



ELSEVIER

## ORIGINAL ARTICLE

# Preoperative skin cultures are predictive of *Propionibacterium* load in deep cultures obtained at revision shoulder arthroplasty

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**Background:** *Propionibacterium*-specific cultures are commonly positive in revised shoulders *without* obvious signs of infection. To help identify patients at risk for these “stealth” presentations of positive *Propionibacterium* cultures, we assessed the value of a preoperative skin culture in predicting the results of deep cultures obtained at the time of revision shoulder arthroplasty in patients without clinical evidence of infection.

**Methods:** The study enrolled 60 patients undergoing revision for a prior shoulder arthroplasty without clinical evidence of infection. A preoperative culture of the skin surface was taken *before* skin preparation. At surgery, multiple (mean 5.9 ± standard deviation 1.6) deep tissue and explant cultures were harvested from the shoulder. Each culture was semiquantitatively reported as the specimen *Propionibacterium* value (SpPV). All SpPVs from the deep specimens from each patient were summed as the total shoulder *Propionibacterium* score (ShPS). The averaged ShPS was the total ShPS divided by the number of deep specimens harvested.

**Results:** A multivariate analysis demonstrated that the preoperative skin SpPV was predictive of the *Propionibacterium* load in the revised shoulders as indicated by the total ShPS ( $P = .004$ ) and averaged ShPS ( $P = .003$ ).

**Conclusions:** In this series of patients, a preoperative culture of the unprepared skin was strongly predictive of the *Propionibacterium* load in revised shoulder arthroplasties without clinical evidence of infection. This result suggests that the results of skin cultures taken before revision surgery may help inform operative management with respect to the need for prosthesis exchange and extended postoperative antibiotic treatment.

**Level of evidence:** Level I; Prospective Design; Prognostic Study

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**Keywords:** *Propionibacterium*; revision shoulders; intraoperative cultures; preoperative skin culture; bacterial load; arthroplasty

The University of Washington Institutional Review Board approved this study (IRB Study #50408).

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*Propionibacterium* are commonly found on the skin and in the dermis of the skin around the shoulder.<sup>6,13,22,25,33</sup> The anaerobic nature of this organism and its ability to feed on sebum in the sebaceous glands enable it to persist in the dermis and evade the usual prophylactic skin surface

preparations or systemically administered antibiotics used at surgery.<sup>22,25,28,29,35</sup> When the sebaceous glands are transected at the time of skin incision, this bacterium can enter the surgical field and potentially contact the implanted prosthesis. This may lead to colonization and biofilm formation, with potential for the bacteria to interact with the surrounding host bone.<sup>2,19,25,36</sup>

Deep tissue and implant specimens harvested from shoulders undergoing revision shoulder arthroplasty are often found to be positive for *Propionibacterium*, even when revision surgery is performed years after the index arthroplasty and even when there is no clinical evidence of infection.<sup>26,34</sup> This is especially the case when *Propionibacterium*-specific culture methods are used, including harvesting 4 or more tissue or explant specimens, culturing on broth as well as aerobic and anaerobic media, and observing the cultures for 2 or more weeks.<sup>3,24</sup>

Shoulders with positive cultures for *Propionibacterium* commonly have a “stealth” presentation: pain, stiffness, or component loosening without any obvious symptoms or signs of infection, such as fever, erythema, wound drainage, or elevated results on conventional laboratory tests for inflammation.<sup>5,8,9,15,37</sup> For these reasons, some authors refer to positive cultures for *Propionibacterium* at revision shoulder arthroplasty as being “unexpected.”<sup>7,16,32</sup>

Specialized serum and synovial tests, such as interleukin-6 and  $\alpha$ -defensin, have shown some value in predicting the results of intraoperative cultures,<sup>8-10,15,37</sup> but their effectiveness in predicting the positivity of deep cultures for *Propionibacterium* in the absence of clinical signs and symptoms of infection remains to be clarified. Advanced molecular techniques for identifying *Propionibacterium*, such as polymerase chain reaction,<sup>4,17</sup> cannot differentiate live from dead organisms, and their results would not be available until a day or so after the patient has left the operating room. Thus, the surgeon approaching a revision shoulder arthroplasty has limited information to inform decisions on how aggressive to be with surgical management (eg, whether to explant all components or to perform a partial exchange) and with post-operative antibiotic therapy (eg, whether to use immediate intravenous antibiotics administered through a peripherally inserted central catheter, oral antibiotics, or no antibiotics).<sup>12,16</sup>

