Review Article

pISSN: 2287-3260 / eISSN: 2287-3279
Hip Pelvis 2024;36(3):161-167
https://doi.org/10.5371/hp.2024.36.3.161

Hip & Pelvis

Evidence-based Approach for Prevention of Surgical Site Infection

Mehmet Kursat Yilmaz, MD*,†, Nursanem Celik, MD*,‡, Saad Tarabichi, MD*, Ahmad Abbaszadeh, MD*, Javad Parvizi, MD, FRCS§

*Rothman Orthopaedic Institute, Thomas Jefferson University, Philadelphia, PA, USA**
Department of Orthopaedics and Traumatology, Istanbul Medipol University School of Medicine, Istanbul, Türkiye†
Istanbul Medipol University School of Medicine, Istanbul, Türkiye‡
International Joint Center, Acıbadem Maslak Hospital, Istanbul, Türkiye§

Periprosthetic joint infection (PJI) is regarded as a critical factor contributing to the failure of primary and revision total joint arthroplasty (TJA). With the increasing prevalence of TJA, a significant increase in the incidence of PJI is expected. The escalating number of cases, along with the significant economic strain imposed on healthcare systems, place emphasis on the pressing need for development of effective strategies for prevention. PJI not only affects patient outcomes but also increases mortality rates, thus its prevention is a matter of vital importance. The longer-term survival rates for PJI after total hip and knee arthroplasty correspond with or are lower than those for prevalent cancers in older adults while exceeding those for other types of cancers. Because of the multifaceted nature of infection risk, a collaborative effort among healthcare professionals is essential to implementing diverse strategies for prevention. Rigorous validation of the efficacy of emerging novel preventive techniques will be required. The combined application of these strategies can minimize the risk of infection, thus their comprehensive adoption is important. Collectively, the risk of PJI could be substantially minimized by application of a multifaceted approach implementing these strategies, leading to improvement of patient outcomes and a reduced economic burden.

Keywords: Periprosthetic joint infection, Total joint arthroplasty, Risk factors, Infection control, Surgical wound infection

INTRODUCTION

Periprosthetic joint infection (PJI) is the most significant factor contributing to failure of primary and revision total joint arthroplasty (TJA)[1]. The number of TJAs is increasing daily. It is predicted that by 2060 in the United States, the volume of patients aged ≥65 years undergoing primary total hip arthroplasty (THA) and total knee arthroplasty (TKA) will increase by 559%[2]. With the increasing number of TJA cases, the incidence of PJI will also increase. With estimated annual hospital spending expected to reach $1.85 billion (approximately $6 per person in the US) by 2030, PJI of the hip and knee still imposes a significant financial burden on the US healthcare system[3].

The consequences of PJI can be severe. Significantly higher mortality has been reported for patients undergoing surgery for treatment of PJI compared to patients undergoing aseptic revision arthroplasty[4]. A study conducted by Berend et al.[5] reported that the mortality rate within 90 days following a two-stage exchange surgery was 4%, while an extra 7% of patients died prior to undergoing the second stage procedure. The 5-year overall survival rates for PJI following THA and TKA are comparable to or lower than those for two of the most commonly occurring cancers in old-

Correspondence to: Mehmet Kursat Yilmaz, MD https://orcid.org/0000-0002-6398-281X
Rothman Orthopaedic Institute, Thomas Jefferson University, 925 Chestnut St., 5th Floor, Philadelphia, PA 19107, USA
E-mail: dryilmazkursat@gmail.com

Received: August 31, 2023 **Revised:** November 20, 2023 **Accepted:** November 20, 2023

er adults in the US (prostate and breast), higher than those for other cancers[6].

Some organizations have discussed the preventive practices approved by the latest clinical practice guidelines for surgical site infection (SSI) and prevention of PJI; for example, Centers for Disease Control and Prevention, International Consensus Meeting on Musculoskeletal Infection, and American Academy of Orthopedic Surgeons[5,7,8]. The purpose of the current study was to review and summarize the 10-step approach for prevention of PJI.

