VIRTUAL PROGRAM GUIDE & PROCEEDINGS

2020 VIRTUAL CONFERENCE

Veterinary Dental Forum

October 30th - November 7th

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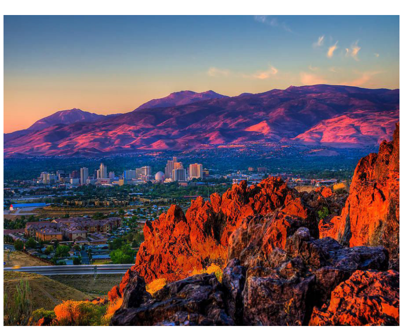

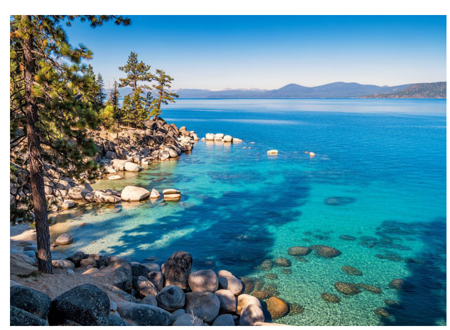

2020 VDF PROGRAM GRID - Friday, October 30th Lectures

FRIDAY	EASTERN	PROGRAM, PRESENTATIONS & SPEAKERS (Schedule is current as of 8.10.20 and is subject to change)
	9.00 – 9.30	**BREAK – VISIT EXHIBIT HALL. Vendors will be present for Q&A, to schedule appointments.**
WELCOME	**9.30 – 9.35**	**PLANNING COMMITTEE CHAIRS WELCOME. Speaker introductions. Sponsor video.**
FUNDAMENTAL/ INTERMEDIATE	9.35 – 10.25	**Rawlinson, J.** RADIOGRAPHIC ANATOMY AND INTERPRETATION
FUNDAMENTAL/ INTERMEDIATE	10.30 – 11.20	**Lobprise, H.** JUVENILE DENTISTRY PATHOLOGY…TREATMENT FOR A HAPPY LIFE
SPECIALIST IN TRAINING	9.35 – 10.25	**Grubb, T., Sager, J.** ANESTHESIA AS A CONTINUUM OF CARE (PART 1)
SPECIALIST IN TRAINING	10.30 – 11.20	**Grubb, T., Sager, J.** ANESTHESIA AS A CONTINUUM OF CARE (PART 2)
	11.25– 11.40	**BREAK – VISIT EXHIBIT HALL. Vendors will be present for Q&A, to schedule appointments.**
FUNDAMENTAL/ INTERMEDIATE	11.40 – 12:30	**Goldschmidt, S.** CONE BEAM CT IN VETERINARY DENTISTRY
FUNDAMENTAL/ INTERMEDIATE	12.35 – 1.25	**Lewis, J.** FELINE FRUSTRATION! STOMATITIS AND SQUAMOUS CELL CARCINOMA
SPECIALIST IN TRAINING	11.40 – 12:30	**Manfra Marretta, S.** RECOGNITION AND SURGICAL TREATMENT OF ORAL TUMORS
SPECIALIST IN TRAINING	12.35 – 1.25	**Manfra Marretta, S.** RECOGNITION AND TREATMENT OF CONGENITAL AND ACQUIRED PALATAL DEFECTS
	1.30 – 2.00	**BREAK – VISIT EXHIBIT HALL. Vendors will be present for Q&A, to schedule appointments.**
	2.00 – 2.05	**MODERATOR INTRODUCTION.** Speaker introductions. Sponsor video.
FUNDAMENTAL/ INTERMEDIATE	2.05 – 2:55	**Stepaniuk, K.** SURGICAL EXTRACTION OF THE MAXILLARY 4th PREMOLAR AND 1st AND 2nd MOLARS IN THE DOG
FUNDAMENTAL/ INTERMEDIATE	3.00 – 3.50	**Manfra Marretta, S.** TECHNIQUES FOR COMPLETING DIFFICULT EXTRACTION IN DOGS AND MANAGING EXTRACTION COMPLICATIONS
SPECIALIST IN TRAINING	2.05 – 2:55	**Snyder, C.** FUNDAMENTAL DECISION MAKING IN MANDIBULAR FRACTURE REPAIR - OPTIMIZING PATIENT OUTCOMES
SPECIALIST IN TRAINING	3.00 – 3.50	**Arzi, B.** CBCT: PRINCIPLES AND INTERPRETATION
	3.55 – 4.00	**MODERATOR THANK YOU.** Reminders for tomorrow and/or announcements. End of General Sessions.
	4.00 – 4.30	**VISIT EXHIBIT HALL. Vendors will be present for Q&A, to schedule appointments.**

2020 VDF PROGRAM GRID - Saturday, October 31st Lectures

SATURDAY	EASTERN	PROGRAM, PRESENTATIONS & SPEAKERS (Schedule is current as of 8.10.20 and is subject to change)
	9.00 – 9.30	**BREAK – VISIT EXHIBIT HALL. Vendors will be present for Q&A, to schedule appointments.**
WELCOME	**9.30 – 9.35**	**PLANNING COMMITTEE CHAIRS WELCOME. Speaker introductions. Sponsor video.**
ADVANCED	9.35 – 10.25	**Arzi, B.** MANAGEMENT OF CAUDAL MANDIBULAR FRACTURES IN CATS
ADVANCED	10.30 – 11.20	**Soukup, J.** COMPUTER-AIDED SURGICAL PLANNING
TECHNICIAN	9.35 – 10.25	**Hoerner, C.** A TECHNICIAN'S ROLE IN VETERINARY DENTISTRY
TECHNICIAN	10.30 – 11.20	**Berg, M.** PERIODONTAL DISEASE – UNDERSTANDING AND TREATING
	11.25– 11.40	**BREAK – VISIT EXHIBIT HALL. Vendors will be present for Q&A, to schedule appointments.**
ADVANCED	11.40 – 12:30	**Castejon Gonzalez, A.** PARTIAL AND TOTAL MANDIBULECTOMY PROCEDURES
ADVANCED	12.35 – 1.25	**Reiter, A.** SURGICAL MANAGEMENT OF CONGENITAL PALATE DEFECTS
TECHNICIAN	11.40 – 12:30	**Mills, A.** COMMON ORAL PATHOLOGY
TECHNICIAN	12.35 – 1.25	**Edwards, A.** MOVE IT OR LOSE IT – ORTHODONTICS FOR THE VETERINARY TECHNICIAN
	1.30 – 2.00	**BREAK – VISIT EXHIBIT HALL. Vendors will be present for Q&A, to schedule appointments.**
	2.00 – 2.05	**MODERATOR INTRODUCTION.** Speaker introductions. Sponsor Video.
ADVANCED	2.05 – 2:55	**Tsugawa, A.** RECENT UPDATE ON HEMOSTATIC AGENTS FOR ORAL AND MAXILLOFACIAL SURGERY
ADVANCED	3.00 – 3.50	**Taney, K.** SKIN FLAPS FOR FACIAL RECONSTRUCTION
TECHNICIAN	2.05 – 2:55	**Berg, M.** DIAGNOSTIC DENTAL RADIOGRAPHS TIPS AND TRICKS
TECHNICIAN	3.00 – 3.50	**Rollings, D.** ROOT CANAL THERAPY INSTRUMENTS
	3.55 – 4.00	**MODERATOR THANK YOU.** Reminders for tomorrow and/or announcements. End of General Sessions.
	4.00 – 4.30	**VISIT EXHIBIT HALL. Vendors will be present for Q&A, to schedule appointments.**

Speaker Biographies

Boaz Arzi, DVM, DAVCD, DEVDC
University of California, Davis
1 Garrod Drive
Davis CA 95616
Dr. Boaz Arzi is a Professor of Dentistry and Oral surgery at the department of Surgical and Radiological Sciences, UC Davis School of Veterinary Medicine. Dr. Arzi completed the residency-training program in dentistry and oral surgery at the school and two years fellowship in the UC Davis Department of Biomedical Engineering. He is a Diplomate of the American Veterinary Dental College (AVDC) and the European Veterinary Dental College. Dr. Arzi is also a Founding Fellow of the AVDC in Oral and Maxillofacial Surgery. Dr. Arzi's clinical and research focus is on oral maxillofacial disorders and regenerative solutions in dogs and cats. His lab also investigates TMJ disorders and treatments across species. Dr. Arzi is the director of the Veterinary Institute for Regenerative Cures (VIRC) at UC Davis. Ultimately, Dr. Arzi's work is translational with the aim of One Health treatment modalities for both human and animal health.

Mary Berg, BS, LATG, RVT, VTS (Dentistry)
Beyond the Crown Veterinary Education
1002 East 850th Rd
Lawrence KS 66047
Mary received her B.S. in Biology/Microbiology from South Dakota State University, her A.S. in Laboratory Animal Science from Redlands Community College, and her A.S. in Veterinary Technology from St. Petersburg College. She is a Charter member of the Academy of Veterinary Dental Technicians and received her Veterinary Technician Specialty in Dentistry in June 2006. Mary worked in research for over 28 years, specializing in products aimed at improving the oral health of companion animals and continues to work with companies to evaluate the efficacy of their products. In addition to her research background, she was the practice manager and dental specialist at a general practice for seven years. Mary is the founder and president of Beyond the Crown Veterinary Education, a veterinary dental consulting service, and is an adjunct professor for two veterinary technology programs. Mary is actively involved in NAVTA, AVDT, and KVTA. She also served on committees for the F4VD, AVMA, and AAVSB. Mary was named the NAVTA Veterinary Technician of the Year by NAVTA in 2020 and received the AVDT's Excellence in Dentistry Education in 2019. She has authored or co-authored over 80 publications, including publications in the Journal of Dental Research, multiple veterinary and veterinary technician journals, and will be releasing a textbook in 2020. Mary is a speaker and wet lab instructor at numerous state and national conferencesWhen not involved in veterinary medicine, Mary lives on a small farm near Lawrence, Kansas with her husband, Doug, a terrier mix, Gypsy, two opinionated cats, Ricochet and Ladybug, and an antique piece of yard art (aka, 29 year old horse). Doug and Mary have two sons and three grandchildren.

Ana Castejon Gonzalez, DVM, PhD, Dip AVDC, Dip EVDC
Ryan Veterinary Hospital, University of Pennsylvania
3900 Delancey St
Philadelphia PA 19104
Dr. Ana Castejon graduated from the Veterinary School of the Universidad Complutense de Madrid, Spain in 2001. She completed a PhD on bone regeneration and osteointegration of dental implants at the same institution in 2005. Dr. Castejon became an Assistant Professor at the Vasco de Gama University in Coimbra, Portugal in 2007 where her clinical, teaching and research interests focused on dentistry, surgery and anesthesia. She then completed a dentistry and oral surgery residency at the University of Pennsylvania School of Veterinary Medicine (Penn Vet) in Philadelphia and became a Diplomate of the American Veterinary Dental College (AVDC) and European Veterinary Dental College (EVDC) in 2017. She is currently a Staff Veterinarian in the Dentistry and Oral Surgery Service at Penn Vet's small animal hospital. Her main interests are oral surgery, oncologic surgery, maxillofacial trauma, and dental and oral developmental pathology.

Amy Edwards, RVT, VTS (Dentistry)
Atlanta Veterinary Dental Services
900 Mansell Rd Ste 19
Roswell GA 30076
Amy Edwards is originally from NC where she graduated from Central Carolina Community College's Veterinary Technology Program in 1997. She relocated to GA in 1999 and has been employed with Atlanta Veterinary Dental Services since 2004. In 2011 she was awarded the title of Veterinary Technician Specialist in Dentistry after completing the 2-year process and passing the board exam in dentistry. She enjoys teaching others the value that dentistry has on the overall health of pets and how to implement dentistry into their clinics. Outside of work Amy enjoys outdoor activities and spending time with her son Vincent. Her 4-legged family members include Viviana, a German Shepherd mix and Tara Grace, a Boston Terrier.

Stephanie Goldschmidt, BVM&S, DAVDC
University of Minnesota COVM
1365 Gortner Ave
St Paul MN 55108
Dr. Goldschmidt completed her dentistry and oral surgery residency at the University of Wisconsin - Madison, where she also completed her undergraduate degree in Animal Science. She received her veterinary degree from the Royal School of Veterinary Studies at the University of Edinburgh, Scotland and then went on to complete a rotating internship at the Veterinary Medical Center of Long Island. Her primary goal is to educate veterinary students so they are prepared to practice general dentistry after graduation. Her subspecialty clinical and research interests include oral oncologic surgery and advanced treatment of dental trauma with root canal therapy/crown placement.

Tamara Grubb, DVM, PhD, DACVAA
Washington State University
2022 Schultheis Rd
Uniontown WA 99179
Dr. Tamara Grubb is a board-certified veterinary anesthesiologist with a strong clinical interest and research focus in pain management. She earned her BS (1985) and DVM (1989) degrees from Texas A&M University and was in mixed animal practice before entering academia. She has a master's degree from the University of Illinois and a PhD in respiratory physiology from the Swedish University of Agricultural Sciences in Uppsala,

Sweden. Dr. Grubb is an associate in a small animal private practice, a certified acupuncturist, and an adjunct professor of anesthesia and analgesia at Washington State University. She serves on the board of directors of the International Veterinary Academy of Pain Management (IVAPM); as co-editor of Veterinary Anesthesia & Pain Management for Veterinary Nurses and Technicians (Teton New Media, 2019); and as co-chair of the AAHA 2020 Anesthesia Guidelines. She has received the Carl J. Norden Distinguished Teaching Award from students at both Washington State and Oregon State Universities.

Candice Hoerner, CVT, VTS-Dentistry
Big Sky Veterinary Dentistry Education
Whitefish MT
Candice began her veterinary career in 1998 and is a Certified Veterinary Technician since 2004. She received her designation of a Veterinary Technician Specialist in Dentistry in 2011, and is the only VTS in Montana. She is currently the President of the Academy of Veterinary Dental Technicians and is the Past-President of the Big Sky Veterinary Technician Association. She enjoys sharing her knowledge and passion of dentistry through lectures, wet labs and in-clinic trainings internationally through her company Big Sky Veterinary Dentistry Education LLC. Her hobbies include knitting, CrossFit, hiking, fishing, camping, and playing with her son in the great outdoors.

John R. Lewis, VMD, FAVD, DAVDC
Silo Academy Education Center/Veterinary Dentistry Specialists
455 Old Baltimore Pike
Chadds Ford PA 19317
Dr. John Lewis obtained his VMD from University of Pennsylvania in 1997 and spent 5 years in general practice prior to returning to the University of Pennsylvania for a residency in dentistry and oral surgery. Dr. Lewis became a diplomate of the American Veterinary Dental College (AVDC) in 2005. At the University of Pennsylvania, Dr. Lewis rose to the rank of Associate Professor of Dentistry and Oral Surgery. Dr. Lewis also served as Residency Director and Chief of Surgery of Ryan Veterinary Hospital at the University of Pennsylvania. Dr. Lewis is Past President of the American Veterinary Dental Society. Dr. Lewis is Editor-in-Chief of the Journal of Veterinary Dentistry, and writes a monthly column for Veterinary Practice News. In 2018, Dr. Lewis opened Silo Academy Education Center, and in 2019, Veterinary Dentistry Specialists, both located in Chadds Ford, PA.

Heidi Lobprise, DVM, DAVDC
Main Street Veterinary Dental Clinic
4100 Kirkpatrick Ln
Flower Mound TX 75028
Dr. Lobprise is a 1983 Texas A & M graduate. She became board certified in dentistry in 1993. After 10 years in industry, she returned to dental specialty practice in 2014. She is the author/co-author of three dental texts, has written many chapters and articles and has lectured internationally.

Sandra Manfra Marretta, DVM, DACVS, DAVDC
University of Illinois COVM
Mesa AZ 85215
Dr. Manfra Marretta received her DVM degree from Cornell University in 1977. She completed an internship, surgical residency and clinical dentistry training at The Animal Medical Center in New York City. She is a Diplomate of the American College of Veterinary Surgeons and a Charter Diplomate of the American Veterinary Dental College and an AVDC and ACVS Founding Fellow in Oral and Maxillofacial Surgery. She is a Professor Emerita in Small Animal Surgery and Dentistry at the University of Illinois. She is the author of over 250 publications including journal articles, chapters, abstracts and proceedings. She is the recipient of numerous awards, including the 2002 AAHA Veterinarian of the Year, The Animal Medical Center Alumna of the Year Award, The University of Illinois' Campus Award for Excellence in Graduate and Professional Teaching and The University of Illinois' College of Veterinary Medicine's All-Round Excellence Award.

Annie Mills, LVT, VTS Dentistry
Animal Dental Center
Parkville MD 21234
Annie Mills LVT, VTS (Dentistry) is a 1983 graduate from Macomb Community College in Macomb, Michigan. Since graduation, she has practiced in small animal hospitals around metro Detroit. In June of 2008, Annie received her VTS in Dentistry. Annie lectures
extensively throughout the country educating technicians in the general practice in all things dentistry.
Annie is currently working with Brett Beckman, DVM, FAVD, DAVDC, DAAPM, seeing referral cases in Atlanta, Georgia as well as Orlando, Florida.

Jennifer Rawlinson, DVM, DAVDC
Colorado State University
300 West Drake Rd
Fort Collins CO 80526
Dr. Rawlinson graduated from Cornell University Veterinary College in 1998. She completed her residency program in Dentistry at the University of Pennsylvania in 2004 and became an AVDC Diplomate in 2005 and AVDC Equine Diplomate in 2014. From 2004-2011, she created and ran the Dentistry Service at Cornell University. Since 2013, she has been running the Dentistry Service at Colorado State University as a tenured Associate Professor.

Alexander Reiter, Dr. med. vet., Dipl. AVDC, EVDC, FF-AVDC-OMFS
University of Pennsylvania
3900 Delancey St
Philadelphia PA 19104
Dr. Reiter is a Diplomate of the American Veterinary Dental College (AVDC) and European Veterinary Dental College (EVDC) and Professor and Chief of Dentistry and Oral Surgery at the University of Pennsylvania's small animal hospital. He also is a Founding Fellow, AVDC Oral and Maxillofacial Surgery (OMFS). His clinical and research interests include oral disease epidemiology, periodontal surgery, oral and maxillofacial surgery (trauma and oncology), palate surgery, and maxillofacial reconstruction.

Denise Rollings, CVY, VTS (Dentistry)
Pet Dental Education LLC
9506 Silver Pine Loop
Fort Myers FL 33967
Denise received her Associate of Applied Science degree in Veterinary Technology from Madison Area Technical College in 2001, graduating with honors. She was subsequently licensed as a Veterinary Technician after passing the National Veterinary Technician Examination. Denise had worked in general practice and emergency medicine, and found her passion for veterinary dentistry. She became a Veterinary Technician Specialist in Dentistry through the Academy of Veterinary Dental Technicians in 2014. After working in specialty dental practices, in 2017, Denise founded Pet Dental Education, LLC, offering on-site training in various aspects of veterinary dentistry for veterinary hospitals nationwide as well as working as a dental educator for several companies. Following her passion for teaching and inspiring others, Denise has lectured and taught labs nationally and internationally on topics ranging from veterinary dentistry, to improving standards of dentistry at individual animal hospitals. She also provides relief work, working for veterinary dentists and general practices. Denise is currently providing care for the patients of Pet Dental Center in Estero FL. Denise resides in Fort Myers, Florida with her husband and fur babies. She dedicates her time to improving oral care to the patients of veterinary hospitals across the country. She has passion for veterinary dentistry and strives to ignite that passion in others. She is a firm believer in improving the quality of our pets' lives, one tooth at a time. In her free time, Denise enjoys spending time with her family and friends, being outdoors and traveling.

Jennifer Sager, BS, CVT, VTS (Anesthesia/Analgesia, ECC)
University of Florida Veterinary Medical Hospitals
2015 SW 16th Ave
Gainesville FL 32610
Jennifer Sager is the current Small Animal Hospital Education and Training Specialist at the University of Florida, College of Veterinary Medicine and Veterinary Hospitals. Prior to this, she was the Anesthesia Service Technician and Supervisor for 14 years. Jennifer has a Bachelor's degree in Biomedical Science from Western Michigan University, and obtained her Veterinary Technology degree in 2003 from St. Petersburg College. In 2008, Jennifer attained her Veterinary Technician Specialty in Anesthesia and Analgesia, following up with a second Specialty in 2009 in Emergency and Critical Care. Jennifer has lectured around the US on various topics of Anesthesia and Critical Care, written three book chapters on Anesthesia (2012), Anesthesia and Critical Care (2018) and Supraglottic Airway Devices (2018), and is a trainer for Midmark Animal Health, teaching the fundamentals of Anesthesia to private practice clinics. Most recently, she contributed to the AAFP Anesthesia Guidelines (2018), and is co-chair of the AAHA 2020 Anesthesia Guidelines. Jennifer is the current President-Elect of the Academy of Veterinary Technicians in Anesthesia and Analgesia. When not in clinics, Jennifer enjoys running, camping, the beach and is a self-proposed cat fanatic.

Christopher Snyder, DVM, DAVDC
Dept of Surgical Sciences
University of Wisconsin-Madison
School of Veterinary Medicine
2015 Linden Dr
Madison WI 53562
Christopher Snyder is a Diplomat of the American Veterinary Dental College and Clinical Associate Professor and Residency Director of the Dentistry and Oral Surgery Service at the University of Wisconsin-Madison School of Veterinary Medicine. He has been recognized as a Founding Fellow, AVDC Oral and Maxillofacial Surgery. After graduating from The Ohio State University College of Veterinary Medicine he completed residency training at the University of Wisconsin-Madison. Dr. Snyder has authored journal articles, textbook chapters and has lectured nationally and internationally. He prides himself on the dentistry and oral surgery education he provides to students at the University of Wisconsin and the residents he has successfully mentored in the specialty. Dr. Snyder's academic and research interests include maxillofacial trauma and reconstruction, oral surgery and creating innovating techniques in veterinary dental education.

Jason W Soukup, DVM, DAVDC
University of Wisconsin-Madison
2015 Linden Drive
Madison WI 53706
Dr. Soukup is a clinical associate professor in dentistry and oral surgery at the University of Wisconsin-Madison School of Veterinary Medicine. He received his DVM from Texas A&M University in 2002. After completing an internship he spent three years in general practice before pursuing advanced training in dentistry and oral surgery at the University of Wisconsin-Madison. He was board-certified by the American Veterinary Dental College in 2009 and became a Founding Fellow-AVDC Oral and Maxillofacial Surgery in 2018. He serves as section head of the Dentistry and Oral Surgery service. His clinical and research interests are in the areas of dental and maxillofacial biomechanics and oral surgical oncology. He is also currently pursuing a PhD in biomechanics and enjoys running in his free time.

Kevin Stepaniuk, DVM, FAVD, DAVDC
Veterinary Dentistry Education and Consulting Services
Ridgefield WA 98642
Kevin S. Stepaniuk is a Diplomate of the American Veterinary Dental College (AVDC) and owns Veterinary Dentistry Education and Consulting Services, dba Veterinary Intraoral Radiology Reading Services and works clinically at Pacific Northwest Veterinary Dentistry and Oral Surgery. He has an undergraduate degree from the University of Calgary, DVM degree from Oklahoma State University and completed a small animal internship at Washington State University. His specialty training was in private practice. He is a previous faculty member and section chief of Dentistry and Oral Surgery at the University of Minnesota. He is an invited international and national renowned lecturer and instructor. Dr. Stepaniuk is a journal and textbook author as well as a reviewer for various dentistry and oral surgery publications. He is past-Executive Board member of the AVDC, and past-president of the AVDS. Dr. Stepaniuk provides continuing education to veterinarians, provides a service for reading intraoral radiographs for veterinary hospitals and veterinarians, and stays clinically active working in private specialty practice.

