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Early Periprosthetic Joint Infection Rates Following Total Hip and Knee Arthroplasty: A Single-Center Study

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Abstract

Objective: Periprosthetic joint infections are one of the frightening complications of total joint arthroplasty. This complication has devastating effects on patients, and the acute ones are mostly healthcare-associated and preventable. In this clinical study, we aimed to determine the incidence of acute periprosthetic joint infections in primary total hip arthroplasty (THA) and primary total knee arthroplasty (TKA) cases performed over 1 year in our tertiary referral center.

Methods: Between February 15, 2015, and February 16, 2016, 212 arthroplasty surgeries were performed, of which 89 procedures were THA and 123 were TKA. In addition, the operating room infrastructure and patient preparations were made following the guidelines for diagnosing and preventing periprosthetic joint infections published in 2013, and cooperation was established with the Infection Committee of Cerrahpaşa Faculty of Medicine.

Results: The mean age of the patients who underwent THA was 51.7 (minimum: 16; maximum: 90), and the mean age of the patients who underwent TKA was 65.3 (minimum: 30; maximum: 85). One of the THA (1.1%) and 3 of the TKA (2.4%) patients were diagnosed with early periprosthetic joint infection and treated accordingly. When all hip and knee arthroplasties were evaluated together, the total infection rate was 1.8%.

Conclusion: Our results were similar to the results of other incidence-indicating publications. The preventive measures mentioned in the guidelines such as the use of mupirocin and the application of a chlorhexidine bath before the day of the surgery, reducing the transfusion rates by application of tranexamic acid, and the use of chlorhexidine and povidone-iodine together for surgical site cleaning were taken in our clinic to decrease the early periprosthetic joint infection rate.

Keywords: Prosthesis-related infections, total joint replacement, arthroplasty

Introduction

Life expectancy has increased dramatically in the last few decades.[1] This situation has significantly increased the number of total hip arthroplasties (THA) and total knee arthroplasties (TKA) performed.[2] While arthroplasty surgeries aim to provide a relatively comfortable and functional life for the patient, they are not without risks.[3] Periprosthetic joint infection (PJI) is one of the most devastating complications of total joint arthroplasties, and it is also one of the most common causes of revision surgeries.[4,5] The rate is increasing exponentially.[6] The PJI treatment strategies differ according to the time elapsed after index surgery and are named early and late PJIs.[7] Early PJIs cover the first 3 months after index surgery, and late PJIs cover the 3 and more months after the surgery.[7] This classification is essential because early PJIs are mostly nosocomial and thus preventable.

To be able to avoid this complication, the fundamental reasons for PJIs should be understood. First, a foreign body such as an implant significantly increases susceptibility to infection, reducing the minimum number of bacteria required for local and hematogenous spread.[8] Local spread accounts for the contamination of the implants by the skin flora or exogenous sources from the surgical room, mainly occurring during prosthesis implantation.[6] Commonly isolated organisms are *Staphylococcus aureus*, coagulase-negative *Staphylococcus*, streptococci, and Enterobacteriaceae.[9] Hematogenous spread occurs when there is an active infection at the time of surgery or the patient's immune system is compromised because of uncontrolled diabetes,[10,11] malnutrition,[12] obesity,[13] smoking,[14,15] kidney disease,[16] and liver disease.[17-19]

The diagnosis of PJI is challenging. Making the right call is essential because even early PJI treatment can cause additional morbidity to the patient, and the risk of infection increases with the number of operations performed. To address the prevention and to make the diagnosis of PJI, the Musculoskeletal Infection Society's (MSIS) standardized algorithm[20] and additionally the recent Centers for Disease Control and Prevention manual were used for follow-up.[21] The MSIS protocol aims to establish a precise diagnosis algorithm, provide guidelines for the prevention of PJIs, and determine optimal treatment according to the PJI classification. The first aspect of the algorithm is the diagnosis, and the diagnostic criteria are summarized in the chart below.

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Major Criteria

- The presence of a sinus tract communicating with the prosthesis.
- A positive culture for phenotypically identical organisms from at least two separate tissue or fluid samples obtained from the affected joint.

Minor Criteria

- Elevated serum C- reactive protein (CRP) and serum erythrocyte sedimentation rate (ESR).
- Elevated synovial white blood cell (WBC) count or two positive change on leukocyte esterase test strip.
- Elevated synovial neutrophil percentage (PMN%).
- Isolation of a microorganism in only one culture.
- Greater than five neutrophils per high-power field in five high-power fields at ×400 magnification.

