Partial Foot Amputation in 11 Dogs

Eleven dogs with malignant tumors of the digits and feet were treated with partial foot amputation. Partial foot amputation involved amputation of one or both central weight-bearing digits. Lameness occurred in all dogs but resolved in eight dogs at a median of 37 days postoperatively. In the remaining three dogs, lameness improved but did not resolve. Tumor control was excellent, with no evidence of local recurrence in 10 dogs. One dog underwent limb amputation. Based on these results, partial foot amputation may be recommended in the management of malignant tumors of the canine foot in which more than one digit must be amputated to achieve adequate surgical margins. J Am Anim Hosp Assoc 2005;41:47-55.

Introduction

Tumors of the foot can originate from osseous or soft-tissue structures. Squamous cell carcinoma (SCC) and malignant melanoma are the most commonly described tumors of the canine digit, although soft-tissue sarcomas, osteosarcomas (OSA), mast cell tumors (MCT), and benign neoplasms have also been reported.1-3 Surgical options for the management of tumors of the foot include digit and limb amputation. Digit amputation provides adequate local tumor control for benign and malignant neoplasms confined to the nail bed, distal phalanges, and bones of the metacarpus or metatarsus.1-3 The 1- and 2-year survival rates in dogs with SCC of the digit not affecting the nail bed are significantly less than the survival rates in dogs with subungual SCC.2 Although the local recurrence rate and metastatic rate were not reported in this prior study, possible causes for the difference in survival rates included higher local recurrence from incomplete resection and/or a different or more aggressive biological behavior of SCC distant to the nail bed.2 Partial foot amputation and limb amputation are alternative surgical options for the management of malignant tumors of the proximal digit and those not confined to the skin, bone, or pads of a single digit.3-5

Limb amputation is a radical procedure, although most dogs adapt to ambulation on three legs within 1 month.6 However, the period of adaptation, especially initially, may be longer and more difficult in dogs without preexisting lameness. Most dogs with tumors of the digit or foot are presented because of the presence of a visible mass rather than for significant lameness.1 Partial foot amputation is a limb-sparing technique defined as the amputation of two adjacent digits. Partial foot amputation is not often recommended, as significant lameness has been reported following amputation of one or both weight-bearing digits.4,5 The purpose of this retrospective study was to examine the outcomes in 11 dogs following partial foot amputation for treatment of malignant tumors of the foot to determine whether partial foot amputation is a viable surgical option.
Materials and Methods

Medical records at Colorado State University Veterinary Teaching Hospital were reviewed for dogs that were treated with digit amputation from January 1992 to June 2002. Inclusion criteria included amputation of two adjacent digits exclusive of the first digit, the presence of a complete medical record, and follow-up telephone interviews with the owner and referring veterinarian that assessed tumor control, limb function, and the level of satisfaction with the outcome of surgery. Eleven dogs that underwent partial foot amputation for the treatment of neoplasia fulfilled the inclusion criteria.

Data retrieved from the records of each animal included signalment, site and type of the lesion of the digit or foot, presence or absence of lameness, surgical findings, adjuvantive treatments, and postoperative outcome. Preoperative diagnostic tests and staging procedures, which were dependent on tumor type, were reviewed. The digits amputated and the level or point of amputation were recorded. The partial foot amputation was classified as “medial-foot” if the second and third digits were amputated, as “mid-foot” with amputation of the third and fourth digits, and as “lateral-foot” with amputation of the fourth and fifth digits. The levels of amputation were subdivided into metacarpophalangeal or metatarsophalangeal joint, metacarpal or metatarsal diaphysis, and carpometacarpal joint.

Four different outcomes were assessed, including survival, tumor control, limb function, and the degree of owner satisfaction with the procedure. Outcomes were assessed by telephone interviews with the owner and referring veterinarian. Survival parameters included whether the dog was still alive and, if not, the cause of death. Tumor control parameters included whether the tumor recurred at the surgical site, whether it metastasized, and if it had metastasized, the site and time of metastasis. Owners were asked to grade the degree of any lameness from 0 to 5, with 0 signifying no lameness and 5 representing nonweight-bearing lameness. The time to return of normal function in the affected limb and the degree of lameness during the postoperative recovery period were also determined. The characteristics of any lameness that persisted were also examined, especially in terms of whether it occurred at a walk, trot, and/or run, and whether the frequency of lameness was occasional, frequent, or constant. Owner satisfaction with the surgical procedure and outcome, both in terms of limb function and tumor control, was classified as dissatisfied, satisfied, or very satisfied.

