



The Diagnosis and Management of Periprosthetic Joint Infections of the Shoulder

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Periprosthetic joint infection of the shoulder is a rare complication of shoulder arthroplasty, which can have a profound effect on a patient's clinical outcome and function. The diagnosis and management of these infections is challenging, largely because of the unique microbiome of the shoulder. As current treatment strategies are based upon the infection literature in hip and knee arthroplasty, there is little evidence to support their effectiveness in the shoulder. Although there continues to be innovations in the diagnosis and treatment of this unique joint infection, improving the understanding of periprosthetic joint infection of the shoulder remains an active area of research.

Oper Tech Orthop 26:53-59 © 2016 Elsevier Inc. All rights reserved.

KEYWORDS periprosthetic infection, shoulder arthroplasty, complications

Introduction

Periprosthetic joint infections (PJIs) of the shoulder are a relatively uncommon complication of shoulder arthroplasty with studies suggesting a rate between 0.7% and 1.8% in primary shoulder arthroplasty and up to 15.4% in revision arthroplasty.¹⁻⁷ National rates of PJI involving the shoulder have remained relatively constant over the past decade, suggesting that surgeons are not much better at preventing them, and that the number of infections encountered would mirror the increase in shoulder arthroplasty utilization.⁶ Projections suggest that >6000 new shoulder PJI cases would be encountered each year in the most conservative of estimates.^{6,8}

Although much of our historical understanding of the diagnosis and management of shoulder PJI has been extrapolated from the literature on hip and knee PJI, it is now understood that the unique microbiome of the shoulder may make correlations between lower extremity PJI and shoulder

PJI inaccurate. It is becoming increasingly recognized that low-virulence organisms such as *Propionibacterium acnes* (*P. acnes*) and coagulase-negative *Staphylococcus* species play a more prominent role in PJI involving the shoulder.^{3,9} This not only underscores the diagnostic challenge of identifying these organisms, but also suggests that the historic rates of shoulder PJI likely underestimate the true incidence of this challenging problem. As our diagnostic tools improve and evolve, it now seems that the harder we search for shoulder PJI, the more likely we are to find it. The goal of this article would be to summarize our current understanding of the diagnosis and management of shoulder PJI through an evidence-based approach.

Clinical Evaluation

It is nearly impossible to completely rule out the possibility of infection in any patient who presents to the hospital with a painful or poorly functioning shoulder arthroplasty with current diagnostic tools. Because of this, the highest index of suspicion must be maintained through all steps of the diagnostic workup and any revision procedures undertaken. It is important to remember that, even in the face of obvious mechanical or soft tissue failure, there may be concomitant infection present within the shoulder. One of the reasons for this vigilance is that we now understand that the usual sterile

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preparation of the shoulder is not sufficient to eliminate *P. acnes* that densely populates the sebaceous glands within the dermal layer of the shoulder.¹⁰ Therefore, it is safe to assume that every surgical wound about the shoulder has the potential to contaminate the deep underlying tissues, and studies have suggested that this is likely the case.¹¹⁻¹³

The identified risk factors for developing a PJI of the shoulder include male sex,^{4,14} younger age,⁴ posttraumatic arthroplasty,¹⁵ and the presence of a postoperative hematoma.¹⁶ Owing to the higher bacterial prevalence within hair follicles and pores, *P. acnes* is more commonly associated with men. A possible explanation for the decrease in infection risk with age may relate to the decrease in sebaceous gland secretion with age, resulting from the concomitant decrease in the endogenous production of androgens.^{17,18} Additionally, infection may be more common following reverse total shoulder arthroplasty¹⁹ and revision surgery.²⁰ Other comorbid conditions such as obesity, diabetes, smoking, malnutrition, chronic kidney or liver disease, and immunosuppression have yet to be identified as risk factors, although this is likely because of the fact that most of the current studies have been underpowered to detect a difference in these parameters.

