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ORIGINAL ARTICLE

Performance of implant sonication culture for the diagnosis of periprosthetic shoulder infection

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Background: Diagnosing infection after shoulder arthroplasty can be a challenge because of the high prevalence of low-virulence organisms, such as *Propionibacterium acnes*. The purpose of this study was to evaluate the utility of implant sonication fluid cultures in the diagnosis of periprosthetic joint infection compared with standard culture techniques in patients undergoing revision shoulder arthroplasty.

Methods: Routine perioperative testing was performed in 53 patients who underwent revision shoulder arthroplasty. In addition to routine tissue and fluid culture, the retrieved shoulder implants underwent sonication with culture of the sonicate fluid. Diagnostic performance of implant sonication culture was determined on the basis of previously defined infection criteria and compared with standard intraoperative cultures.

Results: Of the 53 revision cases that underwent implant sonication fluid culture, 25 (47%) were classified as infected. Intraoperative culture (tissue and fluid) sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and accuracy were 96%, 75%, 77%, 95%, and 85%, respectively. Using a cutoff of >20 colony-forming units per milliliter to exclude contaminants, the sensitivity, specificity, PPV, NPV, and accuracy of implant sonicate culture were 56% ($P < .001$, compared with standard intraoperative cultures), 93% ($P = .07$), 88% ($P = .4$), 70% ($P = .02$), and 75% ($P = .22$), respectively. Without use of a sonication fluid culture cutoff value, the sensitivity, specificity, PPV, NPV, and accuracy of implant sonicate culture were 96% ($P = 1.0$, compared with standard intraoperative cultures), 64% ($P = .38$), 71% ($P = .53$), 95% ($P = .9$), and 79% ($P = .45$).

Conclusions: Implant sonication fluid culture in revision shoulder arthroplasty showed no significant benefits over standard intraoperative cultures in diagnostic utility for periprosthetic joint infection.

Level of evidence: Level III; Diagnostic Study

Keywords: Total shoulder arthroplasty; periprosthetic infection; sonication; cultures; tissue cultures; *Propionibacterium acnes*

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The incidence of infection after primary arthroplasty varies between 0.4% and 4.0%.[1,4,11,28] For revision arthroplasty, the incidence is higher, reported up to 15%.[4] Shoulder periprosthetic joint infection (PJI) can be both a diagnostic and therapeutic challenge that requires unique medical and surgical management compared with other joint infections. There is evidence that the missed diagnosis of PJI is higher for revision shoulder arthroplasty than for other joint revisions, in part because of the low virulence of the commonly cultured shoulder bacteria *Propionibacterium acnes* and coagulase-negative *Staphylococcus* species (CNSS) and the decreased efficacy of the common diagnostic tests for hip and knee PJI with respect to these bacteria in the shoulder.[6,7,9,10,12-15,18,20,22-24,27,29] Therefore, improved diagnostic testing is critical for both identifying and treating infection in revision shoulder arthroplasty.

The presence of multiple positive periprosthetic intraoperative tissue or fluid cultures from a single organism has been one of the primary criteria for diagnosis of PJI[21]; however, different culture techniques have been reported in the literature.[2,3,25,26] Recent studies have suggested improved effectiveness of implant sonicate fluid culturing methods over conventional periprosthetic tissue culture to detect bacteria in total knee and total hip arthroplasty patients because of the ability to disrupt biofilm membranes.[16,17,19,30] With these methods, the prosthetic implant is sonicated, and the subsequent sonication fluid dislodged from the implant, including the biofilm, is then cultured. To date, only 1 study has examined sonication fluid culture in shoulder arthroplasty.[22] Improved sensitivity and specificity for diagnosis of PJI were seen with sonicate fluid compared with tissue culture, although poor sensitivities (<70%) were seen for both culture methods.[22] Given the limited evidence for sonicate fluid cultures in shoulder arthroplasty and the relative complexity associated with preparation and analysis, implant sonication has not been put into widespread clinical use in revision shoulder arthroplasty.

Therefore, the purpose of this study was to evaluate the utility of implant sonication fluid cultures in the diagnosis of PJI compared with standard culture techniques in patients undergoing revision shoulder arthroplasty.

Materials and methods

We evaluated patients of 2 shoulder surgeons (J.P.I., E.T.R.) undergoing revision shoulder arthroplasty between August 2010 and April 2013. Patients taking antibiotics within 2 weeks of the preoperative workup or revision surgery and patients with a chronic inflammatory disease, such as rheumatoid arthritis, were excluded from the study. Sixty-three cases were identified for review.

All patients, regardless of clinical presentation, underwent a preoperative and intraoperative workup for infection. This included obtaining preoperative serum erythrocyte sedimentation rate and C-reactive protein level; preoperative and intraoperative shoulder aspirate culture; and multiple intraoperative tissue specimens for culture, permanent histology, and frozen section analysis. Ten patients were excluded from the study because of the inability to classify these cases into a category of infection (Table I) for analysis, as described later. This included cases in which only 1 culture was obtained, cases with 1 of 2 cultures positive and no other signs of infection, cases with 0 of 2 cultures positive and other positive signs of infection, and cases with negative cultures that were incubated for <7 days. In the remaining 53 patients available for analysis, a mean of 4.5 total specimens (preoperative and intraoperative) were obtained per case for standard culture. There were 5 patients with 2 cultures, 12 patients with 3 cultures, 9 patients with 4 cultures, 9 patients with 5 cultures, 14 patients with 6 cultures, 3 patients with 7 cultures, and 1 patient with 8 cultures. Preoperative fluid was obtained in 36 of 53 cases, and intraoperative fluid was obtained in 36 of 53 cases. Tissue and fluid samples for culture were processed per standard laboratory protocols. Tissues were homogenized using a closed tissue grinding system (Cardinal Health, Dublin, OH, USA) in thioglycollate or brain-heart infusion broth. A single drop from each aliquot was placed onto sheep blood agar, chocolate agar, and MacConkey agar and incubated aerobically for 2 days and placed onto CDC agar and incubated anaerobically to identify *P. acnes*. Plates were examined every 2 days and incubated for a mean of 11.6 days (range, 7-26 days). A 1-mL aliquot was added to thioglycollate enrichment broth, which was also incubated. Turbid broth was subcultured on any day until the final day of incubation.

Table I Criteria for periprosthetic shoulder infection

Category	Criteria
Definite infection	At least 1 positive preoperative or intraoperative finding of infection* and >1 positive culture (preoperative or intraoperative) *or* One positive preoperative culture (aspirate) and 1 positive intraoperative culture with the same organism
Probable infection	At least 1 positive preoperative or intraoperative finding of infection* and 1 positive culture (preoperative or intraoperative) *or* No preoperative or intraoperative findings of infection* and >1 positive culture (preoperative or intraoperative)
Probable contaminant	No preoperative or intraoperative findings of infection* and 1 positive culture (preoperative or intraoperative)
No evidence for infection	No preoperative or intraoperative findings of infection* and no positive cultures (preoperative or intraoperative)

Table created from criteria used in references 7-10, 12, 13.
Reprinted from: Frangiamore SJ, et al. Neer Award 2015: Analysis of cytokine profiles in the diagnosis of periprosthetic joint infections of the shoulder. J Shoulder Elbow Surg. 2017;26:189.[8]

* Preoperative or intraoperative findings of infection: preoperative clinical signs (swelling, sinus track, redness, drainage); positive serum erythrocyte sedimentation rate or C-reactive protein; intraoperative gross findings (purulent drainage, necrosis); positive intraoperative frozen section.