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Minimally Invasive Approaches for Diagnosis and Treatment of Early-Stage Breast Cancer

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LEARNING OBJECTIVES

After completing this course, the reader will be able to:

1. Describe the minimally invasive approaches to breast cancer diagnosis and treatment.
2. List the strengths and weaknesses of minimally invasive diagnostic and treatment procedures.

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ABSTRACT

Breast cancer management has been evolving toward minimally invasive approaches. Image-guided percutaneous biopsy techniques provide accurate histologic diagnosis without the need for surgical biopsy. Breast conservation therapy has become the treatment standard for early-stage breast cancer. Sentinel lymph node biopsy is a new procedure that can predict axillary lymph node status without the need of axillary lymph node dissection. The next challenge is to treat primary tumors without surgery. For this purpose, several new minimally invasive procedures, including radiofrequency ablation, interstitial laser ablation, focused ultrasound ablation, and cryotherapy, are currently under development and may offer effective tumor management and provide treatment options that are psychologically and cosmetically more acceptable to the patients than are traditional surgical therapies. In this review, we give an overview of minimally invasive approaches for the diagnostic and therapeutic management of early-stage breast cancer. The Oncologist 2007;12:1–10

INTRODUCTION

Since the introduction of mammography screening, the detection rate of early, nonpalpable breast lesions has increased dramatically. The diagnostic workup and treatment of these lesions have changed considerably over the past few decades, and the management of breast cancer has been evolving toward minimally invasive approaches [1, 2].

Advances in imaging have enabled us to identify and lo-
ocalize breast lesions with great accuracy. Image-guided percutaneous breast biopsy has been proven to provide accurate histologic diagnosis without the need for surgical biopsy.

Breast conservation therapy has become the treatment standard for early-stage breast cancer patients [3, 4], and sentinel lymph node biopsy allows prediction of axillary lymph node status without the need for axillary lymph node dissection [5]. The next challenge is to treat the primary tumor without surgery. Percutaneous tumor excision, radiofrequency ablation (RFA), interstitial laser ablation, focused ultrasound ablation (FUS), and cryotherapy provide interesting alternatives to open breast surgery. These techniques may offer complete tumor ablation with less psychological morbidity, better cosmetic results, and reduced inpatient care compared with traditional surgery. Today, most minimally invasive protocols for the treatment of early-stage breast cancer are conducted in a research setting and include tumor resection to establish the effectiveness of the ablation procedure, but available data are encouraging; however, surgery remains the standard-of-care local treatment for breast cancer. In this review, we provide an insight of image-guided biopsy techniques and discuss advantages and shortcomings of minimally invasive approaches as alternative treatment options to breast cancer surgery.

**MINIMALLY INVASIVE DIAGNOSIS**

For a long time, open surgical breast biopsy after needle-wire localization was considered to be the standard diagnostic procedure for nonpalpable lesions. This technique involves marking of the lesion by a hooked wire under mammographic or ultrasound guidance, followed by wide surgical excision of the tissue surrounding the tip of the wire. After radiography confirms the presence of the lesion in the excised specimen, a final pathologic diagnosis can be established. This procedure is extremely accurate [6], but associated morbidity and costs are high. Up to 80%–90% of women with nonpalpable breast lesions turn out to have benign disease and, in retrospect, undergo unnecessary surgery. For this group of patients, a minimally invasive procedure offers better options, and therefore image-guided percutaneous biopsy techniques have been developed. Today, international guidelines state that at least 90% of breast cancer patients should have received a diagnosis of malignancy before entering the operating room [7]. Recently, at the 2005 San Antonio Breast Cancer Symposium, Edge et al. presented data from the National Comprehensive Cancer Network [8]. They demonstrated the improved outcome for patients treated with breast conservation when preoperative diagnosis was performed using percutaneous techniques compared with open surgical biopsies. In this series, fewer secondary excisions were necessary.

