Preoperative Skin Cultures Predict Periprosthetic Infections in Revised Shoulder Arthroplasties

A Preliminary Report

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Background: Current approaches do not provide a practical method for the accurate prediction of a Cutibacterium periprosthetic joint infection (PJI) in failed arthroplasties. Thus, surgeons revising failed arthroplasties must decide whether to exchange the implants and to institute antibiotic treatment without knowing the results of cultures of deep specimens obtained at the revision procedure. This study tests the hypothesis that the results of preoperative culture specimens of the skin surface obtained in the clinic can predict the presence of culture-positive Cutibacterium PJIs.

Methods: Revision shoulder arthroplasties performed between October 3, 2017, and February 4, 2020, that had both preoperative clinic culture specimens and surgical culture specimens were included in this analysis. Culture results were assigned a value from 0 to 4. The percentage of the total skin bacterial load contributed by Cutibacterium (Cutibacterium percentage) was determined. To reduce concern about contamination, a robust criterion for culture-positive Cutibacterium PJI was applied: ≥2 surgical specimens with a Cutibacterium value of ≥1. The predictive values for a culture-positive Cutibacterium PJI were determined for a clinic skin culture Cutibacterium value of >1 and a clinic skin percentage of Cutibacterium of ≥75%.

Results: Eighteen cases met the inclusion criteria; of these, 7 (6 male patients) met our criterion for a culture-positive Cutibacterium PJI. For all patients, a preoperative clinic skin Cutibacterium value of >1 predicted the presence of a culture-positive Cutibacterium PJI with an accuracy of 89%, and a clinic skin Cutibacterium percentage of ≥75% predicted the presence of a culture-positive Cutibacterium PJI with an accuracy of 94%. For male patients, a preoperative clinic skin Cutibacterium value of >1 predicted the presence of a culture-positive Cutibacterium PJI with an accuracy of 91%, and a clinic skin Cutibacterium percentage of ≥75% predicted the presence of a culture-positive Cutibacterium PJI with an accuracy of 100%.

Conclusions: A simple culture specimen of the unprepared skin surface obtained in a clinic prior to revision shoulder arthroplasty may provide valuable assistance to surgeons planning a revision arthroplasty.

Level of Evidence: Prognostic Level IV. See Instructions for Authors for a complete description of levels of evidence.

One of the most important decisions that a surgeon must make when revising a failed shoulder arthroplasty is whether to treat the shoulder as if it is infected, recognizing that the culture results of intraoperative specimens will not be available until weeks after the revision procedure. Because the optimal treatment of a shoulder periprosthetic joint infection (PJI) is prosthesis exchange and postoperative antibiotics, the decision to treat for infection must be made at the time of the surgical procedure.

This decision is complicated by the fact that no preoperative tests or intraoperative findings have been established to reliably distinguish a benign shoulder from one with a culture-positive PJI from the most common causative organism, Cutibacterium. Although blood tests, fluid aspirates, intraoperative Gram stains, and histology may be useful for detecting other organisms, these tests lack the sensitivity and specificity necessary to accurately predict the presence of Cutibacterium in a failed shoulder arthroplasty; in part, this is because the...
human host usually does not mount a typical inflammatory response against this commensal organism. The results of cultures for Cutibacterium and other bacteria can be expressed in a semiquantitative way, reflecting the load of the bacteria in the specimen, rather than simply as the presence or absence of the bacteria. Using this approach, it has been shown that the load of Cutibacterium on the skin of the shoulder is strongly influenced by the patient’s age, sex, and health. The semiquantitative results of culture specimens for Cutibacterium taken of the unprepared skin surface in the operating room immediately prior to a primary shoulder arthroplasty have been correlated with the load of this organism in the dermis freshly incised at the surgical procedure. Other studies have shown that the semiquantitative Cutibacterium culture results of skin surface specimens obtained in the operating room prior to a revision shoulder arthroplasty correlated with the load of Cutibacterium in deep tissue and prosthesis explant specimens harvested at the time of the revision arthroplasty. However, to our knowledge, there have been no published studies examining the utility of preoperative skin culture specimens obtained in the clinic prior to revision shoulder arthroplasty in predicting the presence of a culture-positive Cutibacterium PJI. Furthermore, although research has shown that the microbiome of the skin over the normal shoulder is diverse, it is not known whether this diversity is disrupted in patients with periprosthetic Cutibacterium infection.