OPTIMIZATION OF HOST RISK FACTORS

Prior to undergoing joint replacement surgery, collection of detailed information regarding the patient's medical history and overall health is essential to ensure appropriate preoperative assessment and care. Several factors can play a critical role in minimizing the risk of PJI, including postoperative glycemia control, management of immunosuppression, appropriate management of obesity, malnutrition, metabolic syndrome, preoperative anemia, and smoking cessation[9]. Smoking, including its primary component nicotine, has been linked to microvascular constriction and reduced supply of oxygen to tissues[10]. In a comprehensive national database study, Duchman et al.[11] reported an elevated risk of SSI among both current and former smokers, and the rate of wound complications was higher for current smokers compared to former smokers. In addition, preoperative evaluation of vitamin D levels, screening for urinary tract infection, and dental hygiene examinations can contribute to reducing the rates of PJI. Vitamin D deficiency is more common in the US population and studies have demonstrated that low levels of vitamin D can increase the risk of PJI. Preoperative optimization of serum vitamin D should be considered. A higher risk of infection has been reported for patients with uncontrolled diabetes[12]. Hemoglobin A1c (HbA1c) is used for long-term glycemic control and HbA1c should be less than seven[12]. In addition, recent studies have demonstrated the accuracy of fructosamine, a glycemic marker, in prediction of adverse outcomes following THA[13].

REDUCING BIOBURDEN

SSI, a commonly encountered complication following surgery, is characterized by infection at the incision site. It imposes a significant burden on both patients and healthcare systems, contributing to extended hospital stays, increased utilization of healthcare resources, and increased healthcare costs. Use of antiseptic solutions such as chlorhexidine or povidone-iodine is preferred in the effort to avoid SSI. Although both solutions are effective in reducing occurrence of surgical infections, compared with aqueous iodine in any type of surgery, 2.0%-2.5% chlorhexidine in alcohol showed the highest efficacy. Guidelines on prevention of SSIs published by the World Health Organization (WHO), the UK National Institute for Health and Care Excellence (NICE), and the US Centers for Disease Control and Prevention (CDC) have provided contrasting recommendations regarding surgical skin preparation. NICE and WHO support the use of chlorhexidine in alcohol, while the CDC has suggested the use of any type of alcohol-based solution. A study by Jalalzadeh et al.[14] recommended the use of 2.0%-2.5% chlorhexidine in alcohol as an effective preoperative skin preparation for any type of surgery. If this concentration is not available, alternatives such as 0.5% or 4.0% chlorhexidine in alcohol may be used. Hair removal, another aspect of surgical site preparation, can potentially increase the occurrence of SSIs, thus hair removal should be minimized when necessary[9,12,14,15].

In addition, nasal colonization by *Staphylococcus aureus* has been associated with an increased risk of SSIs. And a few studies have also reported that eradicating the pathogen may be helpful in reducing the rate of infection[16].

UTILIZATION OF PERIOPERATIVE ANTIBIOTIC PROPHYLAXIS

Despite limited supporting evidence, CDC guidelines recommend administration of a single preoperative dose for patients undergoing TJA[16]. In addition, according to a study conducted by Christensen et al.[17], no difference in occurrence of acute PJI, superficial infections, reoperations. or overall complications was observed between the 24-hour antibiotic prophylaxis group and the single-dose antibiotic prophylaxis group. In contrast, compared with patients receiving single-

dose antibiotic prophylaxis, patients receiving 24-hour antibiotic prophylaxis had significantly longer lengths of stay, longer operative time, and elevated body mass index, and were more likely to have undergone a bilateral procedure. Regarding antibiotic use, intravenous administration of the first generation of cephalosporin within 30 to 60 minutes before incision as a single and weight-adjusted dose is recommended[18,19]. Prior to the guideline updates, an allergic reaction to penicillin involving skin lesions or local swelling was categorized as a severe allergy, for which clindamycin or vancomycin was recommended as second-line prophylaxis. However, the updated guidelines have excluded skin lesions and local swelling, thereby redefining what constitutes a severe allergy[20]. In addition, considering the high rates of Staphylococcal resistance to clindamycin, the updated guidelines now recommend streamlining the use of vancomycin as the sole option for second-line prophylaxis[21].

