

Intraoperative and postoperative complications of partial maxillectomy for the treatment of oral tumors in dogs

Roxane H. MacLellan DVM

Jennifer E. Rawlinson DVM

Sangeeta Rao BVSc, PhD

Deanna R. Worley DVM

From the Department of Clinical Science (MacLellan, Rawlinson, Rao, Worley) and Flint Animal Cancer Center (Worley), College of Veterinary Medicine and Biomedical Science, Colorado State University, Fort Collins, CO 80523. Dr. MacLellan's present address is Veterinary Specialty Center of Tucson, 4909 N La Canada Dr, Tucson, AZ 85704.

Address correspondence to Dr. Rawlinson (jennie.rawlinson@gmail.com).

OBJECTIVE

To characterize and identify factors associated with intraoperative and postoperative complications of maxillectomy in dogs with oral tumors.

DESIGN

Retrospective cohort study.

ANIMALS

193 dogs that underwent maxillectomy for oral tumor excision from 2000 through 2011.

PROCEDURES

Data were extracted from the medical records regarding dog signalment, tumor location and size, histologic findings, clinical stage, maxillectomy category, surgical approach, and additional treatments provided. These factors were examined for associations with recorded intraoperative and postoperative outcomes.

RESULTS

The most common intraoperative complication was excessive surgical bleeding (103/193 [53.4%]), for which 44 (42.7%) dogs received an intraoperative blood transfusion. These outcomes were both significantly associated with tumor size and location, maxillectomy type, and surgical approach. Dogs treated with a dorsolateral combined intraoral surgical approach were more likely to have excessive surgical bleeding (48/58 [83%]) and had a longer mean duration of surgery (106 minutes) than those treated with an intraoral approach (29/54 [54%] and 77 minutes, respectively). Complications developing within 48 hours after surgery included epistaxis (99/193 [51.3%]), excessive facial swelling (71/193 [36.8%]), facial pawing (21/193 [10.9%]), and difficulty eating (22/193 [11.4%]). Complications developing within 48 hours to 4 weeks after surgery included lip trauma (22/164 [13.4%]), oronasal fistula formation (18/164 [11.0%]), wound dehiscence (18/164 [11.0%]), and infection (13/164 [7.9%]).

CONCLUSIONS AND CLINICAL RELEVANCE

Complications associated with maxillectomy in dogs were generally minor. Aggressive surgical planning, preparedness for hemorrhage and transfusion, careful tissue dissection, and comprehensive pain control are recommended, particularly for dogs with large, caudally located oral tumors requiring extensive excision. (*J Am Vet Med Assoc* 2018;252:1538–1547)

The term partial maxillectomy refers to the en bloc excision of a tumor involving a portion of the upper jaw. This type of procedure can involve the maxillary, incisive, palatine, lacrimal, zygomatic, frontal, and vomer bones as well as the nasal passage, maxillary recess, frontal sinus, eye, zygomatic and parotid salivary ducts, lacrimal duct and gland, and orbit, depending on the size of the excision.¹⁻⁵ Important vessels, nerves, and structures are situated in this region. The external carotid and maxillary

arteries are the primary vascular supply and branch off into the facial, infraorbital, sphenopalatine, major palatine, and minor palatine arteries. The external jugular, maxillary, linguofacial, facial, major palatine, sphenopalatine, and infraorbital veins form the venous drainage. The maxillary branch of the trigeminal nerve separates into the zygomatic, pterygopalatine, and infraorbital nerves. The maxillary and facial nerves supply sensory and motor innervation to the upper jaw, eye, ear, and lips. Any of these structures can be encountered during maxillectomy, and as a result, successful excision of a maxillary tumor with clean margins can be difficult.

Various surgical techniques and approaches for partial maxillectomy have been described.¹⁻⁹ The IO surgical approach for treatment of oral maxillary

ABBREVIATIONS

CI Confidence interval
DL-IO Dorsolateral combined intraoral
IO Intraoral

neoplasia in dogs was initially described in 1985, and it is the primary technique used today.^{6,7} The DL-IO approach was described in 2003, offering an alternative surgical approach to caudally located maxillary tumors if more dorsal access is needed.⁸

Reported intraoperative and postoperative complication rates for maxillectomy in dogs range from 1% to 55%.⁶⁻¹³ Intraoperative complications include hemorrhage, anemia, and severe hypotension resulting in the administration of canine blood product transfusions. Hemorrhage is reportedly the most common intraoperative complication.^{8,9} Hemorrhage resulted in 1 death in a study⁹ involving maxillectomy for the treatment of oral tumors in 69 dogs. In another study⁸ involving caudal maxillectomy in 20 dogs, 6 (30%) dogs required an intraoperative transfusion, 11 (55%) developed severe hypotension from intraoperative blood loss, and 4 (20%) had blood loss without hypotension. In a third study⁷ involving partial maxillectomy, 2 of 17 (12%) dogs required a postoperative blood transfusion.⁷

Reported immediate and short-term complications of partial maxillectomy in dogs and cats include facial swelling, facial deformity, difficulty eating, postoperative lip trauma, wound dehiscence, oronasal fistula formation, dyspnea, sneezing and nasal discharge, drooling, epistaxis, nasolacrimal duct disruption, incomplete surgical margins, and local tumor recurrence.⁶⁻¹³ Wound dehiscence is the most common postoperative complication, with rates ranging from 5% to 33%.^{6-9,11,12} To the authors' knowledge, the incidence and nature of complications associated with various maxillectomies in a large cohort of dogs have not been comprehensively assessed. The purpose of the study reported here was to characterize major and minor intraoperative and postoperative complications of maxillectomy within a large single institutional cohort of dogs and to determine whether tumor size, tumor location, maxillectomy type, or surgical approach was associated with the incidence of specific complications.

Materials and Methods

Animals

Medical records of the James L. Voss Veterinary Teaching Hospital of Colorado State University were searched to identify dogs that had undergone maxillectomy from January 1, 2000, through December 31, 2011. Only dogs admitted for excision of a primary oral tumor not originating from the nasal cavity were included in the study. Any dogs that received neoadjuvant treatment, such as radiotherapy or chemotherapy, prior to maxillectomy were excluded from the study.

