Incisional infection and inflammation are among the most common complications of surgeries in small animals. Many factors have been related to the occurrence of incisional complications, such as the duration of surgery, an increase in the number of people in the operating room, and a dirty surgical site. Infection rates range from 0.8% to 18.1%, depending on the type of procedure. Despite improvements in surgical techniques, these rates still remain high, as a result of an array of factors involved in veterinary surgery. This concern of high infection rates is especially true in orthopedic surgery, where postoperative infection can have major consequences. Tibial plateau leveling osteotomy is one of the most widely used surgical techniques for the treatment of cranial cruciate ligament rupture in dogs. Although TPLO is one of the most commonly performed orthopedic procedures in dogs, the postoperative infection rate ranges from 3% to 7%. As a means to decrease the rates of infection and inflammation at the surgery site, antimicrobial (triclosan)-impregnated suture is available for use in veterinary surgery. Antibacterial suture material creates a zone of inhibition against *Staphylococcus aureus*, *Staphylococcus epidermidis*, and *Escherichia coli* in vitro. In an in vivo study, the use of triclosan-impregnated suture inhibited *S. aureus* colonization of the suture after direct inoculation of the bacteria into the subcutaneous layer where the suture was placed. This antibacterial effect could decrease the rates of infection and inflammation of the surgical site in orthopedic procedures.

The objective of the study reported here was to compare surgical site infection and inflammation rates between the use of nonimpregnated (polydioxanone and poliglecaprone 25) versus triclosan-impregnated (polydioxanone and poliglecaprone 25) suture for incisional closure in dogs undergoing a standardized orthopedic procedure (tibial plateau leveling osteotomy [TPLO]).

**Objective**—To compare surgical site infection and inflammation rates between the use of nonimpregnated (polydioxanone and poliglecaprone 25) versus triclosan-impregnated (polydioxanone and poliglecaprone 25) suture for incisional closure in dogs undergoing a standardized orthopedic procedure (tibial plateau leveling osteotomy [TPLO]).

**Design**—Retrospective cohort study.

**Animals**—283 dogs that underwent TPLO between November 2005 and December 2009.

**Procedures**—Medical records were reviewed for age; body weight; body condition score; use of propofol; perioperative and postoperative administration of antimicrobials; presence of a preoperative infection; use of a jig; technique of joint exploration; type of suture material (triclosan impregnated vs nonimpregnated) used to close the pes anserinus, subcutaneous layer, and subcuticular layer; use of staples or suture to close the skin; and surgery and anesthesia durations. The outcome variables were surgical site inflammation and infection.

**Results**—Rates of infection and inflammation did not differ between surgeries for which triclosan-impregnated suture was used (n = 159 [8.8%, and 18.8%, respectively]) and those for which nonimpregnated suture was used (112 [10.7% and 15.2%, respectively]). The use of staples, compared with suture, to close the skin significantly decreased the inflammation rate.

**Conclusions and Clinical Relevance**—Compared with in vitro conditions, in vivo conditions (where the environment is not controlled and triclosan may elute more quickly from the suture) may decrease the antibacterial effectiveness of triclosan-impregnated suture. On the basis of our findings, triclosan-impregnated sutures did not seem to provide an additional benefit for clinical use and cannot be strongly recommended for elective orthopedic procedures in veterinary medicine. (J Am Vet Med Assoc 2013;242:355–358)
thopedic procedure (ie, TPLO). We hypothesized that use of triclosan-impregnated suture material would result in lower infection and inflammation rates after TPLO, compared with use of nonimpregnated suture.

**Materials and Methods**

**Case selection**—Medical records of dogs that underwent TPLO at the University of Illinois Veterinary Teaching Hospital between November 2005 and December 2009 were reviewed. For incisional closure, polydioxanone and poliglecaprone 25 were used from November 2005 to December 2007, and triclosan-impregnated polydioxanone and poliglecaprone 25 were used from January 2008 to December 2009. To be eligible for the study, dogs had to be reevaluated at the university or by the referring veterinarian at 10 days after surgery and until healing of the osteotomy site.

