Silicone Breast Implants

Magnetic resonance imaging is a powerful noninvasive means by which to study the integrity of silicone breast implants. Silicone has a unique MR resonance frequency and long T_1 and T_2 relaxation times that allow for several MR sequences to provide excellent diagnostic images. The most commonly used sequences include T_2-weighted and STIR (short tau inversion recovery) imaging. The T_2-weighted and STIR sequences are commonly used in conjunction with water suppression. The following are sequences that can be used to investigate normal and ruptured silicone breast implants.

IMAGING OF SILICONE BREAST IMPLANTS

BASIC PROTOCOL

An understanding of the MR characteristics of silicone will be helpful to understand why certain MR sequences are used to differentiate silicone from surrounding breast parenchyma. As previously stated, silicone has a unique MR resonance frequency and long T_1 and T_2 relaxation times that allow for several MR sequences to provide diagnostic images. The MR characteristics of silicone will be more thoroughly discussed in the Critical Parameters section.

MR imaging of silicone breast implants is perfomed with a dedicated bilateral breast coil using a 1.5 T superconducting magnet to help separate the MR signals from silicone, fat, and water. To image patients with silicone breast implants, 4 MR sequences are used, which require ~30 min to complete the examination. Low field strength magnets can be utilized to image the silicone breast implants, however, the signal separation between silicone, fat, and water is poor on certain MR sequences.

Table A21.2.1 lists the necessary hardware to perform the procedure. The available gradient strength will vary from scanner to scanner. The echo times will depend on the MR system used. A dedicated bilateral breast coil is optimal for scanning, however, a shoulder coil, round coil, or flex coil can be used on one breast at a time in the supine position.

Set up patient and equipment

1. Interview (screen) the patient to ensure that he or she has no counterindications such as cardiac pacemakers or other implants containing ferromagnetic materials. Also, be sure to find out if the patient has any health conditions that may require the presence of special emergency equipment during the scanning procedure, or necessitate any other precautions.

   Generally, standard screening forms are used for all patients scanned in a magnetic resonance system. The presence of any ferromagnetic metals may be a health hazard to the

Table A21.2.1 Equipment Parameters Necessary for Imaging of Silicone Breast Implants

Coil type	Dedicated bilateral breast coil (phased-array if available)
Gradient coil strength	Depends on MR scanner
Cardiac gating	No
Peripheral gating	For safety only
Respiratory gating	No
Respirator	Patient dependent
Oxygen	Patient dependent
Use of contrast agent	No

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patient when he or she is inside the magnet, and will also affect the imaging. If in doubt as to the exact composition of the items, it is best to exclude patients with any metal implants; see Shellock and Kanal (1996) for discussion of what implants may be safely scanned using magnetic resonance.

Patients may be accompanied into the magnet room by a friend or family member, who can sit in the room during the scan and comfort the patient as needed. This companion must be screened as well to ensure the absence of loose metal objects on the body or clothing.

2. If this is a research protocol, the patient should sign any necessary forms.
3. Have the patient remove all jewelry and change into a gown to eliminate any metal that might be found in clothing.
4. Have the patient wash off any mascara and other makeup to avoid local tissue heating and image artifacts.
5. Inform the patient about what will occur during the procedure, what he or she will experience while in the magnet, and how to behave, including the following:
   a. If earphones or headphones are used to protect the ears from the loud sounds produced by the gradients, the patient will be asked to wear these, but will be able to communicate with you at any time during the imaging.
   b. The patient will be given a safety squeeze-bulb or similar equipment to request assistance at any time (demonstrate how this works).
   c. For good results, the patient should not talk, and should avoid or minimize swallowing or other movement, during each scan—i.e., as long as the banging sounds continue.
   d. Nevertheless, the patient may call out at any time if he or she feels it necessary.
6. The patient should be told to remove all clothes from the waist up and change into a gown with the opening in front.

   No contrast agent will be used for this MR examination so intraveneous access is not required.

7. Have the patient mount onto the table. Either before or right after the patient lies down, set up any triggering devices or other monitoring equipment that is to be used.
8. Then ask the patient to lie prone on the dedicated bilateral breast coil. The gown should be opened in the front so the breast can be accurately placed in the breast coil.
9. Several pillows should be placed under the patient's head. Have the patient's arms placed parallel to their body. If needed, place a pillow or other support under the knees to make the patient more comfortable.
10. Use the centering light and center the patient's nipples in the coil.

    If the MR technologist is male, a female employee should be present at all times during set up.

    Once this step has been performed, so long as the patient does not move on the table, the table itself can be moved and then replaced in the same position as before without jeopardizing the positioning of one scan relative to another.

11. If the patient is unable to hold still, provide an appropriate sedative.
12. The following 4 sequences consist of the preferred protocol, (1) a transverse scout sequence, (2) a sagittal T_2-weighted sequence with water suppression, (3) a transverse T_2-weighted sequence, and (4) a transverse STIR sequence with water suppression. A GE signa 1.5 T scanner was used for this protocol.

Sequence 1: Rapid transverse positioning pilot

13. To validate the patient's position, run the system's pilot (or scout) scan to ensure correct location of the breast, using the imaging sequence given in Table A21.2.2 or similar parameters.

Sequence 2: Sagittal T_2-weighted fast spin echo with water suppression

14. Bring the sequence for the sagittal T_2-weighted fast spin echo with water suppression up onto the console. Set the imaging parameters as shown in Table A21.2.3.

