Retrospective survey of owners' experiences with palliative radiation therapy for pets

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OBJECTIVE
To describe animal owners' experiences with palliative radiation therapy (PRT) of pets and identify factors influencing satisfaction with their pets' treatment.

DESIGN
Retrospective, cross-sectional study.

SAMPLE
118 owners of dogs, cats, or rabbits.

PROCEDURES
Medical records were searched to identify animals that underwent PRT between 2004 and 2013. Signalment, tumor-related data, and outcome information were recorded. Owners completed an electronic survey assessing satisfaction with treatment (ie, satisfaction with the decision for their pet to undergo PRT and indication that they would choose PRT for their pet again), expectations regarding PRT, and perceptions of their pets' quality of life (QOL) and signs of discomfort from acute adverse radiation effects. Additional data regarding practical aspects of treatment, pet death, communications with veterinarians, and owner demographics were collected. Variables were tested for association with measures of owner satisfaction.

RESULTS
92 of 116 (79%) owners were satisfied with the decision to have their pets undergo PRT. Most (92/118 [78%]) owners reported their pet's QOL improved after PRT; these owners were significantly more likely to be satisfied than those who did not report improved QOL. Owners who perceived their pets had discomfort from adverse radiation effects (38/116 [33%]) were significantly less likely to be satisfied than owners who did not report this observation. Measures of satisfaction were not associated with patient survival time. Twenty-one of 118 (18%) owners indicated they expected PRT would cure their pet's tumor.

CONCLUSIONS AND CLINICAL RELEVANCE
Results suggested that short life expectancy should not deter recommendation of PRT for pets. Protocols that minimize risk of acute adverse effects may be advantageous. Veterinarians should attempt to ensure that owners understand the goals of PRT. (*J Am Vet Med Assoc* 2018;253:307–314)

Tumor response rate and survival time after PRT have been reported for dogs with osteosarcoma and for dogs and cats with soft tissue sarcomas, nasal carcinomas, and many other tumor types, but there is limited information on the effect of PRT on QOL and on owner satisfaction with the decision to treat their pet with PRT.[1–9] The goal of PRT is to improve a patient's QOL through amelioration of specific symptoms, such as pain, bleeding, or obstruction associated with an incurable tumor; such treatment is not intended to extend a patient's survival time.[10] Survival time has been used as a surrogate measure of QOL after PRT because improvements in the pet's QOL may delay an owner's decision to euthanize. However, an owner's decision to euthanize may be influenced by factors other than the patient's QOL; therefore, survival time may not accurately represent the duration of improvement in the patient's QOL, and owner-reported QOL may be a more effective measure of PRT effectiveness. Owners are able to observe the animal in the home environment and are familiar with their pet's normal behavior, activity, and appetite.

Considering that the goal of PRT is to improve the patient's QOL, radiation protocols are usually designed to minimize the risk of adverse effects; however, acute adverse effects have been reported in 11 of 65 (17%) to 57 of 103 (55%) dogs or dogs and cats treated with commonly used PRT protocols.[5,8,9] Acute adverse effects can cause pain and discomfort for 2 to 4 weeks after treatment, and this is undesirable in patients with advanced cancer and short life expectancy.[11] The ob-

ABBREVIATIONS

BED	Biologically effective dose
CI	Confidence interval
PRT	Palliative radiation therapy
QOL	Quality of life

jectives of the study reported here were to describe owners' experiences with PRT of their pets and to identify factors that influence owners' satisfaction with the decision to provide such treatments. The hypotheses were that owner satisfaction with the decision to treat their pet with PRT would not be associated with the pet's survival time after treatment and that satisfaction with the decision would be lower for those who reported that their pets had signs of discomfort from acute adverse effects of radiation.

Materials and Methods

Criteria for case selection

The study protocol was submitted to the University of Saskatchewan's Animal Research Ethics Board and Behavioral Research Ethics Board and was determined to be exempt from review. Medical records of the Regional Veterinary Referral Center, Springfield, Va; Western Veterinary Specialist and Emergency Centre, Calgary, Alberta, Canada; and Western College of Veterinary Medicine, Saskatoon, Saskatchewan, Canada were searched to identify animals that underwent PRT for malignant neoplasia between November 3, 2004, and March 1, 2013, and for which an owner's email address was available. Radiation treatment at these 3 facilities was restricted to small companion animals. Patients for which definitive radiation therapy had been recommended but was declined by owners and patients with previously treated recurrent tumors were not excluded. Patients undergoing hypofractionated treatment with the goal of durable tumor control were excluded.

