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

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\textbf{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 \textit{P. acnes} in intraoperative samples of different tissue layers in patients undergoing first-time shoulder surgery.

\textbf{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.

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

\textbf{Discussion:} \textit{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. \textit{P. acnes} was observed more frequently in the deep tissues than in the superficial tissues. The relative risk for obtaining a positive \textit{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.

\textbf{Level of evidence:} Basic Science, Microbiology.

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\textbf{Keywords:} Propionibacterium acnes; infection; shoulder; contaminant; commensal; anterolateral approach; deltopectoral approach
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%.1,2,22,39,44,45 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 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 al35 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.33 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.
Intraoperative sampling

In each patient, 4 samples were taken. The first sample was taken by a dry skin sample swab (ESwab, Cat. No. 480C; Copan Diagnostics Inc, Murrieta, CA, USA) from the bare skin of the incision area (anterolateral or deltopectoral approach) before any surgical or anesthesiologic disinfection procedures, as described by Patel et al35 (Fig. 1). Surgical site disinfection was conducted by rubbing the skin with 6 consecutive sterile swabs (gauze, 100% cotton, Ref. 22801; Lohmann & Rauscher GmbH & Co KG, Neuwied, Germany) soaked in 100 mL of alcoholic disinfectant (Kodan Tinktur forte gefärbt, 45.0 g 2-propanol, 10.0 g 1-propanol, 0.20 g biphenyl-2-ol; Schüle & Mayr GmbH, Norderstedt, Germany) under strict conditions of the scrubbing time of at least 5 minutes and an additional predetermined time given by the manufacturer of at least 2 minutes. After sterile draping, an incision foil impregnated with iodine (Ioban 2, antimicrobial incise drape, Ref. No. 6651EZ, 60 × 85 cm; 3M Deutschland GmbH, Neuss, Germany) was draped around the entire shoulder to cover all of the bare skin (Fig. 1). The surgical team wore two consecutive pairs of surgical gloves; the outer pair of gloves was exchanged with a new pair after the draping process was completed to reduce contamination. After the skin incision through the cutaneous zone into the subcutaneous zone, the second sample was collected by placing a kidney-shaped basin at the incision site while flushing the operative field with 50 mL of sterile lactated Ringer’s solution (B. Braun Melsungen AG, Melsungen, Germany). The sample was taken with a sterile syringe (10 mL) from the fluid collected in the kidney basin. The syringe and the basin were discarded before the operation proceeded. In the anterolateral group, the third, deep sample was taken from the subacromial space after the coracoacromial ligament was cut and 2 retractors were placed to retract the deltoid muscle. In the deltopectoral group, the sample was taken after the joint capsule was cut, and the joint cavity was presented to the surgeon.

The deep sample was collected carefully by applying 5 to 10 mL of sterile lactated Ringer’s solution into the subacromial space or into the glenohumeral cavity without contacting the superior tissue layers. The sample was then aspirated with a new sterile syringe from the bottom of the subacromial space or the glenohumeral cavity. Finally, a fourth sample was taken from a sterile kidney basin placed on the instruments table until the third sample was collected. This sample served as a quality control. The superficial samples were taken immediately after the incision within 2 minutes after skin preparation and draping were finished. The deep sample was taken approximately 10 minutes after the incision. The time for surgical preparation to the region of interest (subacromial space or glenohumeral cavity) was the same for both approaches. We consider the time from skin preparation to sampling to be short enough to prevent bacterial recolonization, which is known to occur in a time-dependent fashion. All of the samples were placed into a sterile tube for transport; the tube was designed for anaerobic cultivation (BBL thioglycollate medium with calcium carbonate, enriched with vitamin K1 and hemin for culture storage, Cat #297264; Becton, Dickinson, Heidelberg, Germany). Unused, new thioglycollate sample tubes were stored in a refrigerator at 4°C; the expiration dates and temperatures were strictly controlled according to our hospital’s quality management regulations published on our clinic’s intranet site.

