Second intention healing after wide local excision of soft tissue sarcomas in the distal aspects of the limbs in dogs: 31 cases (2005–2012)

Cassandra Y. Prpich, BVSc; Alessandra C. Santamaria, BSc, BVSc; James O. Simcock, BVSc; Hoong Kien Wong, BVSc; Judith S. Nimmo, BVSc, MS; Charles A. Kuntz, DVM, MS

Objective—To determine outcomes for dogs with soft tissue sarcomas in the distal aspects of the limbs that underwent second intention healing after wide excision (2-cm lateral surgical margins and a margin 1 fascial plane deep) of the tumors.

Design—Retrospective case series.

Animals—31 dogs with soft tissue sarcomas in the distal aspects of the limbs that underwent second intention healing following wide local excision of their tumors.

Procedures—Tumors were excised with 2-cm lateral margins and a margin 1 fascial plane deep to tumors. Wounds healed by means of second intention. Time to healing, complications during healing, and information regarding tumor recurrence were recorded.

Results—All tumors were excised with histologically tumor-free margins. Twenty-nine (93.5%) wounds healed completely by second intention (median time, 53 days). Two (6.5%) dogs required free skin graft procedures to facilitate healing. Complications during open wound management developed for 7 (22.6%) dogs. Long-term complications were detected for 8 (25.8%) dogs, including intermittent epidermal disruption (5/31 [16.1%]) and wound contracture (3/31 [9.7%]). All complications were managed conservatively. Local tumor recurrence was detected for 1 (3.2%) dog. Median follow-up time was 980 days (range, 380 to 2,356 days). No patients died because of tumor-related causes.

Conclusions and Clinical Relevance—Results of this study indicated second intention healing of large wounds in the distal aspects of the limbs was complete and typically without complications for dogs that underwent wide excision of soft tissue sarcomas. Wide local excision of soft tissue sarcomas in the distal aspects of the limbs with 2-cm lateral margins and margins 1 fascial plane deep to the tumors provided excellent long-term local tumor control. (J Am Vet Med Assoc 2014;244:187–194)

Soft tissue sarcomas are a heterogeneous group of tumors derived from mesenchymal tissue that have similar biological behaviors. Soft tissue sarcomas are pseudoencapsulated with poorly defined histologic margins, are locally invasive, and can have neoplastic cells that infiltrate through fascial planes.1–3 Soft tissue sarcomas are common neoplasms in dogs, representing 15% of all cutaneous and subcutaneous tumors in such animals.1,6

The most commonly performed treatment for soft tissue sarcoma is wide excision after appropriate staging.4,7 Histologic examination of tissue margins indicating complete tumor resection is predictive of nonrecurrence, and unaffected tissue margins of 2 to 3 cm in all planes are typically recommended6–11 to achieve this goal. If a tumor is overlying a distinct muscle or fascial layer, then removal of the entire muscle or fascial layer allows microsurgically complete excision.4

There is controversy regarding the appropriate surgical treatment for soft tissue sarcomas in the distal aspects of limbs. With wide local excision, recurrence rates of 0%7 and 3%9 have been reported. A large range of recurrence rates have been reported for planned marginal excision as the sole treatment of soft tissue sarcomas in distal aspects of limbs, including recurrence rates of 11% for grade I spindle cell tumors12 and 37%4 and 80%9 for all grades of soft tissue sarcomas.

