



Original research

Are patients being evaluated for periprosthetic joint infection prior to referral to a tertiary care center?

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ABSTRACT

Background: Patients with a painful or failed total joint arthroplasties should be evaluated for periprosthetic joint infection (PJI). The purpose of this study is to determine if patients referred to a tertiary care center had been evaluated for PJI according to the American Academy of Orthopaedic Surgeons (AAOS) clinical practice guidelines.

Methods: One hundred thirteen patients with painful hip (43) or knee (70) arthroplasties were referred to a single provider by orthopaedic surgeons outside our practice between 2012 and 2014. We retrospectively evaluated the workup by referring physicians, including measurement of serum erythrocyte sedimentation rate and C-reactive protein, performance of a joint aspiration if these values were abnormal, and obtainment of synovial fluid white blood cell count, differential, and cultures.

Results: Sixty-two of 113 patients (55%) did not have a workup that followed AAOS guidelines. Serum erythrocyte sedimentation rate and C-reactive protein were ordered for 64 of the 113 patients (57%). Of 25 patients with elevated inflammatory markers warranting aspiration, 15 (60%) had an aspiration attempted, with synovial fluid white blood cell, differential, and cultures obtained in 9 of 12 (75%) aspirations that yielded fluid. Of the 62 patients with an incomplete infection workup, 11 (18%) had a bone scan, 6 (10%) a computed tomography scan, and 3 (5%) a magnetic resonance imaging. Twelve of the 113 patients (11%) were ultimately diagnosed with PJI, with 5 undiagnosed prior to referral.

Conclusions: The AAOS guidelines to evaluate for PJI are frequently not being followed. Improving awareness of these guidelines may avoid unnecessary and costly evaluations and delay in the diagnosis of PJI.

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Introduction

Periprosthetic joint infection (PJI) is a devastating complication that accounted for 25% of revision total knee arthroplasties (TKAs) and 15% of revision total hip arthroplasties (THAs) in a recent study

of the National Inpatient Sample [1]. PJI places a substantial economic burden on the patient and healthcare system [2,3]. Given that treatment is fundamentally different, PJI must be excluded when a patient presents with a painful or failed total joint arthroplasty.

Determining the presence of PJI can be a challenge as there is no gold standard diagnostic tool. In 2010, a multidisciplinary team developed the American Academy of Orthopaedic Surgeons (AAOS) Clinical Practice Guideline on The Diagnosis of Periprosthetic Joint Infections of the Hip and Knee [4,5]. The guidelines were formulated using a rigorous standardized process, including a systematic review of the literature, with the goal of providing physicians with evidence-based recommendations for the workup of PJI.

The purpose of our study is to determine if patients referred to our tertiary center by other orthopaedic surgeons for painful or

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Table 1
Demographics of the 113 study patients.

Variable	Count (%) or mean (range)
Age (y)	62 (37–82)
Gender	
Female	70 (62%)
Male	43 (38%)
Prosthesis	
Total knee arthroplasty	66 (58%)
Total hip arthroplasty	39 (35%)
Unicondylar knee arthroplasty	3 (2.7%)
Bipolar hip hemiarthroplasty	3 (2.7%)
Hip resurfacing	1 (0.9%)
Bicompartmental knee arthroplasty	1 (0.9%)

failed THAs or TKAs had been evaluated for PJI according to AAOS guidelines. We asked the following questions: (1) Of patients referred to our center, what percentage had a serum erythrocyte sedimentation rate (ESR) and C-reactive protein (CRP) drawn followed by selective aspiration of the joint prior to referral? (2) Of the patients with an incomplete PJI workup, how many underwent advanced imaging studies—specifically bone scan, computed tomography (CT), or magnetic resonance imaging (MRI)—prior to referral? (3) What proportion of referred patients was ultimately determined to have a PJI and had this diagnosis been made prior to referral?

Material and methods

After institutional review board approval, a retrospective chart review of all patients referred to a single adult reconstruction specialist at a tertiary orthopaedic care center for evaluation of a painful or failed hip or knee arthroplasty between 2012 and 2014 was performed. Our primary aim was to evaluate referring provider compliance with the AAOS Clinical Practice Guideline for ruling out PJI. A total of 180 patients were identified using the senior author's daily clinic schedule and personal case log as well as billing records. We queried the medical records and Internet to determine the specialty and fellowship training of referring providers. Sixty-seven patients were excluded, including patients referred by non-orthopaedic surgeons (31), referrals within our orthopaedic practice (30), and self-referred patients (2). This left 113 patients with painful or failed hip (43) or knee (70) arthroplasties for inclusion. Demographics of the study cohort are provided in Table 1.