Medical records review

Electronic and hard copy medical records were reviewed by 4 study authors (VCF, MNM, NRG, and GNM). Patient signalment (species, breed, sex, age, and weight), tumor characteristics (type, location, whether regional or distant metastases [or both] were detected at time of diagnosis, and clinical stage for dogs[12] and cats[13] with lymphoma), radiation protocol (total dose, dose per fraction, number of fractions, and treatment dates), presence and type of acute adverse effects, and response to treatment (changes in tumor size, appetite, signs of pain, and activity level) were recorded. The date and cause of death were annotated.

PRT procedures

The radiation protocol was prescribed by 1 veterinary radiation oncologist at each site (MNM, NNG, and GNM). The treatment was designated as palliative when the primary intent was to alleviate clinical signs (without an indication of intent to extend the patient's survival time). The median BED was calculated by use of the following equation:

$$\text{BED} = \text{nd}\left(1 + \frac{\text{d}}{\alpha/\beta}\right),$$

where n = the number of fractions, d = dose per fraction, $\alpha = \log_e$ of cells killed per Gray, and $\beta = \log_e$ of the cells killed per Gray squared. An α/β of 10 Gy was used to compare effects on acutely responding tissues.[14]

Survey development and administration

The survey (**Supplementary Appendix S1**, available at avmajournals.avma.org/doi/suppl/10.2460/javma.253.3.307) was developed by 3 of the study authors (MNM, SNS, and CLW). In May 2013, owners were invited by email to complete a questionnaire on their experiences regarding PRT for their pets. Owners were informed that the data would be published in summary form without identification of individual patients. The survey was administered by use of an online survey tool.[a] Two reminder emails at 1-week intervals were sent to owners who had not completed a questionnaire. Completed questionnaires included the email address of the invited owner, and no owner completed more than 1 questionnaire. The email addresses of owners were removed prior to analysis. Owners were asked whether their pet's QOL improved at any time after radiation treatment and, if so, to rate the improvement at its greatest point as better or much better. Questions were then asked regarding owners' expectations of how PRT would benefit their pet (whether it would cure the tumor, improve QOL, or prolong life, with an additional option for respondents to indicate they could not remember or to add an independent response), how informed they felt about how their pet would benefit from treatment (very inadequately informed, inadequately informed, adequately informed, or very adequately informed), how they heard about the option of PRT, and whether the cost of their pet's PRT was covered (all or in part) by veterinary health insurance. The question regarding owners' expectations of how PRT would benefit their pet allowed multiple answers to be selected, whereas all other multiple-choice questions in the questionnaire allowed only 1 answer. Owners were asked to indicate how difficult or challenging they found costs associated with PRT, the impact of PRT for their pets on their own daily lives, and the distance traveled for radiation treatment (extremely, very, moderately, minimally, or not difficult or challenging); they were also asked to identify which one of these factors they found the most difficult or challenging. Owners were then asked whether they noticed discomfort of the pet from adverse effects in the radiation treatment field during the first month after PRT and, if they had noticed discomfort, whether they would rate their pet as uncomfortable or very uncomfortable. If the animal was not alive, owners were asked to indicate whether they chose euthanasia or the pet died spontaneously (on its own) and whether the decision to euthanize or the pet's death was attributable to problems related or not related to its cancer. Owners were asked how satisfied they were with their decision to elect PRT for their pet (very satisfied, satisfied, neutral, unsatisfied, or very unsatisfied) and whether they would still have opted for PRT for their pet given what they knew at the

time of the survey (very likely, likely, neutral, not likely, or very unlikely). Owners were given the option of a text response to explain the reasoning for the answers given to these 2 questions. They were also asked in a text-response question whether there was anything related to their experience with their pet's PRT that they felt was important to share with veterinarians providing palliative treatments for patients. Responses to open text questions were summarized by 2 authors (VCF and MNM). The final questions addressed owner demographics (age, gender, education level, and family income), and owners were given the option of not completing this section.