Table A21.2.2 Primary Clinical Imaging Parameters for Scout Sequence 1 (Pilot Scan)

Patient position	Prone
Scan type	Gradient echo
Imaging plane (orientation)	Transverse
Central slice or volume center	Laser light centered on nipple of breast
Echo time (T_E)	As short as possible
Repeat time (T_R)	As short as possible
Flip angle (FA)	15°
Fields of view (FOV_x, FOV_y)	360 mm, 360 mm
Resolution (Δx, Δy)	1.41 mm, 2.81 mm
Number of data points collected (N_x, N_y)	256, 128
Slice thickness (Δz)	10 mm
Number of slices	10
Slice gap	5 mm
Number of acquisitions (N_{acq})	1
Swap read and phase encoding	No
Scan time	~30 sec

Table A21.2.3 Primary Clinical Imaging Parameters for Sequence 2 (T_2-Weighted Fast Spin Echo With Water Suppression)

Patient position	Prone
Scan type	Fast spin echo
Imaging plane (orientation)	Sagittal
Central slice or volume center	Image silicone implants only
Echo time (T_E)	190–220 msec
Echo train length (ETL)	8–16
Repeat time (T_R)	3000–5000 msec
Flip angle (FA)	90°
Fields of view (FOV_x, FOV_y)	200 mm, 320 mm (depends on patient)
Resolution (Δx, Δy)	0.78 mm, 1.25 mm
Number of data points collected (N_x, N_y)	256, 256
Slice thickness (Δz)	3 mm
Number of slices	30–38 (depends on patient)
Slice gap	1 mm
Number of excitations (NEX)	2
Number of acquisitions (N_{acq})	2
Swap read and phase encoding	No
Water suppression	Yes
Scan time	~4 min

15. Use the pilot images to locate the breast.

    The image slices for this sequence should only cover the silicone implants in order to obtain thinner slices in less time. This sequence is not designed to evaluate the entire breast parenchyma for breast tumors.

16. Run the scan.

Sequence 3: Transverse T_2 weighted fast spin echo

17. Bring the sequence for the sagittal T_2-weighted fast spin echo up onto the console. Set the imaging parameters as shown in Table A21.2.4.

18. Use the pilot images to locate the breast.

    The image slices for this sequence should only cover the silicone implants in order to obtain thinner slices in less time. This sequence is not designed to evaluate the entire breast parenchyma for breast tumors.

19. Run the scan.

Sequence 4: Transverse inversion recovery fast spin echo sequence with water suppression

20. Bring the sequence for the transverse T_2-weighted fast spin echo up onto the console. Set the imaging parameters as shown in Table A21.2.5.

21. Use the pilot images to locate the breast.

    The image slices for this sequence should only cover the silicone implants in order to obtain thinner slices in less time. This sequence is not designed to evaluate the entire breast parenchyma for breast tumors.

    This sequence provides more robust signal separation between silicone, fat, and water. The fat and water signal will be suppressed making the silicone signal relatively high (silicone

Table A21.2.4 Primary Clinical Imaging Parameters for Sequence 3 (T_2-Weighted Fast Spin Echo)

Patient position	Prone
Scan type	Fast spin echo
Imaging plane (orientation)	Transverse
Central slice or volume center	Image silicone implants only
Echo time (T_E)	190–220 msec
Echo train length (ETL)	8–16
Repeat time (T_R)	3000–5000 msec
Flip angle (FA)	90°
Fields of view (FOV_x, FOV_y)	320 mm, 320 mm (depends on patient)
Resolution (Δx, Δy)	1.25 mm, 1.25 mm
Number of data points collected (N_x, N_y)	256, 256
Slice thickness (Δz)	3 mm
Number of slices	30–38 (depends on patient)
Slice gap	1 mm
Number of excitations (NEX)	2
Number of acquisitions (N_{acq})	2
Swap read and phase encoding	No
Water suppression	No
Scan time	~4 min

Table A21.2.5 Primary Clinical Imaging Parameters for Sequence 4 (Inversion Recovery Fast Spin Echo Sequence)

Patient position	Prone
Scan type	Inversion recovery fast spin echo
Imaging plane (orientation)	Transverse
Central slice or volume center	Image silicone implants only
Echo time (T_E)	190–220 msec
Echo train length (ETL)	8–16
Repeat time (T_R)	3000–5000 msec
Inversion time (T_I)	150 msec
Flip angle (FA)	180°
Fields of view (FOV_x, FOV_y)	320 mm, 320 mm (depends on patient)
Resolution (Δx, Δy)	1.25 mm, 1.25 mm
Number of data points collected (N_x, N_y)	256, 256
Slice thickness (Δz)	3 mm
Number of slices	30–38 (depends on patient)
Slice gap	1 mm
Number of excitations (NEX)	2
Number of acquisitions (N_{acq})	2
Swap read and phase encoding	No
Water suppression	Yes
Scan time	~5 min

only sequence). This is a good sequence if one is looking for free silicone in the breast parenchyma. This sequence can only be performed consistently on a 1.5 T machine.

22. Run the scan.

Process and view the data

23. To better view the silicone implant images, adjust window level settings to see the interior characteristics of the implants.

These MR sequences are optimized to evaluate silicone implants, not breast parenchyma abnormalities. Therefore, the window level settings should be set to optimize the visualization of the silicone breast implants even at the expense of visualizing contrast in the breast parenchyma. For the transverse breast images, have the technologist flip the images 180° prior to printing in order to have the images in radiologic anatomic position.

COMMENTARY

Background Information

History of breast augmentation

During the last century, many different methods have been tried to augment or reconstruct the breast. Unfortunately, the majority of approaches were disappointing with many associated complications. The methods used to augment or reconstruct the breast can be placed into one of three categories, autogenous tissue transplantation, injectable materials, and implantable prostheses.

Autogenous tissue transplantation

One of the first surgical uses of autogenous tissue to correct a breast defect was performed by Czerny in 1895. He removed a lipoma from a patient's thigh to fill out a breast defect. In the mid 1920's, free fat grafts were used for breast augmentation; however, with time, liquefaction or absorption of the free fat graft diminished the cosmetic results. Abdominal fat flaps were first described in the mid 1950's and are still used today, many with excellent cosmetic re-

sults (Letterman and Schurter, 1989; Steinbach et al., 1993).