Sample cultivation and analysis

All of the samples (swabs and thioglycollate broth) were transported to the laboratory immediately after intraoperative sampling. The swabs were streaked on Columbia agar, chocolate agar, Schaedler agar, and Schaedler kanamycin-vancomycin agar plates and finally inoculated in thioglycollate broth (all media from Becton, Dickinson). The thioglycollate broth and the plates were incubated at 37°C for 14 days under aerobic conditions (5% CO2), with the exception of Schaedler agar plates and Schaedler kanamycin-vancomycin agar plates, which were incubated for 14 days under anaerobic conditions. The thioglycollate broth and the plates were examined for bacterial growth on days 1, 2, 7, and 14. The thioglycollate broth with signs of bacterial growth was subcultivated on Columbia agar, chocolate agar, and Schaedler agar plates for at least 2 days. The Propionibacterium species was identified by the typical colony appearance on Columbia and Schaedler agar plates and by use of matrix-assisted laser desorption/ionization time-of-flight mass spectrometry.

The computed statistical analysis was conducted with IBM SPSS Statistics software (v20; IBM Corp, Armonk, NY, USA). Normal distribution of the data was tested and confirmed by the Shapiro-Wilk test. An asymptotic 2-sided Pearson χ2 test was
used to determine whether subacromial injection had an impact on positive bacterial growth and to determine the *P. acnes* growth rates between the tissue layers, the genders, and the anterolateral and deltopectoral approaches.

**Results**

A consecutive 118 patients (mean age, 59.2 years; range, 18-84 years) fulfilled the inclusion criteria. Seventy-five men (mean age, 57.1 years; range, 21-80 years) and 43 women (mean age, 62.9 years; range, 18-84 years) were analyzed. Fifty-three patients (45%) had positive cultures for *P. acnes*. Of these, 10 samples had been obtained from the initial skin sample (4 of which exhibited concomitant growth from the superficial layer samples and 6 from deep layer samples). Furthermore, 9 patients had growth only from the superficial layer, 16 had growth only from the deep layer, and 18 had growth from both the deep and superficial layers (*P < .0001*; Table I). In 71 patients (51 men, 20 women), an anterolateral approach to the shoulder was used; a deltopectoral approach was used in 47 patients (24 men, 23 women) (Fig. 1). Of 118 patients, 32 (27%) reported receiving at least one subacromial injection. This injection was not associated with bacterial growth from the intraoperative cultures (*P = .88* for *P. acnes*; *P = .20* for species other than *P. acnes*; *P = .85* for the anterolateral approach; *P = .92* for the deltopectoral approach; *P = .56* for men; *P = .51* for women; Tables IIa-f). Although not significant, the patients who received a subacromial injection had fewer positive cultures compared with the group that had no injections (12 vs 31 patients; *P = .88*; Table IIa). *P. acnes* growth was found in 45% of the patients from the anterolateral group and in 23.4% of the patients undergoing a deltopectoral approach (*P = .015*; Table III; relative risk, 1.93; 95% confidence interval, 1.08-3.43). The superficial sample showed *P. acnes* growth in 28.2% in the anterolateral group and in 14.9% in the deltopectoral group. The deep tissue sample had *P. acnes* growth in 36.6% in the anterolateral group and in 17% in the deltopectoral group. Forty-seven percent of men showed growth of *P. acnes* compared with 19% of women (*P = .001*; relative risk, 2.53; 95% confidence interval, 1.28-4.9; Table IV). The mean growth time for *P. acnes* was 10.6 ± 3.4 days.

**Discussion**

*P. acnes* is increasingly recognized as a major pathogen associated with nonspecific, insidious “low-grade” infections around the shoulder after open and arthroscopic surgeries. This bacterium was considered a nonpathogenic contaminant for many years; however, this hypothesis has been questioned with growing interest. Because *P. acnes* is difficult to culture, many infections might remain unidentified, and “aseptic loosening” of endoprosthetic implants could actually be an infection. We aimed to investigate the role of *P. acnes* during first-time shoulder surgery.