Kendall Taney, DVM, DAVDC, FAVD
Center for Veterinary Dentistry and Oral Surgery
9041 Gaither Road
Gaithersburg MD 20877
Kendall Taney is a Diplomate of the American Veterinary Dental College and a Fellow of the Academy of Veterinary Dentistry. She is a partner at the Center for Veterinary Dentistry and Oral Surgery in Gaithersburg, Maryland. She attended Virginia Tech and completed general and surgical internships prior to her dentistry residency. Her special interests include maxillofacial reconstruction and she is a candidate in the AVDC Oral and Maxillofacial Surgery Fellowship Program.

Anson Tsugawa, VMD, DAVDC
Dog and Cat Dentist, Inc
9599 Jefferson Blvd
Culver City CA 90232
Dr. Anson J. Tsugawa graduated as a veterinarian from the University of Pennsylvania, School of Veterinary Medicine in 1998. Following graduation, he completed a one-year internship in Small Animal Medicine and Surgery at the Metropolitan Veterinary Hospital (Akron, OH) and a three-year residency in Dentistry and Oral Surgery at the University of California-Davis, Veterinary Medical Teaching Hospital. During the final year of his residency, he was elected as Chief Resident of the Small Animal Clinic.
Dr. Tsugawa became a Board Certified Veterinary Dentist™ (Diplomate of the American Veterinary Dental College) in 2004, and was the 2005 recipient of the American Veterinary Dental College Outstanding Candidate Award, a national award presented to a highly qualified and productive veterinarian who has recently achieved board certification in veterinary dentistry.
He is the previous Chairman of the American Veterinary Dental College Examination Committee, and has also served as President of the North Bay Westside Chapter of the Southern California Veterinary Medical Association. Dr. Tsugawa is currently the Co-Chair of the Foundation for Veterinary Dentistry Grants Committee, serves as a reviewer for several international high impact factor veterinary journals, including Frontiers in Veterinary Science, Journal of Veterinary Dentistry, Journal of the American Veterinary Medical Association and Veterinary Surgery, has authored numerous textbook chapters on veterinary oral and maxillofacial surgery, and recently co-edited a textbook in veterinary dentistry that is recommended reading for candidates preparing for their specialty board examinations.
Dr. Tsugawa lives in Woodland Hills with his wife, Kristina, their blended family, and also two Pug dogs, Ben (a.k.a., Benihana) and Katsu.

VENDOR PRODUCT & SERVICE CROSS-REFERENCE GUIDE

The VDF provides the following vendor product referral guide to help you cross reference products with participating vendors. The products identified below are submitted by vendor companies. Vendor products are represented only if the vendor supplied the requested information on their registration forms or had previous records on file. Please see the complete vendor list, following this cross reference page, for a full list of participating vendors and their product descriptions. The VDF does not endorse any product or company by publishing this listing or other vendor information in this program.

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VENDOR PRODUCT & SERVICE CROSS-REFERENCE GUIDE

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MANAGEMENT OF CAUDAL MANDIBULAR FRACTURES IN CATS

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Oral and maxillofacial (OMF) trauma in cats poses multiple challenges for the clinician. Primarily, understanding the complex oral and maxillofacial anatomy, the innate nature of the cat and the type of trauma are critical to formulating an appropriate treatment plan. Importantly, management of caudal mandibular fractures poses an exceptional challenge due to the anatomic location and the small size of the caudal aspect of the mandible in cats. Imaging by means of computer tomography is the cornerstone of diagnostic imaging for OMFS trauma. This lecture will describe various approaches to caudal mandibular fractures in cats.

Diagnostic imaging of mandibular fracture in cats[1]

The skull is a difficult area to study radiographically because the bone structure is very complex. In recent years, computed tomography (CT) has become more available to veterinarians and more affordable. A study performed at UC Davis prospectively compared the diagnostic yield and contribution of conventional radiographs and CT in cats with OMF trauma. It was found that CT-images are superior to conventional radiographs both in an ability to identify the various anatomic components of the skull but also in the ability to detect OMF injuries. The average number of OMF injuries per cat by radiographs and CT-scan was 3.8 and 7.7, respectively. Separation of the mandibular symphysis, fractures of the pterygoid bones and fractures and dislocations involving the temporomandibular joint were particularly common in this species. CT allows for accurate assessment, diagnosis and treatment planning of OMF in cats. Contiguous thin slices, as well as a tridimensional reconstruction, are recommended.

Multidisciplinary approach to OMFS trauma in cats

The OMF region is rich in diverse functionality and tissue types. Tissues such as the brain, eyes, bones, teeth, for example, require special considerations. Therefore, OMF trauma may require the involvement of several specialists to optimize the outcome.

Management of caudal mandibular fractures in cats[2]

Fractures of the caudal aspect of the mandibles are commonly seen in the cat.[3] The more caudal the fracture is the more it will be surrounded by muscle mass that may prevents gross displacement of the fragments and may provide sufficient stabilization, in combination with a stabilization method (described below). The distal fragment may be displaced dorsomedially due to the muscle pull of the pterygoid muscles. From a regenerative perspective, bone that is surrounded by well vascularized muscle mass such as the masseter, pterygoid and temporal muscles, has suitable conditions for healing, provided that adequate stabilization is provided.

Fractures of the condylar process are the most common TMJ disorder seen in cats (followed by degenerative joint disease).[4] Fractures of the condylar process treated conservatively may heal by a bony union or as a pain-free and functional non-union. Conservative treatment of minimally displaced sub-condylar and pericondylar fractures without joint surface involvement is therefore justifiable. Comminuted and intra-articular fractures may result in TMJ arthrosis and possible ankylosis but the occurrence if ankylosis is rare. I recommend no rushing into a condylectomy procedure and perform this surgery only if TMJ ankylosis is developing.

Techniques for repair of caudal mandibular fractures

A wide variety of surgical and non-surgical methods are available for the treatment of caudal mandibular fractures in the cat.

Tape or nylon muzzle: A tape muzzle is useful in the first aid treatment of caudal mandibular fractures and is also indicated for the definitive treatment of stable and minimally displaced fractures, especially in patients with a deciduous dentition. The use of a tape muzzle can be considered as means of additional support in cases where internal fixation did not achieve optimal stabilization. When using a tape muzzle in cats, an additional strip of tape from the dorsum of the nose over the frontal region is helpful. A commercially available nylon muzzle may be an acceptable substitute provided it fits snugly.

Maxillomandibular fixation: Composite bonding of the canine teeth is commonly used for long-term mouth closure. This method aims to achieve reduction and stabilization of the fracture fragments by restoring and maintaining the normal dental interlock. The advantages of this technique are that no further damage is caused to the teeth or other tissues of the oral cavity, the complications associated with tape muzzling are avoided, and the technique can be applied in animals with poor bone quality. MMF is non-invasive and may achieve good restoration of occlusion. However, once the MMF is placed, reduction of the fracture fragments is completely dependent on the MMF and may not achieve ideal bone union or bone union at all . The main disadvantages are that a rapid return to normal function is not achieved and that the caudal fragment may displace in a dorsomedial direction. Vomiting and postoperative respiratory complications are particularly hazardous.

Miniplates and screws[5,6]: Bone plating is becoming more and more common as allows excellent fracture reduction and quick return to normal function. Maxillofacial mini plates and screws offer more versatility and have been used with success as neutralization or buttress fixation of mandibular, maxillary, and other maxillofacial fractures. Locking miniplate systems designed for mandibular fractures are an effective means for internal fixation of caudal mandibular fracturs in cats provided that a minimum of 2 locking screws can be placed at each fragment (caudal and rostral). Titanium miniplates have a modulus of elasticity and density similar to bone and enable osteointegration with the underlying bone. Selection of the correct miniplate and screws and use of the proper technique are crucial. The ideal and safe region for placing a locking miniplate is along ventrolateral surface of the mandible of cats.

Importantly, the anatomic location of tooth roots and the mandibular canal is an important consideration when planning the miniplate placement and it is important to minimize screw-root involvement during application of the plate.

This lecture will focus on various aspects of managing caudal mandibular fractures in cats. Biomechanical data of internal fixation as well as personal experiences will be shared and discussed.

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PARTIAL AND TOTAL MANDIBULECTOMY PROCEDURES

A.C. Castejón-González, DVM, Dipl. AVDC, Dipl. EVDC, A. M Reiter, Dipl. Tzt., Dipl. AVDC, Dipl. EVDC

Indications of mandibulectomy include oral neoplasia, mandibular fractures with poor or guarded prognosis after stabilization, some cases of osteomyelitis, osteonecrosis, and as salvage procedure for ankylosis.

The type of mandibulectomy needed depends on type, extension and location of the disease, curative or palliative intention of the treatment, and patient status.

The optimal surgical margin for oral tumors is not established; however, based on previous reports and personal experience, we tend to use 0.5 cm for peripheral odontogenic fibromas, 1 cm for acanthomatous ameloblastoma, >1 cm for squamous cell carcinoma, and >2 cm for other tumors if sufficient tissue is available. Soft tissue (skin, oral mucosa, intermandibular, and any other tissue) should be considered in the surgical planning in order to achieve tumor-free margins and functional closure.

A variety of techniques are available. The least invasive technique is the dorsal marginal mandibulectomy that include removal of the gingiva, alveolar mucosa, teeth, alveolar bone, and diseased tissue (tumor or necrotic bone), leaving the ventral border of the mandible intact. This technique usually is indicated in medium to large breed dogs with benign lesions that do not need wide margins. The advantage of this technique is that it preserves normal occlusion. However, it has to be carefully performed to prevent intraoperative mandibular fracture. Post-operative mandibular fracture may happen.

Mandibulectomy rostral to the mandibular first premolar (unilateral or bilateral rostral mandibulectomy) is relatively easy because there are no large vessels that need to be ligated, and it might be possible to keep the most caudal portion of the mandibular symphysis. It is indicated for small tumors in the incisive area of the mandible. Careful planning should be done to avoid leaving tumor cells invading the most caudal part of the symphysis if minimal intraoral lesion is visible. Osteotomies caudal to the mandibular second premolar involve ligation of the vessels at the level of the middle mental foramen (middle mental artery and vein) and also in the mandibular canal (inferior alveolar artery and vein).

Segmental mandibulectomy (excision of a fragment, thus keeping part of the mandible caudal and rostral to the resection) or unilateral rostral mandibulectomy caudal to the second premolar tooth will cause shifting of the lower jaw. The canine tooth opposite to the osteotomy site will traumatize the palate. Extraction or crown reduction with endodontic treatment is necessary. Some pets can keep appropriate occlusion while closing the mouth and show deviation only when opening the mouth. In this case, treatment might not be necessary; however, this is not predictable. Therefore, we recommend treatment of the opposite canine tooth at the time of surgical planning (diagnostic imaging and biopsy) or during the definitive procedure. Elastic training is another option to keep the occlusion; however, it does not work in all cases.

Subtotal mandibulectomy (excision of the mandible rostral to the mandibular foramen) and total mandibulectomy are more involved techniques. The largest vascular structures that need to be ligated are the mental branches (caudal and middle mental vasculature) and the inferior alveolar artery and vein before entering the mandibular canal. These vessels need to be ligated. Bradycardia and asystole can occur during manipulation of the nerve (trigeminocardiac reflex). Commissurotomy increases the visibility and access to caudal structures if a lateral and intraoral approach is selected.

Caudal mandibulectomy (excision of the ramus of the mandible) is performed for tumor resection and in cases of TMJ ankylosis.

Intraoperative complications

- Severe bleeding: Usually because of rupture, transection or inappropriate hemostasis of the inferior alveolar vessels in the mandibular canal, mandibular vessels caudal to their entry into the mandibular canal or maxillary vessels medial to the condylar process during disarticulation of the mandible. Inadequate hemostasis of other vessels in the soft tissue (labial and intermandibular vascularization) may sometimes occur.
- Trigeminocardiac reflex: Causing bradycardia and asystole due to the stretching the branches of the trigeminal nerve. It responds to anticholinergics. Constant communication with the anesthetist prior to manipulation of the branches is recommended.
- Damage of the ducts of the mandibular and sublingual salivary glands.

Postoperative complications

- Dehiscence: It is probably the most common postoperative complication. It can occur due to excessive tension on the suture line, presence of sharp edges on the osteotomy sites or incomplete excision of tumors, infection, and trauma.
- Hemorrhage and hematoma: Due to inadequate hemostasis.
- Excessive swelling, sublingual edema and sublingual sialocele: Sublingual sialocele can occur due to transection of the mandibular and sublingual salivary ducts or damage of the polystomatic portion of the sublingual salivary gland. Identification and ligation of the ducts, if they are involved in the excised tissue, is necessary to prevent sialoceles. Occasionally, it may be transitory after the procedure but resolves on its own after a couple of weeks.
- Trauma of the soft tissues (palate, lip) due to shifting of the opposite mandible toward the surgery site. The teeth that traumatize should be managed with extraction or endodontic treatment. Mandibular reconstruction can be considered in segmental mandibulectomies or bilateral rostral mandibulectomy.
- Recurrence after incomplete resection of tumors.

Reference list available upon request at anacaste@upenn.edu

SURGICAL MANAGEMENT OF CONGENITAL PALATE DEFECTS

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Introduction

The palate separates the nasal cavity and nasopharynx from the oral cavity and oropharynx. Failure in palate development results in an abnormal communication between these two spaces. Palate surgery is generally performed to repair congenital palate defects and re-establish the normal partition between the mouth and oropharynx and nose and nasopharynx.

Embryology

In many species, the medial nasal and maxillary prominences or processes fuse to form the lip and primary palate (upper lip and most rostral hard palate). Some authors suggest that the medial nasal prominences do not contribute significantly to lip formation or that the primary palate in dogs and cats is formed only by the maxillary processes. The secondary palate (majority of the hard palate and entire soft palate) is formed from bilateral palatal shelves that grow out from the maxillary processes. Initially the palatal shelves grow vertically down on either side of the developing tongue. These palatal shelves then elevate rapidly above the tongue and join with each other and the developing nasal septum. The midline epithelium from each palatal shelf degrades, resulting in a fused secondary palate.

Anatomy and Physiology

The hard palate is comprised of the palatine, maxillary and incisive bones and the palatal mucoperiosteum. There are six to ten depressions (palatine rugae) and transverse ridges. The incisive papilla opens at or just rostral to the first ruga on the midline. The major palatine foramina are located medial to the maxillary fourth premolar teeth on either side of the hard palate. One or more smaller minor palatine foramina may be located caudal to each major palatine foramen. The major palatine artery exits through the major palatine foramen, coursing rostrally and supplying the hard palate. Nerves (but no veins) run with the arteries. Several branches enter the palatine fissure and one branch courses between the maxillary canine and third incisor tooth to anastomose with branches of the sphenopalatine and infraorbital arteries. Venous blood of the hard palate is drained through an extensive palatine plexus. The soft palate is continuous with the hard palate and extends just caudal to the last maxillary molar teeth in most dogs and cats. Blood to the soft palate is principally supplied by the minor palatine arteries and drained by a palatine plexus that lies lateral to the palatine muscles. The soft palate muscles include the palatinus (shortening the soft palate rostrocaudally) and the levator and tensor veli palatine (elevating the soft palate dorsally and stretching the soft palate laterolaterally, respectively). The soft palate has a major function in swallowing per se and closing the intrapharyngeal opening during swallowing and vomiting, thus preventing swallowed food, liquid or vomitus from entering the nasopharynx and being subsequently aspirated.

Surgical Principles

The use of radiosurgery, electrosurgery or laser surgery should be avoided to minimize the possibility of tissue necrosis. Digital pressure with gauze sponges is often sufficient to control bleeding. Synthetic, absorbable monofilament material and simple interrupted or mattress sutures are recommended for closure. The best chance of success is with the first procedure. Surgical failure will result in scar tissue formation, making future attempts at closing the palate defect more difficult. Teeth at the surgical site and those that could traumatize flaps may be extracted, and the extraction sites should be left to heal for 6-8 weeks before definitive palate defect surgery. The flaps should be handled as carefully as possible (grasp and manipulate flaps on their connective tissue side with fine Adson 1x2 forceps or by means of stay sutures). The blood supply to the flaps must be maintained under all circumstances. A two-layer suture line should be employed with wide connective tissue surfaces or cut edges being sutured together. The suture lines should preferably not be located over a void, and closure under tension must be avoided.

Congenital Palate Defects

Congenital defects of the formation of lip and palatal structures may be inherited or result from an insult during fetal development (intrauterine trauma or stress). Clefts can occur if the intrauterine insult (trauma, stress, corticosteroids, antimitotic drugs, nutritional, hormonal, viral, and toxic factors) occurs at a very specific time in fetal development (25th to 28th day in dogs). Incomplete fusion of maxillofacial structures during fetal development may result in uni- or bilateral clefts of the upper lip, lateral area of the most rostral hard palate, midline of the hard and soft palate, and the lateral area of the soft palate. Rarely, the soft palate may be markedly reduced in length (hypoplasia). The growth of the palatine portions of facial bones in broad-headed fetuses may not always successfully compete with the growth of the head, and thus brachycephalic breeds tend to be at higher risk of developing defects of the primary and secondary palates.

Cleft Lip—This congenital defect of the primary palate appears as defect of the lip +/- most rostral hard palate and could be associated with abnormalities of the secondary palate. Unilateral defects occur more commonly on the left side. Except for being externally visible, cleft lips rarely result in clinical signs beyond mild local rhinitis, and repair may be performed for esthetic reasons. Simple sliding procedures rarely are successful because there is no connective tissue bed to support the flaps. The most rostral hard palate and the floor of the nasal vestibule are reconstructed by creating overlapping and advancement, rotation or transposition flaps of both oral and nasal tissue or flaps that are harvested from oral soft tissue only. Removal of one or more incisors and also the canine tooth on the affected side 6-8 weeks prior to definitive surgery will facilitate flap management. Lip repair is completed by reconstructive cutaneous surgery to provide symmetry.

Cleft Palate—This congenital defect of the secondary palate is almost always in the midline of the hard palate and associated with a midline soft palate abnormality. Soft palate defects without hard palate defects may occur in the midline or are unilateral; occasionally, soft palate hypoplasia may occur. An association with middle ear pathology was reported in dogs. According to the stage of development and the severity of the cause, other physical or neurological abnormalities may be present. Clinical signs and history of patients with cleft palate include failure to create negative pressure for nursing, nasal discharge (milk coming from the nares during or after nursing), coughing, gagging, sneezing, nasal reflux, tonsillitis, rhinitis, laryngotracheitis, aspiration pneumonia, poor weight gain, and general unthriftiness. The prognosis without surgical repair is guarded because of the continued risk of aspiration.

Timing of Surgery—Management of patients with defects of the secondary palate usually requires nursing care by the owner, which includes transoral tube feeding to avoid aspiration pneumonia. Most procedures for correction of defects of the secondary palate are performed on animals between 3 to 5 months of age. Surgery prior to 3 months of age is challenging due to the presence of delicate and friable soft tissues in very young animals. Postponing surgery until after 5 months of age may result in a wider cleft, as the animal grows, increased risk of aspiration, and compounded management problems, which are not desirable. Because clefts of the primary palate are associated with less severe clinical signs, the operator could postpone surgical repair until after eruption of the permanent incisors and canines, which may need to be removed if they prevent proper flap management.

Overlapped Flap—This technique is preferred for repair of congenital primary and secondary hard palate defects. There is less tension on the suture line, which is not located directly over the defect, and the area of opposing connective tissues is larger, which results in a stronger scar. This technique provides more reliable results for repair of hard palate defects compared to the medially positioned flap technique (the latter is more useful for repair of traumatic midline clefts of the hard palate in cats). Incisions are made in the mucoperiosteum to the bone (full-thickness) along the dental arch about 1-2 mm away from the gingiva and to the rostral and caudal margins of the defect on one side, forming an overlapped flap, and at the medial margin of the defect on the other side, forming an envelope flap. Both flaps are carefully undermined with a periosteal elevator. The major palatine artery exits the palatine shelf of the maxilla about 0.5-1 cm palatal to the maxillary fourth premolar (more rostral in the cat than the dog) and must not be transected during flap elevation. When the artery is identified at the connective tissue side of the overlapped flap, careful dissection close to it will release it from surrounding tissue to accommodate the rotation of this flap. The envelope flap also is undermined with a periosteal elevator on its medial margin to create a pocket of space for the overlapped flap. The overlapped flap is inverted at its base, turned and secured under the envelope flap with horizontal mattress sutures so that large connective tissue surfaces are in contact. Granulation and epithelialization of exposed bone generally are completed in 3 to 4 weeks.

Medially Positioned Flap—The medially positioned flap technique may be utilized for very narrow congenital hard palate defects. Incisions are made at the medial edges of the defect and along the upper dental arch about 1-2 mm away from the gingiva on one or both sides. The mucoperiosteum is undermined with a periosteal elevator (avoiding injury to the major palatine arteries), and the now mobile flaps are slid together and sutured over the defect. The exposed bone next to the teeth is left to granulate and epithelialize. If the relieving incisions are long and gape, a lateral oronasal defect may occasionally result, particularly in narrow-nosed dogs. Another disadvantage is that the rostral aspect of the sutured defect has a tendency to break down. In the case of midline clefts of the soft palate, incisions are made along the medial margins of the defect to the level of the caudal end of the tonsils. The palatal tissues are separated with a blunt-ended scissors to form a dorsal (nasopharyngeal) and ventral (oropharyngeal) flap on each side. The two dorsal and the two ventral flaps are sutured separately in a simple interrupted pattern to the midpoint or caudal end of the palatine tonsils.

Unilateral Soft Palate Defect and Soft Palate Hypoplasia—Repair of unilateral soft palate defects is performed with or without removal of the ipsilateral tonsil. The tonsillectomy incisions can be extended rostrally to meet at the most rostral location of the soft palate defect and continued along the medial edge of the soft palate. The pharyngeal and palatal tissues are separated, and two dorsal and two ventral flaps are sutured separately in a simple interrupted pattern to the midpoint or caudal end of the contralateral tonsil. Treatment of congenital hypoplasia of the soft palate is challenging, but may be treated in similar fashion after bilateral tonsillectomy and extension and continuation of incisions into the rudimentary, uvula-like soft palate tissue. Dorsal and ventral flaps are created and sutured separately in a simple interrupted pattern to the midpoint or caudal end of the tonsillectomy sites.

Other Techniques and Combination of Techniques—If an overlapping flap technique cannot be performed for repair of a cleft of the hard palate, a rotation flap made up of palatal mucoperiosteum and supplied by the major palatine artery on one side may provide a better alternative for repair of midline clefts of the hard palate than the medially positioned flap technique. The connective tissue surfaces and harvesting areas of bilateral overlapping flaps for repair of a midline cleft of the hard palate may be covered with bilateral buccal mucosa flaps following extraction of cheek teeth.

Perioperative Management

Pain is controlled with nerve blocks (maxillary, infraorbital and major palatine), opioids and non-steroidal anti-inflammatory drugs. Antibiotic treatment is usually not required after palate defect surgery in the otherwise healthy patient. Soft food is offered 8 to 24 hours after surgery and maintained for about 2-3 weeks. Feeding tubes are rarely needed in dogs to bypass the oral cavity, but it may be wise to consider placing one in cats. A gel containing dilute chlorhexidine or zinc ascorbate is administered into the mouth for 2 weeks. Elizabethan collars are used to prevent pawing at the surgical site. Skin sutures at sites of lip repairs are removed in 2 weeks. Follow-up surgeries should not be attempted prior to healing of all tissues involved.

