



***Propionibacterium acnes* in shoulder surgery: true infection, contamination, or commensal of the deep tissue?**

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Background: *Propionibacterium acnes* has been linked to chronic infections in shoulder surgery. Whether the bacterium is a contaminant or commensal of the deep tissue is unclear. We aimed to assess *P. acnes* in intraoperative samples of different tissue layers in patients undergoing first-time shoulder surgery.

Methods: In 118 consecutive patients (mean age, 59.2 years; 75 men, 43 women), intraoperative samples were correlated to preoperative subacromial injection, the type of surgical approach, and gender. One skin, one superficial, one deep tissue, and one test sample were cultured for each patient.

Results: The cultures were positive for *P. acnes* in 36.4% (n = 43) of cases. Subacromial injection was not associated with bacterial growth rates ($P = .88$ for *P. acnes*; $P = .20$ for bacteria other than *P. acnes*; $P = .85$ for the anterolateral approach; $P = .92$ for the deltopectoral approach; $P = .56$ for men; $P = .51$ for women). Skin samples were positive for *P. acnes* in 8.5% (n = 10), superficial samples were positive in 7.6% (n = 9), deep samples were positive in 13.6% (n = 16), and both samples (superficial and deep) were positive in 15.3% (n = 18) of cases ($P < .0001$). *P. acnes* was detected in the anterolateral approach in 27.1% (n = 32) of cases and in the deltopectoral approach in 9.3% (n = 11) of cases ($P = .01$; relative risk, 1.93; 95% confidence interval, 1.08-3.43). Thirty-five of the *P. acnes*-positive patients were men (81.4%), and 8 patients were women (18.6%; $P = .001$; relative risk, 2.51; 95% confidence interval, 1.28-4.90).

Discussion: *P. acnes* was detected in more than one third of patients undergoing first-time shoulder surgery. Preoperative subacromial injection was not associated with bacterial growth. *P. acnes* was observed more frequently in the deep tissues than in the superficial tissues. The relative risk for obtaining a positive *P. acnes* culture was 2-fold greater for the anterolateral approach than for the deltopectoral approach, and the risk was 2.5-fold greater for men.

Level of evidence: Basic Science, Microbiology.

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Keywords: *Propionibacterium acnes*; infection; shoulder; contaminant; commensal; anterolateral approach; deltopectoral approach

Ethical Board Commission Rhön-Klinikum AG, Bad Neustadt, gave approval for this study.

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Propionibacterium acnes is a commensal species and dominant member of the human skin microflora. Data from shoulder revision arthroplasty reveal that *P. acnes* is the most commonly observed pathogen, ranging from 19% to 70%.^{1,22,39,44,45} This bacterium has been associated with a variety of postoperative complications in orthopedic surgery, including endoprosthetic infections, persistent postoperative pain, and inflammation.^{1,14,15,22,25-28,30,32,39,41,44,49,54}

P. acnes is found ubiquitously on the skin and in other body sites, including the upper respiratory and gastrointestinal tracts.³⁷ The bacterium colonizes the skin at the human shoulders more frequently than the skin at the knee or hip region.³⁵ *P. acnes* is a non-spore-forming, gram-positive, anaerobic, pleomorphic rod whose end products of fermentation include propionic acid.⁴ *P. acnes* predominates over other constituents of the normal flora in the pilosebaceous follicles¹⁹ and forms biofilms, making it resistant to various antimicrobial agents.¹² Moreover, a flexible gene pool coding for a variety of proteins enables *P. acnes* to colonize and to reside within the human skin and to survive a spectrum of different environments, including aerobic and anaerobic surroundings.^{5,6}

