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What is the Safe Distance Between Hip and Knee Implants to Reduce the Risk of Ipsilateral Metachronous Periprosthetic Joint Infection?

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Abstract

Background Periprosthetic joint infection (PJI), the most common cause of revision after TKA and THA, is a devastating complication for patients that is difficult to diagnose and treat. An increase in the number of patients with multiple joint arthroplasties in the same extremity will result in an increased risk of ipsilateral PJI. However, there is no definition of risk factors, micro-organism patterns, and safe distance between knee and hip implants for this patient group.

Questions/purposes (1) In patients with hip and knee arthroplasties on the same side who experience a PJI of one implant, are there factors associated with the development of subsequent PJI of the other implant? (2) In this patient group, how often is the same organism responsible for both PJIs? (3) Is a shorter distance from an infected prosthetic joint to an ipsilateral prosthetic joint associated with greater odds of subsequent infection of the second joint?

Methods We designed a retrospective study of a longitudinally maintained institutional database that identified all one-stage and two-stage procedures performed for chronic PJI of the hip and knee at our tertiary referral arthroplasty center between January 2010 and December 2018 (n = 2352). Of these patients, 6.8% (161 of 2352) had an ipsilateral hip or knee implant in situ at the time of receiving surgical treatment for a PJI of the hip or knee. The following criteria led to the exclusion of 39% (63 of 161) of these patients: 4.3% (seven of 161) for incomplete documentation, 30% (48 of 161) for unavailability of full-leg radiographs, and 5% (eight of 161) for synchronous infection. With regard to the latter, per internal protocol, all artificial joints were aspirated before septic surgery, allowing us to differentiate between synchronous and metachronous infection. The remaining 98 patients were included in the final analysis. Twenty patients experienced ipsilateral metachronous PJI during the study period (Group 1) and 78 patients did not experience a same-side PJI (Group 2). We analyzed the microbiological characteristics of bacteria during the first PJI and ipsilateral metachronous PJI. Calibrated, full-length plain

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This work was performed at the HELIOS ENDO-Klinik, Hamburg, Germany.

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radiographs were evaluated. Receiver operating characteristic curves were analyzed to determine the optimal cutoff for the stem-to-stem and empty native bone distance. The mean time between the initial PJI and ipsilateral metachronous PJI was 8 ± 14 months. Patients were followed for a minimum of 24 months for any complications.

Results The risk of ipsilateral metachronous PJI in the other joint secondary to a joint implant in which PJI develops can increase up to 20% in the first 2 years after the procedure. There was no difference between the two groups in age, sex, initial joint replacement (knee or hip), and BMI. However, patients in the ipsilateral metachronous PJI group were shorter and had a lower weight (1.6 ± 0.1 m and 76 ± 16 kg). An analysis of the microbiological characteristics of bacteria at the time of the initial PJI showed no differences in the proportions of difficult-to-treat, high virulence, and polymicrobial infections between the two groups (20% [20 of 98] versus 80% [78 of 98]). Our findings showed that the ipsilateral metachronous PJI group had a shorter stem-to-stem distance, shorter empty native bone distance, and a higher risk of cement restrictor failure ($p < 0.01$) than the 78 patients who did not experience ipsilateral metachronous PJI during the study period. An analysis of the receiver operating characteristic curve showed a cutoff of 7 cm for the empty native bone distance ($p < 0.01$), with a sensitivity of 72% and a specificity of 75%.

Conclusion The risk of ipsilateral metachronous PJI in patients with multiple joint arthroplasties is associated with shorter stature and stem-to-stem distance. Appropriate position of the cement restrictor and native bone distance are important in reducing the risk of ipsilateral metachronous PJI in these patients. Future studies might evaluate the risk of ipsilateral metachronous PJI owing to bone adjacency.

Level of Evidence Level III, therapeutic study.

