

1.18. PREVENTION: WOUND MANAGEMENT

Authors: Arash Aalirezaie, Ran Schwarzkopf, Viktor Krebs, Yale Fillingham, Anton Khlopas, Afshin Anoushiravani, Michael A. Mont, Nipun Sodhi

QUESTION 1: Does the type of wound closure (technique and material) affect the incidence of subsequent surgical site infection/periprosthetic joint infection (SSI/PJI)?

RECOMMENDATION: There is a lack of strong evidence clearly demonstrating the superiority of any wound closure method following total joint arthroplasty (TJA). The majority of the high-quality studies demonstrate no difference between the various types of wound closure.

LEVEL OF EVIDENCE: Moderate

DELEGATE VOTE: Agree: 90%, Disagree: 8%, Abstain: 2% (Super Majority, Strong Consensus)

RATIONALE

Currently there are several techniques available for wound closure following TJA, including staples, sutures, adhesives and transdermal systems [1]. Although several randomized clinical trials (RCTs) are available, surgeons primarily select wound closure systems based upon personal preference. The ultimate goal is to use a wound closure system that balances cosmetic appearance, clinical outcomes and cost-effectiveness. Based on the currently-available literature, no closure system has been shown to consistently reduce the risk of SSI/PJI. Despite several level I evidence studies investigating the complications of wound closure systems, they are dramatically underpowered. Below is a summary of the available literature on each method of wound closure.

Conventional Suture and Staples

Historically, TJA wound incisions have been closed using nylon sutures or metal staples. Both options have demonstrated low wound complication rates, easily reproducible application and cost-effectiveness, but require a clinic visit within two weeks of surgery for removal [2]. Many studies have comparatively evaluated outcomes following closure with conventional sutures and staples with inconsistent results. Several RCTs and a retrospective study have reported no significant difference in wound complication rates between sutures and staples [2–7]. Other studies have reported superior outcomes for staple closures, while others have reported an increased incidence of infection with staple closures [8–13].

Barbed Sutures

Barbed sutures have been popularized for eliminating the need for knots while demonstrating superior water-tight closures in cadaveric models [14]. Similar to conventional closure techniques, barbed suture has been evaluated in numerous retrospective studies and RCTs with inconsistent results when compared to conventional closures [15–26]. Likewise, the published meta-analyses on barbed suture closure have provided inconsistent results. The meta-analysis by Zhang et al. reported significantly fewer complications and superficial infections when the arthrotomy, subcutaneous and subcuticular tissues are closed with barbed sutures [27]. A meta-analysis by Meena et al. has indicated a higher rate of infection for barbed sutures, albeit not statistically significant [28]. However, another meta-analysis by Borzio et al. confirmed the cost savings associated with barbed sutures but demonstrated no significant difference in complication rates between conventional and barbed sutures [29].

Non-invasive Skin Closure (e.g., Adhesives, Transdermal Systems)

Currently there are two categories of non-invasive skin closure: adhesives and transdermal systems. The majority of RCTs have demonstrated no difference in cosmetic and clinical outcomes between sutures, staples and adhesive closures [4,6,30]. In the Cochrane review by Dumville et al., the effects of various tissue adhesives were compared with sutures, staples and other methods of skin closure techniques using wound infection and dehiscence as the two outcome measures [31]. The results demonstrated no difference in the risk of wound infection between the closure methods, however, there was wide variability in the definition of wound infection between studies. Regarding wound dehiscence, conventional sutures were significantly better than tissue adhesives, but the analysis relied heavily on low-evidence studies.

Only limited evidence exists on the performance of transdermal closure systems. Ko et al. compared outcomes between staples and a transdermal closure in a small cohort of total knee arthroplasty (TKA) patients, which reported no complications, improved cosmesis and reduced pain scores at time of removal [32]. Similarly, Carli et al. assessed a prospective series of TKA patients that found the transdermal closure cohort avoided home care and had fewer complications than the staple cohort [33].

REFERENCES

- [1] Krebs VE, Elmallah RK, Khlopas A, Chughtai M, Bonutti PM, Roche M, et al. Wound closure techniques for total knee arthroplasty: an evidence-based review of the literature. *J Arthroplasty*. 2018;33:633–638. doi:10.1016/j.arth.2017.09.032.
- [2] Buttaro MA, Martorell G, Quinteros M, Comba F, Zanotti G, Piccaluga F. Intraoperative synovial C-reactive protein is as useful as frozen section to detect periprosthetic hip infection. *Clin Orthop Relat Res*. 2015;473:3876–3881. doi:10.1007/s11999-015-4340-8.
- [3] Shantz JA, Vernon J, Leiter J, Morshed S, Stranges G. Sutures versus staples for wound closure in orthopaedic surgery: a randomized controlled trial. *BMC Musculoskelet Disord*. 2012;13:89. doi:10.1186/1471-2474-13-89.

- [4] Khan RJK, Fick D, Yao F, Tang K, Hurworth M, Nivbrant B, et al. A comparison of three methods of wound closure following arthroplasty: a prospective, randomised, controlled trial. *J Bone Joint Surg Br.* 2006;88:238–242. doi:10.1302/0301-620X.88B2.16923.
- [5] Yuenyongviwat V, Iamthanaporn K, Hongnaparak T, Tangtrakulwanich B. A randomised controlled trial comparing skin closure in total knee arthroplasty in the same knee: nylon sutures versus skin staples. *Bone Joint Res.* 2016;5:185–190. doi:10.1302/2046-3758.5.2000629.
- [6] Livesey C, Wylde V, Descamps S, Estela CM, Bannister GC, Learmonth ID, et al. Skin closure after total hip replacement: a randomised controlled trial of skin adhesive versus surgical staples. *J Bone Joint Surg Br.* 2009;91:725–729. doi:10.1302/0301-620X.91B6.21831.
- [7] Eggers MD, Fang L, Lionberger DR. A comparison of wound closure techniques for total knee arthroplasty. *J Arthroplasty.* 2011;26:1251–1258.e1–4. doi:10.1016/j.arth.2011.02.029.
- [8] Kim KY, Anoushiravani AA, Long WJ, Vigdorichik JM, Fernandez–Madrid I, Schwarzkopf R. A meta–analysis and systematic review evaluating skin closure after total knee arthroplasty—what is the best method? *J Arthroplasty.* 2017;32:2920–2927. doi:10.1016/j.arth.2017.04.004.
- [9] Patel RM, Cayo M, Patel A, Albarillo M, Puri L. Wound complications in joint arthroplasty: comparing traditional and modern methods of skin closure. *Orthopedics.* 2012;35:e641–e646. doi:10.3928/01477447-20120426-16.
- [10] Newman JT, Morgan SJ, Resende GV, Williams AE, Hammerberg EM, Dayton MR. Modality of wound closure after total knee replacement: are staples as safe as sutures? A retrospective study of 181 patients. *Patient Saf Surg.* 2011;5:26. doi:10.1186/1754-9493-5-26.
- [11] Shetty AA, Kumar VS, Morgan–Hough C, Georgeu GA, James KD, Nicholl JE. Comparing wound complication rates following closure of hip wounds with metallic skin staples or subcuticular vicryl suture: a prospective randomised trial. *J Orthop Surg (Hong Kong).* 2004;12:191–193. doi:10.1177/230949900401200210.
- [12] Smith TO, Sexton D, Mann C, Donell S. Sutures versus staples for skin closure in orthopaedic surgery: meta–analysis. *BMJ.* 2010;340:c1199.
- [13] Rui M, Zheng X, Sun SS, Li CY, Zhang XC, Guo KJ, et al. A prospective randomised comparison of 2 skin closure techniques in primary total hip arthroplasty surgery. *Hip Int.* 2018;28:101–105. doi:10.5301/hipint.5000534.
- [14] Nett M, Avelar R, Sheehan M, Cushner F. Water–tight knee arthrotomy closure: comparison of a novel single bidirectional barbed self–retaining running suture versus conventional interrupted sutures. *J Knee Surg.* 2011;24:55–59.
- [15] Chan VW, Chan PK, Chiu KY, Yan CH, Ng FY. Does barbed suture lower cost and improve outcome in total knee arthroplasty? a randomized controlled trial. *J Arthroplasty.* 2017;32:1474–1477. doi:10.1016/j.arth.2016.12.015.
- [16] Gililland JM, Anderson LA, Sun G, Erickson JA, Peters CL. Perioperative closure–related complication rates and cost analysis of barbed suture for closure in TKA. *Clin Orthop Relat Res.* 2012;470:125–129. doi:10.1007/s11999-011-2104-7.
- [17] Gililland JM, Anderson LA, Barney JK, Ross HL, Pelt CE, Peters CL. Barbed versus standard sutures for closure in total knee arthroplasty: a multicenter prospective randomized trial. *J Arthroplasty.* 2014;29:135–138. doi:10.1016/j.arth.2014.01.041.
- [18] Eickmann T, Quane E. Total knee arthroplasty closure with barbed sutures. *J Knee Surg.* 2010;23:163–167.
- [19] Austin DC, Keeney BJ, Dempsey BE, Koenig KM. Are barbed sutures associated with 90–day reoperation rates after primary TKA? *Clin Orthop Relat Res.* 2017;475:2655–2665. doi:10.1007/s11999-017-5474-7.
- [20] Chawla H, van der List JP, Fein NB, Henry MW, Pearle AD. Barbed suture is associated with increased risk of wound infection after unicompartmental knee arthroplasty. *J Arthroplasty.* 2016;31:1561–1567. doi:10.1016/j.arth.2016.01.007.
- [21] Campbell AL, Patrick DA, Liabaud B, Geller JA. Superficial wound closure complications with barbed sutures following knee arthroplasty. *J Arthroplasty.* 2014;29:966–969. doi:10.1016/j.arth.2013.09.045.
- [22] Smith EL, DiSegna ST, Shukla PY, Matzkin EG. Barbed versus traditional sutures: closure time, cost, and wound related outcomes in total joint arthroplasty. *J Arthroplasty.* 2014;29:283–287. doi:10.1016/j.arth.2013.05.031.
- [23] Elmallah RK, Khlopas A, Faour M, Chughtai M, Malkani AL, Bonutti PM, et al. Economic evaluation of different suture closure methods: barbed versus traditional interrupted sutures. *Ann Transl Med.* 2017;5:S26. doi:10.21037/atm.2017.08.21.
- [24] Sah AP. Is there an advantage to knotless barbed suture in TKA wound closure? a randomized trial in simultaneous bilateral TKAs. *Clin Orthop Relat Res.* 2015;473:2019–2027. doi:10.1007/s11999-015-4157-5.
- [25] Ting NT, Moric MM, Della Valle CJ, Levine BR. Use of knotless suture for closure of total hip and knee arthroplasties: a prospective, randomized clinical trial. *J Arthroplasty.* 2012;27:1783–1788. doi:10.1016/j.arth.2012.05.022.
- [26] Maheshwari AV, Naziri Q, Wong A, Burko I, Mont MA, Rasquinha VJ. Barbed sutures in total knee arthroplasty: are these safe, efficacious, and cost–effective? *J Knee Surg.* 2015;28:151–156. doi:10.1055/s-0034-1373741.
- [27] Zhang W, Xue D, Yin H, Xie H, Ma H, Chen E, et al. Barbed versus traditional sutures for wound closure in knee arthroplasty: a systematic review and meta–analysis. *Sci Rep.* 2016;6:19764. doi:10.1038/srep19764.
- [28] Meena S, Gangary S, Sharma P, Chowdhury B. Barbed versus standard sutures in total knee arthroplasty: a meta–analysis. *Eur J Orthop Surg Traumatol.* 2015;25:1105–1110. doi:10.1007/s00590-015-1644-z.
- [29] Borzio RW, Pivec R, Kapadia BH, Jauregui JJ, Maheshwari AV. Barbed sutures in total hip and knee arthroplasty: what is the evidence? A meta–analysis. *Int Orthop.* 2016;40:225–231. doi:10.1007/s00264-015-3049-3.
- [30] Glennie RA, Korczak A, Naudie DD, Bryant DM, Howard JL. MONOCRYL and DERMABOND vs staples in total hip arthroplasty performed through a lateral skin incision: a randomized controlled trial using a patient–centered assessment tool. *J Arthroplasty.* 2017;32:2431–2435. doi:10.1016/j.arth.2017.02.042.
- [31] Dumville JC, Coulthard P, Worthington HV, Riley P, Patel N, Darcey J, et al. Tissue adhesives for closure of surgical incisions. *Cochrane Database Syst Rev.* 2014:CD004287. doi:10.1002/14651858.CD004287.pub4.
- [32] Ko JH, Yang IH, Ko MS, Kamolhuja E, Park KK. Do zip–type skin–closing devices show better wound status compared to conventional staple devices in total knee arthroplasty? *Int Wound J.* 2017;14:250–254. doi:10.1111/iwj.12596.
- [33] Carli AV, Spiro S, Barlow BT, Haas SB. Using a non–invasive secure skin closure following total knee arthroplasty leads to fewer wound complications and no patient home care visits compared to surgical staples. *Knee.* 2017;24:1221–1226. doi:10.1016/j.knee.2017.07.007.