Performance of curative surgery for soft tissue sarcomas of limbs is challenging; there is a higher risk of incomplete excision for tumors in such locations, compared with tumors of the head and neck.13 The most radical procedure to ensure tumor-free surgical margins is limb amputation,14,15 but such procedures may be extreme, and alternative limb-sparing techniques are available. Various reconstruction techniques of distal aspects of limbs have been described, including axial pattern flaps,16–19 pedicle and bipedicle skin flaps,20,21 free tissue transfer,22,23 skin grafts,24,25 and tissue expansion.26,27 The success of each technique varies, and some techniques require specialized equipment or training. Alternative strategies for local control of tumors include the use of radiation therapy before and after surgery in combination with planned marginal excision.28–30 For dogs with soft tissue sarcomas that undergo coarse-fractionated radiation therapy after surgery, other investigators31 found an 18% recurrence rate with 70% of dogs having a 3-year disease-free in.
interval. For dogs that underwent a full course of radiation therapy after surgery, other investigators found a 17% recurrence rate with a median disease-free interval of 1,082 days and 5-year survival rate of 76%. Limited availability, adverse effects, and additional cost associated with radiation therapy may be prohibitive for some owners. Other investigators have evaluated the use of metronomic chemotherapy to delay recurrence of soft tissue sarcomas; outcomes were similar to those for radiation therapy. However, in that study, 40% of dogs had toxic effects of drugs, with 10% developing hemorrhagic cystitis.

Second intention healing is commonly used for management of open wounds in veterinary patients. Advantages of second intention healing include lack of donor site morbidity, no requirement for staged surgery or specialized equipment, and no cross contamination of donor sites with tumor cells. Disadvantages include potential for wound contracture and joint dysfunction (if wounds are located over a joint), delayed healing, and incomplete epithelialization. Some authors recommend use of second intention healing only if a wound involves <30% of the circumference of the limb. To the authors’ knowledge, no studies have been conducted to evaluate the use of second intention healing for the management of wounds created during removal of tumors (including soft tissue sarcomas) from distal aspects of limbs of dogs.

An objective of the study reported here was to determine the success of second intention healing for large wounds of distal aspects of limbs that were created by means of wide excision of soft tissue sarcomas in such locations. Another objective was to determine the rate of local recurrence of soft tissue sarcomas in distal aspects of limbs of dogs that were removed with wide margins (2-cm lateral margins and a margin 1 fascial plane deep to the tumor). Our hypotheses were that wounds treated by means of second intention healing would heal completely and without complications and that wide local excision would provide acceptable local control of soft tissue sarcomas of distal aspects of limbs of dogs.

Materials and Methods

Animals—Medical records of dogs with soft tissue sarcomas admitted to the authors’ surgical referral practice between January 1, 2005, and July 31, 2012, were reviewed. Dogs were included in the study if they had a soft tissue sarcoma that was diagnosed by means of histologic analysis of tissue samples obtained at a site in a distal aspect of a limb (distal to the elbow or stifle joint) and that underwent wide local excision and second intention healing, with a minimum follow-up time of 12 months. Dogs were excluded from the study if they had a tumor or scar that extended proximal to the level of the elbow or stifle joint or if they underwent any form of primary reconstruction after mass removal.

All treatment options were discussed with owners prior to surgery, and wide local excision and second intention healing were selected prior to performance of the procedure. All owners were counseled that dogs that underwent wide local excision and second intention healing would require bandage changes for a long time after surgery.

Data obtained from medical records—Data were obtained from medical records of dogs. Data included signalment (age, sex, and breed) and body weight at the time of tumor removal; tumor location; tumor size; results of tumor staging; whether surgery was performed for primary removal of a tumor or revision of a surgical scar; results of histologic analysis of tissue samples regarding tumor grade, size, presence of residual tumor tissue if a re-excision (ie, second surgery to removed affected tissue) procedure was performed; completeness of tumor removal on the basis of histologic evaluation of surgical margins; time to healing; complications; and information regarding tumor recurrence and treatment.

Procedures—All patients prophylactically received cephalaxin (22 mg/kg [10.0 mg/lb], IV) 30 minutes prior to surgery; administration of that antimicrobial drug was repeated every 90 minutes for the duration of anesthesia. No other antimicrobials were administered perioperatively. All dogs were premedicated with methadone (0.3 mg/kg [0.14 mg/lb], IV) and acepromazine (0.01 mg/kg [0.0045 mg/lb], IV). Anesthesia was induced with alfaxalone (1 mg/kg [0.45 mg/lb], IV) and maintained with isoflurane (1.3% to 2% in oxygen).

