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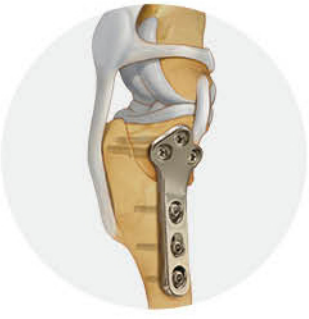

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CLINICAL RESEARCH

WILEY

Preclosure povidone-iodine lavage in total hip replacement surgery: Infection outcomes and cost–benefit analysis

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Abstract

Objective: To report the outcomes and cost–benefit analysis of preclosure povidone-iodine lavage (PrePIL) used to reduce the risk of infection following total hip replacement (THR) surgery.

Study design: Retrospective study.

Animals: One thousand six hundred ninety-nine dogs, 17 cats.

Methods: The medical records of 2213 consecutive THR cases were reviewed to determine the incidence of infection. The last 102 were treated with PrePIL using a commercially sourced 0.035% povidone-iodine solution. Postoperative infection rates were compared. A cost–benefit analysis was used to calculate if a PrePIL protocol is economically feasible.

Results: Twenty-one THRs out of 2111 (0.99%) that did not have PrePIL developed infection. Infection occurred in none of the 102 PrePIL cases. Cost analysis revealed a PrePIL break-even cost at $49.74 and a break-even infection rate of 0.949%. No complications were identified related to the use of PrePIL.

Conclusion: Preclosure povidone-iodine lavage appeared to be efficacious in lowering THR infection rates, and it appeared to be safe for this use based on our 102 consecutive cases. The cost of the PrePIL was minimal compared to the overall cost to resolve THR infection and the potential effect on hip function prognosis. The math formulas developed can be used by surgeons to calculate cost effectiveness and break-even cost based on their THR infection rate, and to compare to the cost of a THR revision and infection resolution.

Clinical significance: At current costs, PrePIL can be used in 2415 THR cases at a similar cost of a single revision surgery and resolution of a periprosthetic infection.

1 | INTRODUCTION

The total cost of an index total hip replacement (THR) surgery in dogs and cats is a sizable financial investment for some owners and infeasible for others. The cost of revision surgery due to THR complications such as infection is an added economic and home care burden on the

Abbreviations: BFX, biological fixation; CFX, cement fixation; PI, povidone-iodine; PJI, periprosthetic joint infection; PrePIL, preclosure povidone-iodine lavage; SL, saline lavage; SSI, surgical site infection; THR, total hip replacement.

owners, exasperating for surgeons, devastating for owners, and increases morbidity for the cat or dog. Reported periprosthetic joint infection (PJI) rates after veterinary THR range from 1.5% to 8.6%[1–8] and PJI rates in humans range from 0.3% to 2.23%,[9–12] although incidence may vary depending on the type of implants used and may increase after revision surgery.[13]

Commercially available antiseptic solutions including povidone-iodine (PI), hydrochlorous acid, sodium hypochlorite, hydrogen peroxide, acetic acid, and chlorhexidine gluconate are used to minimize surgical site infection (SSI) as part of human aseptic technique protocols, intraoperative antiseptic irrigation solutions, and for treatment of infection. Lavage solutions used commonly during veterinary surgery are traditionally limited to normal saline or Ringer's lactate with no antiseptics added, and identification of the ideal lavage solution for animals has little evidence-based data to recommend which solution is effective or superior to the others.

The ideal lavage solution for intraoperative use in joint replacement surgery has a broad spectrum of activity, is bactericidal but not cytotoxic at concentrations required to diminish the bacterial and biofilm load by 99.9% (the minimum biofilm eradication concentrations or MBEC),[14,15] and has a rapid onset to full effect. An in-vitro study reported 0.3% PI to have the greatest efficacy in eradication of methicillin-sensitive *Staphylococcus aureus* and *Escherichia coli* with the least cytotoxicity of common antiseptics against human osteoblasts, chondrocytes and fibroblasts.[14]

