

# Charcoal granuloma mimicking breast cancer: an emerging diagnosis

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## Abstract

**Background:** Image-guided charcoal injection in suspicious breast lesions for preoperative localization is a procedure that has been increasing over the years because it is safer, faster, and more affordable when compared to needle-wire preoperative localization. To date, no complications have been associated with the method. However, in recent years there have been some reports about charcoal granulomas mimicking malignant lesions in some postoperative patients or in a conservative follow-up.

**Purpose:** To report a series of 11 cases which had suspicious imaging findings for malignancy and resulted in charcoal granulomas on histopathological analysis.

**Material and Methods:** A database of 1650 patients that attended our center from January 2007 to June 2018 was reviewed and detected 495 patients who had been previously submitted to ultrasound-guided charcoal marking in a breast lesion. Then, patients whose imaging studies were compatible with new suspicious lesions on mammography, breast ultrasound, and/or magnetic resonance imaging and biopsy of this new lesion indicating charcoal granuloma were selected.

**Results:** From 495 patients who had undergone charcoal localization injections in previous biopsies, we selected 11 who had new lesions with malignant characteristics on imaging studies but histopathological analysis resulted in charcoal granuloma.

**Conclusion:** Charcoal granuloma should be considered in patients with previous preoperative injection localization, since the residual charcoal in the breast tissue may form granulomas and mimic malignant lesions on follow-up imaging studies.

## Keywords

Breast biopsy, mammography, ultrasound, biopsy, artifacts, magnetic resonance

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## Introduction

Charcoal marking technique for the preoperative localization of breast lesions has been used since the early 1990s and has increased in the last decade (1), especially in non-palpable lesions and/or the ones that are difficult to reach with biopsy needles or surgical access. The first publication is from 1987, when Dagnelli et al. described charcoal marking and its advantages compared to the needle-wire preoperative method (2).

The 4% charcoal suspension in physiological saline 0.9% has been used worldwide due to its easy technique in visualizing the lesion and removing it. Other advantages are the possibility of having the marking for longer intervals (>24 h) as well as its lower cost when compared to other methods (3).

The complications linked to charcoal injection are rare and they are similar to those associated with other procedures related to breast lesion diagnosis, such as hematoma development or local inflammation (4).

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**Table 1.** Summary of the selected patients.

Patient	Age (years)	Clinical history	Lesion location	Imaging modality	Lesion characteristics*	Lesion size (mm)	BI-RADS® category†
1	40	Lumpectomy one year before Currently under tamoxifen	Left breast UOQ	MMG US	Mass, spiculated margins	12 × 6 × 12	5
2	72	Partial mastectomy one year before Currently under anastrozole	Left breast UOQ	MMG US	Mass, spiculated margins, posterior acoustic shadowing	10 × 10 × 8	5
3	54	Lumpectomy two years before Previous radiotherapy Currently under tamoxifen	Right breast LOQ	MMG US	Atypical lymph node (cortex > 3 mm)	12 (longest axis)	5
4	66	Lumpectomy one year before Previous radiotherapy Currently under tamoxifen	Left breast UOQ	MMG US	Mass, circumscribed margins, hyperechogenic, posterior acoustic shadowing	19 × 11 × 17	4B
5	60	Suspicious mass in the axillary tail	Left breast UOQ	MMG US	Mass, spiculated margins, heterogeneous	5 × 3 × 7	5
6	76	Lumpectomy one year before Previous radiotherapy Under tamoxifen for 5 years	Left breast RA	MMG US	Mass, circumscribed margins	13 × 8 × 8	4A
7	55	Lumpectomy one year before	Left breast RA	US	Mass, circumscribed margins, posterior acoustic shadowing	8 × 6 × 5	4A
8	53	Follow-up of a peri-areolar lesion with previous histological result of fibroadenoma	Left breast RA	MMG	Mass, spiculated margins	6 × 4 × 3	4C
9	66	Follow-up of a BI-RADS® category 4 lesion diagnosed as fibroadenoma	Left breast UOQ	MMG US	Mass, spiculated margins, intense acoustic posterior shadowing	5 × 5 × 2	4C
10	57	Previous lumpectomy and radiotherapy Currently under tamoxifen and anastrozole	Left breast UOQ	MMG US	Mass, circumscribed margins, intense acoustic posterior shadowing	10 × 7 × 9	4B
11	54	Suspicious lesion with a benign biopsy result (non-specified)	Left breast UOQ	MMG USG MRI	Mass, spiculated margins, taller than wider, enhanced by gadolinium	7 × 6 × 6	5

\*Imaging characteristics were combined for better characterization of the lesion.

