CHAPTER 7

CURRENT IMAGE-GUIDED INTERVENTIONAL PROCEDURES IN THE BREAST

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INTRODUCTION

Currently, with the more widespread use of imaging methods such as mammography (MG), ultrasonography (US), and magnetic resonance imaging (MRI) in the diagnosis of breast diseases, there has been an increase in the rate of determination of non-palpable breast lesions. According to the Breast Imaging Reporting and Data System (BI-RADS) classification in the most recent guidelines applied in breast cancer screening and diagnosis, percutaneous biopsy is recommended for breast lesions which are suspicious in respect of malignancy (BI-RADS 4) or highly suggestive of malignancy (BI-RADS 5) (1). Percutaneous interventional procedures under image-guided are a less invasive, reliable, easier, lower cost, and less time-consuming alternative to surgical biopsies (2).

Interventional procedures may be performed on the breast for diagnostic or treatment purposes. Diagnostic interventional procedures are methods such as fine needle aspiration (FNA), core biopsy (CNB), vacuum-assisted biopsy (VAB), and preoperative marking. Other than these, methods are also used such as the placement of a clip marker before neoadjuvant chemotherapy, vacuum-assisted stereotactic breast biopsy for diagnostic and treatment purposes, and for treatment purposes, cyst aspiration and abscess drainage, Breast Lesion Excision System (BLES), radiofrequency ablation (RFA), cryoablation, focussed US ablation, and interstitial laser photocoagulation.

IMAGE-GUIDED METHODS

The selection of a guidance method is made according to the visibility and accessibility of the lesion, the efficacy of the method, ease of positioning the patient, and the operator experience. With whichever method the lesion can be better visualised, that should be the method selected. The primary rule in sampling sus-

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picious lesions determined in the breast is that the intervention is made by selection including the stages from simple to complex, from easy to difficult, and from low-cost to high-cost. In percutaneous breast biopsies and preoperative marking, US, MG, or MRI can be used as the image-guided method.

Complications such as pain, hematoma, and infection may develop in image-guided percutaneous biopsies. Pain can be prevented with a local anaesthic injection, hematoma by keeping bleeding parameters under control and the application of compression and ice after the procedure, and infection by paying attention to sterility. As there is also a risk of pneumothorax in US-guided core biopsies this can be prevented with an oblique or parallel needle approach.

ULTRASONOGRAPHY

US is the first step preferred for image-guided biopsy. If the lesion can be seen sonographically, US-guided biopsy is preferred as it does not contain radiation, is low-cost and easily accessible, can provide real-time visualisation of the relationship between the needle and the lesion, and sampling can be taken from different parts of the lesion (3). Other advantages of the method are that it can be used for lesions in the axillary region and in all parts of the breast such as intraductal or peripheral localisation in the breast and close to the chest wall.

In recent decades there has been a great increase in the use of US in breast biopsies. While it was initially used in the differentiation of cystic and solid lesions, it is now widely used along with FNA, CNB, VAB, and in marking or therapeutic excision procedures. US is mostly used in core needle biopsies of distortions and masses. US guidance is used for sampling in the differential diagnosis of granulomatous mastitis or in aspiration with the aim of microbiological-cytological examination if collection or abscess has developed in a table of mastitis, and in aspiration of cystic lesions. Before the excision in non-palpable small masses or distortions, US-guided marking with a wire enables the lesion to be totally removed and provides good cosmetic results with minimal tissue volume loss. In pediatric patients and those who are pregnant or lactating, US can be safely used in interventional procedures as there is no exposure to radiation.

As microcalcifications cannot be reliably determined on US, stereotaxis or tomosynthesis is generally preferred. However, with current developments in US techniques and with high-resolution transducers, it is now possible to differentiate some microcalicifcations with US, especially clustered calcifications and calcifications within a mass or dilated ductus, and thus biopsy can be performed US-guided (4, 5).

In US-guided interventional procedures performed the patient is positioned supine or slightly oblique with the ipsilateral arm raised above the head. The patient is prepared after appropriate cleaning of the skin and the administration of local anaesthesia. The lesion is reached by advancing the probe along the long axis with the free hand technique, so that the needle will be parallel to the chest wall at the closest and most appropriate distance to the lesion. After the procedure, bleeding is controlled with compression.

MAMMOGRAPHY

In parallel with the widespread current use of mammography screening, non-palpable breast lesions are determined more often. Stereotactic is a minimally invasive method used in the biopsy or preoperative wire marking of microcalcifications suspected of malignancy, parenchymal distortion and small mass lesions determined only on MG, which cannot be distinguished with sonography (6). Digital mammography or tomosynthesis guidance is used.