COMPUTER-AIDED SURGICAL PLANNING IN ORAL AND CRANIOMAXILLOFACIAL SURGERY

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Oromaxillofacial surgery is an ever-evolving field in which oromaxillofacial surgeons continue to advance novel approaches and improve patient outcomes. Coupled with this advancement is a client base that remains receptive to state-of-the-art interventions that may improve the lives of their pet. The degree and extent to which surgical interventions are employed in oromaxillofacial surgical oncology is expanding. Additionally, efforts to improve the functional and esthetic effects of these surgical procedures are becoming an expectation of client and surgeon, alike. Soft tissue and osseous reconstruction of large defects is more commonplace that in previous decades. Such interventional efforts create significant challenges in surgical planning and execution. A superior three-dimensional visualization of oromaxillofacial region and associated pathology becomes critical.

However, these challenges also provide opportunities for methodological and technological advancement. Veterinary oromaxillofacial surgeons are among those pushing the boundaries of possibilities, employing technologies that allow patient-specific 3-D visualization both on a computer monitor with sophisticated software and in our hands with 3-D printed patient-specific models. Oromaxillofacial surgeons also utilize technology to create patient-specific surgical plans, surgical cutting guides and implants. The use of surgical planning software allows for virtual rehearsal that has been shown to improve surgical precision and decrease intra-operative time. Three-dimensional printing has revolutionized visualization of complex anatomy and pathology, improved surgical planning and allows for improved pre-surgical preparation, particularly in the field of craniomaxillofacial trauma.

As human and veterinary medicine inevitably move toward medical and surgical care that is more patient-specific, the use of computer-aided surgery for planning and execution will become more mainstream. The goal of this manuscript is to provide an overview of the principle elements of computer-aided surgical planning: imaging, segmentation and computer modelling, virtual surgery, implant design/manufacturing and 3-D printing.

Imaging

In order to maximize the benefits of computer-aided surgical planning, it is imperative to select an appropriate imaging modality. In order to make an appropriate imaging selection, understanding the surgical needs and the tissues involved is the first step. Namely, one needs to determine the relative import of spatial resolution and contrast resolution for each patient. Spatial resolution is the ability for an image modality to differentiate between two separate objects. For example, the distinction between the infraorbital canal and the surrounding maxilla. Contrast resolution is the ability for an image modality to differentiate image intensities between two areas. For example, the ability to differentiate areas of tumor contrast enhancement. Both medical computed tomography (CT) and cone beam CT (CBCT) have high spatial resolution but have varying and limited contrast resolution, making these modalities the imaging of choice in hard tissue interventions that are typical of oromaxillofacial surgery. CBCT has many advantages when used appropriately. However, while CBCT has the advantages of ease of use, lower radiation exposure and affordability relative to medical CT, its poor contrast resolution generally precludes its use for oncological surgery planning.

High-resolution CT scans with appropriate bone algorithms and thin images slice is required for oromaxillofacial cases. Slice thickness should be between 0.6 and 1.5 mm thick. However, in most cases, slice interval should be in the lower end of the spectrum, ideally less than or equal to 1.0 mm thick. Volumetric renderings lose fidelity with patient anatomy as slice thickness increases. The desire for thin slices to maximize anatomical detail is often balanced with the demand placed on the imaging equipment and the desire to minimize radiation exposure. Additionally, in cases where delineation of pathology from normal tissues requires contrast studies (i.e. oromaxillofacial tumors), medical CT is currently preferable to CBCT.

A potential alternative to CT imaging is high-powered (7 T) MRI. Only these high-powered systems can produce the submillimeter slice interval detail required for oromaxillofacial surgery. However, they are prohibitively expense and not widely available. Additionally, the requisite radiation exposure is of concern. However, black bone MRI techniques have been developed that can provide the detail and lower radiation exposure needed for hard tissue surgical planning.
Three-dimensional laser scanning provides another opportunity for imaging in cases that require meticulous detail; namely in orthodontics and orthognathic surgery. However, it is currently not being used in veterinary medicine and, therefore, will not be discussed here.

Data Acquisition

Successful surgical planning is highly dependent on the ability of the dataset to accurately duplicate anatomic detail, the dataset to be translated into a computer model and the software to facilitate surgical planning. To this end, datasets are stored in digital imaging and communications in medicine (DICOM) format, which allows for universal sharing between hardware and software systems. Processing of DICOM data into 3D objects allows the operator to manipulate in a variety of software programs. After creation of the computer model, further manipulation allows for surgical planning and exportation of the file, typically as a stereolithographic (STL) file. A commonly used software in both research and clinical practice is Mimics (Materialise, Leuven, Belgium). Importation of the DICOM file into Mimics allows the operator to interact with and manipulate the data in order to create 3D models of any tissue or region of interest (ROI). In order to further design elements (i.e. custom implants, cutting guides, etc.) the 3D model is exported into a compatible design software such as 3-Matic (Materialise, Leuven, Belgium). Mimics and 3-Matic are marketed primarily as a research and engineering platform. However, many veterinary clinicians, including this author, utilize it with success in the clinical setting. Materialise also produces several software products designed for medical use; one of which is designed for craniomaxillofacial surgery (Proplan CMF). The Materialise software suites have the advantage of allowing the operator to transform DICOM files into STL files within the same software environment that is used for surgical planning. This seamless transition improves repeatability and precision. Other software options are designed primarily for image processing and segmentation (i.e. itk-SNAP) and image processing/segmentation with 3D visualization (i.e. 3D slicer, Object Research Systems Dragonfly). 3D Slicer has the advantage of being open source. Other software products target 3D modeling and design (i.e. Strata Sculpt, Geomagic Freeform and Solidworks) and may be more useful in the hands of engineers. Three-dimensional modeling programs are well-suited for planning resections and designing cutting guides and custom implants. However, they are not targeted toward clinical applications and have a steep learning curve.
Alternatively, one could provide the acquired DICOM data set to a third-party vendor for processing, segmentation and product design. Major manufacturers of surgical implants, such as Synthes and KLS Martin offer patient-specific design and implant manufacturing service. This service is offered by Materialise through collaboration with Synthes. Other smaller, private companies (e.g. Voxelmed) and individual engineers also offer this type of service.

Segmentation and Computer Modelling

In order to properly plan a surgery and to design tools to facilitate such a surgery, a few preliminary steps are necessary. After data acquisition and importation of DICOM files into the chosen interface, the area of interest must be digitally partitioned from the surrounding tissue via a process known as segmentation. The goal of segmentation is to identify and separate one or several areas of interest into individual components that are easier to identify and manipulate digitally. Separation of digital components necessarily means that components are labelled according to pixel density.
Segmentation can be performed in a variety of ways but typically involves some form of algorithm to reduce the manual work and time needed. Generally, segmentation begins with a semi-automated process of identifying and assigning pixels to a group based on Hounsfield units (HU). A popular semi-automated algorithm is volume growing in which an anatomic structure within a certain range of HUs is detected and saved as one separate structure. Due to the wide variance in pixel density distribution in a medical CT dataset, the product of this

segmentation steps typically requires at least some manual refinement. The number of manual manipulation tools available is exhaustive and the description of these tools is beyond the scope of this manuscript. The selection of the adequate range of HUs is essential as improper assignment can result in anatomical components being artificially larger or smaller, which can result in improper surgical margins and poorly fitting cutting guides/ implants.

In many cases, particularly when planning osseous reconstruction after tumor resection, it is useful to mirror the healthy contralateral side of the patient onto the pathologic side. This allows the operator to print an anatomically correct 'healthy' avatar that can be used to design or pre-bend (with a 3D printed model) an appropriate implant. Artifacts that result from the segmentation or the 3D-imaging (metal implants etc.) itself must be digitally removed or smoothed out. The challenge lies in only removing the artifacts while maintaining fidelity to the patient's anatomy as mistakes may lead to cutting guides or implants not fitting properly. After all computer models (anatomy and implants) are complete, the final products are computer files that can be exported as an STL file, which is the standard format accepted by most 3D printers.

Virtual Surgery Planning

Virtual Surgery Planning (VSP) is a mechanism by which a surgery is planned and rehearsed within a virtual environment on 3D models. This may be on 3D printed models or 3D computer models. Typically, both modalities are utilized to maximize outcome. Due to the complexity of the craniomaxillofacial region, it has become a rapidly utilized process in oromaxillofacial surgery. Surgical resection of large tumors of the midface, periorbital and zygomatic regions are challenging and require osteotomies often performed without direct visualization of the tumor and/or critical anatomical regions (i.e. maxillary artery, bulla, sinuses and cranial vault). Rehearsing surgeries of this nature virtually, where tolerances for mistakes may be in the submillimeter range, allows for resections to be performed with higher precision, accuracy and confidence. This confidence is increased with implementation of patient-specific cutting guides where vital structures can be accounted for in the design. Additionally, outcomes may be improved. Recent studies demonstrated an improvement in obtaining clean surgical margins when VSP was used. (Tarsitano, 2017; Ricotta, 2018) Accuracy in distance, pitch and roll of osteotomies has also been demonstrated. (Bernstein, 2017; Foley, 2013) This author has utilized VSP in Mimics software to plan and rehearse complex tumor resections of the orbitozygomaticomaxillary complex and to plan complex midface reconstructions.

Implant Design/Manufacturing

An important component of surgical planning is the design of surgery aids like osteotomy or drill guides and custom implants. One of the most crucial aspects of this design phase is the communication between designer and surgeon. Inefficiencies will lead to undesired results and a substantial increase in time necessary to complete the design and manufacturing. After a rough sketch is made it is important to decide what kind and size of screws will be used. As mentioned earlier a variety of CAD-Software programs can be used to create the design of plates and guides. The design evolves in an iterative process until the needs for the patient and type or surgery are met. Material choices should be made early on as it will influence several decisions throughout the design phase. Plates and guides are usually made from either metal such as Titanium, stainless steel or Cobalt Chromium or biocompatible polymers.

Guide design greatly depends on the type and size of the instrument a surgeon will use to make an osteotomy cut. These can be oscillating saws, dental drills or piezotomes. The guide must withstand the forces of the instruments and allow for a precise cut. There should be little to no abrasion from the material the guide is made of. If there are particles that may remain within the body, they need to be biocompatible.

Plates come with the challenge that they need to be strong enough for the forces the animal will put on them. At the same time, you want to minimize weight and foreign material in the body. In addition, they need to reconstruct the defect in the patient's anatomy in a way that resembles the physiological situation. All of the above mentioned has to be achieved while making sure vital structures are not being severed and soft tissue irritation is kept to a minimum.

3D printing
3D printing and its application in veterinary oromaxillofacial surgery has been well covered elsewhere and the authors refer the reader to a recent publication. (Winer, 2017) It's use in the surgical management of craniomaxillofacial trauma is now well-established. This author has found 3D printing to be instrumental in volumetric understanding of craniomaxillofacial pathology and surgery planning, particularly in the surgical correction of non-traumatic acquired disease. While typical use of 3D printing involves solely osseous tissues, given appropriate segmentation any tissue that is contrast enhancing can be printed. This means that large contrast-enhancing tumors can be segmented and printed. Additionally, our service has recently begun designing and printing custom orthodontic appliances.

Limitations
While computer-aided surgery planning offers many substantial advantages, there are some limitations worth considering. Because the process of moving from CT data to a surgical outcome requires numerous steps, mistakes made at one step should be considered iterative. Acquisition of high-resolution CT data that accurately simulates the anatomy of the patient is critical. Therefore, poor choices made in imaging modality and imaging technique can lead to suboptimal outcomes. Mistakes in early steps (e.g. segmentation) can magnify the degree of anatomical infidelity of the 3D models and/or implants leading to poor outcomes. Human error is inevitable and may occur in the virtual setting. Care and time must be taken to get an accurate segmentation outcome. This refinement can take substantial amounts of time in complicated cases. The amount of time needed is proportional to the operator's familiarity with the software environments, which often have significant learning curves. This is one of the major drawbacks of the process. However, time taken prior to surgery leads to decreased intra-operative time and better surgical outcomes.

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SKIN FLAPS FOR FACIAL RECONSTRUCTION

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Resection of large tumors in the head and neck region results in challenging restoration of form and function. Similarly, traumatic loss of tissue, damage from radiation, or congenital deformities in this area may result in large defects that require primary surgical closure. Skin flaps are an integral tool for closure of larger maxillofacial defects. The elasticity and redundancy of skin in the dog and somewhat in the cat can provide a reservoir of healthy tissue and may allow for single stage reconstruction procedures. Local rather than distant skin flaps are typically developed with a single or less frequently a double pedicle. Skin flaps can be generally characterized as random pattern or axial pattern flaps. The blood supply for random pattern flaps is derived from the subdermal plexus. The subdermal plexus is the major vascular network of the skin. It is located within the subcutaneous tissues, both in the fatty layer and superficial and deep to the cutaneous musculature. When developing flaps this should be kept in mind, as preservation of the cutaneous musculature will maintain the integrity of the subdermal plexus. The blood supply to the facial region is richer than the blood supply to the lower extremities which provides some advantage to use of facial skin flaps. Some examples of random pattern flaps include advancement flaps, rotational flaps, and transpositional flaps.

Axial pattern flaps are pedicle skin flaps with direct cutaneous arterial and venous supply and can provide an immediate source of well-vascularized tissue to be relocated to a nearby defect. Four different axial pattern flaps have been well described in the literature with potential for maxillofacial applications: superficial temporal, angularis oris, caudal auricular, and omocervical. Additionally, an axial pattern flap of the facial artery has been described in both the dog and cat. The axial pattern flap utilized will depend on the location and size of the defect. The direct blood supply can allow for development of a longer and larger flap. With random pattern flaps the subdermal plexus can only maintain circulation to a flap approximately half the length of an axial pattern flap. Other studies have shown that loss of the direct cutaneous blood supply to an axial pattern flap results in a 50% failure rate.

Axial Pattern Flap Types

The blood supply to the superficial temporal axial pattern flap is derived from the superficial temporal artery. It is useful for defects in the dorsal nasal area and lateral facial area. The landmarks for the location of the vessels are the caudal border of the zygomatic arch and the lateral border of the caudal orbital rim. The length of the flap can extend to the mid-dorsal orbital rim of the opposite eye.

The caudal auricular axial pattern flap receives blood supply from the caudal auricular artery. This flap is useful for the many areas of the face, the dorsum of the head, and the ear. The flap should be centered over the wing of the atlas and the landmarks for the vessels are the depression between the lateral aspect of the wing of the atlas and the vertical ear canal. The flap length can extend to the spine of the scapula.
The angularis oris artery and vein can provide circulatory support to two different variants of axial pattern flaps. This vascular bundle located in the lateral facial surface caudal to the commissure can be used to develop a skin flap or a buccal mucosal flap. Both types have been described for closure of various defects including hard and soft palate, nasal (including nares), and upper lip.

The cutaneous branch of the omocervical artery provides blood supply to the omocervical axial pattern flap which can be used for some caudal facial defects and ear reconstruction. The vessels originate at the prescapular lymph node. The flap length can extend to the contralateral scapulohumeral joint. This flap is not commonly utilized for maxillofacial defects due to the distance the flap needs to travel to reach the facial region. Development of the caudal auricular and angularis oris axial pattern flaps has decreased usage of this flap for maxillofacial application. The facial axial pattern flap may be considered a combination axial pattern flap as it gives rise to the angularis oris as well as other vascular branches. Two small case series with vascular studies have evaluated the facial artery and the area of skin that is perfuses. Clinical success was noted in one case in a cat and three cases in the dog.

Surgical Considerations

Surgical planning is key to improving survival of skin flaps. The first determination that should be made is whether a random pattern flap will be adequate. If flap viability is likely to be questionable, an axial pattern flap can be considered. Axial pattern flaps require significantly more technical expertise and may increase surgical time and potential complications for the patient. The defect should be measured and the planned skin flap area should be marked prior to making incisions. Larger flaps may need to be rotated significantly to reach the defect. This will decrease the distance the flap can travel and should be taken into consideration when planning the dimensions of the flap, especially length. Suture can be used to mimic the arc of the flap and help with determining the design. The skin flap should only be as long as needed to cover the defect. The flap can be trimmed after development if excess length is noted. This can improve survival of the distal portion of the flap, which is most often where failure occurs and is also generally the most critical area for flap survival. Surgical principles of asceptic technique, gentle tissue handling, and minimal tension must be followed. For random pattern flaps the subdermal plexus should be maintained. Elevation of an axial pattern flap must include the subcutaneous fat and cutaneous musculature if present and the landmarks for vessel origination need to be identified. Care must be taken to avoid transection of the cutaneous artery and vein or survival of the flap will be compromised. Closure of axial pattern flaps should not include subcutaneous tacking sutures that may ligate the direct vasculature. The skin should be apposed with either a continuous or simple interrupted pattern. Overly aggressive manipulation of the base of an axial pattern flap can cause vasospasm which can jeopardize the blood flow to the flap. When closing the donor site care must be taken to direct tension away from the base of the axial pattern flap. Drains may be placed to reduce fluid buildup below the flap and should be removed once fluid production becomes minimal.

Complications such as swelling, partial necrosis, and partial dehiscence are common with skin flaps. Axial pattern flaps are prone to distal flap necrosis due to their length. An area of demarcation or skin darkening can be noted post-operatively immediately, within hours, or within the first several days. Wound dehiscence should be treated conservatively until the blood supply is able to fully establish and declare itself. Secondary procedures to repair dehiscence are often successful due to the new vascular network that develops during the first 7-10 days after surgery. Surgical repair of dehiscence is usually delayed for a minimum of 10-14 days when possible. Use of skin flaps for closure of maxillofacial defects often provides acceptable cosmesis, comfort, and function for the patient. Knowledge of anatomy, proper surgical planning, and ability to anticipate and manage complications is essential for success.

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RECENT UPDATE ON HEMOSTATIC AGENTS FOR ORAL AND MAXILLOFACIAL SURGERY

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INTRODUCTION

The richly vascular regional anatomy of the maxillofacial region typically presents itself as poorly accessible, and the encountered surgical fields often provide obstructed access to the surgical site. Therefore, when surgically induced bleeding does occur, due to this poor accessibility, the pooling of blood may occur rapidly, directly impacting the urgency to effectively identify and control the source of bleeding.

The most common oral surgical procedure performed in the companion animal patient is exodontia (i.e., extractions), and therefore, intraoperative (also referred to as **primary** hemorrhage) and post-extraction hemorrhage are the most likely stage for hemorrhage to be encountered by the veterinary oral and maxillofacial surgeon, and addressing this type of hemorrhage will be the focus of this presentation. In humans, post-extraction hemorrhage is typically considered hemorrhage that persists for greater than 8-12 hours. Post-extraction hemorrhage may further be categorized as either **reactionary** or **secondary** hemorrhage. Reactionary post-extraction hemorrhage is hemorrhage that occurs within two to three hours postoperative, whereas secondary post-extraction hemorrhage may occur up to two weeks post-extraction. In humans, mandibular third molar tooth extractions are the most commonly performed tooth extraction procedure and have a reported 0.6% post-extraction hemorrhage rate (Chiapasco 1993). To the author's knowledge, similar published rates are not available for companion animal extraction procedures.

Although most sources of tooth extraction-related hemorrhage caused by bone and soft tissue bleeding are relatively easily remedied at the time or surgery with direct digital pressure for a few minutes using a gloved finger and a saline-soaked gauze pressure pack, and to lesser degree, thermal sealing (electro- or laser cautery) of vessels, primary closure. Even these seemingly minor bleeds, if not controlled, may result in significant postoperative patient morbidity (i.e., facial swelling, tissue bruising), and may even necessitate re-anesthetizing the patient to re-enter the extraction site(s) to identify and control the source of bleeding. The significant and more worrisome sources of surgical hemorrhage are associated with vascular bleeds from the transection of larger diameter blood vessels, and these are best managed by direct vessel ligation, or ideally avoided through careful, methodical surgical technique.

OBJECTIVE

The topical hemostatic agents discussed here are not advertised as suitable alternatives for sound technique, or when tamponade and vessel ligation are viable options, but rather are recommended for adjunctive use, as an aid, in the promotion of hemostasis; particularly in patients with platelet disorders, congenital/acquired coagulation conditions, or in those receiving anticoagulant/antiplatelet therapy. Aluminum chloride and ferric sulfate, hemostatic agents that are often used to control light gingival bleeding associated with restorative dentistry procedures, tissue glues (cyanoacrylate adhesives), as well as other cutaneous use hemostat products, will be a lesser focus of this presentation.

OVERVIEW OF NORMAL HEMOSTASIS

Stages of hemostasis: vasoconstriction, platelet aggregation (formation of platelet plug), coagulation (stabilization of the plug with fibrin) and fibrinolysis (breakdown of the clot).

TOPICAL HEMOSTATIC AGENTS

Passive hemostatic agents

Passive hemostatic agents provide a scaffold or matrix onto which platelets aggregate to form a clot. These agents are commonly used across disciplines in patients with a normal coagulation profile to control minor hemorrhage.

Collagen-based products

Microfibrillar collagen

Available as sheets, sponges, that can be cut to fit, or also in more specialized forms, such as a flour, for controlling arterial bleeding, and in plug form, for use in extraction sockets or biopsy sites (CollaPlug®[1]). Compared to other products that have not been tested for ophthalmologic or neurologic use, Avitene™[2] is acceptable for use in all procedures, however, still needs to avoided in patients with known bovine allergies since it is derived from bovine dermal collagen. Proteolytic absorption occurs in 2-3 months (<86 days). As these products do require platelet activation and aggregation as their primary mechanism of action, they are less effective in thrombocytopenic patients. In addition to primarily serving as a matrix for platelet aggregation, microfibrillar collagen products also activate the intrinsic coagulation pathway.

Brand name: Avitene™[2]

Absorbable collagen

Sponge-like product manufactured from bovine deep flexor tendon as its collagen source. Highly absorbent, absorbs many times its weight in blood and wound exudate, and also encourages platelet aggregation. The typical resorption period is between 14-56 days (8-10 weeks).

Brand name: HeliTape®, HeliCote®, HeliPlug®[3]

Cellulose-based products (oxidized cellulose and regenerated cellulose)

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[1] CollaPlug®, Zimmer Biomet, Warsaw, IN
[2] Avitene™, BD, Franklin Lakes, NJ
[3] HeliTape®, HeliCote®, HeliPlug®, Integra LifeSciences Corporation, Princeton, NJ

Classic topical hemostatic likened to an interwoven fabric/mesh that was first introduced in the 1960s; that serves as a matrix for clot formation. The lower acidic pH of this product also causes hemolysis when in contact with blood providing a secondary caustic antimicrobial effect. Newer variants of Surgicel®[4] include a powder similar to the consistency of Arista™ AH[5]. Surgicel®[4] is fully absorbable in 7-14 days.

Brand name: Surgicel®[4], ActCel/Gelita-Cel[6]

Gelatin-based products

Gelfoam®[7] is a hydrocolloid created from porcine skin gelatin and has impressive absorption capabilities of up to 40 times its weight. Its hemostatic properties are believed to be purely mechanical, as a matrix for clot formation, and may be used in dry form or moistened with saline, but can also be used with thrombin (i.e., thrombin cannot be used with microfibrillar collagen). Gelfoam®[7] completely resorbs in 4-6 weeks.