†BI-RADS® classification of the lesion performed by a mammary radiologist without the information of the pre-surgical history of charcoal and before histopathological confirmation.

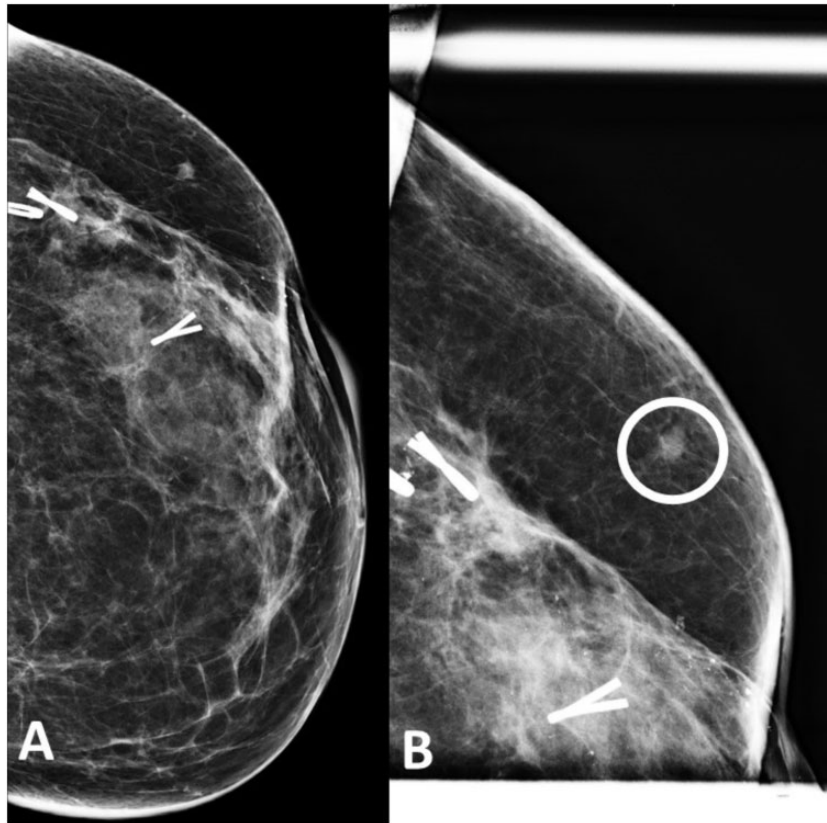
MMG, mammography; US, ultrasound; MRI, magnetic resonance imaging; UOQ, upper outer quadrant; LOQ, lower outer quadrant; RA, retro-areolar.

However, in recent years, cases of charcoal granuloma that remain in the breast tissue have been reported (5).

Although uncommon, charcoal granulomas have been reported as lesions with radiological features comparable to malignant tumor recurrences and can lead to unnecessary biopsies (5), causing anxiety for both the patient and the physician. These cases are identified

mainly on mammography (MMG), breast ultrasound (US), and magnetic resonance imaging (MRI) performed for screening or follow-up after biopsy or surgery.

In this study, we report a series of 11 cases identifying the main radiological and histological aspects of patients with suspected breast cancer and prior charcoal injection for preoperative localization, with



**Fig. 1.** Case 9. Follow-up MMG after segmental resection showing a mass with spiculated margins in the left outer upper quadrant (white circle). (a) Craniocaudal (CC) view. (b) Mediolateral oblique (MLO) view.

histological analysis proven to be charcoal granulomas. This is the largest case series reported to the best of our knowledge, the second one being a series of four cases (4).

## Material and Methods

We performed a retrospective analysis studying a database of 1650 patients who attended our breast-imaging center from January 2007 to June 2018. A total of 495 patients had undergone an US-guided procedure including charcoal marking of a breast lesion and were further evaluated. Our series report comprises 11 of these patients who had a new suspicious lesion identified in one or more of the follow-up imaging studies (MMG, US, and MRI) and a subsequent histopathological study confirming foreign body reactions forming a charcoal granuloma.

