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Aquacel Surgical Dressing Reduces the Rate of Acute PJI Following Total Joint Arthroplasty: A Case–Control Study

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ABSTRACT

An effort to prevent PJI has led to the development of antimicrobial dressings that support wound healing. We sought to determine whether Aquacel Surgical dressing independently reduces the rate of acute PJI following TJA. A single institution retrospective chart review of 903 consecutive cases who received the Aquacel Surgical dressing and 875 consecutive cases who received standard gauze dressing was conducted to determine the incidence of acute PJI (within 3 months). The incidence of acute PJI is 0.44% in the Aquacel dressing group compared to 1.7% in the standard gauze dressing group ($P = 0.005$). Multivariate analysis revealed that use of Aquacel dressing was an independent risk factor for reduction of PJI (odds ratio of 0.165, 95% confidence interval: 0.051–0.533). Aquacel Surgical dressing significantly reduces the incidence of acute PJI.

Periprosthetic joint infection (PJI) is one of the most dreaded complications that occur after total joint arthroplasty (TJA). PJI is reported to occur in 1%–4% and 0.59%–2%of patients who have undergone total knee and hip arthroplasty, respectively [1,2]. The infection causes physical, emotional, and financial strain to patients and their families as well as an immense monetary burden to hospitals and our economy. The annual nationwide cost to control infection is approximately $250 million. The cost of treating an individual PJI can be in excess of $50,000 and if the offending organism is antibiotic resistant, i.e. MRSA, that cost can surpass $100,000 [3,4]. Additionally, perioperative mortality associated with PJI can be 10 times greater than with primary TJA [5,6].

Eradication of infection often requires additional surgery and is distressful for both the treating physician and patient. While there are numerous possible causes for PJI, a few important risk factors related to the wound itself have been identified including wound drainage and superficial wound infections [7]. The traditional approach to wound care consists of a simple dressing that could be removed after 1 or 2 days with the idea that the wound re-epithelializes during that time and can then be left uncovered. [8]. Among efforts to prevent the occurrence of PJI, commercial dressings have been developed to optimize wound healing, seal wound drainage and have antimicrobial properties [9]. In contrast to the conventional use of standard gauze bandages, these dressings feature antimicrobial linings and have shown to decrease surgical site infection rates [10].

The Aquacel Ag Hydrofiber dressing is an antimicrobial dressing that consists of a weaved cellulose center that contours to the skin to eliminate dead space, absorbs exudates, releases ionic silver to reduce microbial activity and supports wound healing [11]. Furthermore, the dressing seals the wound and prevents seepage of drainage beyond the dressing perimeter. The objective of this study was to evaluate the effect of using this dressing on the occurrence of acute PJI in patients undergoing TJA. We hypothesized that the Aquacel Ag Hydrofiber dressing would support healing following surgery and possibly reduce the rate of acute PJI.

Methods

Prior to initiation of the study, institutional review board approval was obtained. Using our computerized joint arthroplasty database, 950 consecutive patients who underwent primary total hip or total knee arthroplasty between October 2010 and March 2012 and received the Aquacel dressing were identified. A list of 950 consecutive patients who received standard dressings and who were admitted to the hospital before implementing systematic use of the Aquacel dressing from April 2007 to August 2010 was generated in a similar fashion. To allow for consistency in the use of the new dressing, data from the initial 6 weeks when Aquacel dressing was utilized were omitted. Exclusion criteria included hip hemiarthroplasty, unicompartmental knee arthroplasty, TJA for fracture treatment, conversion TJA, and revision TJA. Each case was reviewed to verify the exclusion criteria and collect demographic information, medical comorbidities, intraoperative parameters and development of acute PJI. The latter was defined as PJI occurring within 3 months of surgery based on the new definition criteria established by the Musculoskeletal Infection Society [12]. After eliminating patients based on the exclusion criteria, 903 patients with hip (392), knee

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(508) or hip and knee (3) arthroplasties were retained in the Aquacel group and 875 patients with hip (376) or knee (499) arthroplasty in the standard dressing group. The Aquacel dressing was applied on the surgical site in sterile conditions in the operating room and kept in place for 5 days postoperatively. Standard dressing application consisted of sterile xeroform and gauze applied over the incision site in the operating room and wrapped in an ace bandage that remained in place for 2 days postoperatively.