**Tissue Sampling Techniques**

Several different percutaneous biopsy techniques are applied to obtain material of nonpalpable lesions: fine needle aspiration (FNA), large-core needle biopsy, and vacuum-assisted needle biopsy. FNA is a well-established tool for the evaluation of palpable breast lumps (i.e., triple test involving clinical examination, imaging, and FNA) but is less suitable for the diagnosis of nonpalpable breast disease. FNA allows the pathologist to identify the presence of malignant cells but not to distinguish between invasive and in situ cancer. In addition, FNA suffers from high inadequate sampling and false-negative rates [9].

The limitations of FNA have led to the introduction of large-core needle biopsy for the diagnostic workup of nonpalpable breast lesions. With large-core needle biopsy, actual tissue samples are obtained by means of a large-core needle (generally 14-gauge) and an automated biopsy gun. A minimum of four samples is needed, and for lesions containing microcalcifications, specimen radiography is essential in verifying the adequacy of sampling [10, 11].

Large-core needle biopsy is less operator-dependent than FNA. Because it obtains an actual tissue sample, it allows identification of an invasive component. It facilitates the assessment of tumor grade and provides sufficient material for additional immunochemistry staining. Diagnostic accuracy of large-core needle biopsy is high: miss rates of cancer vary from 1% to 7%, whereas false-positive findings are extremely rare [12, 13]. However, in some cases, the severity of the disease is underestimated (i.e., when findings at subsequent surgical excision show a higher degree of pathology than do core biopsy results). In up to 40%–50% of needle biopsies containing high-risk lesions (atypical hyperplasia or lobular carcinoma in situ), the surgical specimen will harbor invasive or in situ cancer (high-risk underestimates). Likewise, up to 23% of the core biopsies containing ductal carcinoma in situ (DCIS) will eventually prove to be invasive cancer (DCIS underestimates). The risk of high-risk and DCIS underestimation seems to be related to the radiologic features and size of the lesion and to the amount of tissue sampled [14, 15].

In an attempt to reduce disease underestimate rates, vacuum-assisted breast biopsy was introduced in 1995. With this technique, tissue samples are acquired by using a single insertion of a probe (generally 11-gauge) and vacuum suction to retrieve core specimens. Advantages are that more material can be obtained in a shorter period of time and that only one single insertion of the biopsy probe is needed. Several studies have reported that vacuum-assisted needle bi-
opsy can reduce the high-risk and DCIS-underestimate rates, as well as the miss rate compared with large-core needle biopsy [16, 17]; however, the costs of vacuum-assisted breast biopsy are substantially higher than those of large-core needle biopsy. Therefore, disease underestimation could be an argument for the use of vacuum-assisted breast biopsy in selected cases, but it may not be cost-effective to use routinely. Some advocate vacuum-assisted needle biopsy as a therapeutic tool for excision of benign breast lesions [18].

**Image Guidance**

Ultrasound guidance is the technique of first choice for percutaneous biopsy (Fig. 1) and can be applied for image guidance of FNA, large-core needle biopsy, and vacuum-assisted needle biopsy. Ultrasound guidance is minimally inconvenient to the patient, allows real-time visualization of the needle penetrating the targeted lesion, is relatively quick, and has low associated costs.

However, a considerable proportion of nonpalpable lesions cannot be identified by ultrasound, including most lesions consisting of microcalcifications only and some small mass lesions surrounded by fatty tissue or located deeply within large breasts. For assisting percutaneous biopsies of these types of lesions, stereotaxis is used (Fig. 2). With stereotactic imaging, two digital images of the targeted lesion are taken at +15 and −15 degrees from a central axis. This allows precise calculation of the coordinates of the lesion. With this information, a biopsy needle can be inserted into the lesion, and while the biopsies are being harvested, repeat stereotactic images can be taken to confirm the position of the needle. Stereotactic image guidance can be provided either by add-on devices, which are attached to standard mammography units, or dedicated prone biopsy tables. With the latter, the patient is positioned in the prone position on a biopsy table while her affected breast passes through an opening in the table.

