Infection Control & Hospital Epidemiology (2024), **45**, 991–993
doi:10.1017/ice.2024.49

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Concise Communication

Bacterial contamination of surgical gloves during clean orthopedic surgery

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Abstract

This study examines the presence of bacterial contamination on surgical gloves and suggests appropriate measures for an aseptic surgical environment. To prevent glove contamination during surgery, surgeons and assistants should change gloves periodically, and scrub nurses should be careful when opening packages and handing over implants.

(Received 2 December 2023; accepted 8 March 2024; electronically published 2 April 2024)

Introduction

The surgical environment for closed fractures or noninfectious arthrosis in the field of orthopedics should be aseptic to minimize the intrusion of bacteria into the patient's body during surgery and to reduce infectious complications. Surgical site infections (SSIs) in arthroplasty have decreased considerably with the development of aseptic surgical methods; however, studies indicate that they still occur in approximately 1% of cases.[1] Studies reporting 30-day mortality rates as high as 19% and 1-year mortality rates as high as 50% among patients who develop infections following hip fracture surgery emphasize the need for efforts to reduce postoperative infections.[2,3] Bacterial contamination on surgical glove surfaces can occur at various stages of surgery, including draping, unpacking, and transferring of artificial inserts (AI) by scrub nurses, as well as contamination following prolonged surgery. This study examined the presence of bacterial contamination on surgical gloves at various stages of surgery and suggests appropriate measures to maintain an aseptic surgical environment.

Methods

The study prospectively examined surgical gloves for bacterial contamination 3 times during each of 35 surgeries performed by a single surgeon for closed fractures or noninfectious arthropathies in orthopedics.

Sample collection

At each collection point, the surgical participants washed the backs and palms of both hands with 50 cc of normal saline while wearing gloves, and the wash solution was collected in a sterile plastic tube. Samples were collected at: phase 1: immediately after donning the surgical gloves (surgeon, first assistant, and scrub nurse); phase 2: immediately after draping (surgeon and first assistant) or immediately after opening the packaging and delivering the AI (scrub nurse); and phase 3: at the end of the procedure (surgeon, first assistant, and scrub nurse). Each sample tube was centrifuged, and 100 µL of the pellet was inoculated onto blood agar medium and incubated at 37°C for 48 hours.

The cultured bacteria were identified using MALDI Biotyper (microflex™ LT/SH, Bruker) and subsequently tested for antibiotic resistance using the Kirby–Bauer disk diffusion method.

Statistical analysis

All statistical analyses were performed using SPSS software (version 21.0; SPSS Inc., Chicago, IL). Differences were considered statistically significant at a two-sided P value of <.05. We used a Cochran's Q test to compare the differences in the proportions of contamination among the three operation phases. The mean difference between the culture-negative and culture-positive results by the operation time was analyzed using the t test. The difference in proportions of contamination between operation methods (fracture fixation vs arthroplasty) was analyzed using the χ^2 test and Fisher's exact test.

Ethical approval

This study was exempted from the approval of the institutional review board (decision number, NON2023-002) because it is not a study on human subjects.

Results

No contamination was found in the washed specimens collected immediately after donning the gloves and before starting the procedure, and no contamination was found in the specimens collected after draping. Contamination was identified on the gloves of the surgeon and first assistant at the end of the surgery in 4 (11.4%) and 5 (14.3%) of the 35 cases, respectively, and on the

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Cite this article: Lee JY, Yun SH, Kang JW, Kong GM. Bacterial contamination of surgical gloves during clean orthopedic surgery. *Infect Control Hosp Epidemiol* 2024. 45: 991–993, doi: 10.1017/ice.2024.49

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Table 1. Details of intraoperative contaminants isolated

Bacteria	Samples (15)
S. hominis	8[a]
S. capitis	2
Bacillus	1
Corynebacterium	2[a]
M. luteus	3
Stenotrophomonas maltophilia[b]	1

[a]Two cases of overlapping contamination with *S. hominis* and *Corynebacterium*.
[b]The bacteria came from the surgeon's stage 3 gloves in the 25th case (total hip revision) and had a CFU of 36. All other samples had CFUs of 10 or less.

gloves of the scrub nurse in 5 (14.3%) of the 35 cases after the AI was handed over and in 1 (2.8%) of the 35 cases at the end of the surgery.