The selected cases were classified according to the patient's clinical history and categorization of their imaging features (MMG, US, or MRI), in accordance to the Breast Imaging Reporting and Data System (BI-RADS®), 5th edition (6).

Inclusion criteria were as follows: (i) patients submitted to charcoal injection in a breast lesion for pre-operative localization; (ii) the presence of at least one imaging study indicating that a biopsy should be performed according to BI-RADS® (assessment categories 4 and 5); and (iii) histopathological study confirming foreign body reaction induced by charcoal injection.

The US-guided marking procedure of all cases used a sterile 4% charcoal-suspension (40 mg of activated charcoal in 1 mL of physiological saline, 0.9%). Approximately 0.7 mL of the suspension was injected when reaching the external edge of the lesion, spreading around it and leaving a trail in the parenchyma.

## Results

From 1650 patients who were part of the database, 495 (30%) had a history of previous charcoal marking of a suspicious breast lesion, and 11 of these (2.2%) had a biopsy that resulted in charcoal-induced foreign body reaction.

The patients' mean age was 59.4 years (age range = 40–76 years). The BI-RADS® assessment category of imaging studies without previous knowledge of

clinical history varied between 4A and 5. The average time between the injection and the detection of the lesion was 2.5 years. The patients' characteristics are shown in Table 1.

All the cases showed abnormalities that suggested malignancy in at least one of the imaging modalities (Table 1). MMG showed masses with spiculated or indistinct margins (Figs. 1–3), US demonstrated solid masses with not circumscribed margins and strong posterior acoustic shadowing (Fig. 4), and MRI revealed solid masses with high signal on T2-weighted (T2W) imaging and contrast-enhancement after gadolinium injection (Fig. 5). None of the patients were symptomatic or had palpable masses at the moment of the imaging study.

Case 11 showed the longest interval regarding the lesion's growth, approximately seven years. The mass

grew insidiously and it was detectable only on retrospective mammographic analysis (Fig. 6).

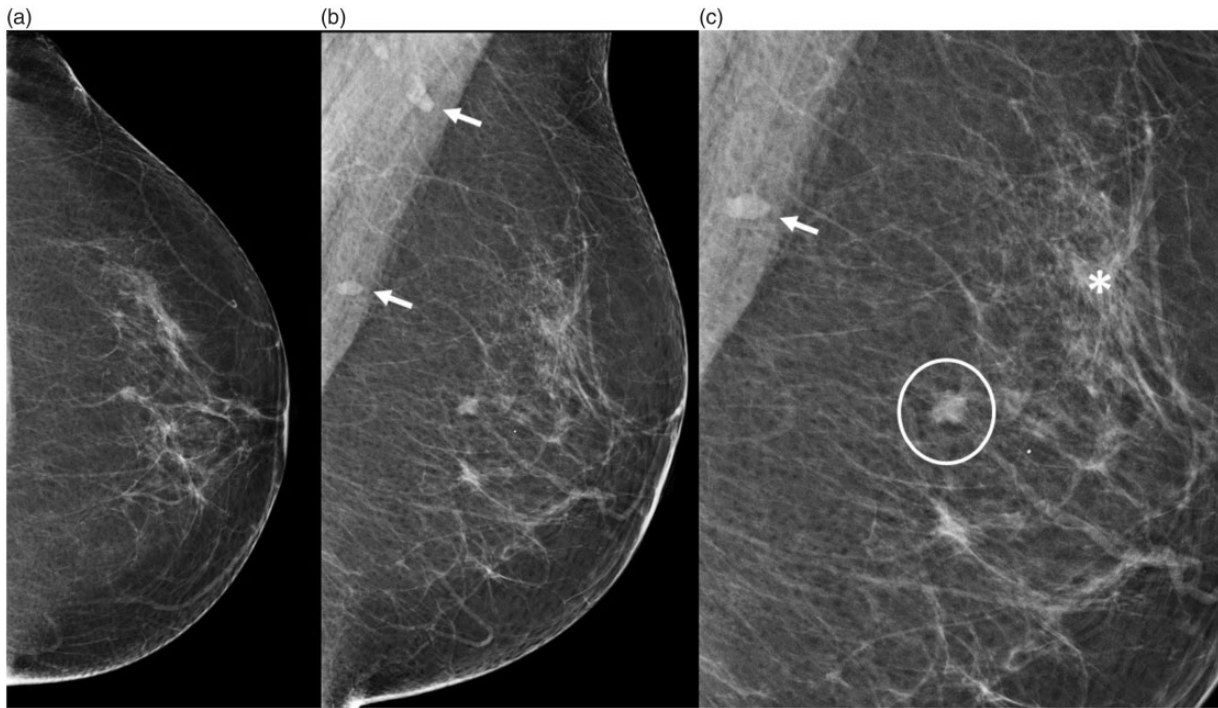
Histopathological analysis showed dark-pigmented charcoal fragments and foreign body granulomatous reactions with phagocytosis, giant-cell bodies, and dispersion of the charcoal molecules (Fig. 7). Other findings included inflammation and fibrosis.

