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Magnetic Resonance Imaging of the Metal Clip in a Breast: Safety and Its Availability as a Negative Marker

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Purpose: This study assesses magnetic resonance (MR) safety of the stainless-steel clip inserted after stereotactic-guided directional vacuum-assisted biopsy (DVAB) of the breast, and evaluates its imaging value.

Methods: We used a sausage as a substitute breast and inserted the clip into it. The MR images of the substitute were scanned using a breast coil, and it was then dissected. After the substitute experimentation, MR scanning of the breast was performed using a dynamic contrast enhanced technique, in which a clip was placed after DVAB for suspicion of ductal carcinoma was seen as grouped amorphous calcifications on mammography.

Results: On every magnetic resonance image of the substitute, the clip was seen as a spotty signal void, with no surrounding artifact. There was no movement and no evidence of increased clip temperature on dissected of the substitute, confirming the safety of breast MR with a clip in place. There was no patient complaint of feeling heat or pain during the MRI examination and there were only biopsy scars on the surgically excised breast specimen material. On the breast MR images, a spreading region of the tumor adjoining the position of the signal void was identified as an early enhancing lesion.

Conclusions: The safety and reliability of breast MR examination using a mammotome clip was demonstrated by both the mock examination and the breast examination. It is possible to localize of tumor spread regions based on the marker position using the clip as a negative signal marker.

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Key words: Magnetic resonance, Breast neoplasm, Diagnosis, Breast biopsy

The increase in screening mammography has led to improved detection of nonpalpable breast cancers[1, 2]. For the pathological diagnosis of nonpalpable mammographically detected breast lesions, stereotactic-guided directional vacuum-assisted biopsy (DVAB) has been widely used since the introduction of the Mammotome (Johnson & Johnson, Tokyo, Japan). It is effective and widely available for diagnosing such abnormalities as microcalcifications on mammography[3, 4].

On the other hand, magnetic resonance (MR) imaging of the breast is helpful with identifying the tumor spread and characteristics, especially the dynamic contrast enhanced technique[5-9]. If disease is detected on MR images, it is necessary to determine the surgical margin by identifying the extent of the disease. For the precise localization of the disease, stereotactic-guided placement of a metallic wire has been ordinarily performed, but there are some disadvantages to this technique such as metallic artifact on MR images or the inconvenience of wire localization on MR.

As an X-ray marker for the breast lesion, a stainless-steel clip (Micromark II, Johnson & Johnson) can be placed after DVAB, and disease localization can be preoperatively performed according to its position on the X-ray[10, 11]. Thus, both the pathological diagnosis and the disease localization can be done in one procedure. MR of metal is contraindicated in some cases because of the risk of movement and rise in the metal's tem-

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Abbreviations:
MR, Magnetic resonance; DVAB, Directional vacuum-assisted biopsy; SE, Spin echo; FSE, Fast spin echo; GE, Gradient echo

perature. If not contraindicated, the images may be insufficient for diagnosis when metal artifact is shown on MR.

In this study, we initially assessed the safety of the stainless-steel clip in MR and evaluated the imaging value by using a clip inserted into substitute breast tissue, and then examined cases with breast lesions.

Materials and Methods

Phantom Experimentation

Column-shaped sausage (major axis 13 cm in diameter, minor axis 7 cm in diameter, made of pork and condiments) was used as a substitute breast. An 11 gauge-length Mammotome needle was inserted into the sausage, and the clip was placed at the 12 o'clock position, using the same technique as breast Mammotome biopsy (Fig 1).

After verification of the clip position on the X-ray (Fig 2), MR images of the phantom were obtained with a 1.5-T system (Magnetom VISION: Siemens Medical Solutions, Erlangen, Germany) using a standard dedicated breast coil. Images were oriented by two orthogonal sections using spin echo (SE), fast spin echo (FSE), and gradient echo (GE) sequences. Imaging parameters were as follows: SE-T1 weighted images (flip angle 90 degree, 374/12 repetition time/echo time msec, 512 × 512 image matrix, with or without fat-suppression), FSE-T2 weighted images (flip angle 180 degree, 4,000/96 repetition time/echo time msec, 512 × 512 image matrix, with fat-suppression), and GE-T1 weighted images (flip angle 90 degree, 170/4.7 repetition time/echo time msec, 256 × 256 image matrix, with or without fat-suppression), all with 3 mm slice thickness, and a FOV of 210 mm.

