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Original Article

Factors Associated with Surgical Field Bacterial Detection during Total Hip Arthroplasty

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Total hip arthroplasty (THA) provides relief from hip pain and improves hip function. However, periprosthetic joint infection (PJI) remains an area of concern. We examined the detection rate of bacteria from surgical fields in wound closure, along with the relationship between bacterial detection rate and type of antiseptic, surgery time, and surgeon experience for 500 patients who underwent THA at our department. The mean age at surgery was 64.3 (±27.3) years. The bacterial detection rate was 4.6%. None of the cases revealed PJI. No significant association between the detection rate and type of antiseptic used or surgery time was observed. However, for patients treated by surgeons with < 10 years of orthopedic experience, a detection rate of 7.3% was found, while a rate of 1.3% was observed for those treated by surgeons with ≥ 10 years of orthopedic experience. This finding indicated that orthopedic experience of less than 10 years was significantly associated with an increased bacterial detection rate (chi-square test, $p = 0.002$). The detection rate was associated with surgeon experience but not with antiseptic type or surgery time. It is possible that intraoperative handling may increase the number of bacteria in surgical fields in wound closure.

Key words: total hip arthroplasty, bacterial contamination, periprosthetic joint infection

Total hip arthroplasty (THA) is a highly effective procedure for relieving pain and restoring function in patients with hip disease, such as osteoarthritis, necrosis of the femoral head, and rheumatoid arthritis. The number of THA procedures performed annually has increased globally [1]. The development of materials for THA has improved durability and dislocation resistance. However, periprosthetic joint infection (PJI) is a severe complication that is often challenging to treat. According to the 2010 guidelines published by the Association for Professionals in Infection Control and Epidemiology, the incidence of surgical site infection (SSI) after THA ranges from 0.7% to 2.4% [2]. There are exogenous and endogenous routes for SSI. With the introduction of the first clean-air system by Charnley, SSI due to exogenous routes has decreased [3]. Resident skin bacteria are the most common endogenous source of SSI, but their migration to the surgical field cannot be completely prevented despite preoperative disinfection [4]. Few reports have assessed the presence of bacteria in the surgical field intraoperatively.

To the best of our knowledge, there are no reports that have investigated the presence of bacteria specifically during joint-replacement surgery in a bio-clean surgical room. In addition, few reports have examined the relationship between bacterial detection and the type of antiseptic utilized or the surgery time. We hypothesized that the bacterial detection rate would be associated with the type of antiseptic used, the surgery

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time, and intraoperative handling. This study assessed the presence of bacteria at the wound edge in THA wound closure and determined whether there was a relationship between the bacterial detection rate and antiseptic type used, the surgery time, and the surgeon's experience.

Materials and Methods

This study was approved by the Kawasaki Medical School Ethics Committee (approval no. 3786). The requirement for informed consent was waived by the ethics committee. The study was conducted in accordance with the Declaration of Helsinki.

The study included 500 individuals (418 women and 82 men) who underwent primary THA in our department between June 2015 and December 2019. The average age at surgery was 64.3 (±27.3) years. The underlying diseases were osteoarthritis of the hip in 443 cases, idiopathic necrosis of the femoral head in 46 cases, rapidly destructive coxarthropathy in 6 cases, and rheumatoid arthritis in 5 cases. Surgery was elective in all cases; those who underwent urgent or semi-urgent THA for trauma such as femoral neck fracture were excluded.

All surgeries were performed in our hospital's bioclean surgical room. Surgeons, assistants, and scrub nurses wore body exhaust suits and double gloves. Approximately 30 min before surgery, 1.0 g cefazolin (2.0 g for patients ≥80 kg) was administered by drip infusion, with additional doses given for each additional 2-h duration of surgery. Cefazolin was regularly administered 5 times every 8 hours for 2 days postoperatively. Iodophor-impregnated drapes were used after surgical field disinfection in all cases. After implantation and before suturing the subcutaneous tissue, the drapes were peeled back to swab the skin at the wound edge. The samples were submitted for culture testing. Cultures were grown for one week to test for the presence of aerobic and anaerobic bacteria.