**Anesthetic and surgical procedures**—All dogs received medetomidine, morphine, and atropine as preanesthetic drugs, and surgical anesthesia was induced with propofol or thiopental followed by intubation and maintenance of anesthesia with isoflurane in oxygen. Cefazolin (22 mg/kg [10 mg/lb], IV) was administered before surgery and every 90 minutes until the end of the surgery.

Dogs underwent arthrotomy or arthroscopy via a craniomedial approach to confirm a cranial cruciate ligament rupture and evaluate the menisci. Treatment of meniscal injuries was performed at the surgeon’s discretion. The joint capsule was closed before proceeding to the TPLO procedure as described by Slocum and Slocum. In some cases, a TPLO jig was not used. The surgical site was closed with triclosan-impregnated or nonimpregnated suture in 3 layers, including pes anserinus, subcutaneous layer, and subcuticular layer. When an arthrotomy was performed, the incision was closed with the same category of suture (ie, triclosan impregnated or nonimpregnated) as the subcutaneous tissue. The skin was closed with staples, nylon, or polypropylene.

Postoperative analgesia included administration of hydromorphone (0.1 mg/kg [0.05 mg/lb], SC, q 6 h) for 24 hours after surgery, followed by deracoxib (1 to 2 mg/kg [0.45 to 0.9 mg/lb], PO, once daily) or carprofen (2.2 mg/kg [1.0 mg/lb], PO, twice daily) administration and tramadol (2 to 5 mg/kg [0.9 to 2.3 mg/lb], PO, t 2 to 3 times daily) administration for 7 days after surgery. Following surgery, the dogs had a modified Robert–Jones bandage applied for the first 12 to 24 hours and were rested for the first 6 weeks at home while undergoing rehabilitation through controlled exercise.

**Medical record review**—The variables evaluated preoperatively included age, body weight, presence of a preoperative infection (skin other than the operated hind limb or urinary tract infection), and body condition score (on a 9-point scale, classified in 3 categories: underweight, 1 to 3; ideal, 4 to 5; and overweight, 6 to 9). The perioperative variables evaluated included anesthetic induction agent (use of propofol or not), duration of surgery (from the incision to last suture) and anesthesia (from anesthetic induction until inhalation anesthetic administration was discontinued), use of perioperative antimicrobials, TPLO as a second cruciate surgery, use of a TPLO jig, technique of joint exploration (arthroscopy or arthrotomy), suture materials used (polydioxanone, triclosan-impregnated polydioxanone, poliglecaprone 25, triclosan-impregnated poliglecaprone 25, polyglyconate, and monofilament synthetic absorbable sutures), and use of staples, nylon, or polypropylene to close the skin. Suture material was categorized as triclosan-impregnated suture and nonimpregnated suture material. When other suture types (polyglyconate and monofilament synthetic absorbable sutures) were used alone or in combination, the data were not used for suture analysis. All 3 layers (the pes anserinus, subcutaneous layer, and subcuticular layer) had to be closed with 1 category of suture (triclosan impregnated or nonimpregnated) to be included. The postoperative use of antimicrobials was the only immediate postoperative variable recorded.

The outcome variables evaluated were inflammation and infection. Inflammation was defined as an incision with ≥ 1 of the following before or at the time of suture removal: redness, swelling, signs of pain, or heat. These signs were evaluated as present or absent. An infection was defined as an incision with ≥ 1 of the following: a positive culture result, drainage > 48 hours after the end of the surgery, abscess, fistula, or dehiscence.

**Statistical analysis**—All analyses were performed with commercial statistical software. Binary logistic regression was used to evaluate the effect of the categorical or numeric variables (surgery and anesthesia time, body condition score, use of propofol, perioperative antimicrobials, preoperative infection, TPLO jig, and scope or arthroscopy or both) on the outcome variable infection. A binary logistic regression was also used to evaluate suture material and staples on the outcome variables (inflammation and infection). The effects of age and body weight on infection were evaluated via an analysis of continuous variables. For all analyses, values of P < 0.05 were considered significant.