## Discussion

This case series showed 11 cases of benign charcoal granulomas, which were mistaken by malignant lesions in patients who had been previously submitted to charcoal marking for suspicious breast lesions. According to our literature review, this is the largest number of patients gathered in the same study. Up to now, the



**Fig. 2.** Case 6. Follow-up MMG after a lumpectomy/segmental resection showing a mass with irregular margins in the left retro-areolar region. (a) CC view. (b) MLO spot compression view (white circle). A similar lesion is seen in a deeper position (black arrow), not biopsied.



**Fig. 3.** Case 8. Follow-up MMG after a lumpectomy/segmental resection showing a mass with spiculated margins in the central region of the left breast (white circle). It is possible to see intramammary lymph nodes (white arrows) and architectural distortion due to surgical manipulation (white asterisk). (a) CC view. (b) MLO view. (c) Magnified CC view (1.5× magnification).

literature has shown a maximum of four cases in the same publication (4,7,8).

Charcoal injection for preoperative localization can be used on a lesion that had already undergone biopsy and came out positive for malignancy or on a highly suspicious lesion simultaneously with the biopsy, even without pathological confirmation, in order to avoid a new invasive procedure (9). The procedure is performed so that the surgeon can locate the lesion precisely and remove it with accuracy. However, there are cases in which the histopathological study proves absence of malignancy and therefore no surgical excision is needed. The charcoal in these cases may remain in the breast parenchyma with no significant damage to the tissue (10).

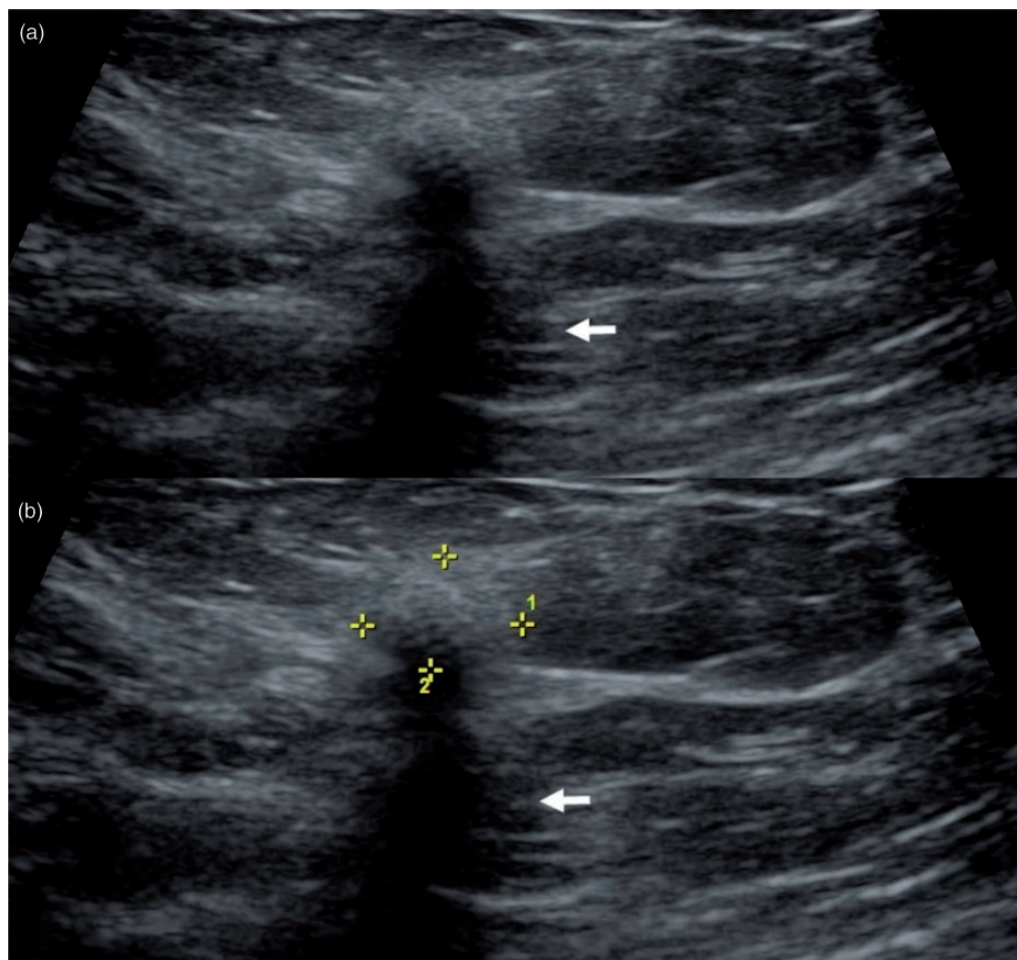
Most of the injected charcoal is also pulled out during the surgical removal of a lesion, but a small amount may be left in the breast around the operative area. Most of the times, the residual substance will not appear in any follow-up imaging studies (8–10), although the literature studies about charcoal injection in breast lesions, its complications and late effects represented on imaging studies are not very comprehensive.