Injectable materials

During the last century, many different materials have been injected into the breast in attempts to augment the breast. One of the first materials injected was paraffin. Several other materials were also injected into the breast, but most, if not all of the materials injected eventually resulted in a poor cosmetic outcome secondary to complications. Complications included granulomatous reactions, inflammatory reactions, necrosis, pulmonary embolism, and death. Direct silicone injections started in the 1950's, again most with eventual complications similar to those identified with paraffin injections (Letterman and Schurter, 1989; Steinbach et al., 1993).

Implantable prostheses

In the 1950's, synthetic sponge prostheses, composed of polyvinyl alcohol or Ivalon, were implanted in the breast. Initial reports were promising, however, scar tissue quickly made these prostheses hard and caused them to shrink. Other synthetic materials were used such as etheron, polyether polyurethane, polypropylene, and even polytef (Teflon), all resulting in complications or poor cosmetic results. A new approach with promising cosmetic results and less complications was reported by Cronin and Gerow in 1963 when they described their use of a silicone gel prosthesis (Cronin and Gerow, 1964).

Several hundred different variations of silicone gel prostheses have been made commercially available over the past 40 years. Breast implants have been placed in 1 to 2 million women for augmentation mammoplasty or reconstruction after mastectomies. Despite the initial enthusiasm, complications related to the silicone-gel implants were reported. These complications include rupture and leakage, fibrous or calcific contracture, localized pain, pareshtesias, and possibly even generalized autoimmune disorders. In 1992, the U.S. Food and Drug Administration (FDA) held hearings about potential complications resulting from the use of silicone gel implants. As a result, the FDA announced it would allow the use of silicone gel implants only under special conditions (Kessler, 1992).

Because of concerns about the potential dangers of rupture and leakage of silicone-gel implants, radiologists are often requested to evaluate the integrity of breast prostheses. Mammography, sonography, and MR imaging have been used to evaluate the integrity of breast implants (Ahn et al., 1993; Gorczyca et al., 1992; DeBruhl et al., 1993; Destouet et al., 1992; Eklund et al., 1988; Harris et al., 1993; Sinha et al., 1993). When compared with other imaging techniques, MR imaging appears to be the most accurate method for evaluating the integrity of breast implants (Gorczyca et al., 1994a,b; Mund et al., 1993; Gorczyca and Brenner, 1997).

Critical Parameters

An understanding of the MR characteristics of silicone will be helpful to understand the different MR sequences that can be used to differentiate silicone from surrounding breast parenchyma. The chemical composition of most medical grade silicones is dimethyl polysiloxane with varying degrees of polymerization (Fig. A21.2.1; Habal, 1984). The MR signal is derived from the protons of the methyl groups. The implant shell (envelope) is also composed of silicone but differs from the gel because of the many additional cross linkages between the methyl groups that result in an elastic solid. Although the implant shell is composed of silicone, only minimal MR signal is produced from the silicone shell because of the many additional methyl group cross linkages.

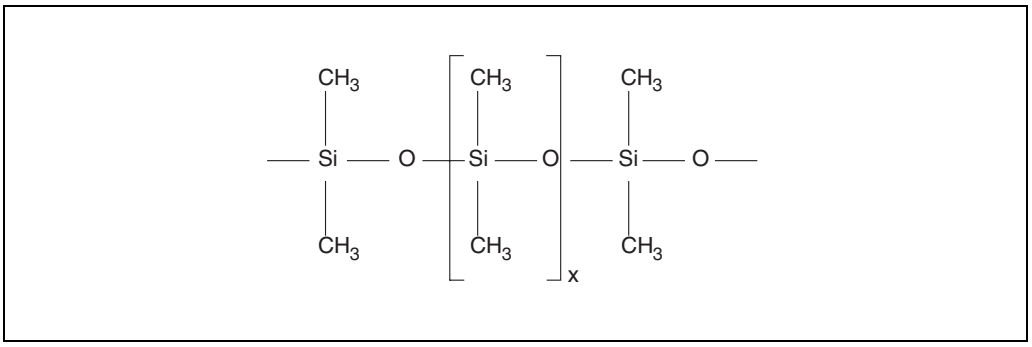

Figure A21.2.1 Chemical composition of silicone (dimethyl polysiloxane).

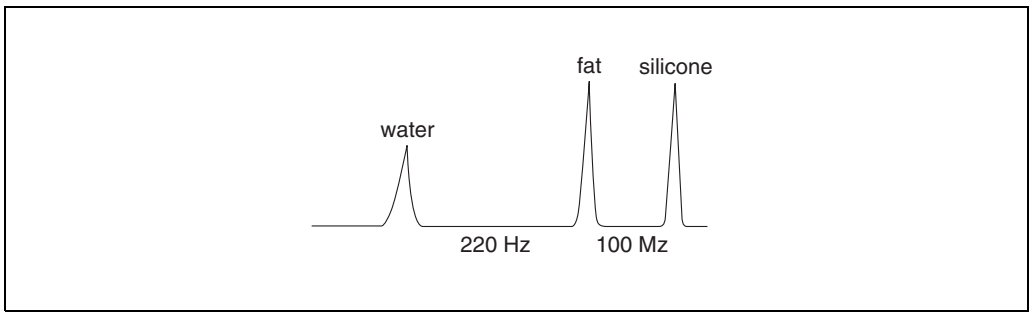

Figure A21.2.2 Relative resonance frequency differences between water, fat, and silicone at 1.5 T. The resonance frequency of silicone is ~320 Hz lower than that of water and 100 Hz lower than that of fat.

