUP-L74M; Hitachi Medical Systems) and for r-US, a 92 mm wideband (frequency range: 10–5 MHz) linear probe (EUP-L53L; Hitachi Medical Systems) that was protected by a water-filled latex cover according to the manufacturer's instructions was used.

Patient comfort and preference regarding BUS scanning procedure were measured by a VAS-based questionnaire that was handed out in print. Question 1a assessed the comfort experienced dur-

ing m-US (m-VAS) and question 1b the comfort during r-US (r-VAS), whereby a VAS = 0 cm corresponded to an uncomfortable BUS examination, and VAS = 10 cm to a comfortable BUS examination. Question 2 assessed patient preference for one of the two scanning techniques (mr-VAS). VAS = 0 cm corresponded to a preference for m-US, and VAS = 10 cm to a preference for r-US. In a supplementary question, patients were asked whether or not they felt less pressure during their preferred US examination compared to the other not preferred technique. In general, patients were not assisted during the completion of the questionnaire. Results of the questionnaires, patient age, and body mass index (BMI) were entered encrypted into a custom online database built on Openclinica Version 3.1.2 (Community Edition).

Statistical analysis

Data from Openclinica and from electronic patient records were exported into R (R Development Core Team 2018, Vienna, Austria) for statistical analysis.

Continuous variables are presented as mean (including standard deviation, SD) and compared between the subgroups using t-test. In the case of non-normal distributions, the median (and interquartile range, IQR) and Mann Whitney U-tests are used. Binary and categorical values are presented as count and frequency and compared using chi-squared tests or Fisher´s exact test.

VAS values are presented as median together with their 95 % confidence interval estimated based on 5000 bootstrap replicates. Patient comfort and preference were evaluated in connection with the presence or absence of a positive family history, a positive personal history (breast cancer, surgery for benign condition, or breast biopsy), BMI, age, and breast density in a linear model. The time needed for m-US was compared to that needed for r-US using a Wilcoxon rank sum test.

A p-value < 0.05 was considered statistically significant.

Results

439 women had dual BUS and completed the VAS-based questionnaire. Incomplete questionnaires led to the exclusion of 17 patients. Thus, analysis was performed in a study population comprising 422 patients.

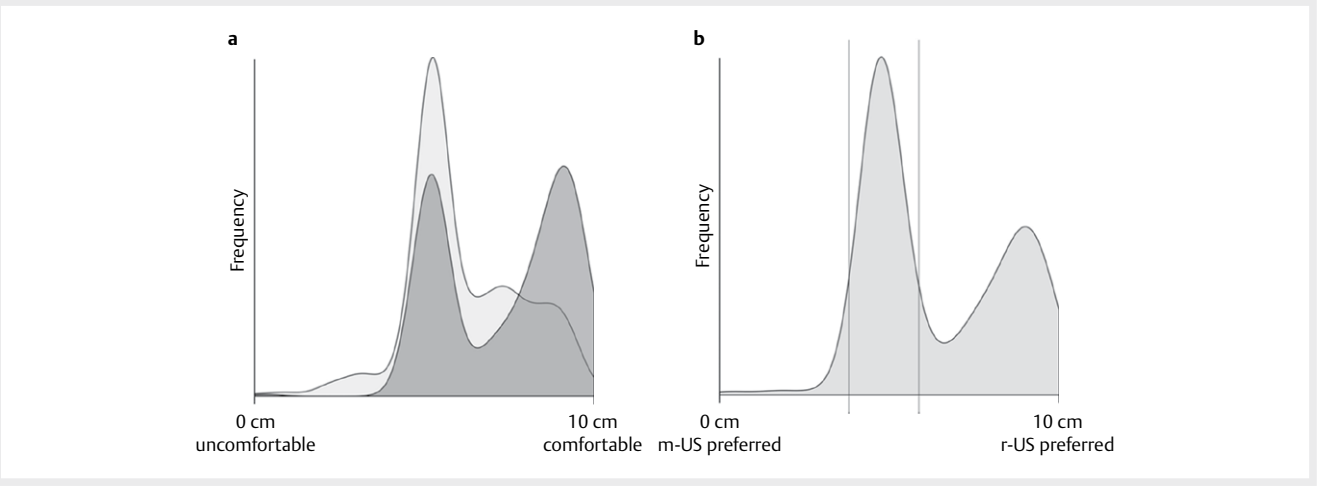
Patient characteristics are shown in ▶ **Table 1**. Patients had a mean age of 49.4 ± 14.2 years and a mean BMI of 24.1 ± 4.8 kg/m². 235 (55.7 %) patients had a family history of breast, endometrial, and/or ovarian cancer. From the study population, 72 (17.1 %) patients had a medical history of breast surgery due to a benign lesion, 84 (19.9 %) had one or more previous breast biopsies and 16 (3.8 %) had a history of BC. In 303 (71.8 %) women more than one lesion was detected. 154 (36.5 %) women had at least one BI-RADS 3 lesion, 36 of which required a biopsy. None of the biopsied BI-RADS 3 lesions revealed a malignancy. In 14 patients US examinations revealed 16 breast lesions that were classified as BI-RADS 4 or 5 and required biopsy. In 9 cases BC was diagnosed. In 3 cases, histology revealed a ductal carcinoma in situ, in 6 cases an invasive ductal carcinoma. No lobular carcinoma was found.