In addition to the application of the Aquacel Surgical dressing, changes in clinical practice during the study period included the use of dual intravenous antibiotic prophylaxis with vancomycin and cefazolin (vs. cefazolin alone previously) and systematic irrigation with dilute betadine before wound closure. These changes occurred 9 and 4 months before the end of the study period respectively. A total of 37 patient-related and procedure-related risk factors were taken into account in a multivariate analysis model where the dependent variable was the development of acute PJI (Table 1). Statistical analyses were performed using R version 2.15.1 (R Foundation for Statistical Computing, Vienna, Austria).

Results

The prevalence of acute PJI was lower in the Aquacel group (0.44%) compared to the standard dressing group (1.71%). Bivariate analysis conducted with Fisher's test first showed this to be statistically significant ($P = 0.005$). A backward stepwise logistic regression model retained 7 independent risk factors for PJI (of 37 variables), including the use of Aquacel dressing, with an independent odds ratio of 0.165 (95% confidence interval: 0.051–0.533). Other independent significant risk factors for infection were as follows: older age, higher body mass index, smoking status, thyroid disease, liver disease and history of steroid treatment (Table 2). Notably, utilization of vancomycin prophylaxis and betadine irrigation were not shown to be significant independent protective factors for acute PJI.

Table 1
List of Patient-Related and Procedure-Related Factors Included in the First Step of the Logistic Regression Model.

Demographic factors	Age
	Gender
	BMI
Procedure-related factors	Joint
	Bilateral procedure
	OR time
	Transfusion need
	Type of anesthesia
	Length of stay
	Aquacel dressing
	Dilute betadine irrigation
Comorbidities	Smoking status
	Frequent alcohol drinking
	History of MI
	Congestive heart failure
	Peripheral vascular disease
	Cerebrovascular disease
	Dementia
	Chronic pulmonary disease
	Connective tissue disease
	Coronary artery disease
	Peptic ulcer disease
	Liver disease
	Diabetes mellitus
	Chronic renal disease
	Malignancy (history, active disease or metastatic disease)
	Rheumatoid disease
	Hypertension
	Dyslipidemia
	Thyroid disease
	Psychiatric disease
	Anemia
	Dysrythmia
	History of DVT or PE
	GERD
	History of steroid treatment
	ASA

ASA = American Society of Anaesthesiologists physical status classification; BMI = body mass index; DVT = deep vein thrombosis; GERD = gastroesophageal reflux disease; MI = myocardial infarction; OR = operating room; PE = pulmonary embolism.

Discussion

PJI is a major healthcare concern with mental, physical and financial burden on affected patients. With projected exponential increases in its incidence and costs, and the predicted reforms of healthcare reimbursement, prevention of this complication is gaining more importance [13]. Wound healing problems and superficial surgical site infections have consistently shown to be determining risk factors for the development of PJI [14,15]. Thus, addressing these specific issues may prevent the occurrence of deep infection. The Aquacel dressing has several features that could positively affect the wound environment: it sequesters fluid to avoid tissue maceration, while at the same time releasing a gel that maintains a relatively humid environment; it is also completely impermeable, preventing bacteria from entering the wound site from the outside environment and maintaining hypoxia in the wound, which has been shown to enhance healing and cellular immunity through the up-regulation of hypoxic-inducible factors [16]. The addition of silver provides antimicrobial activity [17].

