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# Automated breast ultrasound (ABUS): A pictorial essay of common artifacts and benign and malignant pathology

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breast cancer; artifacts; advantages; dense breast; automated breast ultrasound

**Abstract**

Automated breast ultrasound is a three-dimensional ultrasonographic technique allowing the evaluation of women with dense glandular breast tissue. In this group of patients, mammography has a low sensitivity because dense breasts can obscure breast cancer on mammogram. On the other hand, women with dense breast tissue, types C and D on the BI-RADS scale, are at an increased risk of developing breast cancer compared to women with fatty breast tissue. Automated breast ultrasound is a standardized and reproducible ultrasound technique which improves breast cancer detection and is promising in the screening and diagnostic settings: it increases the detection of breast cancer, and helps to differentiate benign and malignant lesions. Unfortunately, automated breast ultrasound also has its limitations and disadvantages due to artifacts caused by poor positioning, and lesion and patient characteristics. Many artifacts can be avoided by training and experience of the performing technician. Furthermore, familiarity of the interpreting breast radiologist with these artifacts and pitfalls will decrease false negative diagnosis of true lesions.

## Introduction

The sensitivity of mammography for the detection of breast cancer in women with dense breasts is rather low, dropping from 86% in fatty breasts to less than 61% in dense breasts(1). The hiding effect of the dense fibroglandular tissue explains the delay in cancer detection, higher rates of interval cancers, large tumor size at detection, and frequent diagnosis of node-positive cancers, leading to a worse prognosis.

On the other hand, extremely dense breast glandular tissue, types C and D according to the 5th edition of the BI-RADS atlas (Breast Imaging Reporting and Data System classification) of the American College of Radiology (ACR), have a 4.7-fold increased risk of developing breast cancer, compared to type A. Therefore, the population of women with dense breasts could benefit from supplemental imaging modalities other than mammography that improve breast cancer detection(2,3).

Automated breast ultrasound (ABUS) is a technique approved by the US Food and Drug Administration (FDA) which is helpful for improving breast cancer detection. It is a standardized technique which is operator-independent, reproducible, and has a similar diagnostic performance to handheld ultrasound (HHUS)(1–3).

This pictorial review gives an overview of the technical principles, practical workflow, imaging anatomy, artifacts, and benign and malignant diseases on ABUS.

 

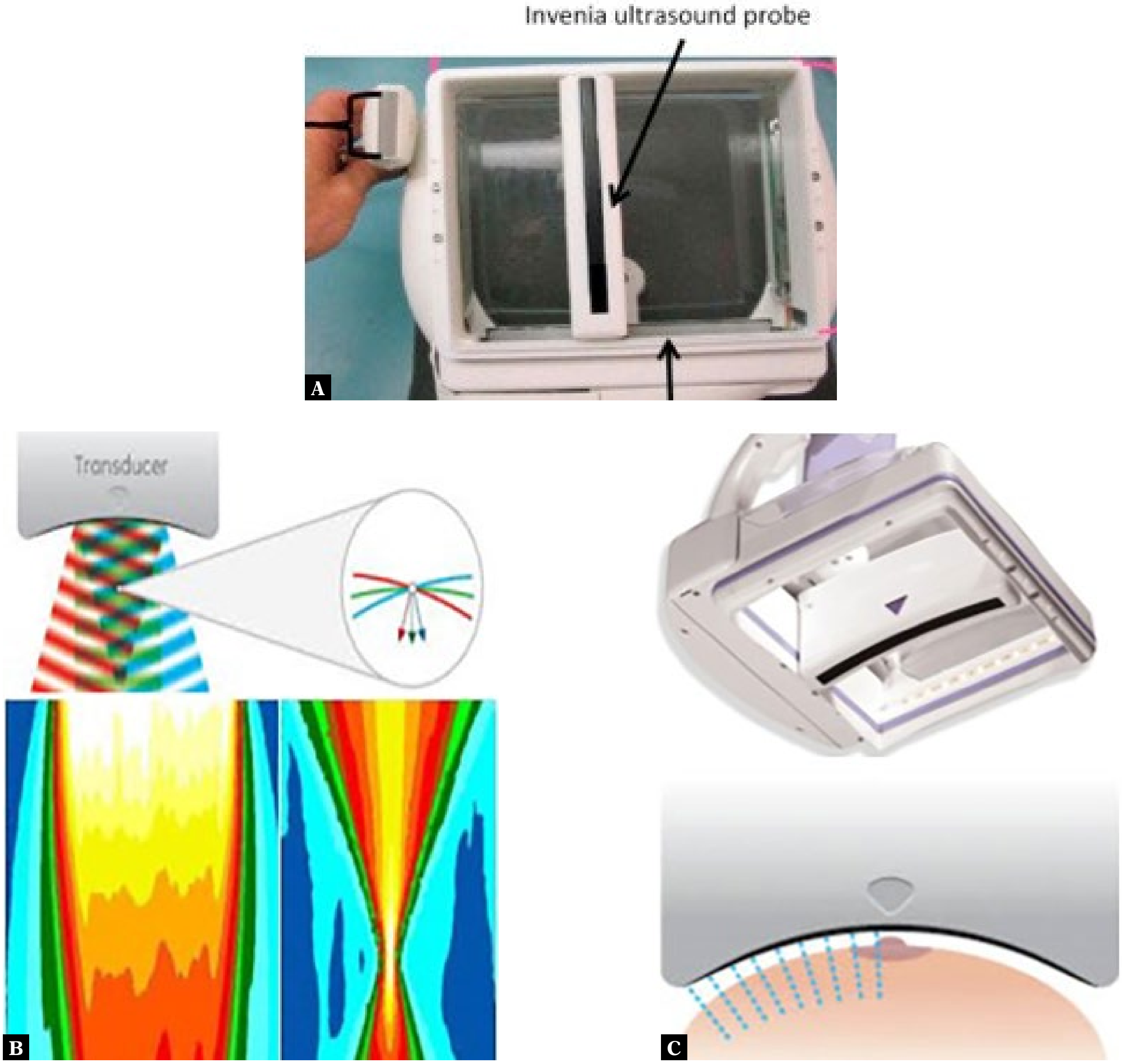


**Fig. 1.** *Transducer plate. Wide and curved high-resolution transducer (**A**, **B**) used for ABUS images for much wider footprint than handheld ultrasound (HHUS) to ensure a uniform compression across the entire breast. Wide bandwidth with a large imaging field of view (FOV) with wide beams in multiple angles, compared to focused beams in HHUS (**C**). (Images used with kind permission from GE Healthcare, USA)*

Knowledge of the limitations of the technique and familiarity with artifacts will improve the skills in interpretation and contribute to eliminating false positives and misinterpretations.

## Technical principles and practical workflow

### Important technical basics of ABUS

The curved surface of the wide transducer used in ABUS creates a good contact with the contour of the breast, in combination with the use of skin lotion and the disposable membrane on the transducer. This ensures a uniform compression across the entire breast (Fig. 1).

The transducer is automatically adjusted in the range of 6–15 MHz, but the applied bandwidth depends on breast thickness, varying from 2.5 to 6 cm. ABUS uses wide beams of 25 mm with coverage of a large field of view (FOV), as opposed to a focused beam in handheld ultrasound (HHUS) (Fig. 1).

Incoherent compounding and crossbeam technology with steered beams in three separate angle groups improves contrast resolution by smoothing out the speckle pattern to optimize resolution at deep structures, such as prepectoral tissue, pleura, ribs, and even behind implants.

ABUS also makes use of high-end software to increase the resolution throughout the images, such as nipple shadow compensation, speckle reduction imaging, and breast border detection.

**Fig. 2.** *Examination position. Supine position with rising arm above the head to acquire the ABUS views covering the breast while using a pillow under the patient's shoulder to get an adequate compression (***A***,* **B***,* **C***). ABUS equipment used in our department – Invenia™ (GE Healthcare, USA, used with permission) (***D***)*

## Practical workflow

High-quality ABUS examination requires highly skilled technicians. Therefore, practical training and instruction of technicians is crucial to obtain good quality images.

This goal can only be achieved with a relaxed and well-informed patient who feels comfortable. Prior to scanning, it is important to instruct the patient not to speak or move during the scan, and to breathe smoothly to avoid motion artifacts.

The examination is performed in the supine position (Fig. 2). The arm is elevated, and usually a pillow is placed under the shoulder to optimize the patient's comfort (Fig. 2).

The most important aspect before starting the ABUS is to spread out the breast tissue evenly, so that the nipple is pointing upwards. The nipple must be positioned just under the center because the upper quadrant contains more tissue than the inferior one.

A hypoallergenic water-soluble lotion is spread on the breast and axilla, and an additional lotion is applied around the nipple to obtain an adequate contact between the probe and the skin to avoid the air bubble artifact.

Three levels of compression may be used to optimize the contact between the probe and the skin. Automated and continuous volume acquisitions are obtained in the axial plane when the transducer moves from the inferior part of the breast to the superior section (Fig. 2). A single movement of the transducer allows the coverage of breast volume of 15.3 × 17 × 5.0 cm, with variable slice thickness of 0.5–10 mm at slice intervals of 0.5 to 2 mm.