Authors: Mitch Harris, Ruwais Binlaksar, Gregory K. Deirmengian, Abhiram Bhashyam, Andre Shaffer, Reema K. Al-Horaibi

QUESTION 2: What is the role for vacuum–assisted incisional dressings (iVAC) in orthopaedic patients?

RECOMMENDATION: Prophylactic iVACs appear to be a reasonable option for improved wound healing and decreasing the infection rate in orthopaedic patients at risk for such complications. Prophylactic iVACs used routinely in uncomplicated cases do not appear to provide benefit and lead to increased costs. Lastly, evidence suggests that iVACs may also play a role in resolving some cases of early, benign postoperative drainage.

LEVEL OF EVIDENCE: Moderate

DELEGATE VOTE: Agree: 85%, Disagree: 11%, Abstain: 4% (Super Majority, Strong Consensus)

RATIONALE

Wound management through the application of negative pressure has been used for decades in multiple surgical disciplines, including plastic surgery, general surgery, trauma surgery, cardiothoracic surgery and orthopaedic surgery. It is thought to act through several mechanisms that result in wound contraction, stimulation of epithelial growth and prevention of fluid collection and wound drainage [1].

Within orthopaedic surgery, the use of iVACs has been investigated in studies spanning multiple sub-disciplinary areas, with moderate-strength evidence suggesting that iVACs may benefit wounds in at-risk patients. In retrospective studies, vacuum assisted incisional dressings were associated with fewer wound complications, deep infections and reoperation than standard surgical dressings following treatment of periprosthetic hip and knee fractures [2]. Similarly, incisional negative-pressure wound therapy (iNPWT) dressings were associated with improved wound healing and fewer surgical site infections following revision total hip or knee arthroplasty (THA/TKA), but there was no difference in wound dehiscence, deep infection or reoperation [3,4]. Similar results were observed when iNPWT was used following total ankle arthroplasty [5], long-segment thoracolumbar fusions [6] and high-risk musculoskeletal oncologic wounds [7]. Two prospective randomized controlled trials have also explored the use of iNPWT in high risk orthopaedic trauma wounds. In industry-funded research, Stannard et al. demonstrated a significant reduction in total infections when iNPWT was used after severe open tibia fractures [8] and high-risk lower extremity fractures (calcaneus, pilon and tibial plateau fractures) [9].

Additionally, evidence suggests that iNPWT decreases postoperative hematoma and seroma size and the time to a dry wound. Multiple prospective randomized controlled trials have further shown that iNPWT decreases hematoma/seroma size and the time to a closed dry wound following high-energy trauma [10], hemiarthroplasty [11], THA [12] and spine fracture care [13]. While there is strong evidence that iNPWT has a causal effect on known risk factors for infection (e.g., persistent hematoma or seroma, continued wound drainage), none of these trials were adequately powered to assess for differential infection rate in wounds treated with iNPWT versus standard surgical dressings.

iVACs, however, do not appear to provide a clinical benefit in routine cases. A retrospective study by Redfern et al. demonstrated no difference in superficial or deep infection rates with the use of iVACs in primary THA and TKA [14]. Three prospective randomized controlled trials have studied the use of iNPWT to prevent infection following standard closure in trauma or arthroplasty. Crist et al. found no difference in the rate of deep infection when iNPWT was used after open reduction internal fixation (ORIF) of uncomplicated acetabular fractures [15]. Similarly, there was no difference in wound healing or wound complications between iNPWT in standard surgical dressings after routine THA or TKA [16,17]. In addition, in routine cases, iVACs incur unnecessary additional cost and may cause iatrogenic problems such as skin blistering [18,19].

Lastly, evidence suggests that iVACs may also play a role in resolving some cases of early, benign postoperative drainage. In a retrospective study of the use of iVACs for 109 patients with benign early postoperative drainage after hip arthroplasty, Hansen et al. found that the intervention halted wound drainage without further surgery in most cases and did not find increased complications specific to the device [20].

In conclusion, the use of iVAC dressings are a reasonable option in orthopaedic patients at risk for wound healing complications and may decrease such complications in such patients. The use of iVACs in all cases is likely unnecessary. In addition, iVACs may also play a role in resolving some cases of early, benign postoperative drainage [11].

REFERENCES

- [1] Siqueira MB, Ramanathan D, Klika AK, Higuera CA, Barsoum WK. Role of negative pressure wound therapy in total hip and knee arthroplasty. *World J Orthop* 2016;7:30–37. doi:10.5312/wjo.v7.i1.30.
- [2] Cooper HJ, Roc GC, Bas MA, Berliner ZP, Hepinstall MS, Rodriguez JA, et al. Closed incision negative pressure therapy decreases complications after periprosthetic fracture surgery around the hip and knee. *Injury*. 2018;49:386–391. doi:10.1016/j.injury.2017.11.010.
- [3] Cooper HJ, Bas MA. Closed–incision negative–pressure therapy versus antimicrobial dressings after revision hip and knee surgery: a comparative study. *J Arthroplasty*. 2016;31:1047–1052. doi:10.1016/j.arth.2015.11.010.
- [4] Helito CP, Bueno DK, Giglio PN, Bonadio MB, Pécora JR, Demange MK. Negative–pressure wound therapy in the treatment of complex injuries after total knee arthroplasty. *Acta Ortop Bras*. 2017;25:85–88. doi:10.1590/1413-785220172502169053.
- [5] Matsumoto T, Parekh SG. Use of negative pressure wound therapy on closed surgical incision after total ankle arthroplasty. *Foot Ankle Int*. 2015;36:787–794. doi:10.1177/1071100715574934.
- [6] Adogwa O, Fatemi P, Perez E, Moreno J, Gazcon GC, Gokaslan ZL, et al. Negative pressure wound therapy reduces incidence of postoperative wound infection and dehiscence after long–segment thoracolumbar spinal fusion: a single institutional experience. *Spine J*. 2014;14:2911–2917. doi:10.1016/j.spinee.2014.04.011.
- [7] Kong R, Shields D, Bailey O, Gupta S, Mahendra A. Negative pressure wound therapy for closed surgical wounds in musculoskeletal oncology patients – a case–control trial. *Open Orthop J*. 2017;11:502–507. doi:10.2174/1874325001711010502.
- [8] Stannard JP, Volgas DA, Stewart R, McGwin G, Alonso JE. Negative pressure wound therapy after severe open fractures: a prospective randomized study. *J Orthop Trauma*. 2009;23:552–557. doi:10.1097/BOT.0b013e3181a2e2b6.
- [9] Stannard JP, Volgas DA, McGwin G, Stewart RL, Obremskey W, Moore T, et al. Incisional negative pressure wound therapy after high–risk lower extremity fractures. *J Orthop Trauma*. 2012;26:37–42. doi:10.1097/BOT.0b013e318216b1e5.
- [10] Stannard JP, Robinson JT, Anderson ER, McGwin G, Volgas DA, Alonso JE. Negative pressure wound therapy to treat hematomas and surgical incisions following high–energy trauma. *J Trauma*. 2006;60:1301–1306. doi:10.1097/01.ta.0000195996.73186.2e.
- [11] Pauser J, Nordmeyer M, Biber R, Jantsch J, Kopschina C, Bail HJ, et al. Incisional negative pressure wound therapy after hemiarthroplasty for femoral neck fractures – reduction of wound complications. *Int Wound J*. 2016;13:663–667. doi:10.1111/iwj.12344.
- [12] Pachowsky M, Gusinde J, Klein A, Lehl S, Schulz–Drost S, Schlechtweg P, et al. Negative pressure wound therapy to prevent seromas and treat surgical incisions after total hip arthroplasty. *Int Orthop*. 2012;36:719–722. doi:10.1007/s00264–011–1321–8.
- [13] Nordmeyer M, Pauser J, Biber R, Jantsch J, Lehl S, Kopschina C, et al. Negative pressure wound therapy for seroma prevention and surgical incision treatment in spinal fracture care. *Int Wound J*. 2016;13:1176–1179. doi:10.1111/iwj.12436.
- [14] Redfern RE, Cameron–Ruetz C, O’Drobinak SK, Chen JT, Beer KJ. Closed incision negative pressure therapy effects on postoperative infection and surgical site complication after total hip and knee arthroplasty. *J Arthroplasty*. 2017;32:3333–3339. doi:10.1016/j.arth.2017.06.019.
- [15] Crist BD, Oladeji LO, Khazzam M, Della Rocca GJ, Murtha YM, Stannard JP. Role of acute negative pressure wound therapy over primarily closed surgical incisions in acetabular fracture ORIF: A prospective randomized trial. *Injury*. 2017;48:1518–1521. doi:10.1016/j.injury.2017.04.055.
- [16] Karlakki SL, Hamad AK, Whittall C, Graham NM, Banerjee RD, Kuiper JH. Incisional negative pressure wound therapy dressings (iNPWTd) in routine primary hip and knee arthroplasties: a randomised controlled trial. *Bone Joint Res*. 2016;5:328–337. doi:10.1302/2046–3758.58.BJR–2016–0022.R1.
- [17] Manoharan V, Grant AL, Harris AC, Hazratwala K, Wilkinson MPR, McEwen PJ. Closed incision negative pressure wound therapy vs conventional dry dressings after primary knee arthroplasty: a randomized controlled study. *J Arthroplasty*. 2016;31:2487–2494. doi:10.1016/j.arth.2016.04.016.
- [18] Gillespie BM, Rickard CM, Thalib L, Kang E, Finigan T, Homer A, et al. Use of negative–pressure wound dressings to prevent surgical site complications after primary hip arthroplasty: a pilot RCT. *Surg Innov*. 2015;22:488–495. doi:10.1177/1553350615573583.

- [19] Howell RD, Hadley S, Strauss E, Pelham FR. Blister formation with negative pressure dressings after total knee arthroplasty. *Curr Orthop Prac.* 2011;22:176. doi:10.1097/BCO.0b013e31820b3e21.
- [20] Hansen E, Durinka JB, Costanzo JA, Austin MS, Deirmengian GK. Negative pressure wound therapy is associated with resolution of incisional drainage in most wounds after hip arthroplasty. *Clin Orthop Relat Res.* 2013;471:3230–3236. doi:10.1007/s11999-013-2937-3.



Author: Feng Chih-Kuo

QUESTION 3: Do antibacterial-coated sutures reduce the risk of subsequent surgical site infection/periprosthetic joint infection (SSI/PJI)?

RECOMMENDATION: The use of antibacterial-coated sutures reduces the risk of SSI following colorectal surgery, however, there is no conclusive evidence that its use reduces the risk of subsequent SSI/PJI in orthopaedic patient populations.

