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ORIGINAL ARTICLE

Low-grade infections in nonarthroplasty shoulder surgery

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Background: Recent studies have identified the diagnostic challenge of low-grade infections after shoulder arthroplasty surgery. Infections after nonarthroplasty procedures have not been reported. This study assessed patient-related risk factors, outcomes, and clinical presentation of low-grade infection after open and arthroscopic nonarthroplasty shoulder surgery.

Methods: The cases of 35 patients presenting with suspected low-grade infection were reviewed. Biopsy specimens taken at revision surgery were cultured in the sterile environment of a class II laminar flow cabinet and incubated for a minimum of 14 days at a specialist orthopedic microbiology laboratory. Patient-related factors (age, occupation, injection), index surgery, and infection characteristics (onset of symptoms, duration to diagnosis, treatment) were analyzed.

Results: Positive cultures were identified in 21 cases (60.0%), of which 15 were male patients (71%). Of all patients with low-grade infection, 47.6% were male patients between 16 and 35 years of age. *Propionibacterium acnes* and coagulase-negative staphylococcus were the most common organisms isolated (81.1% [n = 17] and 23.8% [n = 5], respectively). Of 14 negative culture cases, 9 were treated with early empirical antibiotics (64.3%); 7 patients reported symptomatic improvement (77.8%). Of 5 patients treated with late empirical antibiotics, 4 stated improvement. Patients presented with symptoms akin to resistant postoperative frozen shoulder (persistent pain and stiffness, unresponsive to usual treatments).

Conclusion: Young male patients are at greatest risk for low-grade infections after arthroscopic and open nonarthroplasty shoulder surgery. *P. acnes* was the most prevalent organism. Patients presented with classic postoperative frozen shoulder symptoms, resistant to usual treatments. Interestingly, 78.6% of patients with negative cultures responded positively to empirical treatment.

Level of evidence: Level IV; Case Series; Treatment Study

Keywords: Nonarthroplasty; arthroscopic; *Propionibacterium acnes*; low-grade infection; shoulder; complications

All patients in this study signed consent forms for their anonymized data to be used for scientific and research purposes. Data were analyzed retrospectively, and there was no change in the patients' standard of care or decision-making.

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Infections after shoulder surgery are uncommon but have the potential to cause damaging consequences.[42] Reported infection rates range from 0.43% to 4% for a range of procedures, including fracture management, arthroscopy, arthroplasty, and open rotator cuff repair.[42] During the past 2 decades, a number of organisms that are part of the normal skin flora have been studied, including but not limited to *Staphylococcus aureus*, *Staphylococcus epidermidis*, *Propionibacterium acnes*, and *Corynebacterium* species.[42]

P. acnes is a slow-growing, biofilm-forming, gram-positive anaerobic bacillus.[1,6,9,32] Historically, it was considered a skin contaminant, but it recently has been identified as a "low-grade" orthopedic pathogen, found within the lipid-rich pilosebaceous hair follicles.[39,43] It is frequently found as a commensal of the respiratory tract, gastrointestinal tract, conjunctiva, and skin.[5,6,20,32,62] Clinically, *P. acnes* presents a diagnostic challenge because of its indolent atypical presentation and normal erythrocyte sedimentation rate and C-reactive protein values.[56] *P. acnes* has emerged as a prevalent low-grade organism after shoulder arthroplasty.[2,41,49,50]

Lesser-reported pathogens include *S. epidermidis*,[13,22,56] methicillin-resistant *S. aureus*,[23,29] *Staphylococcus saccharolyticus*,[45] and *Streptococcus* species.[29] Cleeman et al[15] and Lossos et al[34] reported on *S. aureus* as the causative pathogen in shoulder sepsis in 70% and 41% of cases, respectively. A more recent study on isolated shoulder sepsis identified *S. aureus* in 6 of 19 patients and *P. acnes* in 1 patient.[21] Furthermore, *S. aureus* and *S. epidermidis* account for more than half of prosthetic joint infections.[57] These studies confirm the scope of microorganisms complicating shoulder surgery, presenting difficulty in managing patients. Management strategies to prevent low-grade infections have been addressed,[2,17,25] and studies have established patient- and procedure-specific risk factors after shoulder arthroplasty.[7,13,16,24,28,31,37,38,40,41,46,47,49,50,58,59] However, to our knowledge, no studies have addressed patient- and procedure-related risk factors for low-grade infection after nonarthroplasty surgery.