Statistical analysis

Analyses were performed with statistical software.[b] Multivariable logistic regression was used to explore associations between potential risk factors and measures of owner satisfaction. Outcomes of interest included whether owners reported being satisfied with the decision to provide PRT and whether they would choose PRT for their pet again. Responses of very satisfied or satisfied and very likely or likely were categorized as positive responses. If no response was provided, it was assumed to indicate that the owner was unsatisfied with the decision or was unlikely to choose PRT again. Potential risk factors of interest included species of the pet, family income (≤ $125,000/y vs > $125,000/y), owner gender, expectation that the tumor would be cured by PRT, whether an owner felt informed about how the pet would benefit from PRT, whether the owner reported an improved QOL after PRT, whether the owner perceived that the pet had discomfort from acute adverse effects, and patient survival time following PRT. Regarding whether an owner felt informed, responses of adequately or very adequately informed were categorized as adequately informed, and responses of inadequately or very inadequately informed were categorized as inadequately informed.

Models were built with manual backward stepwise regression, with values of $P < 0.05$ considered significant. Generalized estimating equations were used to account for potential clustering of outcomes within veterinary practice. Any variable that, when removed from the model, changed the effect estimates for other factors of interest by > 20% was retained as a confounder. Biologically relevant 2-way interactions were assessed and retained if significant. Similarities in responses within a veterinary practice were accounted for with generalized estimating equations, and the effect of BED (in Gy_{10}; ie, the quantity that allows comparison of the biologic effect on early-responding tissues between different fractionation protocols) on likelihood of discomfort from acute adverse effects of radiation was examined in the same manner.

Results

The medical records search identified 156 patients that met the study inclusion criteria. Completed questionnaires were received from 57 of 82 (70%), 33 of 41 (80%), and 28 of 33 (85%) owners of pets that underwent PRT at Regional Veterinary Referral Center, Western Veterinary Specialist and Emergency Centre, and Western College of Veterinary Medicine, respectively. The overall response rate was 118 of 156 (76%).

Ninety-five of 118 (81%) animals were dogs, 21 (18%) were cats, and 2 (2%) were rabbits. Of the 95 dogs, 12 (13%) were Rottweilers, 12 (13%) were Golden Retrievers, and 12 (13%) mixed-breed dogs. Other commonly represented breeds included Greyhound (5 [5%]); Shetland Sheepdog, Beagle, and Labrador Retriever (4 [4%] each); and Boxer and Border Collie (3 [3%] each). The remaining 36 (38%) dogs were of other breeds. The 21 cats included 13 (62%) domestic shorthair, 3 (14%) Siamese, 2 (10%) domestic medium hair, and 1 (5%) each of Devon Rex, Oriental Shorthair, and domestic long hair. There was 1 dwarf rabbit and 1 lop rabbit.

The median age of dogs was 9.5 years (range, 1.1 to 15.0 years), and median body weight was 22.1 kg (48.6 lb; range, 3.8 to 83.6 kg [8.4 to 184 lb]). Forty-six of 95 (48%) dogs were neutered females, 42 (44%) were neutered males, 5 (5%) were sexually intact males, and 2 (2%) were sexually intact females. The median age of cats was 11.0 years (range, 3.0 to 16.0 years), and median body weight was 3.9 kg (8.6 lb; range, 2.0 to 7.4 kg [4.4 to 16.3 lb]); 16 of 21 (76%) cats were neutered males, and 5 (24%) were neutered females. The 2 rabbits were 9.7 and 5.3 years of age, and both were neutered females. Body weight was recorded for only 1 rabbit (2.5 kg [5.5 lb]).

Osteosarcoma was the most common tumor type in dogs (n = 30), followed by carcinoma (25), lymphoma (9), sarcoma (7), melanoma (7), mast cell tumor (6), hemangiosarcoma (2), and plasma cell tumor, acanthomatous ameloblastoma, pheochromocytoma, and stromal cell tumor (1 each). Five dogs were treated for unknown tumor types. Tumors in dogs were located on an extremity (n = 32), on the body wall or within the body cavity (28), in the oral cavity (12), in the head and neck region (excluding oral and nasal cavities; 14), and in nasal cavities or paranasal sinuses (9). Excluding dogs with lymphoma (n = 9), lymph nodes were evaluated in 35 dogs and categorized on the basis of results of palpation, cytologic examination, or both as having no evidence of involvement (23) or evidence of involvement (12). The remaining 51 dogs had no record of lymph node assessment. Excluding dogs with lymphoma, metastases to sites other than regional lymph nodes were evaluated in 58 dogs and categorized as present (n = 16) or absent (42). Twenty-eight dogs had no record of assessment for metastases. The World Health Organization clinical stages[12] of dogs with lymphoma were I (n = 1), II (1), III (1), and V (2); 4 dogs did not have staging information included in the medical record.