There are not many references regarding long-term consequences of remaining charcoal residues in the breast, as well as the imaging features of late-onset granuloma formation and the different ways they can

be found on the parenchyma, including mimicking malignant lesions, as seen in our report and in other studies (4,11–13).

The histopathological analysis of the area where the charcoal was injected in the breast tissue can show inflammatory abnormalities related to foreign body reaction, in different degrees (14). The intensity of the inflammatory process may vary according to the time of exposure and to other several inherent factors that cause each individual to have a different response. Depending on the degree of inflammatory reaction, the development of foreign body granulomas can be observed in some people in later periods (14,15). Besides the individual inflammatory response (16), the way these abnormalities present on imaging studies will also depend on how much time has passed after the injection and whether there was surgical manipulation causing focal architectural distortion in breast parenchyma.

Charcoal is not visible on US at the time it is injected. The charcoal marking procedure uses a small amount of a 4% suspension, which quickly spreads around the lesion making it hard to predict its exact location. It is, however, possible to detect the echoes movement produced by the high pressure during the injection of the solution (1,2). Months



**Fig. 4.** Case 7. Follow-up US after segmental mastectomy showing a hyperechogenic solid mass with indistinct margins and intense acoustic posterior shadowing (white arrows). (a) Without calipers. (b) Calipers indicating the lesion.