Table A.21.2.6 Relative Signal Intensities of Silicone, Fat, and Water

MR Sequence	Silicone	Fat	Water
Fast spin echo (FSE) T_2-weighted ($T_R \cong 5000$ msec, $T_E \cong 200$ msec)	High	Medium	Very high
FSE with water suppression	High	Medium	Low
Inversion recovery FSE (IRFSE) ($T_R \cong 5000$ msec, $T_E \cong 200$ msec, $T_I = 150$ msec)	High	Low	Very high
IRFSE with water suppression	High	Low	Low

The selection of MR pulse sequences used to image breast implants is determined by the relative Larmor precessional frequencies, as well as the T_1 and T_2 properties of the tissues (fat, muscle, and silicone). The relative resonance frequency of silicone is ~100 Hz lower than fat and 320 Hz lower than water at 1.5 T (Fig. A21.2.2). Since the resonance frequency of silicone is close to fat, when chemical suppression techniques (fat or water suppression) are used, the MR signal from silicone behaves similar to fat. As a result, the silicone signal is high when water suppression is used (Table A21.2.6) and the silicone signal is low when fat suppression is used.

The relative relaxation times of silicone, fat, and water can also be used to obtain MR images that selectively emphasize the signal from silicone. The relaxation times of fat are shorter than those of silicone; therefore, one can use the relaxation time properties of silicone and fat to suppress the fat while maintaining a strong signal from silicone. The use of inversion recovery with a short T_1 (STIR) will suppress the signal from fat while maintaining signal from silicone. To obtain a more selective silicone image, a water suppression pulse can be used in conjunction with an STIR sequence to produce a silicone selective sequence.

Troubleshooting

Failure of water suppression

Occasionally, auto prescan will fail when a water suppression sequence is being performed. To correct this, go into manual prescan (one should see a wave form similar to Fig. A21.2.2—occasionally the fat and silicone peak will merge into one flat peak), adjust to the fat peak, save the frequency, and scan. One helpful suggestion to individuals just starting to image silicone implants is to place a small bag of saline and a small silicone implant in the breast coil when scanning the patient. The saline and silicone bag act as controls so that the radiologist can easily see on the images how the saline and silicone are behaving on the MR sequence being used.

Motion artifact

Do not confuse motion, cardiac, or respiratory artifacts with the collapsed silicone implant shell. Most artifacts will extend beyond the confines of the breast implants.

Window level

It is extremely important to adjust the window level setting to clearly see inside the silicone breast implants. By adjusting the window level, the radiologist will be able to see the

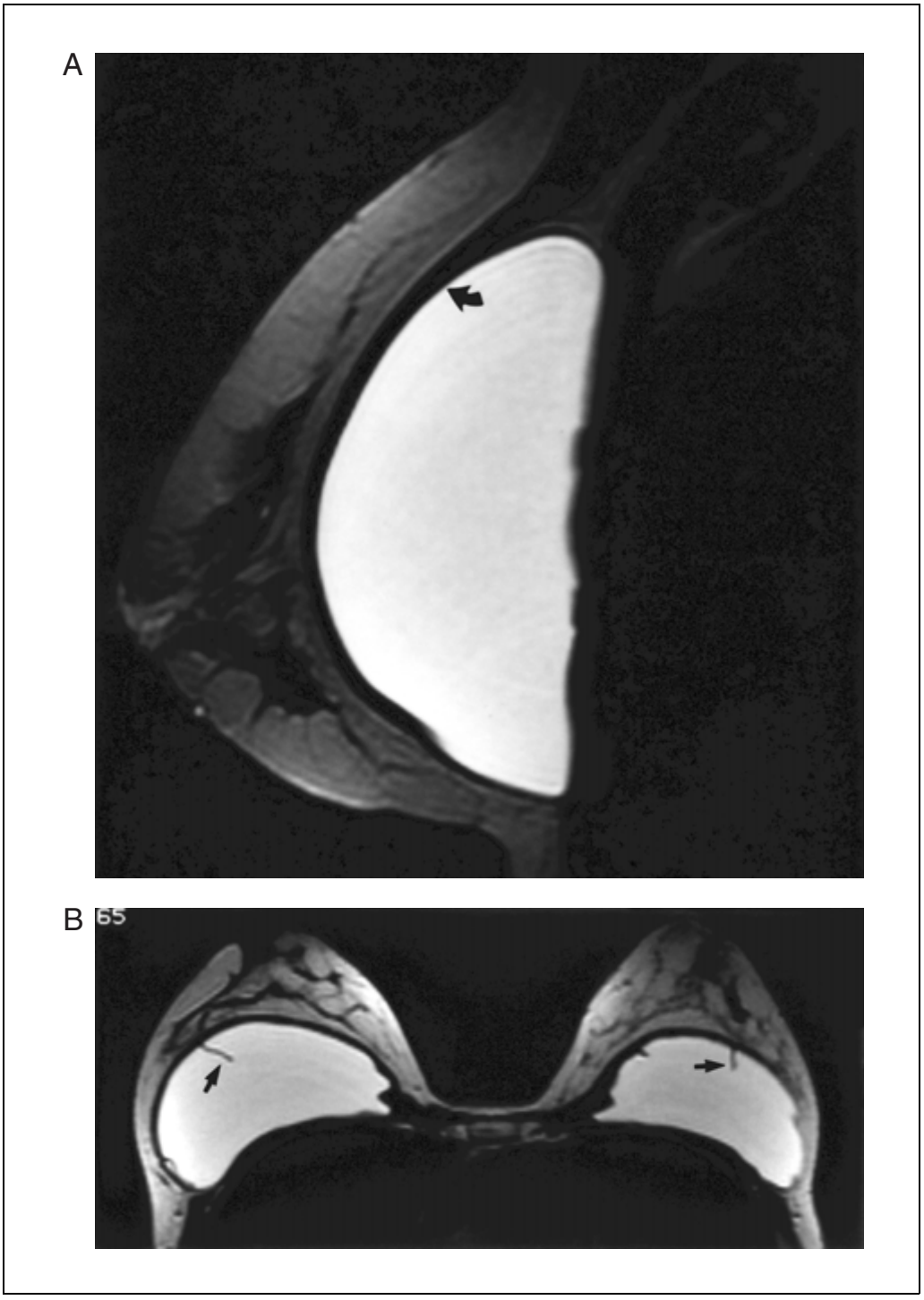

Figure A21.2.3 A 34-year-old woman with normal subpectoral single-lumen silicone implants. (**A**) Sagittal T_2-weighted FSE with water suppression. Pectoralis major muscle = curved arrow. (**B**) Transverse T_2-weighted FSE demonstrates a normal signal-lumen subpectoral silicone implant with normal radial folds (arrows) of the silicone shell extending to the periphery of the implant. These folds are not indicative of rupture or leak.