Preoperative subacromial injections had no impact on bacterial culture results. We observed *P. acnes*–positive cultures in 45% of patients and in 36.4% of intraoperative fluid samples. The anterolateral approach and male gender

<table>
<thead>
<tr>
<th>Table I</th>
<th><em>P. acnes</em> in the superficial and in the deep tissue layer samples</th>
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<tr>
<td></td>
<td><em>P. acnes</em> deep</td>
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<tr>
<td></td>
<td>Negative</td>
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<tr>
<td></td>
<td>Count</td>
</tr>
<tr>
<td><em>P. acnes</em> superficial</td>
<td>75</td>
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</tbody>
</table>

Cross tabulation of *P. acnes*–positive samples taken from the superficial and the deep tissue layers. We expected to observe more positive *P. acnes* cultures from the superficial layer samples; however, the deep layer samples were positive at a higher rate (13.6%) than the superficial samples (7.6%) if there was no growth in the respective other layer. The majority of *P. acnes*–positive patients were positive in both layers (15.3%).

<table>
<thead>
<tr>
<th>Table IIa</th>
<th>Preoperative subacromial injection and positive intraoperative <em>P. acnes</em> samples</th>
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<tr>
<td></td>
<td><em>P = .884</em> Preoperative injection</td>
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<td><em>P. acnes</em></td>
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<td></td>
<td>% of total</td>
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<td>Positive</td>
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<td>% of total</td>
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Cross tabulation of growth rates from intraoperatively taken samples and preoperative subacromial injection for *P. acnes* (IIa) and bacteria other than *P. acnes* (IIb) as well as separate comparison of the anterolateral approach (IIc), the deltopectoral approach (IId), for men (IIe), and for women (IIf). There was no association between previous subacromial injection and positive cultures. There were more patients who had no injection and had positive cultures compared with the patients who received an injection and had positive cultures; however, this difference was not significant.
were risk factors for positive \textit{P. acnes} cultures. Deep samples were more often positive than were superficial samples.

A weakness of our study is the difficulty in sampling different tissue layers. Although care was taken to prevent contamination, we cannot exclude the possibility of contamination, particularly because \textit{P. acnes} resides deep within the sebaceofollicular gland and is insufficiently eradicated by disinfection procedures.\textsuperscript{24} We expected to observe more \textit{P. acnes} in the superficial than in the deep zone, which was not the case (13.6\% deep only vs 7.6\% superficial only; \(P < .0001\); Table I). The test samples were positive in 2 of 118 cases (1.7\%); however, \textit{P. acnes} was not found in these cases. \textit{Staphylococcus cohnii} was detected in one case, and \textit{Bacillus cereus} was detected in the other case. This result might reflect the contamination of probes or media during transport or handling in the laboratory. In revision surgery, tissue biopsy combined with fluid aspiration is the “gold standard” for detecting an infection. A biopsy is reasonable when the bacteria have time to evolve within the tissue. Taking samples in healthy patients is different from taking samples in revision surgery because there are no inert surfaces on which bacteria could have adhered. We hypothesized that \textit{P. acnes} is displaced from the sebaceofollicular glands into the operative field because of insufficient skin disinfection. Therefore, fluid aspiration was selected for this study. We aimed to test fluid sampling in light of the huge number of \textit{P. acnes} growth rates from fluid samples in revision surgery. A different sampling method might have produced different results.

Similar to our study, Levy et al found \textit{P. acnes} in 42\% of samples taken from the glenohumeral cavity in patients undergoing primary shoulder joint replacement.\textsuperscript{25} These authors concluded that \textit{P. acnes} might exist in the joint space as a commensal species before the surgical procedure, leading to implant infections at a later time.\textsuperscript{1,25,42} Those authors reported that care was taken during their sampling with regard to contamination; however, we experienced that avoiding this contamination is difficult. \textit{P. acnes} inhabits the sebaceofollicular glands at a very deep level in the skin, and disinfectants are insufficient to eradicate the bacteria from this location.\textsuperscript{24} The use of adhesive