However, clinical suspicion is paramount, and PJI should be considered even if less than 4 of those criteria are met.[20]

The second aspect of this algorithm is to determine how to prevent and treat this catastrophic complication. The modifiable factors of the patients were documented, and the improvements that could be made in the operating room and its personnel were discussed thoroughly.[20]

In this study, we aimed to define the early PJI incidence in our tertiary hospital, which follows the recent guidelines proposed by MSIS, and to understand the effect of the modifiable patient/hospital factors' role on our PJI rates for future improvements.

Methods

This study was approved by the institutional review board (IRB no.: 83045809/604.01/45955). In addition, written informed consents were obtained from the patients.

Consecutive patients who underwent primary THA and TKA for hip and knee osteoarthritis, respectively, between February 15, 2015, and February 16, 2016, were included in the study. All patients were followed up for at least 1 year. If the patients were lost to follow-up in routine outpatient clinic visits, the patients were called via their contact numbers to elicit their status after 1 year of their arthroplasty surgeries. The patients who were operated bilaterally and had previous hip and knee surgery, also having arthrosis due to rheumatoid arthritis and septic arthritis were excluded from the study due to the higher PJI rate seen in these patient groups.[22,23]

The orthopedic surgeon examined the patients who underwent primary hip and knee arthroplasty. The routine examination was performed in the postoperative first, third, and sixth weeks. The patients could contact their physician in case of any related problems and were invited to the clinic for additional physical examinations. In every examination, the patients were asked to rate their pain according to visual analogue scale (VAS), and the surgical site was evaluated for possible changes associated with infection, such as redness, warmth, and drainage. Additionally, laboratory values such as white blood cell (WBC) count, C-reactive protein (CRP), and erythrocyte sedimentation rate (ESR) were obtained. The patients with clinical suspicion were evaluated by the infectious diseases' specialist as well.

Joint aspiration was performed if the WBC count was higher than 10 000 μL, the CRP value was higher than 5 mg/L, the ESR was higher than 20 mm/h, and/or the patient had a physical examination that also indicated a possible PJI. The joint fluid aspirates were then sent to culture. When specific bacteria were identified in a positive culture for PJI, a single culture was sufficient to confirm the diagnosis. However, if the culture was positive for nonspecific bacteria, then additional joint fluid samples were obtained each 1 week apart, up to 3 times. Periprosthetic joint infection diagnosis was made if the cultures were positive according to the criteria mentioned earlier, and revision surgery was performed afterward. All total hip and knee arthroplasty cases' documents were collected from archives and compared to each other to determine the infection incidence in our clinic. To understand the possible effects of modifiable factors mentioned in the literature, preoperative hemoglobin levels, blood transfusions used, and surgery durations were collected for all patients and compared between PJI and non-PJI patients.

We routinely used several measures to prevent PJI. Although a debated practice, all patients received preoperative topical intranasal mupirocin treatment for 1 week. Patients were also asked to bathe with chlorhexidine 1 night before surgery. Arthroplasty cases were performed in operating rooms that have vertical laminar air flow ventilation. Preoperative hair removal is performed at the operating room with hair clippers. Antibiotic prophylaxis was done by 1 g cefazolin injection 1 hour before the surgery, which was continued 3 times a day for 24 hours. The surgical area is washed with chlorhexidine solutions by the operating room personnel. Surgical staff completes surgical hand washing in 3 minutes using surgical scrubs, as the World Health Organization recommended.[24] Surgical hand antisepsis was completed using additional alcohol rubs. The surgical staff used a double layer of reusable surgical gowns. Initial surgical site preparation was performed using a 10% povidone-iodine solution, left to dry. After achieving dryness of the site, a solution with chlorhexidine gluconate and alcohol was applied for final surgical site preparation. Single-use drapes were used to create an aseptic environment for the surgery. The operating room personnel was instructed not to leave and enter the room unnecessarily. Zimmer Biomet® or Smith& Nephew® products were used for the treatment of THA and TKA patients. None of the surgeries were performed with body exhaust suits. The surgical drains (Bıçakcılar® B-VAK tissue drainage system) were used in all our patients, and they were removed 24 hours after surgery. On the day of surgery, patients were seated on the edge of the bed. On the first day, the patients were mobilized with a walker. Continuous passive motion was also initialized on the first day of the surgery, started with 60° of flexion and gradually increased as tolerated by the TKA patient.

