



# Implementation of a multidisciplinary infections conference affects the treatment plan in prosthetic joint infections of the hip: a retrospective study

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## Abstract

**Introduction** Establishing a systematic multidisciplinary approach in the treatment of prosthetic joint infections (PJI) of the hip and analyzing its effect on clinical decision-making.

**Patients and methods** Forty-six patients diagnosed with PJI of the hip were included in the retrospective study. The treatment plan was either established by a single-discipline approach ( $n = 20$ ) or by a weekly multidisciplinary infections conference ( $n = 26$ ) consisting of at least an orthopedic surgeon, microbiologist and pathologist. Recorded data included the length of hospital stay, number and type of surgeries, medical complications, recovered organisms as well as the number of applied antibiotics.

**Results** Patients discussed in the multidisciplinary infections conference showed a significantly shorter in-hospital stay (29 vs 62 days;  $p < 0.05$ ), a significant reduction in surgeries (1.8 vs 5.1;  $p < 0.05$ ) and a smaller number of antibiotics required (2.8 vs 4.2;  $p < 0.05$ ). No significant difference could be found comparing inpatient complications between the two groups. *Staphylococcus aureus* and coagulase-negative staphylococci were the most frequently recovered organisms in both patient groups.

**Conclusion** This study demonstrates the successful implementation of a weekly infections conference as an instrument to introduce a multidisciplinary approach to PJI of the hip. Implementation of these conferences significantly improves the treatment plan compared to a single-discipline approach, which we therefore highly recommend for other institutions. Multidiscipline may even affect clinical outcome which needs to be further investigated.

**Keywords** Periprosthetic joint infection · Hip · Multidisciplinary conference · Arthroplasty · PJI

## Introduction

Multidisciplinary case conferences, held to ameliorate clinical decision-making, have become the standard of care for malignant neoplasms in the last two decades and are a well-established component of cancer care in many countries [1]. Especially in more complex cases, the multidisciplinary approach of a tumor board is described to be the ideal setting to define the best possible treatment plan [1]. Recent research could link the implementation of these case conferences to an alteration of the treatment plan compared to the conventional single-disciplinary approach [2, 3]. Furthermore, they have been shown to impact diagnosis, patient care, compliance to clinical practice guidelines and may even effect clinical outcome and patient survival [2, 4–7].

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Prosthetic joint infections (PJI) affect approximately 1% of patients following elective hip replacement and about 2–17% who underwent hemiarthroplasty, which is the standard treatment in elderly patients with femoral neck fractures [8–12]. PJI are very challenging complications with a significant economic impact that require a coordinated approach [9, 12]. The current treatment modalities include a multidisciplinary approach including surgery as well as antimicrobial treatment as the main modalities. Surgical management consists of a variety of procedures (e.g., wound debridements, one-stage or two-stage revision, temporary spacer implantation, permanent resection, amputation). Debridement and implant retention is frequently used in early infections, whereas implant removal and reimplantation is favorable in delayed- or late-onset infections. Regarding the antimicrobial administration prophylaxis, length of therapy, exact regimen, and the method of application need to be determined [12–15]. Factors such as previous surgeries, co-morbidities, bone stock, soft tissue integrity, organism virulence and resistance profile have a high impact on the outcome and should therefore be carefully considered in the treatment plan [9, 16].

In this study, we retrospectively analyzed patient records to test the hypothesis that implementation of a multidisciplinary infections conference is a novel and effective approach to significantly improve management of PJI of the hip.

## Methods

### Study setting

This study was conducted at a large University Medical Center located in central Europe. The hospital is a 1500-bed tertiary care provider hosting in-house departments for medical microbiology and pathology. Patients included were treated in the Department of Trauma-, Hand-, and Reconstructive Surgery.

### Infections conference

In 2011 multidisciplinary infections conferences were first established at our institution. Since then the conference is held on a weekly basis. Every patient diagnosed with PJI is included in the conference and discussed every week until discharge. In case of readmission to the hospital the patient is included and discussed again. The conference is organized and prepared by the department of orthopedic and trauma surgery. Three specialties need to take part to validate multidisciplinary decision-making: a senior orthopedic surgeon, a senior pathologist and a senior microbiologist have to be present. Each case was furthermore discussed with a senior radiologist but for organizational reasons in a separate

setting. Apart from PJI, osteomyelitis, soft tissue infections and osteosynthesis associated infections are discussed in the conference as well. The orthopedic surgeon is in charge of case selection and its presentation, orally and in written form beforehand. The presentation document is standardized and includes patient data, past medical history, risk factors, lab results, date of diagnosis, current treatment modalities, operations, current antibiotics and microbiological results if available. The duties of the pathologist include presentation of the histopathological findings obtained by arthrocentesis or during surgery, especially in terms of acute or chronic inflammatory aspects. The microbiologist is responsible for interpretation of microbiological findings, suggests performance of additional microbiological diagnostics if necessary and defines optimal antibiotic regimens. Major case discussion aspects include: type of treatment (operative vs conservative); type and number of surgery; type, number and duration of antibiotics used as well as duration of the inpatient and outpatient treatment. After the discussion, the interdisciplinary treatment plan is established and delivered to each physician in charge. Before establishing these conferences, the treatment plan was defined in a single-discipline approach by the Department of Trauma Surgery. The antimicrobial treatment was determined by the responsible surgeon and based on the results of the obtained antimicrobial resistogram.