In cats, carcinoma was the most common tumor type (n = 10), followed by lymphoma (6), sarcoma (2), melanoma (1), and mast cell tumor (1). One cat

had an unknown tumor type. Tumors were located in the oral cavity (n = 10), in the head and neck region (excluding oral and nasal cavities; 4), on the body wall or within the body cavity (4), in nasal cavities or paranasal sinuses (2), and on an extremity (n = 1). Excluding cats with lymphoma (n = 6), evaluation of lymph nodes revealed no evidence of involvement on the basis of palpation, cytologic examination, or both in 8 cats and evidence of involvement in 1. Six cats had no record of lymph node evaluation. For the 15 cats without lymphoma, metastases to sites other than regional lymph nodes were categorized as absent in 12; the remaining 3 had no record of this assessment. The clinical stages[13] of cats with lymphoma were I (n = 2), II (2), III (1), and V (1).

Both rabbits had sarcoma; tumors were located on the body wall or within the body cavity in one rabbit and on an extremity in the other. There was no record of assessment for regional or distant metastases in these 2 patients.

Animals were treated with a 4-MV linear accelerator at Regional Veterinary Referral Center, with a 6-MV linear accelerator at the Western Veterinary Specialist and Emergency Centre, and with a cobalt 60 therapy machine at Western College of Veterinary Medicine. The median dose per fraction of radiation was 800 cGy (range, 400 to 1,400 cGy), and the median total dose was 2,400 cGy (range, 600 to 4,000 cGy). The most common radiation protocols were as follows: 3 weekly fractions of 800 cGy (n = 29), 4 weekly fractions of 800 cGy (23), and 2 fractions of 800 cGy given 24 hours apart (18). The median BED was 4,080 cGy_{10} (range, 1,120 to 7,200 cGy_{10}). Twenty-one of 118 (18%) pets received a second course of radiation.

On review of medical records, 22 of 118 (19%) patients had acute adverse radiation effects identified on recheck examination or by follow-up with the owners or referring veterinarians. Sixty of 118 (51%) had no acute adverse effects, and 36 (31%) had no assessment for acute adverse effects documented. A response to treatment (decreased tumor size, improved appetite, decreased signs of pain, or increased activity level) was recorded for 75 of 95 (79%) dogs; 10 (11%) had no response to treatment, and 10 (11%) had no information about response to treatment in the medical record. Of the 21 cats, 18 (86%) had a response to treatment recorded in the medical record, 2 (10%) had no response to treatment, and 1 (5%) had no information about response to treatment in the medical record. Both rabbits had a documented response to treatment. The median survival time for all animals was 132 days (range, 6 to 2,352 days). The 1-, 2-, and 3-year survival rates were 24.8%, 8.8%, and 6.6%, respectively. Twelve dogs that were still alive at the time of analysis were censored, and 4 dogs with no documented follow-up or date of death were excluded from this analysis.

One hundred fourteen of 118 (97%) owners completed part or all of the demographic section of the questionnaire. Sixty-six of 114 (58%) respondents were 49 to 68 years of age, 33 (29%) were 35 to 48 years of age, 10 (9%) were 23 to 34 years of age, and 5 (4%) were > 68 years of age. Eighty-four of 113 (74%) respondents were female, and 29 (26%) were male; 42 (37%) had a professional or postgraduate degree, 31 (27%) had a 4-year college degree, 19 (17%) had a 2-year college degree, 12 (11%) had some college education, and 9 (8%) had a high school diploma. Annual combined household income was > $125,000 for 43 of 108 (40%) respondents, between $85,000 and $125,000 for 34 (31%), between $60,000 and $85,000 for 18 (17%), between $40,000 and $60,000 for 5 (5%), and < $40,000 for 8 (7%).