An increasing number of women, including those with an increased familial or genetic risk of breast cancer or women with diagnostic difficulties, are being evaluated with magnetic resonance imaging (MRI). Consequently, a growing number of breast lesions, visible on MRI only, are being detected, posing diagnostic difficulties. Since the development of so-called “breast biopsy coils,” MRI-guided percutaneous large-core or vacuum-assisted needle biopsy has become available in some selected centers. Results of a recent multicenter study have indicated that MRI-guided vacuum-assisted breast biopsy offers an accurate tool for the diagnostic workup of MRI-detected lesions [19]. Nevertheless, a sensible selection of indications for MRI is extremely important to limit the number of patients that require further workup and to reduce costs and unnecessary patient anxiety to a minimum.

Because of the high sensitivity and negative predictive value, ultrasound, stereotactic or MRI guided large-core needle, or vacuum-assisted needle biopsies are now considered standard procedures in the diagnostic workup of nonpalpable breast lesions. As a result, the majority of patients with benign lesions are spared diagnostic open surgery. Complications are rare (<2%) and include hematomas, persistent bleeding, vasovagal episodes, and wound infection [12, 13].

Nevertheless, there are some important caveats. First of all, percutaneous biopsy may completely remove the lesion, which, if necessary, would hamper future surgical excision. This problem is particularly common in the case of small lesions and those targeted with vacuum-assisted 11-gauge biopsy. To manage this problem, dedicated clips that can be inserted to mark the localization of the lesion have been designed. However, migration of the clip by more than 1 or 2 cm off the targeted site is not a rare event. Some advocate hematoma-directed ultrasound guidance to perform excisional biopsy [20].

Physicians should also be aware that the presence of a high-risk lesion (atypical hyperplasia or lobular carcinoma in situ) in needle biopsy specimens always warrants open biopsy because of the high-risk of association with malignancy. Even when using vacuum-assisted breast biopsy, underestimation of the severity of the disease remains a problem, illustrated by high-risk underestimate rates for vacuum-assisted needle biopsy of up to 24% [16, 17].

Finally, quality assurance is essential in percutaneous breast biopsy [21]. Correlation between mammographic or ultrasonographic images and pathologic diagnosis should be evaluated for every case, preferably in a multidisciplinary setting. Discordance between mammographic findings and pa-
thology always requires repeat biopsy or open biopsy. This way, the miss rate is reduced to a minimum.

MINIMALLY INVASIVE TREATMENT APPROACHES

Over the last years, surgical oncology has been evolving toward minimally invasive approaches. For the treatment of liver metastases, ablative techniques are already widely used instead of surgery. As mentioned previously, percutaneous image-guided biopsy techniques have progressively replaced open surgical biopsies and are considered to be the standard procedure for the diagnosis of breast cancer. Several investigators have proposed to use these approaches for the treatment of early-stage cancers and benign tumors of the breast. One of these approaches is the percutaneous stereotactic excision. Other ablative procedures, including radiofrequency ablation, laser interstitial ablation, focused ultrasound ablation, and cryotherapy use either local freezing or heat to cause cell death and tumor destruction. These techniques are currently under development and appear to be safe, as only few complications such as infection, bleeding, or skin burns are described.

Percutaneous Stereotactic Excision

Percutaneous stereotactic biopsy techniques have been used as a treatment option for excision of benign and malignant breast lesions [18]. Stereotactic biopsy systems, including the Advanced Breast Biopsy Instrumentation (ABBI) system (U.S. Surgical, Norwalk, CT, http://www.ussurgical.com), other vacuum-assisted core-sampling devices such as the Mammotome (Ethicon, Cornelia, GA, http://www.ethicon.com), and the Minimally Invasive Breast Biopsy (MIBB; U.S. Surgical Corporation), were developed and subsequently used in a percutaneous excisional purpose.

