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## Brief Report

## Incidence and risk factors of surgical site infection after total knee arthroplasty: Results of a retrospective cohort study



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## Key Words:

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Knee arthroplasty is commonly performed in the case of advanced osteoarthritis, and deep joint infections represent a severe complication following surgery. A 4-year retrospective cohort study was conducted to determine the incidence and risk factors for such surgical site infections. Of the 2439 patients included in the study, 84 of them (3.4%) developed infections. Postoperative bleeding, Ahlbäck's disease, obesity, smoking, and male gender were independent risk factors that should be considered when caring for those patients.

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Elective knee arthroplasty is frequently performed.<sup>1</sup> A rare but severe complication is a deep (periprosthetic) joint infection.<sup>2</sup> The onset of a deep surgical site infection (SSI) negatively impacts the clinical course of patients and contributes to overall morbidity and mortality.<sup>3</sup> Thus, to achieve optimal SSI prevention, knowledge of the risk factors is of great relevance. This study provides data on the incidence of such SSIs, contributing risk factors, and infection control procedures.

## METHODS

A retrospective cohort study over 4 years (2007 to 2010) that included all patients undergoing elective total knee arthroplasty was conducted in the Clinic for Orthopaedic Surgery, a specialized hospital in Hannover, Germany. The clinic has 5 operating theaters equipped with high-efficiency particulate air filtration, as well as 5 general wards. Perioperative single-shot cefuroxime (1.5 g),

antiseptic body washing before surgery, alcohol-based preoperative skin disinfection, and screening for methicillin-resistant *Staphylococcus aureus* were routinely performed. Patients with preexisting knee infections, those who died within 3 days after surgery, and patients for whom we had incomplete datasets were excluded. Surveillance took place according to the well-established Centers for Disease Control and Prevention's National Healthcare Safety Network criteria.<sup>4</sup> Infections were grouped as (1) superficial incisional infections, or (2) organ (periprosthetic joint) infections. Deep incisional infections were grouped together with organ infections. Surveillance was performed during the primary hospital stay ("in-house" infections) and subsequent outpatient visits or readmissions within 1 year. We recorded demographic data, comorbidities, data on surgery, postoperative care measures, and antibiotic prophylaxis or therapy until discharge, death, or onset of infection.

In the descriptive analysis, we calculated either number and percentage or median and interquartile range. In the univariable analysis, patients with and without SSI were compared and relative risks were calculated. The risk factor analysis used a multivariable Cox proportional hazards regression with stepwise variable selection forward, with the outcomes being SSI and the time to SSI or discharge or death. The significance level for entering a variable into the model and for removing a variable from the model was  $P < .05$ . Statistical analyses were performed using SPSS Statistics 25 (IBM; Armonk, NY) and SAS 9.4 (SAS; Cary, NC).

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Results of this study were presented at the 25th European Congress of Clinical Microbiology and Infectious Diseases (ECCMID 2015), April 25–28, 2015, Copenhagen, Denmark, as an e-Poster and are available in an English language abstract in the conference's proceedings.

Conflicts of interest: None to report.

## RESULTS

The study included 2439 patients, and their characteristics are shown in Table 1. Among these patients, 84 SSIs occurred (cumulative incidence = 3.4%). Of note is that the incidence decreased continuously over time, from 4.4% in 2007 to 2.5% in 2010, but this change was not significant ( $P = .10$ ). There were 75 (89.3%) periprosthetic joint infections and 9 (10.7%) superficial incisional infections. The average time from surgery to infection was 65.8 days; 24 infections (28.6%) occurred “in-house”. In 73 (86.9%) of the infections, at least 1 causative pathogen was identified by standard culture methods. Overall, 83 pathogens were detected. Coagulase-negative staphylococci ( $n = 37$ , 44.6%) and *Staphylococcus aureus* ( $n = 27$ , 32.5%) were the dominant microorganisms. Methicillin resistance occurred in 4 of the *Staphylococcus aureus* isolates. There were no other multidrug-resistant bacteria. In 79 (94.0%) of the patients at least 1 operative revision was necessary due to SSI, and in 18 patients (21.4%) a complete change of the implanted joint was required. One patient died while presenting with a SSI during the observation period. The significant results of the multivariable risk factor analysis are shown in Table 2.