In a report comparing intraoperative PI lavage compared to chlorhexidine gluconate lavage in human patients, there was no significant difference in the rate of postoperative infection or need to return for revision surgery. The study concluded that efficacy to prevent infection using PI and chlorhexidine gluconate is equal but the PI was far less expensive.[12] Additionally, the results of an in vitro study concluded that PI is more effective in less time than chlorhexidine gluconate with a mean eradication time of 40 s for PI and >180 s for chlorhexidine gluconate irrigation on three different bacterial isolates.[16] As a result of these findings, commercial aliquots of PI in sterile packaging are available at more cost accessible price points than other antiseptic surgical lavage leaving it as the preference for use during aseptic technique and when cost is a factor.[12]

Despite the common use and effectiveness of a preclosure povidone-iodine lavage (PrePIL) to prevent joint replacement infection in humans[9,17–20] there is a paucity of veterinary literature describing the use of a specific lavage solution and which solution is cost effective. The first goal of this report is to raise awareness of an antiseptic method intended to lower infection rates after THR in companion dogs and cats without causing adverse tissue damage. Our second goal is to describe a cost–benefit analysis model that can be adapted to each individual surgeon's circumstances and case load to help with objective decision making in case-by-case infection mitigation protocols. We also describe clinical use and outcomes of a series of 102 cases that received PrePIL. Based on data in humans, we hypothesize that dilute PrePIL is a safe, efficacious, and cost-effective method to minimize risk of PJI after THR in small animal species.

2 | MATERIALS AND METHODS

2.1 | Case selection

The medical records at two specialty surgery practices were reviewed for dogs and cats receiving THR between 1994–2022. The study population was retrospectively divided into two groups based on whether saline lavage (SL) or PrePIL was used. All cases were performed by the same two surgeons that followed the same infection control protocols including perioperative cefazolin, sewn-in drapes to prevent skin exposure, and postoperative oral antibiotic administration. Routine preclosing cultures were not performed in either group. Cases were included if there was a minimum radiographic follow-up time of 75 days. Cases were excluded if medical records were incomplete or if follow-up data were not available. Postoperative PJI was considered positive based on positive bacterial growth from joint fluid or deep tissue culture, or by the presence of septic suppurative joint fluid cytology and radiographic evidence of osteomyelitis with implant loosening. PrePIL cases are being monitored on an ongoing basis for long-term late infection with yearly radiographic evaluation and client communication.

2.2 | Lavage protocol

The THR PrePIL protocol replicated the technique used in human THR surgery.[9] Povidone-iodine (10%) was supplied in a sterile, single-dose prepack (APLICARE ¾ fluid ounce povidone-iodine solution antiseptic sterile solution, 22.5 ml, Medline Industries, Inc., Northfield, Illinois, 1800 Medline). To create the 0.35% PI lavage solution, a sterile syringe was used to add 17.5 ml of 10% povidone-iodine to 500 ml of sterile isotonic saline solution in a sterile lavage bowl. Routine SL was used to remove gross debris from the wound site prior to the PrePIL lavage which was started immediately before closure. The wound was lavaged from a 60 ml syringe with the dilute PI solution for 3 minutes in a low-pressure

pulsatile matter. A minimum volume of 60 ml of 0.35% PI solution was used in all hips, regardless of bodyweight. No antibiotics were added to the lavage solution. The PI lavage was followed with a sterile isotonic sodium chloride solution lavage before closure in the same manner as the PI lavage. No pathology specimens were harvested. Cases in both groups received the same intravenous perioperative broad-spectrum antibiotics and were discharged with an oral cephalosporin antibiotic postoperatively.

Cases were monitored by physical and radiographic examination at least 75 days after surgery and phone communications at least 120 days after surgery for adverse reactions, wound healing complications, and infection after surgery. Phone communication between the client and clinician consisted of an informal assessment of the dog or cat through general status questions pertaining to typical PJI symptoms (i.e., lameness, inappetence, pain, or incisional swelling or drainage).

2.3 | Product cost

The povidone-iodine solution (APLICARE) cost was determined from suppliers when purchased in bulk 100 pouch quantities. The hospital cost during the study was $2.07 per packet. The cost of the sterile isotonic sodium chloride solution was not included in the overall cost analysis because that was used routinely prior to the study protocol adding PI. No other costs were changed by the lavage protocol.