Brand name: Gelfoam®[7], Vetspon®[8]

Microporous polysaccharide hemospheres (MPH)

MPH is a thrombin-free absorbable plant-based hemostatic powder that is derived from highly purified potato starch. The MPH molecule has a porous surface that acts as a sieve for absorbing water and low molecular weight compounds, <40,000 Da in size, and dehydrates the blood into a gel in a matter of minutes. MPH has a fast absorption profile, through the body's own amylases, in as early as 24-48 hours, and has a favorable 5-year shelf life.

Brand name: Arista™ AH[5]

Chitin/chitosan dressings

Another polysaccharide product, HemCon®[9], is a chitosan dressing derived from the chitin of freeze-dried shrimp exoskeleton. It was modified for oral surgical use from its original function as a combat wound dressing. HemCon®[9] typically dissolves within 48 hours from the surgical wound, facilitating early hemostasis, while allowing natural wound healing to proceed unimpeded. Chitosan products such as HemCon®[9] are cationic (positively charged) and function primarily through their ability to mechanically seal wounds by attracting red blood cells and platelets, both

[4] Surgicel®, Ethicon US, LLC, Cincinnati, OH
[5] Arista™ AH, BD, Franklin Lakes, NJ
[6] ActCel/Gelita-Cel, Coreva Health Science, LLC, Westlake Village, CA
[7] Gelfoam®, Upjohn/Pfizer, Inc., Kalamazoo, MI
[8] Vetspon®, Elanco US, Inc., Greenfield, IN
[9] HemCon®, Tricol Biomedical, Inc., Portland, OR

of which are negatively charged. Due to its lower pH, HemCon®[9] also has reported antibacterial/bacteriostatic properties.

Active/biological hemostatic agents

As their name suggests, these agents have biologic activity and directly participate in the coagulation cascade. Active agents are often combined with passive agents.

Fibrin Sealants - combination of human thrombin and fibrinogen that is applied to the surgical wound creating a crosslinked fibrin clot without the need for platelet activation. Fibrinogen is converted into fibrin monomers by the thrombin, and the monomers aggregate to form the fibrin clot. Newer generation fibrin sealants have faster prep/thaw times and utilize specialized syringes that spray or drip the sealant directly into the surgical wound without the need for bulky pressurized delivery equipment. Fibrin sealants are absorbed in approximately 10-14 days.

Brand name: Tisseel[10], Evicel®[11], Vistaseal™[12]

Topical thrombin/Factor II - sourced from bovine or human plasma, or through recombinant DNA processes. Commonly delivered to the wound in Gelfoam® or combined with gelatin granules - SURGIFLO®[13], which includes a porcine-derived gelatin, or Floseal Hemostatic Matrix[14], a bovine-derived gelatin.

Mechanism of action: initiates the cleavage of fibrinogen to fibrin.

Autologous platelet-rich fibrin membranes prepared from the centrifugation of the patient's own blood.

Mechanism of action: source of fibrin

Antifibrinolytics

Tranexamic acid (TA) - available as an oral solution/mouthwash, as a 5% topical, injection and also in pill form. Delivered to extraction sites in Surgicel®[4], Gelfoam®[7] or gauze as vehicles, or alternatively as an intraoperative irrigant. Used most commonly in the human hemophilia patient, and in patients receiving anticoagulant therapy. Can be used in routine dentoalveolar surgeries, but due to its limited availability, is often reserved for more invasive surgical procedures.

Mechanism of action: this synthetic lysine analogue reversibly binds to plasminogen, prevents plasminogen activation (i.e., the conversion of plasminogen to plasmin), and prevents fibrin clot breakdown

[10] Tisseel, Baxter Healthcare Corporation, Deerfield, IL
[11] Evicel®, Ethicon US, LLC, Cincinnati, OH
[12] Vistaseal™, Ethicon US, LLC, Cincinnati, OH
[13] SURGIFLO®, Ethicon US, LLC, Cincinnati, OH
[14] Floseal Hemostatic Matrix, Baxter Healthcare Corporation, Deerfield, IL

External Use Only!

Mineral zeolite (microporous aluminosilicate minerals)

QuickClot®[15] is a kaolin impregnated gauze. Kaolin is a naturally occurring inorganic aluminum silicate mineral that is derived from clay, and is used as an absorbant (i.e., dehydrates blood), but also directly activates Factor (Hageman) XII.

Alginate dressings

Hydrophilic polymers with potassium salts

WoundSeal®[16] - OTC micropolymer powder that creates a seal (artificial eschar) when applied to a bleeding wound. The polymer unfortunately does not resorb and therefore cannot be used in closed wounds.

OCCLUSIVE AGENTS

Occlusive hemostatic agents serve as mechanical barriers and are indicated for the control of light to even moderate-heavy bone hemorrhage.

Bone wax - the present-day formulation for bone wax is a highly purified beeswax that contains isopropyl palmitate as a softening and conditioning agent. The wax functions as a mechanical hemostatic by blocking the vascular openings with plugs of blood and wax. After hemostasis has been achieved, the bone wax should be removed, as the retained wax will initiate an intense foreign body reaction, characterized by giant cells, plasma cells, and fibrous granulation tissue, that will inhibit osteogenesis.

Alkylene oxide copolymer (OSTENE®[17]) - released in 2006, OSTENE®[17] is a water soluble bone wax alternative that comes in easy-to-mold (at room temperature) sticks that substantially resorbs in 24-48 hours, and does not impede bone healing or promote inflammation. Newer alkylene oxide copolymer variants, alkylene oxide copolymer combined with carboxymethylcellulose sodium salt, are available as an extensive range of hemostatic bone putties by Abyrx, Inc. (Irvington, NY): Absorbable Hemostatic Bone Putty®, Hemasorb Apply®, Hemasorb Plus® and Montage®[18].

SYNTHETIC TISSUE ADHESIVES

Cyanoacrylates as a class of synthetic tissue adhesives are better for closure and/or hemostasis of cutaneous wounds; when they are allowed to slough-off during the healing process rather than break down within the wound into potentially irritating and toxic (cyanoacetate and formaldehyde) breakdown products.

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[15] QuickClot®, Z-MEDICA LLC, Wallingford, CT
[16] WoundSeal®, Biolife, LLC, Sarasota, FL
[17] OSTENE®, Baxter Healthcare Corporation, Deerfield, IL
[18] Absorbable Hemostatic Bone Putty®, Hemasorb Apply®, Hemasorb Plus® and Montage®, Abyrx, Inc., Irvington, NY

Cyanoacrylates (PeriAcryl 90[19], GluStitch Inc., Delta, British Columbia) polymerize in the presence of blood and other oral fluids, such as saliva, is hemostatic, forms a hard mechanical barrier, and may also have bacteriostatic properties. PeriAcryl 90[19] is a blend of n-butyl and 2-octyl cyanoacrylates, and is available in a regular viscosity formulation as well as a high viscosity formulation that is nine times as thick as the regular formulation. Cyanoacrylates are well tolerated by oral tissues, promote healing and shorten surgical times. The butyl and isobutyl cyanoacrylates are the most suitable for use in the oral cavity, and the isobutyl form is the least cytotoxic. Butyl or isobutyl cyanoacrylates that are applied to mucogingival tissues are exfoliated in 4 to 7 days; however, only partial phagocytosis of the adhesive occurs when used in deeper tissues and therefore may result in granuloma formation.

CONCLUSION

As a class of topical hemostatic agents, collagen- and gelatin-containing passive hemostatic products remain as the predominant hemostat selection by the veterinary oral surgeon for addressing tooth extraction site hemorrhage, likely due to product recognition/familiarity, ease-of-use, stability (long shelf life) and affordability, however, if minimizing product absorption time to as short as 24-48 hours is considered an important characteristic for the selection of a topical hemostat, although comparatively more expensive, the potato starch derived microporous polysaccharide hemospheres (Arista™ AH[5]) would be the class leading choice. The shrimp chitin exoskeleton polysaccharide chitosan dressing, HemCon®[9], another lesser known hemostatic agent in the veterinary oral surgical community, should also receive serious consideration as a passive hemostat of choice due to its similarly rapid wound absorption time, and because it has the added benefit of being more slightly more cost effective. The utility of the class of biologic hemostatic agents are easy to recognize, in that they are active participants in stimulating the coagulation cascade, promoting the conversion of fibrinogen to fibrin, and therefore do not require platelet activation/aggregation as their mechanism of action, but they do have the significant drawback of high cost (i.e., especially for human-derived thrombin), and since they are derived most often from human or bovine sources of thrombin, although recombinant forms (Recothrom[20]) are available which have less risk, they still pose a potential risk for allergic reactions (anaphylaxis or anti-product antibodies) in patients. For the control of bone bleeding, alkylene oxide copolymers, such as OSTENE®[17], are favored over traditional bone wax due to its biodissolvability.

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[19] PeriAcryl 90, GluStitch Inc., Delta, British Columbia
[20] Recothrom, Baxter Healthcare Corporation, Deerfield, IL

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CONE BEAM COMPUTED TOMOGRAPHY (CBCT) IN VETERINARY DENTSITSRY

Stephanie Goldschmidt, BVM&S, DAVDC

Cone beam computed tomography (CBCT) is becoming more commonplace in both human and veterinary dentistry. CBCT scanners are similar to conventional multidetector CT scanners in that they have the ability to create a 3D reconstruction of acquired 2D radiographic images. CBCT, however, differs from conventional CT in the way images are acquired and reconstructed. Specifically, in a CBCT the x-ray source is emitted in a cone shape and detected on a flat plane detector. Furthermore, all the images are acquired in a single 270 or 360 º rotation of the gantry. Alternatively, in a conventional CT scanner, the x-rays are emitted in highly collimated fan beam geometry and detected on ceramic detectors. Due to this design, numerous rotations are required to acquire and reconstruct the 3D image.

Due to the differences in image acquisition and reconstruction with CBCT compared to conventional CT there are benefits and negatives to its' use for diagnostic imaging of the head and neck. The benefits of CBCT include a lower radiation dose, lower power requirement allowing a traditional 240V outlet to be utilized, decreased cost and rapid speed allowing for chairside office use, and lastly improved spatial resolution. Improved spatial resolution is one of the largest benefits for CBCT use for the head and neck. Spatial resolution refers to the ability to discern two objects that are very close together. Due to its' superior spatial resolution CBCT has been shown to have significantly superior imaging quality compared to conventional CT for diagnostic imaging of the dentoalveolar structures in both humans and dogs.

The large negative of CBCT compared to conventional CT is its' inability to detect subtle soft tissue changes. This is mostly due to poor contrast resolution as the x-ray beam in the CBCT is not highly collimated i.e. there is increased scatter. For reference, a CBCT scanner, on average, can detect differences in soft tissue of approximately 10 Hounsfield units (HU), while a conventional CT can detect differences as small as 1 HU. This inability to detect differences in soft tissue attenuation makes the CBCT very poor at detecting soft tissue pathology. To further this problem, although it is technically feasible, use of IV contrast with the CBCT has not been validated for use in dogs. Another large negative reported for its use in human dentistry is that motion artifact is more pronounced on the CBCT compared to conventional CT as images are obtained in a single rotation with no image overlap during reconstruction. This is often of no clinical concern in veterinary dentistry patients that are most often anesthetized for oral examination.

In short, the CBCT is a great option for evaluation of dentoalveolar and maxillofacial structures due to its relatively low radiation dose imaging with high spatial resolution obtained in a rapid single gantry rotation. It has been shown to be significantly superior to conventional CT for evaluation of enamel, dentin, trabecular bone, periodontal ligament space, and lamina dura in both humans and dogs. It has also been shown to be superior to dental radiographs in evaluation of dental disorders in brachycephalic dogs and cats. Specifically, abnormal eruption, abnormally shaped roots, periodontitis, and tooth resorption were diagnosed significantly more effectively in brachycephalic dogs with the use of the CBCT scanner. In cats the diagnostic yield of CBCT was significantly higher than radiographs for identifying missing teeth, horizontal bone loss, loss of tooth integrity, and tooth resorption. Furthermore, when evaluating the ability of CBCT to detect normal anatomic structures in brachycephalic dogs and cats, it was again found that CBCT had superior diagnostic yield compared to dental radiographs. The primary limitation in the use of the CBCT is that it cannot take the place of a conventional CT scan for evaluation of soft tissue pathology in the head and neck.

In the authors opinion the CBCT is an extremally useful addition to dental radiographs (or occasionally in place of dental radiographs) for 3D localization of pathology both pre-operatively and intraoperatively, evaluation of the severity of periodontal disease especially in small dogs with crowded teeth, confirmation of the presence of periapical lesions, diagnosis and confirmation of tooth resorptive lesions, and lastly for diagnostic imaging of jaw fractures and bony pathology.

3D Localization of Lesions

One of the most obvious benefits of using the CBCT in place of, or in addition to, dental radiographs is the ability to localize lesions and teeth in 3D for surgical planning. Cases were reviewed showing the obvious benefit of having a chair side CBCT for anatomical localization and surgical planning.

Periodontal Disease

Although periodontal probing and radiographs are the mainstay for diagnosis of periodontal disease, CBCT can be extremely helpful in evaluating the severity of the alveolar bone loss, especially in crowded teeth. This author also finds it extremely useful for evaluation of the maxillary first and second molar, which are often prone to superimposition on dental radiographs.

In humans, it has been shown that dental radiology alone cannot distinguish between bone loss on the buccal or lingual plates and is overall inferior to CBCT in diagnosis of both furcation exposure and vertical bone defects. In one study, correct identification of vertical defects occurred in 82.7% of cases with dental radiographs, while 99.7% were correctly identified with CBCT! Another study revealed that vertical bone pockets were underestimated by an average of 1.5 mm (+/- 2.6mm) with dental radiographs alone.

In dogs specifically, CBCT has been shown to be superior to dental radiographs for diagnosis of periodontal disease in brachycephalic dogs. It was found that indications for extraction due to severe periodontal disease would have been missed in 44.72% of cases if radiographs alone were utilized compared to 100% accurate diagnostic rate if CBCT was utilized (viewed in slices mode).

Cases were reviewed outlining how the CBCT changed the periodontal treatment plan compared to treatment planning based on dental radiographs alone.

Endodontic Disease

Numerous studies in the literature support that CBCT is superior to radiographs for diagnosis of apical periodontitis (periapical lucency representing an abscess, cyst, or granuloma that formed secondary to pulp infection and necrosis). In one article, where pulp infection was experimentally induced in dogs, no evidence of apical periodontitis was noted at day 14 and 47% was detected at day 21 when dental radiographs were utilized as the diagnostic imaging tool. Conversely, an apical lucency was detected in 33% of teeth at day 14 and 83% at day 21 with the use of a CBCT. Another study evaluating successful healing of apical periodontitis following root canal therapy showed that radiographs falsely diagnosed favorable outcomes almost 3 times more than CBCT! In other words, dental radiographs were found to be unreliable in properly detecting the presence of apical lesions and also in the ability to evaluate changes in size of the apical lucency with time.

The primary limitation with dental radiographs and endodontic disease is that this imaging modality is subject to the specific location of the apical bone loss. If the apical lesion is confined within cancellous bone and there is substantial cortical bone still present, this will may mask the appearance of an apical lesion on radiographs. Furthermore, differences in beam angulation or sensor positioning can substantially change the appearance of apical lesions in radiographs making serial monitoring for evaluation of healing more challenging.

Cases were reviewed showing how CBCT was superior at revealing the presence of apical lucency compared to dental radiographs, and due to this changed the clinical treatment plan.

Jaw Fractures and Bony Lesions

It has been shown that CT scan is superior to skull radiographs for evaluation of maxillofacial trauma, with CT demonstrating 1.6 times more injuries in dogs and 2.0 times as many injuries in cats. Although this study was performed with conventional CT viewed in the bony window, CBCT would be expected to have the same outcome and ability to have an increased diagnostic yield for evaluation of the extent and severity of maxillofacial fractures. CT scanning, and now also CBCT scanning due to its rapid chairside availability, is the standard of care for human maxillofacial and dentoalveolar trauma.

Cases were reviewed showing how 3D imaging of maxillofacial trauma was essential for proper treatment planning.

Lastly, bony pathology cases were reviewed showing how CBCT could be used to surgically plan the best place to take a biopsy as well as for advanced surgical planning in place of conventional CT.

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FELINE FRUSTRATION: STOMATITIS AND SQUAMOUS CELL CARCINOMA

John Lewis, VMD, FAVD, Dipl. AVDC

STOMATITIS

Diffuse inflammation of the entire oral cavity is seen commonly in cats. When inflammation is confined to the gingiva, it is referred to as gingivitis. When the inflammation extends beyond the mucogingival line in cats, it is called stomatitis, feline gingivostomatitis (FGS) or mucositis. Cats with stomatitis are often presented with pain upon eating and yawning, hyporexia, halitosis, drooling, lack of grooming, dehydration, and blood-tinged saliva. Stomatitis may be due to a variety of causes, including ingestion of a caustic substance, uremia, viral exposure, plant foreign bodies, allergic response to drugs, or most commonly, immune-mediated causes. Cats are often affected by a histologic type of stomatitis referred to as lymphocytic-plasmacytic stomatitis (LPS), which can involve gingiva, alveolar mucosa, buccal mucosa, sublingual mucosa, and even the mucosa of the caudal oral cavity lateral to the palatoglossal folds. Unilateral manifestations should be investigated for causes other than LPS, such as eosinophilic and neoplastic causes.

Stomatitis can be further characterized based on location. Rostral stomatitis (or rostral mucositis) refers to inflammation adjacent to the teeth, and caudal stomatitis (mucositis) refers to inflammation in the caudal oral cavity lateral to and sometimes including the palatoglossal folds.

The cause of FGS is not clear, but it appears that cats develop inappropriate inflammation in the presence of even small amount of plaque accumulation. Many cats with FGS concurrently shed both herpesvirus and calicivirus.1 These viruses may have an effect on the immune system, resulting in an overzealous or deficient immune response to plaque. Therefore, plaque control in the form of frequent dental cleanings and home care is very important. Unfortunately, many FGS cats are so painful that home care is not feasible. Immunosuppressive agents such as corticosteroids and cyclosporine help in many cases, but when medical therapy fails or causes unacceptable side effects, full mouth extractions or nearly full-mouth extractions have been shown to provide clinical resolution of oral discomfort in approximately 67-80% of cases.2 A review of current therapies of the disease was written in 2016.4

SQUAMOUS CELL CARCINOMA

Oral tumors account for approximately 10% of all feline neoplasia. These tumors are often aggressive and prognosis depends on early detection. The most common oral tumor in cats is squamous cell carcinoma (SCC), which accounts for approximately 70% of all oral tumors in cats.19 The appearance of SCC varies. Some SCCs manifest as an ulcerative area rather than a visible mass, and some can mimic a tooth root abscess that does not heal after extraction of a tooth. If extraction of a tooth seems too easy, it may be due to loss of attachment structures caused by SCC, so when in doubt, biopsy the surrounding bone and soft tissue.

To be able to provide a cure for SCC, early detection is particularly important in cats due to the patient's smaller size and need to obtain clean surgical margins while still maintaining adequate function. Cats do recover more slowly from maxillectomy and mandibulectomy than dogs and therefore require placement of an esophagostomy tube during the recovery period, whereas dogs usually eat and drink within 24 hours after surgery. One study found that 12% of cats undergoing mandibulectomy never regained the ability to eat on their own.5

It is important to obtain a biopsy in suspected cases, because SCC lesions can look similar to other lesions such as feline stomatitis or eosinophilic granulomas. Use of advanced diagnostics such as dental radiographs or CT scan is very helpful in determining which patients may be cured with surgery. Although SCC in cats is historically considered unlikely to metastasize, aspiration of mandibular lymph nodes is warranted prior to mandibulectomy or maxillectomy, one study found a metastatic rate of 31% to the mandibular lymph nodes and a 10% incidence of nodules seen on thoracic radiographs.6 A surgical cure is sometimes not possible, depending on location and size of the tumor. Debulking of these tumors is largely unrewarding, resulting in more bleeding and non-healing ulceration. Sublingual and caudal maxillary masses are unlikely to be cured surgically. However, rostral mandibular and mid-body mandibular masses may be amenable to radical resection by an experienced oral surgeon.

One study that looked at risk factors for development of feline SCC showed an increased risk in cats that wore flea collars. Other risk factors included intake of tuna and a diet consisting of predominantly canned foods.7

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JUVENILE DENTISTRY PATHOLOGY…TREATMENT FOR A HAPPY LIFE

Heidi Lobprise DVM, DAVDC

Introduction -With the rapid changes that can occur as a puppy or kitten grows, a thorough examination at every visit can help monitor the sequence of growth and tooth eruption, or if abnormalities arise. Genetic influence can play an important role in occlusion, with potential problems in both deciduous and permanent dentitions. Developmental abnormalities can be first noticed in young dogs and cats, and acquired lesions from nutritional influences, illnesses or trauma can impact the growing oral cavity as well.
Client education from the beginning is important as well, particularly in dogs if the patient is going to be small or micro at adulthood. Significant periodontal issues often arise in smaller dogs, with longer life spans, so home care, regular examination and professional care are vital.

Developmental Issues - A variety of developmental lesions can be diagnosed in the oral cavity. Primary cleft palates are often associated with unilateral cleft lip, while secondary midline cleft palates often present more critical problems for the pet, particularly the newborn. If the patient can be maintained on tube feeding until further maturation, many of these lesions can be repaired. While waiting for the patient to attain a reasonable, stable size, teeth in the primary cleft region can be extracted to prepare the site for better surgical flap design. Treatment planning may also include the use of auricular cartilage or fascia membranes to support the soft tissue flaps or grafts. Management of opposing mandibular teeth may also be necessary to minimize potential trauma during the healing phase.

Other less common issues may include hypoplasia of the soft palate (unilateral or bilateral) that can cause issues with swallowing, or substances refluxed into the nasal cavity. Microglossia is a rare but lethal malformation of the tongue with abnormal margins not fimbriated and nursing is not successful. Other systemic abnormalities can be seen with this syndrome. Tight lip in SharPei dogs can result in the lower lip covering the mandibular teeth and even interfering in jaw growth. Repair with enhancing the vestibular depth can minimize problems. Craniomandibular Osteopathy (CMO) seen in some terriers (West Highland White) is seen as a periosteal proliferation that can be extensive to the point of encompassing the TMJ and limiting jaw movement. While these often resolve on their own, symptomatic relief for pain and discomfort can be advantageous

Eruption Issues - With most dogs and cats, the deciduous teeth will erupt during 3-6 weeks of age, and the permanent teeth erupt between 4-6 months of age. There will be individual variations, and some small dog breeds are known to have delayed eruptions (Tibetan Terriers). Some permanent teeth do not have corresponding deciduous teeth, but both are formed as ectodermal epithelium is pushed into the ridge of developing mesothelium.

When there is a disruption in eruption, often there is persistent tissue over the tooth that is interfering with the coronal movement of the tooth. A tough gingival covering, called an operculum can be enough to halt movement, but simple excision of the tissue over the crown of the tooth will allow further eruption, as long as the apex is still open. If bone is present over the unerupted crown, it is considered to be embedded, and the bone should be carefully removed without injuring the crown beneath. If the apex is already closed, it is unlikely that additional eruption will occur. Also see dentigerous cyst below.

