INTRODUCTION

Breast implant procedures have been performed since the late 19th century for augmentation, correction of congenital abnormalities, and post-mastectomy reconstruction. Over the years, the surgical options and types of implants available have evolved. As a result, the augmented breast can have a widely variable appearance, and the practicing radiologist must recognize the numerous variations in implant construction that are encountered clinically.

Magnetic resonance imaging is the most accurate method for evaluating breast implants and their complications due to the high sensitivity and specificity (sensitivity 89% and specificity 97%), inherent high soft tissue contrast, and lack of ionizing radiation.1-5 For these reasons, breast MRI has been increasingly used to both screen and diagnose complications in patients with implants. The usefulness of MRI derives from its ability to selectively suppress or emphasize the signal of water, fat, or especially silicone. The high spatial and soft tissue resolution makes MRI ideal for the characterization of breast implants.6

This article reviews the normal appearance, as well as early, late, and rare complications associated with different types of breast implants.

NORMAL APPEARANCE

Proper diagnosis of implant complications requires a thorough understanding of the imaging characteristics of normal implants. Single lumen silicone and saline implants, which consist of a single polymer shell filled with silicone or saline, are the most frequently used devices for breast augmentation/reconstruction. Saline implants have a valve to allow volume adjustment, which helps identify them on MRI.

The classic double lumen implant contains an outer saline shell with silicone on the inside, while reverse double lumen implants have an adjustable inner saline shell and outer silicone shell.2,4,5 MRI sequences that are selective for silicone and fluid help differentiate the implant type.

Saline implants follow fluid signal on all sequences. Silicone implants can have variable signal on T1 and T2 weighted sequences, but display high signal intensity on silicone selective sequence. Each type of silicone gel filled implant has slightly different imaging findings related to the manufacturing process and viscosity of the silicone gel.2

Implants may be placed in a prepectoral or retropectoral location. The benefits of placing implants behind the pectoralis muscle include decreased incidence of capsular contracture and improved visibility of the breast tissue on mammography.7,8 Locating the position of the muscle on MRI using the sagittal images can help differentiate the implant position (Fig. 1).

Normal implants are triangular in shape. They may have numerous and/or complex radial folds on MR imaging which should not be confused with rupture (Fig. 2). Implants placed for congenital abnormalities such as Poland syndrome or pectus deformity may have an atypical or asymmetric appearance which should not be confused with malpositioning. Clinical history can help determine whether the implant is truly malpositioned.

Breast implants are categorized into five implant generations reflecting product development over time. The recent generations of silicone gel implants have a cohesive viscous silicone gel, and as a result, these implants will rarely have a totally collapsed implant shell with rupture, differing from the older generations (Fig. 3). Most of these demonstrate gel leakage and silicone migration.2 The third and fourth implant generations offered models of breast implants with textured or uniformly smooth surfaces.

Before implant insertion, especially in oncoloplastic breast reconstruction, a tissue expander is usually placed into the mastectomy site to stretch the remaining skin in preparation for the placement of a
Figure 1. Normal Implant Appearance in Different Patients. Sagittal silicone selective image of the left breast (A) demonstrates a normal single lumen silicone implant. Note the high signal, normal triangular shape of the implant, and retropectoral position. Axial T2 weighted image of the right breast (B) shows a normal single lumen saline implant. Note the normal triangular shape and the valve (arrow) indicating it is a saline implant. Axial T1 weighted image of the left breast (C) demonstrates a normal single lumen silicone implant in the prepectoral position with pectoralis posterior to the implant. Normal radial folds are present. Axial T1 weighted image (D) demonstrates bilateral prepectoral silicone implants placed for pectus deformity. Although the right implant appears displaced medially, this was the desired position for cosmesis. Axial T1 weighted image (E) demonstrates bilateral prepectoral silicone implants placed for cosmesis in a patient with Poland syndrome. Note that absence of the right breast tissue and chest wall musculature.