2.4 | Cost effectiveness model method

Infection rates from a consecutive series of THR from our medical records prior to PrePIL were used as a historical control group in which only SL was performed prior to closure. We used a cost figure for index THR rounded up to $10 000. We used $5000, or 50% of the cost[21] of the index THR, for the cost of revision surgery and all other costs related to infection resolution. The values used were selected for ease of math calculations and commitment to memory. The cost of the PI ($2.07) was the cost in all cases in which the PrePIL protocol was used.

As an economic model for determining cost effectiveness, we utilized a method previously described by Hatch et al.[22] (Figure 1). Our veterinary model's intent is to define the break-even cost at which the increased cost of implementing the new infection prevention protocol becomes nullified by the cost savings of a subsequent decrease in infections requiring operative treatment. The cost of an index THR surgery, the infection rate, the cost of treating an infection, and the cost of a prevention protocol were all used to calculate cost effectiveness. We determined appropriate values of variables from surgeon queries, our purchasing records, and current average fee ranges rounded up to even numbers for THR case owners. Using the numbers collected, the final break-even infection rate was calculated. If the protocol described decreased the infection rate to the final break-even percentage or below, then PrePIL was considered cost effective and worth prophylactic administration.

$$x \times y = z \times \text{Break even cost}$$

$$21 \times \$\,5000 = 2111 \times \text{Break even cost}$$

$$\text{Break even cost} = \frac{\$\,105,000}{2111}$$

$$\text{Break even cost} = \$\,49.74$$

FIGURE 1 Break even cost of preclosure povidone-iodine lavage (PrePIL). The PrePIL is cost effective when the cost of PrePIL is less than $49.74 using the variables listed below. PrePIL cost $2.07 in this study, much lower than the calculated break even cost of $49.74. x = total number of THR infections; y = estimated cost of revision surgery to resolve an infection; z = total number of THR in the series of cases; break even cost = the break-even cost to attempt to lower the infection rate. THR, total hip replacement.

3 | RESULTS

3.1 | Case demographics

Seventeen cats and 1699 dogs met the study inclusion criteria with a total of 2213 THR procedures performed. There were 16 cats and 1619 dogs in the case series prior to PI lavage use in the SL group, with a total of 2111 procedures performed and 476 dogs having staged bilateral procedures. One cat and 80 dogs were in the dilute PI group with 20 dogs having staged bilateral procedures, 56 dogs having unilateral procedures and five revision procedures performed, resulting in a total of 102 povidone iodine lavage cases. (Table 1 (SL) and Table 2 (PrePIL)).

The primary indication for THR was hip dysplasia with secondary osteoarthritis in 81.8% of cases in the SL group and 86.27% in the PrePIL group. Twenty-nine different breeds were represented in the PrePIL group with German shepherd dogs 18/80 (22.5%), Labrador retrievers 10/80 (12.5%), and Rottweilers 7/80 (8.75%) over-represented. Matching was lacking between cement fixation (CFX) and biological fixation (BFX) cases with

TABLE 1 Demographics of cases before the THR preclosure povidone-iodine lavage (PrePIL) protocol was implemented in the saline lavage (SL) group

Age at surgery	Mean 4.59 years; median 3.50 years	Range 0.43–16.46 years
Sex	F 92; FS 941; M 291; MN 787	1033:1078 female: male
Bodyweight (kg)	Mean 29.91 kg; median 31.36 kg	Range 1.81–86 kg
BCS 1–9	Mean 6.04/9; median 6	Range 2–9/9
Surgery side	Left: right	1001:1010
THR indication	Acetabular fracture union	2 (0.09%)
	Avascular necrosis femoral head	46 (2.18%)
	Capital physeal fracture	90 (4.26%)
	Coxofemoral luxation	172 (8.14%)
	FHO revision to THR	8 (0.4%)
	Hip dysplasia and OA	1728 (81.8%)
	Malunion femur or femoral neck	19 (0.9%)
	Femoral neck fracture nonunion	10 (0.47%)
	Nonhip dysplasia OA	11 (0.5%)
	TPO with OA revision to THR	10 (0.47%)
	Hip laxity round ligament tear	11 (0.5%)
Surgery time (min)	Mean 81; median 80	Range 40–165
THR implant type	CFX cup and CFX stem	867
	Micro/nano CFX cup and CFX stem	171
	Hybrid BFX cup and CFX stem	112
	BFX cup and BFX stem	961
	Total	2111

