Capsular contracture (CC) is one of the most common and difficult-to-treat complications of breast augmentation. It affects between 20% and 50% of all patients who undergo this procedure. While the causes of CC have yet to be definitively determined, bleeding and infection are two likely contributing factors. Current evidence suggests that infection may be a consistent culprit.

Many patients who develop CC never exhibit the classical features of foreign body–related infection, which suggests a subclinical contamination, one that may develop at any postoperative time point and may go unidentified over the long term. Foreign body seeding in the form of a biofilm is not only difficult to diagnose but may be very difficult to treat, especially with routine antibiotic prophylaxis. As with any symptomatology, prevention trumps attempts at cure, and finding the source of this contamination may provide the ultimate solution to the problem.
We hypothesized that the breast and its ducts may represent the source of bacterial contamination of foreign bodies placed around this glandular tissue. Endogenous breast bacteria and its role in CC may in part explain why patients undergoing breast reconstruction suffer higher rates of CC as these procedures represent greater manipulation of the breast tissue. We further hypothesized that bacterial concentrations are likely highest in areas with the most concentrated ductal tissue, namely sites near the nipple. Therefore, significant bacterial concentrations found in breast tissue under standard sterile surgical conditions may demonstrate that the breast is indeed an inherently contaminated surgical site.

**METHODS**

**Patients**

This study was approved by the Institutional Review Board at New York Presbyterian Hospital, Columbia University Medical Center. Healthy female patients presenting for routine reduction mammoplasty were recruited for this study. Patients with any history of breast infection, abnormal mammography, or prior breast surgery were excluded. Twenty-five patients were recruited, for a total of 50 sampled breasts.

**Sample Collection**

Per routine, patients received one dose of preoperative antibiotics consisting of 1 g of intravenous cefazolin. The skin was prepped with Betadine solution and draped in the standard surgical fashion. Intraoperative tissue samples were separately obtained for each breast during tissue excision from the three sites of interest (inframammary, axillary, and periareolar regions). Each tissue sample consisted of approximately 1 g of breast tissue. Samples were collected in sterile specimen containers and sent for routine culture and quantitative bacterial counts.

Note that, in this study, the axillary specimens were obtained through breast reduction incisions and not axillary incisions. As a result, the culture positivity rate may not reflect bacteria associated with the axillary skin and glands. However, for the purposes of obtaining endogenous breast bacteria, axillary samples are representative of the breast tissue in that area.

**Data Processing**

Tissue samples were analyzed for aerobic, anaerobic, and fungal elements. For samples with positive culture results, quantitative bacterial counts were performed and recorded as colony-forming units (CFU) per field in 1 g of breast tissue. Samples with no growth were recorded as 0 CFU per field.

**Statistical Analysis**

Kolmogorov-Smirnov criteria were used to establish the nonnormality of the data set. Statistical analysis was completed with the Wilcoxon signed-rank and McNemar tests. A nonparametric test of significance, the Wilcoxon signed-rank test, was selected because it does not presuppose regular distribution for the studied variables for paired samples. In our sample, it was used to analyze the difference in bacterial counts among the three breast regions sampled. The McNemar test, which analyzes marginal frequencies of two binary outcomes for paired samples, allowed us to test for the significance of percentage positive bacteria cultures in each group. Statistical analyses were performed with Stata/SE 11.0 (StataCorp LP, College Station, TX). All P values reported are two-tailed, and significance levels were set to .05.

**RESULTS**

**Culture Positivity and Bacterial Counts**

The bacterial culture results of 150 breast tissue samples (three per breast for 50 breasts) were obtained and analyzed. Of the 50 breasts analyzed, 19 yielded positive results from at least one site, for a positive culture rate of 38%. Quantitative bacterial counts ranged from 212 to 36,000 CFU per field (Figure 1).

The periareolar region demonstrated a mean bacterial concentration that was, on average, five times higher than that at the inframammary site. The latter site demonstrated bacterial counts that were four times higher than those in the axillary region. These values were found to be statistically significant (Wilcoxon P value < .01 between the periareolar region and either of the other two; Wilcoxon P value < .02 between the inframammary and axillary regions). Similarly, the periareolar region was more likely than the other two sites to yield positive tissue cultures, with decreasing likelihood in the inframammary and axillary regions, respectively (McNemar χ² P < .01 between periareolar and either of the other two sites, and P = .05 between the inframammary and axillary regions; Table 1).

**Bacterial Species Identified**

The most commonly isolated organisms in this study were Staphylococcus species, with S. epidermidis present in 42% of positive cultures. S. epidermidis is a nonmotile gram-positive bacterium found in normal skin flora. A facultative anaerobe, this organism can thrive under many conditions.

The second-most commonly isolated organism was Propionibacterium acnes, present in 31% of positive cultures. In contrast to S. epidermidis, this bacteria is a facultative aerobe. Also present in normal skin flora, it is most commonly found in the sebaceous glands, where it lives on fatty acids. A member of the actinobacteria group, it is most commonly treated with macrolides or fluoroquinolones rather than cephalosporins.

Of the remaining culture specimens, one yielded both S. epidermidis and Corynebacterium sp. Other cultured bacteria included Staphylococcus lugdunensis and Staphylococcus...
There were no fungal elements isolated in any of the specimens (Figure 2).

Again, note that the axillary specimens were obtained through breast reduction incisions and not axillary incisions. The examined axillary tissue was thus taken not from immediately below the axillary skin and associated glands but from the axillary tail of the breast. As a result, culture positivity rates may be artificially low with regard to our bacterial counts. A future study examining fat harvested just below the axillary skin would thus be helpful.