LEVEL OF EVIDENCE: Limited

DELEGATE VOTE: Agree: 92%, Disagree: 3%, Abstain: 5% (Super Majority, Strong Consensus)

RATIONALE

The risk factors for SSI are multifactorial [1]. The presence of suture material, considered a prosthetic implant, logarithmically reduces the number of organisms needed for SSI from 10^5 to 10^2 colony-forming units and therefore increases the rate of a SSI [2]. Triclosan, a broad-spectrum antibacterial agent against gram-positive and gram-negative bacteria, has been effectively used in suture material since 2003 to reduce SSI [3,4]. Triclosan-coated sutures (TCS) can create an “active zone” around the suture, inhibiting *Staphylococcus aureus*, *Staphylococcus epidermidis* and methicillin-resistant strains of *Staphylococci* (MRSA and MRSE), *Escherichia coli* and *Klebsiella pneumoniae* from colonizing on the suture for a minimum of 48 hours in in vitro studies [5,6].

TCS have been reported to reduce SSI in many surgical disciplines. In a randomized controlled trial of colorectal surgery, the use of TCS had a significantly lower incidence of wound infection compared with the use of non-antimicrobial sutures (4.3% vs.9.3%) [7]. In a meta-analysis with level I evidence, no publication bias and a robust sensitivity analysis, the use of TCS provided a reduction of approximately 30% in a population of 5,000 patients after various clean, clean-contaminated and contaminated surgeries [8]. A recent systematic review and meta-analysis included 21 RCTs (6,462 patients) with various surgery types (colorectal, head and neck, abdominal, cardiac and vascular and general surgery) and showed SSIs were reduced significantly by the use of TCS compared with uncoated sutures (relative risk (RR): 0.72, 95% confidence interval (CI) 0.60 to 0.86, $p < 0.001$) [9].

Current clinical guidelines have contradictory suggestions for TCS. The World Health Organization (WHO) [10] and The National Institute for Health and Care Excellence (NICE) [11] support the use of TCS for the risk reduction of SSI. The Infectious Diseases Society of America (IDSA) [12] and The Society for Healthcare Epidemiology of America (SHEA) [13] are against its routine use. The recent Centers for Disease Control and Prevention (CDC) guideline supports consideration of TCS use for the prevention of SSI, balancing clinical benefit and harm [14].

There is little evidence assessing the efficacy of TCS on SSI following total joint arthroplasty (TJA). To our knowledge there has been 1 prospective study involving 2,546 patients undergoing elective TJAs at 3 hospitals [15]. A total of 1,323 patients were randomized to a standard suture group, and 1,223 to the TCS group with SSI at 30 days postoperatively as a primary end-point. Sprowson et al. reported that the rates of superficial SSI were 0.8% in the control group and 0.7% in the TCS group ($p = 0.651$). The rates of deep SSIs were 1.6% in the control group and 1.1% in the TCS group ($p = 0.300$). The rates of deep and superficial SSIs were 2.5% in the control group and 1.8% in the TCS group ($p = 0.266$).

Based on the above level I studies on various types of surgeries and surgical wounds, the use of TCS seems to reduce the rate of SSI.

REFERENCES

- [1] Pulido L, Ghanem E, Joshi A, Purtill JJ, Parvizi J. Periprosthetic joint infection: the incidence, timing, and predisposing factors. *Clin Orthop Relat Res.* 2008;466:1710–1715. doi:10.1007/s11999-008-0209-4.
- [2] Charnley J, Eftekhar N. Postoperative infection in total prosthetic replacement arthroplasty of the hip-joint. With special reference to the bacterial content of the air of the operating room. *Br J Surg.* 1969;56:641–649.
- [3] Jones RD, Jampani HB, Newman JL, Lee AS. Triclosan: a review of effectiveness and safety in health care settings. *Am J Infect Control.* 2000;28:184–196.
- [4] Hranjec T, Swenson BR, Sawyer RG. Surgical site infection prevention: how we do it. *Surg Infect (Larchmt).* 2010;11:289–294. doi:10.1089/sur.2010.021.
- [5] Rothenburger S, Spangler D, Bhende S, Burkley D. In vitro antimicrobial evaluation of Coated VICRYL* Plus Antibacterial Suture (coated polyglactin 910 with triclosan) using zone of inhibition assays. *Surg Infect (Larchmt).* 2002;3 Suppl 1:S79–S87. doi:10.1089/sur.2002.3.s1-79.
- [6] Storch ML, Rothenburger SJ, Jacinto G. Experimental efficacy study of coated VICRYL plus antibacterial suture in guinea pigs challenged with staphylococcus aureus. *Surg Infect (Larchmt).* 2004;5:281–288. doi:10.1089/sur.2004.5.281.
- [7] Nakamura T, Kashimura N, Noji T, Suzuki O, Ambo Y, Nakamura F, et al. Triclosan-coated sutures reduce the incidence of wound infections and the costs after colorectal surgery: a randomized controlled trial. *Surgery.* 2013;153:576–583. doi:10.1016/j.surg.2012.11.018.
- [8] Daoud FC, Edmiston CE, Leaper D. Meta-analysis of prevention of surgical site infections following incision closure with triclosan-coated sutures: robustness to new evidence. *Surg Infect (Larchmt).* 2014;15:165–181. doi:10.1089/sur.2013.177.
- [9] de Jonge SW, Atema JJ, Solomkin JS, Boermeester MA. Meta-analysis and trial sequential analysis of triclosan-coated sutures for the prevention of surgical-site infection. *Br J Surg.* 2017;104:e118–e133. doi:10.1002/bjs.10445.
- [10] World Health Organization. Global Guidelines on the Prevention of Surgical Site Infection. <http://apps.who.int/iris/bitstream/handle/10665/250680/9789241549882-eng.pdf?sequence=1>. Accessed February 13, 2018.
- [11] National Institute for Health and Care Excellence. Surgical site infections: prevention and treatment. Guidance and guidelines. <https://www.nice.org.uk/guidance/CG74> Accessed March 16, 2018.
- [12] Anderson DJ, Podgorny K, Berríos-Torres SI, Bratzler DW, Dellinger EP, Greene L, et al. Strategies to prevent surgical site infections in acute care hospitals: 2014 update. *Infect Control Hosp Epidemiol.* 2014;35:605–627. doi:10.1086/676022.

- [13] SHEA, IDSA, ASHP, SIS. Clinical practice guidelines for antimicrobial prophylaxis in surgery. SHEA. 2013. <https://www.shea-online.org/index.php/practice-resources/41-current-guidelines/414-clinical-practice-guidelines-for-antimicrobial-prophylaxis-in-surgery> (accessed March 16, 2018).
- [14] Berríos-Torres SJ, Umscheid CA, Bratzler DW, Leas B, Stone EC, Kelz RR, et al. Centers for Disease Control and Prevention guideline for the prevention of surgical site infection, 2017. *JAMA Surg.* 2017;152:784–791. doi:10.1001/jamasurg.2017.0904.
- [15] Sprowson[†] AP, Jensen C, Parsons N, Partington P, Emmerson K, Carluke I, et al. The effect of triclosan-coated sutures on the rate of surgical site infection after hip and knee arthroplasty: a double-blind randomized controlled trial of 2546 patients. *Bone Joint J.* 2018;100-B:296–302. doi:10.1302/0301-620X.100B3.BJJ-2017-0247.R1.



Authors: Andy O. Miller, Farshad Adib, Brian M. Smith

QUESTION 4: Does the use of topical incisional sealants (i.e., Integuseal, Dermabond, etc.) reduce the incidence of subsequent surgical site infection/periprosthetic joint infection (SSI/PJI) in patients undergoing orthopaedic procedures?

RECOMMENDATION: While we recognize that the use of topical incisional sealants has the potential to reduce wound drainage, there is no evidence that the use of such products has any impact on the incidence of SSI/PJI.

Strength of the Recommendation: Limited

DELEGATE VOTE: Agree: 93%, Disagree: 2%, Abstain: 5% (Super Majority, Strong Consensus)

RATIONALE

Commercially-available topical incisional sealants (Integuseal, Dermabond, Liquiband and others) aim to add strength and integrity to wound closure and, by sealing the wound, may reduce the incidence of wound drainage. With the creation of an impervious mechanical barrier at the incision, these products are believed to reduce the entry of infecting organisms into the deeper tissues and the potential for subsequent SSI/PJI. These products can be convenient to use, as they may reduce the need for placement and removal of sutures and staples. These products remain popular in a variety of surgical specialties.

Some of the products have also demonstrated bactericidal activities against gram-positive bacteria *in vitro* [1]. However, effectiveness in preventing surgical site infection remains in question. To date, randomized studies across surgical subspecialties have not shown significant reductions in infection rate with the use of these products. Two recent systematic reviews were conducted evaluating the effectiveness of adhesive sealants across multiple surgical specialties, primarily outside of orthopaedics.

In 2010, 14 randomized clinical trials (1,152 patients) were published to determine the relative effects of various tissue adhesives and conventional skin closure techniques on the healing of surgical wounds. Only one of these studies was in the field of orthopaedics. This study demonstrated that sutures were significantly better than tissue adhesives for minimizing dehiscence (10 trials). There was no difference between low viscosity and high viscosity adhesives in respect to dehiscence. Surgical procedures that were described by the studies were diverse and included hand surgeries, blepharoplasty, circumcision and excision of benign skin lesions. None of these trials evaluated incisions around areas of high tension such as the knee.

There was no significant difference in the rate of infection comparing sutures and tissue adhesives. However, no study reported an *a priori* calculation for the sample size and this may be relevant [2].

In 2014, another update of the previous study identified 19 additional eligible randomized clinical trials resulting in a total of 33 studies (2,793 patients). There was low-quality evidence that sutures were significantly better than tissue adhesives for reducing the risk of wound breakdown (dehiscence, rate ratio (RR): 3.35, 95% confidence interval (CI) 1.53 to 7.33, 10 trials, 736 participants that contributed data to the meta-analysis). For other outcomes such as infection rate, patient and operator satisfaction and cost, there was no evidence of a significant difference for either sutures or tissue adhesives. Eighteen trials that compared the use of tissue adhesives with sutures reported wound infection data, however, as eight of these had no cases of infection, only data from the remaining ten studies contributed to the meta-analysis. The studies included for this review did not demonstrate any significant difference in the proportion of infections in incisions closed with tissue adhesives compared with other conventional techniques. No study reported an *a priori* calculation for the sample size, and this may be relevant. Even the largest of the studies would have been unlikely to have been adequately powered to show any significant difference given the relatively low incidence of wound infections following many types of surgery [3].

Recent SSI prevention guidelines from the World Health Organization (WHO) state that, “antimicrobial sealants should not be used after surgical site skin preparation for the purpose of reducing SSI” [4]. A Cochrane review also found that “sutures were significantly better than tissue adhesives for minimizing wound dehiscence” and there was no difference in the SSI when skin adhesives were used [2,3].

The effect of 2-octyl cyanoacrylate (Integuseal) on SSI was evaluated in randomized trials in sternotomy [5,6], colorectal [7] and trauma surgery wounds [8]. A prospective study found that 2-octyl cyanoacrylate reduced the rate of SSI versus the use of staples for skin closure in spinal surgery [9]. The use of Integuseal was also shown to decrease the incidence of SSI in cardiac surgery in another prospective study [10]. Non-randomized data in orthopaedics has evaluated its use in arthroplasty [11] and scoliosis [12] surgery. The arthroplasty study was a single-arm, single-surgeon series of 360 patients with a 0.8% rate of superficial SSI, no PJI and a single case of contact dermatitis.

Data on patients undergoing orthopaedic procedures on the use of Dermabond have not revealed differences in SSI/PJI rates. One randomized trial found no difference in scar cosmesis or infection rate [13], and another two studies found decreased wound drainage with the use of Dermabond, but no difference in SSI/PJI rate [14,15]. No trial was adequately powered to detect a difference. In a large historical control study of hip and knee arthroplasty patients, no differences in infection rate were noted at six-week follow-up [16]. A randomized controlled trial for skin closure after scheduled cesarean delivery demonstrated similar results using Dermabond or a monofilament synthetic suture [17].

Hypersensitivity reactions to these organic sealants are rare, but can be serious [18–22]. A recent report of three patients with blistering periincisional contact dermatitis was found [21,22].

Given the presence of extensive data in other surgical subspecialties suggesting that topical adhesives do not lower surgical infection rates, the lack of data suggesting efficacy in orthopaedics and the rare but serious hypersensitivity reactions to these agents, we cannot recommend the routine use of incisional sealants for the purpose of prevention of SSI/PJI in patients undergoing orthopaedic procedures.