The comfort rating of the entire study population is summarized in ▶ **Fig. 1a**. Both US methods were rarely rated as uncomfortable. Patients were mostly indifferent about the comfort experienced with m-US (light grey). During r-US women either were indifferent about their comfort or felt comfortable as reflected by a bimodal distribution of r-VAS values (dark grey). The median comfort rating during r-US scanning was significantly higher (median r-VAS = 8 cm, IQR [5.3, 9.2]) than comfort during m-US (median m-VAS = 5.6 cm, IQR [5.2, 7.4]) (p < 0.001), indicating that overall r-US was considered more comfortable compared to m-US. Note that for both scanning procedures a considerable number of patients were indifferent with regard to comfort.

▶ **Table 1** Patient Characteristics.

Patient Characteristics	Study Population
Number of patients (%)	422 (100)
Mean age in years (min., max.) [SD]	49.4 (17.5, 83.2) [± 14.2]
Mean BMI in kg/m² (min., max.) [SD]	24.1 (16.5, 45.2) [± 4.8]
Breast Density (%)	**422 (100)**
▪ I	17 (4)
▪ II	174 (41.2)
▪ III	157 (37.2)
▪ IV	38 (9)
▪ n. a.*	36 (8.5)
Patients with a Negative Personal History (%)	**278 (65.9)**
Patients with a Positive Personal History (%) of	**144 (34.1)**
▪ Breast cancer	16 (3.8)
▪ Breast operations with benign histology	72 (17.1)
▪ Breast biopsy	84 (19.9)
Negative Family History (%)	**187 (44.3)**
Positive Family History (%) of	**235 (55.7)**
▪ Breast-Ca	210 (49.8)
▪ Endometrial-Ca	11 (2.6)
▪ Ovarian-Ca	0 (0)
▪ Breast- and endometrial-Ca	5 (1.2)
▪ Breast- and ovarian-Ca	9 (2.1)
▪ Endometrial- and ovarian-Ca	0 (0)
▪ Breast-, endometrial-, and ovarian-Ca	0 (0)
Number of Lesions Detected in Women	
0 lesions (%)	119 (28.2)
≥ 1 lesions (%)	303 (71.8)
Women with BI-RADS 3 Lesions (%)	**154 (100)**
▪ BI-RADS 2 lesion in follow-up	102 (66.2)
▪ Lost for follow-up	16 (10.4)
▪ Biopsy performed	36 (23.4)
BI-RADS 4 and 5 Lesions	**16**
▪ Breast-Ca	9

BMI: body mass index; CA: carcinoma; BI-RADS: breast imaging reporting and data system. *not assessed.



▶ **Fig. 1** **a**) Patient rating of comfort during m-US (light grey) and r-US (dark grey). **b**) Relative patient preference regarding the two US scanning techniques. Vertical lines delimit "m-US preferred" (left), "indifferent" (middle), and "r-US preferred" (right).

With respect to patient preference regarding the two BUS scanning techniques, the mr-VAS values revealed a bimodal distribution (▶ **Fig. 1b**). One peak centered around 5 cm, indicating that a large number of patients did not prefer one scanning method over the other, while the second peak showed a clear preference for r-US. In order to avoid a bias in the analysis from patients with no preference, we divided the patients into 3 subgroups based on their preference: "meander preferred" if mr-VAS < 4 cm, "indifferent" if mr-VAS was between ≥ 4 cm and ≤ 6 cm, and "radial preferred" if mr-VAS > 6 cm. Accordingly, the "indifferent" group consisted of 227 patients (53.8 %), r-US was preferred by 187 patients (44.3 %, "r-US preferred"), and only 8 patients preferred m-US (1.9 %, "m-US preferred").