Figure 2. Radial Folds. Axial T1 weighted image (A) demonstrates normal findings in a patient with a history of right breast cancer status post TRAM flap reconstruction. The patient has a left single lumen silicone implant which shows a normal radial fold. This was placed for cosmesis after right reconstruction. Axial T1 weighted image of a right double lumen implant (B) demonstrates extensive normal radial folds. The implant was intact without rupture. Note that folds may be multiple and complex.
permanent implant. The expander is placed in its collapsed form and fluid is introduced into the tissue expander to slowly inflate it. This process may continue for several weeks or months until the tissue expander is filled to an optimal volume for permanent breast implant placement. Some breast tissue expanders should be considered a contraindication to MRI because of the magnetic marker of the filling valve (Fig. 4). Expander manufacturers list possible consequences such as overheating, possible expander displacement, and possible reduction of magnetization of the marker.

**EARLY COMPLICATIONS**

Implant complications that occur in the immediate post-surgical period include the development of collections around the implant and infection.

**Peri-implant Collections.**

Small seromas or peri-implant fluid collections are considered normal and are favorable. They are felt to be reactive and related to inflammatory response to the implant. Small seromas present as T2 hyperintense fluid collections around the implant on MRI (Fig. 5a). This fluid may be beneficial as it may prevent capsular contracture and implant damage from minor trauma. Large or rapidly growing seromas, however, are problematic (Figs. 5a and b). They can be painful, cause deformity, and increase the risk of infection. Therapeutic aspiration or percutaneous drainage of fluid can be performed when large seromas become symptomatic. Older implants made of polyurethane (no longer used in the United States) can undergo chemical breakdown, inciting an inflammatory response that could lead to the development of complex seromas. However, such fluid collections are usually a late complication of breast implants.

**Infection.**

Infection is reported to be the leading cause of morbidity associated with breast implants, seen in 2.0-2.5% of patients. The majority of cases are perioperative and may be related to contamination of the skin, implant, or surgical instruments. Delayed infections are less common and are generally related to systemic infections. Symptoms of implant-associated infection include redness, swelling, discharge, fever, and pain. The presence of large peri-implant collections increases the risk for infection. MRI findings suggestive of implant infection include the presence of complex fluid collections around the implant, skin thickening, and edema. (Fig. 5c)
**DELAYED COMPLICATIONS**

Delayed complications seen in breast implants include the development of contractures, implant rupture, and gel bleed.

**Contractures.**

Capsular contractures are the most common delayed complication noted in implants. They are caused by excessive scaring around the implant, which leads to deformity and unsatisfactory cosmesis. When contractures are present, the implant can become rounded in shape, losing its normal triangular configuration on MRI. Radial folds are frequently observed in patients with capsular contracture. Occasionally, the capsule tears, allowing part of the implant to herniate into adjacent parenchyma. The capsule sometimes calcifies, and rigid calcium deposits may be palpated immediately adjacent to the implant.

**Rupture.**

Implant rupture is the most common delayed implant complication discussed in the imaging literature. It most often occurs 10-15 years after implant placement. Implant rupture can have various causes, although most ruptures have no obvious traumatic origin and sometimes occur in asymptomatic patients. The incidence of rupture increases with implant age. The average incidence is approximately two implant ruptures per 100 implant-years with an estimated probability of being intact after 5 and 10 years of implantation of 98% and 83-85% respectively.

Saline implant ruptures are readily detected clinically as the implant will significantly decrease in size with extrusion of the fluid. Rupture of silicone implants, however, can be more difficult to recognize. Clinical diagnosis is based solely on nonspecific findings such as palpable nodules, asymmetry, or tenderness. Patients usually present with pain, contour change or deformity of the implant or palpable mass. Clinical evaluation may fail to detect breast implant rupture that occurs over time without loss of breast volume and misshapeness. Breast pain on the clinical examination of implants is a strong predictor of rupture, but the absence of pain does not exclude rupture.

There are two types of silicone implant rupture. The more common intracapsular rupture occurs when there is disruption of the implant shell without

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**Figure 5. Early Implant Complications in Different Patients.** Axial T2 weighted image of bilateral reverse double lumen implants (A) displays a normal amount of fluid around the left implant and a large T2 bright seroma around the right implant in this symptomatic patient in the peri-operative period. Axial T2 weighted image (B) demonstrates bilateral single lumen silicone implants with a large right peri-implant collection, which developed acutely. Axial T1 FS post-contrast image (C) demonstrates skin thickening, edema, and capsular enhancement of the right breast, consistent with implant infection. The patient presented with acute pain and fever. Also seen is bilateral intracapsular rupture.
If rupture occurs and the implant collapses, the “linguini sign” (multiple curvilinear low signal intensity lines within the T2 bright silicone) will be evident on MRI. An earlier sign of rupture where the shell has not completely collapsed produces the “subcapsular line,” “keyhole,” “noose,” and “tear drop” signs on MRI (Fig. 6). The key to distinguishing these signs from a radial fold is identifying silicone on both sides of the implant shell. This can be challenging and multiplanar imaging is helpful, particularly using a combination of both axial and sagittal images.