## DISCUSSION

The incidence of SSIs after total knee arthroplasty usually varies between 0.5% and 2%.<sup>5,6</sup> Thus, the cumulative incidence in our study (3.4%) was rather high, but it decreased continuously thereafter, down to 1% in 2012 (data not shown). We believe that this trend was due to the initiation in 2007 of systematic and standardized SSI surveillance including feedback audits, as well as a hospital-wide training campaign targeting compliance to hand hygiene

that launched in 2008. Moreover, in 2010 an extensive infection control bundle was implemented that included the use of antibiotic-impregnated cement, preoperative skin disinfection with alcoholic povidone-iodine, jet lavage, weight-adjusted administration of antibiotics, restriction of drainage to the first post-surgery day, and education of staff on hand hygiene. This bundle was based on current national (German) and international (Centers for Disease Control and Prevention) guidelines.<sup>7</sup>

The (independent) risk factors obtained from the multivariable analysis are in line with other reports.<sup>8–10</sup> Interestingly, in our study Ahlbäck's disease was an independent risk factor for infection (hazard ratio = 4.49), confirming previous results by Namba et al.<sup>10</sup> (hazard ratio = 2.96). Therefore, we recommend monitoring this special subgroup of patients very closely for any signs or symptoms of infections following surgical procedures. Postoperative bleeding and a preexisting iatrogenic coagulopathy (eg, induced by phenprocoumon) were additional independent risk factors for infection in our study that have been reported before.<sup>3</sup> A postoperative wound healing disorder was another strong independent risk factor and might represent an early and sensitive indicator for developing infection. A prolonged operation time of >180 minutes was also a risk factor and may reflect the increased complexity of the individual procedure.

From an infection control point of view, it was interesting that immediate postoperative stays on a specific ward proved to be a risk factor for SSI development; therefore, infection control training sessions were held especially for the staff of this particular ward that focused on postoperative handling, wound and drainage care, and hand hygiene. These training sessions began in the last year of the study period and were continued thereafter.

Surprisingly, postoperative revision (not infection-associated), antibiotic therapy (excluding single-shot perioperative and urinary

**Table 1**  
Characteristics of the study cohort and results of the univariable risk factor analysis

Item	All patients No. (%) / median (IQR)	SSI No. (%) / median (IQR)	Without SSI No. (%) / median (IQR)	Relative risk	P value
Total	2439 (100)	84 (100)	2355 (100)		
Male gender	784 (32.1)	39 (46.4)	745 (31.6)	1.83	.006
Age (y)	69 (62–75)	69.5 (60.5–75)	69 (63–75)	—	.542
Length of hospital stay (d)	13 (11–14)	14 (12–22)	13 (11–14)	—	<.001
Adiposity ( $\geq 40$ kg/m <sup>2</sup> )	159 (6.5)	9 (10.7)	150 (6.4)	1.72	.115
Surgery due to primary and advanced osteoarthritis	2070 (84.9)	69 (82.1)	2001 (85)	0.82	.441
Regular smoker*	237 (9.7)	17 (20.2)	220 (9.3)	2.36	.002
Regular alcohol consumption <sup>†</sup>	66 (2.7)	3 (3.6)	63 (2.7)	1.33	.495
Cardiac comorbidities	1890 (77.5)	69 (82.1)	1821 (77.3)	1.34	.353
Vascular comorbidities	1023 (41.9)	30 (35.7)	993 (42.2)	0.77	.262
Diabetes mellitus	367 (15.0)	10 (11.9)	357 (15.2)	0.76	.534
Osteoporosis	146 (6.0)	4 (4.8)	142 (6)	0.79	.816
Chronic skin disease (eg, atopic dermatitis, psoriasis)	109 (4.5)	9 (10.7)	100 (4.2)	2.57	.011
Ahlbäck's disease	34 (1.4)	3 (3.6)	31 (1.3)	2.62	.11
Preexisting anticoagulation therapy	657 (26.9)	26 (31)	631 (26.8)	1.22	.384
Preexisting anticoagulation with phenprocoumon	149 (6.1)	12 (14.3)	137 (5.8)	2.56	.004
Preexisting immunosuppressive therapy	164 (6.7)	6 (7.1)	158 (6.7)	1.07	.824
Urinary tract infection prophylaxis with cotrimoxazole	94 (3.9)	1 (1.2)	93 (3.9)	0.30	.377
Antibiotic therapy pre- or postoperative <sup>‡</sup>	323 (13.2)	13 (15.5)	310 (13.2)	1.20	.513
Duration of surgery > 180 min	24 (1.0)	4 (4.8)	20 (0.8)	5.03	.008
American Society of Anesthesiologists score = 2	1919 (78.7)	63 (75)	1856 (78.8)	0.81	.416
PFC Sigma Knee System (DePuy Synthes; Raynham, MA)	1196 (49.0)	32 (38.1)	1164 (49.4)	0.64	.046
Triathlon Total Knee System (Stryker; Kalamazoo, MI)	1052 (43.1)	47 (56)	1005 (42.7)	1.67	.018
Postoperative blood transfusion	541 (22.2)	18 (21.4)	523 (22.2)	0.96	.1
Intraoperative blood transfusion	32 (1.3)	2 (2.4)	30 (1.3)	1.83	.303
Revision following primary surgery (but not due to SSI)	111 (4.6)	6 (7.1)	105 (4.5)	1.61	.277
Postoperative bleeding/hematoma	91 (3.7)	20 (23.8)	71 (3)	8.06	<.001
Postoperative wound healing disorder	44 (1.8)	13 (15.5)	31 (1.3)	9.97	<.001
Postoperative stay at a certain ward (ward A)	932 (38.2)	45 (53.6)	887 (37.7)	1.87	.004