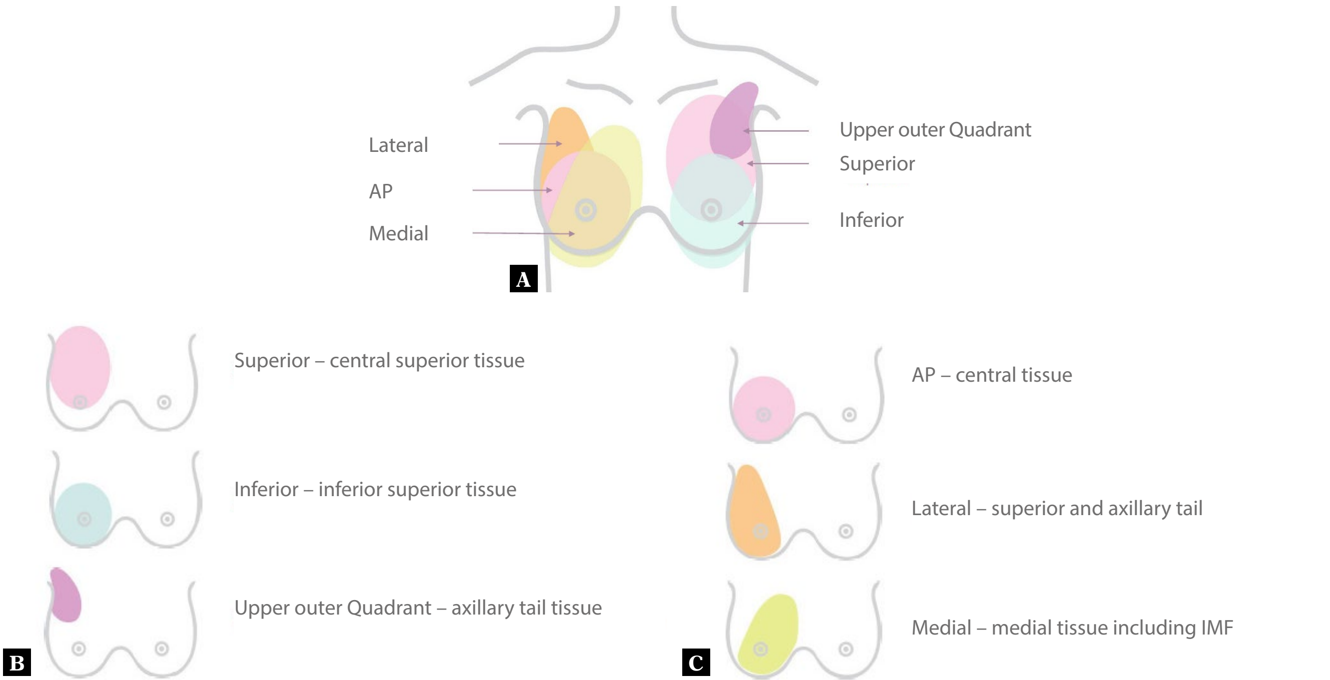


**Fig. 3.** *Scanning views, Overview of the ABUS scanning views (***A***) with three standard views anteroposterior (AP), lateral (LAT), and medial (MED) and additional six views are needed depending on patient body habitus to cover the entire volume of an individual breast. (***B***,* **C***). (Images used with kind permission from GE Healthcare, USA)*

For each breast, three volumes are obtained: the anteroposterior (AP) with the nipple in the center, the lateral view including the upper part and axillary tail of the breast, and the medial volume covering the inner part of the breast with the inframammary fold (Fig. 3). Additional views are often taken in patients with large breasts.

On the first scan, the technician evaluates the depth to ensure that the deep and peripheral breast tissues are included in the FOV. Depending on the breast size, there are five sizes to choose: extra small, small, medium, large, and extra-large, with a depth from 3.5 to 6 cm. The overall examination takes 15–20 minutes[4].

When the examination is completed, the volume data are processed automatically in multi-planar reconstruction with coronal and sagittal views, after which they are transferred to the workstation[5–7].

## ABUS anatomy and advantages in image interpretation

### Axial views

Wide axial views (Fig. 4A) provide detailed information on the nipple and regions behind the areola, the subcutaneous adipose tissue, and the hyperechogenic fibroglandular tissue. Due to the exquisite resolution for deeply located structures, and the large FOV, the evaluation of margins, shape, orientation, and echogenicity of lesions is optimal.[2,6]

### Coronal views

The coronal view (Fig. 4B), with thin-sectional frontal views of the breast at different depths of the breast, is the

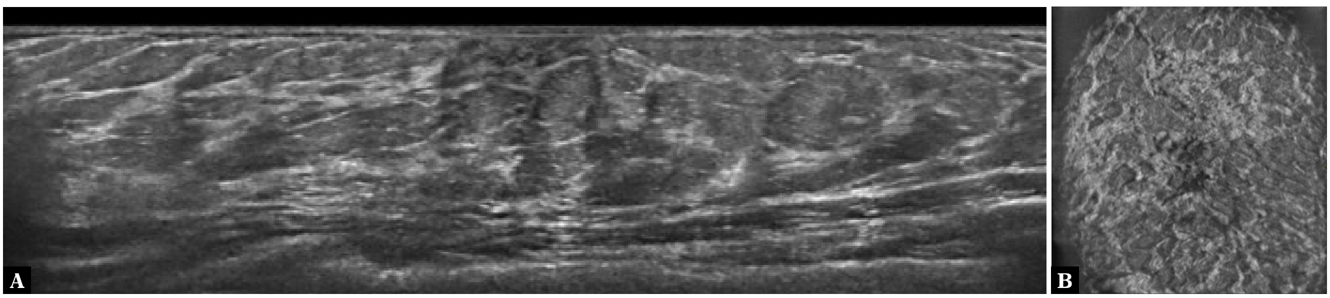


**Fig. 4.** *Imaging planes on ABUS: axial (***A***) and coronal AP (***B***). Note the typical "donut" shape on the AP coronal plane with the nipple in the center*

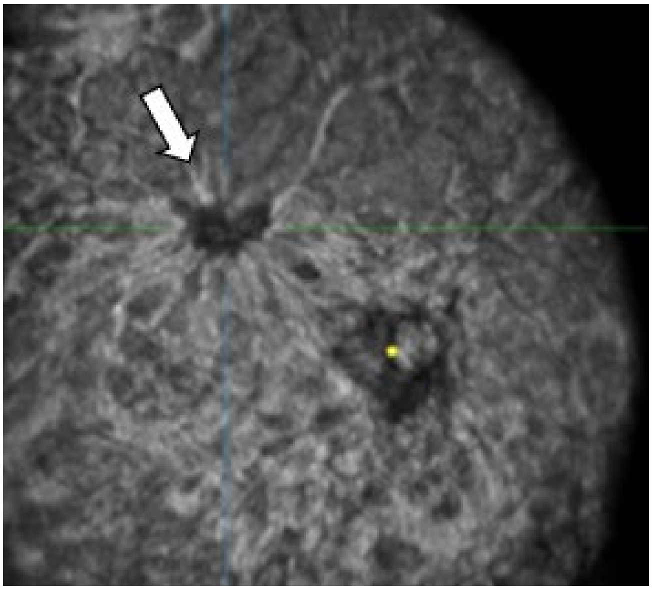

**Fig. 5.** *Retraction sign. Coronal lateral ABUS image of the right breast in a 64-year-old woman shows a strong retraction pattern (white arrow) of the tumor at the upper lateral quadrant. The nipple is marked by the yellow dot*

most valuable view. It allows visualizing the entire breast anatomy from the skin to the pectoral muscles and underlying ribs[3,4].

The coronal views are also very useful for evaluating irregular stellate borders, distortion, and posterior shadowing even in small malignant lesions.

The most reliable sign for the characterization of a suspicious lesion on the coronal view is the retraction phenomenon sign, a stellate pattern in which white spicules are caused by the desmoplastic reaction of the tissue surrounding a malignant lesion (Fig. 5)[2,8,9].

Another major advantage of ABUS is that measurements can easily be done in three directions, and the distance to the skin, the nipple, and other lesions is easily made in case of multifocality or multicentricity.

Due to the similar supine position of the breast during ABUS and the positioning during breast surgery, the coronal views are particularly valuable for surgeons to localize a lesion in the preoperative setting of breast conserving surgery.

ABUS is also useful for monitoring the effects of neoadjuvant chemotherapy and for the evaluation of fibrosis[3,4]. The reproducibility of the ABUS technique makes it a valuable tool in the follow-up of benign lesions as well.

## Disadvantages, limitations and artifacts of ABUS

### Disadvantages and limitations

Compression on the breast is sometimes a challenge, especially on the sternum and axilla, in women with small breasts.

Consequently, ABUS may be a rather painful experience in some women. Although there is less compression in ABUS compared to mammography, it is still more pronounced than in handheld US (HHUS), with three grades of compression in ABUS.