Even if based on different technologies, the sensitivity and specificity of the ABBI biopsy system and vacuum-assisted core biopsy instruments for the diagnosis of breast cancer are both excellent. It has been shown that the positive margins and residual tumor rates are comparable to those obtained with the use of wire-localized excisional biopsies. An important disadvantage is the impossibility to evaluate tumor margins. Patients treated with this approach were highly selected, and conclusions cannot be applied to all breast cancer patients. Prospective multicenter studies are needed to evaluate the efficacy and cost-effectiveness of these different percutaneous excision techniques.

Radiofrequency Ablation

Within all minimally invasive approaches used in the treatment of early-stage breast cancer, the most extensive work and progress have been made with RFA. RFA destroys the tumor with heat. A radiofrequency probe (15-gauge) with RFA electrodes is inserted in the tumor, and an alternating high-frequency electric current (400–500 kHz) is administered. The heat that is generated affects the cell membrane’s fluidity and the cytoskeleton proteins and finally acts on the nuclear structure, resulting in the interruption of cell repli-
cation [22]. This finally leads to irreversible tumor destruction, as tumor cells are more susceptible to heat than are normal cells. The RFA-targeted tumor volume depends on applied tension (up to 200 W). Under imaging guidance, the RFA probe is inserted into the center of the lesion, and a star-like array of electrodes is deployed from the tip of the probe. At least 5 minutes are necessary to gradually reach the target temperature (95°C). This temperature is maintained for 15 minutes to achieve complete ablation and is followed by a 1-minute cool-down period. Temperature is monitored during the entire procedure by sensors.

Ultrasound guidance is preferred to other imaging modalities, because the RFA source typically operates at up to 500 kHz. This frequency interferes, for instance, with MRI acquisitions at all field strengths and produces significant artifacts. More recently, MRI-compatible RFA probes have been developed but remain extremely expensive. After ablation, a coagulated opaque area (hyperechoic) of about 2 cm can be visualized with ultrasound. In the surgical specimen, this area macroscopically appears as a yellow-white appearance and is surrounded by a red rim.

The RFA-targeted tumor volume to be ablated can be increased by increasing the size of electrodes and their number, as well as by increasing conduction using instillation of saline solution. A target zone from 3–5 cm can be destroyed, but RFA can be used with success for tumors up to 3 cm. This way, even large tumors can be completely ablated by RFA with negative margins. Cellular destruction can be confirmed either on percutaneous biopsies or on surgical biopsies by using standard hematoxylin and eosin staining. To evaluate cell viability, additional staining of nicotinamide adenine dinucleotide-diaphorase can be performed. Ablated tissues show coagulative necrosis and protein denaturation.

Radiofrequency ablation has been used successfully for the treatment of primary or metastatic tumors of numerous organs, such as liver, lungs, bones, central nervous system, pancreas, kidneys, or prostate. Several studies evaluated the use of RFA ablation in the treatment of breast cancer. The first pilot study was conducted in 1999. Jeffrey et al. [23] evaluated the feasibility of this technique for breast cancer patients who underwent mastectomy. Five advanced-stage breast cancer patients with lesions of 4–7 cm were treated with RFA. In this study, all tumors showed some cell death. Assessed after definitive surgery, complete destruction was observed in four (80%) of five patients in a diameter of 0.8–1.8 cm around the probe. No complications were reported. In fact, this minimally invasive approach can be used for tumors up to 3 cm.

Another study conducted at The University of Texas M. D. Anderson Cancer Center in collaboration with the Weill Cornell Breast Center and the John Wayne Cancer Institute studied the effectiveness of RFA as a local treatment option for invasive breast cancers smaller than 2 cm. In a series of 30 patients, tumor ablation of up to 87% was achieved without major complications [24–26].