IQR, interquartile range; SSI, surgical site infection.

\*Daily smoking of more than 5 cigarettes.

<sup>†</sup>Daily consumption of strong alcohol or more than 3 glasses of beer.

<sup>‡</sup>Urinary tract infection prophylaxis and perioperative antimicrobial prophylaxis not considered.

**Table 2**  
Independent factors for SSI after multivariable Cox proportional hazard regression (84 patients with SSI vs. 2355 patients without SSI)

Variable	Hazard ratio	95% confidence interval	P value
<b>Risk factors</b>			
Postoperative bleeding/hematoma	6.22	3.55-10.93	<.001
Postoperative wound healing disorder	5.89	3.04-11.42	<.001
Ahlbäck's disease	4.49	1.39-14.57	.012
Duration of surgery > 180 min	4.03	1.33-12.24	.014
Preexisting phenprocoumon therapy	2.90	1.56-5.40	.001
Adiposity > 40 kg/m <sup>2</sup>	2.87	1.38-5.98	.005
Chronic skin disease	2.45	1.21-4.99	.013
Regular smoking	2.22	1.27-3.90	.005
Postoperative stay at a certain ward (ward A)	2.11	1.36-3.27	.001
Male gender	1.69	1.06-2.69	.026
<b>Protective factors</b>			
Revision following primary surgery (but not due to SSI)	0.32	0.13-0.79	.013
Antibiotic therapy pre- or postoperatively*	0.39	0.19-0.79	.009
Postoperative blood transfusion	0.47	0.26-0.84	.012

SSI, surgical site infection.

\*Urinary tract infection prophylaxis and perioperative antimicrobial prophylaxis not considered.

tract infection prophylaxis), and postoperative blood transfusions were independent protective factors. These findings are difficult to interpret in the retrospective setting and should be reassessed in further investigations, particularly because the (intraoperative) use of blood transfusion was found to be a risk factor for SSIs in implant surgery in previously performed studies.<sup>11</sup> Our findings suggest that an early revision might be of benefit if primary wound healing is delayed. The microbial spectrum of causative pathogens observed is rather typical for SSIs in orthopedic implant surgery.

There are some limitations, as this was a single-center study, and results might therefore not necessarily apply to other hospitals and settings. Moreover, patients were only under surveillance in this single hospital (there was no systematic postdischarge surveillance).

Some SSIs could have been missed if patients did not return to this hospital for revision or treatment, resulting in an underestimation of the true burden of disease.

We think that knowledge of the incidence of SSIs and the associated risk factors is crucial for recognizing a potential need for action and developing appropriate infection control measures, especially with respect to deep SSIs following knee arthroplasty, as this is a rather common type of surgical procedure but subsequent infections can have a major impact on patient morbidity. In addition, we would like to emphasize that infection control staff should also look for some hospital-specific factors that may influence infection rates.

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