Although some axillary lymph nodes at level 1 can be visualized, sometimes the axilla is not completely evaluated, depending on the constitution of the patient. A fatty axilla makes it easier to see the lymph nodes.

In contrast to ABUS, HHUS offers the availability of color Doppler and elastography. Another drawback is that ABUS is more time-consuming than full-field digital screening mammography (FFDSM) both in terms of performing the examination and interpreting the findings[10,11].

Although breast implants are not a contraindication for ABUS, and potential leaks and tears can easily be identified, the firm structure can be a challenge for positioning.

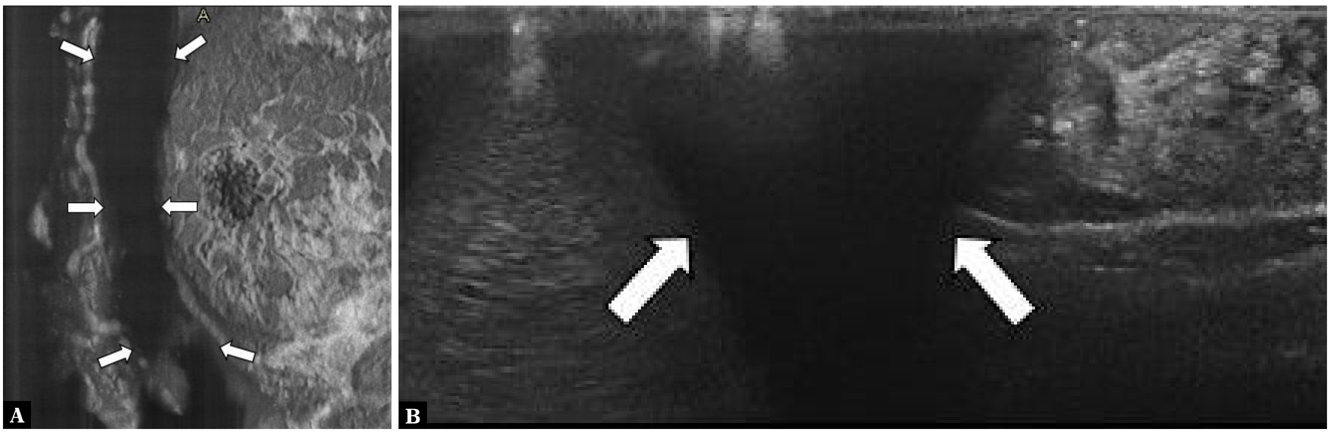


**Fig. 6.** *Drop-out artifact. ABUS in a 21-year-old woman. Coronal anteroposterior (**A**) and axial (**B**) ABUS images of the right breast show a large drop-out artifact as a longitudinal black area (between arrows) along the lateral section of the right breast*


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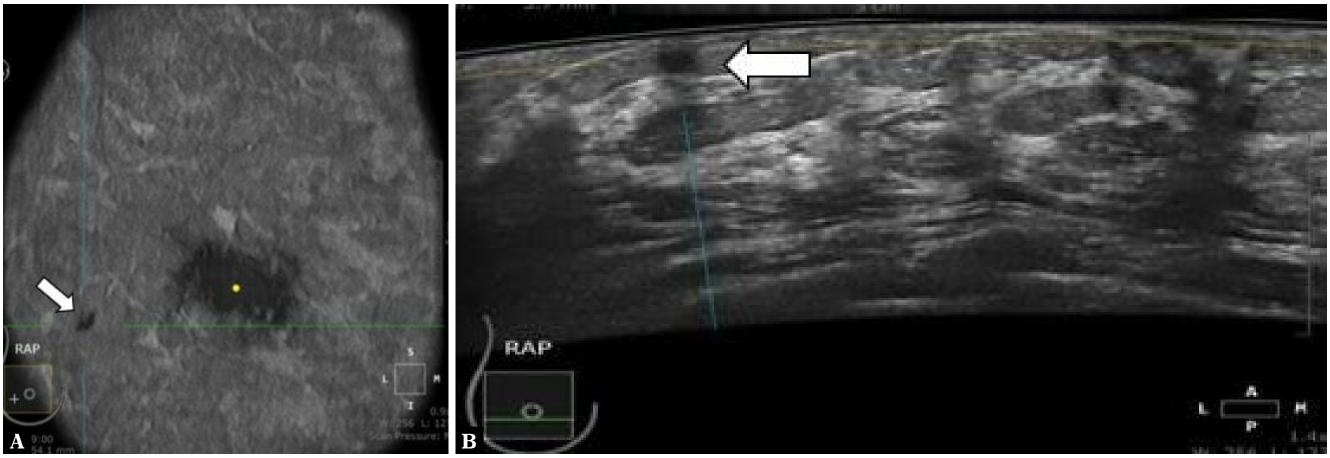


**Fig. 7.** *Air contact artifact. ABUS in a 54-year-old woman. Coronal anteroposterior (***A***) and axial (***B***) ABUS images from the right breast show an air contact artifact as a black hole (arrow) lateral to the right nipple (yellow dot). The nipple is marked by the yellow dot (***A***)*

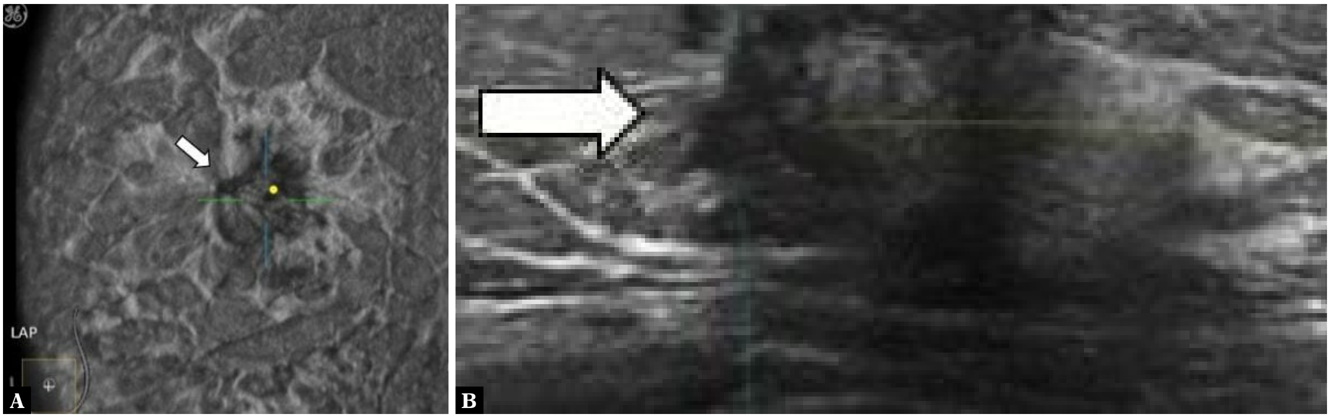


**Fig. 8.** *Nipple shadowing obscuring breast cancer. ABUS images of the left breast in a 54-year-old woman. The reconstructed coronal anteroposterior ABUS plane (***A***) demonstrates an invasive ductal carcinoma (arrow) in the paraareolar area with relatively mild nipple shadowing. Axial ABUS image (***B***) shows more prominent nipple shadowing obscuring the cancer completely (arrow)*

## Artifacts

Recognition and classification of artifact patterns minimizes false-positive interpretations[2] The origin of artifacts can be variable.

*Technique- and software-related artifacts*

- Inadequate transducer positioning: drop-out artifact

A well-performed technique, with a uniform breast compression and smoothing of the superficial tissue before the transducer is placed, can solve the problem of skinfold and drop-out artifacts at the border of the breast (Fig. 6).

Firm breasts and large breast implants may be difficult to compress. Consequently, it can be a challenge to position the transducer correctly and achieve an optimal contact area.

- Air contact artifacts

Sound waves can be entrapped between the transducer and the patient's skin, creating a reverberation pattern from the skin, with a total loss of signal underneath an air bubble. Air bubbles cause typical "black holes" on the image. They can be prevented by using enough water-based lotion and applying an appropriate compression (Fig. 7)[3].

- Nipple shadow

Disturbing acoustic shadowing behind the nipple, due to a column of altered echogenicity and high acoustic impedance of the dense tissue behind the nipple, has a hypoechogenic mass-like appearance. This artifact is often software-related. It is mostly seen on the lateral and medial views due to the tangential ultrasound reflection at curved structures behind the nipple. Therefore, the anteroposterior view is the best view to evaluate the retroareolar region (Fig. 8)[2,3].