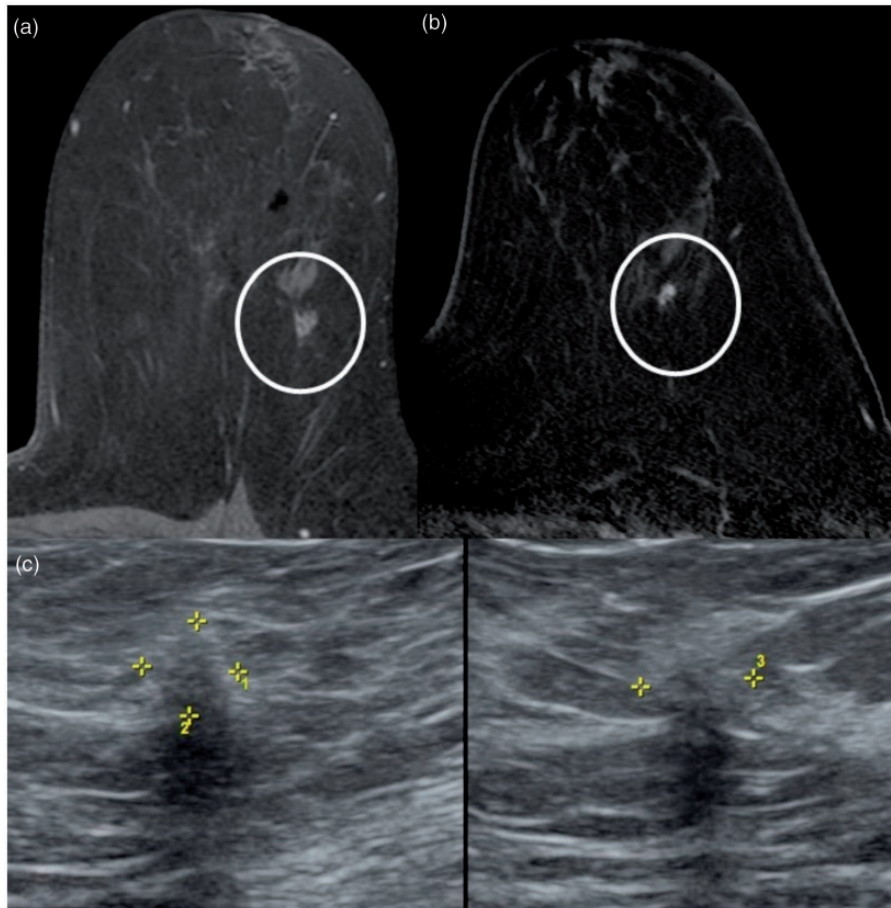
after the injection, charcoal appears as a hyperechogenic undefined area, and later on it causes a chronic inflammatory process (foreign body granuloma), which is associated with a strong posterior acoustic shadowing (Fig. 3). At this time, the lack of information regarding the previous procedure may raise questions concerning the nature of this abnormality, thus misleading diagnosis. This is the stage when a charcoal granuloma can be easily mistaken by a malignant lesion such as breast carcinoma, making it a false-positive (11–13). All of the patients reported in this study went through this misunderstanding.

Mammographic changes related to charcoal marking are usually more subtle and its presence rarely interferes in the exam interpretation, even years after the injection (Fig. 6, case 11). Findings in MMG, found only in some patients, are also related to granuloma formation and can either be seen as masses or grouped calcifications, or even both combined (17,18). Charcoal-related nodules usually have high density

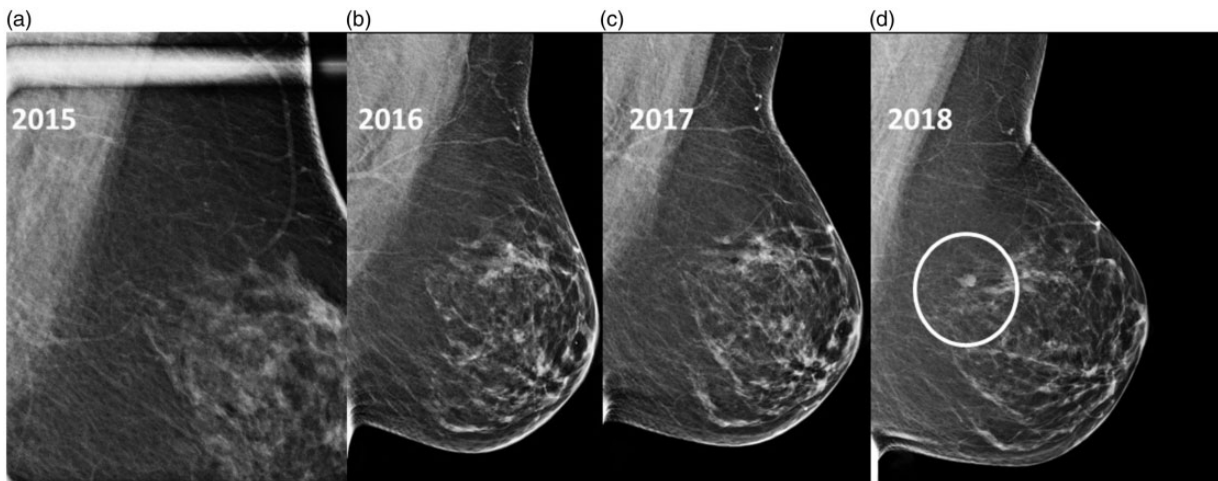
and their margins may be spiculated or microlobulated (18). These two findings can mislead the radiologist who will characterize the lesion as suspicious (BI-RADS® 4) or highly suspicious (BI-RADS® 5) for malignancy, as seen in our cases. (Figs. 1, 2, and 5). Microcalcifications can also be seen associated to masses increasing even further the degree of suspicion of the lesion (19), but this feature was not present in any of the cases in our study.