**Results**

Two hundred eighty-three dogs were included in the study. The overall infection rate was 9.5% (27/283), and the inflammation rate was 16.9% (48/283). The mean ± SD age of the patients at surgery was 6.5 ± 2.4 years, and age did not have a significant (P = 0.191) effect on the postoperative infection rate. The mean body weight of the patients was 38.6 ± 12.3 kg (84.9 ± 27.1 lb), and body weight did not have a significant (P = 0.263) effect on the postoperative infection rate. All patients received perioperative antimicrobials. Seventy-eight percent (220/283) of the patients were considered overweight, and 22% (62/283) were considered having an ideal body weight; 1 dog was considered underweight. The mean surgery and anesthesia durations were 1.7 ± 0.45 hours and 3.5 ± 0.4 hours, respectively, and those durations did not significantly (P = 0.185 and 0.593, respectively) influence postoperative infection rate. Only 1 patient had TPLO as a second cruciate surgery, so this could not be evaluated as a risk factor. The other variables recorded that did not significantly affect postoperative infection and inflammation rates included use of propofol for anesthetic induction (P =
the preoperative infection (skin other than the operated hind limb or urinary tract infection; \( P = 0.629 \)), presence of a preoperative infection (skin other than the operated hind limb or urinary tract infection; \( P = 0.537 \)), postoperative administrations of antimicrobials (\( P = 0.148 \)), TPLO jig placed for the procedure (\( P = 0.823 \)), technique of joint exploration (arthroscopy or arthrotomy; \( P = 0.413 \)), and suture materials used to close the various layers of the incision (\( P = 0.677 \)).

The rates of infection and inflammation did not differ significantly between triclosan-impregnated suture and nonimpregnated suture (\( P = 0.703 \) and 0.677, respectively). The infection rate for triclosan-impregnated suture was 14 of 159 (8.8%), and the inflammation rate was 30 of 159 (18.8%). For the nonimpregnated suture, the infection rate was 12 of 112 (10.7%), and the inflammation rate was 17 of 112 (15.2%). Data for 12 dogs were excluded because they had different suture types or >1 category of suture.

For 10 dogs with nonimpregnated suture, bacterial culture of the incisional site yielded Staphylococcus intermedius (4 dogs), \( S \) aureus (5 dogs), and both Pseudomonas aeruginosa and an Enterococcus sp (1 dog). For 8 dogs with triclosan-impregnated suture, bacterial culture of the incisional site yielded \( S \) intermedius (2 dogs, including 1 dog with a methicillin-resistant \( S \) intermedius isolate), \( S \) aureus (3 dogs, including 1 dog with a methicillin-resistant \( S \) aureus isolate), and Enterococcus sp (3 dogs) variously combined with Corynebacterium sp (2), Seratia marcescens (1), Klebsiella pneumonia (1), or \( E \) coli (1).

When each type of suture (polydioxanone, triclosan-impregnated polydioxanone, poliglecaprone 25, and triclosan-impregnated poliglecaprone 25) used in the closure of the subcuticular layer was evaluated for infection and inflammation, no significant difference was found between suture types. The inflammation rates were 5 of 25 (20%) incisional sites for triclosan-impregnated polydioxanone, 16 of 91 (18%) incisional sites for triclosan-impregnated poliglecaprone 25, 1 of 16 incisional sites for poliglecaprone, and 1 of 11 incisional sites for poliglecaprone 25. The remaining 140 of 283 dogs did not have subcuticular sutures.

The use of staples, compared with suture, to close the skin resulted in a significantly (\( P = 0.036 \)) lowered inflammation rate. Thirty-five of 226 (16%) incisions that had staples in the skin developed inflammation, compared with 9 of 28 (32%) incisions that did not have staples but were closed with suture (polypropylene [14/28] or nylon [14/28]); 29 dogs had only a subcuticular layer (ie, no staple or skin suture).

Discussion

The main findings of this study were that there was no difference in infection and inflammation rates between incisions closed with triclosan-impregnated suture and nonimpregnated suture and that the use of staples to close the skin was associated with a lower rate of inflammation, compared with use of suture (nylon and polypropylene) to close the skin.

In the present study, the overall inflammation and infection rates for TPLO surgical site were 16.9% and 9.5%, respectively. Some variables may have affected the rate of infection in comparison with findings in other studies. \(^1\) Those variables include the number of people in the operating room, less experienced surgeons (residents) performing the surgery, increased length of surgery and anesthesia, and students closing the surgical site. The retrospective nature of the study did limit our ability to evaluate the effect of those variables; however, the TPLO procedure is quite standardized at our institution.