*Patient- or lesion-related artifacts*

- Wandering shadows

Adjacent to the edges of the curved surface of Cooper's ligaments, scattering of ultrasonic waves may lead to a loss of signal and acoustic shadowing. The shadowing may "wander", especially while scrolling through the transverse planes, which is why it is referred to as "wandering shad-

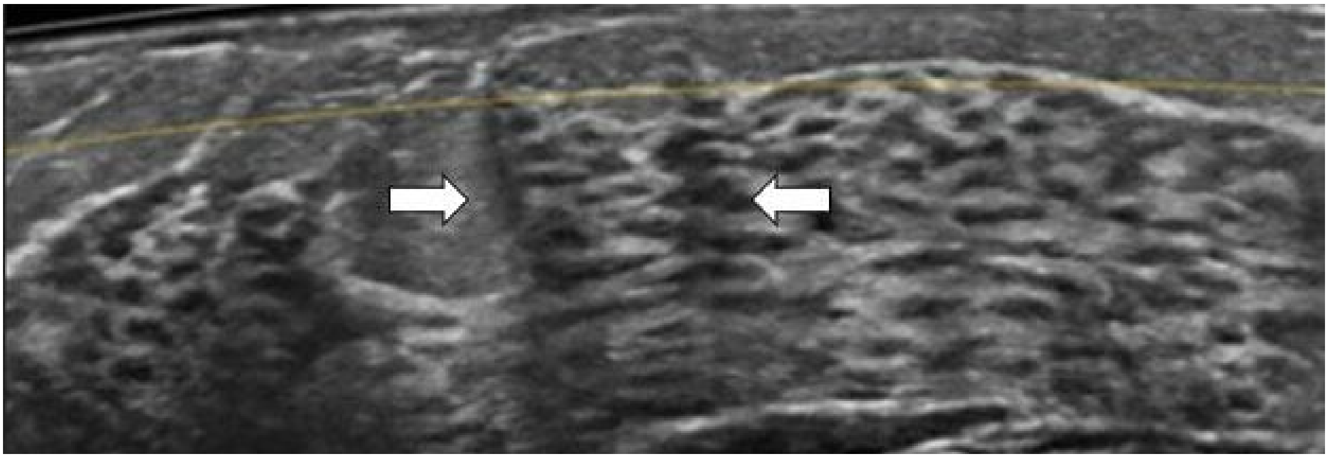

**Fig. 9.** *Wandering shadows in a 50-year-old woman with heterogeneously dense breasts. The axial images from a normal ABUS examination of the right breast shows multiple wandering shadows as dark parallel repetitive linear areas (white arrows). These are caused by sound waves that refract and scatter from the curved surface of Cooper's ligaments, causing wandering shadows in the breast*

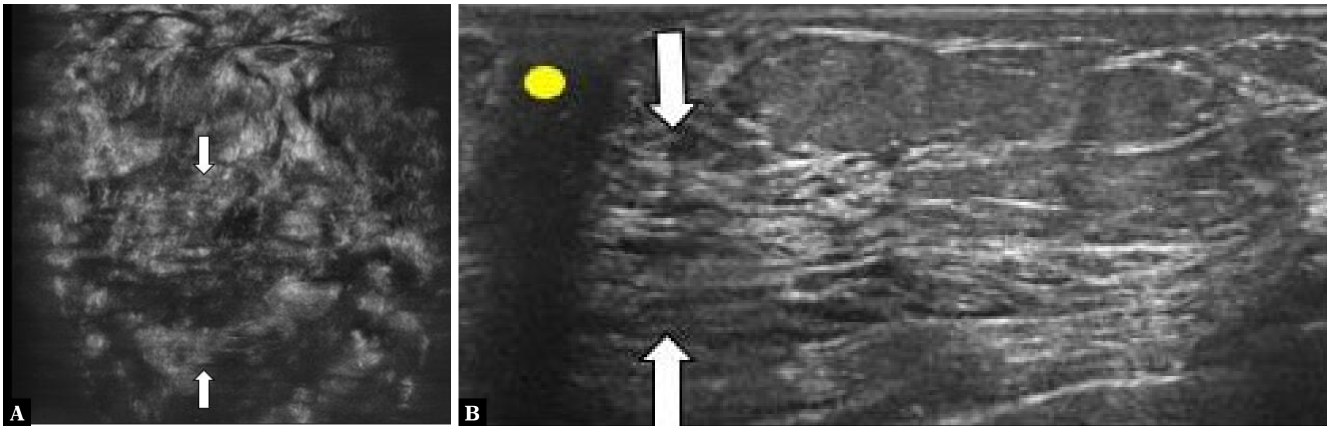


**Fig. 10.** *Sinusoidal distortion due to heavy breathing in a 70-year-old woman. Coronal anteroposterior (**A**) and axial ABUS image (**B**) of the left breast show patterns of heavy breathing artifacts during the acquisition as a cluster of straight lines which are most conspicuous at the posterior deepest aspect of the left breast (between arrows). Nipple shadowing also showed on the axial image (**B**, yellow dot)*

ows" (Fig. 9)[(2)]. Unfortunately, the current ABUS technology does not allow the correction of the transducer angle. The same effect of shadowing can occur in HHUS, but can be corrected by adjusting the angle of the transducer.

- Sinusoidal wave pattern

Heavy breathing or talking may result in sinusoidal waves and image distortion. The waves have the same frequency as breathing. This wave pattern can distort the evaluation of the deeper regions close to the chest wall, especially on the sagittal and coronal reconstructions. Even tachycardia can cause artifacts during scanning (Fig. 10)[(2)].

- Skip artifact

A horizontal or sagittal line artifact on coronal and sagittal views can be created when the transducer moves over the bumpy surface of a firm mass e.g., a fibroadenoma, a region of nodular dense breast tissue or even an implant (Fig. 11)[(2)].

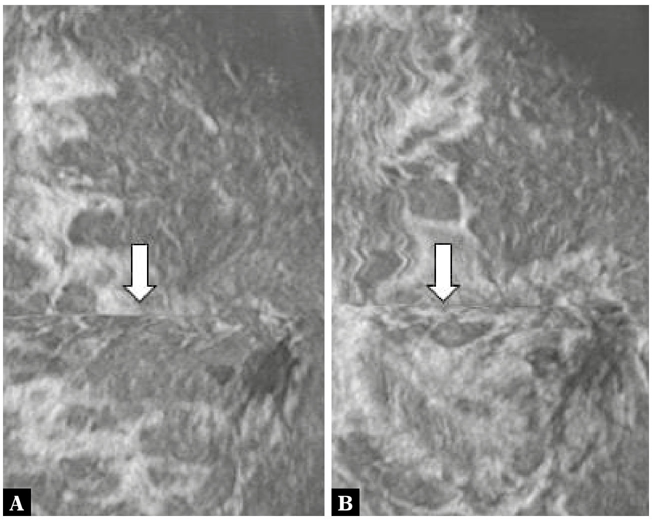


**Fig. 11.** *Skip artifact. Coronal lateral ABUS images (**A**, **B**) of the right breast shows a straight horizontal line (white arrow) caused by a lack of skin contact of the probe due to skipping of the transducer at the nipple*

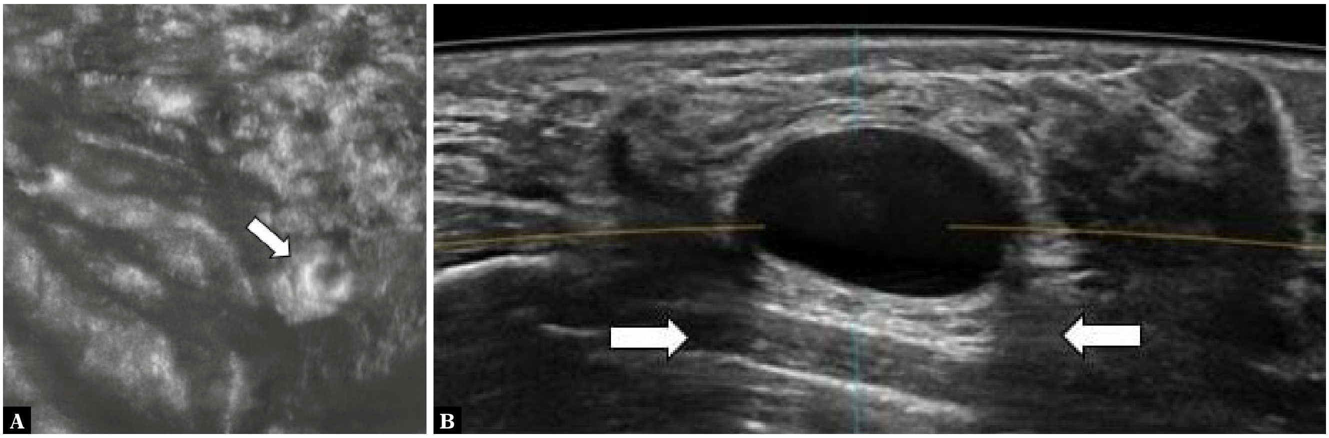


**Fig. 12.** *White wall artifact in a cyst. Coronal anteroposterior reconstruction ABUS image (***A***) shows a round echogenic capsule (white arrow), in the right breast. This is corresponding to the posterior enhancement of the cyst on the axial plane (***B***) (white arrows)*

