Original Study

Journal of Veterinary Dentistry
2017, Vol. 34(3) 148-154

DOI: 10.1177/0898756417715869
journals.sagepub.com/home/jov
SAGE

Comparison of Knotless Barbed Suture Versus Monofilament Suture in the Oral Cavity of Cats

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Abstract

The present study compares a knotless, barbed, absorbable suture material against a conventional monofilament absorbable suture material in oral mucosal wound closure. The parameters measured include time of closure and differences in healing at 2 and 4 weeks postoperatively. A prospective study comparing a knotless, barbed suture system with conventional absorbable sutures was undertaken in 19 cats. Nineteen cats had full mouth extractions performed. Following the extraction procedures, the incisions in the arcades (maxillary and mandibular) were apposed with the barbed, knotless suture system in a continuous pattern on one side and with a conventional smooth suture in an interrupted pattern on the other. Suturing times for each arcade were recorded. The material used to close the first side of each cat varied. Healing, dehiscence, and other complications were assessed at 2 and 4 weeks postoperatively. The average closure time ($\pm$ standard deviation) per quadrant with conventional monofilament suture was 8.7 ($\pm$1.3) minutes, while barbed suture required an average of 5.1 ($\pm$1.1) minutes per quadrant to complete the suture. This difference (95% confidence interval) of 3.6 ($\pm$3.2-4.1) minutes per quadrant was statistically significant ($P < .001$). Dehiscence and ranula-like swelling formation were noted as uncommon postoperative complications, but the differences were not significant between the groups. Barbed, knotless sutures resulted in faster closure times than conventional, simple interrupted, monofilament sutures with similar healing and complication rates. To the author's knowledge, there is no current literature comparing conventional absorbable monofilament sutures to a knotless, barbed, absorbable suture system for closure of oral mucosal incisions in cats.

Keywords

veterinary dentistry, barbed suture, incision healing, knotless suture, oral surgery, oral surgery closure, suture time

Introduction

Barbed, knotless, monofilament suture has gained favor in recent years in human medicine for a variety of applications. These knotless, barbed suture systems were developed to improve operative time and wound closure strength. Common problems with tying knots in an incision are suture breakage, decreased tensile strength, operator sensitive knot security, tissue ischemia, and increased inflammation.[1,2] Knotless sutures have also been shown to allow the tissues to shift along the incision to redistribute tensile and compressive forces, allowing for increased closure strength.[3,4] In the absence of knots, there is less tissue necrosis, inflammation, and possible infection.[5] There is also decreased suture time with knotless suture. In 1 study, knotless suture was shown to decrease operative time by approximately 50%.[6] Many studies in human medicine have compared barbed suture material to smooth monofilament suture material and have shown reduced operative time, improved aesthetics, similar complication profiles, and similar bacterial adherence properties.[5,7-12] However, a recent article revealed barbed suture led to increased postoperative complications for cosmetic surgeries.[13] To the author's knowledge, a small number of studies concerning barbed, knotless suture have been performed in veterinary medicine,[14-16] but no studies have been reported concerning incision closure of the oral mucosa in human or veterinary medicine. The purpose of this study is to evaluate and compare wound closure times and healing of the oral mucosa when apposed with barbed, knotless monofilament, absorbable suture material versus a conventional monofilament, absorbable suture. A second aim of this study was to identify postoperative complications using either suture in the oral cavity at 2 weeks and 4 weeks after suture placement.

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Table 1. Signalment and body condition scores for the 19 cats.