Abbreviations: BCS, body condition score; BFX, biological fixation; CFX, cement fixation; F, female; FHO, femoral head ostectomy; FS, female spayed; M, male; MN, male neutered; OA, osteoarthritis; THR, total hip replacement; TPO, triple pelvic osteotomy.

1144/2111 (54%) of the cases having at least one CFX component in the SL group and only 3/102 (2.9%) of the cases in the PrePIL group having at least one CFX component. The 102 PrePIL cases included 99 BFX procedures. The indication for surgery in five BFX cases was luxation revision. The average time for PrePIL was 3 minutes. The mean surgery time was 81 minutes (range 40–165) in the SL group and mean surgery time was 88 minutes (range 67–185) in the PrePIL group.

TABLE 2 Demographics of cases that received THR PrePIL

Age at surgery	Mean 4.1 years; median 2.5 years	Range 0.63–13 years
Sex	F 8; FS 43; M 14; MN 37	51:41 Female: male
Bodyweight (kg)	Mean 39.7 kg; median 34.8 kg	Range 5–93 kg
BCS 1–9	Mean 6.25/9; median 6	Range 2–9/9
Surgery side	Left: right	54:48
THR indication	Femoral neck fracture	1 (0.98%)
	Avascular necrosis femoral head	2 (1.96%)
	Capital physeal fracture	7 (6.86%)
	Coxofemoral luxation	4 (3.9%)
	Hip dysplasia and OA	88 (86.27%)
Surgery time (min)	Mean 88; median 82	Range 67–185
THR implant type	CFX cup and CFX stem	0
	Micro/nano CFX cup and CFX stem	0
	Micro hybrid BFX cup and CFX stem	3
	BFX cup and BFX stem	99
	Total	102

Abbreviations: BCS, body condition score; BFX, biological fixation; CFX, cement fixation; F, female; FS, female spayed; M, male; MN, male neutered; OA, osteoarthritis; PrePIL, preclosure povidone-iodine lavage; THR, total hip replacement.

3.2 | Infection rate and adverse reactions

Surgical site infection in the SL group was identified in 21/2111 (0.99%) cases prior to adopting the PrePIL protocol. Of the 21 infection cases, 11 were index procedures, and 10 were revision procedures for luxation, fracture, femoral head ostectomy conversion, or implant malposition with loosening. Documented positive bacterial cultures were present in 20/21 cases (95%) (Table 3). The final case was declared to be infected based on suppurative joint fluid cytology and radiographic changes including periostitis and osteolysis resembling osteomyelitis and a nosocomial infection outbreak during that time.

TABLE 3 The saline lavage (SL) group consisted of many breeds of variable ages and bodyweight