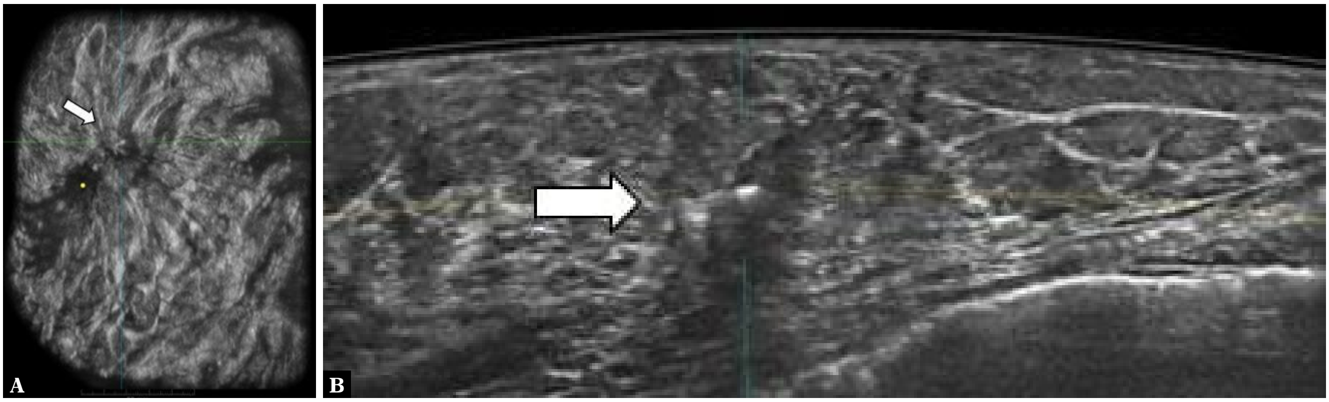


**Fig. 13.** *Surgical scars and clips shadowing. Lateral coronal (***A***) and axial plane (***B***) ABUS images in a 65-year-old woman show a hypoechoic region with lobulated margins and strong posterior shadowing surrounding a metallic surgical clip within the operated area in the upper outer quadrant of the left breast (white arrow). The nipple is marked with the yellow dot on the lateral coronal view (***A***)*

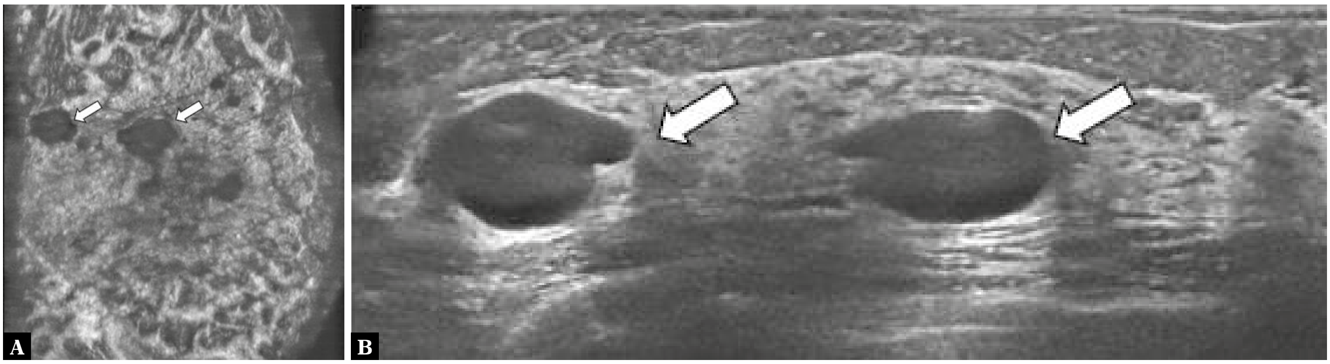


**Fig. 14.** *Multiple cysts in the upper lateral quadrant of the right breast. Coronal anteroposterior (***A***) and axial (***B***) ABUS images in a 38-year-old woman show multiple cysts (white arrows) with an overall acoustic enhancement and subtle intralesional reflections. There are no solid components, and the long axis is parallel to the skin on the axial image*

- White wall artifact

The posterior enhancement of a cyst, seen on HHUS as well, can create a white wall artifact on the coronal plane at the level of the posterior enhancement of the cyst. This can also influence the image interpretation and is not solely a sign of a benign lesion. Using additional planes is often very useful for the correct analysis of artifacts and to prevent misinterpretation (Fig. 12).

- Shadowing due to surgical scars and clips

In patients with surgical scars and clips, the sound attenuation artifact extends posteriorly to the scar at the skin or

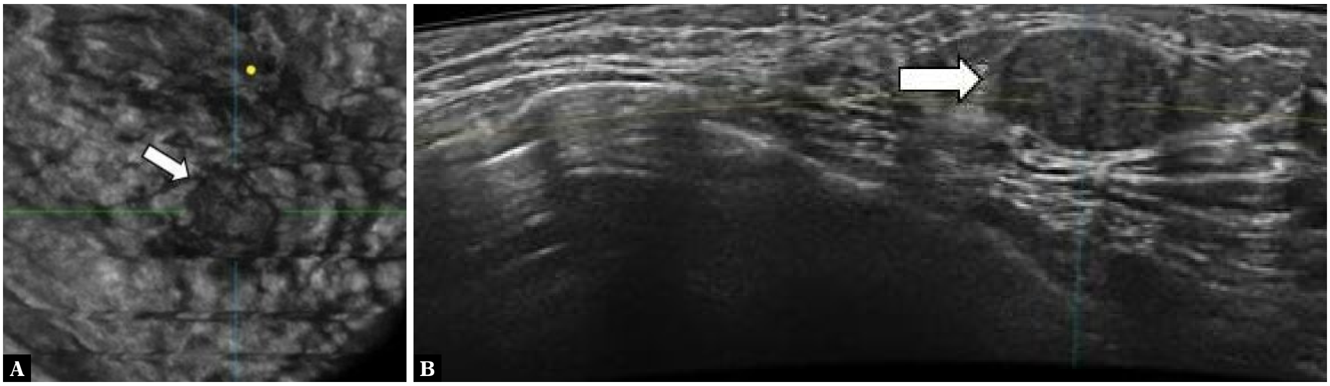


**Fig. 15.** *Fibroadenoma. Coronal lateral (**A**) and axial (**B**) ABUS images of the right breast in a 32-year-old woman with heterogeneously dense breasts and negative screening mammography. ABUS images show a circumscribed hypoechoic lesion (white arrow) within a fine peripheral capsule. The lesion has no posterior acoustic features or the sign of retraction on the coronal plane*

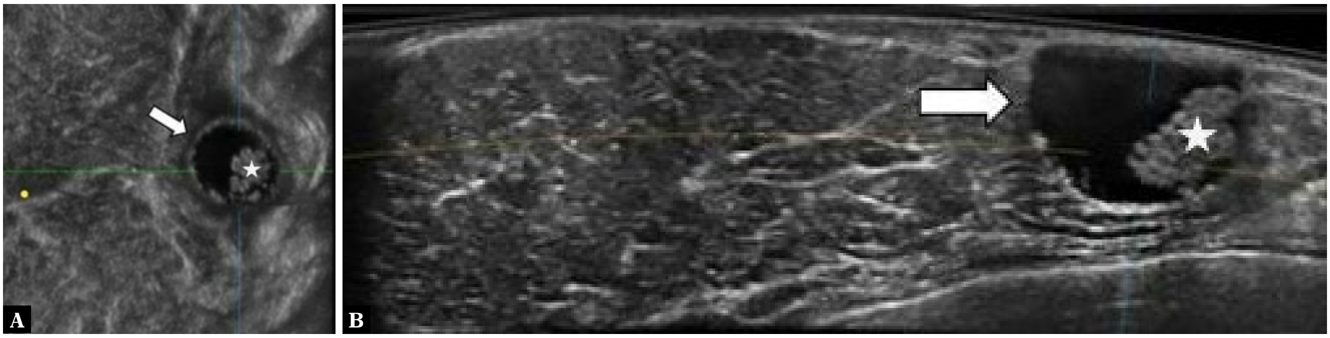


**Fig. 16.** *Fat necrosis in a chronic stage. Lateral coronal reconstruction (**A**) and axial plane (**B**) ABUS images in a 63-year-old woman in the upper outer quadrant of the left breast shows a well-defined lesion with partial cystic components with debris (white arrow and white asterisk) surrounded by edematous fat*

behind this clip respectively. This may mimic tumor recurrence (Fig. 13).

## ABUS appearance of benign lesions

Benign breast lesions are often underdiagnosed on mammography due to dense breast tissue. Therefore, supplemental whole-breast US is useful for visualizing these lesions.

### Cysts

Simple breast cysts are benign round or oval anechoic lesions with retroacoustic enhancement and thin wall[12,13]. The lesions are usually well-defined, with the longest diameter parallel to the skin. In women with multiple cysts, ABUS provides an overview of fibrocystic breast tissue and helps to differentiate cysts from a possible underlying malignancy or a complex or complicated cyst (Fig. 14).

### Fibroadenoma

Fibroadenomas are encountered in 15–25% of women undergoing breast cancer screening and are more common in younger women[14]. They usually manifest as well-circumscribed hypoechoic masses surrounded by a thin hyperechoic capsule, without architectural distortion. Old lesions may be sclerotic, and may contain calcifications and septa. In cases of multifocal or multicentric bilateral fibroadenomas, ABUS is not only useful for complete mapping of all lesions, but also for rendering reproducible images on follow-up examinations (Fig. 15)[15].