Extracapsular rupture, defined as macroscopic silicone extending beyond the fibrous capsule, occurs less commonly. On MRI examination, macroscopic silicone is visualized as high signal intensity deposits (on silicone selective sequences) within the breast tissue, intramammary nodes, internal mammary nodes, and axillary nodes (Figs. 7 and 8). Gel bleed is a term referring to the microscopic leakage of silicone through an intact implant shell (Fig. 9). On MRI, gel bleed can produce subtle high signal intensity on both sides of the implant shell on silicone selective sequences.
RARE COMPLICATIONS

Rare complications of implant placement include the development of new or recurrent breast cancer and post-operative or delayed hematomas. Anaplastic large cell lymphoma is exceedingly rare, but should be considered in any patient with persistent fluid collections around the implant.

Hematoma.

Hematomas are commonly seen in the peri-operative period. They can be large, painful, and require drainage. Delayed hematomas are rare, caused by trauma, coagulopathy, capsular tear, recurrent cancer, or infection. On MRI, hematomas appear as complex fluid collections (Fig. 10).

New or Recurrent Carcinoma.

Implants do not increase the risk for breast cancer; however, they can make detection of breast cancer by mammography and US more challenging. MRI is an imaging technique to evaluate the entire breast and chest wall. MRI evaluation using dynamically enhanced T1 FS MRI sequences allow identification of suspicious enhancing masses and non-mass like enhancement (Figs. 11 and 12). These suspicious findings should be further evaluated with biopsy, as in patients without implants.

Anaplastic Large Cell Lymphoma (ALCL).

Anaplastic large cell lymphoma (Fig. 13) is a type of T-cell lymphoma (non-Hodgkin lymphoma) that is extremely rare, diagnosed in 1:500,000 women in the United States each year. Breast involvement is even more rare with a reported incidence of 3 cases per 100 million women per year in the United States. Two main types have been described: tumors expressing the protein anaplastic lymphoma kinase (ALK-positive) and tumors which do not express the protein (ALK-negative). Some associations have been reported between ALK-negative ALCL and breast implants (both silicone and saline). The FDA describes at least 60 case reports of such an association in the literature, which, although it is a low number, is higher than would be expected from existing epidemiology data.

The FDA performed a formal analysis of the published scientific literature on implant associated ALCL. In their review, the median time from implant placement to the diagnosis of ALCL was 8 years.
Summary

In conclusion, MRI is the best tool for imaging evaluation of acute and delayed breast implant complications. Normal implants are triangular in shape and may have numerous or complex radial folds, which should not be confused with implant rupture. Understanding and recognizing potential complications of breast implants and their significance helps facilitate prompt and appropriate management. The most common complications include contractures and implant rupture. Characteristic imaging findings of intracapsular implant rupture include the “linguini,” “subcapsular line,” “keyhole,” “noose,” and “tear drop” signs on MRI. Small peri-implant fluid collections are normal and may reduce trauma to the implant. Large, complex collections, on the other hand, particularly when delayed and persistent, may be representative of infectious or rarely neoplastic implant complications.

1-23 years). Most patients were diagnosed after seeking treatment for symptoms related to their implants (intractable seromas, fibrous capsule, peri-implant mass, etc.), the most common being persistent peri-implant seroma. In most cases the lymphomatous involvement was confined to the capsule. All tumors were ALK-negative.17

Current recommendations for management of patients with possible implant associated ALCL include pathologic testing of fresh seroma fluid and representative sections of the capsule, including cytologic evaluation of the fluid with Wright Giemsa stained smears and cell block immunohistochemistry testing for cluster of differentiations and the presence or absence of anaplastic lymphoma kinase (ALK positive or negative).17

Until there is more data regarding the development of ALCL in patients with implants, the FDA has requested that all confirmed cases be reported to the FDA.17
References