REFERENCES

- [1] Rushbrook JL, White G, Kidger L, Marsh P, Taggart TF. The antibacterial effect of 2-octyl cyanoacrylate (Dermabond®) skin adhesive. *J Infect Prev.* 2014;15:236–239. doi:10.1177/1757177414551562.
- [2] Coulthard P, Esposito M, Worthington HV, van der Elst M, van Waes OJF, Darcey J. Tissue adhesives for closure of surgical incisions. *Cochrane Database Syst Rev.* 2010:CD004287. doi:10.1002/14651858.CD004287.pub3.
- [3] Dumville JC, Coulthard P, Worthington HV, Riley P, Patel N, Darcey J, et al. Tissue adhesives for closure of surgical incisions. *Cochrane Database Syst Rev.* 2014:CD004287. doi:10.1002/14651858.CD004287.pub4.
- [4] World Health Organization. Global guidelines for the prevention of surgical site infection. 2016. <http://apps.who.int/iris/bitstream/handle/10665/250680/9789241549882-eng.pdf?sequence=1>.
- [5] Schimmer C, Gross J, Ramm E, Morfeld B–C, Hoffmann G, Panholzer B, et al. Prevention of surgical site sternal infections in cardiac surgery: a two-centre prospective randomized controlled study. *Eur J Cardiothorac Surg.* 2017;51:67–72. doi:10.1093/ejcts/ezw225.
- [6] Hanedan MO, Ünal EU, Aksöyek A, Başar V, Tak S, Tütün U, et al. Comparison of two different skin preparation strategies for open cardiac surgery. *J Infect Dev Ctries.* 2014;8:885–890.
- [7] Doorly M, Choi J, Floyd A, Senagore A. Microbial sealants do not decrease surgical site infection for clean-contaminated colorectal procedures. *Tech Coloproctol.* 2015;19:281–285. doi:10.1007/s10151-015-1286-1285.
- [8] Daeschlein G, Napp M, Assadian O, Bluhm J, Krueger C, von Podewils S, et al. Influence of preoperative skin sealing with cyanoacrylate on microbial contamination of surgical wounds following trauma surgery: a prospective, blinded, controlled observational study. *Int J Infect Dis.* 2014;29:274–278. doi:10.1016/j.ijid.2014.08.008.
- [9] Ando M, Tamaki T, Yoshida M, Sasaki S, Toge Y, Matsumoto T, et al. Surgical site infection in spinal surgery: a comparative study between 2-octyl-cyanoacrylate and staples for wound closure. *Eur Spine J.* 2014;23:854–862.
- [10] Dohmen PM, Weymann A, Holinski S, Linneweber J, Geyer T, Konertz W. Use of an antimicrobial skin sealant reduces surgical site infection in patients undergoing routine cardiac surgery. *Surg Infect.* 2011;12:475–481.
- [11] Holte AJ, Tofte JN, Dahlberg GJ, Noiseux N. Use of 2-octyl cyanoacrylate adhesive and polyester mesh for wound closure in primary knee arthroplasty. *Orthopedics.* 2017;40:e784–e787. doi:10.3928/01477447-20170531-03.
- [12] Dromzee E, Tribot-Laspière Q, Bachy M, Zakine S, Mary P, Vialle R. Efficacy of integuseal for surgical skin preparation in children and adolescents undergoing scoliosis correction. *Spine.* 2012;37:E1331–E1335. doi:10.1097/BRS.0b013e3182687d6c.
- [13] Glennie RA, Korczak A, Naudie DD, Bryant DM, Howard JL. MONOCRYL and DERMABOND vs staples in total hip arthroplasty performed through a lateral skin incision: a randomized controlled trial using a patient-centered assessment tool. *J Arthroplasty.* 2017;32:2431–2435. doi:10.1016/j.arth.2017.02.042.
- [14] Siddiqui M, Bidaye A, Baird E, Abu-Rajab R, Stark A, Jones B, et al. Wound dressing following primary total hip arthroplasty: a prospective randomised controlled trial. *J Wound Care.* 2016;25:40, 42–45. doi:10.12968/jowc.2016.25.1.40.
- [15] Khan RJK, Fick D, Yao F, Tang K, Hurworth M, Nivbrant B, et al. A comparison of three methods of wound closure following arthroplasty: a prospective, randomised, controlled trial. *J Bone Joint Surg Br.* 2006;88:238–242. doi:10.1302/0301-620X.88B2.16923.
- [16] Miller AG, Swank ML. Dermabond efficacy in total joint arthroplasty wounds. *Am J Orthop.* 2010;39:476–478.
- [17] Daykan Y, Sharon-Weiner M, Pasternak Y, Tzadikévitch–Geffen K, Markovitch O, Sukenik–Halevy R, et al. Skin closure at cesarean delivery, glue vs subcuticular sutures: a randomized controlled trial. *Am J Obstet Gynecol.* 2017;216:406.e1–406.e5. doi:10.1016/j.ajog.2017.01.009.
- [18] Yagnatovsky M, Pham H, Rokito A, Jazrawi L, Strauss E. Type IV hypersensitivity reactions following Dermabond adhesive utilization in knee surgery: a report of three cases. *Phys Sportsmed.* 2017;45:195–198. doi:10.1080/00913847.2017.1283208.
- [19] Lefèvre S, Valois A, Truchetet F. Allergic contact dermatitis caused by Dermabond®. *Contact Derm.* 2016;75:240–241. doi:10.1111/cod.12597.
- [20] Davis MDP, Stuart MJ. Severe allergic contact dermatitis to dermabond prineo, a topical skin adhesive of 2-octyl cyanoacrylate increasingly used in surgeries to close wounds. *Dermatitis.* 2016;27:75–76. doi:10.1097/DER.0000000000000163.
- [21] Durando D, Porubsky C, Winter S, Kalyon J, O’Keefe T, LaFond AA. Allergic contact dermatitis to dermabond (2-octyl cyanoacrylate) after total knee arthroplasty. *Dermatitis.* 2014;25:99–100. doi:10.1097/DER.0000000000000018.
- [22] Lake NH, Barlow BT, Toledano JE, Valentine J, McDonald LS. Contact dermatitis reaction to 2-octyl cyanoacrylate following 3 orthopedic procedures. *Orthopedics.* 2018;41:e289–e291. doi:10.3928/01477447-20170918-08.



Authors: Gregory K. Deirmengian, Snir Heller, Kier Blevins, Tal Frenkel

QUESTION 5: Does the use of surgical suction drains increase the risk of subsequent surgical site infection/periprosthetic joint infection (SSI/PJI)?

RECOMMENDATION: There is no direct evidence to suggest that the use of surgical drains (for < 48 hours) leads to an increase in the rate of subsequent SSI/PJI. The use of surgical drains lead to a higher volume of blood loss and an increased need for allogeneic blood transfusion, which may indirectly increase the rate of SSI/PJI.

LEVEL OF EVIDENCE: Limited

DELEGATE VOTE: Agree: 90%, Disagree: 7%, Abstain: 3% (Super Majority, Strong Consensus)

RATIONALE

In orthopaedic surgery, the use of surgical drains has been most extensively evaluated in the subspecialty of hip and knee arthroplasty. Most of the studies regarding the use of surgical drains in hip and knee arthroplasty have focused on its effect on blood loss, on the need for transfusions and on their effectiveness in preventing subsequent wound healing complications including PJI and SSI. The purpose of surgical drains is to optimize wound healing by reducing fluid (blood) accumulation in the surgical site. This may be related to several advantages including decreased tissue swelling and skin tension,

which improves skin perfusion and decreases wound complications [1–5], reduced postoperative pain and enhancing recovery [2,5–7] and potentially lower the risk for infection as the hematoma is believed to interfere with the body’s defense mechanisms [7,8].

In a systematic review of the Cochrane database, Parker et al. investigated the utility of closed suction drainage after orthopaedic surgery [9]. The investigation involved 36 studies involving 5,697 surgical wounds and did not find benefit to the use of drains. Some of the outcomes specifically investigated were infection, wound complications, hematoma formation and reoperation. The authors found no difference in the majority of the outcomes between cases with surgical drains and those without surgical drains. The only difference was found in the blood transfusion requirement with drains leading to a greater rate of transfusion. The use of drain reduced the rate of ecchymosis around the incision, the only benefit attributed to the use of surgical drain.

Additional studies illuminated on the incidence of superficial wound infections (Table 1). Only one study by Zeng et al. [7] found a significantly lower rate of wound infection in patients undergoing primary total hip arthroplasty (THA) in whom a surgical drain was used versus those without a surgical drain. However, a pooled analysis found an elevated superficial infection rate in the non-drainage group (rate ratio (RR): 0.76, 95% confidence interval (CI) 0.574 to 1.017, $p = 0.045$). No significant differences in the prevalence of superficial wound infections were noted when studies for THAs and total knee arthroplasties (TKAs) were examined separately (Tables 2 and 3). The duration of drainage was not found to be related to the rate of superficial wound infection, which was 3.3% for the entire cohort and for both arthroplasties types (RR: 1, 95% CI 0.823 to 1.220, $p = 1$). Yet, when reviewing the influence of drainage duration on TKAs by itself, a longer drainage period was found to be related to increased superficial wound infection rates (2.1% vs. 0%). No similar effect was found for total hip replacements (Table 4).

Regarding deep wound infections, the literature shows that the use of a surgical drain in general was not related to increased rates of deep infection. None of the 13 included studies have reported a significant difference in the incidence of deep wound infections (Table 5). Likewise, the pooled results have also failed to demonstrate a significant difference between groups and for THAs and TKAs separately. The rate of deep infection was 1.5% in total, 0.8% for wounds treated with drains and 1.6% for wounds left without drains (RR: 0.7, 95% CI 0.405 to 1.210, $p = 0.185$) (Table 1). Deep infection rates were 1% (0.9% and 1.1% for the drainage and non-drainage groups) and 1.4% (0.7% and 2.4% for the drainage and non-drainage groups) following THAs and TKAs respectively (Tables 2 and 3).

A sub-analysis was performed on the influence of drainage duration on infection rates which found that a longer drainage duration was significantly related to increased deep infection rates. This correlates with results of others who showed increased positive cultures from drainages who were left inside the wound for longer periods [4,10]. The duration of time in which the drainage was left in the wound was stated in 10 studies [3,5,7,11–17], and was either 24 or 48 hours (in 1 study [11] the average duration was 20 hours with a range of 15 to 26 hours, and was added to the 24-hour group for analysis). A longer duration of wound drainage was found to be significantly related to increased rate of deep wound infection, as the prevalence of deep wound infection was 2.7% in the 48-hour group and only 0.3% in the 24-hour drainage group (RR: 0.363, 95% CI 0.1123 to 1.1702, $p = 0.006$). This was also true for a pooled analysis for the total knee arthroplasty group (six studies included, $p = 0.016$), but not for the total hip arthroplasty group (four studies included, $p = 0.162$) (Table 4). It can be summarized that both deep and superficial infection rates were insignificant when drainage duration was limited to shortened periods of time and with prompt removal.

In general, it was found that surgical drains led to an increased need for blood transfusion. This is important regarding SSI/PJI because blood transfusions are believed to be associated with immunosuppression and postoperative infections rates are reported to be higher following blood transfusion [18,19]. Seven studies provided the number of patients treated with blood transfusions after surgery [7,12,15–17,20,21]. Three studies found the drainage group to require significantly higher transfusion rates [12,16,21]. Likewise, the pooled analysis also found this group to necessitate more blood units, as 28% of the patients in the drainage group were given blood, compared to 21.7% in the non-drainage group (RR: 1.16, 95% CI 1.001 to 1.238, $p = 0.013$) (Table 1). Separate analysis for THAs including 4 studies also found the number of patients requiring blood transfusions to be higher in the drainage group (26.3% vs. 20% for the other group, RR: 1.19, 95% CI 1.032 to 1.367, $p = 0.026$). No similar effect was found for TKAs (Tables 2 and 3).