The use of the Aquacel dressing in TJA has previously been shown to create less need for dressing changes, thus decreasing burden on healthcare personnel, diminishing superficial wound problem, and avoiding delays in hospital discharge due to wound healing issues [18]. As the first study to correlate Aquacel dressing with acute PJI, our results show that this dressing is an effective measure to significantly reduce the occurrence of acute PJI after TJA, when compared to standard dressings with gauze and tape. In our series, it independently reduced the rate of acute PJI approximately sixfold.

The cost of one standard Aquacel dressing at our institution is $39.05. The cost to treat a PJI has been variably estimated to range from $50,000 to over $100,000 [13]. A standard taped surgical gauze dressing costs approximately $5.00. Therefore, the additional cost per case for an Aquacel dressing is about $34.00. Infection after TJA has been reported to have an incidence ranging from 1.0% to 2.0% [4]. In the United States., there are over 1,000,000 TKAs and THAs performed annually [19]. Assuming the lowest cost ($50,000) of PJI treatment and the lower incidence (1%) of reported PJI, the annual costs to manage PJI in the United States likely exceed $500,000,000. The cost of using an Aquacel dressing routinely in the United States after TJA would add approximately $27,000,000 in cost. If the reported fourfold reduction in PJI noted in our study is accurate, the cost of PJI management in the United States could be reduced by at approximately $375,000,000 with use of an Aquacel dressing. Therefore, the

Table 2
Factors Included in the Final Logistic Regression Model With Independent Odds Ratios and 95% Confidence Intervals.

	Odds Ratio (95% Confidence Interval)	*P*-value
Aquacel dressing use	0.17 (0.05–0.53)	0.003
Age	1.09 (1.03–1.14)	0.002
Body mass index	1.10 (1.03–1.19)	0.006
Former smoker	3.02 (1.12–8.12)	0.029
Thyroid disease	3.71 (1.42–9.67)	0.007
Liver disease	7.03 (1.43–34.60)	0.017
History of systemic steroid treatment	22.22 (1.83–269.45)	0.015

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additional cost associated with routine use of the Aquacel dressing after TJA can be readily justified.

We recognize several limitations to our study, such as, principally, its retrospective design on a cohort of consecutive patients. Nonetheless, we were able to include a relatively large number of subjects and all changes in practice, as well as potential confounding factors, were taken into account in a multivariate model to ascertain the independent protective effect of the Aquacel dressing. Our main concern was the confounding effect of intravenous vancomycin prophylaxis and dilute betadine irrigation, two practices we implemented based on recent supportive evidence in the literature [20,21]. However, these two factors did not reach a significant effect on the development of PJI in our current study. This lack of significance is possibly due to the limited number of subjects involved since these two practices were introduced at our institution relatively late in the study period. Finally, our main outcome measurement consisted of PJI occurring within 3 months of surgery. We elected to use the 3-month minimum follow-up, in compliance with the recent recommendations of the Center for Disease Control and Prevention, which uses this period to determine if an infection occurring after surgery could be directly attributed to that procedure or not [22].

Despite the aforementioned limitations, this case-controlled study demonstrated that the Aquacel Ag Surgical wound dressing with ionic silver significantly reduced the incidence of acute PJI in our cohort of patients. Its systematic use suggests that it would be an effective measure to prevent the occurrence of acute PJI following TJA and thus diminish the significant healthcare costs and patient morbidity of PJI.