With this background, the search for simple and effective preoperative approaches for predicting the risk of positive intraoperative cultures for *Propionibacterium* in those revised shoulders without clinical evidence of infection becomes compelling.<sup>27,34</sup> The value of reporting culture results in these revision shoulder arthroplasties by *Propionibacterium* load—rather than simply as “positive” or “negative”—has been recently reported.<sup>1,23</sup> In light of these considerations, we suggest that patients with high loads of *Propionibacterium* on the skin surface are likely to have high loads of *Propionibacterium* in their dermal glands and may thus be at higher risk for inoculation of the surgical wound when the skin is incised for prosthesis implantation and at higher risk for *Propionibacterium*-positive cultures at the time of surgical revision.

Given that each individual’s skin microbiome is unique and stable over time,<sup>13,14,31</sup> we hypothesized that the results of a simple preoperative skin surface culture would be predictive of the culture positivity of deep specimens harvested at revision surgery. Our study objective was to determine the prognostic value of a preoperative skin culture in determining the *Propionibacterium* load in specimens obtained intraoperatively at the time of surgical revision.

## Materials and methods

Between October 2015 and June 2017, 63 consecutive patients aged between 18 and 90 years presented to our tertiary shoulder service for prosthetic revision of a prior shoulder arthroplasty without evidence of an obvious shoulder infection. The indication for revision was individualized based on shared patient-surgeon decision making after a full discussion in each case of the identified problems with the shoulder and the prospects for improving its comfort and function with another operation. Results of routine preoperative laboratory tests were available for these patients, but special serologies, joint aspiration, and arthroscopic biopsy specimens were not used in their evaluation.

All 63 patients consented for participation, but the study excluded 3 due to lack of adequate skin cultures before skin preparation in the operating room. The remaining 60 patients, 36 men (60%) and 24 women (40%), were an average age of  $62 \pm 11$  (standard deviation) years (range, 31-84). Their surgical history included 26 prior hemiarthroplasties, 25 prior total shoulder arthroplasties, 6 prior reverse shoulder arthroplasties, 2 prior hemiresurfacings, and 1 antibiotic spacer that were converted to 32 hemiarthroplasties, 21 reverse shoulder arthroplasties, and 7 total shoulder arthroplasties.

On the day of surgery, a standardized swab culture (ESwab #480C, Copan Diagnostics, Inc., Murrieta, CA, USA) was obtained of the unprepared, unshaved skin in the area of the planned incision. Four passes with the swab were taken by a surgical assistant wearing sterile gloves, turning the swab 90° for each pass. After this culture was obtained, the skin in the area of the planned incision was prepared using a standard 70% chlorhexidine solution. Intravenous antibiotics consisting of vancomycin and ceftriaxone were administered only after all deep specimens were harvested. Multiple deep surgical specimens were taken from the shoulder, including synovium, capsule, collar membrane, humeral membrane, periglenoid tissue, humeral explant, and glenoid explant. Previous studies have demonstrated low yield of cultures of joint fluid, so fluid cultures were not included.<sup>1,19,24,34</sup> An individually wrapped sterile forceps or rongeur that had not touched the skin or subcutaneous tissue was opened for the sole purpose of collecting each tissue specimen. Each specimen was placed immediately in a sterile covered cup and sent to the laboratory. An average of  $5.9 \pm 1.6$  cultures were taken per shoulder.

All specimens were processed by the laboratory within 1 hour after surgery in a class 2 laminar flow biological safety cabinet. Specimens were inoculated onto the following microbiological media: blood agar (trypticase soy agar with 5% sheep blood), chocolate agar, *Brucella* agar (with blood, hemin, and vitamin K), and brain-heart infusion broth. The *Brucella* agar plates were incubated anaerobically at 37°C for 21 days. The other media were incubated at 37°C with 5% CO<sub>2</sub> for 21 days. Plates were sealed in a manner that allows sterile aeration without desiccation. Media were examined daily for growth visually but were only opened if growth was noted.

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