We reviewed all referral records to specifically assess compliance with 3 of the AAOS recommendations deemed “strong” (Table 2), including obtaining an ESR and a CRP followed by

selective aspiration of the joint. The algorithm used to evaluate compliance is summarized in Figure 1.

Of the patients with an incomplete infection workup, we noted how many underwent other advanced imaging studies—specifically a whole body bone scan, CT or MRI of the replaced joint—prior to referral. While it was difficult to delineate which studies were done to evaluate for infection (study indications often vaguely cited “pain”), these represented tests that were ordered prior to ruling out PJI with the recommended tests.

Finally, we recorded the proportion of patients ultimately determined to have a PJI using Musculoskeletal Infection Society criteria [6] and whether this diagnosis was made prior to referral.

Infection workup compliance rates were compared for patients with hip vs knee arthroplasties and between orthopaedic surgeons with and without subspecialty training in adult reconstructive surgery using the Pearson's chi-squared test ($P < .05$).

Results

Of the 113 patients referred by orthopaedic providers outside our practice, 62 (55%) did not have a workup that was compliant with AAOS guidelines (Fig. 2a). A serum ESR and CRP were performed for 64 of the 113 patients (57%). Of the 25 patients with elevated inflammatory markers warranting aspiration based on the AAOS guidelines, 15 (60%) underwent attempted aspiration (including 3 aspirations that yielded no fluid). The synovial fluid was sent for a synovial fluid white blood cell (WBC) count, differential, and cultures for only 9 of the 12 patients (75%) with a successful aspiration; cultures alone were obtained in the other 3 cases.

There were 3 hip patients in whom 1 of 2 inflammatory markers was elevated; all 3 had a workup deemed compliant with the AAOS guideline. Two patients had an elevated ESR (but normal CRP), lower suspicion for infection, and questionable plans for revision surgery at the time of referral. Given the AAOS guidelines for selective aspiration of the hip laid out in Table 2, these were considered compliant workups even though the referring physician did not pursue an aspiration. There was 1 hip patient with an elevated CRP (and normal ESR) but high suspicion for infection; this patient underwent aspiration by the referring provider in accordance with the AAOS guideline.

With the sample size available, there was not a statistically significant difference in workup compliance rates for patients with hip vs knee arthroplasties (44% vs 46%, $P = .862$; Fig. 2b and c) or patients referred by adult reconstruction subspecialists vs by other orthopaedic surgeons (49% vs 42%, $P = .493$) (Table 3).

Of the 62 patients with an incomplete evaluation for PJI, approximately one-third (20 patients or 32%) had an advanced

Table 2
Clinical practice guideline recommendations assessed for applicable patients.

Recommendation	Strength of recommendation		
Obtain serum ESR and CRP testing for all patients assessed for periprosthetic joint infection	Strong		
Aspirate joint of patients being assessed for periprosthetic knee infection who have abnormally elevated ESR and/or CRP. Send aspirated fluid for microbiologic culture, synovial fluid white blood cell count, and differential	Strong		
Selective approach to aspiration of the hip based on patient's probability of periprosthetic joint infection and the results of ESR and CRP testing:	Strong		
Probability of Infection	ESR/CRP Elevation	Planned Reoperation Status	Recommended Test
Higher	Both or one	Planned or not planned	Aspiration
Lower	Both or one	Planned	Aspiration or frozen section
Lower	Both	Not planned	Aspiration
Lower	One	Not planned	Re-evaluation within 3 months ^a
Send aspirated fluid for microbiologic culture, synovial fluid white blood cell count, and differential			

^a Strength of recommendation for this component (re-evaluation within 3 months) is “consensus”.

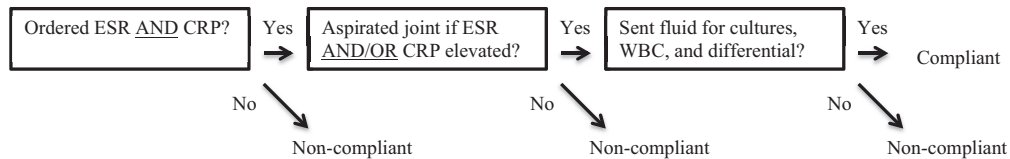


Figure 1. Algorithm used to evaluate PJI workup compliance with AAOS recommendations.

imaging study that is not recommended by the AAOS clinical practice guidelines, including 11 bone scans (18%), 6 CT scans (10%), and 3 MRIs (5%).

Twelve of the 113 (11%) referred patients were ultimately diagnosed with PJI, with 5 of the 12 (42%) infections undiagnosed prior to referral, including 4 patients who had an incomplete workup for PJI.