Introduction

Many patients have more than one joint arthroplasty, and studies have estimated that one in 30 people living in Australia and the United States have at least one shoulder, hip, or knee implant in situ [14, 15, 18]. Furthermore, the number of people living with more than one joint replacement is increasing at a faster pace than the number of those living with only one joint replacement [15]. We have made little headway in preventing periprosthetic joint infection (PJI), the incidence of which has remained somewhat similar over the past 15 years [14, 16, 17]. PJI affects 1% of patients with a joint implant [21]. As a result, the absolute number of patients with PJI is rising. When treating a patient with PJI, there is a 33% to 45% chance the patient will have at least one additional joint implant in situ [1, 11, 12]. The chance of experiencing a PJI in a second joint is 8% to 20% [1, 12]. We do not have a good way to assess the risk of a metachronous PJI (periprosthetic infection in patients who have previously had PJI in another joint, after a lag period) in a joint in a patient who has a PJI in the other joint. The risk appears to be higher in patients in whom the initial PJI is accompanied by systemic inflammatory response syndrome or bacteremia, in whom the PJI is caused by methicillin-resistant *Staphylococcus aureus*, patients who must undergo three or more stages of resection arthroplasty, female patients, and those who have rheumatoid arthritis, all of which are nonmodifiable risk factors [1, 11, 12]. An orthopaedic surgeon might have a positive or negative impact on the chance that a subsequent PJI will develop in patients with an uninfected implant in the same bone as the infected implant.

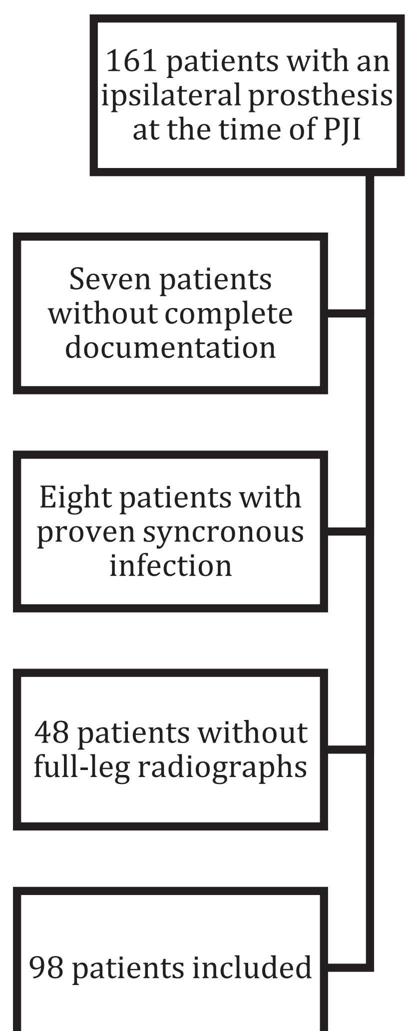

Fig. 1 This flow diagram shows the study's flow.

Although we know that most metachronous PJIs are caused by the same microorganisms that led to the initial PJI, the exact route of infection is not fully understood. Many may be hematogenic, but in a patient with an uninfected implant in the same bone as the infected implant, there is also a chance of continuous infection or infection by inoculation because of surgical procedures. Given the lack of data, there are no recommendations on this matter.

We therefore asked, (1) In patients with hip and knee arthroplasties on the same side who experience a PJI of one implant, are there factors associated with the development of subsequent PJI of the other implant? (2) In this patient group, how often is the same organism responsible for both PJIs? (3) Is a shorter distance from an infected prosthetic joint to an ipsilateral prosthetic joint associated with greater odds of subsequent infection of the second joint?

Patients and Methods

Study Design and Setting

This retrospective study used data from a longitudinally maintained institutional database of patients with PJI. The study was performed at a high-volume tertiary referral arthroplasty center, where approximately 7000 total joint arthroplasties are performed every year, with 400 to 500 PJIs treated each year. Our institution's practice is to perform a preoperative joint aspiration on all patients undergoing revision arthroplasty. Revisions for PJI were based on the International Consensus Meeting criteria [20, 23].