This study tested the hypothesis that the semiquantitative results of skin surface culture specimens obtained in the clinic prior to revision shoulder arthroplasty can accurately predict the presence or absence of a culture-positive periprosthetic Cutibacterium infection. A second hypothesis was that the normal diversity of the shoulder skin’s microbiome can be distorted by an overabundance of Cutibacterium and that the degree of this dysbiosis is also predictive of a culture-positive Cutibacterium PJI.

**Materials and Methods**

From a longitudinally maintained institutional shoulder arthroplasty database, all patients were retrospectively identified who had an open revision shoulder arthroplasty performed by 1 of 2 surgeons at our center between October 3, 2017, and February 4, 2020, and met the inclusion criteria of having a complete set of demographic data, index shoulder diagnosis, index procedure type, and culture specimens of the skin surface obtained in the clinic prior to the revision arthroplasty as well as having the results of intraoperative tissue and explant cultures. Patients who were taking antibiotics within 3 months of the surgical procedure and patients who were not fluent in English were excluded. This study was approved by our Human Subjects Review Committee (STUDY00007300, CR00002924).

For each patient, the results of 3 sets of cutaneous culture specimens were recorded: (1) that of the unprepared skin surface over the area of the skin incision obtained in the outpatient clinic prior to the day of the surgical procedure, (2) that of the unprepared skin surface over the area of the skin incision obtained in the operating room after home showers with chlorhexidine but before skin preparation and administration of intravenous antibiotics, and (3) that of the freshly incised dermis obtained immediately after skin incision (after skin preparation and antibiotic administration). All cutaneous culture specimens were obtained using a swab (ESwab 480C; COPAN Diagnostics) passed twice along the length of the incision. At the surgical revision, a median of 5 samples (mean [standard deviation], 4.5 ± 1.5 samples [range, 2 to 7 samples]) from deep tissues and prosthetic explants were submitted for culture. Samples typically included the capsule, the collar membrane (the membrane between the modular humeral head and the humeral body), the humeral canal membrane, the explanted humeral head, the explanted body, and the explanted glenoid (if present).

All culture specimens were processed by the same laboratory using broth as well as aerobic and anaerobic media with a 3-week observation period, based on a previously published evidence-based study. Culture results for each specimen were given a value based on the laboratory report: 0 for no growth, 0.1 for growth in broth only or for 1 colony only on a plate, 1 for 1+ growth, 2 for 2+ growth, 3 for 3+ growth, and 4 for 4+ growth on a plate, where the values from 1 to 4 indicate the number of quadrants on the streaked plate showing growth. Specimen values were assigned separately for Cutibacterium, for coagulase-negative Staphylococcus, and for other bacterial types. A prior study using this same culturing protocol found that none of the 50 control cultures were substantially positive (specimen Cutibacterium values of ≥1).

For each of the specimens, the percentage of the total bacterial load contributed by Cutibacterium was calculated by dividing the Cutibacterium specimen value by the sum of the Cutibacterium specimen value, the coagulase-negative Staphylococcus specimen value, and the other bacteria specimen value ([specimen value for Cutibacterium x 100%]/[specimen value for Cutibacterium + specimen value for coagulase-negative Staphylococcus + specimen value for other bacteria]). For shoulder skin culture specimens obtained prior to primary shoulder arthroplasty, the mean percentage of Cutibacterium has been reported to be <50%; thus, in the current study, a Cutibacterium percentage of ≥75% was used as a threshold indicating a large preponderance of Cutibacterium relative to other bacteria on the skin.