Data collection

For each dog included in the study, data were abstracted from the medical record regarding signalment, body weight, tumor location and size, histologic diagnosis, clinical stage as determined from thoracic radiographs, lymph node cytologic findings, CT find-

ings for the oral cavity, surgical reports, duration of surgery, preoperative and immediate postoperative PCV, and any intraoperative and postoperative complications. Surgeon and surgical training level were recorded for each procedure. Complications were categorized as intraoperative (during surgery), immediate postoperative (≤ 48 hours after surgery), and short-term postoperative (48 hours to 4 weeks after surgery) on the basis of the recorded time of occurrence.

Surgical technique

Surgical technique and approach were chosen at the discretion of the primary surgeon on the basis of tumor type, location, and extent of neoplastic boundaries. Prior to surgery, regional anatomy was assessed for tension-free closure planning following tumor excision. Aseptic surgical techniques were used for all surgeries. Regional and local blocks were performed if there was no danger of tumor or infection seeding. Antimicrobials (cefazolin, ampicillin, or clindamycin) were administered IV to all dogs during the intraoperative period.

Maxillectomies were performed with an IO or DL-IO approach. For the IO approach, incisions were made intraorally into the alveolar, labial or buccal, and palatal mucosa ideally to create 1- to 3-cm surgical margins around the tumor.³ Intraoral mucosal incisions were made with a scalpel blade; electrocautery was used only for subcutaneous tissues and muscles but was avoided on surgical wound margins. Soft tissue and periosteum were dissected, elevated, and retracted in the region of the anticipated osteotomy site. For the DL-IO approach, an additional cutaneous incision was made extraorally extending from the dorsolateral aspect of the nose or muzzle to the rostral aspect of the eye and zygoma as necessary.^{3,8} The periorbital tissues were reflected from the bone, leaving the bulbus oculi (globe) intact in the conjunctival sac. The submucosa was dissected simultaneously intraorally and extraorally, creating a bipedicle flap. During dissection, major vessels were identified, ligated, and transected as necessary by use of ligatures or hemoclips.

Osteotomies were performed after all soft tissue had been dissected and all accessible major blood vessels had been ligated. Incisions were made with an oscillating saw, piezosurgery unit, or osteotome and mallet. After reflection and removal of the osteotomized bone and soft tissue en bloc, additional blood vessels inaccessible prior to the osteotomy were identified and ligated. Cautery, ligatures, hemoclips, and digital pressure were used to control bleeding. Bleeding from exposed nasal turbinates was controlled with digital pressure, cold saline (0.9% NaCl) solution, or thrombin-impregnated sponges. Transected nasal turbinates were left exposed within the nasal passage. Once bleeding was controlled, various IO and extraoral closure techniques were used to minimize tension at the excision site.

Choice of closure techniques was at the discretion of the surgeon and determined by the size and location of the excision.¹ In general, surgical sites were closed by creating tension-free IO transpositional mucosal flaps via

a combination of sharp and blunt dissection. Mucosal flaps were typically closed in 2 layers: submucosal and mucosal. Closure was performed in simple continuous and simple interrupted patterns, depending on surgeon preference. Monofilament, synthetic, and absorbable suture material was used, although absorption rates of the products used varied by surgeon preference. Intrabony anchorage of subcutaneous soft tissue was used for some closures by placing sutures through predrilled holes in the bone to alleviate undue tension on mucosal sutures. For the DL-IO approach, the dorsal cutaneous incision was closed in 2 layers: subcutaneous and cutaneous.

After surgery, most dogs were kept in the intensive care ward for observation and IV administration of fluids and analgesics. Dogs were offered soft food and discharged from the hospital within 48 hours after surgery if they appeared to be eating adequately and pain appeared to be well controlled. An Elizabethan collar was not routinely applied during the postoperative recovery period unless dogs were observed traumatizing the face. Postoperative care instructions included a soft food-only diet and strict avoidance of any hard chew toys or treats for the first 4 weeks following surgery. Postoperative antimicrobials were prescribed only for dogs with evidence of an infection, and all dogs were sent home with analgesics consisting of NSAIDs or opioid medications prescribed for various durations, depending on the type of resection. Follow-up examinations were recommended to be provided 10 to 14 days after surgery.

For the purposes of the study, each maxillectomy was categorized on the basis of the location and extent of the excision as unilateral or bilateral incisivectomy, unilateral rostral maxillectomy, bilateral rostral maxillectomy, central or segmental maxillectomy, caudal maxillectomy, and unilateral (complete) maxillectomy (**Figure 1**).¹

Statistical analysis

Data were analyzed with the aid of statistical software.^{a,b} Continuous data are summarized as mean and SD. The data (duration of surgery and sequential PCV data) were evaluated for normality of distribution prior to linear regression analysis to compare dogs with and without the various complications. Logistic regression was performed, and ORs were calculated to assess the likelihood of a binary outcome (ie, intraoperative and postoperative complications) given the variables tumor size, tumor location, sur-

gical approach, and resection category. For comparisons of postoperative complications involving variables with 2 categories, the Pearson χ^2 test was used to assess significance. For categories represented by < 5 observations, the Fisher exact test was performed.¹⁴ Values of $P < 0.05$ were considered significant.

Results

Animals

One hundred ninety-three dogs with oral tumors met the inclusion criteria and were included in the study. Dogs included 92 (47.7%) castrated males, 10 (5.2%) sexually intact males, 85 (44.0%) spayed females, and 6 (3.1%) sexually intact females. Mean age