All surgeries were performed by a board-certified surgeon who had training in surgical oncology (CAK). Tumors or scars were removed with 2-cm lateral surgical margins in all directions. Excised tissue was circular in shape if a gross tumor was removed and elliptical in shape if a revision of a surgical scar was performed. Excision was performed by means of a combination of sharp dissection and electrocautery. Deep margins were attained by means of removal of antebrachial fascia (forelimbs) or loose deep crural fascia (hind limbs). Hemostasis was achieved by means of electrocautery. Bupivacaine was applied topically to wounds following tumor removal (maximum dose, 2.0 mg/kg [0.91 mg/lb]). The dimensions of the open wounds were recorded after surgery. The circumference of the limb at the proximal and distal aspect of the wound was measured for the last 3 dogs that underwent surgery during the study period. Analgesia after surgery included methadone (0.3 mg/kg [0.14 mg/lb], IV) [bolus administration as needed] for up to 24 hours, a transdermal fentanyl patch (2 μg/kg/h) for up to 4 days, and NSAIDs for a minimum of 7 days. Administration of NSAIDs was discontinued when dogs were ambulating without evidence of lameness, paid minimal attention to bandages, and had no aversion to direct pressure to wounds.

Ink was applied to surgical margins of resected tissue and samples were placed in neutral-buffered 10% formalin. Tissue samples were not pinned to retain size or orientation. The dimensions of the formalin-fixed tissue samples were recorded. The formalin-fixed tissue samples were examined grossly and visible surgical scars identified. Large tissue samples were cut into parallel slices at consistent intervals (typically every 10 mm). The narrowest visible surgical margins were examined if they were <5 mm in width. Portions of tissue sections that were histologically examined included representative sections of visible masses, abnormal features (such as cavitations, hemorrhagic or discolored areas, and areas of abnormal consistency), and areas of masses that included overlying epidermis or other
structures. Routinely, a transverse section through the center of the mass or surgical scar along the shortest axis and sections at right angles to that section along the longest axis (including longitudinal margins) were examined. If required, additional tissue sections including the narrowest margins were also examined. For large tissue samples, additional transverse sections were examined as necessary; for all re-excised tissue samples, sections were examined including visibly or palpably thickened or nodular areas (particularly near surgical seromas). Tumors were graded as described previously. All tissue samples were histologically examined by a board-certified pathologist (JSN).

A dry, porous, semiocclusive, nonadherent dressing and a modified Robert-Jones bandage were applied over open wounds. The same type of dressing was applied as the inner layer of the bandage during each bandage change, regardless of the phase of wound healing. The frequency of bandage changes was determined on the basis of the appearance of the wound and the condition of the bandage. Typically, bandages were changed every 2 to 3 days until granulation tissue was observed. Bandage changes were always performed by a veterinarian. Bandage changes were typically performed without sedation. Criteria used to indicate that sedation or analgesia was necessary for the bandage change included any type of vocalization or aversion to application of pressure to the wound, nervous or fearful behaviors, and excessive attention by the dog to the bandage. Sedation, when needed, was achieved with butorphanol (0.2 mg/kg [0.09 mg/lb], IV) and acepromazine (0.01 mg/kg, IV).

Outcome—Information obtained regarding outcomes included long-term (any time after which the wound had completely healed) complications attributable to wounds, local tumor recurrence, development of metastasis (if appropriate), and survival status of the patient. This information was obtained by means of communication with referring veterinarians and owners at the end of the study period. In addition, complete medical records were obtained for all patients after they had been treated at the authors’ facility. Tumor recurrence, when it occurred, was confirmed by means of histologic evaluation of tissue samples. Owners were contacted by telephone and asked to indicate their satisfaction with the procedure on a scale of 1 to 10 regarding overall outcome and the frequency and duration of time that bandage changes were required until wound healing. For the scale, 1 was defined as extremely unsatisfied, 5 was neutral, and 10 was extremely satisfied.

Calculated values—For each dog, the surface area of the initial wound and surface area of the formalin-fixed tissue samples were calculated with the following formulas: surface area (cm$^2$) = 1/2 length (cm) X 1/2 width (cm) X π. Surface areas of dogs were calculated with the following formula: body surface area (m$^2$) = 10.1 X (body weight [g]${^{1/3}}$) X 10$^{-4}$.