Many of the aforementioned randomized controlled studies have investigated the use of surgical drains in the setting of hip and knee arthroplasty. It has been established that for most measures, there are no differences when comparing drains to no drains, except increased blood loss and transfusion requirements. Many of these studies have investigated whether drains decrease wound complications and SSI/PJI and they have universally shown no difference, in turn showing that surgical drains do not appear to increase the risk of subsequent SSI/PJI when used for a shortened duration of time.

TABLE 1. Results for total hip and total knee arthroplasties

	Studies Included		Cohort	N (%)	p value
Blood transfusion (patients)	7	Drainage	679	190 (28.0)	0.013
		No-drainage	585	127 (21.7)	
Superficial wound infection	13	Drainage	987	28 (2.8)	0.045
		No-drainage	883	39 (4.7)	

Deep wound infection	13	Drainage	987	8 (0.8)	0.185
		No-drainage	883	13 (1.6)	
Length of stay	6	Drainage	613	6.9±3.3	0.871
		No-drainage	575	6.6±3.3	

TABLE 2. Results for total knee arthroplasty

	Studies Included		Cohort	N (%)	p value
Blood transfusion (patients)	3	Drainage	211	67 (31.8)	0.794
		No-drainage	100	30 (30)	
Superficial wound infection	13	Drainage	410	4 (1.0)	0.727
		No-drainage	296	4 (1.4)	
Deep wound infection	13	Drainage	410	3 (0.7)	0.104
		No-drainage	296	7 (2.4)	

TABLE 3. Results for total hip arthroplasty

	Studies Included		Cohort	N (%)	p value
Blood transfusion (patients)	4	Drainage	468	123 (26.3)	0.026
		No-drainage	485	97 (20)	
Superficial wound infection	13	Drainage	577	24 (4.2)	0.110
		No-drainage	537	35 (6.5)	
Deep wound infection	13	Drainage	577	5 (0.9)	0.767
		No-drainage	537	6 (1.1)	

TABLE 4. Results for duration of drainage, total hip and total knee arthroplasties

	Studies Included		Cohort	N (%)	p value	
Blood transfusion (patients)	5	24 hours	476	104 (21.8)	< 0.001	
		48 hours	98	53 (54.1)		
Superficial wound infection	All	10	24 hours	679	22 (3.3)	1
			48 hours	187	6 (3.3)	

	Knee	6	24 hours	268	0 (0)	0.004
			48 hours	92	4 (2.1)	
	Hip	4	24 hours	411	22 (5.4)	0.282
			48 hours	95	2 (2.1)	
Deep wound infection	All	10	24 hours	679	2 (0.3)	0.006
			48 hours	187	5 (2.7)	
	Knee	6	24 hours	268	0 (0)	0.016
			48 hours	92	3 (3.3)	
	Hip	4	24 hours	411	2 (0.5)	0.162
			48 hours	95	2 (2.1)	

TABLE 5. Characteristics of the studies

Author	Year	Procedure	No. of Wounds With Drainage	No. of Wounds Without Drainage	Mean Age	Male Patients (%)	Length of Follow-Up (Months)
Abolghasemian [3]	2016	Revision TKA	42	41	NA	38 (47)	3
Fichman [16]	2016	Revision THA	44	44	68	40 (45)	1.5
Suarez [18]	2016	Primary THA	59	61	63	60 (52)	1.5
Koyano [2]	2015	Bilateral TKA	51	51	NA	NA	1*
Zhang [14]	2015	Primary UKA	48	48	67	28 (30)	18.3
Zeng [7]	2014	Primary THA	83	85	60	81 (48)	3
Li [19]	2011	Primary TKA	50	50	63	26 (34)	12
Omonbude [11]	2010	Primary TKA	40	38	NA	NA	1.5
Seo [15]	2010	Primary TKA	111	0	73	6 (5)	12
Strahovnik [5]	2010	Primary THA	97	42	66	46 (33)	3
Walmsley [12]	2005	Primary THA	282	295	68	213 (39)	36
Esler [17]	2003	Primary TKA	50	50	73	45 (45)	NA
Kim [13]	1998	Bilateral TKA	69	69	64	10	12

THA, total hip arthroplasty; TKA, total knee arthroplasty; UKA, unicompartmental knee arthroplasty

* No specific follow-up duration was mentioned yet a complication following one month was noted.

** Only patients in the non-proteinase inhibitor groups were included.

REFERENCES

- [1] G. Tucci, A. Amorese ER. Closed suction drainage after orthopaedic surgery: evidence versus practice. *J Orthop Traumatol.* 2006;7:29–32. doi:<https://doi.org/10.1007/s10195-006-0118-9>.
- [2] Koyano G, Jinno T, Koga D, Hoshino C, Muneta T, Okawa A. Is closed suction drainage effective in early recovery of hip joint function? Comparative evaluation in one-stage bilateral total hip arthroplasty. *J Arthroplasty.* 2015;30:74–78. doi:10.1016/j.arth.2014.08.007.
- [3] Abolghasemian M, Huether TW, Soever LJ, Drexler M, MacDonald MP, Backstein DJ. The use of a closed-suction drain in revision knee arthroplasty may not be necessary: a prospective randomized study. *J Arthroplasty.* 2016;31:1544–1548. doi:10.1016/j.arth.2015.08.041.
- [4] Willemen D, Paul J, White SH, Crook DW. Closed suction drainage following knee arthroplasty. Effectiveness and risks. *Clin Orthop Relat Res.* 1991;232–234.
- [5] Strahovnik A, Fokter SK, Kotnik M. Comparison of drainage techniques on prolonged serous drainage after total hip arthroplasty. *J Arthroplasty.* 2010;25:244–248. doi:10.1016/j.arth.2008.08.014.

- [6] Waugh TR, Stinchfield FE. Suction drainage of orthopaedic wounds. *J Bone Joint Surg Am.* 1961;43-A:939–946.
- [7] Zeng W, Zhou K, Zhou Z, Shen B, Yang J, Kang P, et al. Comparison between drainage and non-drainage after total hip arthroplasty in Chinese subjects. *Orthop Surg.* 2014;6:28–32. doi:10.1111/os.12092.
- [8] Alexander JW, Korelitz J, Alexander NS. Prevention of wound infections. A case for closed suction drainage to remove wound fluids deficient in opsonic proteins. *Am J Surg.* 1976;132:59–63.
- [9] Parker MJ, Livingstone V, Clifton R, McKee A. Closed suction surgical wound drainage after orthopaedic surgery. *Cochrane Database Syst Rev.* 2007:CD001825. doi:10.1002/14651858.CD001825.pub2.
- [10] Zamora-Navas P, Collado-Torres F, de la Torre-Solis F. Closed suction drainage after knee arthroplasty. A prospective study of the effectiveness of the operation and of bacterial contamination. *Acta Orthop Belg.* 1999;65:44–47.
- [11] Omonbude D, El Masry MA, O'Connor PJ, Grainger AJ, Allgar VL, Calder SJ. Measurement of joint effusion and haematoma formation by ultrasound in assessing the effectiveness of drains after total knee replacement: a prospective randomised study. *J Bone Joint Surg Br.* 2010;92:51–55. doi:10.1302/0301-620X.92B1.22121.
- [12] Walmsley PJ, Kelly MB, Hill RMF, Brenkel I. A prospective, randomised, controlled trial of the use of drains in total hip arthroplasty. *J Bone Joint Surg Br.* 2005;87:1397–1401. doi:10.1302/0301-620X.87B10.16221.
- [13] Kim YH, Cho SH, Kim RS. Drainage versus nondrainage in simultaneous bilateral total knee arthroplasties. *Clin Orthop Relat Res.* 1998:188–193.
- [14] Zhang Q, Zhang Q, Guo W, Liu Z, Cheng L, Zhu G. No need for use of drainage after minimally invasive unicompartmental knee arthroplasty: a prospective randomized, controlled trial. *Arch Orthop Trauma Surg.* 2015;135:709–713. doi:10.1007/s00402-015-2192-z.
- [15] Seo ES, Yoon SW, Koh IJ, Chang CB, Kim TK. Subcutaneous versus intraarticular indwelling closed suction drainage after TKA: a randomized controlled trial. *Clin Orthop Relat Res.* 2010;468:2168–2176. doi:10.1007/s11999-010-1243-6.
- [16] Fichman SG, Makinen TJ, Lozano B, Rahman WA, Safir O, Gross AE, et al. Closed suction drainage has no benefits in revision total hip arthroplasty: a randomized controlled trial. *Int Orthop.* 2016;40:453–457. doi:10.1007/s00264-015-2960-y.
- [17] Esler CNA, Blakeway C, Fiddian NJ. The use of a closed-suction drain in total knee arthroplasty. A prospective, randomised study. *J Bone Joint Surg Br.* 2003;85:215–217.
- [18] Blumberg N, Heal JM. Effects of transfusion on immune function. Cancer recurrence and infection. *Arch Pathol Lab Med.* 1994;118:371–379.
- [19] Blumberg HM, Jarvis WR, Soucie JM, Edwards JE, Patterson JE, Pfaller MA, et al. Risk factors for candidal bloodstream infections in surgical intensive care unit patients: the NEMIS prospective multicenter study. *The National Epidemiology of Mycosis Survey.* *Clin Infect Dis.* 2001;33:177–186. doi:10.1086/321811.
- [20] Suarez JC, McNamara CA, Barksdale LC, Calvo C, Szubski CR, Patel PD. Closed suction drainage has no benefits in anterior hip arthroplasty: a prospective, randomized trial. *J Arthroplasty.* 2016;31:1954–1958. doi:10.1016/j.arth.2016.02.048.
- [21] Li C, Nijat A, Askar M. No clear advantage to use of wound drains after unilateral total knee arthroplasty: a prospective randomized, controlled trial. *J Arthroplasty.* 2011;26:519–522. doi:10.1016/j.arth.2010.05.031.



Authors: José Gomez, Joseph Karam, Peter F. Sharkey, Mitchell R. Klement

QUESTION 6: What surgical dressing (i.e., occlusive, silver impregnated, dry gauze) is associated with a lower risk of surgical site infection/periprosthetic joint infection (SSI/PJI) in patients undergoing orthopaedic procedures?

RECOMMENDATION: Occlusive and/or silver-impregnated dressings have been proven to reduce the rate of wound complications, SSI and PJI compared to standard gauze dressings and should be considered for routine use. The majority of the literature at present focuses on total joint arthroplasty (TJA). However, further research is required to see if the added antimicrobials (such as silver), the occlusive, active-nature of the dressing or their combination is responsible for the demonstrated reduction in SSI/PJI.

LEVEL OF EVIDENCE: Moderate

DELEGATE VOTE: Agree: 81%, Disagree: 12%, Abstain: 7% (Super Majority, Strong Consensus)

RATIONALE

To successfully prevent SSI and PJI, the patient must be optimized before, during and after orthopaedic surgery. One method of infection prevention gaining recent attention is the type of post-surgical dressing. Wound complications are common after orthopaedic procedures. These are particularly important in TJA as patients are encouraged to mobilize early and often and wounds are over mobile areas such as the knee joint. Appropriate prevention and management is crucial since wound issues can lead to PJI if left untreated [1]. While traditional gauze and tape dressings have been used after surgical procedures for decades, new commercial dressings have questioned this practice [2–4].

Dressings have been classified as passive (gauze, absorbent pads, adhesive tapes, island dressings), active (films, hydrocolloid, hydrofiber, alginate, foam) and interactive (antimicrobial, biomaterial, larva therapy, vacuum dressings) [5]. Passive dressings only serve a protective function, while active dressings promote healing through the creation of a moist environment. Interactive dressings interact with the wound bed to further enhance healing and include, for example, antimicrobial agents (such as silver). An increasing body of literature supports use of a dressing that provides an impermeable barrier to pathogens and preserves a moist environment. Good fluid management capacities are important to prevent excess exudate, which causes maceration and to reduce the frequency of dressing changes thereby reducing the risk of exposure to outside pathogens [5]. While many studies have compared various dressings and the rate of wound complications (defined as blisters, erythema, maceration, leakage) or fluid handling capacity (wear time, mean dressing changes) [5], few have been adequately powered to investigate rates of SSI and PJI [6–12]. Sharma et al. [5]. recently performed a systemic review and meta-analysis on 12 randomized controlled trials (RCTs) [6–17] comparing alternative dressing materials for postoperative management of wounds following TJA. Eight of these studies reported SSI data but no dressing type was superior over another in SSI reduction. However, occlusive film dressings (odds ratio (OR): 0.35, 95% confidence interval (CI) 0.21 to 0.57) or occlusive dressings with hydrofiber (OR: 0.28, 95% CI 0.20 to 0.40) were significantly less likely to have wound complications than those managed with passive (standard) dressings [5]. The authors concluded that there was insufficient evidence available to determine whether the use of these advanced dressings reduced PJI.