If non-palpable breast lesions determined with MG are to be removed with excisional biopsy, preoperative marking is required. By wire marking with MG-guided, images in the craniocaudal (CC) and mediolateral (ML) projection are obtained before localisation of the lesion, and the projection of the lesion closest to the skin is determined. With the patient seated or standing, the image is obtained by compressing the breast with a compression plate that is perforated or has a square opening in the centre and a ruler at the edge. The X and Y co-ordinates of the lesion are determined. After appropriate skin cleaning and the administration of local anaesthesia, the needle is placed perpendicular to the skin and the marking is made with a wire with a hooked tip. Following the marking, under anaesthesia in operating rooms, the mass is removed with surgical excision together with at least 1 cm of negative surgical margin from the area marked with the wire. A specimen radiograph should be taken after the excision to ensure that the marked lesion has been removed.

Stereotactic breast biopsy is a method first defined approximately 20 years ago to avoid diagnostic surgical excision. Stereotactic-guided biopsies are performed with a specially prepared prone table biopsy apparatus or with biopsy units that can be added to a MG or tomosynthesis device with the patient in an upright position. On the prone stereotactic table, the patient lies prone and the breast hangs down through the window in the table (Figure 1). This is more comfortable equipment for the patient as there is less patient movement and a lower rate of vasovagal syncope, but it is not used for routine MG tests as it is expensive and occupies a large

area (7). The additional units are lower cost and can be used for routine MG. As the patient can be positioned more appropriately, lesions with axillary localisation or close to the chest wall can be visualised, but there is a higher probability of patient movement and vasovagal syncope (7).

Figure 1. Prone biopsy table for stereotactic breast biopsy.

In stereotactic biopsy, the breast is compressed in the lateral or CC projection according to the direction of suitable entry and the guide image is obtained. After localisation of the lesion on this image, stereotactic images are obtained at +15° and -15°. The X and Y co-ordinates of the lesion are automatically determined by the computer using these. Local anaesthesia is administered over the projection of the lesion, and making an incision, the needle is advanced to 2-6 mm behind the lesion. If the needle placement is correct, the desired number of pieces can generally be obtained by turning the probe clockwise.

MAGNETIC RESONANCE IMAGING

As MRI has the highest sensitivity of all the breast imaging methods, it has started to be widely used for screening, diagnosis, grading, and treatment purposes. Percutaneous MRI-guided breast biopsy was first applied by Heywang-Köbrunner in 1999, and 98% accuracy has been reported (8). MRI-guided interventional procedures are currently still applied in only a limited number of centres. The most important factor restricting widespread use is that special equipment and experience are required. Other weaknesses of the method are the high rate of false-positive results, difficulties in the management of incidental findings, the

long duration of the procedure, that there is a limited time for biopsy after contrast injection, and that it is an expensive method (8-10).

If lesions determined on MRI examination have not been previously determined on conventional radiological examinations, it is necessary to perform second-look US directed at the target to ensure that the lesion cannot be visualised with US. MRI-guided sampling for definitive histopathological diagnosis should be performed for suspected breast lesions which can only be determined on MRI. MRI-guided histopathological sampling can be performed with various methods. Selection of the method is determined by factors such as the typing of the lesion and recommendation of the radiologist, patient and surgeeon preference, and the costs of the procedure/operation. Histopathological evaluation can be performed with MRI-guided FNA, CNB or VAB methods, marking with MRI-guided wire, or marking with radionuclide occult lesion localisation (ROLL) and subsequent surgical removal of the lesion. In the diagnosis of non-palpable lesions determined only on MRI examination, the first option is tru-cut biopsies compared with surgical excision and aspiration biopsies. In the diagnosis of solid lesions larger than 1 cm, CNB can be performed with a 14 gauge (G) needle. The sensitivity, specificity, and technical success of MRI-guided CNB have been reported to be >95% (11). Due to the lower volume sampling capacity in the sampling of non-mass contrasts, focus, ductal trace, or segmental pathological contrast involvements and hemorrhage which can develop in the second entry to the same sampling trace, rather than CNB, VAB methods are preferred with 7-12 G needles which can make higher volume sampling from different angles with needle rotation from a single entry.