The infection and inflammation rates between the use of triclosan-impregnated suture and nonimpregnated suture did not differ. This was not expected, considering that an in vitro study\(^13\) evaluating the effect of triclosan impregnation found an inhibitory effect of the suture on bacteria such as \( S \) aureus, \( S \) epidermidis, and \( E \) coli. The organisms isolated from infected surgical sites that used triclosan-impregnated suture for our study included some of those bacteria (\( S \) aureus and \( E \) coli). It is unlikely that our findings are related to a type II error, considering that the power of the analysis is high (80%) and the inflammation rates were greater for triclosan-impregnated suture. Our results are similar to the finding of a study\(^11\) conducted in horses evaluating the effect of suture on linea alba closure. That study\(^11\) demonstrated that antimicrobial-impregnated suture did not decrease the chances of incisional complications. However, a study\(^14\) in guinea pigs found a decrease in the colonization of \( S \) aureus after incision inoculation when triclosan-impregnated suture was used in vivo. The discrepancy between our study and the experimental study\(^11\) in guinea pigs could be the result of a less controlled environment in our clinical cases as well as species variation. It is also possible that the triclosan eluted too quickly from the suture to have a persistent clinical effect. \(^1\) In fact, triclosan was shown to reduce bacterial growth of various species of bacteria (Brochothrix thermosphaeta, Salmonella typhimurium, Staphylococcus sp, Bacillus subtilis, Shigella flexneri, and \( E \) coli) inoculated on bovine cutaneous trunci muscles during the first 24 hours but not long term (14 days) where triclosan-incorporated plastics had been placed.\(^18\)

Various characteristics are considered important for suture choice: tensile strength, handling characteristics, ability of suture to resist infection and to be nonreactive, and price. The absence of effect found in this clinical study will help surgeons when choosing the most appropriate suture for orthopedic procedures. The fact that the antimicrobial-impregnated suture is twice as expensive as its equivalent yet does not have a significant benefit on the infection and inflammation rates when used for an elective orthopedic surgery can have an impact on this decision.

Subcuticular suture patterns, staples for skin closure, and suture for skin closure are all used in veterinary surgery. A surgeon’s preference is most likely determined by his or her perception of differences in infection rate, speed, cost, and patient comfort. Our study showed that closing the skin with staples was associated with decreased inflammation rates, a finding that was similar to that of another study\(^19\); however, our results differ from those of other studies\(^20\) that show an increase in inflammation rate when staples are used to close incisions. A potential explanation for our finding could be the decreased tissue reaction caused by the
stainless steel staples. Stainless steel has been shown to cause less tissue reaction, compared with other surgical suture in the skin. A study done in reptiles found that stainless steel caused less inflammation than polyglycatan 910 and chronic gut when used to close the skin. Staples were also found to produce less tissue reaction, compared with polypropylene. Another potential explanation for this finding is the increased surgical trauma and manipulation related to the use of skin sutures, particularly when the closure is performed by students, as is common in a teaching hospital. It is likely that the learning curve of stapling differs from that of skin suturing. When performed by students, stapling is likely to be less traumatic for the tissue, compared with skin suturing. A limitation of this study is that we could not know from the medical record whether the skin closure had been performed by a student. Finally, the material used to close the skin could have an impact on infection at the time of suture or staple removal. In fact, a study conducted in humans showed that when staples were removed, patients had less pain at the suture sites, compared with nylon sutures. In dogs, this could decrease the risk of excessive licking of the incisional site after staples are removed, thereby decreasing the rate of inflammation caused by licking.

Another interesting result of this study was that there was no relationship between preoperative infection and the overall infection and inflammation rates for TPLO. This is likely a type 2 error, considering that a low number of patients (n = 10) had a skin or urinary tract infection and underwent TPLO without being treated with antimicrobials prior to surgery.

In summary, the results of this study highlighted the importance of clinical studies to evaluate modifications to existing biomaterials. On the basis of this study, triclosan-impregnated suture does not seem to provide an additional benefit for clinical use and cannot be recommended for use in a routine, elective orthopedic surgery in veterinary medicine. The decreased complication rate associated with staples for skin closure in this study warrants further investigation.

References