The significance of ultrasound-guided localization of nonpalpable breast lesions using carbon suspension

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Purpose
To evaluate the utility of ultrasound-guided tattooing localization of the nonpalpable breast lesions with carbon suspension.
Patients and methods
This study is a prospective analysis study for 35 patients with main age about 49.7 ±8 years old which had nonpalpable breast lesions for preoperative localization at the period from October 2020 till November 2022.
Results
Thirty-five female patients with mean age 49.7±8 years had 35 nonpalpable breast lesions seen at upper–outer quadrant in 14 (40%) patients, retroareolar region at 11 (31.4%) patients, lower outer quadrant in four (11.6%) cases, lower inner quadrant in three (8.6%) patients and upper inner quadrant in three (8.6%) patients. The lesions size ranged 10–22 mm with mean size about 15±3 mm. The localization procedure take time ranging from 20 to 30 min with mean time about 24.1 min. The duration of the charcoal localization before operation ranging from 1 to 5 days with mean time about 1.8 days. The main complication noted by the charcoal localization technique is pain. Pain was associated with 11.4% of all studied cases while 88.6% had no complications. The localization by charcoal suspension was effective in 33 (94.3%) cases, while only two (5.7%) cases could not be localized.
Conclusion
Localization of nonpalpable breast lesion under US Guidance by Injection of Charcoal Solution is a very simple, safe, and accurate method.

Keywords:
charcoal suspension, nonpalpable breast lesions, preoperative breast localization

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Introduction

The rate of imaging-detected nonpalpable breast lesions has increased with the advent of routine screening for breast cancer. A nonsurgical core needle biopsy helps decrease the frequency of unnecessary surgery by obtaining a histological diagnosis of imaging-detected lesions. However, these lesions tend to be an indication for surgery, when the surgeons hope for complete removal of the lesions, the patient scheduled to undergo conserving surgery. A preoperative localization is very important for a minimal but accurate excision of a nonpalpable lesion [1]. Numerous studies have reported that ultrasound (US) is superior to palpation. These results suggest that US can aid in the detection and management of nonpalpable lesions, possibly due to their small size, deep location, or overlying fibrotic scar tissue related to previous surgery [2]. A requirement for successful breast conservative surgery is a careful preoperative planning with proper localization of the lesion, especially in nonpalpable breast lesions [3]. Several methods such as dyes, hooked wires, and charcoal suspensions have been used by radiologists to localize nonpalpable breast lesions [4]. Needle localization is widely used but the procedure is quite complicated. The complications and failure rates has been reported to range from 1 to 10% due to a lack of communication between the radiologist and surgeon, inadequate wire localization to the dermal calcifications and wire shifting between localization and surgery [1]. Carbon is a naturally occurring element known since ancient time. Carbon, likewise, is a pigment used to produce black ink, as when used in tattoos, leaving an indelible mark because it is biologically inert. When a tattoo needle punctures the skin, a tiny wound is produced. The body responds to injury by signaling macrophages to address the injury and engulf or phagocytose the foreign body. In tattoo ink, the pigment particles are too large to be destroyed,

hence, remain fixed or permanent. The same principle applies to using carbon as an alternative wire-free method to mark lesions in the breast. It is an FDA-approved substance that provides direct visual aid to the surgeon and pathologist. It points to the precise location of the lesion of interest [5]. The use of a sterile aqueous charcoal powder suspension has been reported to stain nonpalpable breast lesions [4]. Carbon marking technique is based on injection of sterile charcoal powder diluted with saline solution into the site of a nonpalpable breast lesion after a preoperative sonographic or stereotactic localization [3].

Patients and methods

This study is a prospective analysis study for patients with nonpalpable breast lesions for preoperative localization. The study was done at Ain Shams University Hospitals, Khazendara General Hospital, and radiological private medical centers for 2 years at the period from October 2020 till November 2022. The study sample was included women presented to women health unit for localization of nonpalpable breast lesions before conservative breast surgery. All female patients with radiologically proven nonpalpable breast lesion that underwent conservative breast surgery, above age of 18 years and with normal coagulation profile were included in the study. The females with large palpable breast lesions, distant metastatic breast lesions, below age of 18 and had abnormal coagulation profile were excluded. The sample size was 35 patients. The study protocol approved by the Ethical Committee of the Radiology Department and the Faculty of Medicine. The patients were subjected to full history taking and re-evaluation of the breast lesion by US before injection. All patients were be placed in an adequate suitable position depending on the site of the lesion, comfortable to both the radiologist and the patient, with both arms elevated and behind the head uncovering the neck, axilla and breast regions. US machine for US-guided charcoal injection linear probe 7–12 MHz was used. A 3 g of charcoal granules was added to 100 ml sterile saline. The resulting suspension was sterilized at 120°C, 20 min then the subcutaneous puncture area was injected first with 4–5 cm of local anesthesia then wide bore hypodermic needle was advanced along the anesthetized track directed to the targeted mass, the charcoal suspension was injected into the mass and through the withdrawal track to stain it up to the skin. The amount of injected solution varies and depends on the size and depth of the target lesion with amount range about 3–5 ml of charcoal solution. The effectiveness and applicability were determined by the surgeons through their ability for proper localization and its affectivity to them.