Clinical signs and symptoms can vary and are often nonspecific. Although overt signs of infection, such as fevers, chills, erythema, swelling, or a draining sinus, are easy to identify, they typically only occur with more virulent organisms.⁵ Some of the most common symptoms, including pain and stiffness, are ubiquitous in nearly all poorly functioning shoulder arthroplasties, but are often the only signs present with low-virulence organisms such as *P. acnes*.¹⁴ A thorough clinical history should be elicited,

noting any postoperative wound-healing issues, superficial wound infections, and potential sources for hematogenous seeding of the shoulder joint.

Diagnostic Evaluation

Radiologic Evaluation

The diagnostic evaluation of a potentially infected shoulder arthroplasty typically starts with radiographs. Radiographs allow for the initial evaluation of other potential causes of a failed shoulder arthroplasty and may demonstrate hallmark findings of infected arthroplasty. Although radiographs cannot confirm an infection, humeral osteolysis, and component loosening have been associated with PJI in the shoulder¹⁴ (Fig. 1). More suppurative infections may also demonstrate joint effusion, periosteal reaction, or endosteal scalloping on radiographs.

The 3-dimensional imaging including computed tomography scans and magnetic resonance imaging of the shoulder is not typically helpful in the diagnosis of shoulder PJI. Largely, this is because the existing implant can create a substantial amount of artifact on advanced imaging, making interpretation of the study very difficult. However, with metal suppression techniques, these studies are often ordered, more for the purpose of determining rotator cuff integrity and bone loss for preoperative planning, than as a diagnostic tool for shoulder PJI.

Radionuclide imaging has not been well studied as a diagnostic tool for identifying infection in shoulder arthroplasty. A labeled white blood cell (leukocyte) imaging study

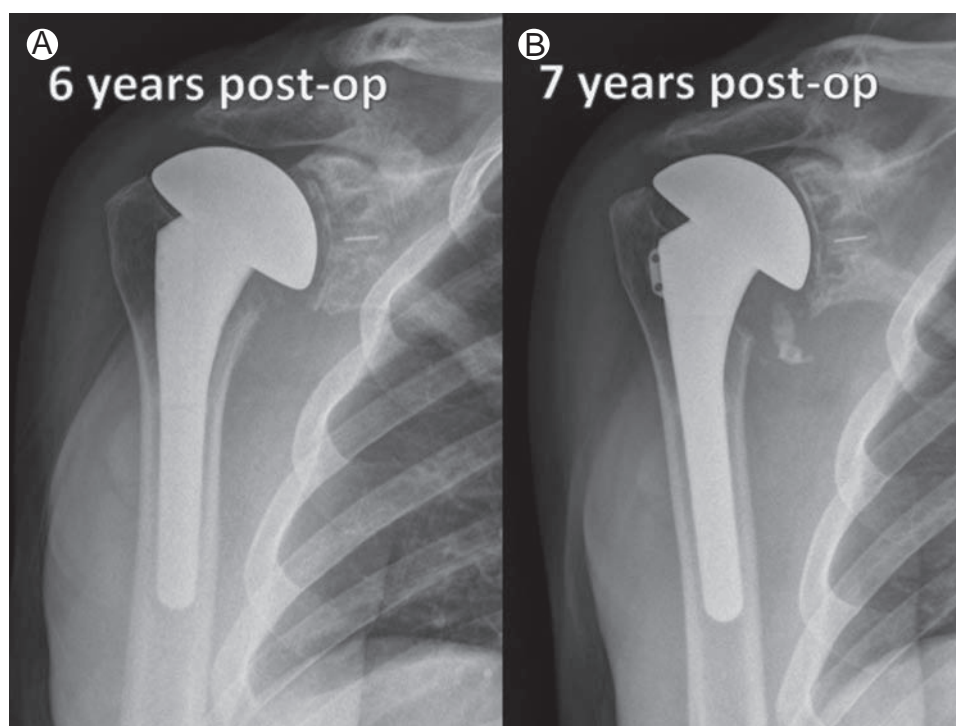


Figure 1 Sequential radiographs of an infected total shoulder arthroplasty, which demonstrate progressive humeral osteolysis most prominent in the inferomedial calcar (A) at 6 years and (B) at 7 years.

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