To assess what might have led to the preference for r-US, examination time, patient characteristics, and level of comfort of the subgroups were analyzed in relation to the US examination technique. However, statistical analysis was performed for the groups "r-US preferred" and "indifferent", but not for "m-US preferred" due to the small number of patients belonging to this subgroup. Compared to patients who had no preference ("indifferent"), members of the "r-US preferred" subgroup rated the level of comfort associated with r-US significantly higher ($p < 0.001$). No difference with regard to the level of comfort for m-US was found for both of these subgroups. Consistent with this finding, 79 % of patients with a preference for r-US stated that they felt a pressure reduction during r-US. The "indifferent" and the "r-US preferred" subgroups were not associated with a difference in the examination time neither for r-US ($p = 0.7$) nor for m-US ($p = 0.6$) (▶ **Table 2**). R-US was significantly faster than m-US also in the "indifferent" subgroup ($p < 0.01$).

In addition, we did not observe an association between patient preference and other parameters including breast size, body mass index, personal history, and family history (▶ **Table 2**).

Discussion

To the best of our knowledge, this is the first time that the comfort patients feel during m-US and r-US has been directly compared and patient preference for either scanning procedure has been evaluated.

Patient comfort and preference during BUS were assessed by VAS in 422 patients. Our data show that patients rate r-US as significantly more comfortable than m-US. Approximately half of the patients clearly prefer r-US over m-US, and a similar number is indifferent about their preference. Only 8 patients (1.9 %) prefer the commonly used m-US.

In contrast to mammography where compression force and time span of compression are a major cause of discomfort [18, 20], the vast majority of patients do not report pain during BUS [19, 22]. In line with not feeling pain, our study shows that patients rarely rate either US method as uncomfortable. Overall, women felt more comfortable during r-US than during m-US scanning. The higher comfort associated with r-US might be the result of the wider probe and the water cushion allowing optimal and efficient radial scanning and a more constant pressure distribution. Consistent with this notion, 79 % of patients with a preference for r-US felt the compression by the probe to be weaker in r-US compared to m-US. We cannot rule out that if a wider probe were used under the same conditions for m-US, patient perception of comfort would be comparable for m-US and r-US. However, the standard ultrasound setup for m-US includes a probe that is narrower than the probe used for r-US.

In accordance with previous findings [9], r-US was significantly faster than m-US. In particular, this difference in examination time was the same for the "r-US preferred" and the "indifferent" subgroups, indicating that although r-US was significantly faster than m-US, this did not seem to sway patients toward a preference for r-US. Despite only a small, statistically non-significant difference in the correlation of examination time and comfort rating between m-US and r-US, it might be possible that the shorter examination time in r-US might have some influence on the higher comfort associated with r-US. In addition, the physician has more time to care for the patient and can focus more on the needs and worries of the patient. This leads to a more patient-centered consultation which is not only more cost-effective but is also associated with a higher level of patient satisfaction and with better compliance [25].

▶ **Table 2** Factors related to subgroups with differential preference for BUS scanning procedures.

	m-US preferred	Indifferent	r-US preferred	p-value ‡
Number of patients (%)	8 (1.9)	227 (53.8)	187 (44.3)	
Mean age in years (min., max.) [SD]	43.5 (18.5, 78.1) [±19.0]	49.6 (18.5, 83.2) [±14.1]	49.3 (20.2, 77.8) [±14.1]	0.86
Mean BMI in kg/m^2 (min., max.) [SD]	24.9 (19.8, 36.4) [±5.6]	24.3 (16.6, 45.2) [±4.9]	23.9 (16.5, 39.8) [±4.5]	0.45
Breast Density (%)	8 (100)	227 (100)	187 (100)	0.533
▪ I	0 (0)	12 (5.2)	5 (2.6)	
▪ II	3 (37.5)	97 (42.7)	74 (39.6)	
▪ III	3 (37.5)	81 (35.7)	73 (39)	
▪ IV	2 (25)	20 (8.8)	16 (8.5)	
▪ Missing	0 (0)	17 (7.5)	19 (10.2)	
Patients with a Positive Personal History (%)	4 (50)	79 (34.8)	61 (32.6)	0.717
Positive Family History (%)	4 (50)	126 (55.5)	105 (56.1)	0.975
Comfort (median VAS value in cm [IQR])				
▪ m-US	7.5 [6.5, 8.8]	5.3 [5.2, 7.5]	6.3 [5.0, 7.4]	0.610
▪ r-US	6 [5.4, 7.1]	5.3 [5.1, 8.0]	9.1 [8.4, 9.5]	<0.001
Pressure Reduction (%)				<0.001
▪ Yes	5 (62.5)	6 (2.6)	149 (79.7)	
▪ No	0 (0)	3 (1.3)	3 (1.6)	
▪ No answer	3 (37.5)	218 (96.0)	35 (18.7)	
Mean Examination Time in Minutes				
m-US (min., max.) [SD]	11.9 (4.3, 17.2) [4.6]	12.9 † (2, 37) [6.1]	13.5 § (1.9, 40) [6.5]	0.60
r-US (min., max.) [SD]	9.2 (3.2, 18.5) [4.8]	7.3 † (1.9, 83.4) [6.9]	7.1 § (2.1, 40.9) [5.6]	0.70