Participants

We identified all one-stage and two-stage procedures performed for chronic PJI of the hip and knee at our tertiary referral arthroplasty center between January 2010 and December 2018 (n = 2352). In this group, 161 patients received an ipsilateral hip or knee implant in situ at the time of undergoing surgical treatment for PJI of the hip or knee (Fig. 1). Sixty-three patients were excluded because they met the following criteria: incomplete documentation (seven patients), unavailability of full-leg radiographs (48), and synchronous infection (eight). Regarding the latter, per internal protocol, all artificial joints were aspirated before revision arthroplasty, allowing us to differentiate between synchronous and metachronous infection. Patients were followed for a minimum of 24 months for any complications. The remaining 98 patients were followed for a mean follow-up period of 85 ± 33 months (Table 1). Twenty percent (20 of 98) of patients experienced ipsilateral metachronous PJI during the study period. The mean time between the initial PJI and ipsilateral metachronous PJI was 8 ± 14 months. The ipsilateral metachronous PJI group was followed for 71 months (range 37 to 102 months), and the other group was followed for 79 months (range 34 to 135 months).

Descriptive Data and Variables

We divided the study population into two groups, one in whom a metachronous infection developed (n = 20) and the other in whom infection did not develop (n = 78). There was no difference in age, sex, BMI, and the initial PJI-affected joint between the two groups. In addition, the groups did not

Table 1. Descriptive data and procedure-related data (n = 98)

Parameter	Value
Age in years, mean ± SD	77 ± 9.6
BMI in kg/m^2, mean ± SD	30 ± 6.2
Height in meters, mean ± SD	1.68 ± 0.1
Weight in kg, mean ± SD	85 ± 21.4
Follow-up in months, mean ± SD	85 ± 33.2
Femur length in cm, mean ± SD	44 ± 7.0
Empty bone distance in cm, median (range)	8 (0-36)
Stem-to-stem distance in cm, median (range)	12 (1-43)
Female, % (n)	65 (64)
Right side, % (n)	56 (55)
Draining sinus (fistula) at first PJI, % (n)	20 (20)
First PJI, % (n)	
Hip	52 (51)
Knee	48 (47)
Difficult-to-treat infections, % (n)[a]	26 (26)
High-virulence infections, % (n)[a]	33 (32)
Polymicrobial infections, % (n)	11 (11)
Fungal infections, % (n)	1 (1)
Gram-positive pathogens, % (n)	17(17)
Culture-negative infection, % (n)	4 (4)
Proximal or distal femur resection, % (n)	14 (14)
Cement restrictor failure, % (n)	18 (18)
One-stage or two-stage protocol, % (n)	
One-stage	76 (77)
Two-stage	23 (23)

[a]Difficult-to-treat infections are defined as those caused by rifampicin-resistant staphylococci, fluoroquinolone-resistant streptococci, enterococci, and fungi. High-virulence infections are defined as those cause by *S. aureus*, *Enterobacteriaceae*, *Streptococcus spp*., and *Candida spp*.

differ in terms of bacterial virulence (high and low virulence were defined by Morgenstern et al. [19]), polymicrobial infection, and difficult-to-treat germs (defined as those caused by rifampicin-resistant staphylococci, fluoroquinolone-resistant streptococci, enterococci, and fungi [2, 7]). Of the patients, 65% (64 of 98) were female; the mean patient age was 77 ± 9.6 years, and the mean BMI was 30 ± 6.2 kg/m^2. The implants were located on the right side in 56% (55 of 98) of the patients. The prosthesis with the primary infection was the hip in 52% (51 of 98) of the patients. The mean follow-up period was 85 ± 33 months (Table 1).

Primary and Secondary Outcome Measures

The primary study goal was to determine whether there were factors associated with the development of subsequent PJI of the other implant in patients with both a hip and knee arthroplasty on the same side who experienced a PJI of one implant. To achieve this, we studied the following patient-related risk factors: sex, age, BMI, rheumatoid arthritis, renal insufficiency (Grade > 3 as defined by Kidney Disease Outcomes Quality Initiative and modified and endorsed by Kidney Disease: Improving Global Outcomes [6]), coronary heart disease, and chronic obstructive pulmonary disease or asthma.