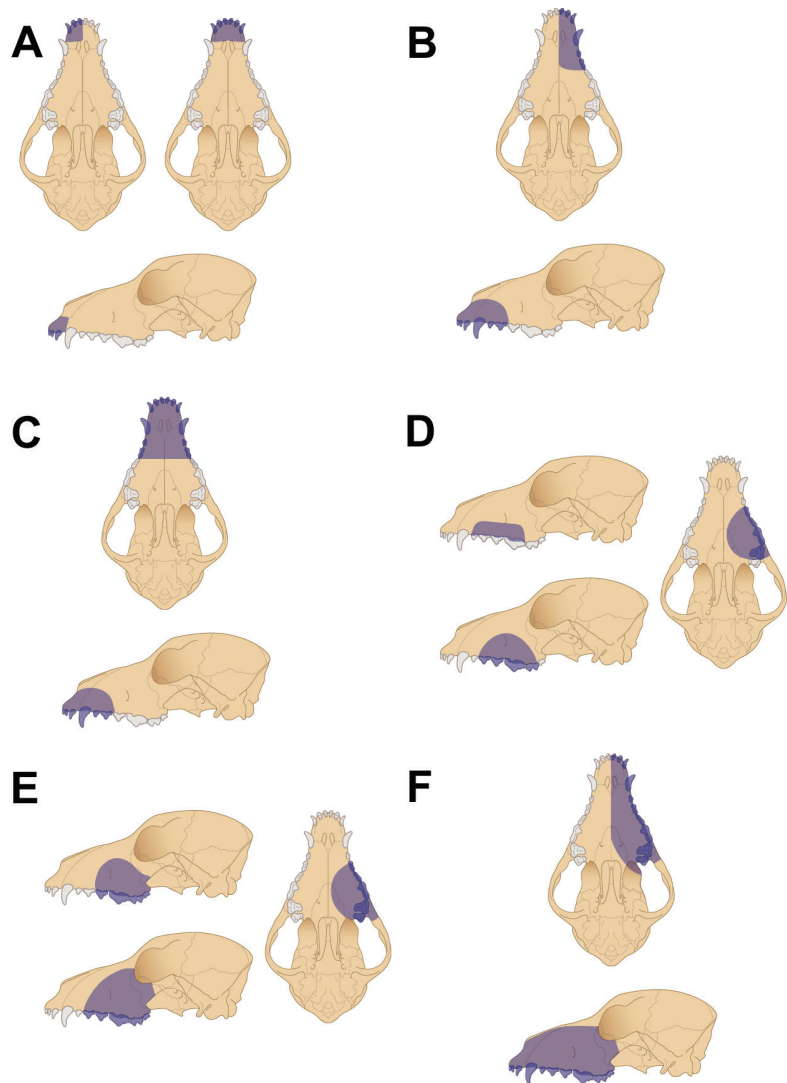


Figure 1—Illustrations of various types of maxillary excisions used for treatment of oral tumors in dogs. A—Unilateral or bilateral incisivectomy. B—Unilateral rostral maxillectomy. C—Bilateral rostral maxillectomy. D—Central or segmental maxillectomy. E—Caudal maxillectomy. F—Unilateral (complete) maxillectomy. From Verstraete FJM, Lommer MJ, Lantz GC. Maxillectomy techniques. In: *Oral and maxillofacial surgery in dogs and cats*. New York: Saunders Elsevier, 2012;455. Modified and reprinted with permission from Elsevier.

of the dogs at the time of surgery was 8.3 years (SD, 2.9 years; range, 0.5 to 15 years). Mean body weight was 29.9 kg (65.8 lb; SD, 11.6 kg [25.5 lb]; range, 6 to 63 kg [13.2 to 138.6 lb]). Body weight was excluded from further statistical analysis because 94.3% (182/193) of the dogs weighed > 10 kg (22 lb).

One hundred forty-five (75.1%) dogs were recorded as purebred dogs, and 48 (24.9%) were recorded as mixed-breed dogs. The most commonly recorded breeds included Golden Retriever ($n = 35$ [18.1%]), Labrador Retriever (25 [13.0%]), Standard Poodle (8 [4.1%]), German Shepherd Dog (6 [3.1%]), Siberian Husky (5 [2.6%]), Beagle (5 [2.6%]), Australian Shepherd (5 [2.6%]), Rottweiler (4 [2.1%]), and Cocker Spaniel (3 [1.6%]).

Presurgical data

All dogs underwent preoperative blood work (CBC, blood typing, and serum biochemical analysis) and preoperative biopsy of the suspected tumor. In 140 (72.5%) dogs, contrast-enhanced CT examination of the oral cavity was performed to evaluate the lymph nodes and determine the extent of tumor margins; 40 (20.7%) other dogs were examined by conventional radiography, IO dental radiography, or MRI to evaluate the extent of the oral mass. The 13 (6.7%) dogs for which no imaging was performed had an incisivectomy performed, a benign odontogenic tumor, or an owner who declined advanced imaging. Most (35/53 [66%]) dogs with no CT scan performed had tumors located rostral to the fourth premolar tooth.

Tumor size consistent with the World Health Organization tumor node metastasis classification system for oral tumors¹⁵ was recorded for 112 dogs. In 22 (19.6%) of these dogs, the tumor measured < 2 cm at the widest margins. In 64 (57.1%) dogs, the tumor measured 2 to 4 cm at the widest margin, and in 26 (23.2%), the tumor measured > 4 cm at the widest margin. Seven of 193 (3.6%) had metastasis to the regional lymph nodes ($n = 5$) or lungs (2). All lymph nodes from which malignant cells were recovered via fine-needle aspiration ($n = 5$ [4.7%] dogs) were excised during anesthesia for the maxillectomy.

The 5 most common tumor types included fibrosarcoma ($n = 48$ [24.9%]), osteosarcoma (34 [17.6%]), squamous cell carcinoma (31 [16.1%]), acanthomatous ameloblastoma (26 [13.5%]), and malignant melanoma (19 [9.8%]). Tumors were located within the rostral portion of the maxilla (first incisor tooth to the mesial aspect of the fourth premolar tooth) in 81 (42.0%) dogs and in the caudal portion of the maxilla (fourth premolar tooth to the caudal aspect of the hard palate) in 112 (58.0%) dogs. Most osteosarcomas (26/34 [76%]), melanomas (14/19 [74%]), and fibrosarcomas (28/48 [58%]) were in the caudal portion of the maxilla. Most squamous cell carcinomas were in the rostral portion of the maxilla (21/31 [68%]). Acanthomatous ameloblastomas were equally divided between rostral and caudal locations.

Maxillectomy

Twenty-six surgeons were documented in the surgical reports over the study period, including surgical residents, surgical postdoctoral fellows, and board-certified surgeons. The study hospital is a training facility, so the identity of the person who had actually performed each surgery was unclear in the medical records, although a primary surgeon and faculty member were consistently listed for each surgery. With maxillectomies classified by location and extent of the excision, the number of dogs represented within each excision category was as follows: incisivectomy, 10 (5.2%); unilateral rostral maxillectomy, 45 (23.2%); bilateral rostral maxillectomy, 26 (13.5%); central or segmental maxillectomy, 21 (10.8%); caudal maxillectomy, 73 (37.8%); and complete maxillectomy, 18 (9.3%). An inferior partial orbitectomy (removal of the ventral orbital margin and rostral zygoma) was performed in conjunction with caudal maxillectomy or unilateral complete maxillectomy in 52 of 91 (57%) dogs.