Statistical analysis

The collected data was revised, coded, and tabulated using Statistical Package for Social Science (IBM Corp. Released 2017. IBM SPSS Statistics for Windows, Version 25.0.; IBM Corp., Armonk, New York, USA).

Normality of data

(1) Shapiro test was done to test the normality of data distribution.

Descriptive statistics

(1) Mean, SD, and range for numerical data.
(2) Frequency and percentage of non-numerical data.

Analytical statistics

(1) Student t test was used to assess the statistical significance of the difference between two study group means.</LIST>
(2) χ^2 test was used to examine the relationship between two qualitative variables.
(3) Probability of results.
(4) A P value is considered significant if less than 0.05 at confidence interval 95%.
(5) Baseline features.

Consent statement

This research was performed at the Department of General Surgery, Ain Shams University Hospitals. Ethical Committee approval and written, informed consent were obtained from all participants.

Results

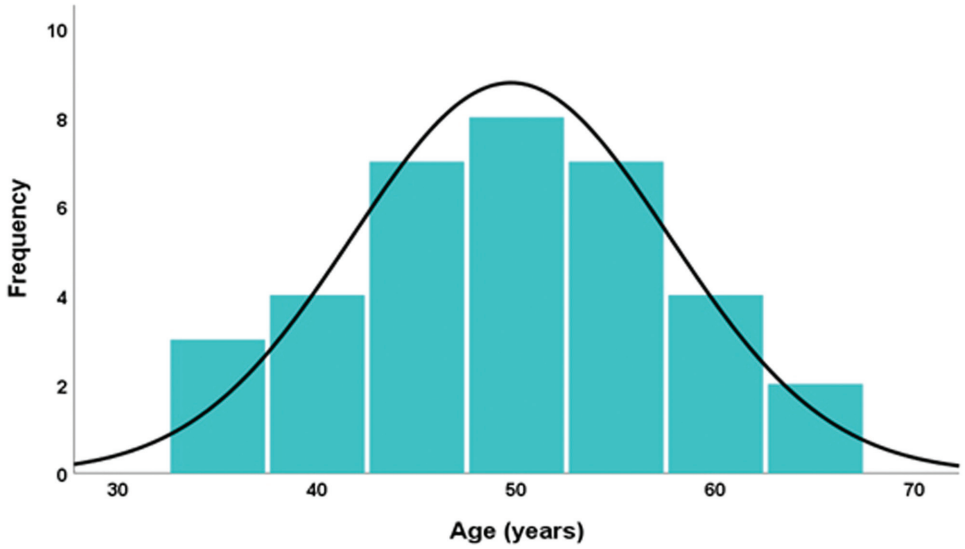
Figures 1–7 show comparison of age distribution, family history, complication, site, size of lesions and lesion localization among all studies cases.

Table 1 the present study was conducted on 35 breast cancer cases, patients with nonpalpable breast lesions. Their mean age was 49.7, ranged from 35 to 66 years.

Table 2 among all studied cases, 14 (40%) females had positive family history.

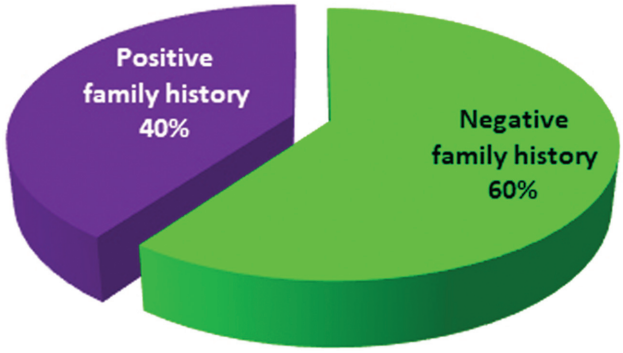
Table 3 mean procedure time was 24.1 min, ranged from 20 to 30 min. While mean duration before