Of 118 respondents, 106 (90%) expected that their pet's QOL would improve after PRT, 94 (80%) expected that PRT would prolong their pet's life, and 21 (18%) expected that PRT would cure their pet's tumor. Cure was selected as an expectation of PRT by 9 of 57 (16%) respondents with pets treated at the Regional Veterinary Referral Center, 5 of 33 (15%) with pets treated at the Western Veterinary Specialist and Emergency Centre, and 7 of 28 (25%) with pets treated at the Western College of Veterinary Medicine. No difference in the proportion of respondents who indicated an expectation of cure was found among the sites ($P = 0.53$). One hundred six of 118 (90%) respondents felt adequately or very adequately informed about how their pet would benefit from PRT, 4 (3%) felt inadequately informed, and 8 (7%) felt very inadequately informed. Those who felt inadequately informed about how their pet would benefit from PRT were not more likely to expect a cure than those who felt adequately informed ($P = 0.44$).

Nine of 118 (8%) respondents indicated that all or some of the PRT cost for their pet was covered by veterinary health insurance. Of these 9, 8 had between 50% and 100% of the cost covered, and 1 had < 50% of the cost covered. Most (78/118 [66%]) respondents learned about the PRT option from a specialist veterinarian, with 28 (24%) having learned about it from their pet's regular veterinarian or another general practice veterinarian. Other owners obtained the information from the internet, media, or other sources or had previous knowledge of radiation treatment (4/118 [3%] each).

Slightly less than half of the respondents (53/116 [46%]) indicated that deciding PRT was the right choice for their pet was the most difficult or challenging factor about their pet's treatment. Cost (21/116 [18%]), distance from the treatment facility (11 [9%]), and impact on their daily life (5 [4%]) were selected as the most difficult or challenging factor by others. The remainder of respondents answering this question (26/116 [22%]) chose the option of other, and comments included the impact on their pet's daily life, knowing that PRT would not cure their animal, and that no factor about their pet's treatment was challenging or difficult.

Most of the 118 (92 [78%]) respondents felt that there was an improvement in their pet's QOL after

PRT. Of the 92 owners reporting an improvement in QOL, 52 (57%) rated the improvement as better and 40 (43%) rated it as much better. Thirty-eight of 116 (33%) respondents perceived discomfort of their pet attributed to adverse effects in the radiation treatment field within the first month after PRT; of these owners, 34 (89%) indicated their pets were uncomfortable and 4 (11%) indicated their pets were very uncomfortable. Owners chose euthanasia for 93 of 105 (89%) animals, whereas 12 (11%) animals died without euthanasia. Most (93/102 [91%]) owners who answered the question indicated that their pet died or was euthanized because of problems the respondents believed were related to the cancer.

Ninety-two of 116 (79%) respondents were satisfied or very satisfied with their decision to use PRT, and the same number indicated that they would have still opted to treat their pet with PRT, given what they knew at the time of the survey. All applicable survey data were available for 112 of 116 (97%) respondents. Owner satisfaction with the decision to have PRT performed and the likelihood of choosing PRT again were not significantly associated with species of the pet ($P = 0.64$ and $P = 0.26$, respectively), family income ($P = 0.37$ and $P = 0.12$, respectively), owner gender ($P = 0.15$ and $P = 0.14$, respectively), or whether an owner felt adequately informed about how their pet would benefit from PRT ($P = 0.23$ and $P = 0.89$, respectively). Although the expectation that PRT would cure the pet's tumor was not significantly ($P = 0.26$) associated with owners' satisfaction regarding the decision to treat, respondents who had expected a cure were less likely to indicate that they would choose the same treatment again (OR, 3.9; 95% CI, 1.2 to 13.1; $P = 0.03$) than were those who did not have this expectation. Survival time was not significantly ($P = 0.11$) associated with owner satisfaction or the likelihood to choose PRT again ($P = 0.08$) after accounting for other potential risk factors.