Case no.	Breed	Sex	Age (years)	Bodyweight (kg)	Implants (CFX, BFX, hybrid)	Organism	Index or revision	Explant (Y/N)
1	Labrador	M	6.2	45	CFX	*B Hemolytic Streptococcus*	Index	Yes
2	Golden retriever	MN	2.9	35	CFX	*Staphylococcus*	Revision	No
3	Mastiff	FS	4.0	85	CFX	Resistant *Staphylococcus*	Revision	Yes
4	German shepherd	M	4.6	24	CFX	*Streptococcus intermedius*	Revision	Yes
5	Norwegian elkhound	F	2.7	24.5	CFX	*Enterococcus*	Revision	Yes
6	English setter	F	4.3	21.8	CFX	*E. coli*	Index	Yes
7	Mixed breed dog	MN	10.0	49.5	CFX	*Streptococcus fecalis*	Revision	No
8	Golden retriever	FS	0.8	26.3	CFX	*Hematogenous Staphylococcus*	Index	No
9	Bassett griffon	FS	2.2	13.6	CFX	*Pseudomonas*	Index	Yes
10	Golden retriever	M	6.5	45.5	CFX	MRSP	Index	No
11	German shepherd	MN	12.2	24.5	Hybrid	*E. coli*	Index	No
12	German shepherd	MN	6.3	32.7	BFX	MRSA	Index	Yes
13	German shepherd	M	1.3	47.7	BFX	MRSA/MRSP	Index	Yes
14	Labrador	MN	6.4	37.3	CFX	*Enterococcus* sp.	Revision	Yes
15	Golden retriever	MN	6.8	36.8	BFX	*Staphylococcus* sp.	Revision	Yes
16	Labrador	M	5.1	35.5	Hybrid	*Actinomyces*	Index	Yes
17	English pointer	FS	6.2	18.6	CFX	*Actinomyces*	Revision	Yes
18	Labrador	FS	1.3	24.5	BFX	*Enterococcus*	Revision	Yes
19	Mixed breed dog	MN	1.4	33.6	Hybrid	*Xanthomonas maltophilia*, *B Hemolytic Streptococcus*	Revision	No
20	German shepherd	FS	1.0	32.3	BFX	*B Hemolytic Streptococcus*, *Enterococcus*, *Staphylococcus aureus*	Index	Yes
21	Presa canario	M	0.8	55	BFX	Not identified	Index	Yes

Note: CFX and BFX cases became infected after both index and revision procedures. Explantation was the most common end solution to control the infection.
Abbreviations: BFX, biological fixation; CFX, cemented fixation, *E. coli*, *Escherichia coli*; F, female; FHO, femoral head and neck ostectomy; FS, female spayed; M, male; MN, male neutered; MRSA, methicillin resistant *Staphylococcus aureus*; MRSP, methicillin resistant *Staphylococcus pseudintermedius*.

$$\text{Cost of revision} \div \text{PI cost} = x$$

$$\$\,5000 \div \$\,2.07 = 2415$$

FIGURE 2 Math formula for costs effectiveness. This formula can be used by any surgeon to determine the number of PrePIL that can be performed for the same cost as a single THR revision surgery and resolution of infection. Cost of revision = estimated cost of revision surgery to treat an infection; PI cost = current cost of PI for THR PrePIL; x = number of THR cases that can receive THR PrePIL equal to the cost of a single THR revision surgery for infection. PI, povidone-iodine; PrePIL, preclosure povidone-iodine lavage; THR, total hip replacement.

No infections (0/102) were identified in the PrePIL group. None of the cases became febrile. No complications were noted with incisional healing, lameness, radiographic evidence of bone pathology or implant loosening, or on physical examination at a mean of 109 days (range 77 days–20.4 months).

Phone or email communication with the owners occurred at a minimum of 120 days (range 120 days–2 years) confirmed owner satisfaction with no clinical signs of pain, no lameness, and a healed incision.

3.3 | Math calculations

In this case series, a break-even PrePIL cost of $49.74 or less per THR procedure was calculated (Figure 1). Using an estimated cost of revision surgery and resolution of infection based on 50% of the cost of the index THR,[21] the number of THR that could be performed using PrePIL that equals the cost of a single infection revision and

$$z \times y \times w = (z \times \text{PI cost}) + (z \times y \times \text{Break even rate})$$

$$\text{Break even rate} = \frac{(w \times y) - \text{PI cost}}{y}$$

$$\text{Break even rate} = \frac{(0.0099 \times 5000) - 2.07}{5000}$$

$$\text{Break even rate} = 0.00949 = 0.949\%$$

FIGURE 3 Equation used to calculate break-even infection rate.[22] An infection rate less than the break-even point at 0.949% in this example is the rate at which PrePIL is cost effective. z = total annual THR; y = revision cost to treat infection; PI cost = cost of the PI; w = infection rate; break even rate = break even infection rate. PI, povidone-iodine; PrePIL, preclosure povidone-iodine lavage; THR, total hip replacement.

resolution surgery is 2415 cases (Figure 2). The break-even infection rate for povidone iodine lavage is anything less than 0.949% (Figure 3).