Discussion

Ruling out PJI is critical in the evaluation of a painful or failed lower extremity arthroplasty. Our study demonstrated that patients are not being adequately assessed for PJI prior to referral for a painful hip or knee replacement, even after the publication of the AAOS clinical practice guidelines in 2010. From 2012 to 2014, 2 years after the publication of this guideline, almost half (43%) of patients referred to our tertiary center did not have an ESR and CRP ordered, with only 60% undergoing a joint aspiration when it was indicated by elevated inflammatory markers. One-quarter (25%) of the surgeons who performed a successful aspiration failed to send the synovial fluid for the recommended tests, including a synovial fluid WBC count, differential, and cultures. Furthermore, one-third (32%) of patients with an incomplete workup for PJI had advanced imaging studies (bone scan, CT, MRI) performed that are currently

not recommended for the evaluation of PJI. Finally, nearly half (42%) of PJIs identified were undiagnosed prior to referral.

This study has several limitations that should be considered when interpreting our results. First, the retrospective nature of the study may have impaired our ability to determine the entire workup undertaken prior to referral even though the senior author requires all old records related to a painful arthroplasty prior to scheduling a referred patient. The requirement of all records may provide our study with a more comprehensive data set, but could also bias our results in terms of which patients are ultimately seen in the office. Similarly, the retrospective format limited our ability to identify indications for advanced imaging studies ordered prior to referral (for instance, whether a bone scan was ordered to assess for component loosening or a CT scan obtained to look for component malrotation). However, we highlight instances when advanced imaging was pursued before basic screening for PJI, which represents a deviation from the AAOS clinical practice guideline regardless of the indication for advanced imaging. Finally, this is a single-center, single-provider study, which may have introduced bias regarding referral patterns and prior workup for infection. However, the high volume and wide referral region of our tertiary care center hopefully allowed the identification of trends in the PJI workup being performed by referring providers in the orthopaedic community.

The reasons for low rates of observed compliance with AAOS guidelines among referring orthopaedic providers are unclear and

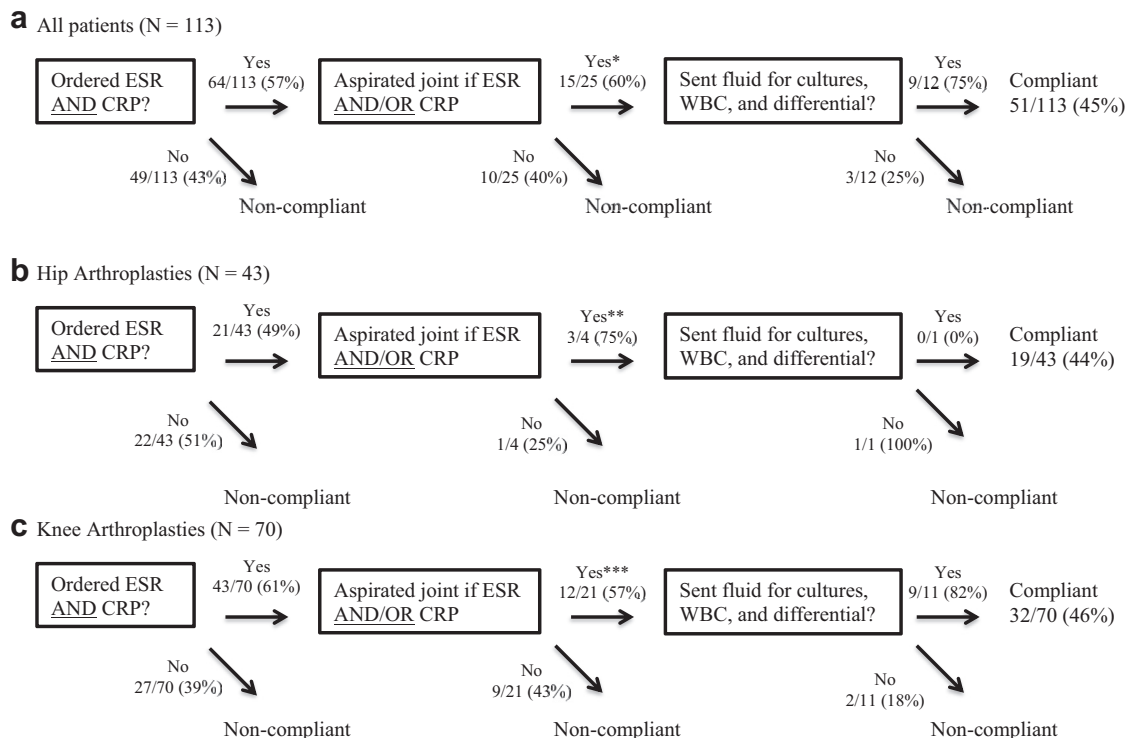


Figure 2. Workup compliance with AAOS PJI recommendations for (a) all referred patients with painful hip or knee arthroplasties, (b) hip arthroplasties only, and (c) knee arthroplasties only. *Includes 3 aspirations that yielded no fluid; **includes 2 aspirations that yielded no fluid; ***includes 1 aspiration that yielded no fluid.

