Clin Orthop Relat Res (2009) 467:531–535
DOI 10.1007/s11999-008-0553-4

ORIGINAL ARTICLE

# A Superficial Swab Culture is Useful for Microbiologic Diagnosis in Acute Prosthetic Joint Infections

**Jordi Cuñé MD, Alex Soriano PhD, Juan C. Martínez MD, Sebastián García PhD, Josep Mensa MD**

Received: 5 February 2008 / Accepted: 17 September 2008 / Published online: 11 October 2008


**Abstract** The literature documents poor concordance between superficial swab and intraoperative tissue cultures in chronic prosthetic joint infections but is less clear in acute postsurgical prosthetic joint infections. We evaluated the relationship between superficial swab and deep intraoperative cultures in 56 patients with acute postsurgical prosthetic joint infections from June 2003 to June 2007; patients receiving antibiotics were excluded. There were 30 hip and 26 knee prostheses. A superficial sample of the wound drainage was taken at admission and three deep samples were obtained during open débridement. Concordance was defined when at least one of the microorganisms isolated in the superficial samples also was found in the deep samples. The analysis also was performed according to the type of microorganism: Staphylococcus aureus, gram-negative bacilli, or other gram-positive microorganisms. Concordance between superficial and deep samples was 80.3% (45 of 56). The sensitivity, specificity, and positive and negative predictive values of superficial cultures to predict the microorganism isolated in deep cultures varied depending on the type of microorganism: 93.7%, 100%, 100%, and 97.5% for S. aureus; 90%, 91.6%, 85.7%, and 94.3% for gram-negative bacilli; and 50%, 75%, 60%, and 66.7% for other gram-positive microorganisms. We therefore believe the superficial swab culture is useful in identifying the etiologic microorganism of acute prosthetic joint infections, especially when S. aureus or gram-negative bacilli were identified.
**Level of Evidence:** Level II, diagnostic study. See the Guidelines for Authors for a complete description of levels of evidence.

## Introduction

The rate of prosthetic joint infection (PJI) is approximately 1% to 3%, despite correct surgical techniques, aseptic measures, and antibiotic prophylaxis [16, 18, 20, 23]. The success rate in acute postsurgical PJI treated with open débridement and prolonged antimicrobial therapy combining fluoroquinolones and rifampin ranges between 76% and 100% [1, 21, 26]. Early diagnosis and surgical treatment are essential to avoid a chronic infection, which increases morbidity, mortality, and economic costs [2–4]. Identification of the etiologic microorganism also is important to select the appropriate antimicrobial treatment. Zimmerli et al. [25] recommended delaying administration of antibiotics until deep samples are obtained during open débridement; however, several studies have identified persistent wound drainage as a major predictor of PJI [8, 12, 17]. Therefore, it would be reasonable to initiate early antibiotic treatment. The problem with this approach is that previous antibiotic therapy is the leading cause for negative cultures of deep periprosthetic samples. As microbiologic

Each author certifies that he or she has no commercial associations (eg, consultancies, stock ownership, equity interest, patent/licensing arrangements, etc) that might pose a conflict of interest in connection with the submitted article.
Each author certifies that his or her institution has approved the human protocol for this investigation, that all investigations were conducted in conformity with ethical principles of research, and that informed consent for participation in the study was obtained.

J. Cuñé (✉), J. C. Martínez, S. García
Department of Orthopaedic Surgery and Traumatology, Hospital Clínic of Barcelona, C/Villarroel 170, 08036 Barcelona, Catalonia, Spain
e-mail: jcune@clinic.ub.es; jocusala@hotmail.com

A. Soriano, J. Mensa
Department of Infectious Diseases, Hospital Clínic of Barcelona, Barcelona, Spain

information is essential for treatment of PJIs and in many cases it is not reasonable to delay antibiotics until obtaining deep samples, it is necessary to evaluate the correlation between microorganisms identified in superficial swabs from wound drainage and those isolated in deep samples.