### Fat necrosis

Fat necrosis is a benign breast condition that can arise from trauma, breast surgery or radiation treatment in fatty breast tissue.

The ultrasound features of fat necrosis vary depending on the stage of the lesion, ranging from multi-cystic appearance surrounded by hyperechogenic edema in the acute phase, hyperechogenic tissue due to edema in the subacute phase, or a peripheral oil cyst in the chronic stage.

Fat necrosis can also present as an angular, spiculated lesion due to fibrosis, and may mimic breast carcinoma. In conjunction with clinical history, ABUS can be helpful for distinguishing it from a true malignancy by meticulous analysis of the follow-up images along with different stages of fat necrosis (Fig. 16)[15].

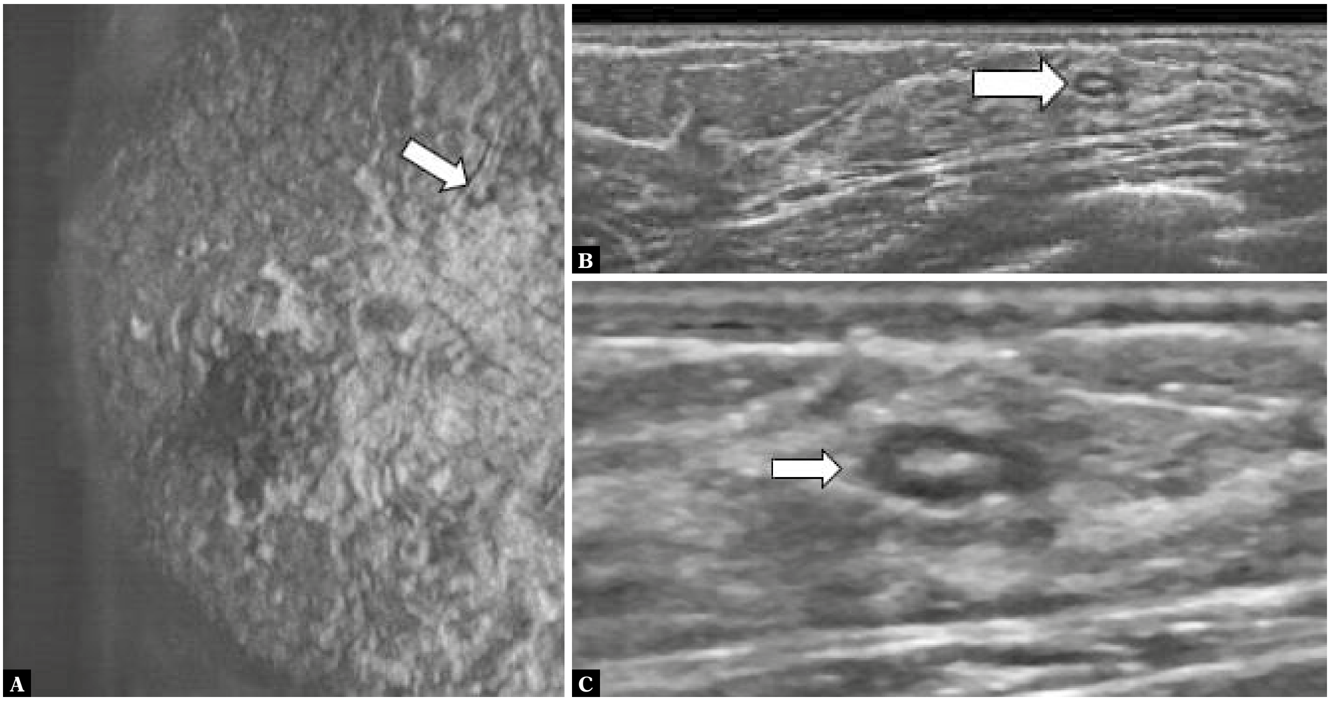


**Fig. 17.** *Intramammary lymph node in the upper outer quadrant of the left breast. Coronal lateral plane (***A***), axial plane ABUS images (***B***) and enlarged axial view (***C***) in a 42-year-old woman show a circumscribed oval lesion with a hyperechoic fatty hilum and hypoechoic peripheral cortex (white arrow)*

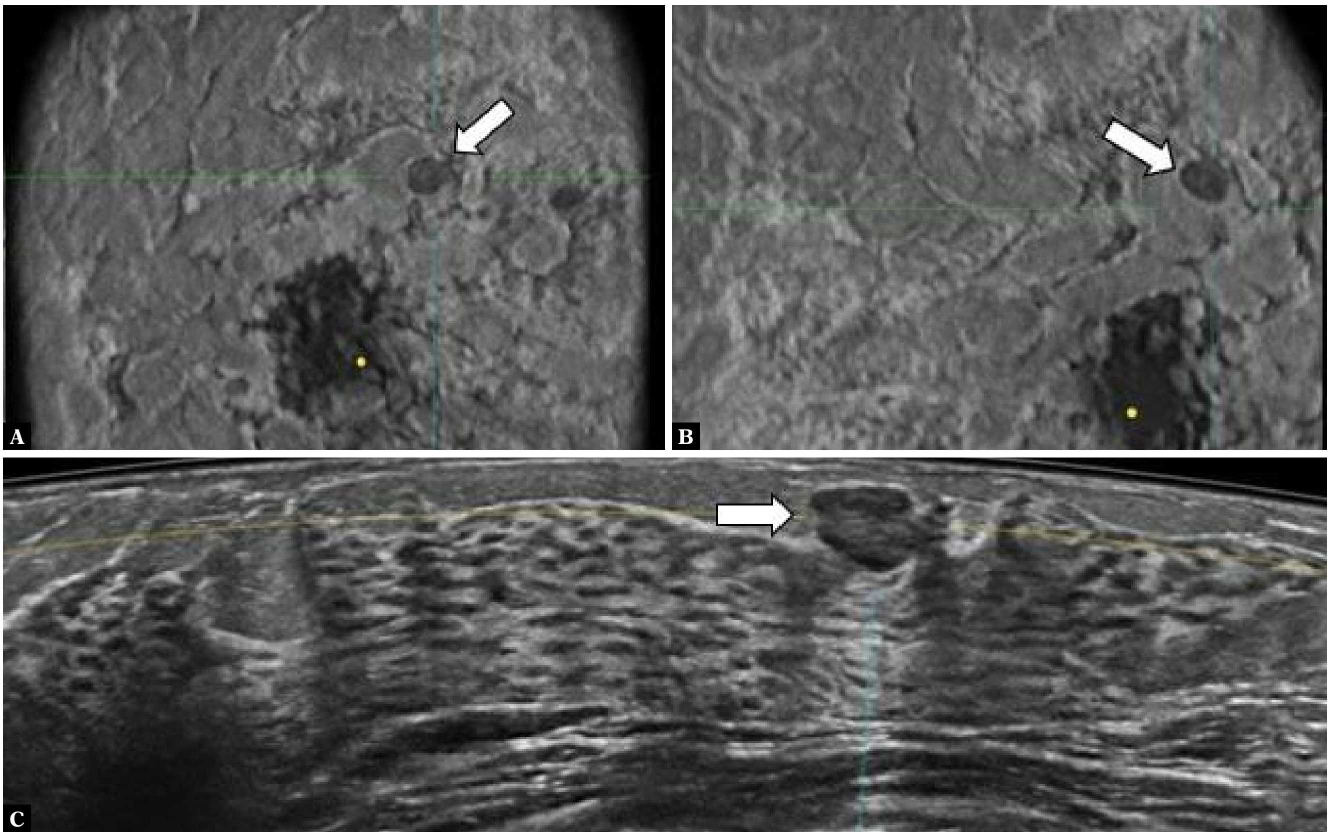


**Fig. 18.** *Papilloma. Coronal anteroposterior (***A***), coronal lateral (***B***) and axial (***C***) ABUS images of the right breast in a 38-year-old asymptomatic woman at a high risk of developing breast cancer. Notice an irregular hypoechoic lesion (white arrow) with a heterogeneous echo pattern and partial posterior acoustic enhancement (arrows). Histological core needle biopsy showed an intraductal papilloma without signs of invasive or in situ carcinoma or atypia*