Statistical analysis—The time to healing was calculated as the time from the date of surgery to the date on which the wound was completely covered with epithelial tissue. The recurrence-free interval was defined as the time between surgical excision and development of local recurrence. Median survival time was calculated by means of the Kaplan-Meier product limit method. Survival time was calculated as the number of days from tumor excision to death. Cause of death was classified as tumor related or non–tumor related. Dogs were censored on the day of last contact if they were still alive or on the date of a non–tumor-related death. The metastasis-free interval was not calculated because metastasis was not detected for any patient during the study period.

Linear regression was performed to determine the association between the surface area of the initial wound and the time to healing. This analysis was repeated with the surface area of the wound indexed (ie, to assess whether healing time was associated with the size of a wound relative to the size of a dog) to the surface area of the dog. For all analyses, values of $P \leq 0.05$ were considered significant. Statistical analysis was performed with a commercially available statistical analysis software program.

Results

By means of the medical records search, 334 dogs with soft tissue sarcoma were identified. Sixty-five of these dogs had tumors of distal aspects of limbs, of which 34 had been treated by means of marginal excision and a full course of radiation therapy; these dogs did not meet the inclusion criteria for the study. Therefore, 31 dogs underwent wide excision of tumors (Figure 1) and met the inclusion criteria for this study. Dogs included 18 females (17 spayed and 1 sexually intact) and 13 males (12 neutered and 1 sexually intact). Median age at the time of tumor removal was 8.9 years (range, 3 to 15.5 years). Median weight was 24.7 kg (54.3 lb; range, 4.0 to 44.1 kg [8.8 to 97.0 lb]). Breeds included Labrador Retriever (n = 9), German Shepherd Dog (2), German Shorthaired Pointer (2), Kelpie (2), Maltese-Shih Tzu cross (2), Siberian Husky (2), mix (2), and 1 each of Blue Heeler, Boxer, Brittany, Bull Mastiff, Cairn Terrier, Cavalier King Charles Spaniel, Deerhound, Doberman Pinscher, Great Dane, Jack Russell Terrier, Miniature Schnauzer, Pomeranian, Rhodesian Ridgeback, and Rottweiler.

Most (27/31 [87.1%]) tumors of dogs were on forelimbs; of the forelimb tumors, 14 (51.9%) were on left forelimbs and 13 (48.1%) were on right forelimbs. Of the 27 forelimb tumors, 8 (29.6%) involved the carpus. Of the 4 (12.9%) tumors on hind limbs, there was an equal distribution between left (2/4) and right (2/4) hind limbs. Staging tests were performed prior to performance of surgery for treatment of tumors for 20 (64.5%) dogs. Eleven (35.5%) dogs underwent thoracic radiography, 8 (25.8%) underwent thoracic CT, and 1 (3.2%) underwent thoracic radiography and regional lymph node aspiration. No patients that underwent staging tests had any evidence of metastatic disease at any time during the study. Ten (32.3%) dogs underwent surgical revision of a soft tissue sarcoma that had been incompletely excised during a previous surgery. The other 21 (67.7%) dogs underwent primary excision of tumors.

![Graph of calculated values](image-url)
Results of histologic examination of tissue samples indicated that 6 of the 10 samples obtained during scar revision procedures contained residual tumor cells. In the other 4 tissue samples, only granulation tissue, seroma fluid, or dermal fibrosis was identified. Most (24/31 [77.4%]) tumors were classified as grade I, and the other tumors were classified as grade II (7/31 [22.6%]). No grade III tumors were identified. All the evaluated surgical margins were free of tumor cells.

The median tumor size, as measured at the longest diameter by the surgeon, was 4 cm (range, 1.5 to 10.0 cm). The median surface area of the wounds at the time of surgery was 43.98 cm² (range, 18.84 to 113.10 cm²). The wounds encompassed a median of 44.1% (range, 42.3% to 74.1%) of the circumference of the limb in the 3 patients for which such information was recorded. The median surface area of formalin-fixed tissue samples was 22.0 cm² (range, 6.05 to 82.07 cm²).