Statistical analyses were performed using the Statistical Package for Social Science Statistics software for Windows, Version 28. Comparisons of total hip and knee arthroplasty groups were done using the independent samples *t* tests and comparisons for the infected patients were done using independent samples Kruskal–Wallis's test, and the significance values were adjusted by the Bonferroni correction for multiple tests. Significance was set at $P < .05$.

Results

Eighty-nine patients underwent THA, and 123 underwent TKA in 1 year (from February 15, 2015, to February 16, 2016). In total, 212 patients were included in the study. All patients were operated unilaterally. The mean ages of THA and TKA patients were 51.7 years (range, 16-90) and 65.3 years (range, 30-85 years), respectively. The mean age of all patients was 59.6 years (range, 16-90).

One (1.1%) THA patient and 3 (2.4%) TKA patients were diagnosed with acute PJI. The overall infection rate was 1.8% when all hip and knee arthroplasty cases were considered.

All TKA surgeries were performed under a thigh tourniquet. The mean surgery duration was 91.9 minutes (minimum: 60 minutes, maximum: 115 minutes) for non-infected THA cases, whereas it was 100 minutes for the infected THA case. As for TKA, tourniquet time was accepted as surgery duration. The mean surgery duration was 79.3 minutes (minimum: 45 minutes, maximum: 110 minutes) for non-infected TKA cases and 90 minutes (minimum: 80 minutes, maximum: 100 minutes) for infected TKA cases. Surgery duration comparisons between infected and non-infected groups among

their corresponding groups were not statistically significant but were longer in the infected groups.

The mean preoperative hemoglobin level was 11.2 g/dL (minimum: 9.5 g/dL, maximum: 13.3 g/dL) for non-infected THA cases and 9.6 g/dL for infected THA cases. The mean preoperative hemoglobin level was 11.8 g/dL (minimum: 9.8 g/dL, maximum: 14.0 g/dL) for non-infected TKA cases and 10.2 g/dL (minimum: 9.8 g/dL, maximum: 10.5 g/dL) for infected TKA cases. The preoperative hemoglobin level comparisons between infected and non-infected groups among their corresponding groups were not statistically significant (*P* for THA = .88, *P* for TKA = .11) but were lower in the infected groups. The mean packed red blood cell transfusion used was 1.9 units (minmum: 0 units, maximum: 4.0 units) for non-infected THA cases and 3.0 units for infected THA cases. The mean packed red blood cell transfusion used was 1.4 units (minimum: 0 units, maximum: 3.0 units) for non-infected TKA cases and 2.0 units (minimum: 1.0 units, maximum: 3.0 units) for infected TKA cases. The packed red blood cell transfusion used comparisons between infected and non-infected among their corresponding groups were not statistically significant (*P* for THA group: 1.00, *P* for TKA group: 1.00) but were higher in the infected groups.

Case 1

A 76-year-old female presented with hip pain and was diagnosed with coxarthrosis. She had no history of smoking or alcohol use. She had a history of hypophyseal adenoma surgery. Additionally, she had hypothyroidism and hypertension. She used levothyroxine, prednisolone, a calcium channel blocker, and risedronate. Her preoperative hemoglobin level was 9.6 g/dL. Cemented THA was performed via a posterolateral approach. The surgery lasted 100 minutes. The patient received 3 packed red blood cells and 1 unit of fresh frozen plasma transfusions. The surgical drain was used postoperatively. Drainage was 250 mL in total before the removal of the drain. Hemorrhagic drainage was seen on the postoperative fifth day. Infectious parameters were elevated, and piperacillin/tazobactam intravenous (IV) with teicoplanin was initiated after consulting with the infectious diseases department. On the 19th postoperative day, the patient complained of hip pain persisting for 4 days, and subsidence of the femoral stem was seen on the X-rays. Single-stage revision arthroplasty was performed on the postoperative 21st day.

No microorganisms were seen on direct microscopy with gram stain; however, there were numerous leukocytes. The patient received 2 units of erythrocyte suspension and 1 unit of fresh frozen plasma transfusion during the revision surgery. Antibiotic treatment was switched to teicoplanin IV and rifampicin IV for 6 weeks. Cultures grew *Staphylococcus epidermidis*, which was resistant to methicillin; therefore, the treatment was continued. A slight increase in the laboratory values was seen on the postoperative 24th day. However, infectious diseases recommended no changes to the treatment regimen. The patient was discharged after the completion of the antibiotic treatment. No clinical signs of infection were present at the time of discharge. No additional complications were encountered during the 8 years of follow-up.