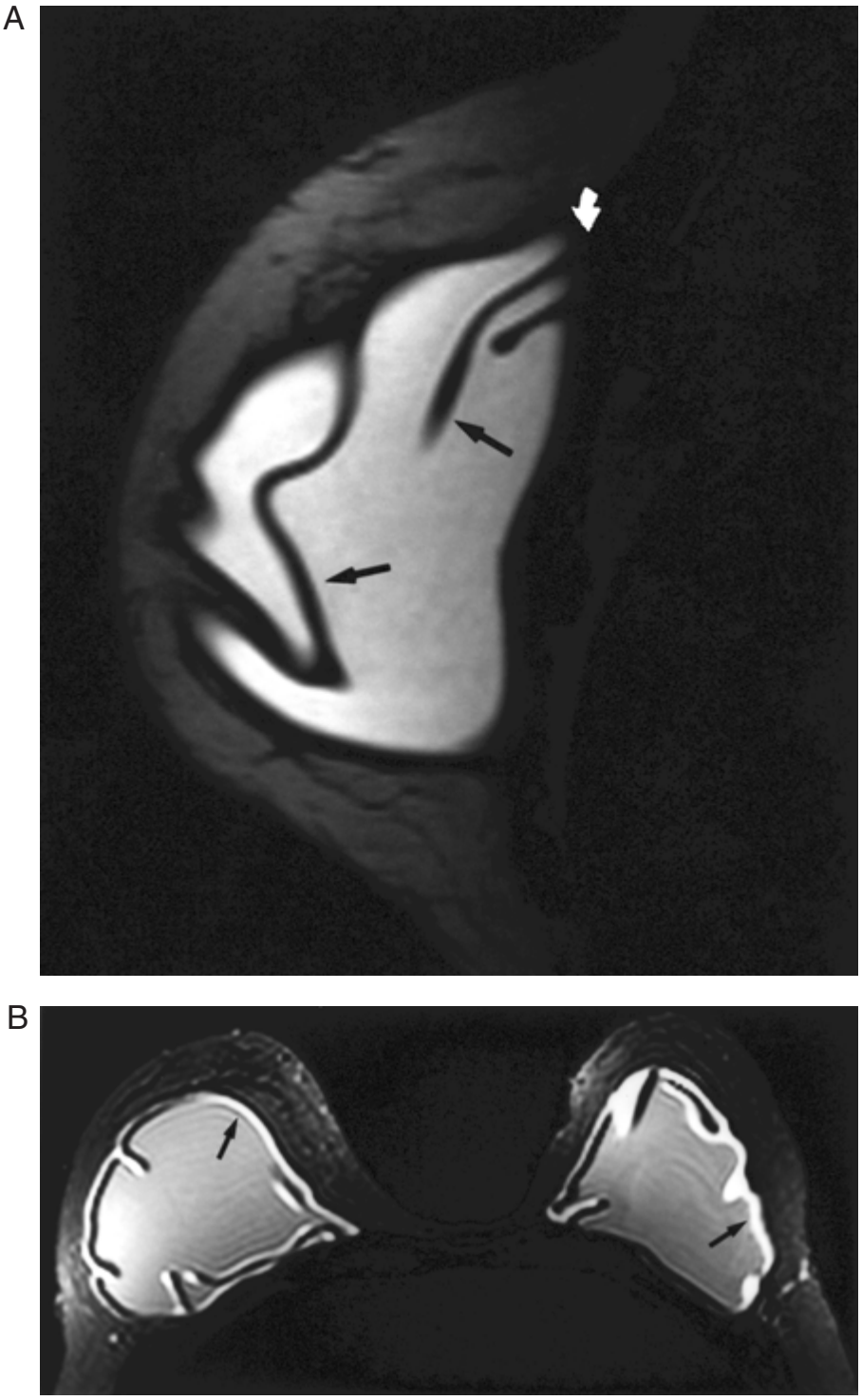

Figure A21.2.4 A 48-year-old woman with normal subglandular double-lumen silicone implants. (**A**) Sagittal T_2-weighted FSE with water suppression. Pectoralis major muscle = curved arrow. (**B**) Transverse T_2-weighted FSE. The very high signal intensity (arrows) surrounding the lower signal silicone on the transverse image (**B**) represents the saline-filled outer lumen. The saline outer lumen is of low-signal-intensity (straight arrows) on the sagittal T_2-weighted FSE with water suppression (**A**).