The usefulness of superficial samples from the wound drainage to predict the microorganism found in deep samples of various sorts of infection is controversial. Concordance between superficial swab and intraoperative tissue cultures has been widely studied in chronic PJIs, showing a poor relationship. However, there is no evidence in acute post-surgical PJIs. For acute PJIs with drainage, several studies suggest superficial cultures obtained by swabbing the draining surface [13, 15] or by material extracted from a syringe into a sinus tract [11, 13] have a high likelihood of predicting the pathogen isolated from deep samples. However, some authors report isolation of bacteria other than S. aureus from the sinus tracts has a low likelihood of predicting the true pathogen [9, 15]. In addition, investigators of two recent studies reported low accuracy of superficial samples compared with bone biopsy even when S. aureus was isolated in the superficial samples [19, 27]. However, these studies involved patients with chronic osteomyelitis [9, 15] or diabetic foot osteomyelitis [19, 27].

The purposes of our study were: (1) to describe the microorganisms identified in superficial and deep cultures in patients with acute PJI; (2) to determine the global concordance between superficial and deep cultures; (3) to evaluate the specific relationship between superficial and deep cultures for different types of microorganisms; and (4) to analyze whether the knee or hip location of the infection could influence the usefulness of superficial samples.

## Materials and Methods

We retrospectively reviewed the records of 58 consecutive patients with acute PJI from June 2003 to June 2007. Two patients who were taking antibiotics or who had taken antibiotics during the 2 weeks before admission were excluded. During this time, 3000 arthroplasties were performed; therefore, 58 patients represented an infection rate of 1.93%. The mean age (standard deviation) of the patients was 74.2 years (11.7 years); 30 were women and 26 were men. Thirty patients had hip and 26 had knee prostheses. Of the patients with hip prostheses, 12 had noncemented monopolar hemiarthroplasties, one had a cemented monopolar hemiarthroplasty, two had cemented bipolar hemiarthroplasties, and 15 had THAs. In our hospital, primary arthroplasty is never performed using antibiotic-loaded cement. The mean age of patients with a hip prosthesis was 76.8 years. The mean age of the 26 patients who had TKAs was 71.3 years.

We defined acute PJI as: (1) the initiation of symptoms (erythema, wound drainage) was less than 15 days postoperatively; (2) the diagnosis of infection was made within the first month after arthroplasty [22]; and (3) a pathogenic microorganism (S. aureus, gram-negative bacilli) was isolated in at least one deep sample. In the case of potential skin contaminants (coagulase-negative staphylococci, Corynebacterium spp), the same microorganism was isolated in two or more deep samples or pus was found during open débridement regardless of the culture results. Following the protocol of our hospital, antibiotics were initiated after taking more than three deep samples from periprosthetic tissue during surgical débridement, except in patients with symptoms or signs of severe sepsis in whom the antibiotic was initiated immediately; these patients were excluded from analysis. The mean (standard deviation) time from arthroplasty to admission for infection was 19 days (12.5 days) and from admission to open débridement was 3.8 days (2.9 days). The Independent Ethics Committee of our hospital approved the study.

The samples for the microbiologic study were always taken before administration of any antibiotic. Following the standard aseptic procedures (hand antisepsis, use of sterile gloves, use sterile patient care equipment), a superficial swab culture from the wound drainage was obtained at admission using a sterile cotton swab (invasive sterile Eurotube® collection swab with Stuart transport medium; Deltalab, Rubí, Spain). At the time of débridement, we submitted at least three periprosthetic samples from different sites to the laboratory for culture. Liquid samples were aspirated from the operative site using a sterile syringe and immediately inoculated into BACTEC™ 9492 blood culture flasks (Becton Dickinson Diagnostic Instruments, Cockeysville, MD) and incubated for 5 days. These flasks contain an enriched medium that allows growth of microorganisms. For this reason, 5 days is an accepted time of incubation [7]. We subcultured positive flasks in aerobic and anaerobic agar media. Swab cultures were obtained by passing a sterile swab (invasive sterile Eurotube® collection swab with Stuart transport medium; Deltalab) over the area of tissue, bone, or fluid suspected of infection. We immediately placed solid tissue samples from pseudocapsule, periprosthetic membranes, or tissue suspected to be infected into a separate sterile universal bottle. Solid tissue and swabs were cultured in aerobic and anaerobic agar media and in thioglycolate broth enriched with vitamin K and hemin and incubated for 10 days. We sent positive cultures for organism identification. Sensitivity testing was performed in all strains, except coagulase-negative staphylococci and Corynebacterium spp from superficial swab cultures.