4 | DISCUSSION

In our case series, dilute PI lavage was cost effective, intuitive to use, and resulted in no known adverse reactions in 102 consecutive THRs in our case series. The infection rate of 0/102 (0%) for the PrePIL group compares favorably to the infection rate of 21/2111 (0.99%) in the SL group. The calculated break-even cost of $49.74 for use of PrePIL in THR cases is considerably higher than the cost per unit of $2.07, suggesting PrePIL use is cost effective. The infection rate of 0/102 (0%) for the PrePIL group is lower than the calculated break-even infection rate for PrePIL (0.949%), supporting the cost-effective use of PrePIL in our mathematical model and clinical cases. Based on our findings, we accept all conditions of our hypothesis.

Advantages and disadvantages should be considered when contemplating the use of a PrePIL lavage. Preclosure povidone-iodine lavage was implemented based on safety and efficacy data from human literature[21–23] as a precautionary measure added to the multimodal approach already in place to minimize PJI in THR cases. Povidone-iodine achieves broad spectrum bactericidal activity by delivering iodine directly to the cell surface where it enters the cells and oxidizes components of the cytoplasmic membranes.[24] A small number of studies report cytotoxicity,[25–28] including osteoblasts, myoblasts, chondrocytes, and fibroblasts, with high-concentration P-I use of 1.4%–5%.[29] Although extremely rare, iodine allergies[30,31] may arise from systemic absorption[32] and result in anaphylaxis.[33] No systemic absorption adverse effects were noted in the 102 cases in our study. Additionally, iodine is known to cause lysis of liposomes and clinicians should consider a SL and be cautioned when using concurrent liposomal bupivacaine for pain management in combination with PrePIL.[34] Povidone-iodine has more advantages than disadvantages and appears to be safe for use in veterinary cases at a dilute concentration of 0.35% based in our 102 cases.

As antibacterial resistant strains of bacteria become more prevalent in veterinary cases, clinicians are ethically obligated to practice antimicrobial stewardship. The World Health Organization and the Centers for Disease Control advocate the use of PI for lavage of wounds during surgical procedures.[35–37] Studies and meta-analysis in multiple disciplines have demonstrated that PI lavage is more effective than lavage with saline, water, or no irrigation,[32,35,38] and addition of antibiotics to the lavage solution is not recommended by the World Health Organization or in pertinent literature.[35,39–41] Despite that, studies are available showing beneficial results when vancomycin is added to the lavage solution in THRs.[42–45] The results of our study show that PI lavage was an effective and cost-efficient risk-mitigator in THR PJI cases without the use of additional antibiotics in the lavage. These results, along with the overall low PJI rate noted in our cases due to the myriad infection reduction protocols in standard aseptic practice suggest that PI lavage without addition of antibiotics is effective and follows current antimicrobial stewardship guidelines.

Success in treating PJI requires an early diagnosis and aggressive treatment often requiring additional surgery and antibiotics.[46] The economic impact of postoperative SSI and PJI is present not only in joint replacement surgery but also following other orthopedic procedures such as tibial plateau leveling osteotomy.[47] Laboratory testing, diagnostic imaging, antimicrobial therapy, surgery, hospitalization, and rehabilitation are reported to be approximately 50% of the mean cost of the original index surgery and the cost could be more.[21,47] Determination of the infection rate following THR should be relatively easy if follow-up examinations including radiographs are performed. Development of deep SSI or PJI timing is not well documented in veterinary medicine but was noted to be evident on average 26 postoperative days following human index THR and 28 postoperative days following index total knee replacements.[9] Due to the early identification of most PJI, we believe that the 75-day minimum radiographic follow up time is an adequate length of time, in conjunction with our >120 days telephonic client follow-up, in the povidone iodine lavage group to identify infection.[9,11]

Povidone-iodine is an effective antibacterial compound and is safe when used with other agents. There are minimal side-effects when used properly. Usage of PI as an antiseptic is nearly universal but the underlying cost benefits are rarely discussed. It might be an assumption that PI

is cost-effective, but it is not used by all surgeons. When considering the complexity of a cost-effective analysis, our math formula is a useful tool for each surgeon to complete simple projections for calculations of cost effectiveness in their own facility with their own case load. The SSI rate is used by this formula to evaluate the cost of intervention of infection control techniques. Effective means to potentially lower SSI and PJI are justifiable economically even with a minimal reduction in infection rates. In addition to PrePIL, a multimodal approach to infection prevention including thorough preoperative examination and laboratory screening of the case, resolution of any dermatopathy, preoperative bathing, and topical skin chlorhexidine antiseptic preparations should be considered.