Delayed exfoliation of the deciduous teeth when the permanent teeth are erupting will cause the permanent one to erupt into an abnormal position. Most will erupt lingual to the deciduous tooth; the maxillary canine will erupt rostral to its deciduous counterpart. Persistent (retained) deciduous teeth are a common cause for permanent base narrow (linguoversion) mandibular canine teeth or rostroversion maxillary canines. (see malocclusions)

Dental Abnormalities

Missing or Extra Teeth - Some dogs and cats have missing teeth (oligodontia or hypodontia) for no known reason, particularly in small breeds. If a tooth is visibly missing – or the deciduous tooth is still in place – the area should be radiographed. If the tooth is truly missing, it should be recorded, and some retained deciduous teeth remain stable if the succedental permanent tooth is not present. Breeds with dermal dysplasias (Chinese Crested dogs) often will have multiple missing permanent teeth and the remaining deciduous teeth may be their only functional dentition.

An unerupted tooth can eventually form a dentigerous cyst. Cells around the neck of the tooth that are normally lost during eruption can cause significant cystic changes when retained under the surrounding tissue. Early cystic changes may be minor, but if left undetected, extensive osseous changes can occur, to the extent of pathological fracture of the jaw. The mandibular first molar of brachycephalic dogs (Boxers, Bulldogs) are most commonly affected. Occasionally an erupted tooth will cause no permanent damage, and continue to mature underneath the gumline, but this is the exception.

If supernumerary (extra) teeth causes any crowding of teeth, predisposing the area to periodontal disease, then extraction may be the best. Some breeds such as Boxers are known for having supernumerary teeth, particularly incisors, and if crowding is not an issue, they can be kept.

Abnormal Tooth Formation - Many teeth can have abnormal formation, from microdontia and macrodontia to extra roots and variations in shape. Two adjacent teeth that fuse together during development are called fusion teeth, and there will be a reduced tooth count with one larger tooth, often with a double crown. Gemination teeth are formed when a tooth tries to 'twin' itself, but the separate is incomplete (complete separation would have resulted in a supernumerary tooth). A 'double crown' will also be present, but the proper number of teeth will be present. Sometime the roots will be fused, or sometimes three roots will be present instead of two. This is most common in the mandibular fourth premolar in cats.

Any disruption in the normal architecture of a tooth during development can be termed 'dilaceration', from the development of curved or twisted roots to abnormal crown formation. If the enamel and dentinal layers do not form properly with an invagination of the enamel into the dentinal layers, this 'dens-in-dente' lesion often results in pulpal exposure, resulting in a non-vital pulp and the need for extraction. A variation of this malformation can be found in the mandibular first molar of small breed dogs, and sometimes the maxillary fourth premolars. A disruption in the eruption and maturation typically results in defects between the crown and roots, abnormal root structure (converging, wide pulp), pulpal stones and bone loss extending from the apex or all around the root structure. A comparison to a human anomaly MIM (molar-incisor malformation) has been discussed, exhibited by narrow, shortened or almost completely absent roots but with clinically normal crowns of the mandibular first molars.

Changes to enamel structures can be genetic or developmental, the result of some noxious stimuli or damage to the enamel organ during formation such as a fever, infection or trauma. Enamel hypoplasia is an inadequate deposition of enamel (thin or underdeveloped), and some lesions are due to hypocalcification of the enamel. Once erupted, this underdeveloped or soft enamel will become pitted, discolored, wear off easily and often be associated with abnormal root structure as well. Lesions may be focal or limited if the insult was discrete or short in time (trauma, short disease), or generalized with more extended disease (distemper). Focal crown lesions can be restored with composites, but more generalized disease benefits from removal of abnormal enamel (scrubbing), smoothing the remaining edges and placing a bonding agent on the exposed dentin. If roots are affected (sometimes completely gone), stability of the remaining crown is assessed: if the structure is non-vital or unsound, then the tooth should be extracted.

The term amelogenesis imperfecta can encompass enamel hypoplasia and hypocalcification, or used for a specific autosomal recessive mutation in the Standard Poodle, Italian greyhound and Samoyed. Dentinogenesis imperfecta will be seen as a discoloration of teeth, from translucent to gray or brown, often generalized. Pulp canals are often obliterated with an amorphous material less dense than typical dentin, and these teeth are prone to fracture and attrition.

Malocclusion – Dental and Skeletal - A normal occlusion is typically defined by a ‘scissor’ bite (maxillary incisors slightly rostral to mandibular incisors), the mandibular canine fitting into the space (diastemal) between the maxillary third incisor and canine, and the mandibular molars and premolars occluding just to the inside of the maxillary premolars and molars. A malocclusion can occur in deciduous teeth or permanent teeth, either due to an incorrect maxilla/mandible length relationship (MAL2, 3 or 4), or the malposition of individual teeth (MAL1).

Deciduous malocclusion: If a deciduous malocclusion has teeth that cause discomfort or physically impact and impede any continued growth of the jaws, then those teeth need to be extracted. These teeth should be removed in advance of the permanent teeth erupting into the same position. Incisors are best extracted at 8-10 weeks, and canine teeth at 10-14 weeks. Brachycephic kittens can present with many variations of maloccluded canine teeth as well.

Extraction of these deciduous teeth is called interceptive orthodontics, as an effort to remove the physical interlock that can impede appropriate jaw growth. If the permanent jaws are destined to be abnormal (Class II or Class III malocclusion), extractions won’t change that. Another reason to extract these deciduous teeth in a timely fashion is that the permanent teeth will erupt into an abnormal position if the deciduous teeth are retained, with most permanent teeth erupting lingual or palatal to the precursor. The maxillary canine will erupt further mesial/rostral, sometimes closing the diastema, and secondarily causing the mandibular canine to be displaced. The most common malocclusion, linguoversion (base narrow) mandibular canines can be caused when the persistent deciduous tooth caused the permanent to erupt lingual to it.

Immature Permanent Malocclusion – Correction of malocclusion of permanent teeth should only be provided if there is resulting discomfort or pain. Linguoversion of the mandibular canine teeth can be managed with gingivectomy of the palatal mucosal ridge for minor issues, composite crown extensions or palatal incline planes for more significant lesions, and even crown reduction with vital pulp therapy or extraction if the tooth cannot be easily tipped into a more comfortable position. In Class 2 MAL (mandibular brachygnathia), mandibular canine placement may be comfortable distal to the maxillary canines. Sometimes extraction of a less strategic tooth such as an incisor may provide sufficient space for canine placement.

Oral Tumors – Certain oral tumors have been found in young animals, and any unusual swelling should always be assessed with examination and imaging. Odonotomas are mixed odontogenic tumors that can have variety of dental tissue components, from disorganized arrangements in complex odontomas to the presence of denticles in compound odontomas. Complete removal/enucleation is typically successful.

Papillary squamous cell carcinomas were once thought to be found only in younger dogs but have been found in older dogs as well. While locally invasive, metastasis has not been reported and surgical excision with 1 cm margins is generally done.

Oral papillomatosis may present as single or multiple wart-like lesions in the oral cavity and is often self-limiting in puppies, but regression can take up to a year. Removal and autologous vaccines have been used with varying results.

Feline Inductive Odontogenic Tumors are uncommon, and while considered benign, can be locally destructive. Complete excision is recommended.

Oral Trauma – Fracture of individual deciduous teeth should be managed with extraction, while fracture immature permanent teeth have options for vital pulp therapy if done in a timely manner (less than 18 months old – with in 14 days).

Maxillofacial fractures in young patients should be managed as conservatively as possible. In very young puppies and kittens, remove any fragments that are completely unsupported, including deciduous or forming permanent teeth. Gentle reduction of segments with suture material to provide non-ridge stability may be enough to then allow the healing of the young to join the pieces back together. Strict, rigid stabilization could interfere with normal growth of the skeletal components and invasive pins or screws can damage permanent tooth buds. Labial buttons may help decrease the amount of fracture movement without stopping oral function completely

With older puppies and kittens at nearly full growth and permanent dentitions, stabilization of fractures with interosseous or interdental wiring and splints may provide sufficient reduction and stability. The toughest part is keeping them from chewing on things!

TECHNIQUES FOR COMPLETING DIFFICULT EXTRACTIONS IN DOGS AND MANAGING EXTRACTION COMPLICATIONS

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Performing dental extractions can be challenging especially when complications are encountered. The purpose of this lecture and laboratory is to provide participants with the knowledge and skills that will make executing difficult extractions in dogs more efficient, less traumatic and be associated with fewer complications. Techniques that will be reviewed include proper surgical approaches including flap design, proper sectioning of multi-rooted teeth, appropriate buccal, interradicular and periradicular bone removal and closure of flaps in complicated surgical extractions. Management of extraction complications including efficient removal of fractured root tips, retrieval of root tips from the mandibular canal and nasal cavity, hemorrhage control, management of complications associated with damaged tooth buds, repair of oronasal fistulas, jaw fractures, delayed wound healing/necrotic bone and ocular injuries will also be reviewed. In the laboratory participants will have the ability to prioritize performing various techniques on specific teeth that they desire additional hands-on laboratory experience to help improve their extraction skills and management of extraction complications.

Complicated Surgical Extractions

A complicated or surgical extraction technique is generally reserved for teeth that are difficult to extract because of their large root structure including the canine teeth, mandibular 1st molars and the maxillary 4th premolars and 1st molars. A surgical extraction may also be performed when teeth are ankylosed or when attempting to retrieve a broken root tip. The teeth most commonly requiring surgical extractions include the canine teeth and the carnassial teeth.

Surgical extraction of the maxillary canine tooth is initiated by making divergent incisions mesial and distal to the canine tooth and creating a mucoperiosteal flap. The buccal alveolar bone is removed as needed with a round bur to easily extract the tooth with luxators and dental elevators. Care should be taken to avoid creating an oronasal fistula during the extraction. The periosteal layer of the flap is incised apically to relieve tension on the flap prior to closure. There are two approaches for the surgical extraction of the mandibular canine teeth including the labial and lingual approach. The labial approach utilizes a mucoperiosteal flap located on the labial aspect of the tooth while a lingual approach utilizes a lingually located flap. Equal amounts of alveolar bone are present buccally and labially so there is no advantage of one technique over the other with regard to bone removal. The mental artery, vein and nerve exit through the mental foramen located near the labial aspect of the apex of this tooth. A lingual approach avoids potential damage to these structures, however, visualization of the surgical site is more challenging with the lingual approach.

When performing a mucoperiosteal flap for the surgical extraction of the maxillary 4th premolar several structures should be carefully avoided. When making the mesial portion of the incision the infraorbital artery, vein and nerve should be avoided as they exit the infraorbital canal immediately rostral to the periapical bone of the mesiobuccal root of the maxillary 4th premolar. These structures can be avoided by digitally retracting them dorsally and not extending this incision too far apically. When making the distal part of the incision, the parotid and zygomatic salivary duct papillae should be visualized and avoided. After raising the mucoperiosteal flap the furcations are located using a round bur. A segment of the cusp is removed by making a V-shaped cut through the buccal aspect of the tooth at the furcation with a #701 or #701L tapered fissure bur. The tooth is checked to confirm that it is completely sectioned through the furcation between the mesiobuccal and distal roots. Alveolar bone over the distal root is removed as needed to remove the distal root. At this point some operators prefer to amputate part of the remaining portion of the crown. The bur is placed in the furcation perpendicular to the tooth at the base of the palatal wall of the mesiobuccal cusp to section between the mesiobuccal and palatal roots. The alveolar bone over the mesiobuccal root is removed as needed to remove the mesiobuccal root. The interradicular bone between the mesiobuccal and palatal roots can be removed as needed to expose the palatal root. When extracting the palatal root it is important to direct the luxator in a slightly palatal direction to follow the palatal direction of the apex of this root. The extraction site is débrided, flushed and closed in a routine manner.

Surgical extraction of the mandibular 1st molar is initiated with a mucoperiosteal flap with two divergent releasing incisions on the mesial and distal buccal aspect of the tooth. The mucoperiosteal flap is raised and the furcation is located and sectioned by removal of a V-shaped section of the cusp overlying the furcation. The distal and mesial edges of the cusps of the tooth may be removed to provide straight line accesses to the periodontal ligament spaces. This is particularly helpful in teeth that are crowded. Buccal alveolar bone is removed as needed to extract the segments. Rough edges of the alveolar bone are reduced with a large round bur, the extraction site is débrided and flushed with sterile saline. The periosteal layer of the flap is released and the flap is closed in a simple interrupted pattern with a monofilament absorbable suture material.

Complications Associated with Extractions
Complications associated with extractions include the following: fractured root tips, root tips displaced into the mandibular canal or nasal cavity, hemorrhage, oronasal fistulas, jaw fractures, delayed wound healing/necrotic bone, and ocular injuries. Careful extraction techniques and appropriate perioperative management can help minimize these complications.

When a tooth root tip is identified on dental radiographs it should be determined if the root must be retrieved and in most cases root fragments should be completely removed. Roots of endodontically and periodontally diseased teeth must always be removed. However, root fragments undergoing severe bony replacement/resorption may be best treated conservatively. When extracting fractured tooth roots a mucoperiosteal flap is raised and some of the buccal alveolar bone over the retained root is removed. When attempting to localize the fractured root the operator should examine the extracted segment to mentally determine the anatomic features of the residual root structure. In addition, the operator should look for a white, hard, non-bleeding structure with a central pulpal red or black spot. Dental radiographs can be extremely helpful in locating fractured root tips. Other techniques that have been described include using the flat end of a cylindrical diamond bur on a high-speed handpiece to flatten the coronal aspect of the fractured root and a small area of the surrounding bone until the root is clearly visible in cross-section. A small round bur (# 1/2) is used to create a “gutter” or space around the root to place an elevator into the expanded periodontal ligament space. It is important to locate the periodontal ligament space while elevating a root because failure to locate this space often results in inappropriate placement of the dental elevator or luxator either on the alveolar bone or tooth. Elevation on the alveolar bone or tooth is ineffective and until the dental elevator or luxator is directed into the periodontal ligament space removal of the root will not proceed efficiently. An instrument that may be helpful in retrieving broken root tips is a titanium root tip remover or fingertip grip instrument that has an extremely sharp surgical screw tip with threads designed to be an anchoring, cutting edge which secures into the root’s dentin once the instrument is gently rotated clockwise into the pulp canal until firmly seated. Once firmly seated the extraction process proceeds as unusual. A luxator or periotome is placed in the space around the root and then a dental elevator is gently rotated and held for 10-20 seconds around the entire circumference of the root. The periodontal ligament space will fill with a small amount of blood and can be observed as a thin red line located between the alveolar bone and the root. The dental elevator or luxator should be directed into this space to permit more effective elevation of the root until it becomes loose and can be removed with small root forceps. The surgical site is débrided, flushed and closed routinely.

Rarely root tips may be displaced into the nasal cavity or mandibular canal as a complication of extractions. It is best to avoid this complication by utilization of careful extraction techniques and avoiding placement of apical pressure on fractured root tips. When attempting to retrieve a misplaced root from the nasal cavity or mandibular canal two dental x-ray views should be taken to help determine the location of the displaced root. Removal of a misplaced root tip should be performed with extreme caution to avoid additional trauma and care should be taken to avoid pushing the root tip deeper into the nasal cavity or mandibular canal. If the root tip can be visualized, the root tip may be carefully grasped with a root tip forceps or gently guided back into the extraction site with a small spoon excavator. Gentle suction and flushing may also help with visualization of a misplaced root tip. If the misplaced root tip cannot be visualized the boney defect in the floor of the alveolus may be carefully enlarged to aid in the visualization and retrieval of the misplaced root tip. Additional boney windows may be required to retrieve root tips that have been pushed deeper into the nasal cavity or mandibular canal. Rhinoscopy may also be helpful in retrieving root tips displaced into the nasal cavity.

Hemorrhage may be a complication of dental extraction. This complication may occur when a vessel in the area of the extraction site is traumatized or when there is significant inflammation of the tissues around the extraction site. Hemorrhage can usually be controlled by direct pressure with a gauze sponge, placement of a clotting agent into the alveolus, with judicious use of electrocautery or laser, ligation of vessels located in soft tissue, and most commonly by closing the gingiva over the alveolus to permit clot formation. In cases in which hemorrhage is excessive or diffuse, a clotting profile is recommended to rule out an underlying coagulopathy. Persistent hemorrhage during or following dental extractions may also be associated with hypertension.

Damage to permanent tooth buds may occur during the extraction of deciduous teeth. The bud of a permanent tooth is located near the apex of the deciduous tooth in very young dogs which predisposes the permanent tooth bud to iatrogenic trauma during extraction particularly in animals less than 10 weeks old. Traumatic injuries of the permanent tooth bud can result in developmental abnormalities including failure of the permanent tooth to erupt, malformation of the permanent tooth, formation of a dentigerous cyst, enamel hypoplasia, and enamel hypocalcification. These problems can be minimized by utilizing careful extraction techniques. When a permanent tooth fails to erupt because of a traumatic episode, surgical extraction is usually recommended to help prevent future complications associated with the unerupted malformed tooth.

Oronasal fistulas may be a complication associated with dental extractions. Oronasal fistulas may be present prior to extraction of periodontally diseased teeth or may be associated with damage to the palatal aspect of the alveolus during extraction of maxillary teeth. Signs associated with oronasal fistulas include sneezing and mucopurulent or hemorrhagic nasal discharge. The most common location of oronasal fistulas in the dog is the palatal aspect of the maxillary canine tooth. Any maxillary tooth may cause an oronasal fistula. Teeth affected with end-stage periodontal disease should be removed and any associated oronasal fistulas should be repaired with a mucoperiosteal flap. Usually a single layer flap repair is sufficient in the repair of most oronasal fistulas, however, utilization of a double layer flap may be considered in the repair of recurrent oronasal fistulas.

Iatrogenic fractures are a serious complication that may be associated with extraction of teeth affected with advanced peridontal disease. The alveolar bone surrounding the mandibular canine teeth and mandibular first molars are particularly susceptible to iatrogenic fractures because of minimal bony support around large roots in small breed dogs with severe periodontal disease. Gentle elevation of these teeth down the root with a sharp instrument with appropriate digital support of the mandible during extraction, and a gentle rotational motion with the dental extraction forceps in the long axis of the tooth will help prevent pathologic fractures. These fractures should be managed conservatively with placement of a freeze-dried bone graft in the extraction site and closure of the site with a mucoperiosteal flap with placement of a tape or cloth muzzle. Alternatively, intraoral acrylic splints may be placed and a soft gruel diet is fed. In severe cases a partial mandibulectomy +/- a cheiloplasty may be necessary.

Delayed wound healing and/or necrotic bone may be a complication of extractions. Flap dehiscence will result in delayed healing and possible bone necrosis. Flap dehiscence can be prevented by utilizing proper flap closure techniques and appropriate postoperative care including feeding a soft diet and avoiding access to chew toys. In non-compliant patients, the surgical site may need to be protected with a basket muzzle during the healing period. Osteonecrosis of the maxillae or mandibles is defined as exposed necrotic bone that fails to heal after six to eight weeks in patients with no history of radiation. Maxillofacial injuries, traumatic tooth extraction, chronic infection, chronic steroid administration and inflammatory processes have been associated with maxillary osteonecrosis in dogs. Clinical signs of osteonecrosis may include: fetid breath, severe oral pain, facial swelling, reluctance or inability to eat, purulent discharge, regional lymphadenopathy, pyrexia, malaise, and exophthalmos. Oral examination may reveal missing teeth, severe oral soft tissue inflammation, mucosal defects/deep ulcerations, and exposed, necrotic bone. Treatment of osteonecrosis involves creating a large mucoperiosteal flap around the site, excising draining tract(s) if present, extracting any teeth remaining in necrotic bone, removing necrotic bone en bloc or with rongeurs until healthy, bleeding bone remains or alternatively performing a partial maxillectomy or mandibulectomy, collecting samples for cytology, bacterial culture and sensitivity testing and histopathology, flushing the surgical area, closing the mucoperiosteal flap with a simple interrupted suture pattern, providing appropriate perioperative pain management and providing long term, broad-spectrum antibiotic therapy pending results of culture and sensitivity testing for 6-8 weeks postoperatively.

Ophthalmic complications of dental extractions include corneal ulceration, periocular bruising, and inadvertent perforation of the retrobulbar space, globe, lens or cornea. Utilization of gentle extraction techniques, maintaining a short finger stop near the tip of the dental elevator, adequate ocular lubrication, and careful placement of counter-pressure on the head during extraction procedures will help minimize ophthalmic complications.

Performing dental extractions can be challenging especially when complications are encountered. However, utilization of proper extraction techniques can help minimize complications. When complications are encountered institution of appropriate management techniques can help address these problems more efficiently, less traumatically and will be associated with fewer additional complications and a more favorable outcome for our patients.

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CANINE DENTAL RADIOGRAPHY: REVIEW OF ANATOMY AND INTERPRETATION

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Take Home Points

1. Dental radiography is necessary in dogs to discern accurate diagnoses and build effective treatment plans.
2. Knowing normal radiographic anatomical features with make differentiating abnormal findings easier.
3. Some “normal” variations in tooth anatomy are critical to treatment planning and extraction technique.
4. Periodontal disease is diagnosed by the level of attachment loss around the tooth root, which is estimated by alveolar crest height.
5. The two main signs of endodontic disease are periapical radiolucency and asymmetrical root canal diameter.
6. Missing teeth in dogs always warrants radiographic exploration due to the variety of conditions that can be associated with missing teeth.

Introduction

Acquiring intraoral radiographs to evaluate canine and feline oral pathology is critical for appropriate treatment planning. Both CR and DR digital systems that produce high quality dental images are available from multiple vendors for a reasonable investment. Intraoral radiography lets clinicians evaluate the health of the periodontium, crown, root, pulp, root apex, alveolar bone, and adjacent bone and soft tissue. The information provided from intraoral radiography allows doctors to see pathology inapparent on oral examination, investigate the severity of periodontal disease, identify vital vs. non-vital teeth, image traumatic lesions of tooth and bone, explore the nature and extent of neoplasia, stage tooth resorption, uncover the cause of missing teeth, visualize odontogenic abnormalities, and determine the severity of palatal defects. The temporomandibular joint can also be imaged satisfactorily with size 4 CR dental film. Many times lesions in dogs will be discovered on radiographs that were unknown previously. Intraoral radiography provides the information necessary for a practitioner to create a complete and thorough dental treatment plan.

Acquisition and Normal Anatomy

Due to the brevity of this presentation, acquisition of intraoral radiographs will be bypassed. There are multiple wet labs provided at the Forum dedicated to teaching intraoral radiographic technique, and it is the author’s experience that image acquisition is best taught with a wet lab which enables a participant to visualize angles. To utilize time most efficiently usually a specialist will take all films required then ask his/her technician to clean and polish the teeth while the radiographs are reviewed. Digital systems either automatically place each film in a labial mounting (DR and some CR systems) or require the practitioner to re-orient films (CR systems) to labial mounting.

Determining maxilla from mandible is quite simple. One main feature is the palatine process of the maxilla, which makes up most of the hard palate. This process creates a distinct radiodense line that is located at the apex of every maxillary canine, premolar, and molar tooth. The maxillary incisors are identified by a U-arch, the incisive canal, and the palatine fissures. The mandibular teeth also have easily identifiable features. The mandibular canal will be present from the coronoid process to the apex of the canine tooth. The middle and caudal mental foramens are located at the first and third premolars, respectively. The canine and incisor teeth will align in a more V-shaped arch, and the symphysis will clearly be visible between the central incisors.

Any approach to reading dental film should include evaluation of adjacent and surrounding anatomy, aka. seeing the forest among the trees. The zygomatic arch, regional bones of the skull, nasal passages, maxillary recess, orbit, hard palate, mandibular canal, and symphysis can have changes independent of the teeth or related to dental anatomy. Prior to evaluating teeth, scan the surrounding anatomy for any abnormalities or variations of normal. Don’t forget to count teeth and look for overall variations in the dental arch during this time as well.