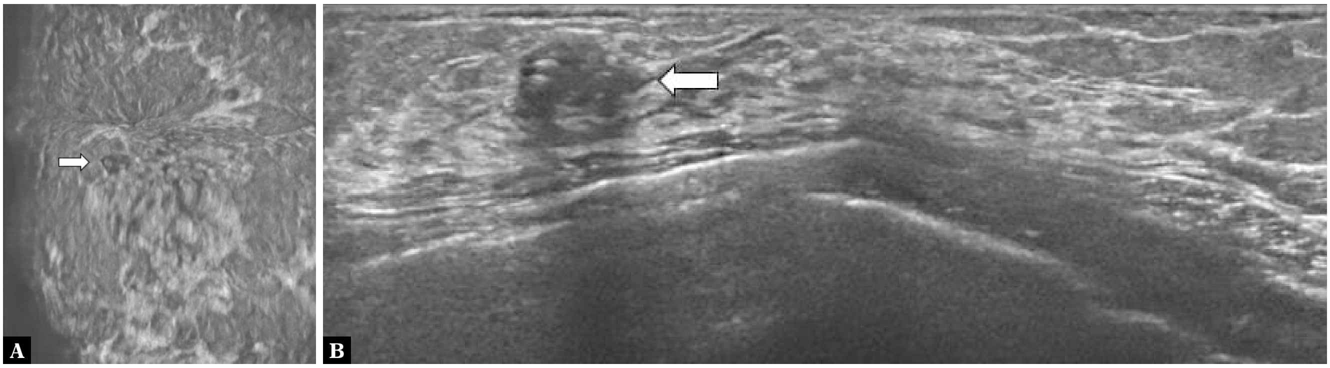

**Fig. 19.** *Radial scar/CSF. Coronal lateral (***A***) and axial (***B***) ABUS images from the left breast in a 30-year-old woman at a high risk of developing breast cancer. ABUS images showed an irregular, indistinct, hypoechoic lesion (white arrows) with posterior acoustic shadowing. Histological examination of the specimen obtained by core needle biopsy showed a CSL without signs of invasive or in situ carcinoma or atypia*

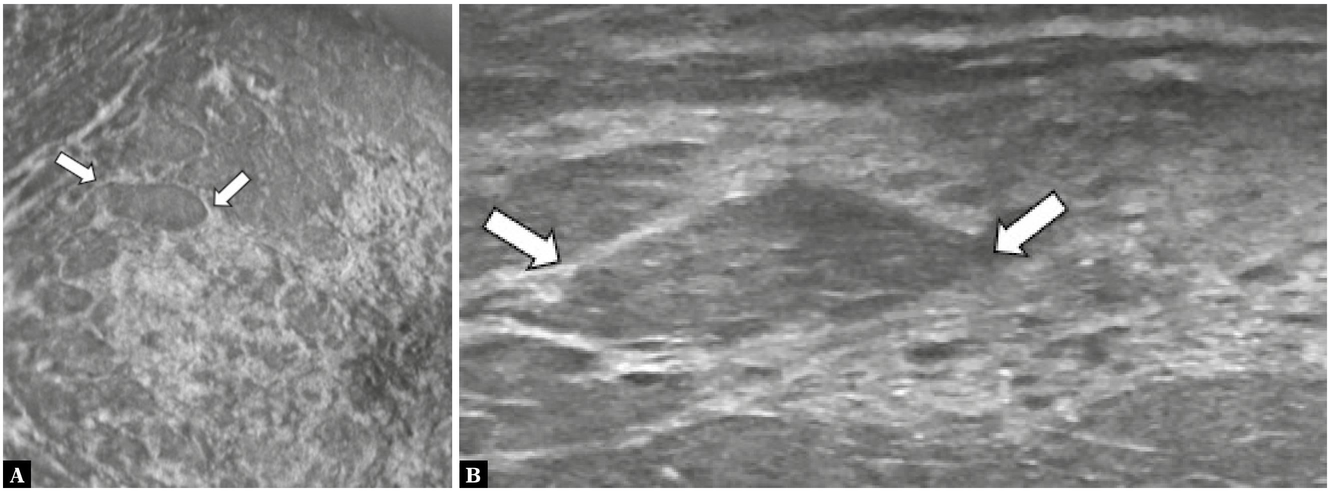

**Fig. 20.** *Lipoma. Coronal lateral (***A***) and axial (***B***) ABUS images of the left breast at the upper outer quadrant in a 46-year-old woman. Notice a well-defined hypoechoic lesion (white arrows) with the long axis parallel to the skin*

## Intramammary lymph node

Intramammary lymph nodes (IMLN) are incidental and common benign findingson US and mammography. They are surrounded by breast tissue in all directions. They are typically circumscribed, smaller than 10 mm, with an oval or reniform shape, and hilar fat. IMLNs are predominantly seen in the upper outer quadrant in the breast and often adjacent to a vein. However, they can be located anywhere in the breast (Fig. 17)[16].

## Intraductal papillary lesions and peripheral papilloma

Intraductal papilloma is a benign neoplasm of the intraductal epithelium with a fibrovascular core. On physical examination, it may present with nipple discharge or a palpable, painless, and mobile mass. It may also be associated with gynecomastia.

The differentiation between intraductal papilloma and papillary carcinoma is not possible with imaging alone. Therefore, a histopathological examination is necessary to make the final diagnosis (Fig. 18).

In case of papillomatosis or multiple peripheral localized papillomas, ABUS can be helpful for the precise evaluation of the location and extent of different lesions[17].

## Radial scar/ Complex sclerosing lesions (CSLs)

Radial scars or CSLs result from an idiopathic process with sclerosing ductal hyperplasia, and are unrelated to surgical scarring. They are considered as B3 lesions, i.e. benign lesions of uncertain malignant potential. On US images, they typically present as a spiculated lesion or hypoechogenic distortion with a central fibrous core, radiating ducts or small cysts. Sometimes, only a spiculated lesion is seen on mammography, with no specific sign on HHUS. ABUS may be useful for detecting architectural distortions with a retraction pattern, especially on coronal images (Fig. 19)[10,18].

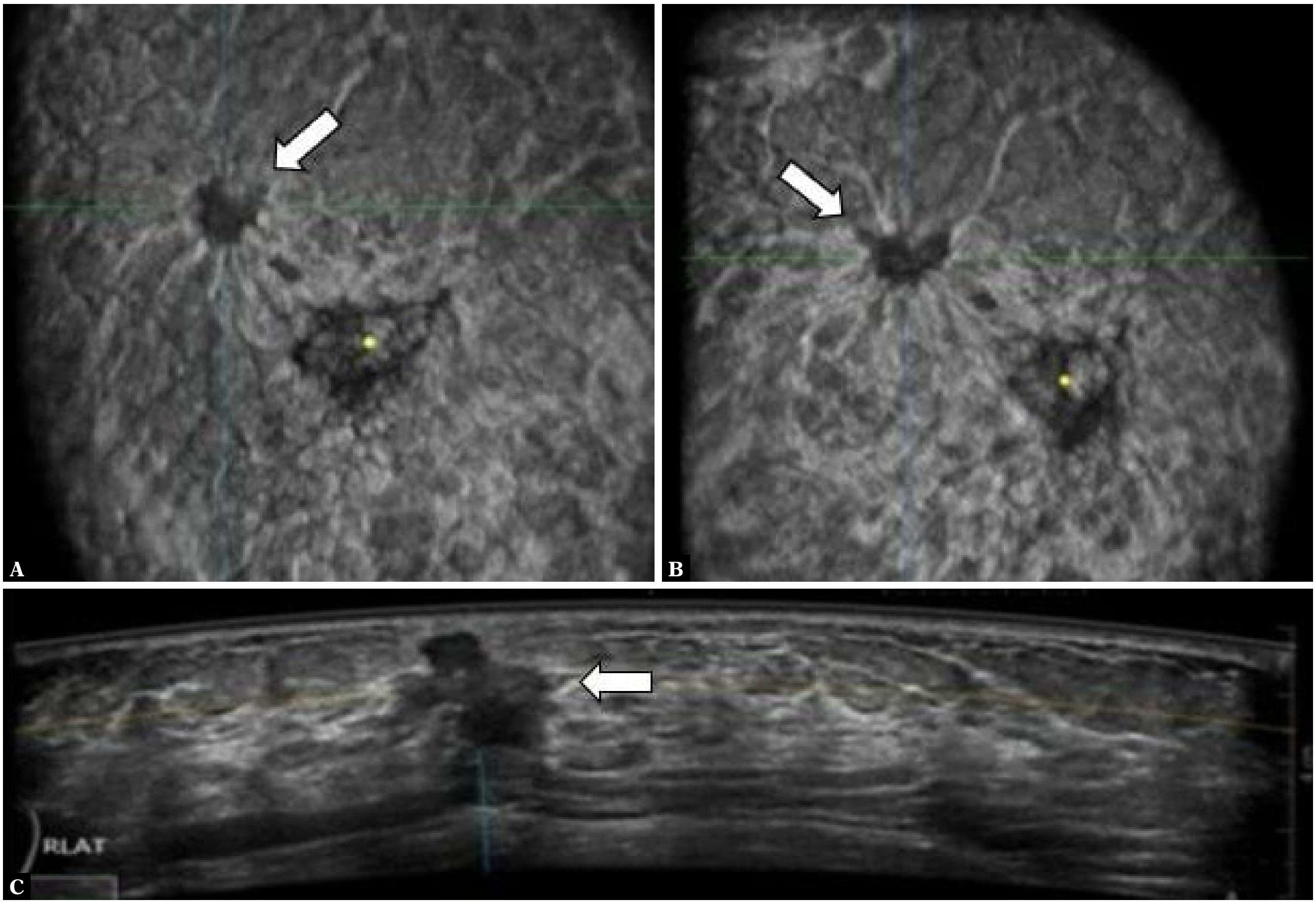


**Fig. 21.** *IDC. Coronal anteroposterior plane (***A***), coronal lateral (***B***) and axial (***C***) ABUS images of the right breast in a 64-year-old woman with heterogeneously dense breasts. ABUS images of the right breast show an irregular, hypoechoic mass with lobulated and spiculated margins, posterior acoustic shadowing, and a retraction pattern on the coronal image (white arrows). The nipple is marked with the yellow dot on the lateral coronal view (***A***,* **B***). Histological evaluation revealed a 14-mm intermediate-grade IDC*

### Lipoma

Lipoma is one of the most common benign breast lesions composed of mature fat cells. Clinically, lipoma presents as a painless asymptomatic lesion or a soft, non-tender palpable mass. On ABUS, it is oval-shaped and longitudinally oriented to the chest wall. The echogenicity of lipomas varies from a mild hyperechoic to iso- or hypoechoic lesion surrounded by a thin echogenic capsule (Fig. 20). Lipomas can be large, and the wide FOV of ABUS allows the coverage of the entire lesion[19].