We compared the superficial cultures with the deep cultures obtained during open débridement. Concordance was defined as when at least one of the microorganisms isolated

in the superficial samples also was found in the deep samples. We performed two analyses of the concordance, the first considering all the pathogens (global concordance) and the second considering three groups according to the type of microorganism isolated: S. aureus, aerobic gram-negative bacilli, and other gram-positive microorganisms. The sensitivity (S), specificity (Sp), positive (PPV) and negative (NPV) predictive values, and positive (PLR) and negative (NLR) likelihood ratios of superficial cultures to predict the culture result of deep samples were calculated. Proportions were compared using Fisher's exact test .

## Results

The most frequent microorganisms identified in superficial and deep cultures were coagulase-negative staphylococci (25% in superficial swabs and 30.1% in deep samples) and methicillin-susceptible S. aureus (17.2% in superficial swabs, 13.2% in deep samples) (Table 1). Methicillin-resistant S. aureus was isolated in 6% of superficial and deep cultures. Although gram-positive cocci predominated (57.8% in superficial and 66.3% in deep cultures), gram-negative microorganisms were identified in 42.2% of superficial cultures and in 33.7% of deep samples. Pseudomonas aeruginosa was the most frequent gram-negative microorganism, followed by Escherichia coli. Superficial cultures were polymicrobial in 11 cases (19.6%) and deep cultures in 14 (25%).

**Table 1.** Microorganisms isolated in superficial swab and deep cultures

| Microorganism | Swab culture | Deep culture |
|---|---|---|
| Total isolates | 64 | 83 |
| Gram positive | 37 (57.8%) | 55 (66.3%) |
| Coagulase-negative staphylococci | 16 (25%) | 25 (30.1%) |
| Methicillin-susceptible S. aureus | 11 (17.2%) | 11 (13.2%) |
| Methicillin-resistant S. aureus | 4 (6.2%) | 5 (6%) |
| Enterococcus spp | 3 (4.7%) | 9 (10.8%) |
| Streptococcus spp | 2 (3.1%) | 2 (2.4%) |
| Corynebacterium spp | 1 (1.5%) | 3 (3.6%) |
| Gram negative | 27 (42.2%) | 28 (33.7%) |
| Pseudomonas aeruginosa | 10 (15.6%) | 8 (9.6%) |
| Escherichia coli | 8 (12.5%) | 6 (7.2%) |
| Enterobacter spp | 4 (6.2%) | 5 (6%) |
| Klebsiella pneumoniae | 3 (4.7%) | 4 (4.8%) |
| Proteus mirabilis | 1 (1.5%) | 5 (6%) |
| Morganella morganii | 1 (1.5%) | |
| Polymicrobial | 11 | 14 |

The global concordance between superficial and deep samples (at least one of the microorganisms isolated in the superficial samples also was found in the deep samples) was 80.3% (45 of 56).

The S, Sp, PPV, NPV, and NLR of the superficial cultures to predict the presence of S. aureus in the deep cultures were 93.7%, 100%, 100%, 97.5%, and 0.06, respectively (it was not possible to calculate the PLR) (Table 2). When S. aureus was isolated in superficial cultures (n = 15), it always was found in deep cultures (100%). Methicillin-resistant S. aureus represented 26% of the S. aureus isolated in our patients. This was in agreement with the global prevalence of methicillin-resistant S. aureus in our hospital. Gram-negative bacilli were isolated in superficial cultures in 18 cases and in deep cultures in 20. When Enterobacter spp (n = 4), Klebsiella spp (n = 3), or Proteus mirabilis (n = 1) was isolated in the superficial swab cultures, it also was present in the deep cultures (100%). P. aeruginosa was isolated in 10 superficial samples and in eight deep samples (80%). E. coli was isolated in eight superficial samples, with six being in deep ones (75%). The S, Sp, PPV, NPV, PLR, and NLR of the superficial cultures to predict the presence of gram-negative bacilli in the deep cultures were 90%, 91.6%, 85.7%, 94.3%, 10.71, and 0.1, respectively. Other gram-positive microorganisms, including coagulase-negative staphylococci (n = 16), Corynebacterium spp (n = 1), Streptococcus viridans (n = 2), and Enterococcus faecalis (n = 3), were isolated in superficial cultures in 20 cases and in deep cultures in 25 cases. The S, Sp, PPV, NPV, PLR, and NLR of the superficial cultures to predict the presence of gram-positive microorganisms in the deep cultures were 50%, 75%, 60%, 66.7%, 2, and 0.66, respectively.