Results

Signalment and Tumor Types

Eleven dogs with partial foot amputations satisfied the criteria for inclusion in this study. The median age of affected dogs was 8 years (range, 4 to 13 years). A variety of sizes of dogs was represented, and the median weight was 10 kg (range, 4.5 to 50 kg). Breeds of dogs in the study included four mixed-breed dogs, and one each of the cocker spaniel, golden retriever, Jack Russell terrier, Labrador retriever, Lhasa apso, miniature schnauzer, and rottweiler. Five dogs were neutered males, and six dogs were spayed females.

Partial foot amputation was performed for oncologic purposes in all dogs. The tumors treated included MCT (n=6, all grade II); OSA (n=2, one each of osseous and extraskeletal origin); and one each of a soft-tissue sarcoma (grade II), synovial cell sarcoma (grade I), and SCC [Table 1]. Partial foot amputation was performed for primary management of the mass in six dogs (case nos. 1, 2, 5, 6, 9, 10) [Figures 1, 2, 3], for incomplete prior excision of a tumor in four dogs (case nos. 3, 4, 8, 11), and following a complication of tumor resection in one dog (case no. 7) [Table 2]. In this last dog (case no. 7), surgical resection of a MCT between the third and fourth digits resulted in vascular interruption and avascular necrosis of the weight-bearing digits, requiring subsequent amputation. Tumors were located between the third and fourth digits of the foot of the right thoracic limb (n=4), left thoracic limb (n=2), right pelvic limb (n=2), and left pelvic limb (n=1). The fourth and fifth digits of the foot of the right pelvic limb (n=1) and the fourth metacarpus of the right thoracic limb (n=1) were also affected. Preoperative lameness was present in only two dogs, one with an extraskeletal OSA (case no. 1) and another with a synovial cell sarcoma (case no. 9).

Diagnostic Tests

Diagnostic tests and staging procedures included hematological tests (n=8), serum biochemical profiles (n=9), urinalyses
Table 1
Clinical Data on 11 Dogs With Partial Foot Amputations

<table>
<thead>
<tr>
<th>Case No.</th>
<th>Signalment*</th>
<th>Tumor Location†</th>
<th>Amputated Digits‡‡</th>
<th>Amputation Level§</th>
<th>Postoperative Lameness</th>
<th>Lameness Severity and Conditions₁</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>9-y, 27.3-kg, SF golden retriever</td>
<td>LF 3-4</td>
<td>Mid LF</td>
<td>MC</td>
<td>Permanent, constant</td>
<td>2, W, T, R</td>
</tr>
<tr>
<td>2</td>
<td>13-y, 35.5-kg, SF Labrador retriever</td>
<td>LF 3-4</td>
<td>Mid LF</td>
<td>MCP joint</td>
<td>Temporary, 120 d</td>
<td>3</td>
</tr>
<tr>
<td>3</td>
<td>9-y, 9.1-kg, CM Jack Russell terrier</td>
<td>RF 3-4</td>
<td>Mid RF</td>
<td>MC</td>
<td>Temporary, 60 d</td>
<td>2</td>
</tr>
<tr>
<td>4</td>
<td>7-y, 10.0-kg, CM cocker spaniel</td>
<td>RH 3-4</td>
<td>Mid RH</td>
<td>MT</td>
<td>Temporary, 180 d</td>
<td>1</td>
</tr>
<tr>
<td>5</td>
<td>9-y, 28.6-kg, SF mixed-breed dog</td>
<td>RF 4</td>
<td>Lateral RF</td>
<td>MCC joint</td>
<td>Permanent, constant</td>
<td>2, W, T, R</td>
</tr>
<tr>
<td>6</td>
<td>8-y, 6.8-kg, SF miniature schnauzer</td>
<td>RH 4-5</td>
<td>Lateral RH</td>
<td>MT</td>
<td>Temporary, 14 d</td>
<td>3</td>
</tr>
<tr>
<td>7</td>
<td>8-y, 23.6-kg, SF mixed-breed dog</td>
<td>RF 3-4</td>
<td>Mid RF</td>
<td>MCP joint</td>
<td>Temporary, 60 d</td>
<td>2</td>
</tr>
<tr>
<td>8</td>
<td>4-y, 50.0-kg, CM rottweiler</td>
<td>LH 3-4</td>
<td>Mid LH</td>
<td>MT</td>
<td>Temporary, 7 d</td>
<td>3</td>
</tr>
<tr>
<td>9</td>
<td>7-y, 4.5-kg, SF mixed-breed dog</td>
<td>RF 3-4</td>
<td>Mid RF</td>
<td>MC</td>
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</tr>
<tr>
<td>10</td>
<td>12-y, 6.8-kg, CM mixed-breed dog</td>
<td>RH 3-4</td>
<td>Mid RH</td>
<td>MTP joint</td>
<td>Permanent, occasional</td>
<td>1, R</td>
</tr>
<tr>
<td>11</td>
<td>7-y, 6.8-kg, CM Lhasa apso</td>
<td>RF 3-4</td>
<td>Mid RF</td>
<td>MCP joint</td>
<td>Temporary, 1 d</td>
<td>1</td>
</tr>
</tbody>
</table>