### Patient selection

All patients with diagnosed PJI of the hip (hemiarthroplasty as well as total arthroplasty) who were treated at our institution between 2006 and 2016 were eligible for retrospective inclusion in the analysis. Inclusion criteria was the diagnosis of PJI according to the International Consensus Group Meeting in 2014 [17, 18].

Overall 46 patients could be identified consisting of 12 infected hemiarthroplasties and 34 total hip arthroplasties. The patients were divided into two groups depending on if they were discussed in the infections conference (year 2012–2016;  $n = 26$ ) or not (year 2006–2010;  $n = 20$ ). Patients treated in the year 2011 in which the conference was established were excluded in order to obtain valid results since the follow-through was not standardized yet during this time. Recorded patient data included age, sex, medical history, including prior surgeries, as well as the ASA (American Society of Anesthesiologists)-Score.

### Retrospective analysis

Retrospective analysis was performed for each patient. Recorded data included type of PJI, length of hospital stay, applied antibiotics, recovered organisms, performed surgeries as well as postoperative complications. In case of

several hospital admissions all days of each hospital stay were summed up. The type of PJI was defined, as commonly described, based on the time to infection: early PJI occurs < 3 months after the last surgery, delayed PJI after 3 months but before 24 months and late-onset PJI occurs > 24 months after surgery [9]. Postoperative complications were categorized as previously described [19]. Grade 1 complications include minor risk events not requiring therapy with the exception of analgesic, antipyretic, antiemetic, and antidiarrheal drugs. Grade 2 complications were defined as potentially life-threatening complications with the need of other medications that are already included in Grade 1 complications. Grade 3 complications were defined as complications with the need for invasive procedures and Grade 4 complications indicated death of a patient [19]. Microbiology results were evaluated based on the number of positive specimens, with a minimum of two collected per patient, colony count on solid media and identified bacterial species. Based on above criteria, a panel consisting of a microbiologist and orthopedic surgeon determined whether a detected pathogen was likely to be the causative agent of infection or rather a contaminant: e.g., the combination of only one positive specimen, with a low colony count and a bacterial species, which is not likely to cause infections of the bone, joint or blood stream, was considered as contamination. Surgical procedures were defined as the final treatment strategy which included either a single- or two-stage exchange, permanent resection or the debridement, antibiotics and implant retention (DAIR) strategy. The DAIR strategy included the removal and replacement of any exchangeable components as well. The two-stage exchange included a temporary antibiotic loaded spacer implantation [9, 12]. End of treatment was defined as the conclusion of the agreed upon treatment regimen without signs of reinfection.

### Statistical analysis

Mean value and range were ascertained for all measurements. Significance was tested by two-tailed *t* test and Mann–Whitney *U* test with a *p* value of < 0.05 indicating statistical significance. The Holm–Bonferroni method was used to control for the family-wise error rate. Normal distribution was tested using the D’Agostino and Pearson omnibus normality test and could be proven in the total number of applied antibiotics as well as number of surgeries performed in patients discussed in the conference.

### Results

A total of 46 patients diagnosed with PJI of the hip were included in the study. 26 patients were discussed in the infections board conference, whereas 20 patients were treated without conference discussion.

Characteristics were similar in both groups. The patients who were treated according to the infections conference consensus had an average age of 71.1 years (range 47–92 years) and consisted of 13 (50%) male and 13 (50%) female patients. The group treated by single-discipline approach was 78.1 years (range 55–95 years) on average including 11 (55%) male and 9 (45%) female patients.

Both groups showed a nearly identical ASA score, portraying an equivalent severity of premedical history (see Table 1).

Regarding the type of PJI, we could detect a different distribution within the two groups. The infections conference collective consisted of 31% early infections, 23% delayed- and 46% late-onset infections, whereas in the group without conference discussion most patients (12/20, 60%) were diagnosed with an early prosthetic joint infection (see Table 1).

Focusing on a potential change in treatment plan, we compared the total number of surgeries as well as the total number of applied antibiotics between both groups. Where the treatment plan was determined by the infections conference, there were significantly less open surgeries ( $p < 0.05$ ) as well as a significantly lesser number of applied antibiotics ( $p < 0.05$ ) (see Table 2).