Closed magnets are usually used because more detailed information is provided because of both the spread and the high tesla power. To be able to perform the procedure in closed magnets, there should be an additional guidance system on the device. The breast must be fixed for the procedure, and breast coils which have compression plates are used for this. Compression plates are designed in the form of grills, rays, or with holes that allow advancement of the needle/guide by fixation. The breast to which the procedure is to be applied is fixed within the coil with compression plates in the breast mediolateral plane with the patient in the prone position. With the T1-weighted sagittal images taken, the procedure is able to be applied and accessibility of the lesion is checked. Precontrast and dynamic postcontrast series are obtained in the axial plane. Reference points are determined on images in the sagittal plane and the centre of the lesion on axial contrast images. By removing the magnet from the patient, local anaesthesia is ad-

ministered to the region where entry is to be made. In the grill system, the guide cannula/needle is placed percutaneously according to the MRI to reach a lesion depth obtained in the position presented by the software. The patient is entered into the MRI unit and cannula localisation is confirmed on T1-weighted series. If the position is correct, FNA, CNB, or VAB are taken. If localisation is to be made, the guide cannula is withdrawn leaving the wire inside the breast. In the ROLL procedure, radioactive material and then diluted MRI contrast material is injected to confirm the application area. After the intervention, the patient is entered into the MR unit a final time to confirm the procedure and check whether or not complications have developed.

PERCUTANEOUS BIOPSY METHODS

Fine Needle Aspiration

Fine needle aspiration biopsy is the most simple percutaneous biopsy method, in which cytological diagnosis is made based on the principle of cells taken from the lesion with a fine needle and empty syringe. For FNA, a 20-25 G injector needle and 10-20 cc injector are required. FNA in the breast is generally made US-guided. After appropriate skin cleaning, the needle attached to the injector is advanced as far as the centre of the lesion under imaging guidance. The aspiration procedure is applied with negative pressure by withdrawing the injector piston while making back and forth movements of the needle at different angles. The aspirated material is fixed on a slide in a thin layer. The slides are dried or fixed in alcohol/formalin and sent to cytopathology.

FNA in the breast is a method well tolerated by patients with a low rate of complications (12). However, there are some disadvantages such as insufficient sampling, false-negative results, not providing a specific diagnosis in benign lesions, not differentiating in-situ/invasive lesions and not evaluating hormone receptor status. Therefore, it is currently preferred with limited indications such as in the sampling of collection and cysts, in the differentiation of cyst-solid with dense content, in small and deep lesions, in lesions in the chest wall, in patients with an implant, and the evaluation of axillary lymph nodes (13). When coagulopathy or hypervascular tumour is suspected, it would be more appropriate to select FNA.

FNA in breast lesions has been reported to have 53-94% sensitivity, and 74-100% specificity (14). The success of the method is closely related to the experience of the practitioner and cytopathologist. Indication selection must be made carefully as FNA has higher rates of false-negative results and insufficient sam-

pling than core needle biopsy. Especially in the differentiation of in-situ and invasive cancer, in papillary lesions, and in the evaluation of atypical and fibroepithelial lesions, diagnostic accuracy is reduced (15).

Core Needle Biopsy

An automatic gun was first used in tru-cut biopsy (CNB) in Sweden in 1982. The automatic gun system started to be used by Parker in 1990 with stereotaxis, and in 1993 as US-guided CNB (16). CNB can be used together with US, stereotaxis, or MRI. Depending on the lesion size and technique, 14-16-18 G CNB needles are used. Coagulation parameters must be checked before the biopsy procedure. After appropriate skin cleaning and local anaesthetic, the lesion is entered with image-guided by making a 2-3 mm incision, or without making an incision. In the automatic tru-cut system, there is a hooked needle on the inner edge and a sharp sheath on the outside and this is connected to the spring mechanism in the gun (Figure 2). When the lesion is entered and the trigger is pulled, the outer cutting section slides over the hooked needle, cuts the tissue, and the tissue is gathered in the hooked part of the needle (17). The number of samples obtained from each lesion varies from 3 to 5. After each sampling, the needle is removed from the breast, and after the tissue sample is taken from the needle, the entry procedure is repeated. Following the procedure, compression is applied for 5-10 mins, then a dressing is applied and the procedure is terminated.