The median time to healing for all wounds (29/31 [93.5%]) that closed completely with second intention healing was 53 days (range, 25 to 179 days). Two (6.5%) dogs had wounds for which free skin graft procedures were performed because of delayed wound healing; these procedures were performed 98 and 103 days after tumor removal. One graft failed after 10 days, and the wound healed by second intention. The other graft procedure was successful with no superficial tissue necrosis. These 2 wounds completely healed 202 and 125 days after tumor removal, respectively.

No intraoperative complications were detected. Complications during management of open wounds developed in 7 (22.6%) dogs. Four (12.9%) dogs were treated with a single course of antimicrobials for treatment of a presumed infection identified on the basis of purulent discharge from the wound. No microbial cultures of wounds were performed during the study period. No consistent antimicrobial protocol was used during the study, as some dogs were treated with antimicrobials by their primary care veterinarians and...
the authors had no control over such treatments. The appearance of wounds improved after antimicrobial treatment for each of those 4 dogs. For 2 (6.5%) dogs, swelling of the paw in the affected limb developed after surgery. For both of those dogs, the swelling resolved after bandage replacement. For 1 (3.2%) dog, minor hemorrhage from an artery developed after surgery; this was treated successfully by means of cauteryization of the blood vessel. Long-term complications were detected for 8 (25.8%) dogs; the most common complication was intermittent disruption of epidermis because of trauma (3 [16.1%] dogs). All those epidermal wounds healed by second intention. Another long-term complication detected was decreased range of motion of the carpus because of wound contracture (3 [9.7%] dogs; 1 each on the palmar, lateral, and dorsal aspect of the carpus). For 2 of the 8 wounds that involved the carpus (2/31 [6.5%] total wounds), contracture was associated with signs of pain and intermittent lameness in the limb. For 1 of the 8 carpal wounds (1/31 [3.2%] total wounds), contracture was mild and was identified only by means of detection of reduced joint range of motion during physical examination. No corrective treatment was performed for any dogs with wound contracture. Lameness was treated conservatively with rest and anti-inflammatory drugs.

Tumor recurrence was detected in 1 (3.2%) dog, 560 days after surgery. In this dog, the initial surgery performed by the authors was a revision of a previously excised grade 1 soft tissue sarcoma with incompletely excised tumor in the surgical margins. Tumor recurrence was confirmed by means of histologic examination of an incisional biopsy sample. Results of repeated thoracic CT did not indicate evidence of metastasis. For the tumor recurrence, this dog was treated by means of wide local excision, and the wound was left open to heal by second intention. The wound healed uneventfully in 75 days. That dog was alive with no evidence of tumor recurrence 1,844 days after the initial surgery.

No patients developed metastasis. No patients died of tumor-related causes. No patients were lost to follow-up. The median follow-up time was 980 days (range, 380 to 2,356 days). Median survival time was not determined because no patients died of tumor-related causes. At the time of completion of the study, tumors were locally controlled for all dogs.

Twenty-one (67.7%) owners were available for interview to determine satisfaction. On a scale of 1 to 10, the median overall outcome satisfaction score was 10. On a scale of 1 to 10, the median score with regard to the frequency and duration of time that bandage changes were required until healing was 8; the 2 owners who provided the lowest scores (score, 3/10) for that question had dogs with the second and third longest wound healing times (169 and 202 days).

Discussion

Ages, breeds, and body weights of dogs in the present study were consistent with those in other studies of soft tissue sarcomas. To the authors’ knowledge, the distribution of soft tissue sarcomas located on the distal aspects of limbs of dogs has not been previously reported. Most (87.1%) dogs in the present study had sarcomas on forelimbs. The reason for this finding was not determined, but 1 possible explanation was that there are a larger number of types of axial pattern flap procedures that can be used for distal aspects of hind limbs than there are for distal aspects of forelimbs. This may have resulted in a bias for performance of wide local excision with second intention healing for tumors on forelimbs. It was also possible that soft tissue sarcomas developed more frequently in forelimbs versus hind limbs, but this could not be determined in the present study.