Surgery was performed with an IO approach in 133 (68.9%) dogs and with a DL-IO approach in 60 (31.1%) dogs. The DL-IO approach was not used for incisivectomy or bilateral rostral maxillectomy or was used minimally ($n = 2$ dogs) for unilateral rostral maxillectomy. Of the 112 dogs treated by central or segmental maxillectomy, caudal maxillectomy, or complete maxillectomy, 58 (51.8%) were treated by a DL-IO approach and 54 (48.2%) by an IO approach.

Intraoperative complications

For all 193 dogs, the most common intraoperative complication was excessive surgical bleeding (hemorrhage), which was identified in the anesthetic record as bleeding that required an intervention, such as aggressive, nonroutine treatment for hypotension or administration of blood products, or identified as a subjective entry of "blood loss." Such excessive bleeding was recorded for 103 (53.4%) dogs, 44 (42.7%) of which received a transfusion with canine blood products for acute hypovolemic anemia. Concurrent hypotension was recorded for 94 (91.3%) dogs with excessive surgical bleeding. Of the dogs with excessive surgical bleeding but no recorded hypotension, intraoperative PCV decreased to < 30%. For all dogs with excessive surgical bleeding regardless of blood pressure status, the mean decrease in PCV from the preoperative value was 17.2% (SD, 6.8%; mean percentage change in PCV, 37.4%; range, 0% to 66%). For the 90 dogs without excessive surgical bleeding, only 42 (47%) had hypotension, and the mean decrease in PCV was 15.0% (SD, 6.3%; mean percentage change in PCV, 31.0%; range, 4% to 58%). No intraoperative deaths were recorded.

Univariate analysis without controlling for other factors revealed that tumor size, tumor location, maxillectomy category, and surgical approach were significantly associated with excessive surgical bleeding and blood transfusion (**Table 1**). Excessive surgical

Table 1—Comparison of intraoperative complication rates for 193 dogs that underwent maxillectomy for oral tumor excision, by tumor diameter (World Health Organization TNM classification system¹⁵) and surgery characteristics.

Variable	Total No. of dogs in category	No. (%) of dogs in category with excessive surgical bleeding	P value	No. (%) of dogs in category receiving a blood transfusion	P value
Diameter at greatest dimension*			< 0.001		0.002
< 2 cm (T1)	22	8 (36)	—	4 (18)	—
2–4 cm (T2)	64	37 (58)	—	14 (22)	—
> 4 cm (T3)	26	24 (92)	—	15 (58)	—
Tumor location			< 0.001		< 0.001
Rostral to the fourth premolar tooth	81	26 (32)	—	7 (8)	—
Caudal to and including the fourth premolar tooth	112	77 (69)	—	37 (33)	—
Maxillectomy category			< 0.001		< 0.001
Incisivectomy	10	0 (0)	—	0 (0)	—
Unilateral rostral maxillectomy	45	16 (36)	—	4 (9)	—
Bilateral rostral maxillectomy	26	10 (38)	—	3 (12)	—
Central or segmental maxillectomy	21	8 (38)	—	1 (5)	—
Caudal maxillectomy	73	56 (77)	—	29 (40)	—
Complete maxillectomy	18	13 (72)	—	7 (39)	—
Orbitectomy performed			< 0.001		< 0.001
Yes	52	43 (83)	—	30 (58)	—
No	141	60 (43)	—	14 (10)	—
Surgical approach*			< 0.001		< 0.001
IO	54	29 (54)	—	7 (13)	—
DL-IO	58	48 (83)	—	30 (52)	—

*Only 112 dogs had tumors or surgeries that could be classified in this manner.

— = Not applicable.

bleeding and blood transfusions were more common in dogs with larger tumors and tumors located in the caudal portion of the oral cavity than in other dogs. Dogs treated with caudal maxillectomy or complete maxillectomy were significantly ($P < 0.001$) more likely to have had excessive surgical bleeding and 3 times as likely to have received a blood transfusion as were dogs with other maxillectomy types. In addition, a greater proportion of dogs treated with maxillectomy involving the orbit had excessive surgical bleeding or received a blood transfusion than did dogs treated with maxillectomy excluding the orbit. Dogs treated with the DL-IO approach were also significantly ($P < 0.001$) more likely to have excessive surgical bleeding than dogs treated with the IO approach and 4 times as likely to have received a blood transfusion.

Mean duration of surgery was significantly ($P < 0.001$) greater for dogs with (95 minutes; SD, 40 minutes) versus without (69 minutes; SD, 36 minutes) surgical bleeding (OR, 1.02; 95% CI, 1.01 to 1.03) and for dogs that received (104 minutes; SD, 42 minutes) versus did not receive (76 minutes; SD, 38 minutes) a blood transfusion (OR, 1.02; 95% CI, 1.01 to 1.03). Mean duration of surgery was significantly ($P < 0.001$) greater with the DL-IO approach (106 minutes; SD, 32 minutes) than with the IO approach (77 minutes; SD, 38 minutes).

For 132 (68.4%) dogs, maxillectomy yielded tumor-free or histologically complete margins, and for 61 (31.6%) dogs, the histologic margins were incomplete. No significant association with incomplete margins was identified for tumor size or location, maxillectomy category or type, or surgical approach.

Only the 5 most common tumor types were statistically evaluated for associations with incomplete margins, revealing that dogs with fibrosarcomas were significantly ($P < 0.05$) more likely to have incomplete margins (24/48 [50%]) than dogs with acanthomatous ameloblastomas (5/31 [16%]) and squamous cell carcinomas (5/26 [19.2%]). No significant difference was identified among proportions of dogs with osteosarcomas (11/34 [32%]), malignant melanomas (6/19 [32%]), or fibrosarcomas with incomplete margins.

Immediate postoperative complications

Records of all 193 dogs were assessed for immediate (< 48 hours) postoperative complications. The most common complications during this period included facial swelling, difficulty eating, epistaxis, and facial pawing (**Table 2**). Postoperative facial swelling, defined as excessive incisional inflammation and edema around the surgical site or periorbital region, was recorded for 71 (36.8%) dogs. The proportion of dogs with facial swelling was significantly ($P < 0.001$) greater with excisions of caudally (54/112 [48.2%]) versus rostrally (17/81 [21%]) located tumors, caudal (42/73 [58%]) or complete (8/18 [44%]) maxillectomy versus other maxillectomy categories, and orbitectomy (31/52 [60%]) versus no orbitectomy (40/141 [28.4%]). No facial swelling was identified in dogs treated with incisivectomy.