The secondary study goal was to determine how often the same organism was responsible for both PJIs. To achieve this, we studied the following PJI-related risk factors: the presence of a draining sinus, a one-stage or two-stage procedure for the initial PJI treatment, type of microorganisms (gram-positive, gram-negative, fungi, and polymicrobial) and microbiological characteristics (high-virulence bacteria, defined as *S. aureus*, *Enterobacteriaceae*, *Streptococcus spp.,* and *Candida spp.*; and difficult-to-treat organisms, defined as rifampicin-resistant staphylococci, fluoroquinolone-resistant streptococci, enterococci, and fungi) [2].

The third study goal was to determine whether a shorter distance from an infected prosthetic joint to the ipsilateral prosthetic joint was associated with greater odds of subsequent infection of the second joint. To achieve this, we analyzed calibrated full-leg radiographs containing three radiographic parameters that may lead to an increased risk of ipsilateral metachronous infection. These were (1) stem-to-stem distance, defined as the distance between the tips of the femoral components of the hip and knee implants (Fig. 2A) (for primary TKA, the pegs of the femoral component on a lateral radiograph were used [Fig. 3]); (2) femoral empty native bone distance (Fig. 2B), defined as the distance between the ends of the cement of both femoral components; and (3) cement restrictor failure, defined as radiographic evidence of cement that unintentionally went beyond the cement stop (Fig. 4).

Ethical Approval

The study was approved by the ethics committee of our institution (approval number 2022-300156-WF).

Statistical Analysis

We used the Shapiro-Wilk test to assess the normality of the distribution of continuous variables. Then, we used descriptive statistics (mean, median, and standard deviation) to describe the patients' variables and radiologic data. Categorical variables were assessed using the chi-square test or Fisher exact test for statistical significance. We compared continuous variables using paired and unpaired t-tests, as appropriate. Receiver operating characteristic (ROC) curves were created and then

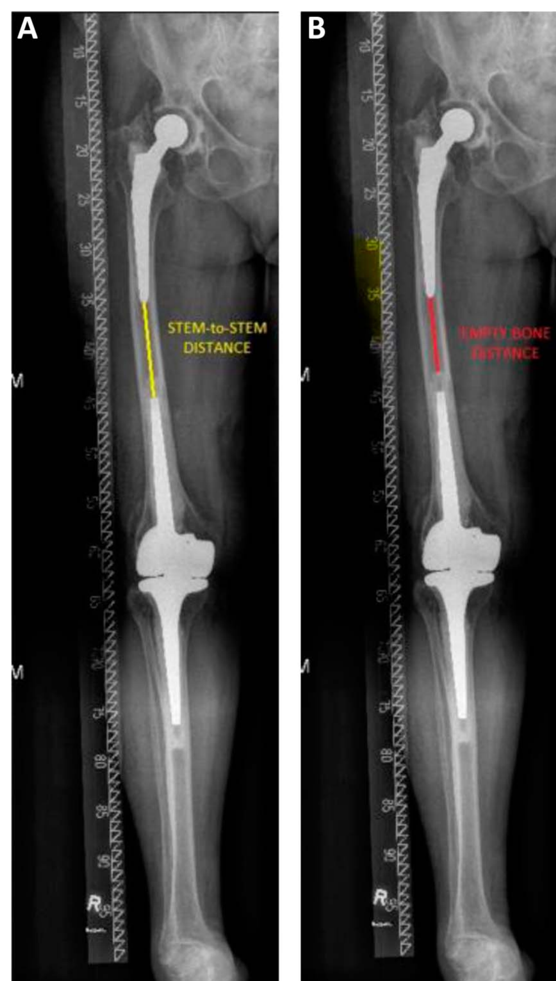

Fig. 2 Radiographic measurement of the (**A**) stem-to-stem distance and (**B**) the empty native bone distance is shown in a revision TKA.