An objective of the present study was to determine the success of second intention healing for large wounds of distal aspects of limbs of dogs. Although second intention healing is commonly used for veterinary patients,33,36,39 some authors have reservations regarding use of that method for distal aspects of limbs. Another author35 advises that second intention healing should be used only for wounds involving < 30% of the circumference of a limb, and other authors36 suggest that wounds encompassing > 50% of a limb are more likely to result in complications than other wounds. These suggestions were not made on the basis of clinical or laboratory data but on the basis of the personal clinical experiences of those authors. It is generally accepted that as the size of a defect increases, tension in the surrounding skin develops, which can overcome the contraction of myofibroblasts.35,36,39,40 The median surface area of the wounds initially created in dogs in the present study was 43.93 cm2 (range, 18.84 to 113.10 cm2). Limb circumference measurements were available for only 3 patients. In these patients, the wounds were between 42.3% and 74.1% of the circumference of the limb. It is the authors’ impression that many of the wounds created were > 30% of the circumference of the limb, although this was not definitively determined. Despite this, the median time to healing was 53 days, and 93.5% of wounds healed without skin grafting procedures or other additional interventions.

No association between the size of a wound and the time to healing was found in the present study. To evaluate this further, the size of a wound was indexed to the surface area of the limb to determine whether healing time was associated with the size of a wound relative to the size of a dog. No association between wound healing time and wound size indexed to body surface area was found. This finding may have been attributable to other factors that may have affected the rate of second intention wound healing. All wounds were bandaged in a consistent manner during the study period. Other factors such as exposed bone, exuberant granulation tissue, mild wound desiccation from bandages becoming wet, excessive bandage pressure, skin elasticity, variations in wound shape, and patient confinement could have affected time to wound healing.33,36,39,40 Such information was not available in the medical records of dogs in this study.

In the present study, bandage changes were performed in a consistent manner for all patients. The inner bandage layer that contacted the wound did not differ regardless of the phase of wound healing. Many types of primary wound dressings and ointments are
available that are intended to enhance wound healing during various phases of wound healing. Such products may speed wound healing, compared with a medication vehicle or saline (0.9% NaCl) solution (control); however, the difference in overall time to healing may be minor or nonexistent. The cost associated with the use of additional medications should be considered, especially when the duration of open wound management is prolonged. Owners of dogs in the present study were aware of the costs of prolonged open wound management. On the basis of the median time to wound healing in dogs in the present study (53 days) and the expected number of bandage changes during that time (13), owners paid less for open wound management (13 bandage changes costing $52 each; total, $676) than they would have paid for performance of a revision surgery of any kind at the authors' facility (minimum cost, $1,300).

When evaluating the size of excised tissue for dogs in the present study, the surface area of the initial wound and surface area of the formalin-fixed tissue sample were calculated; the median values were 43.98 and 2.0 cm², respectively. This discrepancy in surface areas may have been attributable to 2 factors. Routine histologic processing of skin samples results in a decrease in sample size of up to 32%. In addition, the length and width measured for calculation of the surface area of the initial wound for dogs in this study were determined following tumor removal, when the surrounding skin and subcutaneous tissue had retracted. Results of a study of humans in which the relationships among excised skin, wound, and tissue samples prepared for histologic analysis were determined indicated that mean wound area was 20% higher than the planned excision area. The sum of the tissue sample shrinkage (32%) and wound expansion (20%) values could have accounted for the 50% discrepancy between the surface area of the initial wound and the surface area of tissue samples prepared for histologic analysis for dogs in the present study.