BEING GENTLE ON SOFT TISSUE

Failure during any step in the reprocessing of surgical instruments is associated with a higher risk of microorganism transmission. Gloving is crucial for safeguarding both the surgeon and the patient against blood-borne viruses and preventing contamination of the surgical wound by skin flora[22]. In addition, wound infections pose a challenge for physicians, and selection of suture material can play a crucial role in preventing infection. However, objective data guiding selection of materials are limited. Sutures, which act as foreign bodies, harbor bacteria, increasing the risk of infection. While they can promote tissue healing and limit contamination, the choice of suture material can influence resistance to infection[23].

PERFORMING SURGERY AS RAPIDLY AS POSSIBLE

Operative time is a significant factor affecting SSI. In general, longer surgical operation time can result in extended tissue exposure, increased fatigue, and technical errors among the surgical team, as well as reduced systemic defenses of the body[24]. One study demonstrated that the duration of surgery was a significant risk factor for development of SSIs. Employment of strategies to reduce the duration of surgical operations can be a practical approach to reducing the rate of SSIs[25]. A recent study[26] also reported an association of procedure time with increased risk of SSI. Competence of support staff during performance of operations may affect procedure time and this can be improved. Preoperative planning can also be helpful in reducing the time spent on decision making during surgery and in predicting materials requirements[27]. This may include employment of strategies such as the adoption of novel technologies that may be helpful in the effort to enhance operative efficiency, utilization of specialized care teams, and preventing overwork or fatigue among operating staff. Administration of additional doses of antibiotics is a generally accepted approach, in cases when the duration of surgery is prolonged and blood loss is high[28].

ADOPTING STRATEGIES FOR OPTIMAL CONTROL OF BLOOD LOSS

The detrimental effects of allogeneic blood transfusion, both in general and specifically regarding the outcomes of TJA, have been clearly delineated through conduct of extensive research. An association of allogeneic blood transfusion with increased overall mortality and heightened risk of subsequent SSI has been consistently demonstrated. With supporting evidence from several studies, in the bilateral group, an association of the duration of surgery with a significant increase in the incidence of receiving an allogeneic transfusion has been reported. Therefore, emphasis on reducing operation time is important in order to alleviate the need for allogeneic transfusions and their associated risks[29,30]. The results of one study showed significant correlations between transfusion risk and several factors, including advancing age, female gender, lower body weight, preexisting anemia, longer surgical duration, exclusive use of general anesthesia, American Society of Anesthesiologists class higher than II, and undergoing revision surgery[31].

Use of venous thromboembolism prophylaxis agents following TJA has become routine. However, potential side effects including bleeding should be noted. The potential for bleeding associated with the use of these agents should be an important consideration[32].

ESTABLISHING A LESS CROWDED OPERATING ROOM ENVIRONMENT

An association of increased airborne bacterial counts with traffic within the operating room (OR) has been noted. The act of opening doors, which can potentially increase air and wound contamination, can contribute to colonization of bacteria. Numerous studies have reported statistically significant correlations between the frequency of door openings and elevated airborne bacterial counts[33-35]. Studies directly addressing nursing personnel and for implementation of interventions supporting a reduction in OR traffic due to the request for information have been conducted. Low-cost interventions such as door signage explicitly prohibiting entry by nonessential traffic or personnel and use of retractable tape as a physical barrier for OR doors have resulted in significantly increased awareness and have been helpful in addressing concern regarding OR traffic. The impact of these simple yet effective measures can prove substantial in the effort to mitigate the issue[36,37].