Once adjacent structures have been explored, it is time to focus on dental anatomy. Evaluate the tooth from the outside in. First, explore adjacent alveolar bone. This bone will have a cancellous pattern and be less radiodense than the cortical bone lining the alveolus. The cortical bone lining the alveolus is termed the lamina dura, and it appears as a white line surrounding the tooth. Any disruption in the integrity of the lamina dura represents anatomical change that may or may not be pathological, tooth resorption vs. age-related ankylosis. Between the lamina dura and the tooth is the periodontal ligament visible as a radiolucent or black line. At the crown-root junction, 2-3 mm below the apical portion of the dental bulge is the cementoenamel junction and the beginning of the root. The cementoenamel junction (CEJ) is normally located at the same height along the tooth root as the surrounding bone, termed alveolar crestal bone. A difference in height between the CEJ and the crestal bone indicates that alveolar bone has been lost, most likely due to periodontal disease.

The bulk of visible tooth structure is dentin; cementum cannot be seen radiographically. Enamel will appear as a bright white, radiodense covering on coronal dentin though it is usually only visible on canine and molar teeth. The pulp chamber, in the crown, and root canal, in the root, create the radiolucent stripe centered within the dentin, and this channel houses the nerves, vessels, and lymphatics to the tooth. The width of the dentin and root canal will change with age as dentin is continually added throughout the lifespan of the animal; therefore, the dentin will thicken and the root canal will thin. The apex of the tooth is located at the tip of the root, and in dogs, an apical delta is present. Depending on the tooth, there may be multiple roots present. The bifurcation of the roots is simply termed the furcation, and the bone between the roots is the interradicular bone. Bone between teeth in termed interproximal bone. Variations in normal anatomy are common, and it can drastically impact diagnoses and treatment planning. Teeth with dilacerated or supernumerary roots are critical to recognize prior to extraction if indicated.

Common Pathology

Periodontal Disease:

Periodontal disease (PD) is judged by the loss of surrounding alveolar bone and crestal bone height. Radiographic signs of PD include decreased alveolar creat height, widening periodontal ligament space, and irregularities on the surface of the root. PD is categorized as general vs. localized and staged 1-4. Stages of PD are quantified by the relative difference in height between the CEJ and the alveolar ridge along the length of the root. Stage 1 shows normal bone height radiographically and is characterized purely by gingivitis. Stage 2 indicates 1-25% bone loss, and stage 3 is 25-50% bone loss. Stage 4 is bone loss >50%. Depending on the severity of PD, interradicular bone may be lost exposing furcations. Bone loss can also be quantified as vertical or horizontal, which is important when considering bone augmentation. Staging PD and recognizing the different types of bone loss will help develop a treatment plan with long-term success.

Endodontic Disease:

Determining whether a tooth is vital or non-vital is critical to identifying the source of dental related regional swellings and fistulas and to formulating the best treatment plan for traumatized teeth. Two key features to evaluate in suspected non-vital teeth are the thickness of the dentin/pulp and the health of the apex, periodontal ligament, lamina dura, and adjacent apical cancellous bone. Teeth in question are compared to contralateral similar teeth for dentinal and root canal thickness. Widening of the pulp and thinning of the dentin indicates a non-vital tooth, as the tooth is no longer able to age and produce secondary dentin. Resorption of the apex and loss of the periodontal ligament, lamina dura, and apical alveolar bone can also be seen with non-vital teeth as infection within the tooth causes chronic apical inflammation and cellular destruction. This loss of structure is seen as a radiolucent halo around the apices of roots.

Missing teeth:

Missing teeth aren't always teeth that congenitally never formed. Many times missing crowns are associated with fractured teeth, unerupted teeth with or without dentigerous cyst formation, impacted/embedded teeth, or past extractions which may or may not be complete. If a swelling exists in the region of a missing tooth or if an animal in under general anesthesia for exam and cleaning, missing teeth should always be investigated radiographically.

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SURGICAL EXTRACTION OF THE MAXILLARY 4TH PREMOLAR AND 1ST AND 2ND MOLARS IN THE DOG

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"Extractions" – Oral Surgery

"*Extractions*" are surgical procedures that are common in small animal practice. Training and skill along with understanding anatomy are required to become proficient and successful in extraction. Tissues are incised (i.e. intrasulcular incision), tissues are elevated (i.e. mucoperiosteal flap), bone is removed (i.e. alveolectomy), teeth are sectioned (a tooth is a tissue), curettage of the alveolus, osteoplasty/alveoloplasty of the bone, and surgical sites are sutured closed. By definition, extractions are surgery. Therefore surgery (i.e. extractions) are to be performed by veterinary medical doctors. The American Veterinary Dental College position statement; treatment planning and exodontics should be performed only by a veterinarian (www.avdc.org). All extraction treatment planning requires intraoral dental radiography. Furthermore, State and Provincial Departments of Health and Practice Acts restrict diagnosis and treatment decisions/planning to licensed doctors of veterinary medicine.

Anatomy

Successful extractions include the understanding the regional anatomy in order to separate the tooth from the bone. Particularly, understanding the tissues of the periodontium – attachment apparatus of the tooth (i.e. gingiva, alveolar bone, periodontal ligament, cementum). The tooth is anchored in the jaws by the periodontium. The goal of extraction is to cut, fatigue, and/or disrupt the periodontal ligament that holds the tooth to the bone while minimizing any unnecessary trauma to the surrounding supporting bone.

The caudal maxillary dentition is anchored in the maxillary bone. Extraction of the maxillary 4th premolar and maxillary molars requires understanding and respect for vital regional anatomy. This includes, but is not limited to, the parotid and zygomatic salivary papilla and ducts, the maxillary and infraorbital neurovascular bundles, and the orbit and eye. The large maxillary neurovascular bundle is juxtaposed to the dentition as it traverses below the suborbital region into the caudal aspect of the infraorbital canal. The orbital region and eye are closely related to the surgical site and can be severely traumatized with surgical instruments. The parotid and zygomatic salivary papillae/ducts are positioned in the buccal soft tissue just caudal to the maxillary 4th premolar. Although it should not be an issue, the major palatine artery and foramen are located just palatal to the maxillary 4th premolar. These vital structures must be protected from iatrogenic trauma and damage as serious consequences and morbidity can result.

Armamentarium

In order to be successful and to be professionally satisfied performing extractions the following equipment, but not limited to, is recommended: 1) Protective masks (ASTM Level 3), glasses, and gloves, 2) Good lighting, 3) An ergonomic work environment, 4) Surgical Magnification, 5) Scalpel Blades (#15, #15c), 6) Scalpel Handle (round scalpel handle preferred), 7) Water Cooled High Speed Hand Piece – to prevent thermal necrosis of bone, 8) Dental Burs (Such as #330, #1/2, #1, #2, #4, #669, #701, #701L or a bur of your choice, surgical length burs, and a medium or coarse diamond bur), 9) Dental Periosteal Elevators, 10) Dental Luxators, 11) Dental Elevators, 12) Extraction Forceps, 13) Root Tip Picks, 14) Excavators/Oral Surgical Curettes (clean out the alveolus), 15) Atraumatic Tissue Forceps, 16) Needle Holders, 17) Absorbable Suture (4-0 or 5-0 poliglecaprone 25, RB-1 or P-3 needle), 18) Tongue depressor, 19) Minnesota retractor, 20) All instrumentation used delicately and with control – A finger stop should be near the tip of the working instrument to stop the instrument if it slips and, 21) PATIENCE.

Surgical Extraction Techniques

General surgical extraction techniques can be found in the textbooks listed in the suggested readings below. Extractions may be classified as closed or simple extraction not involving a gingival incision. However, I would argue that even a "closed" incisor extraction requires an incision to debride gingival margins as well as curettage of the alveoli prior to suturing. Extraction of the maxillary 4th premolars and molars are classified as an open or surgical extraction that involves cutting of oral and dental tissues.

A diagnosis is made based on oral examination, periodontal probing, and intraoral radiographs. Client consent is obtained for the extraction. The goal is to remove the entire tooth from the alveolus with minimal trauma to the surrounding bone and tissue. The periodontal ligament attaches to the tooth and the alveolar bone in order to anchor the tooth in the mouth. The ligament is designed to withstand short bursts of pressure/force. The ligament must be fatigued by elevation and/or cut with luxation from the supporting alveolar bone in order to remove the tooth. Extracting the tooth is about knowledge, technique, patience and finesse not brute force.

Extraction of The Maxillary 4th Premolar and/or Molars

The oral cavity is rinsed with an oral 0.12% chlorhexidine gluconate solution. Large deposits of plaque and calculus should be cleaned off the teeth. Intraoral radiographs are always obtained for treatment planning. The surgical access can be via an envelope flap or a mucoperiosteal flap depending on the size of the tooth and access necessary for a successful extraction. The flaps allow visualization of the surgical site, alveolar bone removal as needed for the oral surgery, and tension free closure of the surgical site.

If only the 4th premolar is extracted a large envelope or triangular mucoperiosteal flap, releasing incision on mesial aspect only to avoid salivary anatomy, can be utilized. Some references may discuss a pedicle flap but caution is warranted with a distal incision that could result in iatrogenic damage of the salivary papilla and ducts. A triangular mucoperiosteal flap will allow more visualization and tension free closure, if indicated, compared to an envelope flap. A mesial line angle releasing incision is made on the distal aspect of the maxillary 3rd premolars (107 and 207). It is important to avoid a mesial divergent incision as the infraorbital neurovascular bundle will be exiting from the infraorbital foramen in that region. A periosteal elevator(s) is used to lift the mucoperiosteal flap. Alveolectomy, removal of buccal cortical bone, to expose the furcation and remove buccal attachment is performed with oral surgeon's choice of a carbide bur.

The extent of buccal bone removal depends on surgeon preference, extent of pathology, and surgical plan. Buccal alveolar bone is removed from the region of the cementoenamel junction towards the apex, as indicated. The distal aspect of the tooth is sectioned from the mesial aspect by cutting the tooth from the furcation region towards the crown. Avoid sectioning from crown down to the furcation as anatomy can differ and complete sectioning may not occur. Then, the mesiobuccal and mesiopalatal roots are sectioned by directing the bur from palatal towards the buccal root in at a 45 to 55-degree angle from the mesial furcation to the mesial-distal furcation. If there is insufficient space distally or mesially for the surgical instruments, the distal and/or mesial cusps of the maxillary 4th premolar can be removed to provide direct access to the periodontal ligament space and instrumentation placement. An appropriately sized dental luxator and/or elevator (fits the curvature of the tooth root) is used with axial pressure to cut and/or fatigue the periodontal ligament fibers. A finger stop is used near the terminal end of the instrument to protect the patient if the instrument slips. A major pitfall is not placing the instrument in the periodontal ligament space, which results in crushing of alveolar bone. This delays extraction and results in unnecessary surgical trauma. The surgeon's non-dominant hand is used to retract tissues, support the maxillofacial skeleton, receive tactile feedback during the extraction process, and stabilize the patient head during the procedure. Once the elevator is in position, rotation will cause the periodontal ligaments to stretch. Hold the position and wait (15-20 seconds). Bleeding (periodontal ligament is being damaged) should be noted. Repeat the procedure and use a smaller elevator/luxator that fits the curvature of the root as you work apically. Repeat again as needed. Take time to fatigue the ligament and damage the periodontal ligament fibers. Periotomes and automated periotomes may also be used to cut the periodontal ligament. Once the tooth is sufficiently mobile, and only when it is mobile, do you reach for the extraction forceps. The tooth then can be grasped with extraction forceps and rotated on the long axis for delivery of the tooth from the alveolus.

The mesiopalatal root can be extracted by removing the buccal bone on the buccal aspect to the mesiopalatal root. A modified pen grasp, with feather touch, can be used to gently allow the highspeed handpiece and small carbide bur (#330, #1 round, or #2 round) to follow the path of least resistance in the periodontal ligament (PDL) space. Thereby, removing the PDL space and the associated buccal bone. The root is then luxated and/or elevated.

Following removal of all the roots, the alveolus is cleaned with a curette, to remove granulation tissue, purulent debris, and bone fragments, and then lavaged with an isotonic saline/ringers solution. A medium or coarse grit diamond bur (e.g. football shaped) is used to smooth the alveolar bone, alveoloplasty. The surgical site is gently lavaged with sterile saline and/or an appropriate manufactured oral chlorhexidine solution. The whole tooth should be present. Post-operative intraoral radiographs are obtained. Any retained root fragments can be retrieved with the use of root tip picks and additional surgical techniques. An intraoral dental radiograph is obtained to document extraction of the tooth. Most extraction sites do not require osteoconductive material in many author's opinion. A healthy blood clot is a phenomenal osteogenic, osteoinductive and osteoconductive material.

The mucoperiosteal flap is released by bluntly or sharply breaking down the periosteum in the mucoperiosteal flap. Surgical margins are freshened so healthy, non-epithelialized margins are apposed. Slight elevation of the palatal mucosa on the palatal aspect of the surgical site may assist in achieving good suture bites. The flap is sutured without tension (e.g. 4-0 or 5-0 poliglecaprone 25) starting on the mesial and distal aspects of the incision. The marginal incision is then sutured using simple interrupted sutures with 2 mm bites approximately 2-3 mm apart. The releasing incision is sutured in a coronal to apical direction.

If the maxillary molars are included in the surgical extraction (108, 109, 110 and 208, 209, 210) the triangular mucoperiosteal flap is carefully, and simple elevated off the buccal bone adjacent to the dentition distally. Sectioning and extraction of those teeth follows.

Appropriate multimodal post-operative pain management is prescribed for 5-7 days. The patient should be fed soft food for 7-14 days. An oral 0.12% chlorhexidine gluconate rinse PO BID for 7-14 days may be prescribed. Appropriate antibiotics (clindamycin or amoxicillin-clavulanic acid) are prescribed for 7 days, if indicated. A recheck of the surgical site in 2-4 weeks is recommended.

Maxillary 1st and/or 2nd Molar(s)

The regional anatomy is closely juxtaposed. Releasing incisions are not used if only extracting the maxillary 1st and 2nd molars (109, 110, 209, 210). [However, some references will provide alternative techniques with carefully executed releasing incisions avoiding salivary anatomical structures.] An envelope flap is created by lifting the gingiva and mucosa off the buccal bone. Visualization of the tendinous attachment of the masseter muscle on the zygomatic arch may be observed in some patients. The mesiobuccal and distobuccal roots are sectioned towards the palatal root. The palatal root is then sectioned in a mesial to distal direction separating it from the buccal roots. The result is essentially a sectioning resembling a "T". The buccal roots are carefully luxated. The palatal root is removed with a wheel and axle technique. A finger stop on the dental luxator and/or elevator is always used just as with any extraction technique. The surgical is carefully cleaned, smoothed, alveoloplasty, and lavaged with sterile saline prior to closure.

Closure of the mucoperiosteal flap differs in that NO releasing incisions are made. This may damage the salivary system or worse cut the large maxillary neurovascular bundle. Instead, the mucosa that is elevated off the buccal bone margins and oropharyngeal mucosa is stretched and repositioned rostrally and sutured closed.

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CONE-BEAM COMMPUTED TOMOGRAPHY (CBCT): PRINCIPLES AND INTERPRETATION

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Introduction

Imaging techniques are an essential part of providing quality dental, oral and maxillofacial health care. Dental radiography is currently regarded as the gold standard imaging method for dentoalveolar disorders in dogs and cats. For more involved cases such as oral and maxillofacial trauma and congenital deformities, conventional computed tomography (CT) is rapidly becoming the standard diagnostic method. Although introduced to the human dentistry field in 1998 in Europe and approved for use in the USA in 2001, cone-beam CT (CBCT), is regarded as a relatively new technology in veterinary medicine.1;2 CBCT is making steady strides into veterinary dentistry and oral surgery as it provides high-resolution images and rapid image acquisition.3-6 Moreover, with advanced imaging software, CBCT provides transverse, sagittal and dorsal slices, and also multiplanar reconstructions (cross-sections), curved planar reformation ("simulated" distortion-free panoramic images), and indirect volume rendering (tridimensional (3D) rendering) in tooth and bone mode. The challenge for the modern clinician is to decide on a particular imaging modality as a function of the information/diagnostic yield vs. patient risk and cost benefit analysis.7 To make this decision, the clinician needs to have a working knowledge of the technology and its capabilities as well as its limitations. In this lecture, we will describe our clinical experience working with CBCT in various clinical scenarios ranging from periodontal disease to oral and maxillofacial trauma and elaborate on the benefits and limitations of CBCT. Importantly, the text of these proceedings does not intend to replace the excellent CBCT textbooks that are available in the human medical arena.

Principles of CBCT[1;2]

The conventional CT machine uses a fan-shaped X ray beam that captures a series of axial plane sections or from a continuous spiral motion over the axial plane. On the other hand, the CBCT machine uses a cone-shaped beam and a reciprocating flat panel detector that rotates once around the patient, 180-360 degrees, covering the defined anatomical region as opposed to a section-by-section imaging produced by CT. The scanning time varies between manufacturers and is typically 5-40 seconds.

Software

Following a patient's CBCT scan and primary reconstruction, the image data DICOM files are viewable using the native scanner or 3rd party software. The image data are organized into a voxel volume. The voxels dimensions are cubic, ie., isotropic (all side equal) ranging from 70 to 400 microns. Each voxel is assigned a tissue attenuation value and localized on a Cartesian co-ordinate. The visualization software allows the voxel volume to be viewed from any angle. The software allows for viewing of serial multiplanar (3 orthogonal planes) sections, oblique sections and curved plane sections. The section thickness can be controlled by the software and range from 1 voxel to the entire volume. The entire 3D volume can be rendered and displayed using shaded surface display and volume rendering techniques. The shaded surface display employs a threshold to isolate the tissue attenuation values for the selected surface to be displayed. All attenuation values outside the threshold value are eliminated from the displayed. Volume rendering displays the entire volume but the transparency of the various tissue attenuation values, ranging from 0 – 100 %, can be selected and visualized.

Limitations of CBCT[8;9]

CBCT is making rapid entry into veterinary dentistry, oral and maxillofacial surgery but this technology is not without drawbacks. Primarily, CBCT images are affected by artifacts, noise and poor soft tissues contrast.

- Artifacts: distortion or error in the image that is not related to the subject imaged, can be due to beam hardening (cupping artifact, streaks and dark bands), patient motion (lack of sharp images) or scanner related (circular or ring shape artifacts).

- Image noise: due to the large volume being irradiated, non-linear attenuation may result in image degradation.
- Poor soft tissue contrast: CBCT units have substantially less soft tissue contrast then conventional CT. This is of critical importance when deciding on imaging modality for oral tumor work up as well as other disorders involving soft tissues. In addition, intravenous contrast images are severely degraded in CBCT and contrast studies are currently not recommended for this imaging modality. Scan parameters and optimization of the injection time to account for iodine pharmacokinetics are needed prior to incorporating contrast studies in the future.
- Field of view (FOV) or the region in space where CT subject is to be imaged, is fairly limited in CBCT as compared to conventional CT. The FOV needs to be optimized to the medical task at hand and large enough to cover the anatomy to be viewed but sufficiently small to achieve the required resolution. The FOV available is different between the commercial units and although stitching software are available, FOV remains an issue especially when imaging large breed dogs. Importantly, regardless of the FOV that is imaged, it is the responsibility of the clinician to ensure that the complete data set captured is professionally reviewed, not only the target aim of the scan.

Applications in dentistry oral and maxillofacial surgery

Periodontics[3;10-14]

Dental radiographs are currently the gold standard imaging modality for periodontal health assessment. The 2D limitations of dental radiographs, including oblique projection geometry and superimposition, may lead to under- or over-estimation of bone loss. It is established that morphometric analysis of periodontal disease by CBCT is as precise as direct measurement using a periodontal probe. In addition, CBCT was found to be superior to dental radiographs in visualization of the buccal and lingual/palatal periodontal defects and allow precise measurements of infrabony defects, furcation exposure/involvement and dehiscence or fenestrations. Importantly, with the vast variation of skull configuration between dog breeds, CBCT was found to be superior over dental radiographs for the diagnosis of periodontitis in brachycephalic dogs.

Endodontics[10;15;16]

CBCT was found to be superior to dental radiographs in the assessment of periapical lesions. As opposed to dental radiographs, CBCT is capable of precisely demonstrating the lesion position in relationship to important anatomical structures such as the mandibular canal and the maxillary recess. CBCT is also helpful in establishing working length, root canal numbers, determining the degree of root angulation, the presence of root fractures and root resorption.

Orthodontics[17;18]

The use of CBCT in orthodontics offers precise assessment of skeletal growth patterns, dental age estimation, arch dimensions verses tooth size, vsualization and localization of impacted teeth (and presence of pathology) as well as assessment of the cause of the malocclusion such as historic fracture or TMJ disorders.

Temporomandibular joint (TMJ) disorders[19-21]

CBCT offers several possibilities for the precise assessment of TMJ disorders (TMD). Imaging objectives for TMJs include the assessment of the size, shape, quality and spatial relationships of the osseous components of the TMJs. These imaging objectives can be ideally achieved with axially corrected serial sections (oblique sagittal and coronal) aligned perpendicular or parallel mediolateral long axis of the mandibular head on the condylar process. CBCT allows examination of the joint space and multiple degenerative changes of the TMJ if present. Other TMDs such as developmental abnormalities, fractures, luxations, and ankylosis are precisely imaged with CBCT.

Oral tumors[8]

With few exceptions (i.e., osteoma, odontoma), when a tumor invading soft tissues is identified, conventional CT and/or MRI are indicated. This is due to the poor soft tissues resolution and the lack of reliability of contrast studies in CBCT. Some tumors, such as osteoma, that is contained within bone or with their epicenter in bone can benefit from a CBCT scan. The scan can determine the size, shape, location, border characteristics, internal characteristics and effects on adjacent structures. These radiographic features essential in determining the lesion behavior, site of origin and a radiographic diagnosis.

Oral and maxillofacial trauma and fractures[9;22-24]

Although the immediate thought is that CBCT is an excellent tool for assessment of OMF trauma, CBCT should be used only under conditions:

1. The FOV is sufficiently large to include the entire trauma area.
2. The spatial resolution is sufficient to detect bony lesions.
3. The patient does not exhibit neurologic symptoms. It is important to note that in patients with neurologic symptoms and a very extensive injury involving other structures (such as the eye or brain), conventional CT with contrast is mandatory.

If a patent is a good candidate for CBCT imaging following trauma, this imaging modality is especially helpful in understanding and assessing the fracture/s configuration, spatial location and degree of displacement. Especially in challenging cases that require special preoperative planning due to the region's complex anatomy, CBCT is an ideal imaging modality. The use of 3D imaging and 3D printing as needed for precise surgical planning is a strategic advantage of CBCT. The DICOM files obtained by the CBCT are manipulated by a specialized software for volume rendering and 3D imaging. This is routinely indicated for maxillofacial trauma cases. It is also indicated for palatal defects, to compare the size and shape of the osseous defect with the soft tissue defect. Corrective ostectomies for ankylosis and pseudoankylosis of the temporomandibular joint can be very complex and not only involve the condylar process but also the coronoid process, zygomatic arch, and temporal bone. Precise preoperative planning and practicing a virtual osteotomy is possible with 3D images and specialized CBCT software.

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RECOGNITION AND SURGICAL TREATMENT OF ORAL TUMORS

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The diagnosis and treatment planning for a wide variety of oral and maxillofacial tumors can be challenging and have been previously discussed.[1-5] Based on the definitive diagnosis and location of oral and maxillofacial masses appropriate treatment plans can be developed. The various locations of oral and maxillofacial masses include the gingiva, lip, tongue, palate, mandible and maxilla. Based on the location and tumor type, surgical treatment options may include, gingivectomy, partial lip resection, partial glossectomy and various mandibulectomy and maxillectomy procedures.