Cat	Sex/Reproductive Status	Breed	Approximate Age, Years	Initial Weight, kg	Body Condition Score
1	M/N	Domestic shorthair	7	6.04	7/9
2	F/unknown	Domestic shorthair	4	3.94	6/9
3	F/S	shorthair	5	3.12	4/9
4	M/N	Domestic shorthair	5	6.56	8/9
5	F/S	Domestic shorthair	5	3.60	4/9
6	M/N	Domestic shorthair	3	4.18	5/9
7	M/N	Domestic shorthair	3	5.10	5/9
8	F/S	Domestic shorthair	4	3.70	5/9
9	M/N	Domestic shorthair	5	5.82	5/9
10	M/N	Domestic shorthair	4	5.00	5/9
11	M/N	Domestic shorthair	3	3.78	5/9
12	M/N	Domestic shorthair	6	6.22	7/9
13	F/unknown	Domestic shorthair	9	3.78	5/9
14	F/unknown	Domestic shorthair	9	3.22	5/9
15	M/N	Domestic shorthair	5	3.88	5/9
16	F/S	Domestic shorthair	3	3.10	4/9
17	F/S	Domestic shorthair	2	3.10	4/9
18	F/unknown	Domestic shorthair	9	4.84	5/9
19	F/unknown	Domestic shorthair	2	5.50	5/9

Materials and Methods

Animals

Nineteen domestic shorthair cats residing in a local animal shelter with clinical signs of significant oral inflammation and dental disease requiring extraction of most of their dentition (gingivitis, periodontitis, caudal mouth mucositis, tooth resorption) were chosen for this study. The exact age of the cats was unknown. They were estimated to be between 2 and 8 years of age (Table 1). Each cat received a complete physical examination and blood work prior to inclusion in the study. Blood work consisted of FeLV/FIV testing as well as a complete blood count and chemistry screen. All cats were FeLV/FIV negative. Mild changes in blood work, mostly consisting of hyperglobulinemia (11/19 cats, average 5.9 g/dL [2.8-4.8]), monocytosis (7/19 cats, average 0.85 K/μL [0.05-0.67]), and neutrophilia (9/19 cats, average 13.23 K/μL [1.48-10.29]), were noted, but no other significant abnormalities were appreciated. Ten of the 19 cats were diagnosed with gingivostomatitis and tooth resorption, 4 of the 19 cats with periodontitis and tooth resorption, and 5 of the 19 cats with only gingivostomatitis. The overall level of oral inflammation was distinguished between cats with periodontitis and gingivostomatitis as friable, inflamed oral mucosa that may affect wound closure and healing.

Experimental Design

For 19 cats, extraction of all teeth (full mouth extraction) was performed. Radiographic confirmation of complete root removal was performed in all cases. Following extractions, the right maxilla and mandible were sutured with a 4-0 monofilament, absorbable suture in a simple interrupted suture pattern, while the left maxilla and mandible were sutured with a 3-0 unidirectional (variable loop), knotless, barbed, absorbable suture in a continuous pattern. All extractions and suturing were performed by the same surgeon. The suturing of each quadrant was timed and recorded without the surgeon's knowledge. For each cat, the side that was operated on first was alternated (all odd numbered cats had the right quadrants extracted and sutured first, while the even numbered cats had the left quadrants extracted and sutured first) to control for surgeon fatigue. Each cat received a complete oral examination that included intraoral photographs at 2 and 4 weeks postoperatively to assess healing[17] and document any complications.

Procedure

Each cat was premedicated with intramuscular injections of buprenorphine (0.015 mg/kg) and atropine (0.022 mg/kg) administered 15 minutes prior to induction. A 22-gauge intravenous catheter was placed in a shaved and antiseptically scrubbed cephalic vein. Anesthetic induction was initiated with diazepam 0.1 mg/kg intravenously followed by propofol 4 to 6 mg/kg intravenously to effect. Due to the fractious nature of 1 cat, induction was initiated with sevoflurane in a tank. An endotracheal tube was placed, cuffed, and secured in place with plastic ties. Anesthesia was maintained with sevoflurane gas and oxygen administered to effect. Bilateral infraorbital foramen blocks and bilateral inferior alveolar blocks were performed in all cats with 0.5% bupivacaine[a] at 1.25 mg per quadrant. The oral cavity was rinsed with a 0.12% chlorhexidine rinse.[b] Full mouth intraoral radiographs were performed for each cat. Extractions began with either the right or left maxillary arcade, depending on the aforementioned schedule. One large pedicle flap was created by making a single incision along the alveolar margin over the entire arcade with a #15 scalpel blade, and elevated with a Molt periosteal elevator. Buccal cortical alveolectomy and tooth sectioning were performed with a #2 surgical length round bur operated on a high-speed hand piece with abundant water cooling.[18] All teeth in