The microorganisms isolated in deep samples were different in hip and knee prostheses. In knee PJIs, S. aureus

**Table 2.** Analyses results of microorganisms

| Group | Sensitivity | Specificity | Positive predictive value | Negative predictive value | Positive likelihood ratio | Negative likelihood ratio |
|---|---|---|---|---|---|---|
| S. aureus | 93.7% | 100% | 100% | 97.5% | * | 0.06 |
| Gram-negative bacilli | 90% | 91.6% | 85.71% | 94.3% | 10.71 | 0.109 |
| Other gram-positive microorganisms | 50% | 75% | 60% | 66.7% | 2 | 0.66 |

* Not possible to calculate.

was isolated in 12 of 26 cases (46.2%), whereas in hip PJIs, it was identified in only four of 30 cases (13.3%). In contrast, gram-negative bacilli were found in four knee PJIs (15.3%) and in 14 hip PJIs (46.7%). However, we observed no differences ($p = 0.1$) in the usefulness of superficial cultures between hip and knee prostheses.

## Discussion

Our main purposes were to describe the microorganisms identified in superficial and deep cultures in patients with acute PJI, to determine the global concordance between superficial cultures obtained from wound drainage using a swab and deep periprosthetic cultures, to evaluate the specific relationship between superficial and deep cultures for different types of microorganisms, and to analyze whether the knee or hip location of the infection could influence the usefulness of superficial samples.

There were three main limitations to our study. (1) The design of the study was retrospective; therefore, a risk for selection bias was present. However, in our hospital, there is a strict protocol for management of PJI as seen by the fact that superficial and deep samples were obtained from all patients admitted with wound drainage, except two who were receiving antibiotic therapy. (2) The analysis of subgroups of microorganisms was performed with a low number of cases (ie, 15 with S. aureus), but the correlation was high, suggesting our results are reliable. (3) The lack of a susceptibility pattern for coagulase-negative staphylococci and Corynebacterium spp isolated from superficial swabs was another possible limitation. In these cases, the concordance was established at species level; therefore, we could not rule out the possibility of finding different clones in superficial and deep samples, with the accuracy of superficial swab cultures being lower than that presented in our study when other gram-positive microorganisms different from S. aureus were identified. However, this limitation did not modify the main conclusion of our study, ie, isolation of gram-positive microorganisms different from S. aureus in a superficial swab culture does not predict the result of deep samples.

The microbiology data from our cohort were consistent with data from other studies of PJI [10], where the most commonly isolated microorganisms were coagulase-negative staphylococci and methicillin-susceptible S. aureus. Methicillin-resistant S. aureus represented 25% of all S. aureus, which was similar to the prevalence of methicillin-resistant S. aureus in bacteremia or respiratory samples in our hospital. S. aureus and gram-negative bacilli were the etiologic agents in 35 of 56 acute postsurgical PJIs (62.5%). Similar etiology was documented by Tsukayama et al. [22] in 35 acute postsurgical prosthetic hip infections in which S. aureus and gram-negative bacilli were identified in 26 cases (74%). However, in comparison with other studies, our rate of gram-negative bacilli was higher. Our patients had a mean age of 74 years whereas the mean age of patients in the study by Tsukayama et al. [10] was 69 years, although we are uncertain whether this age difference would influence the spectrum of bacteria.