A pilot study of ultrasound-guided RFA of breast tumors up to 3 cm was conducted by Izzo et al. [27]. All patients had surgical resection of the tumor. Complete ablation and necrosis were obtained in 25 of 26 patients. One patient suffered full-thickness skin burns. Ultrasound guidance was used to localize the tumor and monitor the ablation.

Only one case report described stereotactic-guided RFA followed by delayed surgical resection with complete tumor ablation [28]. In this case, 4 weeks after RFA, there was no residual tumor on the surgical specimen marked by a clip.

Burak et al. [29] used breast MRI before and after RFA ablation. Ten women with invasive breast cancer were treated with RFA followed by surgical excision 1–3 weeks later. Before RFA ablation, MRI showed enhancement in 90% of patients; after RFA ablation, no residual lesion was visualized in 89% of patients. The only patient with MRI enhancement after RFA ablation had residual disease upon pathology. MRI may accurately assess the size of the tumor and extension of disease preoperatively, but it also enables visualization of the ablation zone.

Finally, Hayashi et al. [30] treated 22 women with clinically T1N0 biopsy-proven breast cancers with ultrasound-guided RFA followed by surgery 1–2 weeks later. The procedure was well-tolerated under local anesthesia and sedation. Tumor ablation was complete in 19 of 22 patients, but five patients had residual disease at a distance from the ablation zone. For that reason, the investigators concluded that RFA could not be proposed as an alternative to open surgery.

**Focused Ultrasound Ablation**

Thermal tumor ablation has also been evaluated using FUS. After localization of the tumor within the breast, ultrasound can be focused and rapidly generate a substantial increase in local temperatures of up to 90°C by converting acoustic energy into heat. FUS ablation heats the tumor and causes cell damage and tumor death [31]. FUS is based on a 1.5-MHz ultrasound source. Tumor ablation is monitored through temperature probes and skin monitors. Duration of FUS ablation is usually 10 minutes. Very small lesions can be targeted by this approach. Therefore, high-resolution imaging techniques, such as MRI, need to be used for accurate detection and monitoring [32, 33]. FUS has been used to treat fibroadenomas in nine women under local anesthesia. Ab-
lition was nearly complete in eight (73%) of 11 cases as assessed by MRI. The only reported adverse effects were pain and minimal skin bruising [34]. For breast cancer, several groups investigated FUS in pilot studies including patients with inoperable tumors, but the results were not verified on surgical specimens [35, 36].

Gianfelice et al. [37] used MRI-guided FUS to treat 12 patients with invasive breast tumors smaller than 3.5 cm. Tumor destruction was satisfactory; up to 88.3% of the tumor tissue was destroyed. No major complications were reported.

Recently Wu et al. [38, 39] completed the largest series in the field of FUS. Forty-eight women were randomized to undergo either modified mastectomy (25 patients) or FUS followed by surgery (23 patients) after 2 weeks. Tumor ablation was complete with additional surrounding normal tissue. Patients reported transient edema with spontaneous resolution 7–10 days after the procedure. The major advantage of FUS over other ablative techniques is that no skin incisions are needed. However, tumors close to the skin may be treated with less success and with such adverse effects as skin burns.

**Laser Ablation**

Another technique currently being investigated for local treatment of breast cancer is laser ablation. Laser ablation is a technique that generates heat and subsequently causes cell death and tumor destruction. Laser energy is delivered directly to the target tumor through a fiberoptic probe inserted under imaging guidance. Several laser types have been evaluated and used for thermal ablation: the Nd:YAG laser (1064 d, 1,320 nm), semiconductor diode laser (805 nmD), and argon laser (488 and 514 nmD).

Laser type 805 nmD was used more because it is a portable device and may be applied in tumors through special needles. Laser ablation consists in delivering 2–2.5 W in 500 s (>1,000 J for each fiber) on the tumor. The size of tumor destruction can be increased with the use of several fibers. Laser treatments may be performed under imaging guidance (mammography, ultrasound, or MRI). A target temperature of 80°C–100°C is generated during 15–20 minutes to obtain tumor ablation. The appearance of macroscopically ablated tissue is that of concentric rings. The laser generates a central cavity corresponding to the destroyed tumor surrounded by a pale zone that is associated to liponecrosis, peripheral hemorrhages, and nonviable zones. It is suggested by some investigators that the outer rim represents the limits of cancer destruction [40].