* SF=spayed female; CM=castrated male
† LF=left thoracic limb; RF=right thoracic limb; RH=right pelvic limb; LH=left pelvic limb; 3=third digit; 4=fourth digit; 5=fifth digit
‡ Mid=third and fourth digits; Lateral=fourth and fifth digits
§ MC=metacarpal; MCP=metacarpophalangeal; MT=metatarsal; MCC=carpometacarpal; MTP=metatarsophalangeal
₁ 1=mild; 2=moderate; 3=severe; W=walk; T=trot; R=run
<table>
<thead>
<tr>
<th>Case No.</th>
<th>Diagnosis</th>
<th>Adjuvant Therapy</th>
<th>Local Recurrence</th>
<th>Metastasis Treatment</th>
<th>Metastasis Time (d)</th>
<th>Survival Time (d)</th>
<th>Treatment Alive</th>
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<tr>
<td>1</td>
<td>OSA-ES</td>
<td>Transient cisplatin implant</td>
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<td>2</td>
<td>MCT</td>
<td>Radiation therapy</td>
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<td>No</td>
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<td>Soft-tissue sarcoma</td>
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<td>MCT</td>
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<td>Soft-tissue sarcoma</td>
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<td>None</td>
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<td>1312</td>
<td>Yes</td>
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<td>8</td>
<td>SCC</td>
<td>Limb amputation</td>
<td>No</td>
<td>Not applicable</td>
<td>None</td>
<td>1766</td>
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<td>9</td>
<td>Synovial cell sarcoma</td>
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<td>No</td>
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<td>None</td>
<td>2561</td>
<td>Yes</td>
</tr>
<tr>
<td>10</td>
<td>MCT</td>
<td>None</td>
<td>No</td>
<td>None</td>
<td>None</td>
<td>3028</td>
<td>Yes</td>
</tr>
</tbody>
</table>

* OSA=osteosarcoma; ES=extraskeletal; MCT=mast cell tumor; SCC=squamous cell carcinoma
(n=3), three-view thoracic radiographs (n=6), abdominal ultrasonography with guided aspirates of the liver and spleen (n=3), and bone marrow aspiration (n=6). Laboratory abnormalities were infrequent, nonspecific, and included elevated \( \gamma \)-glutamyl transferase (n=3) and mild hyperglycemia (n=2). There was no evidence of pulmonary metastasis on the thoracic radiographs of any dog. Abdominal ultrasonography and cytopathology of bone marrow aspirates and guided aspirates of the spleen and liver were performed for tumor staging in dogs with MCT. Systemic mastocytosis was not detected in any dog.