Case 2

A 77-year-old male presented with knee pain and was diagnosed with gonarthrosis. He had no history of smoking or alcohol use. He did not have any previous surgical history. He had hypertension, which was well controlled with an angiotensin-converting enzyme inhibitor. His preoperative hemoglobin level was 10.2 g/dL. Cemented TKA was performed utilizing a tourniquet. The surgery duration was 90 minutes, and the tourniquet pressure was 300 mmHg. The patient received 3 units of packed red blood cells in addition to 1 unit of fresh frozen plasma transfusions. A surgical vacuum drain was used. On the first day of surgery, drainage was 300 mL in total, and the drain was removed. Following the removal of the drain, swelling due to hematoma was seen in the operated knee. The hospital stay was extended due to hemorrhagic discharge from the incision. On postoperative day 4, WBC was within the normal range. However, the CRP value was elevated. Clinical progression and elevation in the infectious parameters were observed, and irrigation/debridement with polyethylene insert change was performed on the postoperative 18th day. Nine liters of fluid were used for the irrigation. Microbiological samples revealed gram-positive diplococcus under direct microscopy with numerous leukocytes. Ampicillin 4 × 2 g IV treatment was initiated empirically per consultation with the infectious diseases department. Cultures grew methicillin-resistant coagulase-negative *Staphylococcus*. Teicoplanin and rifampicin treatment commenced on the second day after debridement. A dramatic change in the laboratory values was seen, which was correlated with an improvement in the patient's clinical condition. The patient was discharged on the postoperative 21st day after the debridement. No additional complications were encountered during the patient's 8 years of follow-up.

Case 3

A 52-year-old female presented with knee pain and was diagnosed with gonarthrosis. She had no history of smoking or alcohol use. She had undergone an arthroscopic meniscectomy of the same knee 9 years ago. She did not have any comorbidities. Her preoperative hemoglobin level was 10.5 g/dL. Cemented TKA was performed utilizing a tourniquet. The surgery lasted for 80 minutes, and the tourniquet pressure was 320 mm Hg. The patient received 1 unit of erythrocyte suspension and 1 unit of fresh frozen plasma transfusions. The surgical drain was used postoperatively. Drainage was 200 mL in total before the removal of the drain. She was discharged on the postoperative fifth day with no signs of infection. During the follow-up, she was readmitted on the postoperative 23rd day due to drainage from the midline of the incision for a week. Irrigation and debridement without polyethylene change was performed. Ten liters of fluid were used for the irrigation. No microorganism was seen on direct microscopy with gram stain; however, there were many leukocytes. Teicoplanin and rifampicin treatment was initiated after consulting with the infectious diseases department. Cultures grew Methicillin-resistant *Staphylococcus aureus*. Initial treatment was maintained for 6 weeks. Serous discharge was seen during the first week after the debridement. However, no additional drainage occurred afterward. The patient was asymptomatic and considered to be cured of PJI. No further complications were seen for the 7.5-years follow-up.

Case 4

The 81-year-old female presented with knee pain and an inability to walk for 10 minutes, also diagnosed with gonarthrosis. She had no history of smoking or alcohol use. She did not have any previous surgery. Her comorbidities were hypertension and major depression. She was using a calcium channel blocker and a selective serotonin reuptake inhibitor. Her preoperative hemoglobin level was 9.8 g/dL. Cemented TKA was performed utilizing a tourniquet. The surgery lasted for 100 minutes, and the tourniquet pressure was 320 mm Hg. The patient received 2 units of erythrocyte suspension and 1 unit of fresh frozen plasma transfusions. The surgical drain was used postoperatively. Drainage was 350 mL in total before the removal of the drain. She was discharged on the eighth postoperative day after an uneventful hospital stay. She was readmitted on

the postoperative 16th day due to discharge from the wound for 3 days. Linezolid IV and rifampicin IV treatments were initiated after consulting with the infectious diseases department. The patient refused surgical treatment, and the antibiotic treatment was continued until the infectious parameters decreased to normal values in the postoperative seventh week. On the postoperative 59th day, 18F-FDG-labeled leukocyte positron emission tomography/computed tomography was performed, and increased activity on the lateral femoral condyle was detected. This activity was considered a sign of infection. However, there were no clinical signs of infection, and the acute phase reactants were within normal levels; therefore, no further treatment was performed. The last follow-up available was 2 years after surgery, which revealed no abnormal findings.