For each revision, the sum of all of the specimen values, a Shoulder Score, was calculated for each organism (Shoulder Score for Cutibacterium, Shoulder Score for coagulase-negative Staphylococcus, and Shoulder Score for other bacteria). To reduce concern about contamination and false-positive results, a robust criterion for culture-positive Cutibacterium PJI was applied: ≥2 surgical specimens with a Cutibacterium value of ≥1, yielding a Shoulder Score for Cutibacterium ≥2. For each revised shoulder, the mean Shoulder Scores for Cutibacterium, coagulase-negative Staphylococcus, and other bacteria were calculated by dividing the respective Shoulder Scores by the number of specimens submitted.
The possibility of culture-negative infections was not considered in this study.

The characteristics of the patients who underwent a revised shoulder arthroplasty and who did or did not have a culture-positive *Cutibacterium* PJI were compared, including patient sex and age at the time of the index arthroplasty; race; marital status; diabetes; type of insurance; body mass index (BMI); American Society of Anesthesiologists (ASA) class; use of tobacco, narcotics, or alcohol; diagnosis; surgical procedure on the shoulder prior to the index arthroplasty; type of index arthroplasty; time from the index arthroplasty to open revision; and the results of preoperative and perioperative cultures.

For these comparisons, an unpaired t test (Microsoft Excel) was used for continuous variables and the Mann-Whitney U test\(^1\), for semiquantitative culture results.

To test the first hypothesis, we assessed the sensitivity, specificity, positive predictive value, negative predictive value, and accuracy of a clinic skin *Cutibacterium* value of >1 for a culture-positive *Cutibacterium* PJI\(^2\). To test the second hypothesis, we assessed the sensitivity, specificity, positive predictive value, negative predictive value, and accuracy of a percentage of the total clinic skin culture specimen bacterial load contributed by *Cutibacterium* (*Cutibacterium* percentage) of ≥75% for a culture-positive *Cutibacterium* PJI.

We performed this analysis for all patients and for male patients only.

**Results**

Eighteen cases met the inclusion criteria; of these, 7 (6 male patients) met the criterion for a culture-positive *Cutibacterium* PJI. Of the 11 male patients who underwent revision arthroplasty, 6 met the criterion for a *Cutibacterium* PJI (Shoulder Scores for *Cutibacterium* of 10.1, 6.3, 4.1, 4.1, 2.4, and 2.1). Of the 7 female patients, only 1 met the criterion (Shoulder Score for *Cutibacterium* of 2). The first hypothesis was that the results of skin surface culture specimens obtained in the clinic prior to a revision shoulder arthroplasty are a valuable predictor of the presence or absence of a culture-positive *Cutibacterium* PJI; this hypothesis was supported by this study. The clinic skin *Cutibacterium* value was >6 times greater for the *Cutibacterium* PJI group (2.6 ± 1.7) than for the no-PJI group (0.4 ± 0.5) (p = 0.002) (Fig. 1, Table I). For all patients, a preoperative clinic skin *Cutibacterium* value of >1 predicted the presence of a culture-positive *Cutibacterium* PJI with an accuracy of 89%; for male patients only, the accuracy was 91% (Table II).

The second hypothesis was that a greater preponderance of *Cutibacterium* is predictive of the presence of a culture-
## TABLE I Characteristics of Patients without and with a Culture-Positive Cutibacterium PJI