References

1. Adeli B, Parvizi J. Strategies for the prevention of periprosthetic joint infection. J Bone Joint Surg 2012;94(11 Suppl A):42.
2. Bozic KJ, Ong K, Lau E, et al. Estimating risk in Medicare patients with THA: an electronic risk calculator for periprosthetic joint infection and mortality. Clin Orthop Relat Res 2013;471(2):574.
3. Berbari EF, Hanssen AD, Duffy MC, et al. Risk factors for prosthetic joint infection: case–control study. Clin Infect Dis 1998;27:1247.
4. Parvizi J, Pawasarat IM, Azzam KA, et al. Periprosthetic joint infection: the economic impact of methicillin-resistant infections. JOA 2010;25(6 Sup):103.
5. Cataldo MA, Petrosillo N, Cipriani M, et al. Prosthetic joint infection: recent developments in diagnosis and management. J Infect 2010;61(6):443.
6. Fisman DN, Reilly DT, Karchmer AW, et al. Clinical effectiveness and cost effectiveness of 2 management strategies for infected total hip arthroplasty in the elderly. Clin Infect Dis 2001;32(3):419.
7. Pulido L, Ghanem E, Joshi A, et al. Periprosthetic joint infection: the incidence, timing, and predisposing factors. Clin Orthop Relat Res 2008;466(7):1710.
8. Berg A, Fleischer S, Kuss O, et al. Timing of dress removal in the healing of surgical wounds by primary intention: quantitative systematic review protocol. J Adv Nurs 2011;68(2):264.
9. Vasconcelos A, Cavaco-Paulo Artur. Wound dressings for a proteolytic-rich environment. Appl Microbiol Biotechnol 2011;90(2):445.
10. Hutchinson JJ, McGuckin M. Occlusive dressings: a microbiologic and clinical review. Am J Infect Control 1990;18(4):257.
11. Hopper GP, Deakin AH, Crane EO, et al. Enhancing patient recovery following lower limb arthroplasty with a modern wound dressing: a prospective, comparative audit. J Wound Care 2012;21(4):200.
12. Parvizi J, Zmistowski B, Berbari EF, et al. New definition for periprosthetic joint infection: from the Workgroup of the Musculoskeletal Infection Society. Clin Orthop Relat Res 2011;469(11):2992.
13. Kurtz SM, Lau E, Watson H, et al. Economic burden of periprosthetic joint infection in the United States. J Arthroplasty 2012;27(8, Supplement):61.
14. Pulido L, Ghanem E, Joshi A, et al. Periprosthetic joint infection: the incidence, timing, and predisposing factors. Clin Orthop Relat Res 2008;466(7):1710.
15. Berbari EF, Osmon DR, Lahr B, et al. The Mayo Joint Infection Risk Score: implication for surgical site infection reporting and risk stratification. Infect Control Hosp Epidemiol 2012;33(8):774.
16. Okumura CYM, Hollands A, Tran DN, et al. A new pharmacological agent (AKB-4924) stabilizes hypoxia inducible factor-1 (HIF-1) and increases skin innate defenses against bacterial infection. J Mol Med 2012;90(9):1079.
17. Jones SA, Bowler PG, Walker M, et al. Controlling wound bioburden with a novel silver-containing Hydrofiber dressing. Wound Repair Regen 2004;12(3):288.
18. Hopper GP, Deakin AH, Crane EO, et al. Enhancing patient recovery following lower limb arthroplasty with a modern wound dressing: a prospective, comparative audit. J Wound Care 2012 Apr;21(4):200.
19. Kurtz SM, Ong K, Lau E, et al. Projections of primary and revision hip and knee arthroplasty in the United States from 2005 to 2030. J Bone Joint Surg Am 2007;89:780.
20. Brown NM, Cipriano CA, Moric M, et al. Dilute betadine lavage before closure for the prevention of acute postoperative deep periprosthetic joint infection. J Arthroplasty 2012;27(1):27.
21. Smith EB, Wynne R, Joshi A, et al. Is it time to include vancomycin for routine perioperative antibiotic prophylaxis in total joint arthroplasty patients?J Arthroplasty 2012;27(8 Suppl):55. http://dx.doi.org/10.1016/-j.arth.2012.03.040. [Epub 2012 May 17].
22. Mangram AJ, Horan TC, Pearson ML, et al. Guideline for prevention of surgical site infection, 1999. Centers for Disease Control and Prevention (CDC) Hospital Infection Control Practices Advisory Committee. Am J Infect Control 1999;27(2):97.

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