The final multivariable model for factors associated with owner satisfaction included whether the owner reported an improvement in the pet's QOL after PRT and whether the owner perceived that the pet had discomfort from adverse effects. Owners who felt that there was an improvement in their pet's QOL after PRT were more likely to be satisfied with their decision to provide the treatment (OR, 5.7; 95% CI, 1.6 to 21; $P = 0.009$) and more likely to choose PRT again (OR, 8.3; 95% CI, 2.7 to 26; $P < 0.001$) than were those who did not report an improved QOL. Owners who indicated that their pet had discomfort from acute adverse effects were less likely to report satisfaction (OR, 3.3; 95% CI, 2.4 to 4.4; $P < 0.001$) and less likely to indicate that they would choose PRT again (OR, 5.4; 95% CI, 1.2 to 25; $P = 0.03$). Increasing BED in Gy_{10} was associated with a higher likelihood of owner-reported discomfort from adverse radiation effects in the first month after PRT (OR, 1.01 [per unit increase in Gy_{10}]; 95% CI, 1.00 to 1.02; $P = 0.02$).

Sixty-three of 118 respondents provided answers to the question regarding what they felt was important to share with veterinarians providing palliative treatments for patients. The most common answers were summarized as owners desiring an honest explanation of the expected benefits and adverse effects of PRT (23/63 [37%]), compassion from the veterinary team (15 [24%]), and a clear explanation of the expected benefits and adverse effects of PRT (13 [21%]).

Discussion

Response rates for 3 studies[15–17] in which QOL questionnaires were sent to owners of cats and dogs undergoing treatment for cancer were 28 of 47 (59%), 68 of 91 (75%), and 31 of 35 (89%). The response rate of 118 of 156 (76%) for owners of pets that had received PRT in the present study was comparable to those results, and taken together, these findings indicate that owners of pets that are undergoing or have undergone such treatments are willing to share their perceptions of their pets' QOL. In previous studies[1,8,18,19] of PRT that included comparable radiation protocols, the percentages of patients that had a response to treatment (79/103 [77%] to 24/26 [92%]) were similar to that found in our study (75/95 [79%]). The proportion of owners who reported that their pet showed discomfort from acute adverse effects of PRT (38/116 [33%]) in the present study was also comparable to proportions of patients that developed acute adverse radiation effects (16/48 [33%] to 57/103 [55%]) in those previous studies.

The proportion of animals deemed to have a response to treatment on the basis of medical records review in the present study was similar to the proportion of owners who reported an improved QOL (92/118 [78%]). The difference between the incidence of acute adverse effects recorded in the medical records (22/119 [19%]) and the proportion of animals with owner-reported discomfort from acute effects (38/116 [33%]) may have been attributable to lack of patient follow-up or lack of records annotation (with 36 [31%] patients having no documentation of adverse effect assessment) or owners mistaking signs of tumor-related discomfort for acute adverse effects.

Survival times of > 1, 2, and 3 years have been reported for individual dogs that received PRT,[1,2,8] similar to results for the population of animals included in the present study. Possible explanations for long survival times in patients treated with protocols for palliation include incorrect presumptive diagnoses, additional courses of radiation treatment, and unintentional cure or long-term tumor control. Patients without a definitive diagnosis may have a different tumor type than expected or a benign condition, resulting in a greater response duration than expected on the basis of a presumptive diagnosis. Additional courses of radiation treatment at the time when clinical signs recur might also extend survival time. It is also possible that some more radiosensitive tumors can be cured or have a longer duration of remission than expected. In the present study, hypofractionated protocols with the goal of durable tumor control

were excluded. However, use of a protocol such as 4 fractions of 8 Gy could be expected to cure a certain percentage of tumors, particularly among radiosensitive tumor types, depending on the dose-response curve.

The goal of PRT is improvement of QOL, not cure of disease, and the proportion of survey respondents in the present study whose expectations included that their pet's tumor would be cured (21/118 [18%]) was surprising. This expectation impacted one of the measures of owner satisfaction, the likelihood that owners would choose to have their pet undergo PRT again, supporting the need to explore possible reasons for expectation of cure. Unrealistic expectations regarding PRT have also been reported in human patients; despite a diagnosis of metastatic disease, 12 of 60 (20%) patients surveyed at the time of referral expected that PRT would cure their cancer.[20] Expectation of a cure has been shown to persist in human patients even after consultation with a radiation oncologist; in another study,[21] 17 of 100 (17%) human patients surveyed prior to consultation with a radiation oncologist expected that PRT would cure their metastatic cancer, and there was no change in their belief after the consultation. Reasons for owners' expectation that PRT would cure a pet's tumor in the present study could have included inaccurate prediction of prognosis by a veterinarian, lack of clear communication to an owner regarding prognosis, different understandings of the meaning of a cure, or owners' denial of their pets' advanced disease and unrealistic expectations regarding the outcome despite having been adequately informed. Routine assessment of owner understanding of the goal of PRT may help veterinarians better communicate prognosis information to pet owners, as an individual's understanding of the prognostic implication of terms such as metastatic and palliative may be different from what the veterinarian expects; some human patients were found to expect a cure even when they correctly indicated that they had metastatic disease and that their treatment was palliative.[22] Denial in human patients that have been fully informed can be an attempt to minimize the emotional impact of the prognosis and reduce psychological stress, and given the high level of attachment that can exist between an owner and an animal, denial might occur for the same reasons in pet owners even when they have been fully informed of a poor prognosis.[22]