UTILIZING AN ANTISEPTIC IRRIGATION SOLUTION

While chlorhexidine combined with alcohol is effective for preoperative skin preparation, use of povidone-iodine along with chlorhexidine for this purpose is still a common practice among many orthopedic surgeons[38]. The results of one study indicated that the shortest time to elimination of *S. aureus* and *Cutibacterium acnes* with no growth at any exposure time was achieved with use of 0.35% povidone-iodine[39]. Povidone-iodine was also effective in eliminating *Staphylococcus epidermidis* after 90 seconds of treatment[39].

ENSURING PROPER CLEANING OF IMPLANTS AND INSTRUMENTS

Sterilization of implants and instruments during all steps of an operation is essential in preventing infection[40]. Several methods can be used for sterilization, including heat (steam), dry heat, radiation, ethylene oxide gas, vaporized hydrogen peroxide, and other sterilization methods (chlorine dioxide gas, vaporized peracetic acid, nitrogen dioxide, etc.)[41]. Based on the rates of microbiological contamination, changing gloves after draping, prior to handling implants, and whenever visible perforation is detected is recommended. Considering the correlation between the duration of surgery and increasing rates of microbiological contamination, changing gloves at least once per hour is advisable, unless there are other compelling reasons to do so[42]. Over time, increasing contamination can affect all types of implant materials. Taking simple precautions, such as covering the implant set, can reduce the risk of contamination[43].

OPTIMIZING WOUND CARE

Wound healing is an important factor in prevention of PJI. Recently, use of innovative surgical bandages, such as hydro fiber absorbent dressings, as an effort to minimize medication requirements while promoting enhanced wound healing and preventing infiltration of external bacterial into the wound site has been increasingly recommended[44,45]. According to Lung et al.[46], the efficacy of chlorhexidine gluconate is comparable to that of dilute betadine in preventing PJI, while also reducing the incidence of superficial drainage and wound complications that necessitate unplanned visits to the emergency department during the acute postoperative period. The suture should fulfill its intended purpose while minimizing adverse reactions as well as the risk of infection, ensuring sufficient duration of effectiveness and strength. However, a suture with greater strength or high tensile strength is not considered universally superior due to the required increase in suture thickness and the potential for unintended tissue constriction, which could potentially exacerbate the inflammatory response[47].

CONCLUSION

Prevention of SSI and PJI is more important than diagnosis and treatment. The more PJIs that can be prevented, the greater the reduction of the economic and mental burden inflicted by PJI on the state and patients. Given the multifactorial nature of infection risk, mobilization of all healthcare professionals toward prevention through use of a variety of strategies is essential. In addition, with the continued introduction of novel preventive methods in this sphere, confirming the reliability of these strategies remains critical. Combined application of these individually important

strategies can minimize the risk of infection.

Funding

No funding to declare.

Conflict of Interest

Javad Parvizi has been a deputy editor since January 2021, but had no role in the decision to publish this article. No other potential conflict of interest relevant to this article was reported.