Our department routinely uses a disinfection method that requires povidone-iodine application to the surgical field after surgeon handwashing. However, in this study, one of four antiseptics, including alcohol-containing chlorhexidine (A-group), alcohol (B-group), benzethonium chloride (C-group), and povidone-iodine (D-group), was applied to the surgical field before surgeon handwashing, and povidone-iodine was applied afterward. In addition, the conventional approach that involved only disinfecting the surgical field with povidone-iodine after the surgeon washed his hands was used in the control group (E-group).

During the study period, the 500 enrolled cases were alternately allocated to the five methods of disinfection, with 100 cases allocated to each group. Culture results were deemed positive when at least one strain of bacteria was identified. If multiple strains were identified simultaneously, all positive cultures were regarded as a single detection. The presence of PJI was investigated. Eight surgeons took part in the study. Surgeons were grouped based on their experience level: either <10 years (4 surgeons) or ≥10 years (4 surgeons).

The chi-squared test was used to analyze differences in detection rates between patient groups subjected to different operative conditions. Differences in the surgery time by detection rate and surgeon experience were analyzed using the Mann–Whitney *U* test. All statistical analyses were performed using SPSS, Version 23.0 (IBM Japan, Ltd., Tokyo, Japan). Values of $p < 0.05$ were considered significant.

Results

Detected bacteria (Table 1). Culture results revealed 15 cases of coagulase-negative *Staphylococcus* (5 of these were *Staphylococcus epidermidis*), 5 cases of *Propionibacterium acnes*, and 1 case each of methicillin-susceptible *Staphylococcus aureus* (MSSA), *Corynebacterium* spp., gram-positive cocci of an unidentifiable strain, and anaerobic gram-positive bacilli of an unidentifiable strain. The detection rate was 4.6% (23/500), including 1 case of double infection. No patients displayed PJI.

Relationship between bacterial detection rate and other factors (Table 2). No significant relationship between the detection rate and antiseptic type was detected ($p = 0.95$).

The overall mean surgery time was 107.4 (±32.7) min. Positive-culture cases had a mean surgery time of 108.6 (±29.4) min, whereas negative-culture cases measured 107.4 (±32.9) min. This difference was not significant ($p = 0.55$). Progressively longer surgical times associated slightly elevated positive-culture rates: 3.7% (6/163) for <90 min, 4.2% (9/216) for 90-120 min, and 6.6% (8/121) for ≥120 min; however, these differences were not significant ($p = 0.48$).

Table 1 Bacteria detected from surgical fields upon wound closure during total hip arthroplasty

Detected bacteria	Cases
Coagulase-negative *Staphylococcus* spp.	15 (5 of these were *Staphylococcus epidermidis*)
Propionibacterium acnes	5
Methicillin-susceptible *Staphylococcus aureus* (MSSA)	1
Corynebacterium spp.	1
Gram-positive cocci (unidentifiable strain)	1
Anaerobic gram-positive bacilli (unidentifiable strain)	1

The detection rate was 4.6% (23/500), including one case of double infection.

Table 2 Antiseptic, surgery time, and years of surgeon experience as factors of bacterial detection rate

			Positive-culture rate	
Antiseptic	A-group	Alcohol-containing chlorhexidine → Povidone-iodine	6.0%	(6/100)
	B-group	Alcohol → Povidone-iodine	4.0%	(4/100)
	C-group	Benzethonium chloride → Povidone-iodine	4.0%	(4/100)
	D-group	Povidone-iodine → Povidone-iodine	4.0%	(4/100)
	E-group	Only povidone-iodine	5.0%	(5/100)
Surgery time	< 90 min		3.7%	(6/163)
	90–120 min		4.2%	(9/216)
	> 120 min		6.6%	(8/121)
Years of surgeon experience	< 10 years		7.3%	(20/275)
	≥ 10 years		1.3%	(3/225)

No significant differences were observed between the detection rate and disinfectant type or the surgery duration ($p > 0.05$). Less experience was associated with a significantly higher detection rate than more experience ($p = 0.002$).