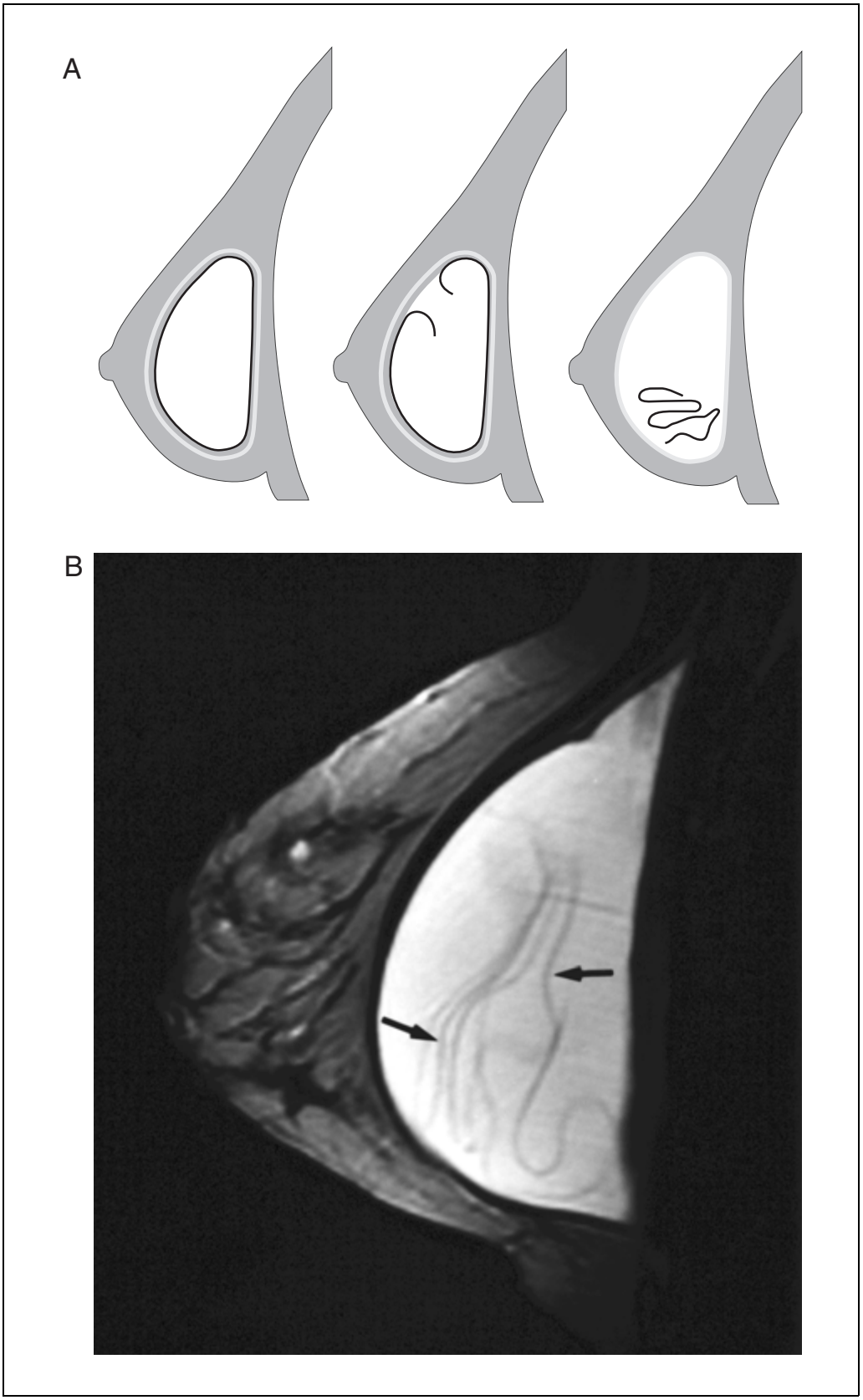

Figure A21.2.5 Intracapsular rupture. (**A**) Unlike an intact implant (left), in early intracapsular ruptures (center), silicone gel surrounds implant shell, but is contained by the fibrous capsule. Later, the collapsed implant shell floats within the silicone gel (linguine sign, right). Light gray line = fibrous capsule, black line = implant shell. (**B**) Patient presented with pain in both breasts. Sagittal T_2-weighted image shows multiple curvilinear low-signal-intensity lines within the left implant known as the linguine sign (arrows). Intracapsular rupture of the left implant was found at surgery.