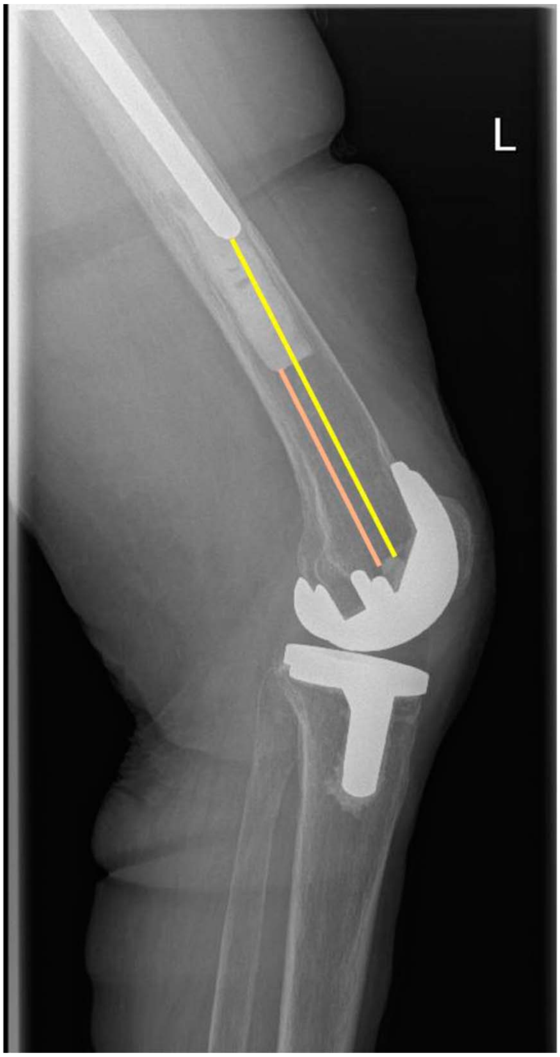

Fig. 3 Radiographic measurement of the stem-to-stem distance (yellow) and the empty native bone distance (red) is shown in a patient undergoing a primary TKA.

studied to analyze the cutoff for stem-to-stem distance and empty native bone distance. A post hoc power analysis was performed for stem-to-stem distance, empty bone distance, and cement restrictor failure. All p values < 0.05 were considered statistically significant. All data were analyzed using SAS® version 9.3 (SAS Institute).

Results

Factors Associated With the Development of Ipsilateral Metachronous PJI

Patients in whom ipsilateral metachronous PJI developed were shorter and weighed less than those in whom an

Fig. 4 This figure shows radiographic evidence of cement restrictor failure with cement protruding distally to the cement stop used for the revision THA.

infection did not develop (1.6 ± 0.1 m and 76 ± 16 kg for height and weight, respectively) (Table 2). We found no

Table 2. Demographic data of patients with ipsilateral and metachronous PJI and those with contralateral PJI

Parameter	Contralateral metachronous PJI at the final follow-up (n = 78)	Ipsilateral metachronous PJI at the final follow-up (n = 20)	Mean difference (95% CI)	p value
Age in years, mean ± SD	76 ± 10	80 ± 7	-4 (-8 to 1)	0.14
BMI in kg/m^2, mean ± SD	30 ± 6	29 ± 6.5	1 (-2 to 4)	0.47
Height in m, mean ± SD	1.7 ± 0.1	1.6 ± 0.1	0.1 (0 to 0.1)	0.003
Weight in kg, mean ± SD	87 ± 22	76 ± 16	10 (0 to 21)	0.04
Femur length in cm, mean ± SD	44 ± 8	42 ± 4	2 (-1 to 6)	0.21

differences in age, sex, the initial prosthetic joint involved, or BMI between groups (Table 3). We found no differences in the incidence of PJI-induced fever (15% [3 of 20] versus 4% [3 of 78]; $p > 0.01$), rheumatoid arthritis (20% [4 of 20] versus 9% [7 of 78]; $p > 0.01$), or renal insufficiency (40% [8 of 20] versus 21% [16 of 78]; $p > 0.01$) between groups (Table 3). We also found no differences in femur length between groups (42 ± 4.1 cm versus 44 ± 7.6 cm; $p > 0.01$).