\begin{table}[h]
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\begin{tabular}{llll}
\hline
\textbf{Table IIb} & Preoperative subacromial injection and positive intraoperative samples for bacteria other than \textit{P. acnes} & \\
\hline
& Preoperative injection & Total & \\
& No & Yes & \\
\hline
\textbf{Other than \textit{P. acnes}} & & & \\
Negative & 60 & 26 & 86 \\
& \% of total & 50.9\% & 22.0\% & 72.9\% \\
Positive & 26 & 6 & 32 \\
& \% of total & 22.0\% & 5.1\% & 27.1\% \\
\hline
\textbf{Total} & 86 & 32 & 118 \\
& \% of total & 72.9\% & 27.1\% & 100.0\% \\
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\textbf{Table IIc} & Preoperative subacromial injection and positive intraoperative \textit{P. acnes} samples in the anterolateral approach & \\
\hline
& Preoperative injection & Total & \\
& No & Yes & \\
\hline
\textbf{\textit{P. acnes}} & & & \\
Negative & 26 & 13 & 39 \\
& \% of total & 36.6\% & 18.3\% & 54.9\% \\
Positive & 22 & 10 & 32 \\
& \% of total & 30.9\% & 14.8\% & 45.1\% \\
\hline
\textbf{Total} & 48 & 23 & 71 \\
& \% of total & 67.6\% & 32.4\% & 100.0\% \\
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\textbf{Table IIe} & Preoperative subacromial injection and positive intraoperative \textit{P. acnes} samples in men & \\
\hline
& Preoperative injection & Total & \\
& No & Yes & \\
\hline
\textbf{\textit{P. acnes}} & & & \\
Negative & 33 & 7 & 40 \\
& \% of total & 44\% & 9.3\% & 53.3\% \\
Positive & 27 & 8 & 35 \\
& \% of total & 36\% & 10.7\% & 46.7\% \\
\hline
\textbf{Total} & 60 & 15 & 75 \\
& \% of total & 80\% & 20\% & 100\% \\
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\end{tabular}
\end{table}
drapes might confound our observation of more \textit{P. acnes} in the deep tissue. Falk-Brynhildsen et al compared the effect of adhesive drapes on microbiologic samples taken from the operative field during cardiac surgery at different time points.\textsuperscript{16} In the draped group, more \textit{P. acnes} were observed in the samples taken at a later time than in the group without a drape.\textsuperscript{16} A Cochrane database review revealed no evidence that plastic adhesive drapes reduce surgical site infection rates, and there was some evidence that drapes increase infection rates.\textsuperscript{52} Sealing of a greater skin area could have led to a displacement of \textit{P. acnes} from the sebaceofollicular unit to deeper tissue levels because of sweating underneath the foil.\textsuperscript{11,16,52} The results might have been biased according to this hypothesis because our samples from the deep tissue were taken at a later time compared with the superficial samples. These authors, however, did not use the iodine-impregnated foil that we used in our study. Iodine might inhibit bacterial growth, making it superior to the nonimpregnated types; however, there is no clear evidence for this hypothesis.\textsuperscript{52}

To better distinguish infection from contamination, Levy et al obtained histopathologic specimens from the intra-articular synovia in 13 of 23 patients (56.5%).\textsuperscript{25} Of these, 11 were reported to have moderate, mild, or minimal signs of synovitis. However, synovitis does not indicate whether \textit{P. acnes} was present intra-articularly before surgery because synovitis is increasingly recognized in a significant proportion of patients with primary osteoarthritis. On the basis of this observation, several other studies implicated joint inflammation and synovitis in the pathogenesis of osteoarthritis.\textsuperscript{10} Culture-independent molecular techniques, such as multicolor fluorescent in situ hybridization or fluorescent immunoassays, are needed to further clarify this point.\textsuperscript{7} \textit{P. acnes} is able to survive in \textit{intracellular} colonies;\textsuperscript{5-8} the bacterium hides in macrophages, which have been implicated in serving as a niche for its spread.\textsuperscript{18} There is increasing evidence that chronic inflammation promoted by \textit{intracellular} colonies of \textit{P. acnes} is associated with the evolution of prostate cancer.\textsuperscript{2,6,8,13}

### Table II

<table>
<thead>
<tr>
<th>Preoperative subacromial injection and positive intraoperative \textit{P. acnes} samples in women</th>
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<tr>
<td>\textit{P} = .506</td>
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<td>Other than \textit{P. acnes}</td>
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<tr>
<td>Negative</td>
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<td>Positive</td>
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### Table III

<table>
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<th>\textit{P. acnes} in the anterolateral and the deltopectoral approach</th>
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<tr>
<td>\textit{P} = .015</td>
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### Table IV