|                                | No PJI (N = 11) | Cutibacterium PJI (N = 7) | P Value |
|--------------------------------|-----------------|---------------------------|---------|
| No of male patients            | 5               | 6                         | 0.151   |
| Age* † (yr)                    | 51 ± 15 (23 to 73) | 48 ± 15 (27 to 63)       | 0.638   |
| BMI* † (kg/m²)                 | 33 ± 7 (23 to 42) | 26 ± 4 (22 to 31)        | 0.009   |
| ASA class* †                   | 2.5 ± 0.7 (1 to 3) | 1.7 ± 0.5 (1 to 2)       | 0.017   |
| Time from index to revision* † (yr) | 1.9 ± 1.7 (0.2 to 5.5) | 1.7 ± 0.6 (0.9 to 2.3)   | 0.697   |
| Time from clinic culture to revision* † (days) | 19 ± 19 (1 to 62) | 33 ± 42 (1 to 97)       | 0.420   |
| Diagnosis for index procedure  |                 |                           | <0.001  |
| Primary osteoarthritis         | 10%             | 72%                       |         |
| Cuff tear arthropathy          | 18%             |                           |         |
| Secondary arthritis            | 18%             |                           |         |
| Capsulorrhaphy arthropathy     | 27%             | 14%                       |         |
| Osteonecrosis                  | 9%              |                           |         |
| Other                          | 18%             | 14%                       |         |
| Index procedure                |                 |                           | 0.308   |
| Total shoulder arthroplasty    | 9%              | 14%                       |         |
| Ream-and-run arthroplasty      | 27%             | 72%                       |         |
| Hemiarthroplast                 | 37%             | 14%                       |         |
| Reverse arthroplasty           |                 |                           |         |
| Clinic skin surface culture* ‡ | Specimen Cutibacterium value | 0.4 ± 0.5 (0.0 to 1.0) | 2.6 ± 1.7 (1.0 to 6.0) | 0.002 |
| Specimen coagulase-negative Staphylococcus value | 0.2 ± 0.4 (0.0 to 1.0) | 0.2 ± 0.4 (0.0 to 1.0) | 0.617 |
| Specimen other bacteria value  | 0.9 ± 0.5 (0.0 to 2.0) | 0.5 ± 0.8 (0.0 to 2.0)  | 0.124   |
| Operating room skin surface culture* ‡ | Specimen Cutibacterium value | 0.4 ± 0.7 (0.0 to 2.0) | 2.7 ± 2.2 (0.1 to 7.0) | 0.004 |
| Specimen coagulase-negative Staphylococcus value | 0.2 ± 0.4 (0.0 to 1.0) | 0.2 ± 0.4 (0.0 to 1.0) | 0.818 |
| Specimen other bacteria value  | 0.8 ± 1.5 (0.0 to 5.0) | 0.5 ± 0.5 (0.0 to 1.0)  | 0.928   |
| Operating room skin dermal culture | Specimen Cutibacterium value | 0.2 ± 0.6 (0.0 to 2.0) | 1.7 ± 1.7 (0.0 to 5.0) | 0.038 |
| Specimen coagulase-negative Staphylococcus value | 0.0 ± 0.0 (0.0 to 0.0) | 0.0 ± 0.0 (0.0 to 0.1) | 0.653 |
| Specimen other bacteria value  | 0.0 ± 0.0 (0.0 to 0.1) | 0.0 ± 0.0 (0.0 to 0.0)  | 0.787   |
| Type of revision* ‡            |                 |                           | 0.007   |
| Complete prosthesis exchange   | 37%             | 86%                       |         |
| Head exchange only             | 18%             | 14%                       |         |
| Revision reverse arthroplasty  | 18%             |                           |         |
| Hemiarthroplasty to total shoulder arthroplasty | 9% | | |
| Spacer                         | 9%              |                           |         |
| Explantation                   |                 |                           |         |
| Sum of values of deep cultures from surgery* ‡ | Shoulder Score for Cutibacterium (points) | 0.1 ± 0.4 (0.0 to 1.2) | 4.4 ± 2.9 (2.0 to 10.1) | 0.001 |
| Average Shoulder Score for Cutibacterium§ (points) | 0.0 ± 0.1 (0.0 to 0.2) | 0.8 ± 0.4 (0.3 to 1.7) | 0.001 |
| Shoulder Score for coagulase-negative Staphylococcus (points) | 0.2 ± 0.6 (0.2 to 2.0) | 0.0 ± 0.0 (0.0 to 0.1) | 0.818 |
| Average Shoulder Score for coagulase-negative Staphylococcus§ (points) | 0.1 ± 0.2 (0.0 to 0.7) | 0.0 ± 0.0 (0.0 to 0.0) | 0.787 |
| Shoulder Score for other bacteria (points) | 0.5 ± 0.7 (0.0 to 2.0) | 0.3 ± 0.5 (0.0 to 1.0) | 0.889 |
| Average Shoulder Score for other bacteria§ (points) | 0.1 ± 0.2 (0.0 to 0.7) | 0.1 ± 0.1 (0.0 to 0.3) | 0.719 |