Recently, two interactive dressings are gaining popularity. One is the Aquacel® Ag surgical dressing (ConvaTec) that both maintains a moist environment through use of a weaved cellulose center (hydrofiber) that allows it to contour to the skin and prevents the growth of microorganisms by

releasing antimicrobial ionic silver when in contact with fluid [18,19]. Another is the Silverlon[®] Surgical Dressing (Argentum Medical) with a woven nylon dressing that is silver plated and embedded in a waterproof foam adhesive [20]. Three large cohort, case-controlled studies have retrospectively investigated the utility of these dressings for PJI reduction after TJA. All three studies used the Musculoskeletal Infection Society (MSIS) criteria for PJI [18–20]. Cai et al. compared 903 patients receiving an Aquacel Ag dressing (removed at 5 days) to 875 receiving a standard xeroform and gauze dressing removed at 2 days postoperatively after TJA [19]. They reported an acute PJI rate (within 3 months of surgery) of 0.44% in the Aquacel Ag dressing group compared to 1.7% in the standard gauze dressing group ($p = 0.005$).

A multivariate analysis revealed that use of Aquacel dressing was an independent risk factor for reduction of PJI (OR: 0.165, 95% CI 0.051 to 0.533, $p = 0.003$) [19]. These results were corroborated by Grosso et al. who compared 605 patients with Aquacel Ag dressing (removed at 7 days) to 568 xeroform and gauze dressings (removed at 2 days and changed every other day) after TJA [18]. The incidence of acute PJI for patients managed with a sterile xeroform dressing was 1.58% (9/568). The incidence of PJI for patients managed with the use of Aquacel dressing was 0.33% (2/605, $p = 0.03$). Similar to Cai et al., a multiple logistic regression demonstrated use of an Aquacel dressing as a protective factor for PJI (OR: 0.092, 95% CI 0.017 to 0.490, $p = 0.005$) [18]. Tisosky et al. evaluated 309 patients with the Silverlon dressing (removed at 7 days) compared to 525 patients with xeroform and gauze (removed at 2 days) after TJA [20]. They found an overall infection rate of 8.4% in the control group versus 3.9% in the Silverlon group (OR: 0.38 95% CI 0.25 to 0.58, $p = 0.012$). There was no PJI in the Silverlon group vs. 12 (2.3%) in the control ($p = 0.007$). In addition, the superficial infection rate was 6.1% in control vs. 3.9% in Silverlon (OR: 0.54, 95% CI 0.34 to 0.87, $p = 0.011$). In a multivariate logistic regression the Silverlon dressing was independently associated with decreased infection (OR: 0.39, 95% CI 0.27 to 0.57, $p < 0.0001$) [20]. Finally, Kuo et al. performed a prospective, RCT comparing the Aquacel Ag to a standard dressing in 240 TKA patients [21]. They found that the Aquacel Ag dressing was independently associated with a reduction in SSI (as defined by the Centers for Disease Control and Prevention (CDC) [22]) when controlling for confounding variables (OR: 0.07, 95% CI 0.01 to 0.58, $p = 0.01$) [21].

In conclusion, active and interactive dressings have been shown to reduce the rates of SSI and PJI after joint arthroplasty compared to passive dressings. The benefit of adding antimicrobial/antiseptic agents such as silver or 0.2% polyhexamethylene biguanide [23] in postoperative dressings is still controversial as few studies have compared active dressings to interactive dressings [24]. In addition, studies investigating the use of active or interactive dressings in foot and ankle surgery [25], hip fracture surgery [26] and spinal fusion [27] are limited and have not demonstrated a reduction in SSI. Finally, formal cost-effectiveness studies will be needed to see if the increased price of the occlusive, silver-impregnated dressings (USD \$30 to \$40) [19,20] compared to standard dressings (USD \$2 to \$5) is justified for routine versus selective use by the reduction in cost with decreased SSI/PJI.

REFERENCES

- [1] Pulido L, Ghanem E, Joshi A, Purtill JJ, Parvizi J. Periprosthetic joint infection: the incidence, timing, and predisposing factors. *Clin Orthop Relat Res*. 2008;466:1710–1715. doi:10.1007/s11999-008-0209-4.
- [2] Berg A, Fleischer S, Kuss O, Unverzagt S, Langer G. Timing of dressing removal in the healing of surgical wounds by primary intention: quantitative systematic review protocol. *J Adv Nurs*. 2012;68:264–270. doi:10.1111/j.1365-2648.2011.05803.x.
- [3] Vasconcelos A, Cavaco-Paulo A. Wound dressings for a proteolytic-rich environment. *Appl Microbiol Biotechnol*. 2011;90:445–460. doi:10.1007/s00253-011-3135-4.
- [4] Hutchinson JJ, McGuckin M. Occlusive dressings: a microbiologic and clinical review. *Am J Infect Control*. 1990;18:257–268.
- [5] Sharma G, Lee SW, Atanacio O, Parvizi J, Kim TK. In search of the optimal wound dressing material following total hip and knee arthroplasty: a systematic review and meta-analysis. *Int Orthop*. 2017;41:1295–1305. doi:10.1007/s00264-017-3484-4.
- [6] Dobbelaere A, Schuermans N, Smet S, Van Der Straeten C, Victor J. Comparative study of innovative postoperative wound dressings after total knee arthroplasty. *Acta Orthop Belg*. 2015;81:454–461.
- [7] Cosker T, Elsayed S, Gupta S, Mendonca AD, Tayton KJJ. Choice of dressing has a major impact on blistering and healing outcomes in orthopaedic patients. *J Wound Care*. 2005;14:27–29. doi:10.12968/jowc.2005.14.1.26722.
- [8] Springer BD, Beaver WB, Griffin WL, Mason JB, Odum SM. Role of surgical dressings in total joint arthroplasty: a randomized controlled trial. *Am J Orthop*. 2015;44:415–420.
- [9] Langlois J, Zaoui A, Ozil C, Courpied J-P, Anract P, Hamadouche M. Randomized controlled trial of conventional versus modern surgical dressings following primary total hip and knee replacement. *Int Orthop*. 2015;39:1315–1319. doi:10.1007/s00264-015-2726-6.
- [10] Burke NG, Green C, McHugh G, McGolderick N, Kilcoyne C, Kenny P. A prospective randomised study comparing the jubilee dressing method to a standard adhesive dressing for total hip and knee replacements. *J Tissue Viability*. 2012;21:84–87. doi:10.1016/j.jtv.2012.04.002.
- [11] Abuzakuk TM, Coward P, Shenava Y, Kumar VS, Skinner JA. The management of wounds following primary lower limb arthroplasty: a prospective, randomised study comparing hydrofibre and central pad dressings. *Int Wound J*. 2006;3:133–137.
- [12] Ravnskog FA, Espehaug B, Indrekvam K. Randomised clinical trial comparing hydrofiber and alginate dressings post-hip replacement. *J Wound Care*. 2011;20:136–142. doi:10.12968/jowc.2011.20.3.136.
- [13] Ravenscroft MJ, Harker J, Buch KA. A prospective, randomised, controlled trial comparing wound dressings used in hip and knee surgery: Aquacel and Tegaderm versus Cutiplast. *Ann R Coll Surg Engl*. 2006;88:18–22. doi:10.1308/003588406X82989.
- [14] Koval KJ, Egol KA, Polatsch DB, Baskies MA, Homman JP, Hiebert RN. Tape blisters following hip surgery. A prospective, randomized study of two types of tape. *J Bone Joint Surg Am*. 2003;85-A:1884–1887.
- [15] Lawrentschuk N, Falkenberg MP, Pirpiris M. Wound blisters post hip surgery: a prospective trial comparing dressings. *ANZ J Surg*. 2002;72:716–719.
- [16] Koval KJ, Egol KA, Hiebert R, Spratt KF. Tape blisters after hip surgery: can they be eliminated completely? *Am J Orthop*. 2007;36:261–265.
- [17] Harle S, Korhonen A, Kettunen JA, Seitsalo S. A randomised clinical trial of two different wound dressing materials for hip replacement patients. *J Orthop Nurs*. 2005;9:205–210. doi:10.1016/j.joon.2005.09.003.
- [18] Grosso MJ, Berg A, LaRussa S, Murtaugh T, Trofa DP, Geller JA. Silver-impregnated occlusive dressing reduces rates of acute periprosthetic joint infection after total joint arthroplasty. *J Arthroplasty*. 2017;32:929–932. doi:10.1016/j.arth.2016.08.039.
- [19] 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;29:1098–1100. doi:10.1016/j.arth.2013.11.012.
- [20] Tisosky AJ, Iyoha-Bello O, Demosthenes N, Quimbayo G, Coreanu T, Abdeen A. Use of a silver nylon dressing following total hip and knee arthroplasty decreases the postoperative infection rate. *J Am Acad Orthop Surg Glob Res Rev*. 2017;1:e034. doi:10.5435/JAAOSGlobal-D-17-00034.
- [21] Kuo FC, Chen B, Lee MS, Yen SH, Wang JW. AQUACEL[®] Ag surgical dressing reduces surgical site infection and improves patient satisfaction in minimally invasive total knee arthroplasty: a prospective, randomized, controlled study. *Biomed Res Int*. 2017;2017:1262108. doi:10.1155/2017/1262108.
- [22] Horan TC, Andrus M, Dudeck MA. CDC/NHSN surveillance definition of health care-associated infection and criteria for specific types of infections in the acute care setting. *Am J Infect Control*. 2008;36:309–332. doi:10.1016/j.ajic.2008.03.002.
- [23] Mueller SW, Krebsbach LE. Impact of an antimicrobial-impregnated gauze dressing on surgical site infections including methicillin-resistant staphylococcus aureus infections. *Am J Infect Control*. 2008;36:651–655. doi:10.1016/j.ajic.2007.12.005.
- [24] Schwartz J, Goss S, Facchin F, Manizate F, Gendics C, Braitman E, et al. A prospective two-armed trial assessing the efficacy and performance of a silver dressing used postoperatively on high-risk, clean surgical wounds. *Ostomy Wound Manage*. 2014;60:30–40.

- [25] Galli MM, Protzman NM, Brigido SA. Utilization of silver hydrogel sheet dressing on postsurgical incisions: a pilot study in foot and ankle surgery. *Foot Ankle Spec.* 2013;6:422–433. doi:10.1177/1938640013507108.
- [26] Kadar A, Eisenberg G, Yahav E, Drexler M, Salai M, Steinberg EL. Surgical site infection in elderly patients with hip fractures, silver-coated versus regular dressings: a randomised prospective trial. *J Wound Care.* 2015;24:441–442, 444–445. doi:10.12968/jowc.2015.24.10.441.
- [27] Epstein NE. Do silver-impregnated dressings limit infections after lumbar laminectomy with instrumented fusion? *Surg Neurol.* 2007;68:483–485; discussion 485. doi:10.1016/j.surneu.2007.05.045.



Authors: Per Gundtoft, Andres Orlando Villanueva, Tommaso Bonanzinga, Hamidreza Yazdi, Carlos Arturo Romero, Mauricio Cordova

QUESTION 7: When should sterile surgical dressings be removed and how frequently should subsequent dressings be changed following orthopaedic procedures?

RECOMMENDATION: The dressing placed over the surgical wound under sterile conditions in the operating room should be changed based on saturation of the dressing. Early removal and frequent changes of the surgical dressing are not needed if there is no significant bleeding or drainage on the original dressing. If the dressing remains dry, wound coverage for a minimum of 48 hours has been recommended.