Difficulty eating, defined as signs of pain on opening the mouth, inappetence, anorexia, or minimal to no water consumption, was identified in 22 (11.4%) dogs immediately after surgery. A significantly ($P = 0.02$) greater proportion of dogs with caudally

Table 2—Number (%) of dogs (n = 193) that developed various complications within 48 hours following maxillectomy for oral tumor excision, by maxillectomy category.

Maxillectomy category	Total No. of dogs in category	Epistaxis (n = 99)	Facial swelling* (n = 71)	Facial pawing (n = 21)	Difficulty eating (n = 22)
Incisivectomy	10	3 (30)	0 (0)	0 (0)	0 (0)
Unilateral rostral maxillectomy	45	21 (47)	12 (27)	3 (7)	3 (7)
Bilateral rostral maxillectomy	26	12 (46)	5 (19)	3 (12)	1 (4)
Central or segmental maxillectomy	21	10 (48)	4 (19)	2 (10)	2 (10)
Caudal maxillectomy	73	41 (56)	42 (58)	10 (14)	12 (16)
Complete maxillectomy	18	12 (67)	8 (44)	3 (17)	4 (22)

*The distribution of dogs with facial swelling differed significantly (Pearson χ^2 test, $P < 0.05$) among maxillectomy categories.

Table 3—Number (%) of dogs (n = 164) that developed complications within 48 hours to 4 weeks following maxillectomy for oral tumor excision, by maxillectomy category.

Maxillectomy category	Total No. of dogs in category	Lip trauma (n = 22)	Oronasal fistula (n = 18)	Dehiscence (n = 18)	Infection (n = 13)	Epiphora (n = 15)
Incisivectomy	5	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Unilateral rostral maxillectomy	38	8 (21)	1 (3)	3 (8)	1 (3)	1 (3)
Bilateral rostral maxillectomy	18	3 (17)	1 (6)	1 (6)	1 (6)	1 (6)
Central or segmental maxillectomy	18	1 (6)	2 (11)	2 (11)	2 (11)	0 (0)
Caudal maxillectomy	68	7 (10)	11 (16)	9 (13)	7 (10)	9 (13)
Complete maxillectomy	17	3 (18)	3 (18)	3 (18)	2 (12)	4 (24)

(18/112 [16.1%]) versus rostrally (4/81 [5%]) located tumors had difficulty eating. A significantly ($P = 0.01$) greater proportion of dogs treated with (11/52 [21%]) versus without (11/141 [7.8%]) orbitectomy also had difficulty eating. No significant association with difficulty eating was identified for tumor size, maxillectomy category, or surgical approach. For all but 2 dogs, the observed difficulty eating resolved within the immediate postoperative recovery period. Both of those dogs had undergone large caudal maxillectomies involving orbitectomy.

Minor epistaxis was recorded for 99 (51.3%) dogs. No significant association with this variable was identified for tumor size, tumor location, maxillectomy type, or surgical approach. In only 1 dog was epistaxis protracted, resulting in excessive hemorrhage due to ligature failure that necessitated an immediate second surgery.

Postoperative facial pawing was recorded for 21 (10.9%) dogs. Wound dehiscence occurred in 7 (33%) of these dogs, 5 of which developed an oronasal fistula. Facial pawing was more common in dogs treated with the DL-IO approach (11/58 [19%]) than in dogs treated with the IO approach (4/54 [7%]), but this difference was not significant ($P = 0.07$). Facial pawing was not significantly associated with tumor size, tumor location, maxillectomy type, or orbitectomy.

Short-term complications

Short-term (48 hours to 4 weeks after surgery) postoperative follow-up data were available for 164 dogs. Short-term postoperative complications (ie, those noted 48 hours to 4 weeks after surgery) included lip trauma, oronasal fistula formation, wound dehiscence, infection, and epiphora (**Table 3**). Lip trauma, considered mild to severe injury to the en-

tire lip or the labial skin or mucosa in the region of the maxillectomy site secondary to contact with mandibular teeth, was the most common short-term postoperative complication, recorded as defined for 22 (13.4%) dogs. Such trauma was observed in dogs with both rostrally (11/61 [18%]) and caudally (11/103 [10.7%]) located tumors. Lip trauma was also recorded for > 10% of dogs treated with unilateral rostral maxillectomy (8/38 [21%]), central maxillectomy (3/18 [17%]), and complete maxillectomy (3/17 [18%]). No lip trauma was recorded for dogs treated with incisivectomy. Lip trauma only occurred in dogs with tumors > 2 cm in diameter.

A greater proportion of dogs treated with the DL-IO approach (9/58 [16%]) versus the IO approach (2/54 [4%]) had lip trauma. Most dogs with lip trauma (14/22 [64%]) were managed conservatively with frequent monitoring. Treatments for the remaining 8 (36%) dogs with lip trauma included antimicrobials (n = 2), cheiloplasty (2), odontoplasty (2), crown reduction with vital pulp treatment of a mandibular tooth (1), and extraction of a mandibular tooth (1). For 9 dogs with lip trauma, the injury was recorded as having healed completely. Continued monitoring or no mention of resolution was recorded for all other affected dogs.

Oronasal fistulae were recorded for 18 (11.0%) dogs. Mean time to fistula formation was 19 days (SD, 12 days). Duration of surgery was significantly ($P = 0.002$) longer for dogs with (111 minutes; SD, 49 minutes) versus without (82 minutes; SD, 37 minutes) fistula formation in that for every 1-minute increase in this variable, the risk of fistula formation increased by 2% (OR, 1.02; 95% CI, 1.01 to 1.03). Immediate surgery to repair the fistulae was attempted for 13 dogs; for 7 of these dogs, surgery was successful, and for the remain-

ing 6 dogs, the fistula subsequently recurred. Of these 6 dogs with unsuccessful treatment, 3 dogs underwent multiple surgeries to repair the fistulae. One of these dogs was euthanized because of recurrent, persistent fistula. Another dog had an unresolved, chronic fistula that persisted after 2 attempted surgical repairs, which included an angularis oris axial pattern flap. The third dog with a persistent oronasal fistula was treated with an obturator. A significantly ($P = 0.02$) greater proportion of dogs with caudally located tumors developed oronasal fistulae (16/103 [15.5%]) than did dogs with rostrally located tumors (2/61 [3%]). Oronasal fistula formation occurred only when tumors were > 2 cm in diameter. No association with this outcome was identified for maxillectomy category, surgical approach, or orbitectomy.