This study addresses patient-specific risk factors for low-grade infection after nonarthroplasty shoulder surgery and investigates the isolated low-grade organisms. Furthermore, the clinical presentations of low-grade infection after shoulder surgery are described.

Materials and methods

During a 3-year period, a total of 35 patients were identified as having suspected postoperative low-grade infection. This was the time during which the authors have been using a specialist orthopedic microbiology service to reduce culture and interpretation variables within the study. Low-grade infection was suspected on the basis of clinical suspicion, with ongoing postoperative chronic pain and stiffness unresponsive to all nonoperative treatments (such as corticosteroid and hydrodistention injections and rehabilitation). Anagnostakos et al[4] defined low-grade infection as a subacute or chronic infection with lack of any typical local infection signs. Richards et al[41] used a similar definition for infection while evaluating risk factors for deep infection. All patients had a magnetic resonance imaging scan to exclude any other structural causes for their ongoing pain and stiffness. All patients underwent an arthroscopic assessment, and synovial biopsy specimens were sent from representative areas of the shoulder. These were from the rotator interval,[47] anterior capsule, and posterior capsule. Samples were taken from areas of the glenohumeral joint (GHJ) and synovium in these 3 areas to ensure a geographic spread. The GHJ was clinically stiff and painful in all cases and thus believed to be the site of infection. This was performed through an arthroscopic cannula, ensuring no skin contact, and a separate biopsy forceps was used for each area. Three samples were placed in 3 separate sterile universals, with a total of 9 specimens (3 × 3 samples per universal). The only other procedure performed at surgery was removal of any foreign suture material from the previous surgery.

The specimens were placed in sterile universals at surgery and transported immediately at room temperature to a specialist UK orthopedic microbiology laboratory (UK Orthopaedic Microbiology Service [UKOMS], Sheffield, UK) for analysis, using United Kingdom Accreditation Service (UKAS) 15189 accredited procedures, as described. Routine culture was carried out using strict aseptic technique inside a class II laminar flow cabinet to prevent aerosol contamination. All media used were purchased from Oxoid (Basingstoke, UK) and consisted of both directly inoculated plates (chocolate agar [CA] and anaerobic recovery isolation agar [ARIA]) and the enrichment broths brain-heart infusion (100 mL) and fastidious anaerobic broth (25 mL). The CA was incubated in air +5% CO_2 and the ARIA plate in anaerobic conditions, both for 48 hours. The broths were incubated for 14 days in air, after which they were subcultured onto the CA and ARIA and incubated as before. All were incubated at a temperature of 36°C ± 1°C. The broths were also examined for turbidity on a daily basis and if turbid were subcultured at that point as well as at day 14. All agar plates were read at both 24 and 48 hours; any colonies isolated were identified using matrix-assisted laser desorption ionization time-of-flight mass spectrometry (Bruker, Coventry, UK) and had sensitivities performed using European Committee on Antimicrobial Susceptibility Testing (EUCAST) guidelines.

Demographic data collected from the electronic medical records included age, gender, and occupation. Onset of symptoms, duration to infection diagnosis, and whether patients were empirically treated were recorded. The index surgery performed and patient-related characteristics (age, gender, and history of injection use on the surgical shoulder) were documented to determine potential risk factors for low-grade infection. The surgical procedure immediately before revision surgery at which specimen samples were collected was defined as the index surgery. The primary end point of the study was identification of low-grade infection after the index procedure. For patients identified with a positive culture, type of organism isolated and length in days for culture growth were extrapolated. Data were extracted from the microbiology reports and clinic notes. Types of organisms are reported as absolute numbers and percentage of positive cultures. A single surgeon (L.F.) performed all revision procedures, and 1 specialist orthopedic microbiologic laboratory analyzed the samples.

A power calculation was performed with a study power of 0.80, an α of .05, and assumptions of a clinically significant positive culture rate in the arthroscopy cases of 23% from the rotator interval.[47] Using these assumptions, we required 24 cases in the study to meet a certainty of 80% (power of 0.80).