No intraoperative complications of dogs in this study were detected. Complications during open wound management were detected for 7 (22.6%) dogs. Four (12.9%) dogs received a single course of antimicrobials for treatment of a presumed infection identified on the basis of purulent discharge from the wound. No microbial cultures of wounds were performed during the study period; therefore, the true incidence of infections was not determined. Purulent discharge may have been attributable to a phase of wound healing because wounds in the inflammatory and debridement phases commonly have serosanguinous to purulent exudates. Two (6.5%) dogs in this study had paw swelling after surgery, presumably because of inappropriately tight bandages. For both of these dogs, paw swelling resolved after the bandage was replaced. Although information regarding bandage complications has been published, the incidence of such complications is not known, to the authors' knowledge. Given the estimated number of bandage changes that were performed for dogs during the study period (13 bandage changes/ dog × 51 dogs = 403 bandage changes), the authors feel that the 0.5% of bandage changes that resulted in paw swelling is a favorable finding. Further studies would be needed to determine the incidence of bandage-associated complications.

The most common long-term complication of dogs in this study was intermittent epidermal disruption because of trauma (5 [16.1%] dogs). The epidermis of wounds that heal by epithelialization is more fragile and easily traumatized than the epidermis of wounds that heal by contraction. Experimentally created wounds in rabbits, the amount of wound contraction decreases after 42 days, and epithelial cell migration may be required for healing of the remaining portion of an open wound. In the present study, 4 of the 5 dogs with intermittent epidermal disruption had wound healing times >42 days. Wounds with a healing time >42 days typically healed without complications.

Another long-term complication detected in dogs in this study was decreased range of motion of the carpus because of wound contracture, which developed in 3 (9.7%) dogs. They were 3 of the 8 dogs in the present study that had wounds that involved the carpus. Contracture caused signs of pain and intermittent lameness in 2 of 8 dogs with carpal wounds (6.5% of dogs in the study). All dogs in the study with tumors involving the carpus underwent removal of the joint capsule to obtain clean margins during surgery. Second intention healing of large wounds over the flexor surface of a joint can cause contracture because the inelastic scar tissue produced prevents joint extension. Methods commonly used to prevent contracture include physical therapy, immobilization, or primary wound closure. None of these methods were used for dogs in the present study. Lameness of dogs was treated by means of strict rest and administration of NSAIDs for 2 weeks. Because lameness was mild, such conservative treatment was successful for the 2 affected patients in this study. For future cases, the authors strongly advocate the use of preventative measures when excising tumors over a carpus of a dog to prevent potential detrimental wound contracture over the joint.

One of the objectives of the present study was to determine the effectiveness of 2-cm lateral margins and a margin 1 fascial plane deep to the tumor or scar on local tumor recurrence. All of the tumors in dogs in the present study were excised with tumor-free surgical margins as determined by means of histologic examination. Results of other studies indicate histologically tumor-free surgical margins are predictive of nonrecurrence of soft tissue sarcomas. Results of another study that included 104 dogs that underwent soft tissue sarcoma excision in a first-opinion practice indicated that the degree of surgical resection (marginal, narrow, or wide) was not significantly related to rate of survival or tumor recurrence; however, the disease-free interval was significantly shorter for dogs with histologic evidence of incomplete tumor resection in tissue margins than it was for other dogs. Results of other studies in which wide local excision of soft tissue sarcomas of distal aspects of limbs was evaluated indicate tumor recurrence rates of 0% to 3%. In the present study, 1 (3.2%) dog had tumor recurrence 560 days after surgery. Interestingly, this dog underwent re-excision of a previously incompletely excised soft tissue sarcoma (1 tumor re-
rence in the 10 dogs that underwent re-excision). Other authors31 reported a case series of 41 dogs that underwent primary re-excision of soft tissue sarcomas and found a tumor recurrence rate of 15%. The rate of tumor recurrence in dogs in the present study for first-attempt wide local excision (0/21) and primary re-excision (1/10) was comparable to results of those other studies. These results supported the conclusion of other authors31,32 that a first-attempt wide excision is more effective for prevention of tumor recurrence than performance of a revision surgery.