*The values are given as the mean and the standard deviation, with the range in parentheses. †Student t test. ‡Mann-Whitney U test. §The score was divided by the number of samples submitted for culture.
positive Cutibacterium PJI; this hypothesis was also supported. The mean clinic skin percentage of Cutibacterium for the Cutibacterium PJI group was 81% ± 16% (range, 50% to 97%), 5 times higher than the percentage of Cutibacterium for the no-PJI group, 16% ± 20% (range, 0% to 50%) (p < 0.001). Six (86%) of the 7 cases of Cutibacterium PJI had a Cutibacterium percentage of ≥75%, and none (0%) of the 11 no-PJI cases had a Cutibacterium percentage of ≥75% (Fisher exact test; p < 0.001). For all patients, a Cutibacterium percentage of ≥75% predicted the presence of a culture-positive Cutibacterium PJI with an accuracy of 94%; for male patients only, the accuracy was 100% (Table II).

In this series of revised shoulders, there were no culture-positive PJIs by organisms other than Cutibacterium; in other words, no patient had ≥2 culture specimens from the revision surgical procedure with a specimen non-Cutibacterium bacteria value of ≥1.

The Shoulder Score for Cutibacterium was >40 times greater for the Cutibacterium PJI group (4.4 ± 2.9) than for the no-PJI group (0.1 ± 0.4) (p = 0.001) (Fig. 2, Table I). The mean

### Table II: Prediction of a Culture-Positive Cutibacterium PJI*

| Clinic Skin Cutibacterium Value >1 | Cutibacterium Percentage ≥75% |
|-----------------------------------|-------------------------------|
| Sensitivity 71% (29% to 96%)       | 86% (42% to 100%)              |
| Specificity 100% (72% to 100%)    | 100% (72% to 100%)             |
| Positive predictive value 100%    | 100%                           |
| Negative predictive value 85% (63% to 95%) | 92% (64% to 99%)            |
| Accuracy 89% (65% to 99%)         | 94% (73% to 100%)              |

For male patients only

| Sensitivity 83% (36% to 100%)       | 100% (54% to 100%)              |
| Specificity 100% (48% to 100%)     | 100% (48% to 100%)              |
| Positive predictive value 100%     | 100%                            |
| Negative predictive value 83% (46% to 97%) | 100%                           |
| Accuracy 91% (59% to 100%)         | 100% (72% to 100%)              |

*The values are given as the percentage, with or without the 95% confidence interval in parentheses.

![Fig. 2](https://example.com/figure2.jpg)

The results of intraoperative cultures are shown as the Shoulder Scores for Cutibacterium, coagulase-negative Staphylococcus (CoNS), and other bacteria, comparing shoulders with (PJI) and without (no PJI) a Cutibacterium PJI. The percentage of the total bacterial load contributed by Cutibacterium is shown by the numbers above the Cutibacterium columns. These percentages demonstrate the dysbiosis of the deep tissues in shoulders with Cutibacterium PJI.
Shoulder Score for Cutibacterium was significantly greater (p = 0.001) for the Cutibacterium PJI group (0.8 ± 4.4) than for the no-PJI group (0.0 ± 0.1). The Shoulder Scores for coagulase-negative Staphylococcus and other bacteria were similar between the Cutibacterium PJI and no-PJI groups.