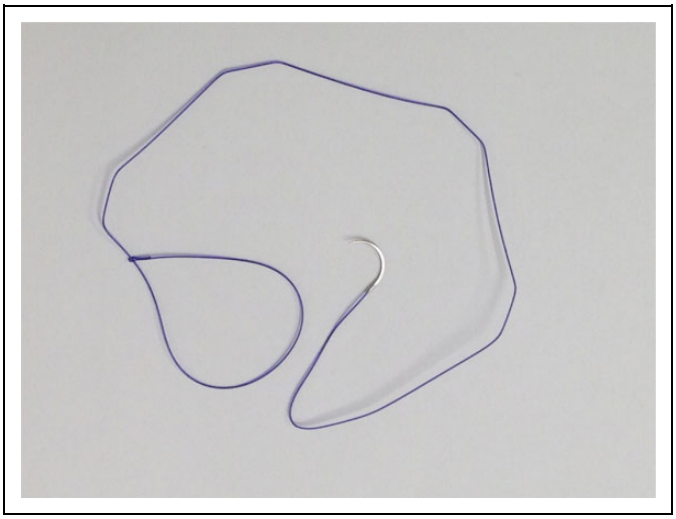

Figure 1. Unidirectional barbed suture with variable loop end.

the arcade were extracted using a #2 Wiggs winged dental elevator, and intraoral radiographs were performed following the extractions to confirm complete removal of all dental tissue. Osteoplasty was performed with a #2 surgical length round bur on a high-speed hand piece to smooth any sharp bone edges. The flap margins were debrided and horizontal periosteal releasing incisions on the buccal mucoperiosteal flaps were created with a #15 scalpel blade. The right maxillary arcade was sutured with 4-0 poliglecaprone 25[c] in a simple interrupted pattern (including an initial surgeon's throw and 5 additional throws) spaced 3 mm apart. Suture time was recorded. The same was performed for the right mandibular arcade, and suturing time was recorded as well. The left maxillary arcade was apposed with 3-0 knotless, unidirectional (variable loop), barbed, absorbable suture consisting of polyglycolic acid and polycaprolactone[d] (Figure 1). Suturing began at the caudal most point in the arcade. After the first bites through both sides of the incision, the needle was passed through the variable loop and pulled taught against the incision. A simple continuous pattern was continued along the length of the incision. When the rostral end of the incision was reached, the suture was pulled taut and back stitched twice before cutting the suture to end the incision.[19] Suturing time was recorded. The same was repeated for the left mandible.

All cats were administered postoperative injections of cefovecin[e] (8 mg/kg) and slow-release buprenorphine[f] (0.12 mg/kg) subcutaneously. All cats were hospitalized overnight on maintenance intravenous fluid therapy before returning to the shelter for monitoring and continued care. Instructions for all cats were to feed soft food for 2 weeks with no access to hard toys or treats. A normal diet of dry kibble could be resumed after the initial 2 weeks. Additional analgesics were provided by the shelter as needed.

At 2 weeks and 4 weeks postoperatively, all cats had oral examinations performed (some under sevoflurane gas due to temperament) and photographs were taken (Figure 2).