<table>
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<th>\textit{P. acnes} and gender</th>
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<tr>
<td>\textit{P} = .001</td>
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<td>\textit{P. acnes}</td>
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The site of the surgical approach affected the \textit{P. acnes} growth rates. An almost 2-fold greater risk was associated with the anterolateral approach compared with the deltopectoral approach (\textit{P} = .015; relative risk, 1.93; 95% confidence interval, 1.08-3.43). The shoulder skin was reported to have a greater burden and prevalence of \textit{P. acnes} compared with the axilla, the knee, and the hip.\textsuperscript{35} Differences in the burden of \textit{P. acnes} between the anterolateral and the deltopectoral incisional areas might explain the difference in the risk (Fig. 1). The anterior and posterior acromion is dominated by \textit{P. acnes}\textsuperscript{35} (Fig. 2). In contrast,
Staphylococcus species had a greater burden in the axilla compared with the acromion. This result is in agreement with reports showing that there is a greater involvement of P. acnes in open rotator cuff surgery compared with shoulder arthroplasty. A retrospective analysis of postoperative infections by Athwal et al regarding open rotator cuff repairs (4886 cases, 1975 to 2003) revealed that P. acnes was the most commonly found organism (20 of 39 infections; 51%). These data strengthen our observation of a 2-fold greater risk for the anterolateral approach. A retrospective analysis during a 33-year period of shoulder arthroplasty reported P. acnes as the second most common organism (19%) after Staphylococcus aureus (31%). Achermann et al reported P. acnes to be the most common pathogen (38%) in periprosthetic infections retrospectively analyzed from 1571 primary shoulder arthroplasties. The differences in infection rates between these studies might result from different surgical approaches. Whereas the deltopectoral approach is used for arthroplasty in our department, the anterolateral or “anterosuperior” approach is favored by some surgeons because this approach provides better exposure of the glenoid. In accordance with the data reported herein and with the literature, we express concern about the use of the anterolateral approach for orthopedic implants with regard to a possibly greater risk of P. acnes infection.

Our data demonstrate that P. acnes colonization of intraoperative samples is predominantly a male problem, confirming reports from shoulder revision surgery and topical skin testing. Men have more sebaceous glands with a greater volume, resulting in a greater P. acnes load. A strong positive correlation has been reported between male sex, pore size, and sebum excretion. White men reportedly have a sebum average of 3 mg/cm² of skin surface (with large interindividual variability), whereas white women have only 0.7 mg/cm².

Two patients in our study group encountered a postoperative infection requiring revision surgery. During the revision, intraoperative samples confirmed the presence of P. acnes in both cases. The patients were both male and were positive for P. acnes in all tissue layers (skin, superficial, and deep) at the index operation. Male gender and younger age were reported by Singh et al as significant risk factors for development of a deep periprosthetic infection. The burden of P. acnes in men might play a role in this increased risk, and P. acnes subtypes might differ in their pathogenicity. Subtype-specific differences could be determined through viruses that infect bacteria, known as bacteriophages. These bacteria-infecting viruses are common in nature and outnumber bacteria (10:1). Phages could be found as prophages inserted into bacterial genomes. There is evidence that interactions between prophages and bacteria contribute to bacterial pathogenicity and might partly explain the differences in pathogenicity observed with P. acnes. However, much is unknown about the interaction between phages and P. acnes. Further studies of these interactions, including studies of the contribution of prophages to bacterial pathogenicity, are of great importance. There is some evidence that women carry fewer P. acnes phages than men do, which was correlated with a lower abundance of P. acnes on women. Further investigation is necessary to identify P. acnes subtypes and the bacteriophages infecting them to better understand why P. acnes leads to a pathologic condition only in some cases.

**Conclusion**

Intraoperative P. acnes colonization is common in shoulder surgery. More than one third of patients having first-time shoulder surgery were P. acnes positive from fluid samples of different tissue layers. This positivity was not associated with previous subacromial injections. Deep samples from the subacromial space and the glenohumeral joint cavity had more P. acnes growth compared with superficial samples from the subcutaneous zone. Male sex and the anterolateral approach were of increased relative risk. On the basis of our data, we conclude that the deltopectoral approach should be...
preferred whenever possible for any procedure using orthopedic implants.

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References


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