The Cutibacterium PJI group had a higher percentage of male patients, lower BMI, lower ASA score, higher rate of primary arthritis as the indication for the index arthroplasty, and higher rate of the ream-and-run procedure in contrast to primary arthritis as the indication for the index arthroplasty, male patients, lower BMI, lower ASA score, higher rate of the index arthroplasty were not significantly different between the Cutibacterium PJI group and the no-PJI group.

**Discussion**

To our knowledge, this study is the first to demonstrate the high percentage of Cutibacterium in the skin culture sample were predictive of a culture-positive Cutibacterium PJI. Obtaining a skin culture is a noninvasive and relatively inexpensive test that can be conveniently done in the clinic before the surgical procedure so that the results will be known before the date of revision arthroplasty. These results can be used in combination with other patient characteristics to plan the revision procedure, including the need for prosthesis exchange and postoperative antibiotics.

Figures 3-A and 3-B show a case demonstrating the utility of preoperative skin culture specimens obtained in the clinic in predicting the presence of a culture-positive Cutibacterium PJI at the surgical revision of a shoulder without other clinical manifestations of infection.

In Table IV, the results for male and female patients are compared with those in a prior study of patients having skin swabs submitted for culture prior to elective primary shoulder arthroplasty. It is of interest that, for both male and female patients undergoing primary arthroplasty, the mean values for the skin specimen Cutibacterium value and the Cutibacterium percentage lie between the corresponding values for the patients with Cutibacterium PJI and those with no PJI in the current study.

As recently emphasized by Ricchetti et al., periprosthetic shoulder infections differ from those of the knee and hip because of the indolent nature of the common infecting organism, Cutibacterium. As a result, the guidelines for the diagnosis and treatment of these PJIs are different from those for the joints of the lower extremity. Traditionally used preoperative diagnostic laboratory values, such as erythrocyte sedimentation rate,
A 60-year-old man presented with increasing shoulder pain and stiffness of insidious onset at 2 years after a short-stemmed total shoulder arthroplasty performed at an outside hospital. He was a nonsmoker in good health with a BMI of 28 kg/m$^2$ and ASA class of 2. He had no systemic signs or laboratory evidence of infection. Fig. 3-A His pre-revision radiograph suggested humeral component loosening. A preoperative clinic swab of his unprepared skin over the shoulder incision area grew 3 Cutibacterium, 1 coagulase-negative Staphylococcus, and no other organisms, for a Cutibacterium percentage of 75%. At the time of the surgical procedure, there was no synovitis, no free joint fluid, and a loose humeral component. Frozen sections of the periprosthetic tissue showed no neutrophils and no organisms. Fig. 3-B In view of the results of his clinic cultures, but in the absence of clinical signs of infection, he had a single-stage revision of the total shoulder arthroplasty to a ream-and-run arthroplasty with impaction allografting of a standard smooth stem inserted after thorough debridement and irrigation. Immediately after the surgical procedure, he was administered intravenous ceftriaxone through a peripherally inserted central catheter. When his intraoperative cultures were finalized at 3 weeks after the surgical procedure, they showed 3+ growth from the explanted stem, 2+ growth from the humeral-head component, 1+ growth from the glenoid component, and 0.1+ growth from each of the humeral periosteum, the collar membrane, and the humeral membrane, for a Shoulder Score for Cutibacterium of 6.3 points and a mean Shoulder Score for Cutibacterium of 1.1 points. No other types of bacteria were recovered from his surgical specimens. At the last follow-up, the patient had discontinued antibiotics and was continuing to regain comfort and function after the revision.

|       | Skin Specimen | Cutibacterium Value | Cutibacterium Percentage |       | Skin Specimen | Cutibacterium Value | Cutibacterium Percentage |
|-------|----------------|---------------------|--------------------------|-------|----------------|---------------------|--------------------------|
|       | Cutibacterium PJI | 2.8 ± 1.7           | 86% ± 10%                |       | 1              |                      | 50%                      |
|       | No PJI          | 0.6 ± 0.5           | 25% ± 20%                |       | 0.2 ± 0.4      | 10% ± 19%            |                          |