On the basis of the consensus of three radiologists, the depiction of the clip, the presence of artifact, and the presence of spatial distortion were carefully evaluated to confirm the usefulness of MR imaging.

To confirm the safety of breast examination, movement of the clip or evidence of increased temperature was ascertained by dissecting the phantom into pieces.

Breast MR

After the phantom experimentation, MR scan of a breast lesion was performed.

A mammogram of a 58-year-old woman showed grouped amorphous microcalcifications in the upper-outer portion of the left breast (Fig 3). The tumor was not palpable and was not depicted on ultrasound. To rule out malignancy, stereotactic vacuum-assisted biopsy was performed, and the clip (Micromark II) was placed after the biopsy. Pathological examination showed ductal carcino-

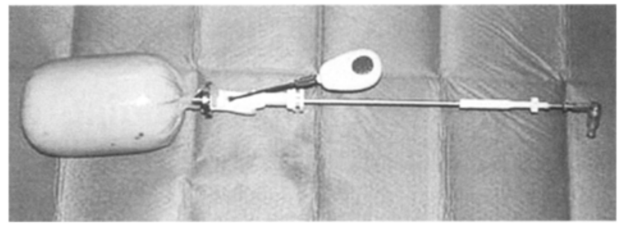

Fig 1. Mammotome needle was inserted in the sausage-phantom, and the clip was placed.

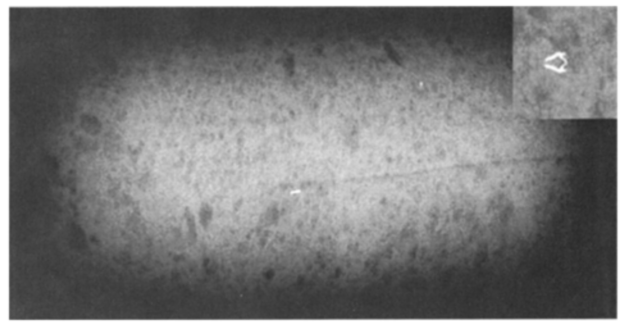

Fig 2. The stainless-steel clip (Micromark II) inserted in the sausage phantom.

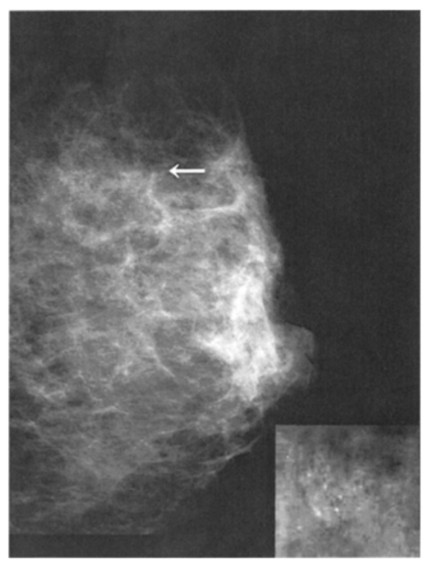

Fig 3. Mammogram of a 58-year-old woman showing grouped amorphous microcalcifications in the upper-outer portion of the left breast (arrow and magnification below).

ma *in situ*. After informed consent, MR scan was performed before the operation to assess the spreading region and to estimate the character of the tumor.

The MR images of the breast were scanned with a 1.5-T system (Magnetom VISION) using a standard dedicated bilateral breast coil. The imaging protocol consisted of an initial scout view, coronal fat-suppressed FSE-T2-weighted images, coronal dynamic GE-T1 weighted dynamic series, and sagittal fat-suppressed GE-T1 weighted images, all using the same parameters as the phantom scan.

The dynamic series consisted of 15 individual T1-wieghted images; one was obtained before, and 14 after, rapid bolus intravenous injection of 15 mL of gadolinium chelate (Omniscan; Daiichi Seiyaku, Tokyo, Japan) at a rate of 3 mL/sec and a subsequent 10 mL saline solution flush using an automatic injector. The scanning time of one series was 29 sec, and each series was scanned at 30 sec intervals. Both the early-phase images and the late-phase images were calculated by subtracting the pre-contrast enhanced images from the enhanced images at 60 sec and 420 sec after the bolus injection of the contrast material.