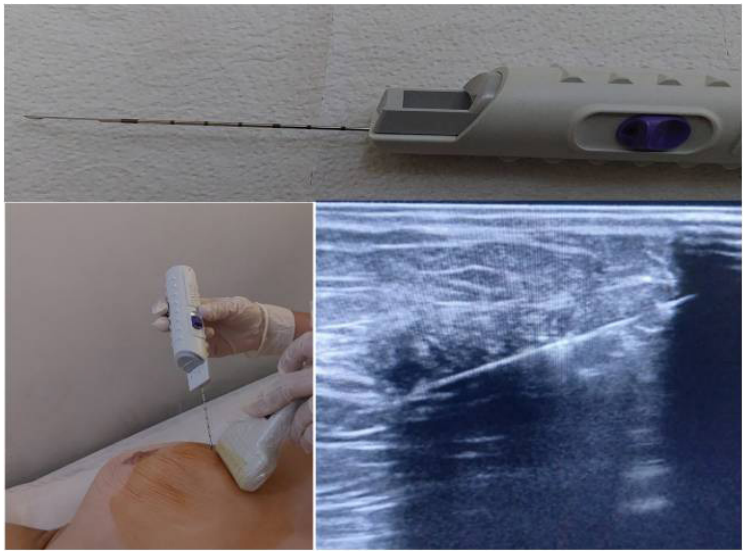

Figure 2. Ultrasonography-guided breast biopsy procedure with a 16 G core biopsy needle.

The important advantages of CNB are that definitive histological typing can be made, the differentiation of in-situ/invasive cancer, tumour grade can be defined, and hormone receptor analysis can be performed. Compared with FNA, the sensitivity, specificity and diagnostic accuracy rates are high. As larger pieces can be taken than in FNA, the problem of insufficient material is minimised. However, the major limitation is incomplete characterisation of the diagnosis and underestimation. This generally occurs in cases with atypical ductal hyperplasia or ductal carcinoma in-situ (DCIS) as the diagnosis can change according to the size of the sample evaluated (1, 18). There are also limitations of CNB in the differential diagnosis of DCIS and lobular carcinoma in-situ, in the differentiation of tubular carcinoma and low-grade invasive ductal carcinoma from adenosis and sclerosing lesions, in the differentiation of mucosal-like lesions from mucinous carcinoma, and in the diagnosis of papillary lesions and radial scar, and in these cases, excisional biopsy is recommended (12).

US-guided core biopsy (US-CNB) can be applied to suspected microcalcifications that can be seen on US. It is recommended that 5-12 samples are taken because of the histological heterogenity of microcalcifications. Specimens of the sample tissues taken should be visualised with MG to check whether or not there are microcalcifications. Despite the high diagnostic accuracy of US-CNB in microcalcifications, the rates of insufficient biopsy, false-negatives, and underestimation are higher compared to stereotaxis-guided VAB (19). Therefore, for microcalcifications which can be determined on US, VAB remains the more accurate and acceptable biopsy method.

Vacuum-Assisted Biopsy

Vacuum biopsies were developed at the end of the 1990s to be able to obtain larger tissue samples and because of the limitations of core biopsy such as underestimation and the difficulties in evaluating distortions and microcalcifications. VAB has been reported to have 85-100% sensitivity, 90-100% specificity, and 99% diagnostic accuracy, and is the percutaneous biopsy method with the highest accuracy (20). Compared to CNB, it has the advantages of the use of higher calibrated needles and with the vacuum effect formed by the device attached to the biopsy gun, the removal of more tissue by applying negative pressure. However, it is more expensive than other percutaneous biopsy methods as single-use biopsy needles and a special vacuum biopsy device are required. The most common diagnosis indication for VAB is breast lesions defined as category 3 and 4 according to BI-RADS (21). As there is a greater risk of hematoma because compression is not

applied US-guided, VAB is generally preferred in biopsies performed stereotaxis and MRI-guided, and it is primarily used in the diagnosis of microcalcifications.

US-VAB is generally performed in the diagnosis of small breast lesions (<5 mm), in the diagnosis of cases with insufficient FNA/CNB, or when the diagnosis is not compatible radiologically and pathologically (21). Routine procedures are made with a 10 or 11 G needle, but for larger lesions or therapeutic excisions, a 7 or 8 G needle is used. The easiest approach to the lesion in US-VAB is, after positioning the patient, and applying local anaesthetic to the skin and subcutaneously around the lesion, to make a 2-3 mm incision. Advancing the needle image-guided, it is placed within the lesion or below the lesion if excision is to be performed. When the device is operated, tissue is absorbed into the sample collection section from the lesion in front of and above the cutting part of the needle. Several consecutive samplings can be made from a single entry by turning the needle clockwise without removing it from the breast. After removal of the samples, the biopsy space can be aspirated to eliminate any remaining bleeding, and if a microcalcification area or a suspected lesion is to be completely removed, radio-opaque clips can be placed. The possibility of epithelial migration and spread is reduced with the elimination of multiple entries. It may be possible to completely remove lesions smaller than 1 cm with VAB. Even if the lesion is totally excised, surgical excision is necessary in lesions which are histopathologically high-risk or malignant. However, there are studies in literature reporting rates of 3-39% residual lesion remaining after total excision with US-VAB (21, 22).