Surgical wound dehiscence was recorded for 18 (11.0%) dogs, of which 14 (78%) had dehiscence caudal to the canine teeth. No association with dehiscence was identified for tumor location or size, maxillectomy category, or surgical approach. However, dogs with wound dehiscence had a significantly ($P < 0.001$) longer mean duration of surgery (114 minutes; SD, 45 minutes) than those without wound dehiscence (82 minutes; SD, 37 minutes; OR, 1.02; 95% CI, 1.01 to 1.03).

Thirteen of 164 (7.9%) dogs developed a surgical site infection. Most ($n = 11$) of these dogs had caudally located tumors. In 8 dogs, the infection was associated with dehiscence or the development of an oronasal fistula at the surgical site.

Epiphora was recorded for 15 of 164 (9.1%) dogs, none of which had been treated with incisivectomy or central maxillectomy. A significant ($P = 0.01$) association with epiphora was identified for dogs that had an orbitectomy (vs no orbitectomy).

Uncommon postoperative complications included mucoid ocular discharge ($n = 9$ [5.5%]), protracted sneezing (9 [5.5%]), nasal deviation (8 [4.9%]), enophthalmos (8 [4.9%]), dyspnea (6 [3.7%]), third-eyelid prolapse (5 [3.0%]), subcutaneous emphysema (5 [3.0%]), exophthalmos (4 [2.4%]), lagophthalmos (2 [1.2%]), sialoceles formation (2 [1.2%]), scleritis (2 [1.2%]), and corneal ulcer (1 [0.6%]). Iatrogenic contralateral ocular trauma was recorded for 2 (1.2%) dogs. One of these 2 dogs developed scleritis secondary to inadvertent surgical scrub contact, and the other sustained a corneal ulcer from insufficient artificial lubrication. These uncommon postoperative complications were not statistically analyzed for associations with other variables owing to the small sample size.

Three (1.8%) dogs died during the short-term postoperative period. This included 1 dog that had undergone caudal maxillectomy to remove an osteosarcoma and was euthanized 12 days after surgery owing to complications from repeated dehiscence and a nonhealing oronasal fistula. Another dog treated with complete maxillectomy to remove an osteosarcoma was euthanized 24 days after surgery owing to local recurrence of the tumor. The third dog had under-

gone complete maxillectomy to remove a peripheral odontogenic fibroma and died 6 days after surgery of complications due to underlying heart disease.

Discussion

The purpose of the present study was to characterize intraoperative and postoperative complications associated with maxillectomy for removal of oral tumors in dogs and to determine whether tumor size, tumor location, maxillectomy type, and surgical approach were associated with specific complications. The most common intraoperative complication was excessive surgical bleeding, and the most common immediate postoperative complication was epistaxis. Lip trauma was the most common short-term postoperative complication, followed by oronasal fistula formation and surgical site dehiscence. Although complications were frequent, they were generally minor and manageable with a few exceptions, and the incidence of death resulting from the surgery was low. Overall, the dogs appeared to tolerate the maxillectomies well.

The high incidence of excessive surgical bleeding identified in the present study (53.4%) corresponded with previously reported data for maxillectomies in dogs.^{1-5,8-10,13,16} Some degree of intraoperative bleeding is to be expected with maxillectomy considering the aforementioned vascular anatomic characteristics and challenging nature of the procedure. The subjective determination of excessive surgical bleeding represented a limitation of the present study. Because each anesthesiologist and surgeon likely had a different perception of what constitutes excessive surgical bleeding, data for this variable may have been under- or overestimated. To more accurately determine whether excessive surgical bleeding existed, the amount of blood lost during surgery could have been measured quantitatively, but this was not possible. Because excessive surgical bleeding has been recognized as a serious and likely complication of maxillectomy, it has been recommended that blood typing and blood product access be established before surgery begins, particularly when tumors are large (> 2 cm in diameter), located in the caudal portion of the mouth, and involve excision of the caudal portion of the maxilla, the orbit, or a DL-IO approach.⁸

Recording of instruments used to perform osteotomies in the present study varied in quality and completeness. Therefore, we were precluded from exploring potential associations between different types of osteotomy instruments and the incidence of excessive surgical bleeding or blood transfusion. Use of a pneumatic oscillating saw or osteotome and mallet may result in inadvertent damage and transection of major and minor regional blood vessels. Therefore, an osteotomy performed with these instruments should be done as quickly as possible to minimize excessive surgical bleeding.^{3,8} Quick removal of the excised bone allows for visual identification and hemostasis of hemorrhaging vessels. For

some maxillectomies performed in the present study, a piezosurgery unit was used to perform the osteotomy. Incisions made with a piezosurgery unit are achieved through microvibrations, and the unit can be set to target only mineralized tissue, thereby preventing the user from inadvertently cutting nerves, blood vessels, and soft tissue. Consequently, vessels can be visually identified and ligated as the bone is removed.^{17,18} This drastically reduces the likelihood of excessive surgical bleeding during the osteotomy. However, the piezosurgery unit is fairly slow in the performance of osteotomies, particularly those involving thick mineralized tissue.¹⁷

Although a sterile handpiece on a water-cooled, high-speed drill was not used in any of the maxillectomies performed in the present study, this use is described in the literature.^{1,19} These high-speed drills are able to cut faster than piezosurgery units and allow for more precise osteotomies than pneumatic oscillating saws and osteotomes with mallets; therefore, use of high-speed drills may provide for more control around sensitive vascular areas while minimally increasing the duration of surgery. In addition, round diamond burs can be exchanged with bone-cutting burs to allow for rounding and smoothing of mineralized tissue.^{1,18,19}

The use of a high-speed drill is a concern in human medicine owing to reports of induced emphysema in the local tissues secondary to air insufflation,¹⁸ although this complication has not been reported for dogs. In addition, use of high-speed drills typically involves distilled water for irrigation, and the water hosing cannot be sterilized. Therefore, the use of these drills for surgery has the potential to damage fibroblasts and introduce microorganisms into local tissues.¹⁸ The use of an autoclavable surgical handpiece on a low-speed oral surgery unit with a built-in sterile saline solution irrigation system has been suggested to reduce the risk of tissue damage and contamination.¹⁸ Overall, choice of osteotomy instruments is typically made on the basis of surgeon preference, excision type, and surgical access, given that not all instruments can be maneuvered in small, tight spaces, such as those along the caudal portion of the maxilla and periorbital region. It should be emphasized that regardless of the instruments used for osteotomy, ligation of all accessible major blood vessels supplying the region to be excised should be performed prior to osteotomy. Temporary carotid artery ligation can be performed to decrease the blood flow to the ipsilateral maxillary artery in dogs with large, extensive, or anatomically risky excisions²⁰; however, no dogs in the present study had preemptive carotid artery ligation.