Microbiology of Metachronous PJI

Patients in whom ipsilateral PJI developed were no more likely to present with difficult-to-treat organisms (20% [4 of 20] versus 28% [22 of 78]; $p > 0.1$), high-virulence organisms (25% [5 of 20] versus 34% [27 of 78]; $p > 0.1$), or polymicrobial infections (10% [2 of 20] versus 12% [9 of 78]; $p > 0.1$) than those who did not (Table 3). Patients who underwent bone resections as part of the treatment of

Table 3. Surgical characteristics of patients with ipsilateral and contralateral metachronous PJI

Parameter	Contralateral metachronous PJI at the most-recent follow-up (n = 78)	Ipsilateral metachronous PJI at the most-recent follow-up (n = 20)	Odds ratio (95% CI)	p value
Female	62 (48)	80 (16)		0.19
Initial PJI				
Hip	54 (42)	%45 (9)		0.62
Knee	46 (3 6)	55 (11)		
Difficult-to-treat infections[a]	28 (22)	20 (4)		0.57
High-virulence infection[a]	34 (27)	25 (5)		0.59
Polymicrobial infections	12 (9)	10 (2)		0.33
Fungal infection	0 (0)	5 (1)		0.45
Gram-positive pathogens	15 (12)	25 (5)		0.33
Culture-negative infections	4 (3)	5 (1)		0.23
Proximal or distal femur resection	5 (4)	50 (10)	0.2 (0.1 to 0.3)	0.001
Cement restrictor failure	5 (4)	70 (14)	0.1 (0.0 to 0.2)	0.001
Same bacteria causing the ipsilateral metachronous PJI	0 (0)	70 (14)		
Fever at presentation	4 (3)	15 (3)		0.09
Rheumatoid arthritis	9 (7)	20 (4)		0.23
Renal insufficiency	21 (16)	40 (8)		0.09
Coronary heart disease	15 (12)	10 (2)		0.73

Data are presented as % (n).
[a]Difficult-to-treat infections are defined as those caused by rifampicin-resistant staphylococci, fluoroquinolone-resistant streptococci, enterococci, and fungi. High-virulence infections are defined as those cause by *S. aureus*, *Enterobacteriaceae*, *Streptococcus spp*., and *Candida spp*.

PJI had higher odds of having metachronous PJI than those who underwent single-stage exchange arthroplasty (50% [10 of 20] versus 5% [four of 78]; p < 0.01).

Minimum Safe Distance Between Implants

Patients in whom ipsilateral metachronous PJI developed had a shorter stem-to-stem (8 ± 5 cm versus 14 ± 7 cm; p < 0.01) and empty native bone distance (5 ± 4 cm versus 11 ± 7 cm; p < 0.01) (Table 4) and higher risk of extrusion of cement past their restrictor (70% [14 of 20] versus 5% [four of 78]; p < 0.01) than patients in whom such an infection did not develop (Table 3).

Analysis of the ROC curve (Table 5) showed a cutoff of 7 cm for the empty native bone distance (p < 0.01), with a sensitivity of 72% and specificity of 75% (Fig. 5). A cutoff of 9 cm for the stem-to-stem distance was found (p < 0.01), with a sensitivity of 74% and specificity of 70%. In absolute numbers, this means that 7% (four of 61) of patients with an empty native bone distance of more than 7 cm experienced ipsilateral metachronous PJI, whereas 43% (16 of 37) of patients with an empty native bone distance of less than 7 cm experienced ipsilateral metachronous PJI (p < 0.01).

Discussion

PJI, the most common cause of failure and reason for revision after TKA and THA, is a devastating complication with a challenging diagnosis and treatment process [5, 8, 28]. Moreover, the incidence of a much more severe condition such as multiple PJIs (including synchronous and metachronous) has been rising because of the expanding number of patients with more than one prosthetic joint, and it has become necessary for orthopaedic surgeons to have a deeper understanding of multiple PJIs [12, 22]. Identifying the risk factors, micro-organism patterns, and safe distance between implants for metachronous PJIs as well as patients who may benefit from additional investigation is essential in these patient groups. This clinical study emphasized that patients with a shorter stature and narrow stem-to-stem distance between two implants should be more careful regarding the risk of ipsilateral metachronous PJI.

Limitations

First, the sample was relatively small, even though more than 2000 exchange arthroplasties for PJI were performed in almost a decade at our tertiary referral center using a consistent philosophy that has been in place since the 1980s. This could have led to a Type II statistical error; that is, failure to identify statistically significant findings that would have been found if the sample was larger. Nevertheless, important and new findings were already detectable, regardless of the small number of patients available for analysis.