Figure 1



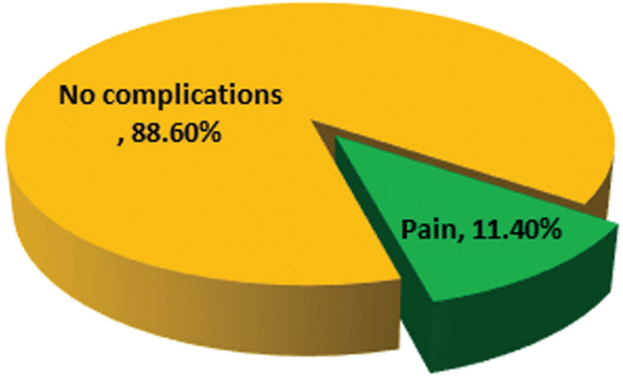
Age distribution among all studied cases.

Figure 2



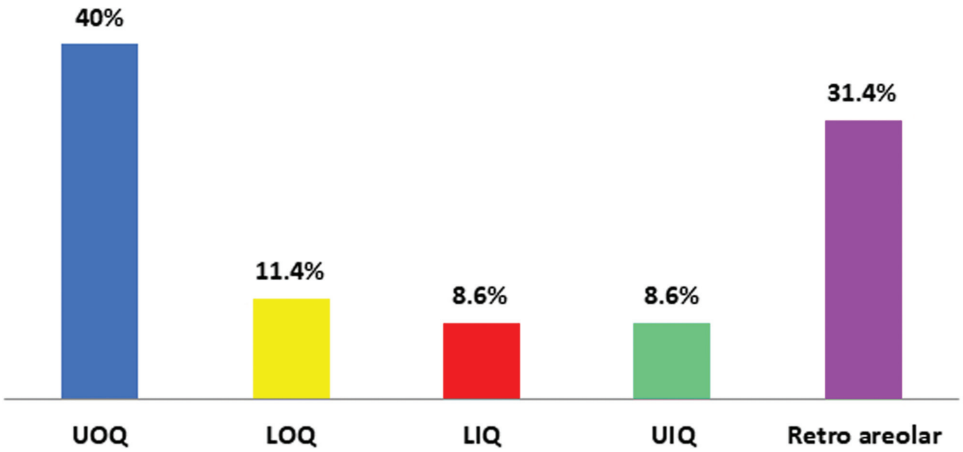
Family history among all studied cases.

Figure 3



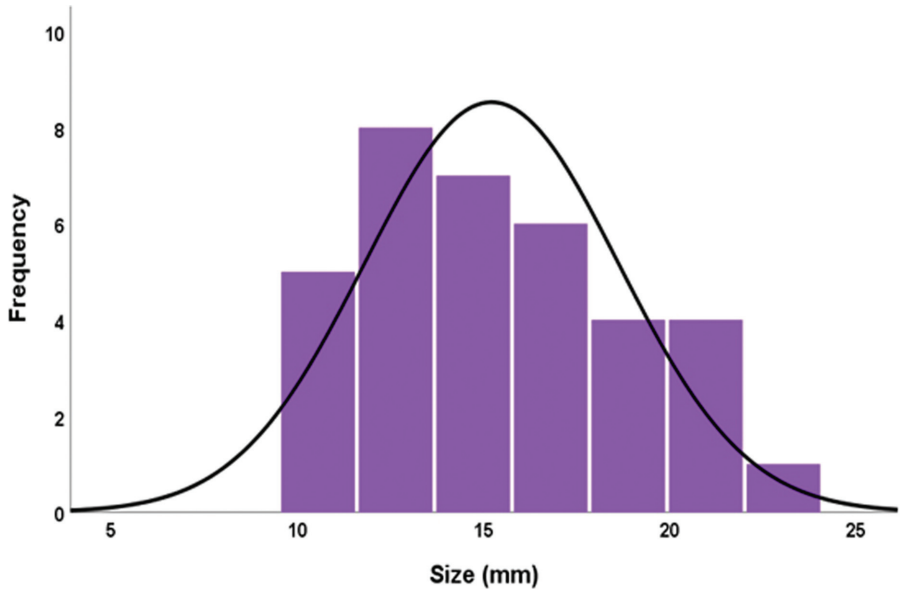
Complications among all studied cases.