Our study has its limitations. We found that only 11 patients from the 495 who underwent charcoal injection procedures came for complete follow-up. Therefore, we do not have the complete data of the other 484 patients' outcomes. Unfortunately, we could not add more cases and details to this report, which would help us during the diagnostic process of charcoal granulomas mimicking breast cancer.

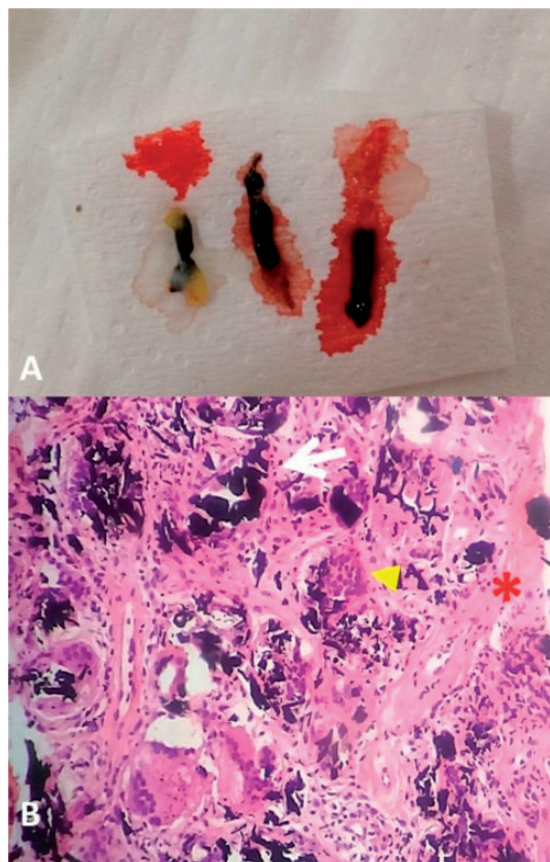
In conclusion, the correlation with previous exams and the previous knowledge of the patient's medical history obtained by a good anamnesis will definitely



**Fig. 5.** Case 11. Follow-up MRI of a biopsy-proven benign lesion. (a) T1W post-gadolinium sequence in axial plane shows a mass with spiculated margins and heterogeneous enhancement in the left outer upper quadrant (white circle). (b) Sagittal subtraction sequence using the first phase after contrast injection shows rapid initial gadolinium uptake (white circle). (c) US showing a mass with indistinct margins (between calipers) and intense posterior acoustic shadowing.



**Fig. 6.** Case 11. Follow-up MMGs demonstrating the four-year evolution of a mass with spiculated margins in the right outer upper quadrant (white circles). (a) MLO spot compression view dating from 2015 shows grouped calcification that were previously biopsied and submitted to charcoal injection for preoperative localization. (b–d) MLO views in successive years: (a) 2016; (b) 2017; and (c) 2018). Biopsy was performed after the last MMG due to the fast-growing component and suspicious morphology of the lesion.



**Fig. 7.** (a) Macroscopic aspect of fragments obtained by percutaneous core needle biopsy, which are typical of charcoal granuloma in a suspicious lesion. It is possible to note the dark pigmentation of the fragments. (b) Histopathological analysis in hematoxylin and eosin and a 400 $\times$  augmentation lens showing foreign-body giant cell phagocytosing charcoal particles (yellow arrow), fragments of charcoal clustered in the parenchyma (white arrow), and traces of fibrosis (red asterisk).

facilitate the diagnosis when it comes to charcoal granuloma imaging, avoiding unnecessary biopsies. One must think of charcoal granuloma as a differential diagnosis whenever a patient has undergone a breast biopsy with charcoal injection for preoperative localization, especially when the lesion was proven to be benign and thus not removed or in patients who have been submitted to cancer treatment, even asymptomatic (20).

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