P. acnes-positive cultures have been reported in samples from the glenohumeral cavity during an initial operation for shoulder arthroplasty, and this bacterium has been suggested to play a role in the pathogenesis of glenohumeral osteoarthritis.²⁵ However, there is a possibility of obtaining false-positive results because of contamination; therefore, positive cultures are of uncertain significance.¹⁵ Preoperative disinfection insufficiently penetrates the pilosebaceous follicles, where approximately 25% of the cutaneous bacterial population is localized.²⁴ *P. acnes* might be displaced into deeper tissue levels during the procedure, leading to false-positive results. We aimed to assess the rate of *P. acnes*-positive cultures taken from healthy patients during a first-time open shoulder surgical procedure. Whether preoperative subacromial injection had an impact on bacterial growth rates was tested before further analysis. We examined whether the rate of positive cultures differs between superficial samples of the cutaneous/subcutaneous layer and samples of the deep tissue, including the glenohumeral cavity. In addition, we examined whether the anterolateral and the deltopectoral approaches differ in positive culture rates and whether previously reported gender differences could be confirmed. We hypothesized that there would be more *P. acnes*-positive cultures in the superficial than in the deep layer and that there would be more positive cultures in men than in women.

Methods

From October 2012 to October 2013, 118 consecutive patients were recruited (75 men, 43 women; mean age, 59.2 years; range, 18-84 years). Patients were included if no prior surgery was

performed on the respective shoulder. Patients were asked to participate when an anterolateral approach for open rotator cuff reconstruction/open subacromial decompression or a deltopectoral approach for shoulder arthroplasty or open anterior shoulder stabilization was planned. Patients with systemic inflammatory diseases, those who had used systemic or topical antibiotics or anti-inflammatory medications within 6 months before surgery, and patients with tumors were excluded from further investigations. The patients with any subacromial injection before the surgery were allocated to a separate group. The impact of preoperative subacromial injection on the rate of positive intraoperative culture samples was correlated for the whole sample, for the separate anterolateral and deltopectoral approach groups, and for men and women before further statistical analyses. Patients were excluded from further investigation when the exclusion criteria were met during or after the recruitment process or when intraoperative sampling was concluded as insufficient by the surgeon on the basis of the stringent intraoperative sampling protocol requirements. The preoperative intravenous administration of antibiotics was withheld until the final intraoperative sample was collected. The withholding time for the antibiotic medication was strictly controlled to comply with the guidelines for perioperative antibiotic applications by the expert commission of the Paul-Ehrlich-Gesellschaft.⁵⁰ Each patient was informed at least 24 hours before surgery, and each patient signed an informed consent statement. Patients were informed with special attention to the withholding of antibiotics during surgery. Although this was compatible with the given guidelines, we explained to each patient the association of a surgical site infection and the time point of antibiotic administrations after the incision. Antibiotics were always administered before the implantation of foreign bodies. A study by Miliani et al³¹ of 7278 patients reported no difference in surgical site infection when antibiotics were delayed even after the incision. Another study by Koch et al²³ reported that the optimal antibiotic timing should be as close as possible to the incision, ideally within 4 minutes. Therefore, the administration of the antibiotic 10 minutes after the incision might have less risk than at 60 or 30 minutes before the incision because the tissue levels of the drug might be too low during a later phase of surgical intervention when the antibiotics are needed to prevent bacteria from adhering to inert surfaces, as reported by Marti et al.⁵¹ Ethical board commission approval was obtained before data collection. Written consent was provided by all patients.

All of the patients underwent postoperative antibiotic treatment for 3 days (Unacid [2 mg ampicillin + 1 mg sulbactam, intravenously, 1-1-1]; Pfizer Pharma GmbH, Berlin, Germany). The positivity of a *P. acnes* culture was reported 14 days after the procedure at the earliest. At this time point, the patients were already discharged from the hospital. There is no evidence in the literature supporting the prophylactic administration of antibiotics until the final culture result is received, and prophylactic antibiotics can even be harmful with regard to the development of resistance or of *Clostridium difficile* infection. Antibiotics were given before the implantation of foreign bodies. Prophylactic antibiotic treatment should address the adhesion of bacteria to foreign bodies because this adhesion is the first step of building biofilms on inert surfaces. Because antibiotics were given before the implantation of foreign bodies, we do not consider there to have been an increased risk of infection and therefore did not change the management when a sample was *P. acnes* positive.

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