On the basis of the consensus of three reviewers who specialize in breast radiology, all the MR images were evaluated with regard to the depiction of the clip, existence of surrounding artifact, spatial distortion of the image, lesion characteristics, and the spreading region of the tumor localized by the marker point.

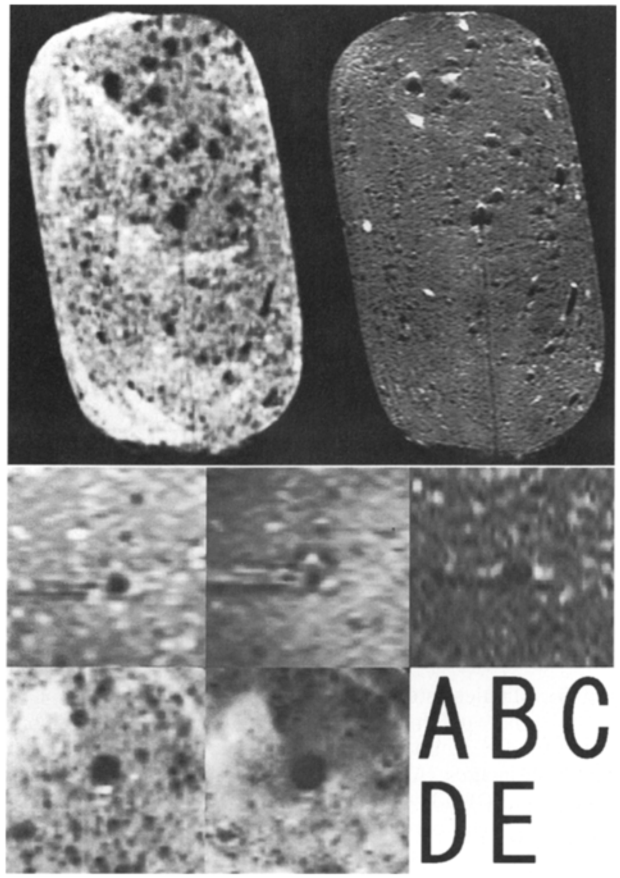

Fig 4. (Top) Stainless-steel clip in the phantom was depicted as a spotty signal void on the top of the insertion scar (GE-T1 weighted image and fat-suppressed FSE-T2 weighted image). (Bottom) The diameter of the central signal void was 4 mm, 4 mm, 5 mm, 6 mm, and 6 mm on SE-T1 weighted images (A), fat-suppressed SE-T1 weighted images (B), fat-suppressed FSE-T2 weighted images (C), GE-T1 weighted images (D), and fat-suppressed GE-T1 weighted images (E), respectively.

Results

Phantom Experimentation

The MR images of the metallic clip in the sausage phantom are shown in Fig 4. On the X-ray image (Fig 2), the scar of the Mammotome needle insertion and the clip are shown. On the MR images, the insertion scar is correspondingly depicted, and a small spotty signal void, the so-called centered black-hole, is depicted at the top of the scar. The actual size of the clip is 2 × 2 mm, and the diameter of the signal void was 4 mm, 4 mm, 5 mm, 6 mm, and 6 mm on SE-T1 weighted images, fat-suppressed SE-T1 weighted images, fat-suppressed FSE-T2 weighted images, GE-T1 weighted images, and fat-suppressed GE-T1 weighted images, respectively. On the T1 weighted images with fat-suppression, the clip was depicted as a small-sized centered signal void, with an area of high signal on its rim, and a bit of surrounding signal void. Though these signal voids result from metal artifacts, they so thin that they were not considered to compromise the imaging diagnosis. There was no other surrounding artifact or spatial distortion on any image.

There was no movement and no evidence of rise in temperature on dissection of the phantom, confirming the safety of scanning the clip.

Breast MR

There was no complaint such as feeling heat or pain during the MRI examination and only scars from the biopsy on the operated breast specimen material were noted.