Comparing the total length of hospital stay between the two groups, we could show that the patients where the treatment plan was established by the conference had a significantly ( $p < 0.05$ ) shorter hospital stay (see Table 2). Focusing on the different types of PJI, a significant difference in all three parameters could be observed in delayed/late-onset PJI (see Table 2).

Also, the type and strategy of surgery differentiates both groups. Without conference discussion, the favored type was the debridement, antibiotics and implant retention strategy (9/20, 45%), whereas following conference consensus most patients were either treated with the one-stage (9/26, 35%) or two-stage exchange (8/26, 31%), followed by DAIR (7/26, 27%). In contrast, with the single-discipline approach the one- and two-stage strategy were performed in 15% and 25% retrospectively. Permanent resection as the definite treatment was the least frequent choice in both groups (see Table 3). Early PJI was most commonly treated by DAIR, while delayed/late-onset PJI

**Table 1** Mean ASA score and type of PJI in absolute and relative numbers in both groups

	Mean ASA Score	Type of PJI		
		Early	Delayed	Late onset
With infections conference	3.4 ± 0.8	8 (31%)	6 (23%)	12 (46%)
Without infections conference	3.1 ± 0.8	12 (60%)	4 (20%)	4 (20%)

**Table 2** Mean length and standard deviation of hospital stay in days, mean absolute number of performed open surgeries and mean number of applied antibiotics for all types, early and delayed/late-onset PJI

	Mean length of hospital stay	Mean number of open surgery	Mean number of antibiotics
All types of PJI			
With infections conference	29 ± 14	1.8 ± 1	2.8 ± 1.2
Without infections conference	62 ± 43	5.1 ± 4.3	4.2 ± 2
<i>p</i> value	0.0006*	0.0003*	0.008*
Early PJI			
With infections conference	42 ± 15	2.3 ± 1	2.5 ± 0.9
Without infections conference	61 ± 46	6 ± 4.9	3.8 ± 2
<i>p</i> value	0.28	0.047	0.1
Delayed/late-onset PJI			
With infections conference	23 ± 9	1.6 ± 0.9	2.9 ± 1.3
Without infections conference	64 ± 42	3.9 ± 3.1	4.9 ± 2.2
<i>p</i> value	0.0005*	0.007*	0.02*

\*Statistical significance following alpha correction analysis according to Bonferroni–Holm

**Table 3** Definite surgical treatment in both groups, compared for all types, early and delayed/late-onset PJI

	DAIR	One-stage exchange	Two-stage exchange	Permanent resection
All types of PJI				
With infections conference	7 (27%)	9 (35%)	8 (31%)	2 (7%)
Without infections conference	9 (45%)	3 (15%)	5 (25%)	3 (15%)
Early PJI				
With infections conference	4 (50%)	2 (25%)	1 (12.5%)	1 (12.5%)
Without infections conference	8 (67%)	1 (8%)	2 (17%)	1 (8%)
Delayed/late-onset PJI				
With infections conference	3 (17%)	7 (39%)	7 (39%)	1 (5%)
Without infections conference	1 (12.5%)	2 (25%)	3 (37.5%)	2 (25%)

Due to the small patient number in each category no statistical analysis was performed

patients frequently received a one- or two-stage exchange procedure (see Table 3). Due to the small numbers of patients in each subcategory statistical significance was not determined.

Analysis of recovered organisms revealed *Staphylococcus aureus* and coagulase-negative staphylococci to be the most common organisms in both groups followed by *Enterococcus* species in the group without case discussion and *S. agalactiae* in the collective with conference decision (see Table 4). 23 recovered organisms classified as contamination by the microbiology were not included. Regarding inpatient complications, no significant difference between both groups could be found, even though patients who were discussed by the conference showed a higher rate without any complications (see Table 5).

**Table 4** Absolute and relative distribution of recovered top 3 organisms in both groups

	Distribution of recovered organisms
With infections conference	Coagulase-negative staphylococci (8; 28.5%) <i>S. aureus</i> (6; 21%) <i>S. agalactiae</i> (3; 11%) Other (8; 28.5%) No intraoperative findings (3; 11%)
Without infections conference	Coagulase-negative staphylococci (9; 35%) <i>S. aureus</i> (7; 27%) <i>Enterococcus</i> species (5; 19%) Other (5; 19%)

## Discussion

Regarding the treatment of PJI a multidisciplinary approach is frequently recommended, but so far no ideal setting is described which meets the needed requirements

**Table 5** Inpatient complications in each group, subcategorized according to severity

Complications	None	I	II	III	IV	V
With infections conference	6	6	7	3	0	4
Without infections conference	3	2	6	2	4	3

No significant difference between both groups and each category could be found

[12, 16]. Previous studies could show the promising development of multidisciplinary tumor conferences in the context of cancer care with a change of treatment plan in up to 74% [20–23]. Moreover, numerous studies could identify tumor conferences to improve patient outcome and survival [5–7, 21]. This systematic multidisciplinary approach is therefore widely accepted as a vital and crucial component of cancer care [24]. Due to the comparable complexity of PJI and malignancies it was highly assumable that multidisciplinary conferences positively influence treatment of PJI as well, which lead to our initiation of said discussions.