Statistical Analysis

To determine if closure time was statistically different between the suture types, we first conducted a 1-way repeated-measures analysis of variance with suture type as a fixed effect and cat as a random effect. We then assessed how this relationship was affected when we repeated the analysis and controlled for quadrant, order of suture type, preoperative periodontitis status, and preoperative gingivostomatitis status. Secondary outcomes of healing were compared between suture type with generalized estimating equations with specific complication as the response, suture as a fixed effect and cat as a random effect. All analyses were conducted using R with a priority significance level of .05.[20]

Results

Data analysis was done based on data from 19 cats. The average (SD) closure time for the monofilament suture was 8.7 ($\pm$1.3) minutes. Times for the mandible ranged between 6.56 and 11.15 minutes and the range for the maxilla was between 7.19 and 12.55 minutes. Closure with barbed suture required 5.1 ($\pm$1.1) minutes on average. The range for the mandible was between 3.36 and 7.00 minutes and the range for the maxilla was between 4.17 and 7.20 minutes. This difference (95% CI) of 3.6 ($\pm$3.2-4.1) minutes was statistically significant ($P < .001$). The difference remained significant even when controlling for quadrant, order of suture, preoperative periodontitis, and preoperative gingivostomatitis ($P < .001$). At week 2, all 38 quadrants sutured with monofilament suture were completely healed compared to 36 (94.7%) of 38 quadrants sutured with the barbed suture ($P > .99$). The remaining 2 of 38 quadrants had small areas of dehiscence (Figure 3). These areas measured 15 and 6 mm in length and were noted over the midsection of the maxillary arcades in both cases. Suture material was present and intact cranial and caudal to the areas of dehiscence over these arcades at the 2-week recheck and both cats had originally been diagnosed with gingivostomatitis. In both cases, the areas were expected to heal by second intention and no further sutures were placed. There was 1 (2.6%) quadrant with a ranula-like swelling in the monofilament suture group and 2 (5.3%) quadrant with ranula-like swelling in the barbed suture group ($P = .57$; Figure 4). It should be noted that all 3 cases with ranula-like swellings were diagnosed with gingivostomatitis. At week 4, all 38 quadrants in both suture groups were completely healed, and there was only 1 (2.6%) incidence of ranula-like swelling in the monofilament group compared to no (0%) incidence of ranula-like swelling in the barbed suture group.

Discussion

The knotless, barbed suture system was shown to have a significantly decreased suture time when compared to the monofilament group on average by 41.37%. Although closure times may vary among operators, this finding is consistent with many