Corresponding to the phantom experimenta-

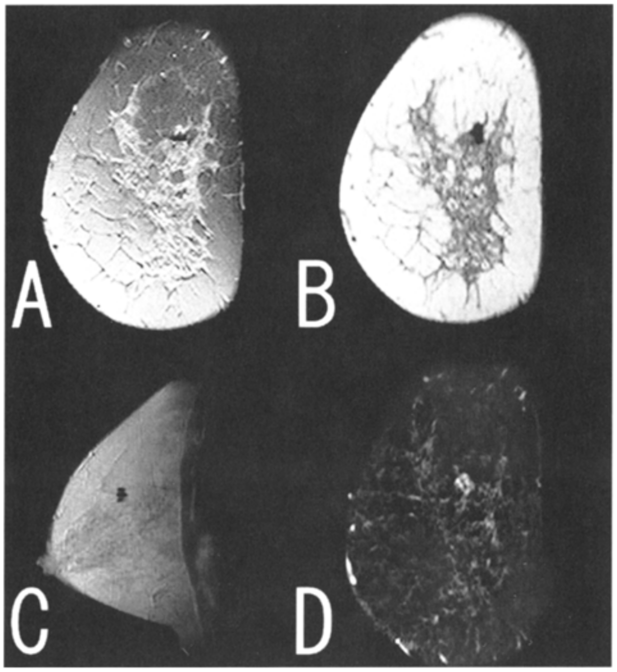

Fig 5. Stainless-steel clip in the breast was depicted as a spotty signal void on each MR image. The size of the signal void was 4 × 3 mm, 5 × 3 mm, and 6 × 4 mm on FSE-T2 weighted images (A), GE-T1 weighted images (B), and fat-suppressed GE-T1 weighted images (C), respectively. The region of ductal carcinoma *in situ* was depicted as a focal-spreading early-enhancing lesion adjoining the signal void of the clip (D).

tion, a spotty signal void is depicted on the breast MR images (Fig 5). The sizes of the signal void were 4 × 3 mm, 5 × 3 mm, and 6 × 4 mm on FSE-T2 weighted images, GE-T1 weighted images, and fat-suppressed GE-T1 weighted images, respectively. On the early-phase subtraction image, the spreading region of the tumor could be determined as an early enhancing focal lesion adjoining the subtracted signal void of the clip.

Discussion

The safety and reliability of breast MR scan with a stainless-steel clip inserted after Mammotome biopsy were confirmed by the phantom experimentation, and there was no complaint on a breast study.

On every MR image, the clip was depicted as a signal void with no other surrounding artifact and there was no spatial distortion on any image. Thus, by using the clip as a negative marker on the contrast-enhanced MR images, the region of tumor spread could be determined based on the marker point. Therefore, whenever the tumor is not apparent on X-ray, the tumor can be determined by the spreading size or direction from the X-ray apparent marker position, so it is useful in determining the precise surgical margin for tumor excision.

Previously, MR of intracranial aneurysm clips or surgical clips has been reported[12-15]. In these reports, there have been almost no critical complaints, and the appearance of metallic artifact has been investigated. Comparison of the spin echo and gradient echo techniques has shown that the spin echo image can reduce the surrounding metallic artifacts, as shown by our experimentation. In our study, though there was no diagnostically embarrassing artifact on any clip-inserted image, the sizes of the signal void of the clip were a little bit larger on GE images than on SE or FSE images, and a little bit larger on the fat suppressed images than on the non-fat suppressed images. When the tumor is very small in size or when almost all of the tumor is resected by the Mammotome biopsy, smaller lesion analysis is required. In such cases, using spin echo or non-fat suppressed techniques may be required to reduce the size of the signal void of the clip.

Clip placement after DVAB enables both a pathological diagnosis and disease localization in one procedure. Subsequent MR imaging enables identification of the tumor spread, and then the precise excision region can be preoperatively determined because the excision region can be determined by the extent of spread on MR images based on the location of the clip, even if the tumor is not seen on X-ray. In conclusion, MR imaging of the clip in a breast is safe and effective. Recently, since the detection of nonpalpable breast cancers has increased especially ductal carcinoma *in situ*, MR may identify the tumor location and spread preoperatively after clip placement at the time of DVAB.

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