A mammography unit for stereotaxic-guided VAB (S-VAB) requires a console for the calculation of the lesion co-ordinates, a prone biopsy table, a vacuum unit, breast biopsy needle and marking set. The patient is positioned prone on the table with the breast hanging down from the opening in the mid-section of the table. The breast is angled appropriate to the projection where the biopsy will be made and compressed for a biopsy window area of a square 5 x 5 cm. After appropriate cleaning of the area, local anaesthesia and a skin incision, the needle is placed in the breast according to the 3-dimensional co-ordinates of the target. Images are taken to confirm that the target is in front of the needle, then by turning the probe according to the localisation of the microcalcifications, tissue is removed serially. At the end of the biopsy, magnification images of the specimens must be taken to ensure sufficient microcalcifications have been removed. Compression should be applied after the procedure to prevent bleeding.

It is recommended that MRI-guided VAB is used for non-mass lesions, focus, ductal trace or segmental pathological contrast involvements, for masses which

can only be seen on MRI, and for lesions with parenchymal distortions which have been determined as radiologically-pathologically discordance (23). After appropriate skin cleaning, local anaesthesia, and a 3-4 mm skin incision, the guide needle is placed within or adjacent to the lesion from the incision line. The relationship of the needle and lesion is confirmed on MRI then a 9/11 G biopsy needle is placed by being passed within the guide. After attachment, the vacuum device is operated and tissue parts are removed.

PREOPERATIVE MARKING METHODS

In centres where VAB is not available, image-guided localisation is required in the diagnosis of microcalcifications determined as suspicious on MG and parenchymal distortions, or for the excision of non-palpable lesions which are radiologically and pathologically discordance as a result of biopsy. The standard method used in preoperative localisation is the needle-wire combination (Figure 3). Marking with a wire should be made US-guided if the lesion can be seen on US, and digital mammography or tomosynthesis-guided for microcalcification and parenchymal distortions that cannot be determined on US, and MRI-guided for lesions that can only be determined on MRI.

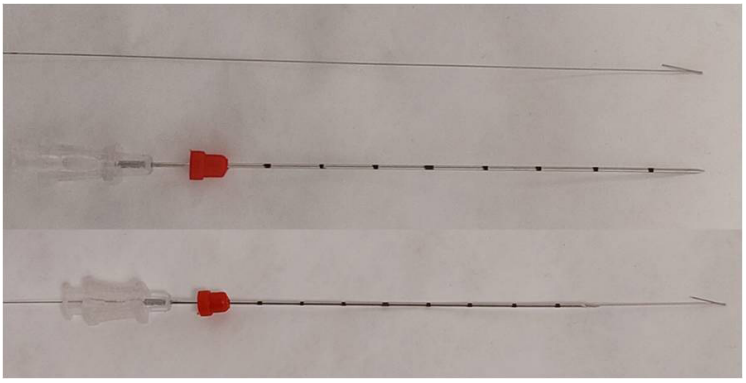

Figure 3. Combination of needle and hook-shaped wire used to image-guided localisation preoperatively marking breast lesions.

Although there are many types of needle, the most frequently used is the hook-shaped wire developed by Kopans. The wire marking procedure should be performed on the same day as the operation to prevent migration of the wire within the breast. In US-guided wire marking, after appropriate skin cleaning and local anesthesia, a needle is passed into the non-palpable lesion while the probe is fixed over the lesion. The wire is advanced within the needle and when it is seen to

emerge from the tip of the needle, holding the wire stable, the needle is pulled back and withdrawn from the breast. The end of the wire should be adjusted to be 1 cm forward of the lesion, and while the ipsilateral arm is in 90° abduction, the projection of the lesion is marked on the skin with a pen, the distance of the wire from the skin distally and the depth of the lesion from the skin are measured and recorded, and the surgeon must be informed.