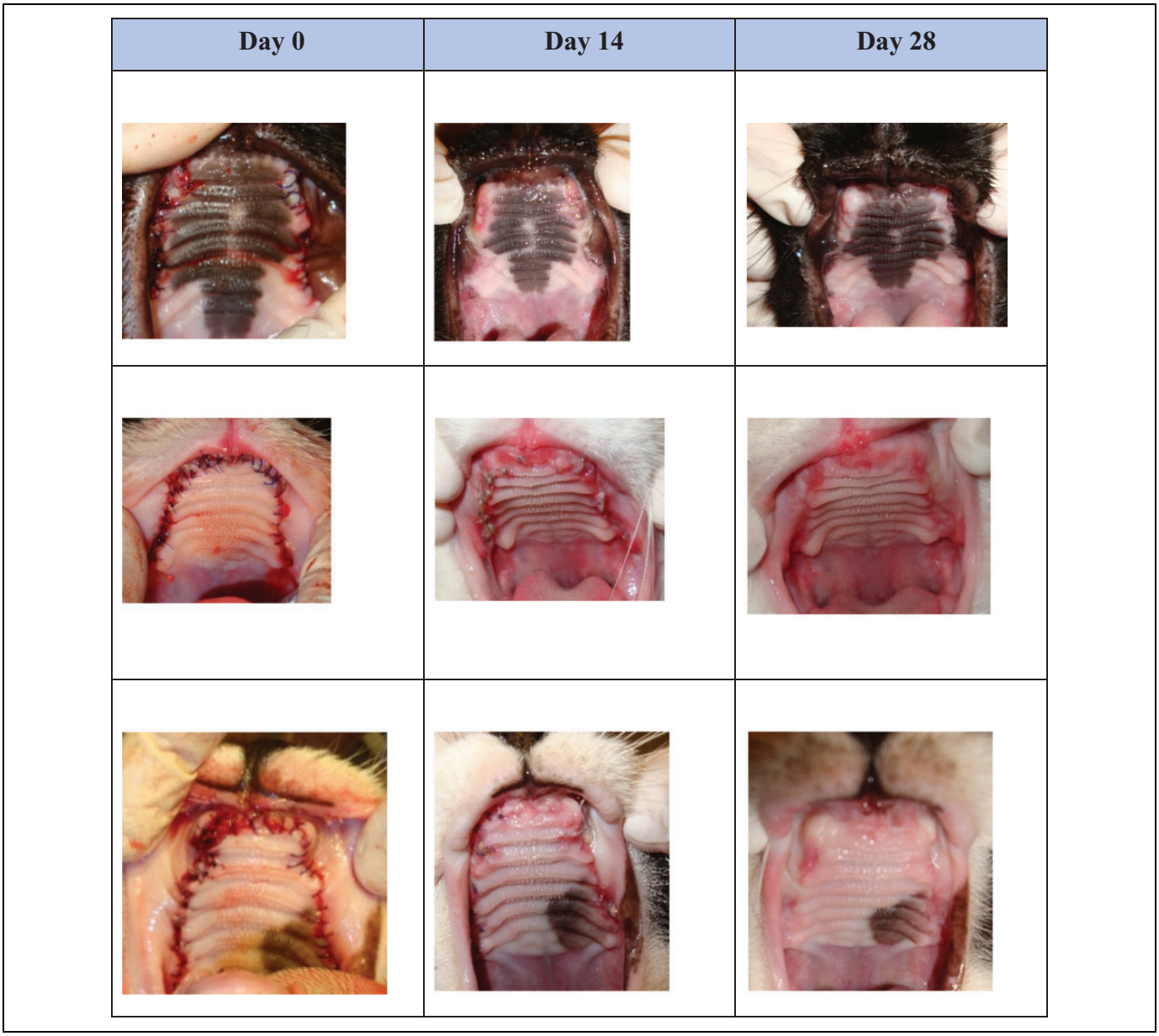

Figure 2. Oral maxillary mucosa of 3 cats. The photographs indicate immediately postoperatively (left), at the 2-week recheck (middle) and the 4-week recheck (right). Note in each row, conventional suture was placed in the right maxillary quadrant and knotless suture in the left maxillary quadrant.

studies performed in human medicine on dermal wound closure.[6,7,16] By week 2, 100% of the quadrants in the monofilament suture group and 94.7% of the quadrants in the barbed suture group showed adequate wound healing. The mild dehiscence noted in 2 of 38 quadrants of the barbed suture group may have been complications related to severe inflammation (both cases occurred in cats with significant gingivostomatitis), surgical technique, tissue handling, or the suture itself. By the fourth week, all quadrants in all groups were completely healed which is consistent with previous studies in human medicine for dermal closures.[2,6-8,10] These studies show that barbed suture has a similar healing time and complication profile as smooth monofilament suture for a variety of wound closures. Sublingual swellings in both groups were not found to be significant and may have been due to edema of the inflamed sublingual tissues. The swellings were not aspirated, so it cannot be concluded that these swellings were true ranulas.

The smooth, monofilament, absorbable suture chosen for this study was poliglecaprone 25,[c] considered one of the most compatible suture materials for intraoral use.[21] It has one of the lowest amounts of tissue drag, is the most pliable absorbable suture, and has good knot security.[22] Poliglecaprone 25 loses 20% of its tensile strength after 2 weeks and is completely absorbed in 90 days.[21,22] Most oral surgeons prefer 5-0 suture for intraoral incision closure,[21,22] but 4-0 was used in this case in order to have comparable results to its 3-0 barbed suture