**DISCUSSION**

While most surgeons will agree that the breast likely harbors significant endogenous bacteria, few practitioners address this issue when performing routine breast surgery. There is, to date, minimal published data on the nature of this bacteria and none regarding its distribution within the breast tissue itself. Culture results from infected breast abscesses or capsule specimens reveal different species of bacterial contamination, ranging from common skin flora to atypical Mycobacteria, but the most common culprit by far is *S. epidermidis*. In the setting of *S. epidermidis* contamination, foreign body seeding remains a difficult problem to prevent as well as treat. Surface proteins allow this bacterium to bind to foreign bodies. Once established, the resultant biofilm allows for the binding of other species of bacteria, as well as a decrease in metabolism that contributes to antibiotic resistance.

While there are few established criteria for predicting postoperative breast infections, certain risk factors have been associated with higher incidences of breast abscess formation. Obesity, race, and tobacco use have been implicated in certain breast infections, as have prior radiation and extensive lymph node dissection. Studies on the vulnerability of tissue expanders suggest that while the membrane is not permeable to bacteria, the port site is, which may contribute to an increase in bacterial contamination for breast reconstruction patients. Recurrent breast abscesses are also more likely to harbor gram-negative bacteria as opposed to normal skin flora, and these organisms are generally resistant to routine cefazolin antibiosis.

Routine perioperative antibiotics administered as single-dose, single-agent pharmacologic regimens have not been shown to be effective for preventing the development of biofilms on prosthetic materials. In fact, this type of seeding often requires a 1000-fold increase in medication potency for effective treatment, and routine antibiotics are largely ineffective. Once established, these bacterial coatings become effectively embedded on the implant itself, as opposed to the capsule. As a result, tissue cultures from capsulectomy specimens may remain negative.

| Table 1. Mean Bacterial Counts and Percentage of Positive Cultures per Sampled Site |
|---------------------------------|-----------------|-----------------|-----------------|-----------------|
|                                 | Axillary        | Inframammary   | Periareolar     | Overall         |
| Mean bacterial count, CFU/field | 69              | 272            | 1238            | 401             |
| Specimens with positive cultures, % | 10              | 22             | 38              | 23              |

*aThe difference among the three groups was statistically significant, *P* < .01.*
even in the presence of a significant subclinical infection of the foreign body. With such a strong, constant, and elusive bacterial presence on the implant itself, patients are likely to endure long-term consequences of chronic inflammation.

Given that the management of a seeded implant is exponentially more difficult than the management of a routine postoperative infection, prevention is paramount. Many techniques have been suggested for short- and long-term decontamination of the breast pocket, including postoperative antibiotics administered for several days, redraping of the surgical field, and Betadine irrigation. Antimicrobial implant coatings and antibiotic-filled prostheses have also been attempted in the hopes of providing a continuous drug delivery system. None of these methods have proven to significantly affect the rate of CC nor that of postoperative breast infections.

The only intervention to date that seems to decrease the risk of CC is the use of triple-antibiotic irrigation for the breast pocket. These data suggest that infection is the main culprit in this process and that the contamination is polymicrobial—or at least consists of a species that requires double coverage. This finding is consistent with studies of *S. epidermidis*, a common skin flora that cannot be effectively eradicated with a single pharmacologic agent. In their report, Adams et al noted that even with said irrigation, patients undergoing manipulation of the breast tissue itself (as in mastopexy) were still more likely to suffer CC. This finding further supports our hypothesis that CC caused by infection in the breast implant pocket is likely due to bacteria present in the glandular tissue itself. Once violated, the ducts spill their contents into the field, rendering a contaminated surgical site.

The question then remains about how to prevent breast implant seeding. Patients undergoing procedures in known contaminated fields are more likely to be given broad-spectrum antibiotics, and foreign materials are less likely to be placed under such circumstances. We argue that this issue becomes most relevant when the breast tissue itself is manipulated during the procedure or when incisions are made near the nipple. Nipple shields have been applied to protect the field from contamination with ductal bacteria, but we suggest a more aggressive approach. For patients who are undergoing placement of a foreign body in the breast—and especially for those in whom a periareolar incision is planned—broader-spectrum antibiosis should be considered, along with triple-antibiotic irrigation of the implant pocket. Obtaining routine cultures of the glandular tissue nearest to the prosthetic device may also be considered. For patients with a history of breast infection, gram-negative coverage should be routinely included.

Today, most surgeons would categorize breast surgery as “clean” when asked or when documenting their cases. However, 80% of breast and plastic surgeons routinely prescribe perioperative antibiotics in the management of their surgical patients. Perhaps protocol should more accurately reflect what experience has already demonstrated: The breast is not a clean surgical site.

**CONCLUSIONS**

The breast harbors significant concentrations of endogenous bacteria. Even under sterile operating conditions, this bacteria remains a concerning presence, one that may translate into the contamination of a foreign body placed around the breast. Routine preoperative antibiotic prophylaxis is likely inadequate to prevent the formation of biofilms on breast implants, and typical treatment regimens for identified infections are likely to be ineffective. Furthermore, as bacterial concentrations are highest near the nipple, breast implants placed through a periareolar incision may be more susceptible to this contamination and to subsequent infection-related complications.

**Disclosures**

The authors declared no potential conflicts of interest with respect to the research, authorship, and publication of this article.
**Funding**

The authors received a research grant from the Department of General Surgery at Columbia University Medical Center for the processing of the samples.

**REFERENCES**