Our data suggest superficial swabbing performed at the time of hospital admission is useful to predict the microorganism isolated in deep samples obtained during open débridement. The efficacy of superficial swabbing was greater when the isolated microorganism was S. aureus or aerobic gram-negative bacilli with S, Sp, PPV, and NPV higher than 85% for both microorganisms. Weinrauch tried to predict the microorganism in acute PJI by culturing the drain tip after a primary knee and hip arthroplasty, obtaining a poor correlation between tip cultures and development of infection [24]. The importance of early diagnosis and treatment of acute PJI was described by Brandt et al. [3]. They described the evolution of 33 cases resulting from S. aureus and reported prostheses débrided longer than 2 days after onset of symptoms were associated with a higher probability of treatment failure than those débrided within 2 days of onset (relative risk, 4.2; 95% confidence interval, 1.6–10.3). In a recent publication, Jaberi et al. [5] recommended early surgery with irrigation and débridement in the operating room for patients with persistent wound drainage after a hip or knee arthroplasty. We found the PPV of finding S. aureus or gram-negative bacilli in the superficial culture performed at admission was 100% or 85%, respectively (Table 2).

Recent studies of chronic osteomyelitis have not found a relationship between superficial swabbing and deep samples [6, 19, 27]. The humid environment of a chronic ulcer or fistula likely promotes overgrowth of skin or opportunistic flora (ie, coagulase-negative staphylococci, Corynebacterium spp, or P. aeruginosa), and therefore, it seems logical that superficial samples in chronic osteomyelitis or chronic PJIs are not likely to reveal the true pathogen. This supposition is supported by the findings of Mackowiak et al. [9], who found the pathogen isolated in deep samples was absent more often in the later superficial culture than in the initial one (31% versus 82%). Pellizzer et al. [14] also suggested, for the initial monitoring of antimicrobial treatment in severe diabetic foot infection, swabbing and deep tissue cultures appeared equally reliable. However, deep culture was more sensitive than swabbing in monitoring ulcers that were still active after 30 days of treatment. In the case of acute postsurgical PJIs, the patient is evaluated only several days after wound drainage starts and this may explain our findings.

A superficial swab culture is an easy and useful method to identify the etiologic microorganism of acute PJI early, especially when S. aureus or gram-negative bacilli are identified. Although superficial samples provide

information in advance, deep samples are still the gold standard for diagnosing PJIs. Superficial samples could help surgeons to identify resistant microorganisms early and to start specific antibiotic treatment while waiting for definitive results of deep cultures.