Potential associations between tumor characteristics (eg, type, location, and stage) and measures of owner satisfaction were not examined in the present study owing to the low numbers of patients in each stratum. These factors could have influenced owner satisfaction with PRT of their pets; however, the present study was not sufficiently powered to investigate this. Satisfaction of owners who do not consider euthanasia as an option for their pet during or after PRT could also differ from that of owners who do consider euthanasia. To investigate the effect of this factor, knowledge of owner intent prior to the patient's death would be needed because the actual cause of death of an animal might not reflect the owner's intent. For example, a pet belonging to an owner who would consider euthanasia could have died spontaneously before the option of euthanasia was raised by the veterinarian. For this reason, we did not examine potential effects of euthanasia versus spontaneous death on measures of owner satisfaction.

Previous studies[23,24] have shown that owners of animals with cancer are satisfied with palliative treatments that improve QOL, even when survival time is short. This is consistent with our findings that both the likelihood of owner satisfaction with their decision to treat and the likelihood that they would choose PRT again for their pet were significantly greater when owners believed that their pets' QOL improved after PRT and that neither of these measures of owner satisfaction was significantly associated with pets' survival time. In another study,[25] 22 of 23 (96%) owners whose dogs had radiation therapy, including 18 (78%) whose dogs underwent PRT, said they would choose to treat with radiation therapy again in a similar situation and that freedom from tumor-related discomfort was the most important factor in this choice. In a study[23] that included 26 dogs and cats that had undergone limb amputation because of cancer, all owners indicated they were satisfied with their decision to have amputation performed, regardless of pets' survival time, which was < 1 year in 17 (65%) patients. All animals except for 1 dog in that study[23] had satisfactory functional status. Similarly, other investigators found that 17 of 19 owners whose dogs had a median survival time of 5.5 months after surgical treatment of hemoperitoneum attributed to neoplasia were happy with their decision to treat their dog, and 16 of 19 were satisfied with their dog's QOL after treatment.[24] Even though long-term survival is not expected for patients undergoing PRT, temporary alleviation of clinical signs associated with a tumor can give owners valued time with their pets.

Owners who reported that their pet had discomfort from adverse radiation effects in the first month after radiation treatment were less satisfied (by both measures used in the present study) with their decision to treat their pet with PRT than were those who did not report this observation. Acute adverse effects can cause pain and discomfort for several weeks after radiation therapy and may thus decrease a patient's QOL in a situation where the remaining expected life span may be short. The presence and degree of acute adverse effects depend on the radiation dose intensity and the relative radiosensitivity of the organ being irradiated and are predictable; as expected, we found that increasing BED in Gy_{10} was associated with a higher likelihood of owner-reported patient discomfort from acute adverse radiation effects.[26] The associations found between perceived discomfort from acute radiation adverse effects and measures of owner satisfaction in the present study suggested that dose protocols expected to cause minimal or no discomfort from adverse effects should be prescribed

for PRT. However, adjustment of dose protocols to minimize the risk of acute adverse effects should not compromise the probability of tumor response, as response to treatment (and improved QOL) is important to owner satisfaction.

The desire for honesty in communication regarding the expected benefits and adverse effects of PRT was identified by 23 of 63 (37%) owners who answered this question as a factor that they felt was important to share with veterinarians who provide palliative treatments for patients. A study[27] on information expectations of owners of dogs with life-limiting cancer had a similar finding; the central qualification of the information expected by owners was that it be the truth. Compassion and clear explanations were also commonly identified as important to owners in our study, consistent with the finding in another study[28] that owners of dogs with life-limiting cancer expect information to be communicated in understandable language and with compassion.