Significant associations were identified in the study reported here among duration of surgery, presence of excessive surgical bleeding, receipt of a blood transfusion, and type of surgical approach. Although it may appear intuitive for duration of surgery to increase with excessive bleeding and transfusion,

no cause-and-effect relationship can be inferred to have existed between these variables because other variables such as tumor location, size, and type may have influenced the results. No attempt was made to control for these and other potential confounders in the analyses. A DL-IO approach is typically used for caudally located tumors involving a double surgical approach and possibly an orbitectomy; therefore, we believe that our observation that the DL-IO approach was associated with a longer duration of surgery than the IO approach was reliable.

Epistaxis, excessive facial swelling, facial pawing, and difficulty eating were immediate postoperative complications consistent with previously reported findings for dogs after undergoing maxillectomy.^{3,7,9,10,12,13,16} Although epistaxis was the most common immediate postoperative complication, this is a common consequence of any procedure involving the nasal cavity and was expected to have been mild and self-limiting after maxillectomy.¹ Immediate protracted epistaxis was unusual and occurred in only 1 dog following surgery. Postoperative facial swelling and discomfort were anticipated; therefore, a multimodal pain control plan was implemented, which involved NSAIDs and opioid derivatives. When the risk of tumor seeding was minimal, intraoperative administration of a regional anesthetic block was also used to reduce patient discomfort following surgery.

Excessive facial swelling associated with resections involving the caudal portion of the maxilla (caudal maxillectomy and complete maxillectomy) was not considered routine. Because of the increased amount of both hard and soft tissue trauma associated with these maxillectomy categories versus others, this finding was no surprise. It was also noted that difficulty eating was more likely to occur with caudally (vs rostrally) located tumors. Because excessive swelling and difficulty eating were not statistically evaluated for interdependence, the excessive facial swelling may have exerted pressure on regional tissue and the suture line, causing an increase in postoperative discomfort and difficulty eating. In addition, pawing at the face may have been caused by excessive facial swelling, neuropathic facial pain from transected regional nerves, or tension on the incision.²¹ Given that difficulty eating and facial pawing for the most part resolved within the 48-hour immediate postoperative period, these complications were likely linked to the swelling, and as the immediate postoperative swelling improved, dogs likely became more comfortable, resulting in the resolution of facial pawing and difficulty eating.

Lip trauma is a reported minor complication of a rostral maxillectomy^{3,6-8,12,13} and was identified in 13.4% of the dogs in the present study. Contrary to previous reports, lip trauma was approximately as common in dogs with caudally located tumors (10.5%) as in dogs with rostrally located tumors (18.3%). Lip trauma can be attributable to postoperative neuropraxia, denervation of maxillary soft tis-

sue, and anatomic relocation of tissue to achieve closure. Most dogs with lip trauma in the present study received no treatment for this trauma, and the lesions were generally managed conservatively until fully resolved. Callusing of traumatized tissue, a decrease in the amount of postoperative swelling, and resolution of postsurgical neuropraxia may have contributed to the full resolution of untreated lip trauma.

Oronasal fistula formation and wound dehiscence are known complications of maxillectomy. Each complication was recorded for 11.0% of dogs in the present study. In addition, fistula formation was significantly associated with tumors of the caudal aspect of the maxilla. Reported causes of oronasal fistula formation and wound dehiscence after maxillectomy include infection, inadequate vascular supply to surgical wound margins, high tension or motion at the incision, secondary trauma by mandibular teeth, and inappropriate chewing by the patient during the healing period.^{1,13,22-24} In 1 study,¹¹ the postsurgical dehiscence rate was 33%, with 80% of fistulae occurring caudal to the canine teeth. It has been suggested that dehiscence may be prevented by avoiding use of electrocautery at surgical wound margins and creating tension-free oral closures.¹⁰ As suggested by data recorded in the medical records and surgical reports of the present study, focused presurgical planning for tension-free closures and avoidance of surgical margin electrocautery may have contributed to the lower proportion of dogs with postsurgical dehiscence and oronasal fistulae formation than previously reported. Chronic dehiscence and persistent oronasal fistula formation have the potential to influence postoperative morbidity and mortality rates. In the present study, 1 dog was euthanized because of persistent dehiscence and chronic oronasal fistula formation only 2 weeks after surgery. In 3 dogs with persistent fistulae, multiple surgeries were required for repair.

Ocular problems are rare following maxillectomy in dogs, unless the procedure involves partial inferior orbitectomy.²⁵ Epiphora is an expected consequence of caudal or complete maxillectomy with or without an orbitectomy owing to the transection of the nasolacrimal duct.^{7,8,10,11} Although stent placement in the lacrimal duct has been recommended to facilitate re-epithelization of the duct, none of the surgeons in the present study elected to use this technique.^{7,10} Epiphora is a minor complication, and the few dogs that developed this condition in the present study had minimal aftercare associated with tearing.

Performed retrospectively at a tertiary referral institution over an 11-year period, the present study had several limitations. Inconsistent and changing medical record keeping and small sample sizes prevented evaluation of some potentially important variables (eg, osteotomy excision instruments, presurgical imaging, and clean surgical margins) for associations with outcome. In addition, the study population included a high proportion of dogs weighing > 10 kg with tumors > 2 cm in diameter in the caudal por-

tion of the mouth, which would have required more technically challenging excisions. This high proportion was most likely attributable to the presence of a specialized surgical oncology center at the study institution, resulting in selection bias. In addition, the large number of surgeons with different amounts of experience performing the surgery did not allow for consistency or standardization of surgical technique. As a result, reported complications could be over- or underrepresented relative to rates that might be expected in the general population of dogs with oral tumors undergoing maxillectomy.