Second, the study was at risk of assessment bias and transfer bias because metachronous PJIs could have been missed if patients remained relatively asymptomatic or went to other hospitals for treatment. However, it seems very unlikely that this would change the main finding of this study; that is, that a minimum distance should be kept between the infected implant that is being revised and the uninfected implant in the same femur.

Third, 30% (six of 20) of patients with ipsilateral metachronous PJI had different bacteria in the metachronous PJI than in the initial PJI. This weakens our hypothesis that these metachronous infections are caused by either contiguous spread or direct inoculation, to some extent. However, it is a well-known phenomenon that recurrent infection (in the same or in another artificial joint) is often caused by different or additional micro-organisms [3, 4], which is probably related to the overall health status of the host. Additionally, the chance a metachronous infection of an implant will develop in the same femur is higher than when the implant is in the contralateral femur, indicating that infections by either contiguous spread or direct inoculation plays a role [24].

Factors Associated With the Development of Ipsilateral Metachronous PJI

Patients in whom ipsilateral metachronous PJI developed were shorter and weighed less than those who did not

Table 4. Empty bone and stem-to-stem distance of patients

Parameter	Contralateral metachronous PJI at final follow-up (n = 78)	Ipsilateral metachronous PJI at final follow-up (n = 20)	Mean difference (95% CI)	p value
Empty native bone distance in cm, mean ± SD	11 ± 7	5 ± 4	6 (4 to 9)	0.001
Stem-to-stem distance in cm, mean ± SD	14 ± 7	8 ± 5	6 (3 to 9)	0.001

Table 5. An ROC analysis of the empty bone and stem-to-stem distance of patients

Test result variable	Cutoff value, cm	Sensitivity, %	Specificity, %	AUC	95% CI AUC	p value
Empty native bone distance	7.0	72	75	0.78	0.67 to 0.89	0.001
Stem-to-stem distance	9.0	74	70	0.75	0.64 to 0.87	0.001

ROC = receiver operating characteristic; AUC = area under the curve.

experience ipsilateral metachronous PJI, but we otherwise found no differences between groups in age, sex, the initial prosthetic joint involved, and BMI. Ninety-eight patients had an uninfected THA or TKA implant in situ at the time of receiving surgical treatment for ipsilateral PJI of the hip or knee. During a mean follow-up duration of more than 7 years, one of five patients experienced ipsilateral metachronous PJI. Although this is in line with earlier studies [9, 13], previously identified factors did not apply to our study population. Considering demographic data that may have an impact on the risk of ipsilateral metachronous PJI, age, BMI, and sex did not differ between those with PJI and those without in this study. Similarly, Lee et al. [12] compared patients with a single PJI and multiple PJIs, and found that the same demographic data (age, sex, and BMI) did not change the risk of PJI [17]. On the other hand, a respective evaluation of weight and height showed that patients with ipsilateral metachronous PJI were shorter and thinner, and there was a difference between groups with and without PJI in terms of these two parameters. In addition, in a study by Komnos et al. [11], the presence of coexisting rheumatoid arthritis led to an increased incidence of multiple PJIs. In the present study, however, rheumatoid arthritis, renal failure, and coronary artery disease were not associated with a difference between patients with same-side PJI and those without.

Microbiology of Metachronous PJI

Patients with ipsilateral PJI were no more likely than those without to present with difficult-to-treat organisms, high-virulence organisms, or polymicrobial infections. The rate of difficult-to-treat organisms was reported to be up to 38% in patients undergoing one-stage exchange arthroplasty after PJI [27]. In addition, research comparing one- and two-stage exchange arthroplasties performed after PJI found that the rate of reinfection was higher in patients infected with difficult-to-treat organisms [26]. The rate of difficult-to-treat organisms was found to be 20% to 30% in both groups of the present study, in which the risk of reinfection was still high although lower than that reported previously. Infection with highly virulent organisms was associated with a poor outcome and a high risk of revision