Figure 4



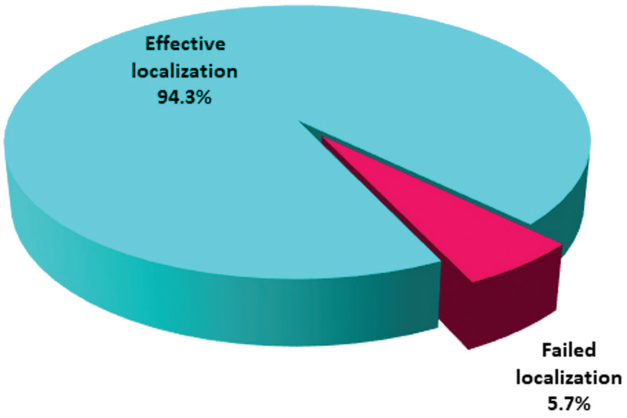
Sites of lesions among all studied cases.

Figure 5



Size of lesions among all studied cases.

Figure 6



Localization among all studied cases.

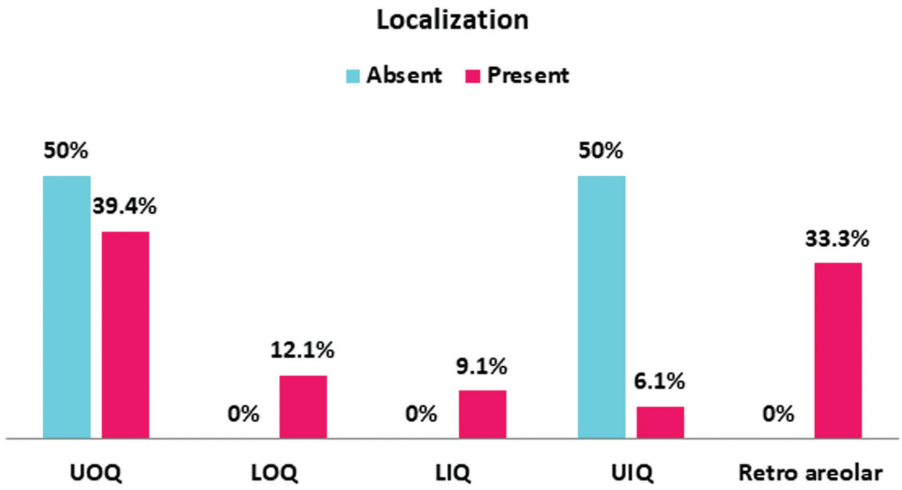
surgical operation was 1.8 days, ranged from 1 to 5 days.

Table 4 pain was associated with 11.4% of all studied cases while 88.6% had no complications.

Table 5 sites of studied lesions included upper–outer quadrant (UOQ) in 40%, lower outer quadrant (LOQ) in 11.4%, lower inner quadrant (LIQ) in 8.6%, upper inner quadrant (UIQ) in 8.6% and retroareolar site in 31.4%.

Mean size of studied lesions was 15.2, ranged from 10 to 22 mm.

Figure 7



Sites of lesions according to localization.

Table 1 Age among all studied cases

	Cases (*N*=35)
Age (years)	
Mean±SD	49.7±8
Minimum–maximum	35–66

Table 2 Family history among all studied cases

	Cases (*N*=35)
Family history	
Negative	
N (%)	21 (60)
Positive	
N (%)	14 (40)

Table 3 Time before and during procedure among all studied cases

	Cases (*N*=35)
Procedure time (min)	
Mean±SD (minimum–maximum)	24.1±4.3 (20–30)
Duration before surgical operation (days)	
Mean±SD (minimum–maximum)	1.8±0.1.1 (1–5)

Table 4 Complications among all studied cases

	Cases (*N*=35)
Complications	
No	
n (%)	31 (88.6)
Pain	
n (%)	4 (11.4)

Table 5 Lesions' characteristics among all studied cases

	Cases (*N*=35)
Site of lesion	
UOQ	
n (%)	14 (40)
LOQ	
n (%)	4 (11.4)
LIQ	
n (%)	3 (8.6)
UIQ	
n (%)	3 (8.6)
Retroareolar	
n (%)	11 (31.4)
Size (mm)	
Mean±SD	15.2±3.4
Minimum–maximum	10–22

LIQ, lower inner quadrant; LOQ, lower outer quadrant; UIQ, upper inner quadrant; UOQ, upper–outer quadrant.

Association of lesion sites with other studied parameters

Table 6 no significant association was found between site of the lesions with age, family history, lesional size, operative time, duration before operation and complications ($P>0.05$ for each).