MG-guided marking can be made with perforated compression plates, grid reference systems or the stereotactic method. Before the procedure a 90° mediolateral image is taken. The approach to the lesion from the shortest possible distance is determined by the position in which the marking is made. When marking with perforated or grid compression plates, the distance of the lesion from the skin is measured by manual estimation on the image and the distance the needle is to be advanced is determined. Following local anaesthesia, the needle is advanced as far as the level of the lesion then the compression plate is raised and by taking a control mammograph in the other plane perpendicular to this plane while the needle is within the breast, the needle localisation and depth are checked. The wire is advanced to be 1 cm forward of the lesion, then the needle is withdrawn leaving the wire in place (Figure 4). In stereotactic marking, the lesion co-ordinates are determined automatically by the device.

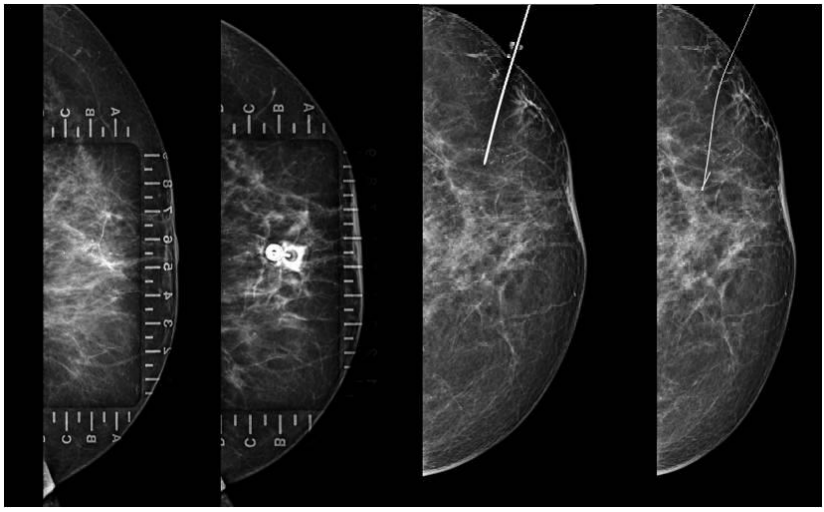

Figure 4. Wire localization by mammographic guidance for excisional biopsy.

After surgical excision, that the marked lesion was completely removed with sufficient surrounding tissue should be checked on a specimen image by the radi-

ologist who performed the marking, and after marking with US, it should be seen on the specimen US that the lesion has been removed.

Other than marking with a wire, techniques can be used such as ROLL, marking the skin projection with a pen, carbon localisation, marking with blue dye, or intraoperative ultrasound. The ROLL procedure, a method inspired by sentinel lymph node biopsy, is known to be as effective as the needle-wire system (24, 25). This method can be performed in the 24 hours before the operation, stereotactically if the lesion is seen on MG, US or MRI-guided if it is seen on US or MRI. Human serum albumin macroaggregate bound with 1-1.5 mci Tc99m is injected with 0.3-0.5 ml saline. Excisional biopsy is performed in the operating theatre with the aid of a gamma probe. With an incision made at the site where the gamma probe shows the highest activity, the tissue showing activity is excised and then it is checked that no significant activity remains in the cavity.

PERCUTANEOUS EXCISIONAL DEVICES

When the importance of sample volume became more evident, percutaneous methods of excision were developed as an alternative to surgical excision. The first example of these devices is Advanced Breast Biopsy Instrumentation (ABBI). It is based on the principle of extensive removal of the lesion determined mammographically, and vacuum-assisted aspiration and wire ring diathermy are used under the guidance of stereotactic biopsy units. Although high rates of accuracy and low rates of underestimation have been reported, it has not been widely adopted because of disadvantages such as residual tumour, positive margins and the removal of a large amount of normal breast tissue (26).

BLES is a diagnostic and treatment method, developed for the purpose of excision, which requires a special device and probe. It can be used US-guided or stereotaxis. It is applied more to benign lesions and lesions smaller than 2 cm. The thick probe in BLES is advanced as far as the lesion under imaging guidance. Small arms activated by radiofrequency coming from the tip of the probe surround the lesion like a cage and separate it from the tissue. Then the lesion entrapped in the arms is removed in a single piece together with the needle.

In addition, there have been trials in recent years in the treatment of early stage breast cancer and fibroadenomas of minimally invasive/non-invasive percutaneous treatment methods which create coagulation necrosis and tumour destruction with energy conducted by an electrode placed in the centre of the target tissue, such as cryotherapy, radiofrequency ablation, microwave ablation, focussed US ablation and interstitial laser photocoagulation.

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