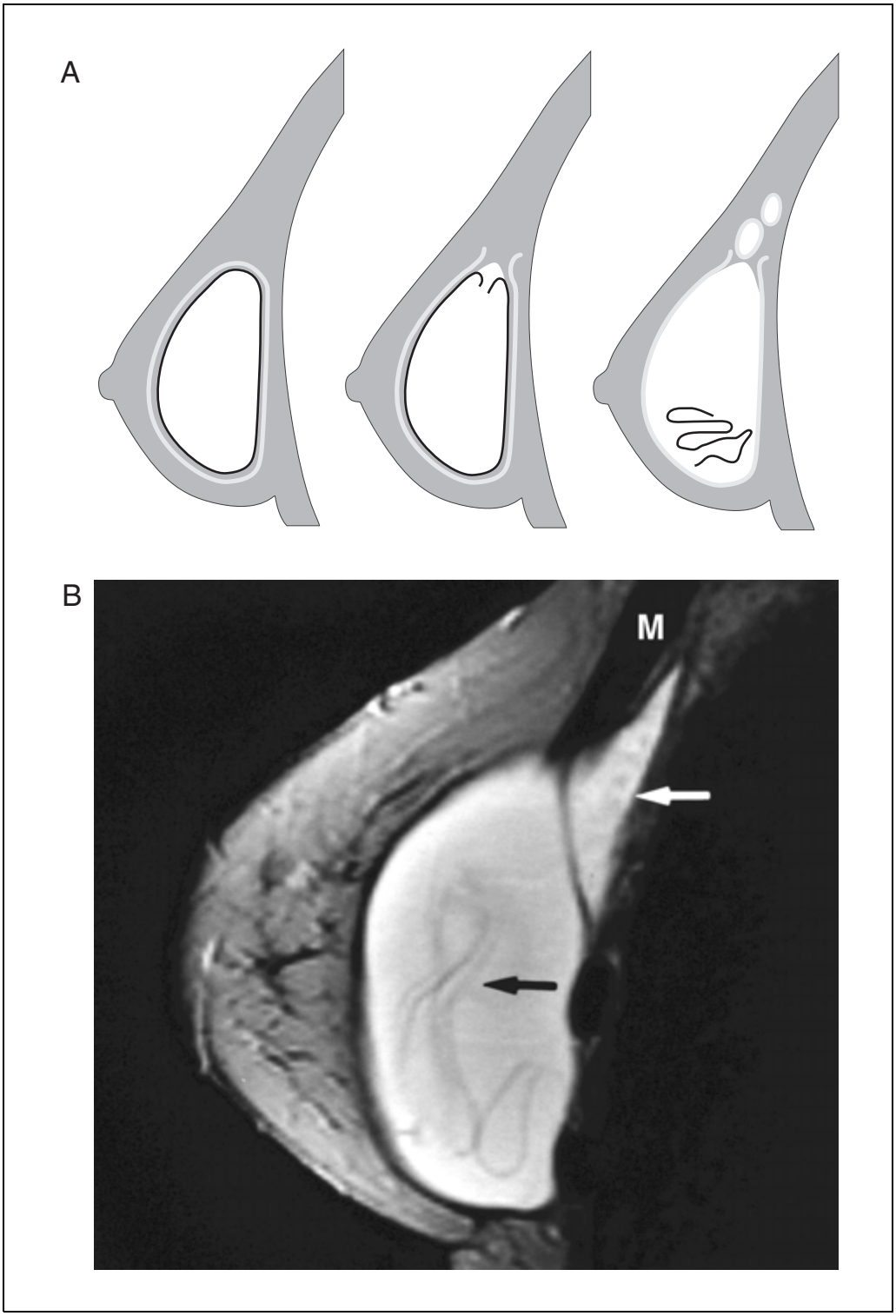

Figure A21.2.6 Extracapsular rupture. (**A**) Intact implant has uninterrupted shell and fibrous capsule (left). Disruption of shell and fibrous capsule (center) will allow silicone to extravasate into surrounding breast tissue (right). Light gray line = fibrous capsule, black line = implant shell. (**B**) Patient presented with right breast pain. The sagittal T_2-weighted image demonstrates extracapsular silicone (straight white arrow) and collapse of the silicone shell (straight black arrow), M = pectoralis muscle.

collapsed implant shell or normal radial folds. These MR sequences are optimized to evaluate silicone implants, not breast parenchymal abnormalities, therefore, concentrate on windowing on the silicone implants, not the breast tissue.

Saline implants

Radiologists new to MR imaging of silicone implants can become easily confused by saline implants if they are imaged by MRI. If a breast implant is completely dark when a water suppression sequence is performed, the implant is not a silicone implant—it is a saline implant. If the radiologist is not sure, a bag of saline can be placed in the coil and compared with the breast implant. Furthermore, saline implants do not have to be imaged by MR imaging because when saline implants rupture, the saline is absorbed by the body. Ruptured saline implants can be easily detected by mammography.

Anticipated Results

Appearance of normal implants

Several hundred different types of breast implants were commercially available over the past 40 years (Middleton and McNamara, 2000). Most silicone implants are composed of an outer silastic elastomer shell (envelope), filled with viscous silicone gel. The implants are usually oval and have a smooth or textured surface. After surgical placement, a thin fibrous capsule (scar tissue) normally forms around the prosthesis. MR imaging often shows radial folds, normal infoldings of the silastic elastomer shell (Fig. A21.2.3). These folds may appear prominent, but should not be confused with implant rupture or leak. Radial folds, even when prominent, extend to the periphery of the implant and the folds are relatively few in number.

Although hundreds of different types of silicone implants have been produced, single-lumen (Fig. A21.2.3) and double-lumen silicone implants (Fig. A21.2.4) are the most commonly encountered. A single-lumen silicone implant has an outer silastic shell containing the viscous silicone gel. A double-lumen silicone implant typically has an inner lumen that contains the thick viscous silicone gel surrounded by a smaller outer lumen that contains saline. Breast implants may be surgically placed in a subglandular location, that is, anterior to the pectoralis major muscle, or subpectoral, posterior to the pectoralis major muscle (Fig. A21.2.3 and Fig. A21.2.4).

A variety of other types of implantable prostheses are occasionally encountered, including expander implants (reverse double lumens—saline in the inner lumen, silicone in the outer lumen), multicompartmental implants, foam implants, and single lumen silicone implants with saline directly injected into the silicone at the time of surgery. Occasionally, two or even more implants are placed in one breast, a configuration commonly known as stacked implants. Some implants have a coating of polyurethane covering the surface of the silicone envelope. These implants typically have a moderate to large amount of reactive fluid surrounding the implant. The many different implantable prosthesis can be easily differentiated from direct silicone injections into the breast. Saline implants, where the lumen is filled with saline have become more popular since the FDA limited the use of silicone gel implants in 1992.

Appearance of ruptured breast implants

Implant ruptures can be divided into two major categories, intracapsular and extracapsular rupture.

Intracapsular implant rupture, the most common type of rupture, is defined as rupture of the implant shell (elastomer envelope) with silicone leakage that does not macroscopically extend beyond the fibrous capsule that commonly forms around silicone implants (Gorczyca et al., 1992). The most reliable MR criterion for intracapsular rupture is the presence

Figure A21.2.7 *(at right)* Focal rupture without complete collapse (uncollapsed implant rupture) or extensive gel bleed of implant shell. (**A**) Normal infolding of implant shell causes radial folds (left). Gel bleed is microscopic silicone leakage through an intact implant shell (center). Silicone may enter a radial fold, resulting in an inverted teardrop sign (right). A focal tear in the implant shell without complete collapse of the implant shell (uncollapsed implant rupture) can have an identical appearance. Light gray line = fibrous capsule, black line = implant shell. (**B**) Focal rupture of implant shell without complete collapse of implant shell (uncollapsed implant rutpure). Sagittal T_2-weighted FSE image shows inverted teardrop signs (straight arrow), indicating silicone within a radial fold and outside of the implant lumen itself. At surgery, a small tear within the implant shell was found. The inverted teardrop sign is not specific, this sign has been seen with both focal ruptures and extensive gel bleeds with intact implant shells.