The history and clinical signs of oral tumors may vary depending on the tumor type and location. Tumors in the rostral aspect of the mouth may be noticed by the owner while caudal pharyngeal masses are rarely observed by the owner and are often presented later in the course of the disease. The history and clinical signs of patients with caudal pharyngeal tumor may include hypersalivation exophthalmos or facial swelling, epistaxis, weight loss, halitosis, bloody oral discharge, dysphagia or pain on opening the mouth or occasionally severe cervical lymphadenopathy especially cases with squamous cell carcinoma of the tonsil.[5]

Oral masses may be benign or malignant. The gross appearance of an oral swelling or mass can be assessed for benign or malignant characteristics, however, histopathology is required to confirm the diagnosis.[3] Gross characteristics of benign masses include: pedunculation, slow growth, bilateral symmetry of lesions and association with diseased teeth.[2,3] Gross characteristics of malignant masses include: broad-based attachment, rapid growth (+/-) necrosis, no association with diseased teeth, focal mobility of tooth or teeth in an otherwise healthy mouth.[2,3] Dental radiography is invaluable in the initial assessment of oral masses.[1] Dental radiographs of a focal benign oral mass may reveal primary dental disease at the affected site while dental radiographs of a malignant oral mass may reveal irregular bone destructive and productive patterns inconsistent with underlying dental disease.[2] Destructive boney lesions may have a “motheaten” appearance while productive periosteal reactions secondary to malignant lesions may appear as spiculated new bone formed at right angles to the outer cortex, or as radiating “sunburst” patterns.[3]

Preliminary assessment of exfoliating masses can be obtained using fine needle aspirates and cytological evaluation; however, definitive diagnosis of oral masses is based on histopathology. Small or pedunculated masses may be marginally resected to obtain a biopsy, however attempts to remove large oral masses with excisional biopsies are not recommended until a histopathologic diagnosis is available for surgical treatment planning.[1,2] Following confirmation of oral malignancy clinical staging is performed. Advanced imaging techniques can provide a more precise evaluation of the primary tumor site and help facilitate surgical and radiation treatment planning. A wide variety of mandibulectomy and maxillectomy techniques have been described for the surgical management of malignant oral tumors with the procedure selected depending on the location and extent of the tumor.[1,2]

A tumor is a commonly used, but non-specific, term for a neoplasm.[6] The word tumor simply refers to a mass.[6] This is a general term that can refer to benign (generally harmless) or malignant (cancerous) growths.

Malignant Oral and Maxillofacial Tumors

In dogs, malignant oral tumors account for 6% of cancer cases; in cats, malignant oral tumors accounts for 3% of cancer cases.[2] The most common malignant oral tumors in dogs are malignant melanoma, squamous cell carcinoma, and fibrosarcoma.[2] Male dogs have 2.4 times greater risk of developing oral cancer than female dogs.

The most common malignant oral tumor in cats is squamous cell carcinoma, followed by fibrosarcoma.[2,7]

A simple preliminary evaluation of exfoliating malignant masses may be obtained using fine needle aspirates and cytological evaluation.[2] However, the definitive diagnosis of malignant oral tumors is based on biopsy of the tumor followed by histopathologic evaluation. When obtaining biopsy specimens for histopathologic evaluation care should be taken to avoid taking superficial biopsies since they reveal only inflammation or gingival hyperplasia. Multiple biopsies taken from different parts of the lesions are also recommended.[1] Acceptable tissue sampling methods for obtaining diagnostic biopsy specimens include: punch biopsy, deep Tru-cut biopsy, Jamshidi core biopsy and deep wedge incisional biopsy.[2] The use of electrosurgery in obtaining oral tumor biopsies is not recommended due to the risk of specimen distortion.[2]

Following the histological diagnosis of malignant oral tumors, clinical staging should include a complete blood count, serum biochemistry profile, urinalysis, fine needle aspirates of regional lymph nodes, and thoracic radiographs.[2] Abdominal ultrasound should be considered for the purposes of ruling out concurrent or metastatic disease.[1,8] Advanced imaging techniques provide a more precise evaluation of the primary tumor site and facilitate surgical and radiation treatment planning.[2] Computed tomography is often required to evaluate the full extent of invasion of maxillary masses and caudal mandibular masses.[1] Magnetic resonance imaging can reveal the extent of deep soft tissue infiltration and lymph node involvement.[1] The diagnostic results are utilized for therapeutic treatment planning. Factors to consider prior to recommending surgery include: oral examination findings, diagnostic imaging results, histopathological diagnosis, recommended surgical margins based on tumor type and size,[1,8] intent of surgery (curative, debulking surgery, surgery for local control or palliative surgery) and availability of local tissues for surgical closure.[2] The intent of surgery should always be curative, however, in some circumstances this may not be possible due to the large size and location of the tumor. The decision to perform a palliative or cytoreductive surgery is often a difficult one, and the veterinarian needs to educate the client and referring veterinarian about the risks and benefits of this type of surgery.[5] Debulking or piecemeal removal of a mass should generally only be performed when the mass is physically causing obstruction or significantly impairing function.[5] Debulking of a tumor has little benefit unless the removal results in only residual microscopic amounts of tumor remaining which can be treated with alternative modalities. Palliation of symptoms caused by obstructive masses by removing most of or portions of large masses can temporarily improve quality of life in some cases, however, this should only be performed when necessary since excessive bleeding can often occur and dehiscence is very common.[5] To avoid client disappointment and frustration, the surgeon should strive for a surgical cure.

Malignant or benign but invasive oral masses require a proactive surgical approach to achieve complete excision and prevent local recurrence.[2] The type of procedure selected depends on the location and extent of the tumor.[2] A wide variety of mandibulectomy and maxillectomy techniques have been described for the surgical management of malignant oral tumors.[1,2,9] Various mandibulectomy techniques include: unilateral rostral mandibulectomy bilateral rostral mandibulectomy, rim excision/mandibulectomy, segmental mandibulectomy, caudal mandibulectomy, total mandibulectomy and one-and-a-half mandibulectomy.[1,2,8] Various maxillectomy techniques include: unilateral incisivectomy, bilateral incisivectomy, unilateral rostral maxillectomy, bilateral rostral maxillectomy, central/segmental maxillectomy, caudal maxillectomy and unilateral (complete) maxillectomy.

Regardless of the mandibulectomy or maxillectomy procedure being performed, strict adherence to fundamental surgical principles can improve surgical outcome and decrease postoperative complications.[2] These important surgical principles for planning mandibulectomies and maxillectomies have been previously described[1,2,5,8] and include the following: plan for adequate surgical margins, plan for complete mucosal closure, preserve local blood supply and minimize trauma, use sharp dissection rather than electrosurgery to minimize postoperative dehiscence, harvest/undermine large mucosal flaps to avoid tension on suture line, position suture line over bone when possible and use a two-layer closure when possible.

Following completion of the surgical procedure the resected surgical specimen should be marked or inked with a marking material[2] such as Alcian blue or India ink. This will facilitate margin evaluation by the pathologist. Immediate postoperative radiographs of the surgical site will also provide a baseline for future monitoring.[2]

Recommendations for postoperative care following maxillectomy and mandibulectomy procedures have been previously described[1,2,5,8] and include appropriate pain management, intravenous fluid therapy for 24 hours or until patient resumes eating/drinking, soft food diet for 2-4 weeks, possible esophagostomy or gastrostomy feeding tubes in selected cases, no chew toys, restrict activities (such as grooming and rough play) until healed and consider basket muzzles or Elizabethan collars for non-compliant patients, re-evaluate surgical sites two weeks postoperatively for skin suture removal, adjunct oncologic therapy may be initiated (if indicated) after surgical sites have healed, re-evaluate six weeks postoperatively, remove any residual oral sutures and treat traumatic dental occlusion as needed and re-examine surgical site every three months for one year with thoracic radiographs for patients diagnosed with malignant oral neoplasia.

Our goal in treating our veterinary patients with oral tumors should include prolonging the quality of life for these patients while appropriately advising owners about their various treatment options so that they can select the best treatment option(s) for their pets.[5]

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RECOGNITION AND TREATMENT OF CONGENTIAL AND ACQUIRED PALATAL DEFECTS

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Congenital palatal defects can be subdivided into several different categories including cleft hard palate, cleft soft palate, and hypoplastic soft palate. Cleft hard palatal defects are always associated with cleft soft palatal defects. Cleft soft palatal defects may occur without hard palatal defects. Hypoplasia or the congenital absence of the soft palate has a somewhat guarded prognosis for complete resolution of clinical signs since the function of the soft palate cannot be surgically restored.

Two basic techniques for the repair of palatal defects are most commonly utilized. The first technique involves removal of the epithelium from the edges of the defect and complete periosteal elevation of the palatine mucosa bilaterally on each side of the cleft. Bilateral releasing incisions are made near the upper dental arches to permit apposition of the edges of the midline defect. The overlapping flap technique, the second basic technique, may be preferred by some surgeons because there is less tension on the suture line, the suture line is not located directly over the defect, and the area of opposing connective tissue is larger which results in a stronger scar. The need for releasing incisions is also unnecessary in most cases with the overlapping flap technique.

The overlapping flap technique is performed by creating two mucoperiosteal flaps. One flap is hinged at the end of the palatal defect and is turned beneath the other flap. A vest-over-pants type suture pattern of synthetic absorbable suture material is utilized to maintain the connective tissue surfaces of both flaps in position. This technique provides a wide area of connective tissue contact without tension.

Cleft soft palatal defects are repaired using a double flap technique in which incisions are made along the medial margin of the palatal cleft on each side. A small scissors is utilized to divide the palatal tissue into a dorsal and ventral component. The two dorsal flaps are sutured together using absorbable suture material in a simple interrupted pattern with the knots located intranasally. The two ventral flaps are sutured using a similar material and pattern with the knots located intraorally. The edge of the repaired soft palate should reach the midpoint or caudal end of the tonsils and oppose the tip of the epiglottis when the tongue is in normal position.

Acquired palatal defects that have etiologies other than dental disease are usually located in the hard palate. These acquired palatal defects are caused by various types of trauma including dog bites, blunt head trauma, electrical burns, gunshot wounds, dehiscence of surgical sites, foreign body penetration and pressure necrosis. The acute inflammatory reaction and the overall clinical status of the patient with acute trauma should be managed prior to surgical correction of the palatal defect. Various surgical techniques can be utilized to repair acquired palatal defects including buccal flaps, rotation flaps, angularis oris flaps, split palatal U-flaps and island flaps. The technique selected for repair of an acquired palatal defect depends on the location of the defect. In general, the simplest technique and the technique that will provide the largest flap with no tension is recommended.

Buccal flaps can be utilized to repair defects associated with oronasal fistulas secondary to periodontal disease. The edges of the defect are debrided to remove all of the epithelial margins of the palatal defect and divergent incisions are made mesial and distal to the defect through the gingiva, mucogingival line and alveolar mucosa. The periosteal layer of the flap is incised on the inner layer of the flap to release the tension on the flap prior to closure.

Transposition flaps are recommended to repair defects located in the hard palate lateral to the midline and rostral to the maxillary fourth premolar tooth. These flaps should be made significantly larger than the defect to be covered. A small rim of tissue is excised from the edge of the defect. The transposition flaps are then made by making a U-shaped incision with one arm of the U next to the defect. The flap is raised using a curved Freer periosteal elevator while avoiding traumatizing the major palatine artery and leaving the caudal edge of the flap attached. Small holes may be predrilled in the hard palate to allow placement of sutures to help secure the flap. The flap is then transposed to cover the defect and sutures are preplaced between the inner most layer of the flap and the predrilled holes in the palate without traumatizing the major palatine artery. The flap is then sutured in place using a simple interrupted pattern using fine monofilament absorbable suture material leaving the exposed palatal bone of the donor site to heal by second intention.

The split palatal U-flap can be used to repair acquired hard palatal defects located in the caudal hard palate. The edges of the palatal defect are debrided and a large U-shaped flap is created rostral to the defect. The major palatine arteries should be preserved during the creation of the U-flap. The U-flap is divided on the midline. One side of the U-flap is rotated 90 degrees into the defect and sutured in place. The second side of the U-flap is rotated 90 degrees and sutured to the previously rotated flap. The flaps may be similar in size and shape or the one placed rostrally can be slightly longer than the caudal one covering the defect. Small holes may be predrilled in the hard palate rostral to the palatal defect in an area of the palate that will be covered by the second flap to help hold the flap in apposition with the hard palate. The site from which the U-flap is harvested fills with granulation tissue and will be covered with epithelium in 4-8 weeks.

A variation of the split palatal U-flap, the island palatal flap has been used in the repair of a caudal palatal defect which occurred following an extensive caudal maxillectomy procedure. Caudal palatal defects in these types of cases are often located in areas that are deficient in local mucoperiosteal tissue with local perifistula tissues having tension at the time of initial repair, or subsequent to wound contraction. The island palatal flap in a previously reported case was harvested from the side of the palate that had remained intact following the previously performed caudal maxillectomy procedure. An island palatal flap is created by making a large, full-thickness, U-shaped flap positioned over the hemimaxilla with the base of the flap located caudal to the major palatine foramen. The mucoperiosteum is gently raised to avoid traumatizing the major palatine artery during its course along the hard palate and where it enters through the major palatine foramen approximately one-centimeter palatal to the maxillary fourth premolar. The final caudal incision in made through the base of the flap at the level of the maxillary first molar to complete the harvesting of the island palatal mucoperiosteal flap. All flap incisions are full-thickness thereby isolating the attachments of the island palatal mucoperiosteal flap to the major palatine neurovascular pedicle. The margins of the fistula are debrided and the island palatal mucoperiosteal flap is rotated into the defect and sutured in place with monofilament absorbable suture material in a simple interrupted pattern. The portion of the rotated palatal flap bordering the denuded anteriorally located donor site is not sutured and the donor site is left to heal with granulation tissue and reepithelialization. The island palatal mucoperiosteal flap can be utilized in the repair of defects in the caudal oral cavity within a 180-degree rotation arc of the ipsilateral major palatine foramen.

Large single or bilateral buccal flaps can be utilized to repair large palatal defects that are more centrally located in the palate. In cases in which teeth are present in the region in which the buccal flaps are to be harvested, a staged procedure is required. The teeth in the region of the proposed buccal flaps are surgically extracted and the alveolar bone can be recontoured to reduce alveolar bone height as needed. Approximately eight weeks later the definitive surgical repair of the large palatal defect can be performed by creating the buccal flaps bilaterally if needed and advancing the flap(s) over the defect. Any palatal mucosa that will be located beneath the flap must be debrided of all epithelium to permit proper healing. In cases in which bilateral buccal flaps are utilized to cover large mid-palatal defects, overlapping the buccal flaps may provide additional strength for the repair by providing a double-layer closure over the defect. In these cases, it is important to remove the epithelial layer in the region of the 1st buccal flap which will be covered by the second overlapping buccal flap.

When palatal defects cannot be repaired alternatives for control of clinical signs include fabrication of obturators or placement of permanent feeding tubes.

Ventral Approach to Nasal Cavity/Nasopharynx

The ventral approach to the nasal cavity or nasopharynx can be used in the removal of foreign bodies and in the treatment of nasopharyngeal stenosis and choanal atresia.

A ventral approach to the nasopharynx is utilized primarily for increasing exposure of the nasopharynx as is needed in the treatment of nasopharyngeal stenosis in cats. Cats with acquired nasopharyngeal stenosis usually present with a history of nasal obstruction of several months duration. The most significant clinical sign in these cats is stertorous breathing or wheezing upper respiratory noise. When the cat's mouth is held open the respiratory noise and distress are relieved indicating that the clinical signs are nasal in origin. Definitive diagnosis of nasopharyngeal stenosis is confirmed with a small-bore, flexible fiberoptic endoscope. The endoscope is placed dorsal to the caudal edge of the soft palate and directed rostrally. In normal cats the caudal nares are seen at approximately the level of the hard palate and form an ovoid orifice. In cats with acquired nasopharyngeal stenosis the caudal nares are reduced to a pinhole-sized orifice by the presence of a thin but tough membrane. Attempts to pass a thin catheter from the external nares through the ventral meatus on each side will be unsuccessful in cats with nasopharyngeal stenosis. The treatment of choice for acquired nasopharyngeal stenosis is surgery. The cat is placed in dorsal recumbency with the mouth taped open. A midline incision is made in the soft palate and the cut edges are retracted laterally. The stenotic nasopharyngeal opening is enlarged by carefully excising the abnormal membrane with a fine iris scissors, alternatively the abnormal tissue may be removed with laser surgery. The soft palate is sutured with 5-0 or 6-0 Monocryl in two layers.

The ventral approach to the nasal cavity has been utilized to remove ventrally located non-endoscopically retrievable foreign bodies, biopsy nasal tumors, and to attempt surgical correction of choanal atresia in the dog. A ventral rhinotomy for retrieval of a foreign body or for removal of choanal webbing is initiated by making a midline incision in the palatal mucoperiosteum from the level of the second premolar through the rostral one-third of the soft palate as needed. The mucoperiosteum is elevated from the midline with a periosteal elevator exposing the caudal aspect of the hard palate preserving the major palatine arteries as they exit through the major palatine foramina approximately one cm palatal to the fourth premolars. A large round bur is used to remove a 1 centimeter wide by 2-centimeter long section of midline palatal bone or as needed to expose the caudal aspect of the nasal cavity. The foreign body, tumor or anomalous choanal atresia membrane is removed through the defect created in the hard palate. The rhinotomy is closed in two layers using 4-0 Monocryl in a simple continuous pattern in the nasal mucosa-submucosa and 4-0 Monocryl in a simple interrupted pattern for the nasal mucosa-submucosa layer. Removal of the anomalous choanal atresia membrane may result in nasopharyngeal stenosis from scar/stricture formation following surgery. The potential for development of this surgical complication may be decreased with laser surgery. Treatment of severe or recurrent nasal obstruction may be treated with permanent tracheostomy in symptomatic cases.

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ANESTHESIA AS A CONTINUUM OF CARE PARTS 1 AND 2

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Anesthesia causes changes in physiologic homeostasis that can result in patient morbidity or even mortality. The main goal of the anesthesia team is to ensure that there are no anesthetic mishaps and that anesthesia is safe for the patient. But this takes more than just focusing on one phase of anesthesia. In fact, anesthesia cannot be defined merely by the time that the patient is unconscious, but rather by a continuum of care that begins at home with the owner and does not end until the patient returns home to the owner for follow-up care. Anesthesia is a multi-dimensional procedure involving not only the patient's individual characteristics, but also appropriate drugs and drug dosages, specific and critical equipment, diligent physiologic monitoring and support, effective client communication and the use of highly trained staff. Using this information, a template for standardized procedures structured in a systematic, step-wise continuum has been described.[1,2] This approach to veterinary anesthesia is analogous to the growing emphasis on checklists as error-prevention and organizing tools in human medicine. Standardized methods that use medical-specific checklists have been shown to improve the quality and consistency of healthcare delivery in a variety of clinical settings, including anesthesia. The goal is to make the anesthesia period as safe as possible for dogs and cats as dictated by the mantra, 'there are no safe anesthetic agents, there are no safe anesthetic procedures, there are only safe anesthetists.'

The anesthesia continuum begins at the pet's home with the pet owner administering prophylactic drugs like analgesics, anxiolytics and antiemetics, as well as fasting the pet. In the hospital, the anesthesia continuum includes all four phases of anesthesia: preanesthesia, induction, maintenance and recovery. Anesthesia starts with a preanesthetic evaluation and stabilization (if necessary) of the patient, preparation of all anesthetic equipment, and selection of appropriate drugs with precise calculation of drug dosages for all phases of anesthesia. Induction and careful intubation, followed by intraoperative monitoring and physiologic support in the maintenance phase are the next steps, with continued monitoring and support into the recovery phase. Post-anesthesia care, as communicated by the veterinary staff with the pet owner in the clinic and at home, completes the continuum. Provision of analgesia and client/staff communication and education are critical throughout the entire process.

The new AAHA 2020 Anesthesia Guidelines[1] emphasize the continuum of anesthesia in a patient-focused, step-by-step process that is easy to implement and to follow in every practice and the Steps and Phases outlined in those Guidelines will be followed in this presentation. An Online Education Center (www.AAHA.org/anesthesia)[2] with a large volume of information, diagrams, photos, checklists, etc. accompanies the Guidelines. The Guidelines and Resource Center are open access and can be utilized for more in-depth information.

PHASE I: Preanesthesia: Individualized Anesthetic/Analgesic Plan & Client Communication

STEP 1: Pre-anesthetic Evaluation and Plan Considerations
The preanesthesia phase includes not only the choice of preanesthetic sedatives and analgesics, but also a full preanesthetic evaluation and stabilization of the patient, if necessary. **The preanesthetic patient evaluation is critical for patient safety** as it promotes identification of individual risk factors and underlying physiologic changes or pathologic compromise that will impact the anesthetic plan.

STEP 2: Client Communication/Education
Once the initial plan is formulated, pertinent information regarding the anesthetic procedure and **pet-specific risk factors should be discussed with the pet owner**. Tailoring each patient's anesthetic plan to their specific needs allows the anesthesia team to provide optimum care, including patient-specific anesthetic monitoring performed by a dedicated anesthetist. The anesthesia team should clearly communicate to the pet owner that

these measures will decrease the likelihood of anesthetic complications both during the procedure and in the recovery period.

Phase I potential complications: Failure to develop a thorough and patient-specific plan can lead to numerous complications that could occur at any phase of anesthesia. DEVELOP THAT PLAN! Failure to communicate thoroughly with the client can lead to failure of the owner to do their part when the pet is at home and to discontented clients because expectations/outcomes were not clearly described.

PHASE II: Day of Anesthesia: From Doorknob (home) to Doorknob (home) and Everything In-Between

STEP 1: Anesthesia begins at home
The pet owner begins the continuum of anesthesia with fasting the pet and administering medications as directed by the anesthesia team.

STEP 2: Equipment Preparation
Anesthetic equipment is considered **"life-critical"** because patient safety can be adversely affected if the equipment is not functioning optimally or is used incorrectly. Prior to the start of any general anesthesia or sedation-only procedure, it is critical to ensure that all equipment and monitors are turned on, functioning, and have undergone appropriate safety checks. Gather all necessary equipment, including the anesthesia machine, breathing circuit, endotracheal tube and intubation tools (eg, laryngoscope, stylet) and anesthetic monitors. Leak testing the anesthesia machine BEFORE anesthetizing EACH patient is critical for patient and staff safety. A daily equipment checklist is highly recommended for every practice.

STEP 3: Patient Preparation
If sick or injured, the patient should be stabilized before anesthesia as anesthesia and surgery can exacerbate pre-existing physiologic compromise. Appropriate stabilization, with inherent decreased ASA status, can decrease the risk of anesthetic death by 3-6 times.[3,4] At a minimum, every patient should have a thorough physical exam, which includes an accurate body weight. Further preparation, including serum chemistry analysis and a complete blood count is recommended for most patients. More patient-specific preparation could include urinalysis, imaging, and specific blood parameters dictated by the patient's underlying comorbidities. All patients should have an intravenous catheter to facilitate drug administration and fluid support. A patient preparation check list is recommended for every practice.

STEP 4: Anesthetic Protocol
The protocol should address all phases of anesthesia (preanesthesia, induction, maintenance and recovery) and include analgesics and sedatives along with anesthetic drugs.