**Surgical Technique**

Partial foot amputation was performed in all dogs using a modified single-digit amputation technique. An elliptical incision was performed around the affected digits, extending from the distal aspect of the palmar or plantar surface of the base of the digits to the dorsal aspect of the metacarpus or metatarsus [Figure 4]. The incision included surgical margins of at least 2 cm around the tumor or the scar from previous incomplete tumor excision. In the fore foot, interosseous muscles were sectioned; tendons of the common and lateral digital extensors and superficial and deep digital flexors were transected; and branches of the dorsal and palmar common digital and metapodial artery and vein were either ligated or cauterized at the planned level of amputation. Similarly, in the hind foot, interosseous muscles were sectioned, and tendons of the long and lateral...
digital extensors and superficial and deep digital flexors were transected. Branches of the dorsal and plantar metatarsal and common digital artery and vein were either ligated or cauterized at the planned level of amputation. A high-speed burr or bone cutters were used to perform amputations through the diaphysis of either the metacarpus or metatarsus (n=6). Disarticulation of either the metacarpo- or metatarso- phalangeal joint was completed by incising through the joint capsule and collateral and sesamoidean ligaments (n=5). The distal metacarpal or metatarsal condyles were not rongeured, and the palmar or plantar sesamoids were not routinely removed. The digits and tumor were removed en bloc with the digital pads, although metacarpal and metatarsal pads were preserved. Wound closure was usually performed in three layers, with the interosseous muscles and subcutaneous tissues apposed using absorbable suture material in an interrupted pattern, and the skin apposed with interrupted sutures of absorbable or nonabsorbable material [Figure 5].

A mid-foot amputation was performed in nine dogs [Figure 4], and a lateral-foot amputation was done in two dogs. Amputation was performed at the level of the metacarpo- or metatarsophalangeal joint in four dogs, at the distal metacarpal or metatarsal diaphysis in six dogs, and at the carpometacarpal joint in one dog. Tumor margins were evaluated histopathologically in all cases, with the excision judged to be complete in eight dogs and incomplete in three dogs (case nos. 2, 9, 11).

**Adjunctive Therapies**

Postoperative management involved analgesics and bandages. Analgesia was provided in all cases with nonsteroidal anti-inflammatory drugs, opioids, or both. Carprofen (n=7) or piroxicam (n=4) was administered for 10 to 21 days following surgery. Opioid drugs administered included fentanyl in patch form (n=2) and morphine (n=5). Opioids were not used for more than 5 days postoperatively. A modified Robert-Jones bandage was applied to all operated limbs and was supplemented with a Mason metasplint in four dogs. The frequency of bandage changes and the duration of bandaging could not be determined from the medical records or from follow-up telephone calls.

Four dogs received additional therapy for their tumors [Table 2]. Radiation therapy was used in one dog (case no. 2) with an incompletely excised, grade II MCT of the mid-foot. External-beam radiation, consisting of 12 fractions of 3.2 Gy, was administered for a total dose of 38.4 Gy. The targeted radiation therapy protocol of 15 fractions was not reached in this dog, as acute radiation-induced moist desquamation and foot pad necrosis necessitated premature termination of radiation therapy. In one dog (case no. 9), thoracic limb amputation was performed 17 days after incomplete excision of a grade I synovial cell sarcoma. A local cisplatin implant was inserted at the surgical site in one dog (case no. 1), but it was removed 10 days postoperatively because of a surgical wound infection. One dog with a metacarpal OSA (case no. 5) was treated with an alternating protocol of intravenous doxorubicin (30 mg/m²) and carboplatin (300 mg/m²) administered every 3 weeks, for six total doses.

**Outcomes**

Surgical complications included lameness (n=11) and one superficial skin infection. In the dog with the surgical site infection (case no. 1), a biodegradable cisplatin implant was inserted into the wound cavity to reduce the risk of local tumor recurrence. The infection resolved following antimicrobial therapy and removal of the biodegradable sponge.

Lameness occurred in all dogs following surgery [Table 1]. Eight of the dogs returned to normal function, and lameness persisted in three dogs (case nos. 1, 5, 10). The median time to resolution of lameness was 37 days (range, 1 to 180 days). In one dog (case no. 2), the lameness that persisted for 120 days was partially attributed to digital pad necrosis secondary to adjunctive radiation therapy. The median severity of the immediate postoperative lameness
was 3 (range, 1 to 3). In the three dogs with persistent lameness, the lameness was graded as mild, with moderate to significant weight bearing, and was present either occasionally at a run (n=1) or constantly at a walk, trot, and run (n=2). These three dogs were diagnosed with OSA (n=2) or MCT (n=1). Both dogs with OSA weighed >25 kg, while the dog with MCT weighed 6.4 kg. Carpal hyperextension was diagnosed in one dog (case no. 5) following a lateral-foot amputation at the level of the carpometacarpal joint. Based on limb function and the degree of tumor control following partial-foot amputation, owners were either satisfied (n=4) or very satisfied (n=6).