REFERENCES

1. Jafari SM, Coyle C, Mortazavi SM, Sharkey PF, Parvizi J. Revision hip arthroplasty: infection is the most common cause of failure. Clin Orthop Relat Res. 2010;468:2046-51. https://doi.org/10.1007/s11999-010-1251-6
2. Shichman I, Roof M, Askew N, et al. Projections and epidemiology of primary hip and knee arthroplasty in Medicare patients to 2040-2060. JB JS Open Access. 2023;8:e22.00112. https://doi.org/10.2106/JBJS.OA.22.00112
3. Premkumar A, Kolin DA, Farley KX, et al. Projected economic burden of periprosthetic joint infection of the hip and knee in the United States. J Arthroplasty. 2021;36:1484-9.e3. https://doi.org/10.1016/j.arth.2020.12.005
4. Zmistowski B, Karam JA, Durinka JB, Casper DS, Parvizi J. Periprosthetic joint infection increases the risk of one-year mortality. J Bone Joint Surg Am. 2013;95:2177-84. https://doi.org/10.2106/JBJS.L.00789
5. Berend KR, Lombardi AV Jr, Morris MJ, Bergeson AG, Adams JB, Sneller MA. Two-stage treatment of hip periprosthetic joint infection is associated with a high rate of infection control but high mortality. Clin Orthop Relat Res. 2013;471:510-8. https://doi.org/10.1007/s11999-012-2595-x
6. Kurtz SM, Lau EC, Son MS, Chang ET, Zimmerli W, Parvizi J. Are we winning or losing the battle with periprosthetic joint infection: trends in periprosthetic joint infection and mortality risk for the Medicare population. J Arthroplasty. 2018;33:3238-45. https://doi.org/10.1016/j.arth.2018.05.042
7. Jiranek W, Kigera JWM, Klatt BA, et al. General assembly, prevention, host risk mitigation - general factors: proceedings of international consensus on orthopedic infections. J Arthroplasty. 2019;34(2S):S43-8. https://doi.org/10.1016/j.arth.2018.09.052
8. Tubb CC, Polkowksi GG, Krause B. Diagnosis and Prevention of Periprosthetic Joint Infections. J Am Acad Orthop Surg. 2020;28:e340-8. https://doi.org/10.5435/JAAOS-D-19-00405
9. Wang K, Li W, Liu H, Yang Y, Lv L. Progress in prevention, diagnosis, and treatment of periprosthetic joint infection. Evid Based Complement Alternat Med. 2021;2021:3023047. https://doi.org/10.1155/2021/3023047
10. Møller AM, Pedersen T, Villebro N, Munksgaard A. Effect of smoking on early complications after elective orthopaedic surgery. J Bone Joint Surg Br. 2003;85:178-81. https://doi.org/10.1302/0301-620x.85b2.13717
11. Duchman KR, Gao Y, Pugely AJ, Martin CT, Noiseux NO, Callaghan JJ. The effect of smoking on short-term complications following total hip and knee arthroplasty. J Bone Joint Surg Am. 2015;97:1049-58. https://doi.org/10.2106/JBJS.N.01016
12. Alamanda VK, Springer BD. Perioperative and modifiable risk factors for periprosthetic joint infections (PJI) and recommended guidelines. Curr Rev Musculoskelet Med. 2018;11:325-31. https://doi.org/10.1007/s12178-018-9494-z
13. Shohat N, Goswami K, Breckenridge L, et al. Fructosamine is a valuable marker for glycemic control and predicting adverse outcomes following total hip arthroplasty: a prospective multi-institutional investigation. Sci Rep. 2021;11:2227. https://doi.org/10.1038/s41598-021-81803-6
14. Jalalzadeh H, Groenen H, Buis DR, et al. Efficacy of different preoperative skin antiseptics on the incidence of surgical site infections: a systematic review, GRADE assessment, and network meta-analysis. Lancet Microbe. 2022;3:e762-71. https://doi.org/10.1016/S2666-5247(22)00187-2
15. Webster J, Osborne S. Preoperative bathing or showering with skin antiseptics to prevent surgical site infection. Cochrane Database Syst Rev. 2015;2015:CD004985. https://doi.org/10.1002/14651858.CD004985.pub5
16. Iannotti F, Prati P, Fidanza A, et al. Prevention of Periprosthetic Joint Infection (PJI): a clinical practice protocol in high-risk patients. Trop Med Infect Dis. 2020;5:186. https://doi.org/10.3390/tropicalmed5040186
17. Christensen DD, Moschetti WE, Brown MG, Lucas AP, Jevsevar DS, Fillingham YA. Perioperative antibiotic prophylaxis: single and 24-hour antibiotic dosages are equally effective at preventing periprosthetic joint infection in total joint arthroplasty. J Arthroplasty. 2021;36(7S):S308-13. https://doi.org/10.1016/j.arth.2021.02.037
18. Aboltins CA, Berdal JE, Casas F, et al. Hip and knee section, prevention, antimicrobials (systemic): proceedings of international consensus on orthopedic infections. J Arthroplasty. 2019;34(2S):S279-88. https://doi.org/10.1016/j.arth.2018.09.012
19. Hehl J, Jones D, Stohler S. Clinical practice guideline surgical