Because of the perceived difficulties in management of large open wounds of the distal aspects of limbs, other authors33,34 have advocated marginal excision of soft tissue sarcomas in distal aspects of limbs; tumor recurrence rates in those studies were 11% to 80%. For the study12 in which an 11% recurrence rate was found, all tumors were grade I, and the follow-up time was shorter than it was in those other studies33,34 (range, 210 to 2,202 days). Those factors may have contributed to the low tumor recurrence rate determined in the previously mentioned study12. In that study,12 5.7% of dogs died because of tumor-related causes, all of which were related to local recurrence. In another study12 a 37% tumor recurrence rate was found for 27 dogs with soft tissue sarcoma treated by means of marginal excision; median time to recurrence was 333 days after the initial surgery. The follow-up time in that study was long (median, 781 days). Dogs with tumors of all grades were treated; tumors of dogs in that study12 included grade I tumors, 12 (44.4%) grade II tumors, and 2 (7.4%) grade III tumors. Of the 10 dogs with tumors that recurred in that study, 6 underwent further marginal excision. Of the dogs in that study,12 12% were euthanized because of failure of local tumor control, and overall, 31% were euthanized owing to any tumor-related cause (median time to euthanasia, 826 days after surgery). In the present study, 24 (77.4%) dogs had grade I tumors and 7 (22.6%) had grade II tumors. The distribution of tumor grades for dogs in the present study was similar to that determined in another study3; these findings suggested that soft tissue sarcomas of the distal aspects of limbs in dogs typically have a low grade. The recurrence rate of tumors in dogs in the present study was low (3.2%), and at the time of the end of the follow-up period, no patients had died of tumor-related causes (median follow-up time, 980 days). At the time of completion of the study, local tumor control had been achieved in 100% of dogs. These results compare favorably with the results of other studies in which marginal excision was performed for treatment of tumors of distal aspects of limbs. The recurrence rate determined in the present study may have been artificially low because microscopically detectable recurrence may have developed without grossly visible evidence of tumor recurrence or because gross recurrence may have developed without detection by owners or referring veterinarians.

In another study31 in which primary re-excision of incompletely excised soft tissue sarcomas in dogs was evaluated, 22% of resected scars contained tumor cells. This finding was in contrast to the finding of the present study that approximately 60% of resected scars contained residual tumor cells. In the present study and that other study, re-excision procedures were performed at an early time after the first procedures when gross evidence of tumors was not detected. In humans, 24% to 59% of scars resected after removal of soft tissue sarcomas contain tumor cells.32-36 These findings were similar to the variation between findings of the present study and those of that other study31 of dogs with soft tissue sarcomas. Such variation in results may have been attributable to errors in selection of tissue sample sections for histologic examination because only limited sections from the margins of samples were reviewed by pathologists. Alternatively, the pathologist who histologically examined tissue samples in the present study may have been rigorous when searching for residual tumor cells.

Satisfaction of owners of dogs in the present study was evaluated by means of telephone surveys. The median score (scale, 1 to 10) with regard to overall outcome was 10. The median score with regard to the frequency and duration of bandage changes required until wound healing was 8. Although the owner satisfaction survey was not validated, these results may be important because they suggest a high level of owner satisfaction regarding management of large open wounds of dogs. This finding may have been attributable to the education of clients prior to performance of surgical procedures.

A limitation of the present study was the retrospective study design. Details regarding each bandage change, which may have allowed determination of conclusions regarding factors that affected time to wound healing other than wound size, were not available in the medical records. In future prospective studies, collection of photographic images for measurement of wounds at the time of each bandage change would allow calculation of surface area for each of those times and may allow more detailed analysis of second intention healing of wounds in dogs. Another limitation of this study was the small sample size; this may have caused type II errors. In addition, necropsies were not performed for dogs, which prevented evaluation of metastasis and recurrence of tumors at the time of death.

Results of this study indicated that wide excision and second intention healing were typically successful for treatment of dogs with soft tissue sarcomas. Owner satisfaction with the procedure was high. The tumor recurrence rate detected after a surgical procedure in which 2-cm lateral margins and margins 1 fascial plane deep to tumors were used was comparable to recurrence rates after wide local excision and was favorable when compared with results for dogs that undergo marginal excision alone. The surgical method used in this study was a useful treatment option for the management of soft tissue sarcomas on distal aspects of limbs in dogs.

References


c. GraphPad Prism, version 5.0. GraphPad Software Inc, La Jolla, Calif.