Regarding surgeon experience, the positive-culture rates were 7.3% (20/275) when the surgeon had < 10 years of experience and 1.3% (3/225) when the surgeon had ≥ 10 years of experience. Operation by less experienced surgeons was associated with a significantly higher detection rate ($p = 0.002$). The mean surgery time was 102.0 (± 31.5) for surgeons with ≥ 10 years of experience and 109.0 (± 33.1) min for surgeons with < 10 years of experience. Although surgeons with ≥ 10 years' experience tended to have shorter surgery times, the difference was not significant ($p = 0.46$).

Discussion

In this study, the bacterial detection rate was 4.6%. The detection rate was associated with surgical experience but not with antiseptic type or duration of surgery.

Previous studies on cultured samples collected prior to wound closure in orthopedic surgeries include Bernard *et al.*, who reported 97 positive cases (8.3%) out of 1,036 total cases [5]. Our study showed a relatively lower positive detection rate, probably because all our patients underwent non-emergent surgery in a bio-clean surgical room.

Moreover, we investigated the relationship between the bacterial detection rate and the antiseptic type used in our study. Bacteria present on the skin surface typically include transient and resident flora. Transient flora, such as *Staphylococcus aureus*, *Escherichia coli*, and *Pseudomonas aeruginosa*, may be relatively easy to eliminate through disinfection but are more likely to cause infection. Resident flora, including *Propioni-*

bacterium acnes and coagulase-negative *Staphylococci* such as *Staphylococcus epidermidis*, are less likely to cause infection but are impossible to eradicate completely. The most frequent cause of SSI is *Staphylococcus aureus* [6,7]. However, an upward trend in infections caused by coagulase-negative *Staphylococcus* has recently been observed in immunocompromised hosts [8,9]. Therefore, preoperative skin disinfection is required to minimize the infection risk due to both transient and resident flora.

The antiseptics compared in the present study are widely used against common bacteria; however, each has distinct features. Alcohol acts instantly but lacks residual antiseptic effects, making it suitable for eliminating transient flora. Povidone-iodine, chlorhexidine, and benzethonium chloride act slowly but produce residual effects that are effective against resident flora. The 2015 Japanese Orthopaedic Association (JOA) clinical practice guideline on the prevention of SSIs in bones and joints lack a recommendation for any specific antiseptics since no evidence has accumulated suggesting differences in the incidence of SSI in bone and joint surgery [10]. Theoretically, a hybrid solution of povidone-iodine, chlorhexidine, or benzethonium chloride, which produces residual antiseptic effects, with fast-acting alcohol should be effective for combating both transient and resident flora. Alcohol-containing preparations have been suggested to be more beneficial for sterilization in some reports [11,12]. Recent international guidelines have recommended the same. The 2018 International Consensus Meeting (ICM 2018) on musculoskeletal infection reached a consensus strongly in favor (91%) of using alcohol-containing preparations [13]. SSI prevention guidelines from the U.S. Centers for Disease Control and Prevention have recommend the same [14]. The effectiveness of chlorhexidine compared with povidone-iodine has also been reported [15,16]. The WHO's global guidelines for the prevention of SSIs strongly recommended sterilization using alcohol-containing chlorhexidine rather than alcohol-containing povidone-iodine [17]. Our study found no significant differences in bacterial detection rates based on the type of antiseptic used. Interestingly, detection rates tended to be slightly elevated in the group treated with alcohol-containing chlorhexidine.

It is possible that more than the type of antiseptic used, surgery time and intraoperative handling influence bacterial detection rates. In fact, ample disinfection against resident flora can only temporarily maintain sterile conditions, as resident skin bacteria gradually appear from the hair follicles or sweat glands. Johnston *et al.* reported that the number of bacteria in the surgical field rebounded 30-60 min after disinfection [4]. The relationship between the surgery time and SSI incidence has been examined in many studies. Ridgeway *et al.* studied 16,291 cases of THA and reported that the infection rate increased significantly for surgeries lasting ≥120 min [18]. The ICM 2018 [13] reached a unanimous consensus that prolonged surgical times are related to SSI. They concluded that coordinated efforts to reduce operative times without technically compromising procedures could minimize infection risk. In this study, longer surgery times associated slightly increased bacterial detection rates. However, the difference between groups was not significant.