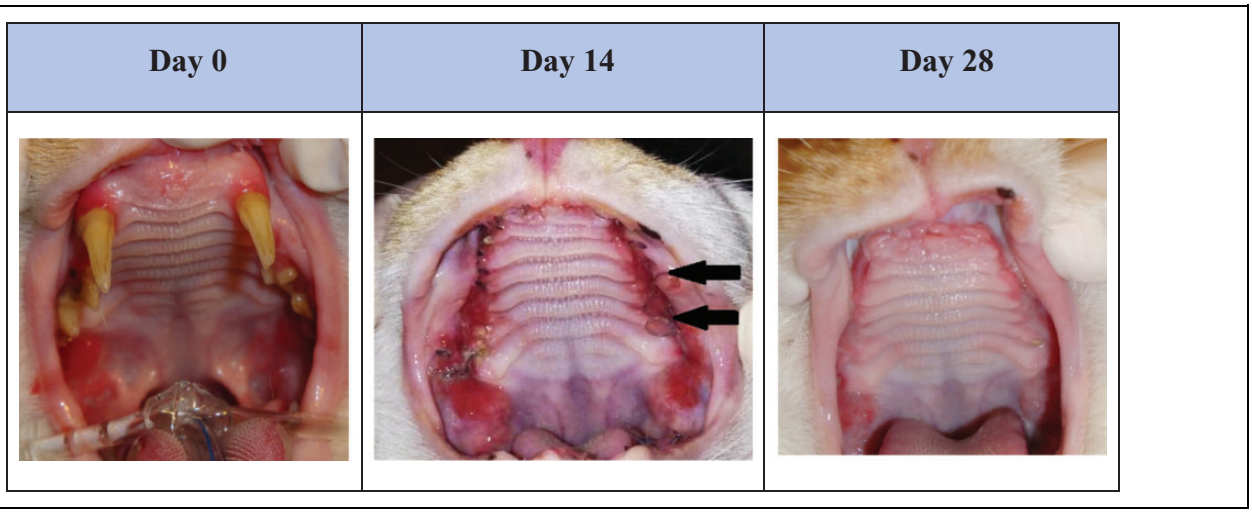

Figure 3. Oral mucosa of the 2 cats with maxillary incisional dehiscence at the 2-week recheck and resolution at 4 weeks. Note the images in the left column were taken prior to surgery and indicate the presence of gingivostomatitis. The images in the middle column reveal the areas of dehiscence noted by the black arrows at the 2-week recheck. The images in the right column were taken at the 4-week recheck and reveal resolution of the areas of dehiscence, though residual oral inflammation remains.

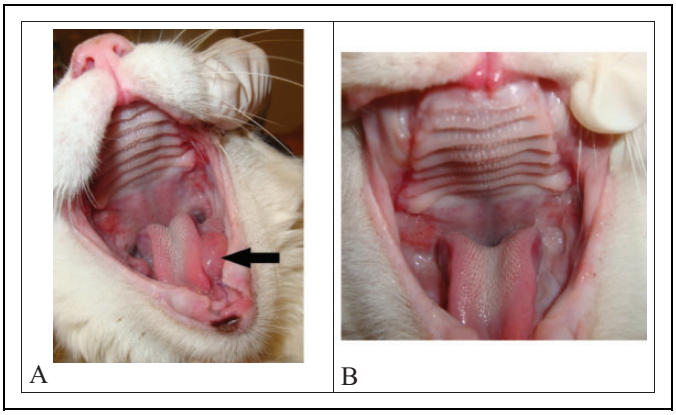

Figure 4. A, The image on the left reveals a postoperative left mandibular ranula-like swelling (black arrow) at the 2-week recheck. B, Sublingual swelling resolution by the 4-week recheck.

counterpart. When compared, suture size of the barbed suture was one size smaller due the fact that the barbs comprise 30% of the suture diameter.[9] The 4-0 barbed suture was not available for use in a unidirectional manner when this study was performed. It has since been developed, and future studies comparing 4-0 barbed suture to the standard 5-0 smooth monofilament should be undertaken.