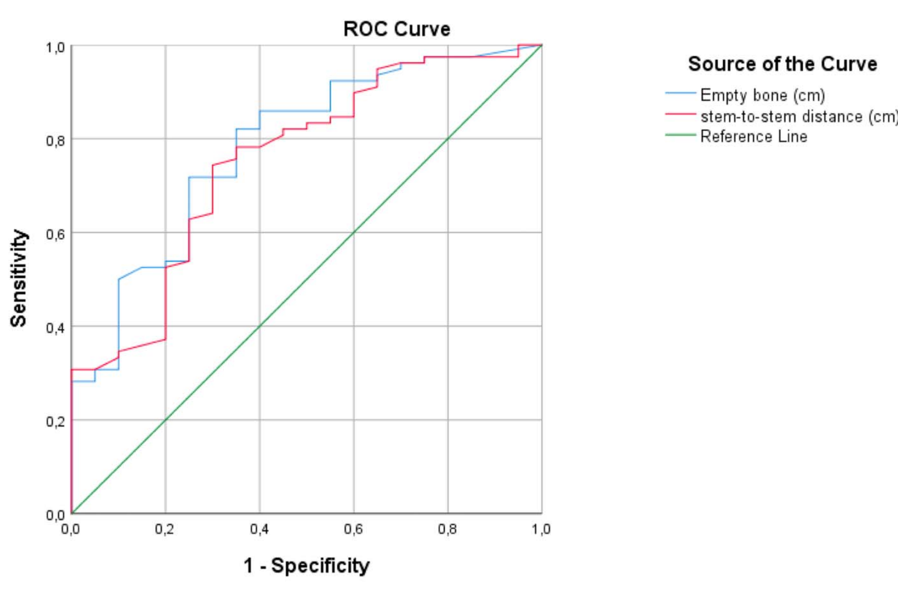

Fig. 5 A receiver operating characteristic curve analysis was used in this study to determine the optimal cutoff for the stem-to-stem and empty native bone distance. A color image accompanies the online version of this article.

[6, 25]. In the present study, 25% to 35% of the patients in both groups were infected with highly virulent organisms and therefore were at risk of reinfection. Similarly, polymicrobial infection was also reported to be a major risk factor for reinfection [10]. In this study, the rate of polymicrobial infection was 10% to 15% in both groups, which led to an increased risk of reinfection. These risk factors, which were present in both groups at similar rates, did not create a difference in reinfection.

Minimum Safe Distance Between Implants

Interestingly, we found differences when examining basic biometrics of the patients and their femurs, particularly the remaining femoral distance between implants. Patients with ipsilateral metachronous PJI were shorter, weighed less, and tended to have shorter femurs. They also had shorter stem-to-stem distances, shorter empty native bone distances, and a higher risk of extrusion of cement past the restrictor. We found that patients with an empty native bone distance of at least 7 cm and stem-to-stem distance of 9 cm were less likely to have an ipsilateral metachronous PJI, with sensitivity and specificity values for these cutoffs ranging between 70 and 80%. These findings provide indirect evidence that at least a proportion of metachronous PJIs are caused by contiguous spread or direct inoculation instead of via the hematogenic route. This implies that an uninfected implant in the same bone as the infected implant is associated with a higher risk of metachronous PJI. The ROC analysis showed that maintaining a gap of 7 cm of empty native bone between the femoral implants could reduce the risk of ipsilateral metachronous PJI from 43% to 7%. Based on our results, we recommend a stem-to-stem distance of at least 7 cm. In these situations, extrusion of cement of more than 2 cm beyond the restrictor can compromise a distant joint. Extrusion compromises the empty native bone distance and therefore the biological buffer zone for the bone to protect the uninfected implant.

Conclusion

The risk of ipsilateral metachronous PJI in patients with multiple joint arthroplasties is associated with shorter stature and stem-to-stem distance. Appropriate position of the cement restrictor and native bone distance are important in reducing the risk of ipsilateral metachronous PJI in these patients. We recommend maintaining a minimum of 7 cm of native bone between the uninfected implant and the revised implant for PJI of the hip or knee to reduce the risk of ipsilateral metachronous PJI.

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