This study found that surgical experience of <10 years was the only risk factor for an elevated bacterial detection rate. It is difficult to assess how surgical experience affected the bacterial detection rates determined in this study; however, multiple factors may be considered. Iodophor-impregnated drapes are thought to potentially reduce SSI incidence and were used in all cases in the present study [19,20]. The use of iodophor-impregnated drapes hinders the transfer of resident skin bacteria to the surgical field through close adhesion. During surgery, the rough handling of retractors may cause drape separation and increase the likelihood of additional resident skin bacteria appearing at the wound edge. In addition, there is the potential for contamination due to the presence of falling bacteria. Contamination occurs in 14.5% of cleaned light handles [21], as well as in 56% of the top portions of C-arm receivers with cleaned covers [22]. Moreover, it is widely thought that the number of people in the operating room and the frequency of door opening/closing are correlated with the level of falling bacteria [23,24]. The ICM 2018 unanimously recommended limiting movement in and out of the operating room [13]. These various factors may have produced differences in bacterial detection rates.

There are several limitations of this study. First, the number of cases observed was relatively few. Consequently, this study reported only one case of *Staphylococcus aureus*, which is considered the most common causative SSI agent. Additionally, the present study did not include any case of PJI. Therefore, the

direct relationship between bacterial detection in the surgical field and PJI remains unclear. In the future, it may be necessary to enroll a larger number of participants to examine the relationship between bacteria detected in the surgical field and causative bacteria of PJI. Furthermore, in this study, it was not possible to determine the mechanism by which the surgeon's experience affected the bacterial detection rate. It may be possible to clarify this relationship by comparing the condition of drapes used by different surgeons at the time of wound closure. It is possible that bacterial detection was affected by intraoperative handling rather than the use of antiseptics or the surgery time.

The bacterial detection rate in surgical fields was 4.6% (23/500). The rate was related to surgical experience rather than the type of antiseptic used or the surgery time. Thus, it is possible that intraoperative handling may increase the number of bacteria detected from surgical fields in wound closure. We consider that intraoperative handling with utmost caution may reduce PJI.