Metastasis was diagnosed in two dogs. Metastasis of a digital SCC occurred to the popliteal lymph node of the same limb 157 days after a mid-foot amputation and was treated by pelvic limb amputation (case no. 8). This dog was disease-free and alive 1312 days after the initial partial foot amputation. In case no. 5, a single pulmonary metastasis was detected 574 days after a lateral-foot amputation for an osteosarcoma. Pulmonary metastasectomy was performed 60 days later, because the radiographic size of the pulmonary mass had increased by 40% (from 10-mm to 14-mm diameter), and no further pulmonary lesions were detected on thoracic radiographs and computed tomography scans. This dog was alive 962 days after partial foot amputation, with no evidence of local recurrence or distant metastasis.

There was no evidence of tumor in any dog at the termination of the study. The minimum follow-up time was 455 days, with a median of 1138 days (range, 455 to 2968 days). The median follow-up time for the six dogs with MCT was 1171 days (range, 464 to 3028 days). Individual follow-up times were 455 days for the dog with extraskeletal OSA; 553 days for the dog with soft-tissue sarcoma; 962 days for the dog with metacarpal OSA; 1312 days for the dog with digital SCC; and 1766 days for the dog with synovial cell sarcoma. Seven dogs were still alive (range, 455 to 3028 days), and four dogs had died from unrelated causes (range, 464 to 2561 days) by the end of the study.

Discussion

In the study reported here, partial foot amputation was performed in 11 dogs for local management of malignant tumors of the digits and foot. The locations of the tumors in these dogs precluded single-digit amputation, because the tumors involved the proximal digit or other areas of the foot, such as the interdigital webbing and pads of the digit, metacarpus, or metatarsus. Furthermore, adequate surgical margins could not be achieved with more conservative surgery because of the tumor size or the extent of surgical scar formation following incomplete tumor resection. Limb amputation was not initially performed in these dogs, as it was thought that partial foot amputation would provide comparable local control of the tumor while preserving limb function.

Local tumor control was excellent following partial foot amputation. Local recurrence was not reported in any dog, although two dogs had adjunctive therapy. The two dogs with histopathological evidence of incomplete tumor resection had either fractionated radiation therapy or a limb amputation to prevent local tumor recurrence. The use of adjunctive radiation therapy following incomplete excision of MCT is controversial, as there have been no significant differences reported in local recurrence rates following complete and incomplete MCT excision.11 One dog in the present study did not receive further treatment after incomplete excision of a MCT, but it was alive and disease-free 3028 days postoperatively.

Long-term systemic tumor control was good following partial foot amputation in the dogs of this report. Excluding the dog in which early limb amputation was performed, only two of 10 dogs had evidence of metastasis after a median follow-up time of 962 days (range, 455 to 3028 days).

Limb function following partial foot amputation was good to excellent. Partial foot amputation resulted in non-weight-bearing lameness in all dogs postoperatively. Pain control with analgesic drugs and bandaging were necessary during the immediate postoperative period. However, in most circumstances, analgesic drugs and bandages were discontinued within 21 days of the surgery. Eight (73%) dogs returned to normal limb function, while three (27%) dogs had varying degrees of persistent lameness. The degree of lameness in the latter three dogs was mild and did not seem to significantly impact the quality of life. The origin of lameness in these dogs was not determined, although possible causes included the dogs’ body weight and carpal instability arising from partial foot amputation at the level of the carpometacarpal joint (case no. 5).

Single-digit amputation of the third or fourth digit, amputation through a joint (phalangophalangeal, metacarpophalangeal, or metatarsophalangeal), and failure to remove metacarpophalangeal or metatarsophalangeal sesamoid bones have been reported as having a worse outcome.4,5,14 It should be realized, however, that minimal information has been published on single-digit amputation in dogs, and these results remain unsubstantiated.14,15 The findings of the study reported here contradict these earlier reports, as limb function was good to excellent even with removal of one or both weight-bearing digits, following amputation at different anatomical levels, and without removal of the sesamoid bones.