To our best knowledge, this is the first study, where a standardized multidisciplinary infections conference was developed and then successfully established.

We retrospectively analyzed patients with PJI of the hip depending on whether the treatment plan was established by a conference or not. Similar to multidisciplinary cancer conferences our results show that performing these discussions led to a significant alteration in the treatment plan, displayed by an absolute reduction in the number of antibiotics applied and open surgeries performed, especially in patients diagnosed with delayed/late-onset PJI. Reducing the use of antibiotics is the foremost prerequisite for sustainable control of antimicrobial resistance, which is a growing problem in the world [26]. Improving the usage of antibiotics could possibly be explained by a more pronounced consideration and reevaluation of treatment indications as well as including a microbiologist specialized in bone- and soft tissue infections as a constant board member. Focusing on recovered organisms in the context of prosthetic joint infections our results show a typical distribution with coagulase-negative staphylococci and *S. aureus* as the most common organisms [25, 26]. As stated, we showed a reduction in number of surgeries performed following infections conferences, which possibly could lead to fewer related complications. However, based on the data obtained in this study it was not possible to demonstrate a significant difference in the amount and severity of inpatient complications, even though the case discussion group showed fewer severe complications compared to the patients without discussion conference. Greater patient numbers and a prospective study design would be needed to confirm this hypothesis though.

Furthermore, our results show that the patient group without case discussion had a significantly longer hospital stay (29 vs 62 days;  $p < 0.05$ ). This was particularly true in

late/delayed PJI. A longer hospital stay could be linked to decreasing patient life quality [27–29] and is furthermore associated with higher economical costs, therefore indicating another potential benefit of these infections case conferences. The overall cost to the American health care system to treat PJI was \$566 million in 2009 and is expected to exceed \$1.62 billion in 2020. In regard to this huge economic impact a systematic approach like we present in establishing the infections conferences seems to be inevitable and prudent [9, 30]. A reasonable explanation for our results could be that positive multidisciplinary interactions lead to consequent treatment response and therefore allow early patient discharge. Furthermore, due to the weekly follow-up a close multidisciplinary reevaluation including the decision of the optimal time of discharge is ensured. Our results were obtained at different time periods which could bias the inpatient duration as well. Nevertheless, the patient collective in both groups had similar characteristics allowing its comparison by reducing bias due to different premedical histories which also might influence duration of hospital stay.

The limitations of the study include its retrospective nature, a lack of randomization, and the relatively small number of patients. Furthermore, data collection focusing on the total time course of applied antibiotics was not possible for all patients so that this important information is not covered by this study. Also, the different distribution of the types of PJI as well as different surgical procedures like DAIR, one-stage or two-stage exchange and permanent resection within the two groups could lead to a potential bias. Moreover, different conference participants of each specialty with individual opinions could affect the results as well. Furthermore, one might argue that similar results could be achieved in a different setting by implementation of a fixed consultant service. Still, in our opinion, this cannot replace the vivid multidisciplinary discussion taking place in the modality of a conference. The results of our study do not allow to comment on prognostic outcome and need to be carefully interpreted since outcome parameters were not obtained. A prospective study could further strengthen our results.

In conclusion, due to the successful implementation of a multidisciplinary infections conference our study demonstrates a feasible and effective solution to ensure the multidisciplinary approach to treating PJI of the hip. Whether infections conferences positively affect clinical outcome is a question which needs to be answered by further studies.

The current study demonstrates that performing these conferences significantly alters the treatment plan when compared to a single-discipline approach. The results show a particularly positive impact on the clinical course of delayed/late-onset PJI, underlining its importance in these patients. Additionally, this study shows that the properly performed infections conference led to a decrease in the usage of antibiotics, a reduction in surgeries performed as well as a shortened hospital stay. This reflects the positive impact that infections conference could have not only clinically, but also economically and regarding antibiotic stewardship. Therefore, infections conferences are a worthwhile measure to improve patient care and ensure economical feasibility.

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### Compliance with ethical standards

**Conflict of interest** D. Ntalos, J. Berger-Groch, H. Rohde, L. G. Grosserlinden, A. Both, A. Luebke, M. J. Hartel and T. O. Klatte declare that they have no conflict of interest.

**Human/animal rights statement** This article does not contain any studies with human participants or animals performed by any of the authors.

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