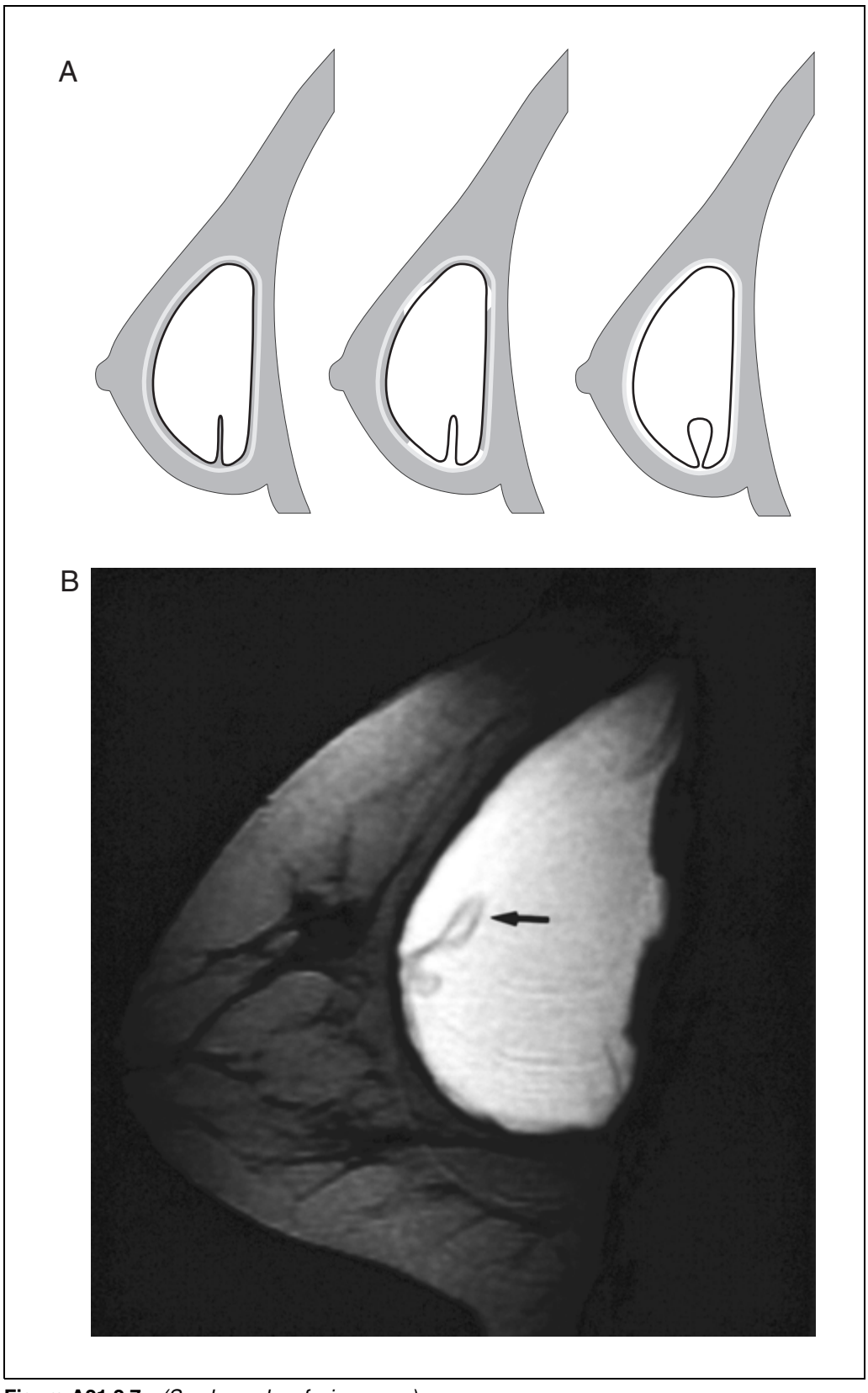

Figure A21.2.7 *(See legend on facing page.)*

of multiple curvilinear low-signal-intensity lines seen within the high-signal-intensity silicone gel, the so-called linguine sign (Fig. A21.2.5). These curvilinear lines represent the collapsed implant shell floating within the silicone gel. Rarely, intracapsular rupture will show multiple hyperintense foci on T_2-weighted images or multiple hypointense foci on water-suppression images within the implant lumen. When less than six foci of water droplets are identified within a silicone implant without other evidence of rupture, one must be careful not to definitely diagnose a ruptured implant. The authors have three cases that all showed several small water droplets within the implants (no other MR findings were noted to suggest rupture) and all proved to be intact at the time of surgery.

Extracapsular silicone implant ruptures are defined as ruptures of both the implant shell and the fibrous capsule with macroscopic silicone leakage that extends beyond the fibrous capsule into surrounding tissues. Focal areas of high signal intensity, representing free silicone, can be identified on MR images (Fig. A21.2.6). In addition to free silicone in the surrounding breast parenchyma, the linguine sign is often present with extracapsular ruptures. The multiplanar capabilities of MR imaging allow precise localization of free silicone.

Unlike ruptures, gel bleed is microscopic silicone leakage through an intact implant shell (Brody, 1977). Most if not all implants will eventually have gel bleed, however, the majority of gel bleeds cannot be detected by MR imaging. Only when gel bleed is extensive can silicone gel be detected outside the silicone shell. A focal or early intracapsular rupture can have a similar appearance to a large gel bleed and it can be difficult if not impossible to differentiate these two entities on MR images (Fig. A21.2.7).

In the authors' experience, other signs, such as focal or diffuse irregularity of the contour of the implant or reactive fluid surrounding the implant, are not reliable signs of silicone implant rupture.

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Key References

Gorczyca and Brenner, 1997. See above.

A comprehensive reference text written for the clinician and radiologist covering the history of silicone breast implants, classification, radiologic imaging, pathology, immunologic, and medical legal aspects of silicone breast implants.

Shellock and Kanal, 1996. See above.

Covers a number of important patient management issues related to MR imaging, including recommended safety procedures, a list of metallic implants that have been tested for MR compatibility, and a list of other sources on MR safety.

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