LEVEL OF EVIDENCE: Limited

DELEGATE VOTE: Agree: 97%, Disagree: 3%, Abstain: 0% (Unanimous, Strongest Consensus)

RATIONALE

Sterile dressings are applied to the skin following primary closure in most orthopaedic surgery. Dressing acts as a physical barrier, which protects the wound from contamination until the continuity of the skin is restored [1]. The first phase of the wound healing cycle is the hemostasis phase, during which the continuity of the skin is restored. In the clean wound, with regular edges following incisions, the wound is usually closed within 48 hours [2]. The general practice is to cover surgical incisions post procedure to control postoperative bleeding, to absorb exudates and to provide protection [3]. The ideal dressings produce a moist, warm and clean environment that promotes wound healing [4,5]. However, the moist environment created by a dressing left on the wound for a longer period could increase the risk of maceration, leading to weakening of the tissue and wound [6].

Concerning the prevention of surgical site infections (SSIs), the ideal timing of dressing removal is an unresolved issue. Some professionals prefer to leave wounds uncovered from the moment of closure, others uncover them after a certain time and still others keep them covered until suture removal [3]. Clinical guidelines from the Centers for Disease Control and Prevention (CDC) and the British National Collaborating Centre for Women's and Children's Health (the latter commissioned by the National Institute for Health and Clinical Excellence in 2008) mainly recommend covering surgical incisions with a dressing for a period of at least 48 hours postoperatively. Uncovered or early exposed wounds seem to be associated with an increased risk of contamination and SSIs, but some studies suggest that longer dressing periods have no benefits [3]. While an abundance of studies comparing different dressings was available, no meta-analyses or systematic reviews of randomized control trial (RCT) of early vs. late removal of sterile dressings in orthopaedic surgery exist. One RCT comparing removal of a bulky dressing after 2 weeks compared to after 48 to 72 hours following carpal tunnel decompression found no significant difference in wound complication, but the study consisted of a rather small cohort of 94 patients, none of whom developed a SSI [7].

One systematic review on early vs. late dressing removal including all surgical specialties was identified, in which 3 RCTs were included with a total of 280 patients [8]. Participants in the 3 studies were randomized to early dressing removal (< 48 hours following surgery) or delayed dressing removal (continued dressing for > 48 hours following surgery). The primary outcome was surgical site infection as defined by Horan [9]. There was no significant difference in the proportion of people who developed superficial SSI between the early and delayed dressing removal groups. No deep SSI or deep dehiscence was reported in the early or in the delayed dressing removal groups [8].

In addition to the systematic review, two randomized controlled trials were identified, which investigated the effect of early removal of wound dressing on the risk of infection. The primary outcome for both studies was SSI. Heal et al. compared removing the dressing within the first 12 hours with leaving the dressing on for the first 48 hours and found no statistically significant difference in the incidence of surgical site infection [10]. In a similar study, Chrintz et al. compared removal of dressing after 24 hours with keeping the wound dressed until removal of the sutures and found no statistically significant difference in the incidence of surgical site infection [11].

If the dressing is disturbed less often, the risk of infection is reduced and this aids the healing process [12]. Every time a dressing is changed, there is a potential risk for introducing pathogens into the wound, which can subsequently lead to SSI or PJI. Wound dressings keep the wound near core body temperature, which increases the rate of mitotic cell division and leukocyte activity that is necessary for wound healing. When a dressing is changed, it takes three to four hours for the cellular activity of the wound to resume. Hence, episodic cooling associated with dressing changes should be avoided as much as possible. Also, fewer dressing changes protects the wound from repeated exposure to pathogens in the surrounding air [13].

The costs associated with a wound dressing depends on two factors: the unit cost of the dressing and the number of dressing changes required [14]. Fewer dressing changes can decrease the costs.

Dressing changes can also be affected by dressing type. Modern dressings need less frequent changes and can decrease the rate of acute SSI and periprosthetic joint infection (PJI) [15]. Abuzakuk et al. demonstrated that there were less dressing changes for hydrofiber dressings within the first five postoperative days compared to the use of a central pad group. They theorized that leaving the hydro fiber dressing undisturbed for a longer period of time could help prevent wound infections [16]. Hopper et al. showed that, wear time for the traditional dressing (two days) was significantly shorter than for the modern dressing (seven days, $p < 0.001$), and required more changes. They also found that the modern dressing can create less need for dressing

changes, thus decreasing burden on healthcare personnel, diminishing superficial wound problems and avoiding delays in hospital discharge due to wound healing issues [17].

REFERENCES

- [1] Cosker T, Elsayed S, Gupta S, Mendonca AD, Tayton KJJ. Choice of dressing has a major impact on blistering and healing outcomes in orthopaedic patients. *J Wound Care*. 2005;14:27–29. doi:10.12968/jowc.2005.14.1.26722.
- [2] Lawrence WT. Physiology of the acute wound. *Clin Plast Surg*. 1998;25:321–40.
- [3] Berg A, Fleischer S, Kuss O, Unverzagt S, Langer G. Timing of dressing removal in the healing of surgical wounds by primary intention: quantitative systematic review protocol. *J Adv Nurs*. 2012;68:264–270. doi:10.1111/j.1365–2648.2011.05803.x.
- [4] Svensjö T, Pomahac B, Yao F, Slama J, Eriksson E. Accelerated healing of full–thickness skin wounds in a wet environment. *Plast Reconstr Surg*. 2000;106:602–612; discussion 613–614.
- [5] Dyson M, Young S, Pendle CL, Webster DF, Lang SM. Comparison of the effects of moist and dry conditions on dermal repair. *J Invest Dermatol*. 1988;91:434–439.
- [6] Cutting KF, White RJ. Maceration of the skin and wound bed. 1: its nature and causes. *J Wound Care*. 2002;11:275–278. doi:10.12968/jowc.2002.11.7.26414.
- [7] Ritting AW, Leger R, O'Malley MP, Mogielnicki H, Tucker R, Rodner CM. Duration of postoperative dressing after mini–open carpal tunnel release: a prospective, randomized trial. *J Hand Surg Am*. 2012;37:3–8. doi:10.1016/j.jhssa.2011.10.011.
- [8] Toon CD, Lusuku C, Ramamoorthy R, Davidson BR, Gurusamy KS. Early versus delayed dressing removal after primary closure of clean and clean–contaminated surgical wounds. *Cochrane Database Syst Rev*. 2015:CD010259. doi:10.1002/14651858.CD010259.pub3.
- [9] Horan TC, Gaynes RP, Martone WJ, Jarvis WR, Emori TG. CDC definitions of nosocomial surgical site infections, 1992: a modification of CDC definitions of surgical wound infections. *Infect Control Hosp Epidemiol*. 1992;13:606–608.
- [10] Heal C, Buettner P, Raasch B, Browning S, Graham D, Bidgood R, et al. Can sutures get wet? Prospective randomised controlled trial of wound management in general practice. *BMJ*. 2006;332:1053–1056. doi:10.1136/bmj.38800.628704.AE.
- [11] Chrintz H, Vibits H, Cordtz TO, Harreby JS, Waadegaard P, Larsen SO. Need for surgical wound dressing. *Br J Surg*. 1989;76:204–205.
- [12] Lawrence JC, Lilly HA, Kidson A. Wound dressings and airborne dispersal of bacteria. *Lancet*. 1992;339:807.
- [13] Chowdhry M, Chen AF. Wound dressings for primary and revision total joint arthroplasty. *Ann Transl Med*. 2015;3:268. doi:10.3978/j.issn.2305–5839.2015.09.25.
- [14] Tustanowski J. Effect of dressing choice on outcomes after hip and knee arthroplasty: a literature review. *J Wound Care*. 2009;18:449–450, 452, 454. doi:10.12968/jowc.2009.18.11.44985.
- [15] 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;29:1098–1100. doi:10.1016/j.arth.2013.11.012.
- [16] Abuzakuk TM, Coward P, Shenava Y, Kumar VS, Skinner JA. The management of wounds following primary lower limb arthroplasty: a prospective, randomised study comparing hydrofibre and central pad dressings. *Int Wound J*. 2006;3:133–137.
- [17] Hopper GP, Deakin AH, Crane EO, Clarke JV. Enhancing patient recovery following lower limb arthroplasty with a modern wound dressing: a prospective, comparative audit. *J Wound Care*. 2012;21:200–3. doi:10.12968/jowc.2012.21.4.200.



Authors: Emmanuel Thienpont, Georgios Komnos, Jessica Amber Jennings, Elvira Montañez, Carlos Jiménez-Garrido, Michael A. Harris

QUESTION 8: Do patients need to refrain from getting a surgical incision wet or submerging it in water to prevent surgical site infection/periprosthetic joint infection (SSI/PJI)? If so, for how long postoperatively?

RECOMMENDATION: Patients need to refrain from getting the surgical incision wet for the first 48 hours after surgery.

LEVEL OF EVIDENCE: Limited

DELEGATE VOTE: Agree: 86%, Disagree: 11%, Abstain: 3% (Super Majority, Strong Consensus)

RATIONALE

Adequate postoperative wound hygiene is of major importance for prevention of SSI. However, limited literature about postoperative washing is available. Wound re-epithelialization of the incision occurs within 48 hours, although this process can vary among patients [1]. Due to lack of evidence regarding the best manner of managing surgical wounds in the postoperative period, surgeons' instructions to patients for treating surgical wounds vary. A time period of two weeks is widely proposed to prevent contamination of sutures themselves [2], since this is the time frame for staple or suture removal [3].

The 2008 National Institute for Health and Clinical Excellence (NICE) guidelines [4] suggest keeping surgical wounds covered and dry for at least 48 hours after surgery. During this time, wounds may be washed with a sterile saline solution. Only one randomized controlled trial with a relatively low number of 32 patients has evaluated if showering can affect bacterial load after primary total knee arthroplasty (TKA) [5]. Yu et al. evaluated wound colonization by bacteria at various points up to 2 weeks, in 2 groups consisting of 16 patients each. One group was allowed to shower at two days postoperatively and the other group was instructed to wait until two weeks. They reported no statistically significant differences in terms of microorganism prevalence, with no infections noted during the study. Greater patient satisfaction was noted in the early shower group. However, a significant limitation of the study was its small sample size [5]. Hsieh et al. in another clinical trial compared wound-related outcomes following general surgical procedures in 2 equal groups comprising of 222 patients [6]. One group was allowed to get the surgical wound wet at 48 hours after surgery and the other delayed washing until stitch removal. They demonstrated that clean and clean-contaminated wounds can be safely showered 48 hours after surgery. Postoperative showering did not increase the risk of surgical site complications. Increased patient satisfaction and lower cost of wound care are two benefits reported for early wound washing. Heal et al. conducted a large prospective randomized controlled trial for minor skin excisions within general practice [7]. They concluded that wounds can be allowed to get wet in the first 48 hours after minor skin excision without increasing the incidence of infection.

In a systematic review, Dayton et al. found nine randomized clinical trials which showed that there was no reason to avoid showering or bathing the surgical wound as part of routine hygiene during the healing period [8]. In addition, there was no increased risk of surgical wound infection following wound washing at 12 hours after surgery. In two Cochrane database reviews Toon et al. [9] and Chang [10] reported that no conclusive evidence is currently available regarding the benefits or harms of early versus delayed postoperative showering or bathing for the prevention of wound complications. They recommended further randomized controlled trials to compare early versus delayed postoperative showering or bathing.

Several other studies, not directly related to arthroplasty, including general surgical incisions [11], sutured wounds [12], spinal surgical sites [13] and foot and ankle surgeries [14] have failed to demonstrate increased infection rates when early showering was allowed. Nevertheless, published data also demonstrate similar rates of SSI in surgical wounds that remained covered or uncovered and washed with tap water in the first 48 hours following surgery [15,16]. Additionally, cleaning with tap water versus sterile saline was found to have no effect on the incidence of infection [17].

The role of wound submersion in terms of SSI is further complicated by the availability of occlusive dressings, which have gained wide acceptance recently [18]. Dressings that are impermeable to water have been reported to reduce incidence of infection after joint arthroplasty [19–21].