Laser ablation for the treatment of early-stage breast cancer has not been studied extensively, but some have shown that small tumors can be ablated with negative margins [41, 42]. Harms et al. [42] treated 12 breast cancer patients by using rotating delivery of excitation off-resonance under MRI guidance. For all tumors smaller than 3 cm, tumor ablation was successful (100%). The procedure was well-supported and realized under local anesthesia. Interestingly, on MRI scans, the hypointense appearance of the treated zone was correlated with the effectiveness of the ablation treatment.

Dowlatashahi et al. [43, 44] recently developed a technique of laser ablation under stereotactic guidance followed by surgery. They treated 36 patients diagnosed with breast cancers using a 16- to 18-gauge laser probe with similar results. Complete tumor ablation was total in 67% of patients that underwent standard surgery 1–8 weeks after the procedure. No adverse effects were reported except for minimal skin burns in two patients. The authors proposed to protect the skin by irrigation with saline solution and by applying ice packs after laser ablation. After technical improvements, the success rate for complete tumor ablation rose to 93%.

**Cryotherapy**

Cryotherapy was initially developed and used in the treatment of nonoperable liver metastases from colorectal cancers [45]. Cryotherapy uses coldness to achieve tumor destruction [46]. Energy is produced by an external generator composed of an argon or nitrogen freezing system and a helium heating system. Cryosurgery involves the use of a freezing probe linked to the generator (Fig. 3). Several probes (up to seven) can be used simultaneously to treat larger tumors, as thermal conduction increases the volume of cooled tissue. The probe is inserted in the center of the tumor under imaging guidance (ultrasound or MRI) through a tiny incision. Once the probe is positioned correctly, an iceball is created at the needle tip. This iceball destroys the tumor as well as 5–10 mm of additional breast tissue surrounding the lesion. During each freeze cycle, temperatures from −185°C to +70°C are obtained and constantly monitored. The length and sequence of freeze cycles can be modulated depending on the tumor volume to be ablated. Tumor destruction can be monitored in real time under ultrasound or MRI. In particular, the growth of the iceball and its proximity to the overlying skin or underlying muscles can be observed.

Tumor destruction is the result of cell damage from membrane rupture during the successive freeze-thaw cycles. In the center of the tumor, cells are completely destroyed, but in the periphery, a necrotic zone of some millimeters with viable cells is observed (Fig. 4). In this matter, the cryotherapy ablation zone needs to be larger than the tumor size to be effective [47]. With the use of a
nitrogen cryotherapy probe, Rabin et al. [48] were able to freeze mammary tissue from 37°C to −55°C within 15 seconds. Although the efficacy of cryotherapy has been previously demonstrated in animal tissue models, only a case study presented a single breast cancer patient treated for two invasive lobular tumors in the same quadrant [49]. Subsequent percutaneous biopsies were performed and demonstrated no residual or persistent disease. However, no surgical excision was performed, as is the case in most minimally invasive ablation trials.

Recent scientific communications reported successful treatment of 13 of 25 breast cancer patients with cryotherapy ablation [50]. Pfleiderer et al. [51] reported the results of 15 patients with tumors smaller than 16 mm. These patients were treated with ultrasound-guided cryotherapy, and successful tumor ablation was achieved. Within the next 5 days, patients underwent surgical excision. When patients with tumors 23 mm or larger were treated, incomplete necrosis was seen in all excised specimens. With tumors less than 16 mm, cryotherapy ablation was complete. However, in two patients, residual in situ disease was found in the surrounding area.