Our retrospective study design was unable to account for all possible confounders that may affect infection rates. The incidence of infection following CFX fixation could be different from that following BFX fixation which could affect break-even cost effectiveness calculations. There was a small percentage 3/102 (2.9%) of PrePIL cases in which CFX was used instead of cementless fixation for the femoral component in Micro-THR cases. The risk of infection after cemented compared to cementless fixation is unknown but based on our current study, it is suspected to be higher. With the technology swing towards press-fit BFX fixation and potential for antibiotic, silver, or povidone-iodine[48] coated implants, the infection rate in the future may be projected to be less.

None of the cases in the PrePIL group developed clinical or radiographic signs of infection with sufficient follow up for acute periprosthetic infection detection when referenced with the human literature and average documented total hip infection times of 26 days.[9] The exact number of days that infection was diagnosed in the SL group was not well documented due to the large number of cases and the highly variable number of days of follow-up after the index THR procedure. The infection rate of 21 out of 2111 is the minimum number of SL group PJI, and the actual number could only be higher. "Late infections" were not within the scope of this study even though none were identified within the current study time range; however, yearly evaluations are scheduled for long-term monitoring.

Anecdotally, veterinary practices use many products in an "off-label" fashion to conserve resources. Nonsterile containers of PI (Betadine, Avrio Health L.P., Stamford, Connecticut) are present in most surgical facilities. Potential contamination of commercially available aliquots in these nonsterile containers could potentially increase the risk of infection.[32,49] Our study design did not include use of nonsterile containers of PI, and we cannot recommend these products as an alternative to individual-use, sterile aliquots as described in our study.

Other limitations to our study are predominantly related to its retrospective design. Slight changes in the lavage volume or duration beyond exactly 3 minutes (180 s) may have occurred during the study, and it was not feasible to determine the impact of these changes on the rate of infection. Similarly, there were 5/102 (4.9%) cases in which a revision was performed due to luxation resulting in either implant exchange or neck lengthening. In these cases, closing cultures were performed before PI lavage and all were negative for bacterial growth. None of the five revision cases that received PrePIL developed infection. A prospective, multi-institutional randomized trial with hundreds or perhaps thousands of cases is indicated to eliminate these potential confounding factors. Such studies may be limited by time, cost prohibitive expense, and number of cases for adequate power analysis. Additionally, masking clinicians to this treatment may be difficult due to the inherent color of PI lavage in comparison to SL. Due to the discrepancy in case numbers within each group and the low infection rate overall, the break-even point could be different with more cases in both groups. However, the presented case numbers provide a general idea of safety and efficacy of prePIL and present a useful formula that can be adapted to individual case numbers. Given the low unit cost and positive clinical safety profile of the PrePIL intervention combined with the human literature advocacy and our findings, we conclude that preclosure THR dilute PI lavage represents a cost-effective means of reducing postoperative deep infection in veterinary THR surgery.

In conclusion, we found that at current costs, PrePIL can be used in 2415 THR cases before reaching the break event cost of a single revision surgery to resolve a periprosthetic infection. The clinical safety profile seen in our cases and our cost–benefit analysis demonstrates that using PrePIL during the THR procedure should be considered as a cost-effective method to lower the infection rate in THR cases.

AUTHOR CONTRIBUTIONS

Israel SK, DVM, DACVS: Completed the medical record review, data accumulation, and writing of the manuscript. Jaramillo E, DVM: Completed the medical record review, data accumulation, final review of the manuscript. Liska WD, DVM, DACVS: Completed the medical record review, data accumulation, and writing of the manuscript.

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CONFLICT OF INTEREST

The authors declare no conflicts of interest related to this report.

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