*The values are given as the mean and the standard deviation.
C-reactive protein level, and serum interleukin-6, may not be elevated in cases of Cutibacterium PJI. Consequently, the diagnosis and the surgical and antibiotic treatments have been based largely on clinical suspicion, patient characteristics, and intraoperative findings. Although newer testing procedures, such as synovial fluid analysis, lowered thresholds for frozen-section analysis, culturing of bacterial variants, polymerase chain reaction (PCR) analysis, and use of implant sonication may hold the potential for increasing accuracy and sensitivity in the diagnosis of indolent infections, the predictive value of these tools has yet to be demonstrated for the detection of Cutibacterium PJI. Recent publications have pointed to the use of serum interleukin-6, synovial fluid alpha-defensin\(^\text{36}\), synovial fluid interleukin-6\(^\text{44}\), combined synovial fluid cytokine analysis\(^\text{14}\), and the synovial alpha-defensin lateral flow test\(^\text{13}\) in the diagnosis of PJIs; however, these studies have not specifically evaluated the value of these tests in predicting culture-positive Cutibacterium PJI. The culturing of arthroscopically obtained tissue samples has been shown to have predictive value for Cutibacterium PJI\(^\text{14,32-34}\), but this test is substantially more invasive and expensive than a skin specimen for culture obtained in the clinic. Further studies are needed to evaluate the relative value of different modalities in predicting the presence of a culture-positive Cutibacterium PJI.

The results of our study need to be viewed in light of certain limitations. First, in this preliminary report, the sample size was small. As such, there were differences between the cohorts that might have been significant with a larger sample size. Second, patients with and without culture-positive Cutibacterium PJIs differ in characteristics other than the results of clinic skin cultures; these characteristics may also be of use in predicting the presence of a culture-positive Cutibacterium PJI. Third, we did not compare the value of preoperative clinic cultures with other preoperative and intraoperative methods for predicting the presence of a Cutibacterium PJI. Fourth, although our protocol is to obtain preoperative clinic culture specimens on all revision arthroplasties, this was not always possible during the time of this preliminary study. Fifth, the cases represented the practice at 1 center; therefore, the selection of patients for revision arthroplasty and the culturing protocols may not have been representative of those used in other practices. Sixth, it was possible that culture-negative infections were missed in our study. As emphasized by Palan et al.\(^\text{21}\), fungi and mycobacteria may be responsible for 7% to 15% of culture-negative shoulder PJIs. The criteria for establishing this diagnosis remains undefined. Seventh, in their 2019 report on the Proceedings from the 2018 International Consensus Meeting on Orthopedic Infections: Evaluation of Periprosthetic Shoulder Infection, Garrigues et al.\(^\text{41}\) pointed to “the current lack of a uniform definition of PJI specific to shoulder arthroplasty” and particularly the difficulty in defining a Cutibacterium PJI. This report pointed out that, although Cutibacterium may be less virulent than some other organisms, it is widely recognized as a definite pathogen. A robust criterion for culture-positive Cutibacterium PJI was applied; ≥2 surgical specimens with a Cutibacterium value of ≥1. This criterion may be stricter than that used in other centers.

In conclusion, in spite of its small sample size, this study demonstrates that the results of cultures of preoperative skin swabs obtained in the clinic are highly correlated with the presence or absence of a culture-positive Cutibacterium PJI in revised shoulder arthroplasties. Both the absolute value of the Cutibacterium load and the percentage of the total bacterial load contributed by Cutibacterium were highly predictive of the presence of a culture-positive Cutibacterium PJI. We conclude that a simple culture specimen of the unprepared skin surface obtained in the clinic prior to a revision shoulder arthroplasty may provide valuable assistance to surgeons planning a revision arthroplasty with respect to the need for prosthesis exchange and postoperative antibiotics.

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