Discussion

Eighty-nine patients underwent THA, and 123 underwent TKA in 1 year. In total, 212 patients were included in the study, and 1 (1.1%) THA patient and 3 (2.4%) TKA patients were diagnosed with acute PJI. The overall infection rate was 1.8% when all hip and knee arthroplasty cases were considered. Cases with PJI did not have significantly lower preoperative hemoglobin levels. Additionally, packed red blood cell transfusion was not significantly different between infected and non-infected groups. Our country's national nosocomial infection surveillance report was prepared in 2019, and the PJI rates were found to be 1.45% for THA and 0.45% for TKA. According to this data, our PJI rate was lower for THA but higher for TKA.[25]

Adeli and Parvizi[26] classified the risk factors into 3 groups: patient-related, surgery-related, and operating room-related. Patient-related risk factors for PJI include older age, cardiac disease, immunocompromisation, peripheral vascular disease, inflammatory arthritis, history of joint infection, renal and liver disease, psychiatric disorders, alcohol and tobacco use, anemia, malnutrition, and diabetes. The patients with PJI did not have any of these risk factors except one with major depression. However, age is also one of the potential risk factors for PJI. [27] Contrary to recent literature, which suggests that younger age is a risk factor for PJI[28], 3 out of 4 of our patients were older than 75 and also older than the mean age of their groups. The exact effect of age on PJI is yet to be understood.[29] Hypothyroidism is another risk factor for PJI,[30] and 1 of the patients was on levothyroxine treatment for this condition. Thyroid-stimulating hormone levels should be optimized before surgery, although the exact cut-off values are yet to be determined.[31] Another major risk factor is anemia. All our patients' preoperative hemoglobin levels were lower than their group's mean preoperative hemoglobin levels, and all our PJI patients received more blood transfusions than their corresponding. Allogeneic blood transfusion is considered to be a significant risk factor for PJI. However, the literature has conflicting views on the effect of transfusions on PJI risk. Pulido et al[32] found that allogeneic transfusion was associated with a higher PJI rate, whereas a recent meta-analysis concluded that blood transfusion was a protective factor.[28] Preoperative anemia is a risk factor for PJI, and special attention should be given to preparing the patients in the preoperative period to decrease the need for transfusion. Postponing the surgery to improve the preoperative hemoglobin levels would have reduced the needed blood transfusion, thus reducing the PJI risk for our patients. Also, the widely accepted use of tranexamic acid may decrease blood loss and limit the need for transfusions in the postoperative period.[33-35] Another essential tool is hypotensive anesthesia, which is especially important in reducing intraoperative blood loss and reducing the need for allogeneic transfusion.[36,37]

Surgery-related factors may also increase the risk of PJI. Surgery duration longer than 90 minutes [38] and 127 minutes are suggested to increase the risk of PJI in different studies. [39-41] These risk factors were identified in 2 out of 3 TKA PJI cases. As a modifiable risk factor, special efforts should be made to shorten the surgical time. We routinely use evacuation drains for total hip and knee arthroplasty cases. Hematoma formation is a known risk factor for PJI. However, the exact effect of surgical drains is still debated.[42] The surgical drains were removed on the first postoperative day. Prolonged use of these devices may increase the rate of PJI as backflow may occur through the drain tube. [43-45] Meticulous hemostasis and not using surgical drains may reduce the risk of PJIs. Our cases show higher drainage volumes before removal, which might be associated with hematoma formation, an excellent medium for bacteria. Using tranexamic acid for surgical site hemostasis, perioperatively and postoperatively, might help us avoid this situation. Tranexamic acid is an effective way to reduce intraoperative and postoperative blood loss[33,35,46], which may decrease the need for evacuation drains.