Cryotherapy seems more successful in treating invasive than in situ disease. Roubidoux et al. [52] recently reported their experience with cryotherapy ablation for small (<2-cm) breast cancers. With ultrasound guidance, seven of nine treated patients had no residual disease. Roubidoux et al. also demonstrated that in these seven patients, echogenicity was increased at ultrasound and density at mammography. These characteristics may indicate complete ablation.

More recently, Sabel et al. [53] reported results from a multi-institutional study of cryotherapy for early-stage breast cancer. Twenty-one women with invasive tumors ≤2 cm were treated with cryotherapy ablation followed by surgical resection 1–4 weeks later. All tumors <1 cm were completely ablated. For larger tumors up to 1.5 cm, only those without an extensive in situ component were destroyed. Tumors >1.5 cm were not adequately treated. The investigators suggested that cryotherapy is safe and can be recommended for invasive lesions <1.5 cm with less than 25% of in situ disease upon percutaneous preoperative biopsy.

Additional protocols evaluating the use of cryotherapy in the treatment of early-stage breast cancers are underway. Our group completed a pilot study on MRI-guided cryotherapy at the Geneva University Hospitals. Histologically confirmed invasive breast cancers (≤2 cm, T0-1) were treated by cryotherapy. Surgery was performed 1 month after the procedure. Tumor ablation was assessed preoperatively by MRI studies and compared to pathology specimens. The results of the pilot study are encouraging [54].

Several investigators reported that cryotherapy ablation can successfully be applied as a treatment option for benign tumors such as fibroadenomas [55, 56]. Currently, the U.S. Food and Drug Administration has approved cryotherapy without resection as a treatment option for core biopsy-proven fibroadenomas. For early-stage breast cancer, cryotherapy is promising, as this technique can be realized under local anesthesia. However, as mentioned previously, cryotherapy ablation needs to be limited to tumors less than 1–1.5 cm. Additional research is needed to overcome in situ residual disease.

**IMPLICATIONS FOR BREAST CANCER MANAGEMENT**

The aim of breast conservation surgery is to remove the entire tumor, achieve negative surgical margins, and preserve the breast and patient’s body self-image. Minimally invasive approaches must offer at least the same advantages as
surgery and should be at least equivalent to tumor excision with proven negative surgical margins. Minimally invasive ablation techniques may replace surgical resection in the future. If they do, having imaging modalities that can detect tumor destruction would be essential.

The evolution toward minimally invasive approaches is possible due to two major occurrences in breast cancer diagnosis and management. With the wide implementation of mammography screening programs and women’s awareness, breast tumors are detected earlier and are smaller. They can therefore be treated more easily with minimally invasive approaches.

Several patient categories may benefit even more from these minimally invasive techniques. Elderly breast cancer patients are often undertreated and have a worse outcome [57] compared with younger patients. Alternatives to conventional surgery as minimally invasive approaches may allow these patients with multiple comorbid conditions to be suitable for local treatments and be cured. Another category including women treated with neoadjuvant chemotherapy [58] represents another appealing challenge to be overcome in the future by novel and less invasive approaches. Residual disease can potentially be ablated without the need for surgery in an outpatient setting and can increase quality of life for these patients.

CONCLUSION
Minimally invasive diagnosis and treatment of early breast cancer is showing its value. Percutaneous image-guided biopsy techniques have replaced open surgical biopsies and are considered to be the standard procedure for the diagnosis of breast cancer. None of the ablative techniques described herein are used alone in current clinical practice for the treatment of breast cancer and are used only in study settings. Surgery remains the standard local treatment of breast cancer, with radiation therapy if needed clinically. The value of these treatments compared with traditional open surgery needs to be confirmed by large prospective studies. In addition, cost-effectiveness and long-term effect on cosmetic outcomes still need to be investigated.

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DISCLOSURE OF POTENTIAL CONFLICTS OF INTEREST
The authors indicate no potential conflicts of interest.

REFERENCES


FURTHER READINGS


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