## References


1. Barberan J, Aguilar L, Carroquino G, Gimenez MJ, Sanchez B, Martinez D, Prieto J. Conservative treatment of staphylococcal prosthetic joint infections in elderly patients. *Am J Med.* 2006;119:993.e7–10.
2. Barrack RL. Economics of revision total hip arthroplasty. *Clin Orthop Relat Res.* 1995;319:209–214.
3. Brandt CM, Sistrunk WW, Duffy MC, Hanssen AD, Steckelberg JM, Ilstrup DM, Osmon DR. Staphylococcus aureus prosthetic joint infection treated with debridement and prosthesis retention. *Clin Infect Dis.* 1997;24:914–919.
4. Fitzgerald RH Jr. Problems associated with the infected total hip arthroplasty. *Clin Rheum Dis.* 1986;12:537–554.
5. Jaberi FM, Parvizi J, Haytmanek CT, Joshi A, Purtill J. Procrastination of wound drainage and malnutrition affect the outcome of joint arthroplasty. *Clin Orthop Relat Res.* 2008;466:1368–1371.
6. Kessler L, Piemont Y, Ortega F, Lesens O, Boeri C, Averous C, Meyer R, Hansmann Y, Christmann D, Gaudias J, Pinget M. Comparison of microbiological results of needle puncture vs superficial swab in infected diabetic foot ulcer with osteomyelitis. *Diabet Med.* 2006;23:99–102.
7. Levine BR, Evans BG. Use of blood culture vial specimens in intraoperative detection of infection. *Clin Orthop Relat Res.* 2001;382:222–231.
8. Looner JU, Lotke PA. Aseptic complications after total knee arthroplasty. *J Am Acad Orthop Surg.* 1999;7:311–324.
9. Mackowiak PA, Jones SR, Smith JW. Diagnostic value of sinus-tract cultures in chronic osteomyelitis. *JAMA.* 1978;239:2772–2775.
10. Moran E, Masters S, Berendt AR, McLardy-Smith P, Byren I, Atkins BL. Guiding empirical antibiotic therapy in orthopaedics: the microbiology of prosthetic joint infection managed by debridement, irrigation and prosthesis retention. *J Infect.* 2007;55:1–7.
11. Mousa HA. Evaluation of sinus-track cultures in chronic bone infection. *J Bone Joint Surg Br.* 1997;79:567–569.
12. Patel VP, Walsh M, Sehgal B, Preston C, DeWal H, Di Cesare PE. Factors associated with prolonged wound drainage after primary total hip and knee arthroplasty. *J Bone Joint Surg Am.* 2007;89:33–38.
13. Patzakis M, Wilkins J, Kumar J, Holtom P, Greenbaum B, Ressler R. Comparison of the results of bacterial cultures from multiple sites in chronic osteomyelitis of long bones: a prospective study. *J Bone Joint Surg Am.* 1994;76:664–666.
14. Pellizzer G, Strazzabosco M, Presi S, Furlan F, Lora L, Benedetti P, Bonato M, Erle G, de Lalla F. Deep tissue biopsy vs superficial swab culture monitoring in the microbiological assessment of limb-threatening diabetic foot infection. *Diabet Med.* 2001; 18:822–827.
15. Perry CR, Pearson RL, Miller GA. Accuracy of cultures of material from swabbing of the superficial aspect of the wound and needle biopsy in the preoperative assessment of osteomyelitis. *J Bone Joint Surg Am.* 1991;73:745–749.
16. Pulido L, Ghanem E, Joshi A, Purtill JJ, Parvizi J. Periprosthetic joint infection: the incidence, timing, and predisposing factors. *Clin Orthop Relat Res.* 2008;466:1710–1715.
17. Saleh K, Olson M, Resig S, Bershadsky B, Kuskowski M, Gioe T, Robinson H, Schmidt R, McElfresh E. Predictors of wound infection in hip and knee joint replacement: results from a 20 year surveillance program. *J Orthop Res.* 2002;20:506–515.
18. Schutzer SF, Harris WH. Deep-wound infection after total hip replacement under contemporary aseptic conditions. *J Bone Joint Surg Am.* 1988;70:724–727.
19. Senneville E, Melliez H, Beltrand E, Legout L, Valette M, Cazaubiel M, Cordonnier M, Caillaux M, Yazdanpanah Y, Mouton Y. Culture of percutaneous bone biopsy specimens for diagnosis of diabetic foot osteomyelitis: concordance with ulcer swab cultures. *Clin Infect Dis.* 2006;42:57–62.
20. Soriano A, Bori G, Garcia-Ramiro S, Martinez-Pastor JC, Miana T, Codina C, Macule F, Basora M, Martinez JA, Riba J, Suso S, Mensa J. Timing of antibiotic prophylaxis for primary total knee arthroplasty performed during ischemia. *Clin Infect Dis.* 2008;46:1009–1014.
21. Soriano A, Garcia S, Bori G, Almela M, Gallart X, Macule F, Sierra J, Martinez JA, Suso S, Mensa J. Treatment of acute post-surgical infection of joint arthroplasty. *Clin Microbiol Infect.* 2006;12:930–933.
22. Tsukayama DT, Estrada R, Gustilo RB. Infection after total hip arthroplasty: a study of the treatment of one hundred and six infections. *J Bone Joint Surg Am.* 1996;78:512–523.
23. van Kasteren ME, Mannien J, Ott A, Kullberg BJ, de Boer AS, Gyssens IC. Antibiotic prophylaxis and the risk of surgical site infections following total hip arthroplasty: timely administration is the most important factor. *Clin Infect Dis.* 2007;44:921–927.
24. Weinrauch P. Diagnosis value of routine drain tip culture in primary joint arthroplasty. *ANZ J Surg.* 2005;75:887–888.
25. Zimmerli W, Trampuz A, Ochsner PE. Prosthetic-joint infections. *N Engl J Med.* 2004;351:1645–1654.
26. Zimmerli W, Widmer AF, Blatter M, Frei R, Ochsner PE. Role of rifampin for treatment of orthopedic implant-related staphylococcal infections: a randomized controlled trial. Foreign-Body Infection (FBI) Study Group. *JAMA.* 1998;279:1537–1541.
27. Zuluaga AF, Galvis W, Saldarriaga JG, Agudelo M, Salazar BE, Vesga O. Etiologic diagnosis of chronic osteomyelitis: a prospective study. *Arch Intern Med.* 2006;166:95–100.