There has always been potential for dehiscence when using suture in a continuous pattern as there are fewer knots. The knotless suture has barbs placed in a helical pattern along its length angled in the direction opposite the needle to anchor in the tissue.[19] The barbed, monofilament, absorbable suture chosen for this study is made of a polyglycolic acid and polycaprolactone copolymer. It has been compared in studies against poliglecaprone 25 due to similar biomechanics.[9,23-25] In these studies, in vitro tensile and break strengths of the barbed suture (0, 2-0, and 3-0) were stronger than the conventional smooth monofilament (2-0, 3-0,and 4-0).[9,23] They also revealed that the barbed suture copolymer was comparable and more efficient at soft tissue approximation than poliglecaprone 25 one size smaller.[24,25]

As these cats were from a shelter and would be lost to follow up, oral examinations were performed at 2 and 4 weeks postoperatively to evaluate healing. Healing was defined as the completion of reepithelialization, which in the oral cavity, should occur by the third week[17] as well as the absence of visible suture material present in the oral cavity, which in the author's experience is usually around 4 weeks with poliglecaprone 25. Most extraction sites are reevaluated only 1 to 2 weeks postoperatively to determine if healing has occurred.[18] Future studies evaluating tensile and break strength within the oral mucosa should include a longer follow-up period.

The use of postoperative antibiotics in oral surgery is controversial. The American Veterinary Dental College's position on the matter indicates that systemic antibiotics should be considered only for animals that are immunocompromised, have severe underlying systemic disease, and/or have severe oral infection.[26] As some of these cats had severe oral infections and were unable to be medicated orally due to their temperament, a long-acting injectable antibiotic (cefovecin) was administered. In order to prevent antibiotic use from factoring into the healing process, all cats were administered the same antibiotic protocol.

An anecdotal observation made during this study was significant needle drag toward the end of each closure with the barbed suture, which caused irregular suturing. This may have been due to the fact that the only unidirectional needle type available at the time of this study, in an appropriate needle size (1/2), was a taper point. The standard recommended needle size and type for keratinized oral tissue is 3/8 to 1/2 inch circle with a reverse cutting edge or taper cut point.[18,22] The ideal barbed suture available for use in dentistry and oral surgery may be unidirectional barbed suture with a reverse cutting 3/8 to 1/2

inch circle needle of a smaller size (4-0), which has been developed by a variety of manufacturers.

Another subjective observation made during this study was the overall comfort level of the cats did not appear to be affected based on the suture type. According to the follow-up phone calls with the shelter, most cats were eating comfortably. Some cats with significant gingivostomatitis required additional analgesic care, but the discomfort was assumed to be from oral inflammation and not due to the suture material itself. Future studies would be necessary to objectively determine the level of comfort with barbed suture in the oral cavity.

Conclusion

The purpose of the study was to evaluate whether barbed, absorbable suture allows for faster closure times of the oral mucosa with comparable healing times and complication profiles compared to monofilament suture. This study does show a significantly decreased closure time. Futures studies are necessary to further evaluate the suture type, suture size, needle type, and needle size within the feline oral cavity.

Author Note

The author declares that although Surgical Specialties Corporation supplied the suture material. The author has no affiliation with this company and does not benefit financially from this research.

Acknowledgments

The author would like to thank Little Shelter Rescue on Long Island, New York, for allowing us to provide dental care for their shelter cats. The author would also like to acknowledge the Veterinary Medical Center of Long Island, West Islip, New York, for providing the materials/equipment and Surgical Specialties Corporation for providing the knotless suture required for this experimental design. The author acknowledges Daniel T. Carmichael, DVM, DAVDC, for his assistance and support throughout the study. The author also acknowledges Scott Hetzel for his assistance with statistical analysis of this study.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

Materials

a. Marcaine, Bupivacaine Hydrochloride, USP. Hospira, Inc., Lake Forest, IL, USA.
b. C.E.T. 0.12% Chlorhexidine Rinse; Virbac Animal Health, Forth Worth, Texas.
c. Monocryl; Ethicon Inc, US, LLC, Somerville, NJ, USA.
d. Quill®Monoderm; Surgical Specialties Corp, Reading, Pennsylvania.
e. Convenia; Zoetis Inc, US, Kalamazoo, MI, USA.
f. BuprenexSR, SR Veterinary Technologies, LLC, Fort Collins, CO, USA.

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