site infection prevention. National Association of Orthopaedic Nurses; 2021.
20. Alamanda VK, Springer BD. The prevention of infection: 12 modifiable risk factors. Bone Joint J. 2019;101-B(1_Supple_A):3-9. https://doi.org/10.1302/0301-620X.101B1.BJJ-2018-0233.R1
21. Jones R, Quartuccio KS, Stern JL, Heintz EV, Pillinger KE, Myers TG. Antibiotic stewardship interventions improve choice of antibiotic prophylaxis in total joint arthroplasty in patients with reported penicillin allergies. Clin Orthop Relat Res. 2021;479:1484-94. https://doi.org/10.1097/CORR.0000000000001739
22. Bali RK. Operating room protocols and infection control. In: Bonanthaya K, Panneerselvam E, Manuel S, Kumar VV, Rai A, eds. Oral and maxillofacial surgery for the clinician. Springer Nature; 2021. 173-94.
23. Masini BD, Stinner DJ, Waterman SM, Wenke JC. Bacterial adherence to suture materials. J Surg Educ. 2011;68:101-4. https://doi.org/10.1016/j.jsurg.2010.09.015
24. Ercole FF, Franco LM, Macieira TG, Wenceslau LC, de Resende HI, Chianca TC. Risk of surgical site infection in patients undergoing orthopedic surgery. Rev Lat Am Enfermagem. 2011;19:1362-8. https://doi.org/10.1590/s0104-11692011000600012
25. Li GQ, Guo FF, Ou Y, Dong GW, Zhou W. Epidemiology and outcomes of surgical site infections following orthopedic surgery. Am J Infect Control. 2013;41:1268-71. https://doi.org/10.1016/j.ajic.2013.03.305
26. Simon S, Hollenbeck B. Risk factors for surgical site infections in knee and hip arthroplasty patients. Am J Infect Control. 2022;50:214-6. https://doi.org/10.1016/j.ajic.2021.11.006
27. Cheng H, Chen BP, Soleas IM, Ferko NC, Cameron CG, Hinoul P. Prolonged operative duration increases risk of surgical site infections: a systematic review. Surg Infect (Larchmt). 2017;18:722-35. https://doi.org/10.1089/sur.2017.089
28. Hanssen AD, Osmon DR. The use of prophylactic antimicrobial agents during and after hip arthroplasty. Clin Orthop Relat Res. 1999;(369):124-38. https://doi.org/10.1097/00003086-199912000-00013
29. Pedersen AB, Mehnert F, Overgaard S, Johnsen SP. Allogeneic blood transfusion and prognosis following total hip replacement: a population-based follow up study. BMC Musculoskelet Disord. 2009;10:167. https://doi.org/10.1186/1471-2474-10-167
30. Ross D, Erkocak O, Rasouli MR, Parvizi J. Operative time directly correlates with blood loss and need for blood transfusion in total joint arthroplasty. Arch Bone Jt Surg. 2019;7:229-34. https://doi.org/10.22038/ABJS.2019.28534.1736
31. Rashiq S, Finegan BA. The effect of spinal anesthesia on blood transfusion rate in total joint arthroplasty. Can J Surg. 2006;49:391-6.
32. Choi YS, Kim TW, Chang MJ, Kang SB, Chang CB. Enhanced recovery after surgery for major orthopedic surgery: a narrative review. Knee Surg Relat Res. 2022;34:8. https://doi.org/10.1186/s43019-022-00137-3
33. Alizo G, Onayemi A, Sciarretta JD, Davis JM. Operating room foot traffic: a risk factor for surgical site infections. Surg Infect (Larchmt). 2019;20:146-50. https://doi.org/10.1089/sur.2018.248
34. Lansing SS, Moley JP, McGrath MS, Stoodley P, Chaudhari AMW, Quatman CE. High number of door openings increases the bacterial load of the operating room. Surg Infect (Larchmt). 2021;22:684-9. https://doi.org/10.1089/sur.2020.361
35. Panahi P, Stroh M, Casper DS, Parvizi J, Austin MS. Operating room traffic is a major concern during total joint arthroplasty. Clin Orthop Relat Res. 2012;470:2690-4. https://doi.org/10.1007/s11999-012-2252-4
36. Buckner L, Lacy J, Young K, Dishman D. Decreasing foot traffic in the orthopedic operating room: a narrative review of the literature. J Patient Saf. 2022;18:e414-23. https://doi.org/10.1097/PTS.0000000000000833
37. Osborn NS, Hoehmann CL, McCormack R, Owens J. Operating room traffic in total joint arthroplasty: one simple measure toward solving a complex problem. JB JS Open Access. 2020;5:e20.00015. https://doi.org/10.2106/JBJS.OA.20.00015
38. Mastrocola M, Matziolis G, Böhle S, Lindemann C, Schlattmann P, Eijer H. Meta-analysis of the efficacy of preoperative skin preparation with alcoholic chlorhexidine compared to povidone iodine in orthopedic surgery. Sci Rep. 2021;11:18634. https://doi.org/10.1038/s41598-021-97838-8
39. Christopher ZK, Tran CP, Vernon BL, Spangehl MJ. What is the duration of irrigation? An in vitro study of the minimum exposure time to eradicate bacteria with irrigation solutions. J Arthroplasty. 2022;37:385-9.e2. https://doi.org/10.1016/j.arth.2021.10.013
40. Spiegel C, Nogler M, Coraça-Huber DC. Sterilization procedures for titanium alloy surfaces leads to higher expression of biofilm-related Staphylococcus aureus genes. Antibiotics (Basel). 2022;11:1647. https://doi.org/10.3390/antibiotics11111647
41. U.S. Food and Drug Administration (FDA). Sterilization for medical devices. FDA; 2023.
42. Kim K, Zhu M, Munro JT, Young SW. Glove change to reduce the risk of surgical site infection or prosthetic joint infection in arthroplasty surgeries: a systematic review. ANZ J Surg.