Overall, bacteria were detected in 15 of 315 samples, resulting in a contamination rate of 4.7%. Among the contaminating bacteria, *Staphylococcus hominis* was the most common, including two cases of overlapping contamination with *Corynebacterium* (Table 1). *S. hominis* was tested for antibiotic resistance: all cases were sensitive to novobiocin, and six cases were resistant to oxacillin. The surgeries included in this study were 10 total hip arthroplasties, 11 bipolar hemiarthroplasties, 4 total hip revisions, 3 intramedullary nails, and 7 proximal femoral nails. There was no statistical difference in contamination rates among the surgeon, first assistant, and scrub nurses and no statistical significance in the association between operating time and contamination. The contamination rates did differ significantly between the phases, with the surgeon, first assistant, and scrub nurses all being aseptic in phase 1 and showing contamination as they progressed to the next phase (Table 2). The scrub nurses had five cases of contamination in phase 2, compared with zero contaminations in phase 2 for the surgeon and first assistant, which was a statistically significant difference ($P = .007$). In the comparison of contamination rates by surgery type (metal fixation vs arthroplasty), no statistically significant differences were found. No SSIs were reported in 3 months of follow-up for the 35 cases.

Discussion

In this study, we found no contamination immediately after gloving and draping. However, after surgery, the gloves of the surgeon, first assistant, and scrub nurse showed contamination rates of 11.4%, 14.3%, and 2.8%, respectively. After handing over the AI, the contamination rate on the scrub nurse's gloves was 14.3%.

During surgery, the glove surface is mainly exposed to bacteria from the patient's skin and airborne particles in the operating room.[4–6] The high contamination rate for scrub nurses in phase 2 suggests that delivery of the AI can also cause bacterial contamination. It has been speculated that static electricity or air turbulence generated by unpacking of the implant causes particle movement on the surface of the packaging. Despite reports that longer surgeries and revision arthroplasty increase the infection risk,[7,8] our study found no significant difference in operation time between the contaminated and non-contaminated groups. Interestingly, the contaminated group had a shorter operation time. This was observed for the surgeon, assistant, and operating nurses, but the large variation in operating time (35–240 min) for the uncontaminated group appears to lack power. Given that Wang et al[9] reported higher infection rates in total hip and knee arthroplasties that took longer than 90 minutes, the mean operative time of 88 minutes in this study might not have provided sufficient time to increase the risk of contamination. *S. hominis* made up the largest proportion of the contaminating bacteria in this study. It is a skin-dwelling bacterium that is known to be abundant in the pubic area and that can invade deeper tissues and cause infections through skin damage or during surgical procedures.[10] As the participants in this study had hip surgery and the surgical site was close to the pubic area, it is possible that *S. hominis* was a commensal bacterium on the patient's skin and more attention should be given to disinfecting the patient's skin in the future.

This study has some limitations. First, the study has a small sample size of 35 operations performed by a single surgeon. Second, it does not segment the stages of surgery. To minimize disruption to the surgical procedure during this study, samples were collected only three times and did not account for glove changes after puncture that occurred during surgery. Third, the analysis is subject to bias because it considered the operations in which an implant was used, rather than just one type of operation. However, the unique aspect of this study is the collection of samples by centrifugation of rinsed normal saline from the glove surfaces to increase the detection rates. In addition, the results of the study provide valuable insight into the contamination that occurs after the unpacking and transfer of AI.

Table 2. Statistical analysis

		Operator[a]		Assistant[a]		Scrub nurse[a]		
		Culture +	Culture −	Culture +	Culture −	Culture +	Culture −	*P* value
Phase 1	Culture +	0	–	0	–	0	–	N/A
	Culture −	–	35	–	35	–	35	
Phase 2	Culture +	0	–	0	–	5	–	.007
	Culture −	–	35	–	35	–	30	
Phase 3	Culture +	4	–	5	–	1	–	.197
	Culture −	–	31	–	30	–	34	
P value		.018		.007		.015		

[a]The number of participants in the 35 operations was as follows: 1 surgeon, 1 first assistant, and 3 scrub nurses.

https://doi.org/10.1017/ice.2024.49 Published online by Cambridge University Press

Acknowledgments. We would like to express our sincere gratitude to Dr Kunhyung Kim of the Center for Industrial Health, Korean Industrial Health Association, for his invaluable contribution in performing the statistical analysis. We are also deeply grateful for the dedicated cooperation of the members of the nursing staff in operating room 13.

Financial support. None reported.

Competing interests. All authors report no conflicts of interest relevant to this article.

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https://doi.org/10.1017/ice.2024.49 Published online by Cambridge University Press