It was noticed that patients with UIQ had older age and larger tumor size. However, this was not significant.

Studied cases

Table 7 the charcoal suspension was used for preoperative marking of nonpalpable

Breast lesions as localization tool. It was effective in 33 (94.3%) cases, while only two (5.7%) cases could not be localized.

Table 8 cases with effective localization were 33 cases, their mean age was 49.7, ranged from 35 to 66 years; 42.5% had positive family history, 39.4% were located at UOQ, 12.1% at LOQ, 9.1% at LIQ, 6.1% at UIQ and 33.3% at retroareolar site; mean size was 15.2, ranged from 10 to 22 mm.

While cases with failed localization were only two cases, their mean age was 50.5, ranged from 50 to 51 years; none had positive family history, 1 was located at UOQ, and 1 at UIQ; mean size was 15, ranged from 11 to 19 mm.

No significant differences were found between cases with effective and failed localization regarding age, family history, site, lesional size, operative time, duration before operation and complications.

Discussion

In this prospective study done for 35 female patients we aimed to evaluate the utility and efficacy of US-guided tattooing localization of the nonpalpable breast lesions with carbon suspension as good alternative localizer method.

Our study was settled at Ain Shams University Hospitals, Khazendara General Hospital, and radiological private medical centers for 2 years.

We included in this study female patients more than 18 years old with nonpalpable breast lesions which prepared to conservative breast surgery and came to our department for preoperative localization.

The mean age of the patients was 49.7 years old which is similar to three studies [6] with mean age 52.2 years old [7] with mean age 53 years old [8] with mean age

Table 6 Association of sites with different studied parametres among all studied cases

	UOQ	LOQ	LIQ	UIQ	Retroareolar	*P*
Age (years)						
Mean±SD	50±8.5	48.0±8.8	49.7±9.7	53.3±3.1	49.0±8.5	0.932
Minimum–maximum	35–66	42–61	39–58	50–56	37–64	
FH						
Negative						
n (%)	7 (50)	2 (50)	2 (66.7)	3 (100)	7 (63.6)	0.417
Positive						
n (%)	7 (50)	2 (50)	1 (33.3)	0	4 (36.4)	
Size (mm)						
Mean±SD	15.5 (3.1)	13.8 (1.7)	13.7 (6.4)	18.7 (2.5)	14.8 (3.3)	0.333
Minimum–maximum	11 (22)	12 (16)	10 (21)	16 (21)	11 (20)	
Time (min)						
Mean±SD	23.4 (3.6)	23.8 (4.8)	20.0 (0.0)	26.7 (5.8)	25.5 (4.7)	0.259
Minimum–maximum	20 (30)	20 (30)	20 (20)	20 (30)	20 (30)	
Duration before operation (days)						
Mean±SD	1.6 (1.2)	2.3 (1.0)	1.3 (0.6)	1.7 (0.6)	2.1 (1.3)	0.651
Minimum–maximum	1 (5)	1 (3)	1 (2)	1 (2)	1 (5)	
Complications						
n (%)	13 (92.9)	4 (100.0)	3 (100.0)	3 (100.0)	8 (72.7)	0.311
n (%)	1 (7.1)	0	0	0	3 (27.3)	

LIQ, lower inner quadrant; LOQ, lower outer quadrant; UIQ, upper inner quadrant; UOQ, upper–outer quadrant.

Table 7 Localization among all studied cases

	Cases (*N*=35)
Localization	
Failed	
n (%)	2 (5.7)
Effective	
n (%)	33 (94.3)

50.8. In contrast the main age in this study was different to three studies [9] with mean age 43 years [10] with mean age 59.5 years and [11] with mean age 59.4 years, yet the age did not make any difference in localization with no value in charcoal localization method and technique.

The technique used in our study was done under complete aseptic condition with skin sterilization, mass localization by linear probe of US, injection of sterile 3% charcoal solution through wide bore needle at nearest point of the lesion in vertical and tangential planes with tattooing of the lesion and withdrawal track to the skin.

The injected 3% charcoal suspensions amount is similar to three studies [7,8,9], it contrast the charcoal concentration was different at Rose *et al.* [10], Lucca *et al.* [11], and Tran *et al.* [12] with concentration 4% charcoal suspension, yet in our study the 3% charcoal suspension showed good staining of the lesion and track of tissue with good detection by the surgeon, the more concentration the more staining of tissue.