Amputations of the digits in ruminants and swine are analogous to partial foot amputation in dogs because of their different pedal anatomy.16-18 Prior reports of amputations of the digits in cattle have revealed poor results in heavier cattle and with amputation of the thoracic limb digits.18 In contrast, excellent results have been reported following amputation of the digits in sheep and pigs, both of which have a body weight closer to dogs.19,20 In the present study, the median body weight of affected dogs was only 10 kg, and permanent postoperative lameness was reported in the thoracic limb of two of four dogs with a body weight >25 kg. Postoperative lameness may be more likely in large dogs and following partial foot amputation in a thoracic limb, as higher weight-bearing loads are transmitted through the thoracic limb, and this load is proportionally greater in large dogs.21
In humans, ray resection is defined as the amputation of a digit and corresponding metatarsus.\textsuperscript{22,23} Ray resection of the hallux (first digit) and multiple ray resections are not recommended, as load redistribution results in transfer lesions, such as ulceration or trauma, in adjacent digits.\textsuperscript{23} In the study reported here, the weight-bearing portion of the foot was reconstructed with the second and fifth digits and included intact digital pads following mid-foot amputation. Reconstruction was not required after a lateral-foot amputation because of preservation of the third digit. The metacarpal or metatarsal pads were preserved in all cases. Ulceration or trauma of the digital, metacarpal, or metatarsal pads was not reported in any dog following partial foot amputation. Persistent lameness was uncommon in this study, possibly because foot reconstruction resulted in adequate load redistribution with acceptable absorption and transfer of weight-bearing forces. Further investigations using force-plate analysis are required to validate this supposition.

Partial ray resection, with preservation of the proximal metatarsus, is recommended in humans to prevent joint instability.\textsuperscript{24} One dog in this study (case no. 5) with a persistent weight-bearing lameness had a lateral amputation performed at the level of the carpometacarpal joint, resulting in carpal instability and mild carpal hyperextension. Amputation at the level of either the carpometacarpal or tarsometatarsal joint should be avoided because disruption of the collateral ligaments and palmar or plantar fibrocartilage may result in instability and lameness.

Owners of the dogs in this study were either satisfied or very satisfied with partial foot amputation for both local tumor control and limb function, regardless of the absence or presence of lameness. Pre- and postoperative orthopedic examination and kinetic and kinematic gait analysis would have been preferable to owner opinions for assessing subjective and objective degrees of lameness following partial foot amputation.\textsuperscript{25} These techniques were not performed because of the retrospective nature of the study. The subjective method utilized in this study for assessment of limb function following partial foot amputation was considered acceptable, as owner assessment and numerical grading scales are both regarded as reliable and reproducible in the evaluation of lameness and postoperative outcomes in animals.\textsuperscript{26,27}

**Conclusion**

Partial foot amputation was performed as a modification of the single-digit amputation technique in 11 dogs for local control of malignant foot tumors. Local tumor control following partial foot amputation was excellent, with no evidence of local recurrence after a median follow-up time of 962 days. Limb function was good to excellent despite amputation of one or both weight-bearing digits. Further investigations are needed to determine whether the risk of permanent postoperative lameness is greater in dogs weighing >25 kg and following amputations at the level of the carpometacarpal or tarsometatarsal joints.

\textsuperscript{a} Rimadyl; Pfizer Animal Health, Exton, PA 19341
\textsuperscript{b} Piroxicam capsules; Teva Pharmaceuticals, North Wales, PA 19454
\textsuperscript{c} Duragesic; Janssen Pharmaceutical Products, Titusville, NJ 08560
\textsuperscript{d} Morphine Sulfate (Immediate Release) Oral Solution; Roxane Laboratories, Columbus, OH 43216
\textsuperscript{e} MS Contin; Purdue Frederick Company, Stamford, CT 06901
\textsuperscript{f} OPLA: Kensey Nash Corporation, Exton, PA 19341
\textsuperscript{g} Doxorubicin HCl injection; Bedford Laboratories, Bedford, OH 44146
\textsuperscript{h} Paraplatin; Bristol-Myers Squibb Oncology, Princeton, NJ 08543