Different criteria can help identify patients with PJI, such as American Academy of Orthopaedic Surgeons (AAOS), MSIS, and Infectious Diseases Society of America (IDSA) criteria. We used the MSIS criteria to identify patients with PJI. However, it should be acknowledged that these are supplementary criteria, and they do not have sensitivity and specificity to be sure. [47]

Preoperative skin preparation is an essential step in preventing PJI. [42,48] Chlorhexidine-based preparation solutions are shown to reduce infection rates compared to povidone-iodine-based solutions. We use both techniques in a stepwise fashion. As our incidence rate is similar to the literature, combining these solutions may also effectively prevent PJI. These findings support the idea that meticulous surgical site preparation with a povidone-iodine and chlorhexidine combination may decrease the PJI rate. Hair removal is performed using clippers in the operating room area.[26,49] It is essential to do this procedure in the preoperative area, not the surgical room, to limit the particles in the operating room.

The quality of the air inside the operating room is of paramount importance. Our operating rooms were equipped with vertical laminar airflow systems. Although it was debated, recent studies show that laminar airflow is vital in preventing PJI. [26,50-52] Since the laminar flow depends on the enclosed environment inside the room, it is crucial to avoid the unnecessary opening of the doors during the surgery. [50] Moreover, each person should be considered a source of contamination, and the number of personnel inside the operating room should be minimized. Body exhaust systems may also decrease the number of particles that reach the surgical field. However, there are different exhaust airflow patterns, which, in some cases, increase contamination. [53] We think it is also essential to provide routine training to the operating room personnel to decrease the PJI rate. Operating room personnel are frequently given training on the importance of this matter to minimize the door opening during the surgery. It is also important to have enough consumables (i.e., gauze pads, sutures) and all of the equipment that may be needed in case a complication arises in addition to the standard equipment.

In our institution, surgical staff use a 4-minute hand wash and scrubbing before each case, double glove, and change the outermost layer after draping. Double gloving is considered an effective measure to reduce the number of innermost glove perforations;[54] however, using 3 sets of gloves may also be utilized. One of every 3 gloves gets contaminated, half of which occurs during the draping. [26] Changing the gloves every 3 hours or earlier is essential if a puncture is seen. [55]

Preoperative decolonization of *Staphylococcus aureus* carriage with intranasal mupirocin administration is a cost-effective way to prevent *S. aureus* surgical site infections. [56,57] We routinely use intranasal mupirocin starting 1 week before surgery, and only 1 out of 4 patients had an *S. aureus* infection.

Treatment aims to minimize morbidity and mortality by eradicating the infection and enabling the patient to mobilize independently as soon as possible. Treatment success is defined as the absence of signs of infection and symptoms of PJI. Although the debridement and implant retention (DAIR) method was considered appropriate for a minimal subgroup of PJI patients,[58-60] current literature supports its use if the symptoms appear during the first 4-6 weeks in the postoperative period.[61] All 4 patients were successfully treated with the DAIR method. Tornero et al[62] found that more than 1 comorbidity, symptoms appearing later than postoperative 15 days, higher mean CRP levels, and a higher percentage of culture-positive samples were associated with a higher failure rate for DAIR. Cobo et al[63] found that, although not statistically significant, longer symptom duration and Methicillin-resistant *Staphylococcus aureus* infection was associated with failure of DAIR. Azzam et al[60] found that infection with Staphylococcal species and frank purulent fluid around the implant were significant risk factors for debridement failure. Another study reported no recurrence of infection 1 year after the DAIR method for early PJI after THA in 20 patients. These results suggest that the DAIR method is effective for early PJI.[64]

The main limitation of the study is the low number of cases. Our university hospital focuses on arthroplasty surgeries, but due to the low PJI complication rate, we presented our PJI cases individually for an insight into diagnosis and treatment. To increase clinical relevance, we also compared the modifiable factors of our patients to understand which factors can be improved in the future, but it was not possible to obtain statistically significant data with such a low number of infections.

Considering these findings, our infection rate is within acceptable limits, and we still work with our infection committee in our institution to improve the rate of PJI. In addition, we continue to educate our staff and raise awareness about PJI. As a conclusion, following the periprosthetic joint infection prevention and diagnosis guidelines led to acceptable PJI rates in our hospital. Also, defining the PJI early allowed DAIR surgery to be successful without the need for a more invasive approach like component exchange.

Data sharing: Available upon request.

Ethics Committee Approval: Ethical committee approval was received from the Ethics Committee of Istanbul University Cerrahpaşa Medical Faculty (Approval no: IRB no.: 83045809/604.01/45955, Date: 05 February 2016).

Informed Consent: Written informed consent was obtained from the patients who agreed to take part in the study.

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