M-US indicates meander-like ultrasound; r-US indicates radial ultrasound; BMI indicates body mass index; IQR indicates interquartile range; VAS indicates visual analog scale; and BI-RADS indicates breast imaging reporting and data system. ‡ statistical analysis of the indifferent vs. r-US preferred group. †statistical analysis of the examination time for m-US and r-US for the "indifferent" group. $p < 0.01$ § statistical analysis of the examination time for m-US and r-US for the "r-US preferred" group. $p < 0.01$.

A considerable number of patients appeared to have no preference for either scanning procedure and chose VAS values around the middle of the scale. Patients who consider BUS a necessity to rule out a malignancy might truly not care which scanning procedure is employed.

R-US was not only considered more comfortable but was also the preferred scanning procedure for 44.3 % of patients. The preference for r-US and higher comfort was accompanied by a notion of a pressure reduction during r-US in 79 % of the patients with a preference for r-US. We conclude that the preference for r-US is predominantly a function of comfort and to some extent might also be influenced by the examination time.

Only 1.9 % of patients preferred m-US scanning. In contrast to r-US, a preference for m-US scanning was not related to a higher comfort rating. These patients might prefer a known technique, thus putting trust before comfort.

Patients with a family history of BC were shown to suffer from distress prior to MG due to their awareness of the increased risk [15]. However, women with a positive family history of gynecological cancer did not show a preference for r-US more often than patients with a negative family history, indicating the family history does not influence the rating.

Even though women with dense breast tissue are more likely to experience pain during MG [19, 20], they did not rate comfort during m-US and r-US differently and did not show a specific preference for either of the two scanning methods. This suggests that breast tissue density might not be a comfort-determining factor.

Patient satisfaction during a medical procedure, which is influenced by perceived comfort and also by the examination time [25], has a significant impact on the adherence to follow-up procedures and, therefore, on the quality of health care [6]. Compliance with BUS has been shown to be about 80 % [26]. However, compliance tends to decrease over time, as reported for MG where it decreased

from 88 % to 47 % in 3 years of regular follow-up [27]. Women with previous BC and women at high risk who undergo regular BUS and are less likely to strictly follow BC screening regimes [15] might adhere better to their regular BUS appointments if comfort during BUS was improved and examination time reduced. By reducing the examination time and thereby costs, r-US provides a benefit not only to the patient but also to healthcare workers and institutions.

Due to the additional time requirement, only 422 women, who underwent both r-US and m-US, were willing to fill in the VAS-based questionnaire. Thus, our study population might not fully reflect the patient collective from a breast center. Another limitation is that in order to avoid bias in the scanning procedure due to knowledge of findings from the first examination, the study was designed such that corresponding US examinations were conducted by different examiners. Therefore, we cannot rule out that the examiner has an effect on patient comfort. Furthermore, the difference in probe width in r-US (92 mm) versus m-US (50 mm) and the water cushion used for the r-US examination might influence patient preference and comfort. It should also be noted that the present study omitted the examination of patient ethnicity, socio-cultural variances, and ultrasound findings (i. e., BI-RADS category).

Conclusion

Patients examined by r-US experience a higher level of comfort as well as a significantly shorter examination time. Both parameters which are possibly related to the wider probe required for radial scanning have a positive effect on patient compliance. However, r-US-specific probes are not commonly available in breast units. As the sensitivity and specificity in the detection of malignant breast lesions in r-US is equal to that of m-US [9], a switch from the commonly used m-US to r-US would promote patient compliance and could reduce health care costs.

Ethics Approval

The study was approved by the local ethics committee.

Consent to Participate

Informed consent (participation in the study, publication) was obtained from all participants.

Consent for Publication

We confirm that all steps of scientific research were performed in accordance with relevant guidelines and regulations.

Availability of Data and Material

The datasets used and/or analyzed during the study are available from the corresponding author on reasonable request.

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Conflict of Interest

The authors declare that they have no conflict of interest.

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