Owner-reported assessments of signs of pain and discomfort in pets were included in the present study, resulting in the potential for misjudgment and bias. Owners spend more time with animals in their home environment and are familiar with their pets' habits, but they may not correctly identify signs of pain. A study[29] of dogs with osteoarthritis found that owners could identify some behaviors associated with pain, but not necessarily the lameness itself. This could result in incongruence between owner perceptions of QOL and the actual QOL of animals if key prompting questions about specific clinical signs are not asked. This so-called proxy effect has also been observed in human medicine, where agreement between caregivers' assessments of QOL and patients' own assessments was only fair to moderate; studies[30,31] of human patients receiving palliative care have shown that family members correctly estimate the presence or absence of pain and other symptoms 71% to 74% of the time. Recall bias, in which a former state cannot be accurately recalled because of memory effects, was another limitation of our study because owners were surveyed retrospectively. Other biases that may have affected owner assessments of their pets' QOL include social desirability responding (eg, owner reluctance to evaluate the veterinary caregivers negatively by reporting a poor treatment outcome), context effect (if questions in an earlier part of the questionnaire influenced respondents' later rating of QOL), and mood of the owner at the time of questionnaire completion.[32] Because of the retrospective study design, we chose to ask owners only whether their pet's QOL had improved or not and to rate any improvement as better or much better in an effort to limit recall bias that could have been greater with a more detailed assessment of their pet's QOL. A QOL scoring questionnaire or a pain scoring tool such as the Canine Brief Pain Inventory[33] could provide a more objective measure of patient QOL if applied prospectively. Owners who completed the questionnaire in the present study may have had a different experience with PRT for their pets than did owners who chose not to complete the questionnaire; therefore, our findings may not have represented the true experience of the overall population of owners of such pets.

It is important to consider that, although the dogs, cats, and rabbits included in the present study were treated at 3 different referral or specialty hospitals, approximately one-fifth of pet owners surveyed in the present study expected that PRT would cure their pets' tumors, and this expectation was negatively associated with 1 of the 2 measures of owner satisfaction. Veterinarians should endeavor to ensure that owners understand that the goal of PRT is improvement of QOL, not cure of disease.

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Footnotes

a. University of Saskatchewan Fluid Survey tool, version 4.0. Available at: www.usask.ca/ict/services/research-technologies/Fluid%20Surveys/index.php. Accessed Jan 22, 2014.
b. Stata SE, version 14.0, StataCorp, College Station, Tex.

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From this month's *AJVR*

Use of crown height of the maxillary first molar tooth to approximate the age of horses

James L. Carmalt et al

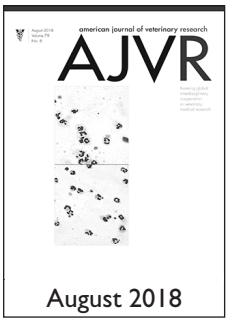
OBJECTIVE
To identify whether age, sex, or breed is associated with crown height of the left and right maxillary first molar tooth (M1) measured on CT images, to develop a mathematical model to determine age of horses by use of M1 crown height, and to determine the correlation between M1 crown height measured on radiographic and CT images.

SAMPLE
CT (n = 735) and radiographic images (35) of the head of horses.

PROCEDURES
Crown height of left and right M1 was digitally measured on axial CT views. Height was measured on a lateral radiographic image when available. Linear regression analysis was used to identify factors associated with crown height. Half the data set was subsequently used to generate a regression model to predict age on the basis of M1 crown height, and the other half was used to validate accuracy of the predictions.

RESULTS
M1 crown height decreased with increasing age, but the rate of decrease slowed with increasing age. Height also differed by sex and breed. The model most accurately reflected age of horses < 10 years old, although age was overestimated by a mean of 0.1 years. The correlation between radiographic and CT crown height of M1 was 0.91; the mean for radiographic measurements was 2.5 mm greater than for CT measurements.

CONCLUSIONS AND CLINICAL RELEVANCE
M1 crown height can be used to predict age of horses. Results for CT images correlated well with those for radiographic images. Studies are needed to develop a comparable model with results for radiographic images. (*Am J Vet Res* 2018;79:867–873)



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