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References

1. Abdelaal MS, Restrepo C and Sharkey PF: Global perspectives on arthroplasty of hip and knee joints. Orthop Clin North Am (2020) 51: 169–176.
2. Springer BD, Cahue S, Etkin CD, Lewallen DG and McGrory BJ: Infection burden in total hip and knee arthroplasties: an international registry-based perspective. Arthroplast Today (2017) 3: 137–140.
3. Charnley J: A clean-air operating enclosure. Br J Surg (1964) 51: 202–205.
4. Johnston DH, Fairclough JA, Brown EM and Morris R: Rate of bacterial recolonization of the skin after preparation: four methods compared. Br J Surg (1987) 74: 64.
5. Bernard L, Sadowski C, Monin D, Stern R, Wyssa B, Rohner P, Lew D and Hoffmeyer P: The value of bacterial culture during clean orthopedic surgery: a prospective study of 1,036 patients. Infect Control Hosp Epidemiol (2004) 25: 512–514.
6. Arciola CR, Cervellati M, Pirini V, Gamberini S and Montanaro L: Staphylococci in orthopaedic surgical wounds. New Microbiol (2001) 24: 365–369.
7. Weinstein MA, McCabe JP and Cammisa FP Jr.: Postoperative spinal wound infection: a review of 2,391 consecutive index procedures. J Spinal Disord (2000) 13: 422–426.
8 Ammon P and Stockley I: Allograft bone in two-stage revision of the hip for infection. Is it safe? J Bone Joint Surg Br (2004) 86: 962–965.
9. Babcock HM, Matava MJ and Fraser V: Postarthroscopy surgical site infections: review of the literature. Clin Infect Dis (2002) 3: 65–71.
10. Committee on Clinical Practice Guideline on the Prevention of Surgical Site Infections in Bone and Joint: The Japanese Orthopaedic Association (JOA) clinical practice guideline on the prevention of surgical site infections in bone and joint. Nankodo, Tokyo (2015) (in Japanese).
11. Saltzman MD, Nuber GW, Gryzlo SM, Marecek GS and Koh LJ: Efficacy of surgical preparation solutions in shoulder surgery. J Bone Joint Surg Am (2009) 91: 1949–1953.
12. Bibbo C, Patel DV, Gehrmann RM and Lin SS: Chlorhexidine provides superior skin decontamination in foot and ankle surgery: a prospective randomized study. Clin Orthop Relat Res (2005) 438: 204–208.
13. Schwarz EM, Parvizi J, Gehrke T, Aiyer A, Battenberg A, Brown SA, Callaghan JJ, Citak M, Egol K, Garrigues GE, Ghert M, Goswami K, Green A, Hammound S, Kates SL, McLaren AC, Mont MA, Namdari S, Obremskey WT, O'Toole R, Raikin S, Restrepo C, Ricciardi B, Saeed K, Sanchez-Sotelo J, Shohat N, Tan T, Thirukumaran CP and Winters B: 2018 International Consensus Meeting on Musculoskeletal Infection: Research Priorities from the General Assembly Questions. J Orthop Res (2019) 37(5): 997–1006.
14. Berríos-Torres SI, Umscheid CA, Bratzler DW, Leas B, Stone EC, Kelz RR, Reinke CE, Morgan S, Solomkin JS, Mazuski JE, Dellinger EP, Itani KMF, Berbari EF, Segreti J, Parvizi J, Blanchard J, Allen G, Kluytmans JAJW, Donlan R and Schecter WP; Healthcare Infection Control Practices Advisory Committee: Centers for Disease Control and Prevention guideline for the prevention of surgical site infection, 2017. JAMA Surg (2017) 152: 784–791.
15. Molina ME, Nonweiller DE, Evans JA and Delee JC: Contaminated anterior cruciate ligament grafts: the efficacy of 3 sterilization agents. Arthroscopy (2000) 16: 373–378.
16. Tuuli MG, Liu J, Stout MJ, Martin S, Cahill AG, Odibo AO, Colditz GA and Macones GA: A randomized trial comparing skin antiseptic agents at Cesarean delivery. N Engl J Med (2016) 374: 647–655.
17. World Health Organization: WHO global guidelines on the prevention of surgical site infection. (2016) (Cited 2021 Feb 26) Available from: https://www.who.int/gpsc/SSI-outline.pdf?ua=1.
18. Ridgeway S, Wilson J, Charlet A, Kafatos G, Pearson A and Coello R: Infection of the surgical site after arthroplasty of the hip. J Bone Joint Surg Br (2005) 87: 844–850.
19. Ritter MA and Campbell ED: Retrospective evaluation of an iodophor-incorporated antimicrobial plastic adhesive wound drape. Clin Orthop Relat Res (1988) 228: 307–308.
20. Webster J and Alghamdi AA: Use of plastic adhesive drapes during surgery for preventing surgical site infection. Cochrane Database Syst Rev (2007) 4: CD006353.
21. Davis N, Curry A, Gambhir AK, Panigrahi H, Walker CR, Wilkins EG, Worsley MA and Kay PR: Intraoperative bacterial contamination in operations for joint replacement. J Bone Joint Surg Br (1999) 81: 886–889.
22. Biswas D, Bible JE, Whang PG, Simpson AK and Grauer JN: Sterility of C-arm fluoroscopy during spinal surgery. Spine (Phil Pa 1976) (2008) 33: 1913–1917.
23. Quraishi ZA, Blais FX, Sottile WS and Adler LM: Movement of personnel and wound contamination. AORN J (1983) 38: 146–147, 150–156.
24. Panahi P, Stroh M, Casper DS, Parvizi J and Austin MS: Operation room traffic is a major concern during total joint arthroplasty. Clin Orthop Relat Res (2012) 470: 2690–2694.