The site of lesions seen at UOQ 14 (40%) patients, retroaroelar region 11 (31.4%) patients, LOQ four (11.4%) patients, LIQ three (8.6%) patients, and UIQ three (8.6%) patients which similar to two studies [8,13] where suspicious lesions were mostly located in the upper–outer quadrant.

The duration of the charcoal localization before surgical intervention in our study was ranged from 1 to 5 days with mean time about 1.8 days, this is similar to one study with time interval from same day of operation till 6 days in Farouk *et al.* [9], which is differ from other studies which reported time interval between localization and surgical intervention 1 day up to 6 months in Abd Alhafez *et al.* [8], same day of surgical intervention [12]. Same day and from an hour up to 1 day in Kim *et al.* [6].

The size of the lesions ranging from 10 to 22 mm with main size 15.2±3. Which is different from two studies [8] with mean size 10.9 mm (4–20 mm) and Ko *et al.* [1] with mean size 10 mm (4–32 mm).

The localization procedure took time ranging from 20 to 30 min with mean time about 24.1 min.

The main complication noted by the charcoal localization technique is pain. Pain was associated

Table 8 Association localization with other parameters among all studied cases

	Localization		
	Absent *N*=2	Present *N*=33	*P*
Age (years)			
Mean±SD	50.5±0.7	49.7±8.2	0.888
Minimum–maximum	50–51	35–66	
FH			
Negative			
n (%)	2 (100)	19 (57.6)	0.506
Positive			
n (%)	0	14 (42.4)	
Site of lesion			
UOQ			
n (%)	1 (50)	13 (39.4)	0.766
LOQ			
n (%)	0	4 (12.1)	0.601
LIQ			
n (%)	0	3 (9.1)	0.656
UIQ			
n (%)	1 (50)	2 (6.1)	0.166
Retroareolar			
n (%)	0	11 (33.3)	0.324
Size (mm)			
Mean±SD	15±5.7	15.2±3.4	0.333
Minimum–maximum	11–19	10–22	
Time (min)			
Mean±SD	20.0±0.0	24.3±4.3	0.173
Minimum–maximum	20–20	20–30	
Duration before operation (days)			
Mean±SD	1.5±0.7	1.8±1.1	0.699
Minimum–maximum	1–2	1–5	
Complications			
n (%)	2 (100.0)	29 (87.9)	0.601
n (%)	0	4 (12.1)	

LIQ, lower inner quadrant; LOQ, lower outer quadrant; UIQ, upper inner quadrant; UOQ, upper–outer quadrant.

with 11.4% of all studied cases while 88.6% had no complications. No other significant complication noted during our study like inflammatory response similar to Farouk *et al.* [9]. In contrast two studies shows inflammatory response in about 50% of patients in Cavalcanti *et al.* [14] and Abd Alhafez *et al.* [8].

Two patient was failed in localization in our study, one patient was failed due to precipitations of charcoal particles due to nonshaking syringe made the solution more transparent and made the lesion difficult in localization by the surgeon, the other patient had very hard mass which cannot be punctured by the needle and mimicking needle blockage with over pressure on the syringe the staining solution was around the lesion and not staining it.The needle blockage by large charcoal particles was overcomed by force pressure on it or replacing the needle. No skin over staining was noted in our study.

The surgeon was told that usage of diathermy in controlling bleeding and resection of the tissue is prohibited because it can mimic the staining tissue and lesion which make it more difficult to localize.

No significant association was found between site of the lesions with age, operative time, duration before operation and complications ($P>0.05$ for each).

The charcoal suspension was used for preoperative marking of nonpalpable breast lesions as localization tool. It was effective in 33 (94.3%) cases, while only two (5.7%) cases could not be localized.

This study has two main limitations. First, the duration period of localization before the surgical intervention (mean, 1.8 days) which be due to late referral of the patient by the surgeon, this lead to absent of long period follow up of the charcoal staining and its fixability, in Abd Alhafez *et al.* [8] it can be up to 6 months before surgery. Second, the effect of the charcoal suspension staining on the tissue itself and the further histopathological assessment by the pathologists is not evaluated at this study. These limitations need more researches to give good evaluation of the new localization technique by the charcoal suspension.

Conclusion

(1) Charcoal localization technique by time has increasing its role as localizer in nonpalpable breast lesions due to its efficacy, availability and price in comparison to other localization methods.
(2) In our study, localization of nonpalpable breast lesion under US Guidance by Injection of Charcoal Solution is a very simple, safe and accurate method. Time interval between localization and surgical excision gave chance for better preparation and cooperation between radiologist and surgeon.

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Nil.

Conflicts of interest
There are no conflicts of interest.

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