Table 3
Compliance with AAOS guidelines by subspecialty of referring orthopaedist.

Subspecialty of referring provider	Compliance rate (%)
Adult reconstruction	23/47 (49)
General orthopaedics	17/43 (40)
Other orthopaedic subspecialty ^a	11/23 (48)

^a Includes sports, spine, hand, pediatrics, and foot and ankle subspecialists.

may include unfamiliarity with recommendations, an assumption that the necessary workup will be undertaken at the tertiary referral center, or an inappropriately low suspicion for infection in a surgeon's own patient. The purpose of AAOS clinical practice guidelines is to provide physicians with evidence-based recommendations based on a systematic review of the published literature by a multidisciplinary group of experts in a process that is subject to peer review and updates. In this study, we limited our analysis to patients referred by fellow orthopaedic surgeons, as it may be unfair or unrealistic to expect referring physicians in other specialties to be familiar with an orthopaedic society's guidelines. Nonetheless, rates of observed compliance were low, and not significantly different between adult reconstruction specialists and orthopaedists in other subspecialties with the sample size available. This suggests that mere lack of knowledge of guidelines was not fully responsible for poor compliance. That said, promoting greater awareness of clinical practice guidelines among the orthopaedic community, and among other practitioners who commonly care for arthroplasty patients, is a tangible goal for the AAOS that could enhance patient care by ensuring that a basic workup for PJI is properly undertaken.

It is plausible that referring providers assume that an appropriate diagnostic workup will be undertaken at the tertiary care center and thus abstain from pursuing a workup to rule out PJI. For instance, in orthopaedic oncology, there is an emphasis on the biopsy of musculoskeletal tumors being performed by the oncologic specialist who will perform the definitive surgery, due in part to a greater frequency of major errors when the biopsy is performed at a referring institution [7-9]. We are unaware of studies showing parallel errors as it pertains to joint aspiration in the arthroplasty literature. As a busy tertiary referral center, we believe that proper early workup by referring practitioners to rule out PJI, including joint aspiration in the setting of elevated inflammatory markers, can expedite care and help to avoid the ordering of expensive advanced imaging studies with unproven utility [4,5] and potentially harmful side effects (eg, radiation exposure, intravenous contrast-related renal toxicity).

Practitioner skepticism regarding strength of evidence or clinical utility also could have contributed to poor compliance with the AAOS-recommended practices assessed in this study. Evaluation after guideline development has been performed for other topics [10-20]. While some studies found improvements in care standardization with clinical practice guidelines [14,16], one critique has been that “the quality and usefulness of CPGs (clinical practice guidelines) are determined primarily by the strength and clarity of underlying evidence” [21]. In the case of PJI, we focused on workup parameters with the strongest available evidence [5]—parameters that have widely been accepted as standard of care for the initial evaluation of painful hip or knee arthroplasties [6]. ESR and CRP have been demonstrated to be excellent screening tests for PJI [22-26], with combined diagnostic sensitivity reaching 97.6% [25]. Multiple level I studies have verified the high diagnostic accuracy of synovial fluid WBC and neutrophil differential in the setting of THA [27-29] and TKA [22-30], solidifying aspiration as the appropriate next step when inflammatory markers are elevated. Finally,

obtaining cultures enables the identification of infecting bacteria and targeting of antibiotic therapy; superior specificity (91%-100%) vs sensitivity (50%-92.8%) supports the use of cultures as a “rule in” test for PJI [27,31-36]. Given the abundance of supporting data, it remains possible but perhaps less likely that skepticism about strength of evidence or clinical utility was a major driver of poor compliance with the AAOS recommendations assessed.

Conclusions

Overall, we found poor adherence to the AAOS clinical practice guideline for PJI workup by orthopaedists referring patients with painful or failed hip or knee arthroplasties to our center. This was associated with a considerable number of undiagnosed periprosthetic infections. The noncompliant workups, including ordering of advanced imaging, likely contributed to added expense and a delay in proper care. Future work should explore reasons for provider noncompliance to target education on evaluating patients for PJI.

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