Maxillectomy is known to be part of an effective treatment strategy for oral neoplasia in dogs and humans.^{1,26-28} Complications associated with maxillectomy in the present study were generally minor and non-life-threatening. However, we highly recommend aggressive surgical planning, preparedness for hemorrhage and transfusion, careful tissue dissection, and comprehensive pain control to address, minimize, or prevent the types of complications identified herein. This is particularly important for dogs with large, caudally located tumors requiring extensive excision. With adequate planning and preparation, we believe that maxillectomy can be a viable and safe treatment option for oral maxillary tumors in dogs.

Acknowledgments

Presented in abstract form at the 29th Annual Veterinary Dental Forum, Monterey, Calif, October 2015.

The authors thank Drs. Stacie Seelye, Yoav BarAm, Christopher MacLellan, and Stephen Withrow for their assistance.

Footnotes

- a. R, version 3.1.1, R Foundation for Statistical Computing, Vienna, Austria.
- b. SAS, version 9.4, SAS Institute Inc, Cary, NC.

References

1. Lantz GC. Maxillectomy techniques. In: Verstraete FJM, Lommer MJ, eds. *Oral and maxillofacial surgery in dogs and cats*. Oxford: WB Saunders Co, 2012;451-465.
2. Salisbury SK. Maxillectomy and mandibulectomy. In: Slatter DH, ed. *Textbook of small animal surgery*. Philadelphia: WB Saunders Co, 2003;561-572.
3. Liptak JM, Lascelles BDX. Oral tumors. In: Kudnig ST, Seguin B, eds. *Veterinary surgical oncology*. Chichester, England: Wiley-Blackwell, 2012;119-177.
4. Fossum TW. Surgery of the oral cavity and oropharynx. In: Fossum TW, Dewey CW, eds. *Small animal surgery*. St Louis: Elsevier Mosby, 2013;386-392.
5. Verstraete FJ. Mandibulectomy and maxillectomy. *Vet Clin North Am Small Anim Pract* 2005;35:1009-1039.
6. Withrow SJ, Nelson AW, Manley PA, et al. Premaxillectomy in the dog. *J Am Anim Hosp Assoc* 1985;21:49-55.
7. Salisbury SK, Richardson DC, Lantz GC. Partial maxillectomy and premaxillectomy in the treatment of oral neoplasia in the dog and cat. *Vet Surg* 1986;15:16-26.
8. Lascelles BDX, Thomson MJ, Dernel WS, et al. Combined dorsolateral and intraoral approach for the resection of tumors of the maxilla in the dog. *J Am Anim Hosp Assoc* 2003;39:294-305.
9. Wallace J, Matthiesen DT, Patnaik AK. Hemimaxillecto-

- my for the treatment of oral tumors in 69 dogs. *Vet Surg* 1992;21:337-341.
10. Salisbury SK. Problems and complications associated with maxillectomy, mandibulectomy, and oronasal fistula repair. *Probl Vet Med* 1991;3:153-169.
 11. Schwarz PD, Withrow SJ, Curtis CR, et al. Partial maxillary resection as a treatment for oral cancer in 61 dogs. *J Am Anim Hosp Assoc* 1991;27:617-624.
 12. Lascelles BDX, Henderson RA, Seguin B, et al. Bilateral rostral maxillectomy and nasal planectomy for large rostral maxillofacial neoplasms in six dogs and one cat. *J Am Anim Hosp Assoc* 2004;40:137-146.
 13. Liptak JM. Partial maxillectomy. In: Griffon D, Hamaide A, eds. *Complications in small animal surgery*. Ames, Iowa: John Wiley & Sons Inc, 2016;237-244.
 14. Campbell I. Chi-squared and Fisher-Irwin tests of two-by-two tables with small sample recommendations. *Stat Med* 2007;26:3661-3675.
 15. Owen LN. TNM classification of tumours in domestic animals. In: Owen LN, ed. *TNM classification of tumours in domestic animals*. Geneva: World Health Organization, 1980;53-53.
 16. Liptak JM, Withrow SJ. Cancer of the gastrointestinal tract. In: Withrow SJ, Vail DM, Page RL, eds. *Withrow and MacEwen's small animal clinical oncology*. 2nd ed. St Louis: WB Saunders Co, 2013;381-431.
 17. Hennet P. Piezoelectric bone surgery: a review of the literature and potential applications in veterinary oromaxillofacial surgery. *Front Vet Sci* 2015;2:8.
 18. Terpak CH, Verstraete FJM. Instrumentation, patient positioning, and aseptic technique. In: Verstraete FJM, Lommer MJ, eds. *Oral and maxillofacial surgery in dogs and cats*. Oxford, England: WB Saunders Co, 2012;55-68.
 19. Gingerich W, Stepaniuk KS. Bilateral rostral maxillectomy in the dog. *J Vet Dent* 2013;30:125-130.
 20. Holmberg DL, Pettifer GR. The effect of carotid artery occlusion on lingual arterial blood pressure in dogs. *Can Vet J* 1997;38:629-631.
 21. Rusbridge C, Heath S, Gunn-Moore DA, et al. Feline orofacial pain syndrome (FOPS): a retrospective study of 113 cases. *J Feline Med Surg* 2010;12:498-508.
 22. Marretta SM, Smith MM. Single mucoperiosteal flap for oronasal fistula repair. *J Vet Dent* 2005;22:200-205.
 23. Salisbury SK, Richardson DC. Partial maxillectomy for oronasal fistula repair in the dog. *J Am Anim Hosp Assoc* 1986;22:185-192.
 24. Van de Wetering A. Repair of an oronasal fistula using a double flap technique. *J Vet Dent* 2005;22:243-245.
 25. Matthiesen DT, Marretta SM. Results and complications associated with partial mandibulectomy and maxillectomy techniques. *Probl Vet Med* 1990;2:248-275.
 26. Kreeft AM, Smeele LE, Rasch CRN, et al. Preoperative imaging and surgical margins in maxillectomy patients. *Head Neck* 2012;34:1652-1656.
 27. Frazier SA, Johns SM, Ortega J, et al. Outcome in dogs with surgically resected oral fibrosarcoma (1997-2008). *Vet Comp Oncol* 2012;10:33-43.
 28. Tuohy JL, Selmic LE, Worley DR, et al. Outcome following curative-intent surgery for oral melanoma in dogs: 70 cases (1998-2011). *J Am Vet Med Assoc* 2014;245:1266-1273.