## ABUS appearance of breast cancers

Despite the histological heterogeneity of breast cancer, the retraction phenomenon sign is almost a constant finding on ABUS in all histological types[2,20,21].

### Invasive ductal carcinoma (IDC)

IDC is the most frequent type of breast carcinoma, accounting for 80–90% of all cases. The ultrasound appearance varies depending on the proliferation rate and hormone receptor status. More indolent subtypes or hormone-receptor positive types of IDC are often hypoechoic, irregular, or indistinct, have spiculated margins, and show posterior acoustic shadowing. The retraction phenomenon is present in the majority of IDCs on coronal views (Fig. 21, Fig. 22)[22–24].

On the other hand, more aggressive invasive cancers, such as triple-negative IDCs and other high-grade IDCs have mostly circumscribed or micro-lobulated borders, are often round, and have posterior acoustic enhancement[9]. Therefore, these lesions seem to mimic benign tumors, which can lead to false negative results on ABUS[2].

### Invasive lobular carcinoma (ILC)

About 11% of invasive cancers are of the lobular type[25]. In the majority of ILCs, the US features consist of a hypoechoic irregular mass with indistinct angulated margins, an echogenic halo, and posterior acoustic shadowing[26]. ILCs may also manifest without a distinct mass or with hyper- and isoechoic patterns, either with or without focal acoustic shadowing, commonly with subtle distortion. This is more frequently observed in ILCs than in IDCs[26].

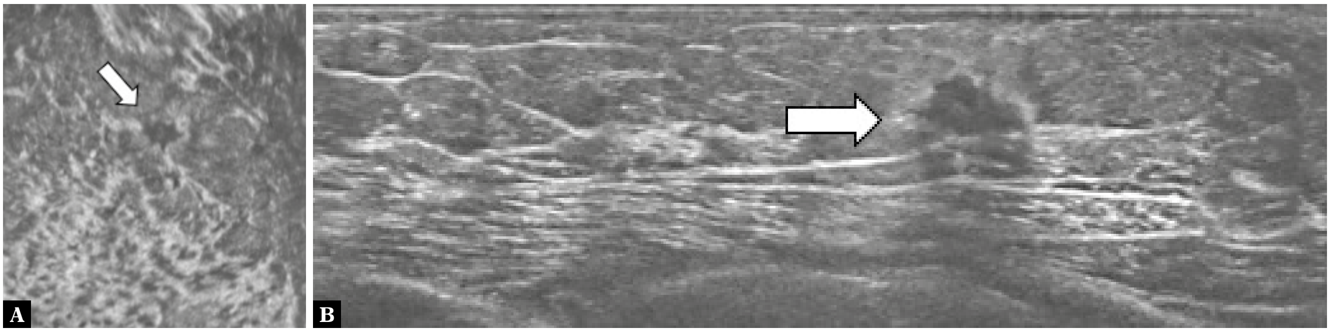


**Fig. 22.** *Triple negative IDA. Coronal lateral plane (***A***) and axial plane (***B***) ABUS images of the left breast in a 72-year-old woman with heterogeneously dense breasts. Notice an irregular hypoechoic mass (white arrow) with spiculated margins. A strong retraction phenomenon was seen on the coronal plane. Histological analysis confirmed a 15-mm IDA*

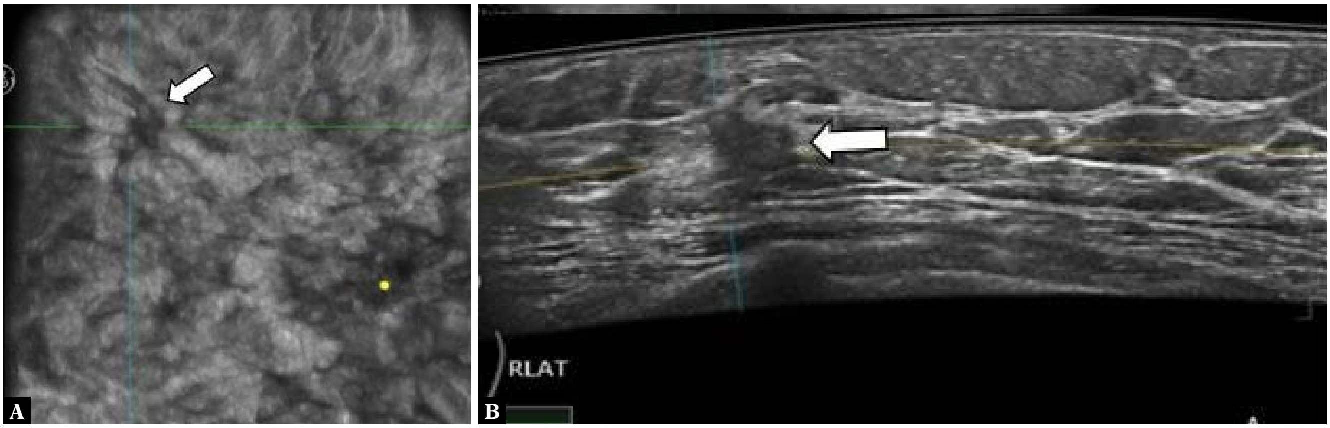


**Fig. 23.** *ILC. Coronal lateral plane (***A***) and axial (***B***) ABUS images in a 50-year-old woman with heterogeneously dense breasts. ABUS images of the right breast show an irregular non-parallel mass (white arrow) with indistinct and angular margins. An extensive retraction pattern is seen on the coronal image. Histological analysis confirmed a 12-mm ILC*

Consequently, the extent of ILCs is often underestimated with US, but nevertheless US has a higher sensitivity for depicting ILCs than mammography[3]. In addition, ABUS may be very useful for ILC detection by demonstrating a retraction pattern on coronal images even in the absence of a distinct mass (Fig. 23).

### Invasive tubular cancer (ITC)

ITC accounts for 2% of all breast cancers, and it is a low-grade cancer[25]. Its US appearance typically consists of a small hypoechoic irregular mass with an echogenic halo. The margins are often spiculated, with the presence of posterior acoustic shadowing. It commonly causes a severe retraction pattern on coronal ABUS images.

### Colloid carcinoma or invasive mucinous carcinoma

This histological type accounts for 2% of all breast cancers[25]. It is a mucin-producing ductal cancer presenting on US as a complex solid/cystic mass, commonly oval or lobulated, with posterior acoustic enhancement. A small mucinous tumor can be falsely interpreted as a tiny cyst. A retraction pattern on coronal ABUS images is often demonstrated and even subtle architectural distortions on multiplanar reformatted ABUS images can often be used as clues to suggest the diagnosis.

### DCIS, ductal carcinoma in situ

This cancer type presents as tiny intraductal microcalcifications on mammography or as non-mass enhancement or ductal enhancing pattern on MRI. Most cases of DCIS are difficult to detect by US. Subtle US changes include duct dilatation with discrete intraductal microcalcifications[27]. They are also difficult to depict on ABUS, unless extensive.

## Conclusion

ABUS is a useful technique for the evaluation of dense breasts, and it is helpful to surgeons in the preoperative setting of breast conserving surgery, documenting multifocality and multicentricity. With ABUS, it is possible to evaluate the extent of the lesion and its distance to the skin, nipple, and other lesions.

Familiarity with the limitations of the technique and artifacts contributes to improving the interpretation of findings and may help avoid false positives.

Knowledge of imaging semiology on ABUS is a prerequisite for the correct characterization of benign and malignant breast lesions in daily practice.

### Conflict of interest

*The authors do not report any financial or personal connections with other persons or organizations which might negatively affect the contents of this publication and/or claim authorship rights to this publication.*

### Author contributions

*Original concept of study: DAJ, SD. Writing of manuscript: DAJ, SD. Final acceptation of manuscript: DAJ, SD, KW, MA, CV, FV. Collection, recording and/or compilation of data: DAJ, SD, KW. Critical review of manuscript: SD, KW, MA, CV, FV.*

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