Showering after surgery remains a controversial issue in orthopaedic surgery. A potential harm would be wound-related complications. On the contrary, benefits of early showering would be improvement in quality of life and better rehabilitation outcomes [22].

REFERENCES

- [1] Hunt T, Hopf H, Hussain Z. Physiology of wound healing. *Adv Skin Wound Care*. 2000;13:6–11.
- [2] Otten JE, Wiedmann–Al–Ahmad M, Jahnke H, Pelz K. Bacterial colonization on different suture materials – a potential risk for intraoral dentoalveolar surgery. *J Biomed Mater Res B Appl Biomater*. 2005;74:627–635. doi:10.1002/jbm.b.30250.
- [3] Smith TO, Sexton D, Mann C, Donell S. Sutures versus staples for skin closure in orthopaedic surgery: Meta-analysis. *BMJ (Online)*. 2010;340:747. doi:10.1136/bmj.c1199.
- [4] NICE. Surgical site infections: prevention and treatment. National Institute for Health and Clinical Excellence 2008:1–29.
- [5] Yu AL, Alfieri DC, Bartucci KN, Holzmeister AM, Rees HW. Wound hygiene practices after total knee arthroplasty: does it matter? *J Arthroplasty*. 2016;31:2256–2259. doi:10.1016/j.arth.2016.03.040.
- [6] Hsieh PY, Chen KY, Chen HY, Sheng WH, Chang CH, Wang CL, et al. Postoperative showering for clean and clean–contaminated wounds. A prospective, randomized controlled trial. *Ann Surg*. 2016;263:931–936. doi:10.1097/SLA.0000000000001359.
- [7] Heal C, Buettner P, Raasch B, Browning S, Graham D, Bidgood R, et al. Can sutures get wet? Prospective randomised controlled trial of wound management in general practice. *BMJ*. 2006;332:1053–1056. doi:10.1136/bmj.38800.628704.AE.
- [8] Dayton P, Feilmeier M, Sedberry S. Does postoperative showering or bathing of a surgical site increase the incidence of infection? A systematic review of the literature. *J Foot Ankle Surg*. 2013;52:612–614. doi:10.1053/j.jfas.2013.02.016.
- [9] Toon CD, Sinha S, Davidson BR, Gurusamy KS. Early versus delayed post–operative bathing or showering to prevent wound complications. *Cochrane Database Syst Rev*. 2013;CD010075. doi:10.1002/14651858.CD010075.pub2.
- [10] Chang IW. Early versus delayed post–operative bathing or showering to prevent wound complications: a Cochrane review summary. *Int J Nurs Stud*. 2016;61:258–259. doi:10.1016/j.ijnurstu.2016.04.008.
- [11] Carlson G. Early versus delayed postoperative bathing or showering to prevent wound complications. *Clin Nurse Spec*. 2015;29:76–77.
- [12] Noe J, Keller M. Can stitches get wet? *Plast Reconstr Surg*. 1988;81:82–84.
- [13] Carragee EJ, Vittum DW. Wound care after posterior spinal surgery. Does early bathing affect the rate of wound complications? *Spine*. 1996;21:2160–2162.
- [14] Feilmeier M, Dayton P, Sedberry S, Reimer RA. Incidence of surgical site infection in the foot and ankle with early exposure and showering of surgical sites: a prospective observation. *J Foot Ankle Surg*. 2014;53:173–175. doi:10.1053/j.jfas.2013.12.021.
- [15] Harrison C, Wade C, Gore S. Postoperative washing of sutured wounds. *Ann Med Surg*. 2016;11:36–38. doi:10.1016/j.amsu.2016.08.015.
- [16] Ploegmakers IBM, Olde Damink SWM, Breukink SO. Alternatives to antibiotics for prevention of surgical infection. *Br J Surg*. 2017;104:e24–33. doi:10.1002/bjs.10426.
- [17] Fernandez R, Griffiths R. Water for wound cleansing. *Cochrane Database Syst Rev*. 2008. doi:10.1002/14651858.CD003861.pub2.
- [18] Boateng JS, Matthews KH, Stevens HNE, Eccleston GM. Wound healing dressings and drug delivery systems: a review. *J Pharm Sci*. 2008;97:2892–2923. doi:10.1002/jps.21210.
- [19] Kuo FC, Chen B, Lee MS, Yen SH, Wang JW. AQUACEL® Ag surgical dressing reduces surgical site infection and improves patient satisfaction in minimally invasive total knee arthroplasty: a prospective, randomized, controlled study. *BioMed Res Int*. 2017;2017:1–8. doi:10.1155/2017/1262108.
- [20] 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;29:1098–1100. doi:10.1016/j.arth.2013.11.012.
- [21] Dobbelaere A, Schuermans N, Smet S, Van Der Straeten C, Victor J. Comparative study of innovative postoperative wound dressings after total knee arthroplasty. *Acta Orthop Belg*. 2015;81:454–461.
- [22] Liebs TR, Herzberg W, Rther W, Haasters J, Russlies M, Hassenpflug J. Multicenter randomized controlled trial comparing early versus late aquatic therapy after total hip or knee arthroplasty. *Arch Phys Med Rehabil*. 2012;93:192–199. doi:10.1016/j.apmr.2011.09.011.



Author: Paul Lachiewicz

QUESTION 9: What is the definition of persistent wound drainage?

RECOMMENDATION: There is no validated definition of “persistent wound drainage.” In the absence of such data, we define persistent wound drainage as any continued fluid extrusion from the operative site occurring beyond 72 hours from index surgery.

LEVEL OF EVIDENCE: Consensus

DELEGATE VOTE: Agree: 78%, Disagree: 17%, Abstain: 5% (Super Majority, Strong Consensus)

RATIONALE

Early wound drainage is not uncommon in patients undergoing total joint arthroplasty (TJA), and can be observed in up to 10% of patients [1–3]. Serous or serosanguinous drainage shortly after the procedure is benign and can be explained by the surgical disruption of superficial capillaries. On the contrary, many publications have noted the severity of persistent drainage, which may potentially be a sign of an evolving infectious process [2,4–8]. The previous 2013 International Consensus Meeting on Periprosthetic Joint Infection (ICM) reached a strong consensus that continued drainage after 72 hours postoperatively should be closely monitored and that a wound persistently draining greater than 5 or 7 days after diagnosis should be re-operated on without delay [5]. It is also advisable to refrain from collecting culture samples of the drainage early on, since these will often yield normal skin flora [4].

In a study conducted by Patel et al. composed of 2,437 total hip and knee arthroplasty (THA and TKA) patients, they concluded that every additional day of wound drainage increased the probability of developing a wound complication following THA and TKA, by 42% and 29% respectively [9]. In addition, Galat et al. performed a study of 17,784 patients who underwent primary TKA and discovered that patients who require earlier surgical intervention for wound-healing complications are at a significantly increased risk for additional interventions, such as deep infection surgery, resection arthroplasty, muscle flap coverage or amputation [3].

The difficulty lies in accepting a definition for “persistent drainage” to allow for timely intervention, since literature is not consistent. For instance, in a recent study involving 127 orthopaedic surgeons who replied to wound drainage questionnaires, the highest portion of respondents (36.7%) defined persistent wound drainage as greater than 5 days postoperatively, while other respondents defined the duration as anywhere from greater than 1 day to greater than 14 days postoperatively [10]. Weiss and Krackow were among the first to attempt defining persistent drainage [1]. Several other authors afterward defined persistent wound drainage by time, type of exudate (serous, sanguineous, purulent, etc.), site (wound or from suction drains) and presence of microorganisms from culture. See Table 1 below for a list of predominant definitions that have developed.

TABLE 1. Literature with definitions of persistent wound drainage

Author	Year	Number of Procedures	Definition	Additional Notes/ Conclusions
Weiss [1]	1993	597	1. Drainage for 4 consecutive days after POD 5 2. Drainage that significantly soaks a 2”x 2” gauze dressing 3. Drainage that emanated from the same specific site(s) along the wound	Primary and revision TKA, 1.3% developed persistent drainage
Saleh [6]	2002	2,305	2 days PO for non-infected cases, 5.5 days PO for infected cases.	12.7-times greater risk of SSSI for wounds draining more than 5 days
Jaberi [2]	2008	11,785	Drainage greater than 48 hours post-op that soaks through post-op dressings	Primary and revision TJA, 2.9% developed persistent drainage
Butt [11]	2011	77	Continued drainage beyond POD 4	Primary TKA, periarticular local anesthesia, subvastus approach, and tourniquet time led to less wound drainage
Hansen [12]	2013	109	Continued drainage beyond POD 3 or 4	Primary and revision THA
Parvizi [5] (2013 ICM on PJI)	2013	n/a	Continued drainage from operative site greater than 72 hours post-op	Strong consensus among delegates. Persistent drainage more than 5 or 7 days after diagnosis should be re-operated on without delay.

POD, postoperative day; TKA, total knee arthroplasty; TJA, total joint arthroplasty; SSSI, superficial surgical site infection; ICM, international consensus meeting; PJI, periprosthetic joint infection

REFERENCES

- [1] Weiss AP, Krackow KA. Persistent wound drainage after primary total knee arthroplasty. *J Arthroplasty*. 1993;8:285–289.
- [2] Jaberi FM, Parvizi J, Haytmanek CT, Joshi A, Purtill J. Procrastination of wound drainage and malnutrition affect the outcome of joint arthroplasty. *Clin Orthop Relat Res*. 2008;466:1368–1371. doi:10.1007/s11999-008-0214-7.
- [3] Galat DD, McGovern SC, Larson DR, Harrington JR, Hanssen AD, Clarke HD. Surgical treatment of early wound complications following primary total knee arthroplasty. *J Bone Joint Surg Am*. 2009;91:48–54. doi:10.2106/JBJS.G.01371.
- [4] Lonner JH, Lotke PA. Aseptic complications after total knee arthroplasty. *J Am Acad Orthop Surg* 1999;7:311–324.
- [5] Parvizi J, Gehrke T, Chen AF. Proceedings of the International Consensus on Periprosthetic Joint Infection. *Bone Joint J*. 2013;95-B:1450–1452. doi:10.1302/0301-620X.95B11.33135.
- [6] Saleh K, Olson M, Resig S, Bershadsky B, Kuskowski M, Gioe T, et al. Predictors of wound infection in hip and knee joint replacement: results from a 20 year surveillance program. *J Orthop Res*. 2002;20:506–515. doi:10.1016/S0736-0266(01)00153-X.
- [7] Eka A, Chen AF. Patient-related medical risk factors for periprosthetic joint infection of the hip and knee. *Ann Transl Med*. 2015;3. doi:10.3978/j.issn.2305-5839.2015.09.26.
- [8] Zmistowski B, Tetreault MW, Alijanipour P, Chen AF, Della Valle CJ, Parvizi J. Recurrent periprosthetic joint infection: persistent or new infection? *J Arthroplasty*. 2013;28:1486–1489. doi:10.1016/j.arth.2013.02.021.

- [9] Patel VP, Walsh M, Sehgal B, Preston C, DeWal H, Di Cesare PE. Factors associated with prolonged wound drainage after primary total hip and knee arthroplasty. *J Bone Joint Surg Am.* 2007;89:33–38. doi:10.2106/JBJS.F.00163.
- [10] Wagenaar F–C, Löwik CAM, Stevens M, Bulstra SK, Pronk Y, van den Akker–Scheek I, et al. Managing persistent wound leakage after total knee and hip arthroplasty. Results of a nationwide survey among Dutch orthopaedic surgeons. *J Bone Jt Infect.* 2017;2:202–207. doi:10.7150/jbji.22327.
- [11] Butt U, Ahmad R, Aspros D, Bannister GC. Factors affecting wound ooze in total knee replacement. *Ann R Coll Surg Engl.* 2011;93:54–56. doi:10.1308/003588410X12771863937124.
- [12] Hansen E, Durinka JB, Costanzo JA, Austin MS, Deirmengian GK. Negative pressure wound therapy is associated with resolution of incisional drainage in most wounds after hip arthroplasty. *Clin Orthop Relat Res.* 2013;471:3230–3236. doi:10.1007/s11999-013-2937-3.