2019;89:1009-15. https://doi.org/10.1111/ans.14936
43. Menekse G, Kuscu F, Suntur BM, et al. Evaluation of the time-dependent contamination of spinal implants: prospective randomized trial. Spine (Phila Pa 1976). 2015;40:1247-51. https://doi.org/10.1097/BRS.0000000000000944
44. Ratto N, Arrigoni C, Rosso F, et al. Total knee arthroplasty and infection: how surgeons can reduce the risks. EFORT Open Rev. 2017;1:339-44. https://doi.org/10.1302/2058-5241.1.000032
45. Cai J, Karam JA, Parvizi J, Smith EB, Sharkey PF. Aquacel surgical dressing reduces the rate of acute PJI following total joint arthroplasty: a case-control study. J Arthroplasty. 2014;29:1098-100. https://doi.org/10.1016/j.arth.2013.11.012
46. Lung BE, Le R, Callan K, et al. Chlorhexidine gluconate lavage during total joint arthroplasty may improve wound healing compared to dilute betadine. J Exp Orthop. 2022;9:67. https://doi.org/10.1186/s40634-022-00503-w
47. Pacer E, Griffin DW, Anderson AB, Tintle SM, Potter BK. Suture and needle characteristics in orthopaedic surgery. JBJS Rev. 2020;8:e19.00133. https://doi.org/10.2106/JBJS.RVW.19.00133