STEP 4a. Pain Management
Effective analgesia throughout the entire anesthesia continuum is an integral component of patient health and welfare. Analgesia has numerous advantages as a component of general anesthesia, including improved anesthetic safety by promoting a decreased inhalant dose, thus decreasing the likelihood of inhalant-mediated dose-dependent adverse effects such as hypotension and hypoventilation.

STEP 4b. Pre-anesthetic anxiolytics and sedatives
In addition to pre-anesthetic analgesic drugs, pre-anesthetic sedatives and anxiolytics are an important component of the continuum of anesthesia care. Benefits include decreased stress/anxiety and dose reduction of induction and maintenance drugs, which have dose- dependent adverse effects. Reduced patient stress can reduce risk of harm to staff members who are restraining/handling patients. The ASA status and energy level dictate which sedative(s) to use. After premedication, physiologic monitoring and support are conducted as indicated by the patient's health status. Early support of body temperature should be initiated in all patients.

Thermal supplementation is critical as hypothermia can cause numerous adverse effects.

STEP 4c. Anesthetic Induction
Pre-oxygenation should be considered part of the preanesthetic/induction sequence. This is especially critical in patients with airway disease (eg, pneumonia, asthma), breathing difficulty (eg, upper airway dysfunction, limited thoracic movement [eg, thoracic injury, impingement on diaphragm from dilated stomach or gravid uterus]) and in patients with expected difficult intubation (eg, upper airway collapse or airway foreign body). A patient's sedation level following pre-anesthetic drugs will influence the dose of induction drug, which should always be dosed 'to effect'. Typically, appropriate premedication will result in lowered doses of induction drugs. Anesthetic induction is best achieved by intravenous (IV) administration of fast-acting drugs.

Tracheal intubation is an essential part of maintaining an open and protected airway and an endotracheal (ETT) or supraglottic device should be placed immediately after the induction drugs are administered. The length of the tube should be assessed prior to intubation. The proper length will allow the distal tip of the tube to lie midway between the larynx and the thoracic inlet. The largest diameter ETT that will easily fit through the arytenoid cartilages without trauma should be used. Once the patient is intubated and connected to a breathing circuit, ensure that oxygen is flowing, close the pop-off valve or push down the button on the safety pop-off valve and administer one manual breath to 20cm H20 while listening at the patient's mouth to determine if a leak is present. If detected, slowly inflate the cuff while simultaneously administering a manual breath. Once the leak has disappeared, immediately open the pop-off valve or release the button on the safety pop-off valve and secure the ETT to the patient's head. The button-type pop-off valve is recommended since the button must be pushed down to close the system and automatically re-opens once the pushing is stopped. Failure to open the pop-off valve can be catastrophic for the patient.

STEP 4d. Anesthetic Maintenance
Anesthesia is typically maintained using inhalant anesthetics delivered in oxygen and dosed **'to effect'**. In select patients, maintenance can also be achieved using continuous infusions or intermittent doses (IV or IM) of injectable agents, or a combination of injectable and inhalant drugs. During the maintenance phase continue physiologic monitoring, support, and analgesia.

Physiologic monitoring: Vigilant monitoring, interpretation of physiologic changes, and response to patient physiologic status by well trained and attentive staff are critical. Both multiparameter electronic monitors and hands-on assessment of the patient by the anesthetist should be utilized. Body temperature monitoring is critical. Without appropriate monitoring, anesthetic complications can rapidly become anesthetic emergencies. Monitoring significantly decreases the likelihood of anesthetic death.[3]

Physiologic support: Oxygen should be delivered throughout the procedure and the patient may require supplementary breaths or even full ventilatory control. Balanced crystalloid fluids should be administered for most patients undergoing a surgical procedure. Fluid volume should increase or decrease depending on the patient's health status and fluid needs. Body temperature support is critical as hypothermia causes numerous adverse effects.

Trouble-shooting anesthetic complications: Immediate and effective response to complications during anesthesia is critical. The most common complications are hypotension, hypoventilation, hypoxemia, hypothermia and some arrhythmias like sinus tachycardia and bradycardia. Complications in the cardiovascular and respiratory systems are generally the most acutely life-threatening. Other complications can include hypothermia, gastro-esophageal reflux/aspiration, etc….

STEP 4e: Recovery
The recovery phase of anesthesia is as – or sometimes more - critical to safe anesthesia as all of the other

phases of anesthesia. Although many complications occur throughout anesthesia, between 47% and 60% of all anesthetic-related canine and feline deaths, respectively, occur during the postoperative period of anesthesia, with most occurring within the first three hours.[3] Thus, patient care and monitoring of the recovering patient by trained personnel is critical and should be maintained with the same vigilance as during the maintenance phase of anesthesia.

Phase II potential complications: Failure to prepare the patient for safe anesthesia can be disastrous, as can failure to prepare/check the anesthetic equipment (including not only the anesthesia machine but also the equipment for monitoring and support). In fact, failure to properly maintain/check the equipment is one of the most common causes of complications. Other complications include mishaps during intubation, failure to monitor diligently, providing inadequate or inappropriate physiologic support (eg, not maintaining body temperature, inadequate/ excessive supplemental IV fluid administration, etc…). Of course, drug over- or under-dosing and failure to provide analgesia will also lead to complications.

PHASE III: RETURN HOME

Once the patient has been discharged, the anesthesia continuum comes full circle. Pet owners can benefit from receiving anesthetic discharge instructions, in addition to a surgical discharge form. This guides post-operative care by the pet owner, addressing possible complications that could be encountered and outlining when the veterinary team should be contacted.

Phase III potential complications: The owner may not follow through with instructions – especially administration of drugs and/or keeping pets confined or at least decreasing activity. These complications can be alleviated by having thorough conversations with the owners, providing handouts regarding pet care and initiating follow-up progress reports by phone calls/texts, etc.

SPECIAL FOCUS of the Guidelines: Staff Education and Safety Training

Staff training is critical for anesthetic safety. Training is the first step in providing quality patient care through scientific and knowledge-based practice. A cornerstone of the implementation and success of this objective is the veterinary staff, from the veterinarians, technicians, assistants, to the receptionist/office personnel. Creating a cohesive team and providing the educational training resources for the staff is key to patient and personnel safety. Untrained staff can lead to unhappy, unproductive employees, who are inefficient, and could compromise patient care with procedural mistakes. This can lead to a decline in customer service, ultimately leading to a decrease in practice revenue due to the loss of clients. *Potential complications without adequately trained staff:* Too numerous to count!

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FUNDAMENTAL DECISION MAKING IN MANDIBULAR FRACTURE REPAIR – OPTIMIZING PATIENT OUTCOMES

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Facial fractures represent less than 10% of all fractured bones in dogs. Fractures in canine patients are commonly associated with animal-animal interactions, blunt force trauma (hit by car), falls from heights or pathologic fracture related to periodontal disease. Dogs and humans demonstrate similar trends with regard to location and age of those affected. Fractures associated with younger patients (human or canine) create challenges with fixation and may potentially impact growth and development. It's also been shown that many of these trauma patients, as high as 72%, demonstrate evidence of concurrent dentoalveolar trauma, most of those being younger trauma patients. (Soukup 2013)

When describing the demographics of typical mandibular fracture cases in canine and human populations, similarities are noted regarding the age and sex of those affected. In one study out of Brazil (Lopes 2005), male dogs under the age of 2, and over the age of 8 were overrepresented. When evaluating the caseload at UW, 33% of maxillomandibular fracture patients were under 12 months of age (Mulherin 2014) which has been reported by others. (Kitshoff 2013, Umphlett 1990) A similar human study (Ellis 1985) evaluating the records of 2000+ cases of maxillofacial injury revealed predominately young males (in their 20's and 30's) were the most prevalent. Physical assault was the most frequent cause of injury in those patients. Causes predisposing fracture are likely multifactorial in both veterinary medicine and human medicine. The increase in incidence in older dogs was likely associated with periodontal disease in which periodontal disease related pathologic fractures in humans is not as common. Fractures in the area of the mandibular first molar are likely associated with particular root anatomy and possibly being a stress riser with decreased buccal cortical bone thickness overlying the mesial root and decreased mandibular bone height involving the distal root. (Snyder 2016)

When we think about how maxillofacial injuries could impact subsequent growth and development of younger patients, an understanding of how the maxillae and mandibles grow is important. These bones of the face and skull grow by appositional growth. Since no true growth plates exist in the maxilla and only the coronoid and condylar process have growth plates, the effects of maxillofacial trauma may have greater impact on facial symmetry related to soft tissue injury and scarring. The cephalocaudal gradient of growth if the phenomenon that states that the further a bone is away from the brain, the greater and more delayed the growth will occur to reach skeletal maturity. Because of this, injuries in juvenile pets that involve the mandible stand to have a greater impact on jaw growth since an increased potential for growth exists. Because we said that the condylar process has a growth plate that is responsible for ramus height, computed tomography should be recommended in younger patients to screen for injuries in this area.

The goals of repair should be: a quick return to function, a comfortable occlusion and stabilization of fracture fragments. When considering methods of fixation for mandibular fractures, location for fixation placement is crucial. Whether or not the fracture is favorable or unfavorable will be important in determining if the method of fixation should be load-sharing or load-bearing. Favorable fractures are mandible fractures that course cranially and ventrally. When acted on by: gravity, the presence of a bolus of food in the mouth, upwards pulling of the masseter and temporalis muscles and downward and caudal pull of the digastricus- all these vector forces aid in reducing and compressing the fracture. Oblique fractures coursing caudolingually are also considered favorable since the inward pull of the pterygoid muscles and intermandibular sling will serve to generate compression on those fracture planes. In an evaluation of fracture orientations through the M1 tooth, it was noted that caudolingual orientations occurred significantly more frequently ($p=0.022$) and caudoventrally ($p=0.057$). (Scherer 2019) Favorable fractures can sometimes can be stabilized using a single form of load-sharing fixation. Unfavorable fractures frequently require the stabilization of the alveolar crestal bone and the ventral cortex because all of the above stated forces serve to distract the fracture fragments. The alveolar crestal bone is considered the tension surface while the ventral cortex is considered the compression surface. In favorable fractures, stabilization of the tension surface may be all that is required for bony healing. Ultimately if the animal's pain can be treated and the animal can be supported nutritionally, one could argue that no animal must be euthanized due to a jaw fracture considering even with a fibrous union they can be made functional and comfortable. Intractable bleeding or fractures involving temporomandibular joint luxation are situations where immediate treatment is necessary.

Maxillomandibular fixation (MMF) is the simplest method of fixation for simple fractures. By realigning the patient's bite or occlusion, the bone fragments should also become anatomically approximated. Putting a patient into MMF can be done for stabilization until the patient can be surgically repaired, or it can serve as a sole means of fixation. Whether a loose-fitting muzzle (loose enough for them to get their tongue out and lap food), composite bonding of the canine teeth in a semi-open position or use of labial buttons (Goodman 2016) these methods of fixation can permit healing. A major consideration with these variations of techniques is that the TMJ shouldn't be immobilized for more than 3-5 weeks at a time (especially in young animals). With each patient being considered uniquely, and relative to expectations of healing and extent of disease, the composite should be removed and/or the muzzle or buttons should be modified to encourage increased range of motion. These forms of fixation have the highest likelihood for post-operative malocclusion but should be considered as an alternative to euthanasia.

Interdental wiring and composite splint fabrication have become the most widely used methods of fixation by veterinary dentists. Perfect alignment and apposition is difficult with this technique but approximation of bone fragments and reasonable stabilization will likely result in secondary bone healing. In addition, this noninvasive fracture repair technique eliminates the need for surgically opening the fracture site, disturbing the fracture hematoma and stripping away the periosteum necessary for early healing and callous formation. The combination of interdental wiring and composite splinting offers a stronger construction rather than either technique used alone. New advancements in a bioresorbable mineral-organic adhesive has demonstrated promise in benchtop ultimately load to failure testing where adhesive with interdental composite bisc-acryl composite splinting was stronger than interdental wire and bis-acryl composite which had been previously defined as the strongest non-invasive form of fracture repair. (Geddes 2020) Wiring and splint fabrication can be performed with reasonable training and materials much cheaper than traditional orthopedic hardware. These methods are applied to the tension surface of the fracture and can make a favorable fracture stable. Clients must be counseled appropriately to remove hard objects from the patient since the composite can be brittle.

Fractured composite can be repaired after cleaning the remaining composite but does require general anesthesia. Composite splints are typically worn for 6-10 weeks with the patient restricted to softened food and the splint rinsed after each meal. Use of medicated oral rinses helps reduce halitosis. Limitations exist with the placement of splints and wires if the patient has mixed dentition. Understanding and anticipating deciduous tooth exfoliation can be helpful in determining if using the splint for 6-10 weeks is reasonable. In one study by Guzu (2017), wire reinforced composite splints with disease teeth in the fracture line requiring treatment took an average of 2.4 months to heal while fractures not requiring dental work healed in 1.46 months.

In situations where the practitioner fears deciduous teeth anchoring the splint and being exfoliated, mandibular cerclage wires can be place through simple stab incisions in the ventral mandible. This orthopedic cerclage wire can be tightened down in the mouth after a first layer of composite and covered with a subsequent layer of composite. Patients that are this young usually will be sufficiently healed in 6-8 weeks or sooner.

Forms of internal fixation can be tricky and difficult to place in juvenile patients due to overwhelming presence of developing tooth buds. Interfragmentary wiring, external skeletal fixation and plates/screws all have particular advantages and disadvantages. Depending on the state of the patient's dentition, interfragmentary wiring may offer the best flexibility for implant placement. Avoiding the mandibular canal and associated neurovascular bundle, developing permanent teeth and deciduous tooth roots are all important criteria to minimize long-term complications.

What to do with unerupted teeth in the fracture line is controversial in human jaw fracture repair. On one hand, those hard tissue structures aid in the reduction of the fracture. Removal of additional bone to remove the unerupted tooth may serve to destabilize the fracture reduction. It has also been reported that approximately 50% of unerupted human teeth in the fracture line will erupt with an abnormality. Enamel defects (hypocalcification, hypomineralization), the absence of either a crown or root, tooth nonvitality and endodontic disease or impaction are all possible results of the injury. Owners and the pet's primary veterinarian should be carefully counseled on what to watch for in these cases.

Bolstered by readily available advanced forms of diagnostic imaging, great strides have occurred in the area of improved knowledge and application of maxillofacial miniplate systems for use in veterinary trauma and reconstruction. The use of titanium craniomaxillofacial (CMF) miniplates have been become increasingly available for use in veterinary CMF surgery. Caudal fractures, and fractures in edentulous areas of the mandible are ideal for miniplate fixation. One study in cats (Greiner 2017) evaluating single plate fixation comparing locking and non-locking constructs demonstrated that locking constructs exhibited greater stiffness and strength. In a canine study (Arzi 2016) evaluating single or double plate configurations for strength and stiffness in a critical size defect model, double plate fixation was found to be slightly stronger and stiffer, however there were significantly more tooth related injuries with the double plate technique.

In conclusion, the goals of jaw fracture management should be centered on a quick return to function, a comfortable occlusion and providing a stable means of fixation. Juvenile patients often complicate fracture management because of their deciduous or mixed dentition and their potential to reach skeletal maturity. Conversely, they tend to heal quickly. Client communication is key since the full extent of the effects on growth and development of teeth or the facial bones won't be known until almost 1 year of age (in most breeds). Efforts should be made to recommend diagnostic imaging that will provide the most information. Evaluating fractures for type of fixation application is unique to each patient and advantages and disadvantages of non-invasive and rigid forms of fixation should be carefully weighed. The more prepared you are with information, the more accurate your long-term prognosis may be.

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DIAGNOSTIC DENTAL RADIOGRAPHS - TIPS AND TRICKS

Mary L. Berg, BS, LATG, RVT, VTS(Dentistry)

Here are some quick tips for great x-rays every time:

1. You need a diagnostic x-ray – not a perfect x-ray. A diagnostic x-ray allows for the visualization of 2-3 mm of bone around the apex of the root and the level of the alveolar bone. The crown does not need to be on the x-ray.
2. The entire tooth does not need to be on one view. If both roots are visible but on two separate x-rays, it's okay!
3. Get all the teeth in as few views as possible. This saves time and gives a quick survey of the oral cavity. If more detail is needed, additional view should be obtained.
4. Every patient, every time! Not only will this help you become faster at taking x-rays, but it is also better medicine. Remember the patients can't tell us where it hurts.
5. Proper positioning of the animal is key! Place the animal (both dog and cat) in sternal recumbency for the maxillary views and dorsal recumbency for the mandibular. Ensure that the dental arcade is parallel to the table, and the mouth is straight, not tilted in either direction.
6. The sensor (film) should always be placed with the teeth on the very edge of the sensor with the remainder of the sensor inside the mouth, and the sensor should be flat or parallel to the table for maxillary views.
7. High and through the eye on the maxilla!
8. The sensor should be placed parallel to the jaw in the posterior mandibular views (308-311 & 408-411) but returned to a flat or parallel to the table view for the anterior mandibular teeth.
9. Don't fight the tongue for mandibular views!
10. If the x-ray doesn't show what you want to see, determine if the sensor has moved first before changing your tube head.
11. Ideally, the tooth roots should be the same length in the x-ray as in the mouth. If the roots are too long to increase your angle, they are too short, decrease your angle. Think about the position of the sun and your shadow. It will help you correctly adjust your tube head.
12. ALWAYS x-ray missing teeth and pre and post extractions.
13. Practice makes perfect!!!

Dental radiographs are an essential part of the oral exam. The crown is just the tip of the iceberg. Approximately 42% of dental pathology is found subgingivally. Radiographs will help diagnose pathology that is not visible from the surface, confirm suspect pathology, as well as help, demonstrate the pathology to the client. Survey radiographs can also increase your clinic's revenue.

Ideally, a full survey set of radiographs should be taken on all patients annually. This survey series should have all the teeth in as few x-rays as possible. Radiographs are essential when the following problems are present: periodontal disease, endodontic disease, FORL's, draining tracts, trauma, oral masses, dental abnormalities, and pre, intra, and post-surgical evaluations.

Dental radiograph units are relatively inexpensive. You can check with dental supply companies and purchase used units very reasonably. Medical radiograph machines can be used but are inconvenient, and they don't show the detail necessary to make a definitive diagnosis. Dental radiograph units allow for accurate positioning without having to move the patient. They are compact, maneuverable, have limited settings, and less radiation scatter. The settings for kVp and milliamperage are preset, leaving exposure time as the only adjustable setting.

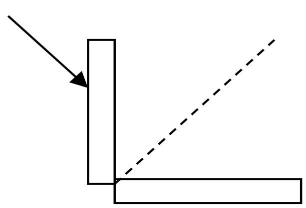
As with all radiation, it is important to observe radiation safety guidelines. The amount of radiation should be kept to a minimum. If possible, step outside of the room but if it isn't possible stay at least 6 feet away and out of the line of the beam. Always wear your film badge. There is a full range of positioning devices available to help keep the film in place. A gauze 4X4 works very well, are disposable and inexpensive.

Proper patient and sensor positioning will make taking dental x-rays easier. The patient should be placed in sternal recumbency with the maxillary arch parallel to the table for the maxillary views and dorsal recumbency with the mandibular arch parallel to the table for the mandibular views. The sensor should always be placed in the mouth flat (or parallel to the table) with the cord coming out the front of the mouth for all views except the posterior mandibular teeth on dogs (308 to 311 and 408 to 411), where the sensor is placed parallel the mandible.

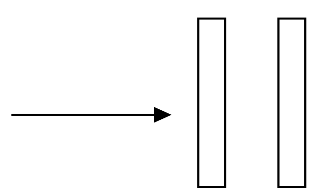
A full radiographic survey will include; anterior maxilla, anterior mandible, posterior maxilla (left & right), posterior mandible (left & right). There may need to be a need for additional views for specific teeth or in larger animals.

There are two intraoral radiograph techniques commonly utilized in veterinary dentistry. The simplest is the parallel technique and is used in the caudal mandible. This view will include the molars and caudal premolars. In the parallel technique, the sensor is placed parallel to the mandible, and the beam is directed at a 90-degree angle to the sensor.

The other technique is the bisecting angle. The bisecting angle minimizes distortions of the teeth. The bisecting angle is used for the anterior teeth, maxilla, and mandible, the posterior maxilla teeth. In this technique, the beam is aimed at the imaginary line bisecting the plane of the tooth and the plane of the film.



Bisecting Angle

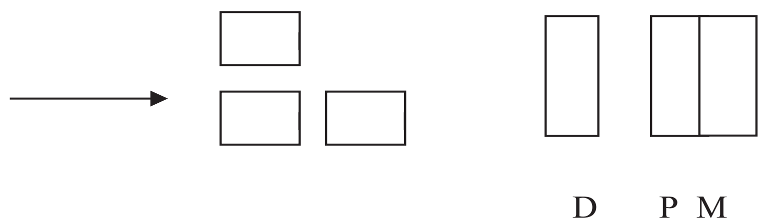


Parallel Technique

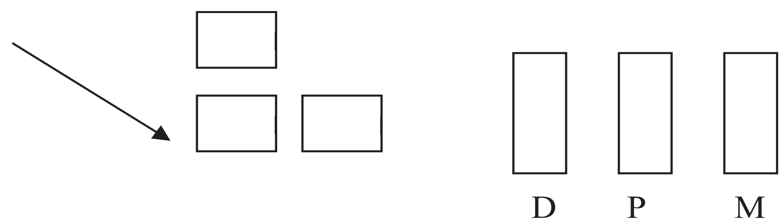
If the beam is not perpendicular to the bisecting angle, the image of the tooth will be distorted. If the angle is too low, it will cause elongation and too high it will cause foreshortening. However, since the bisecting angle technique can be difficult to understand for many individuals, a method that uses the angles on the tube head to assist in positioning is much easier to understand. This technique requires the patient to be properly positioned as state earlier in sternal or dorsal recumbency. See the Easy Guide to Dental X-ray Positioning.

The maxillary P4 is a three rooted tooth. If you use the bisecting angle technique, the palatal root will be superimposed behind the mesiobuccal root. Using the SLOB rule will result in viewing all three roots. (Same Lingual, Opposite Buccal) The tube head is shifted slightly rostral or caudal to visualize all three roots. If the tube head is moved caudally, the palatal or lingual root will be most caudal on the radiograph. If the tube head is moved rostrally, the lingual root will be the most rostral root on the radiograph. Remember, the tube head pulls the palatal root towards itself. PP = Pulls Palatal

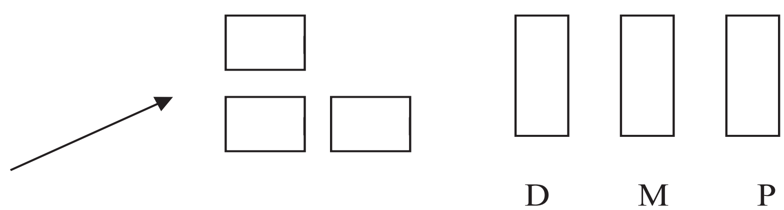
Standard bisecting angle:



SLOB Rule tubehead caudal



SLOB Rule tubehead rostral



In cats, radiographs of the maxillary premolars and molars utilizing the bisecting angle technique result in the superimposition of the zygomatic arch or the apex of the root. With the advancement in digital x-ray technology, it is not as crucial that the zygomatic arch avoided as the apexes of the roots can be seen through the arch.

References: Available upon request.

UNDERSTANDING PERIODONTAL DISEASE AND TREATMENT

Mary L. Berg, BS, RVT, LATG, VTS (Dentistry)

Oral disease is one of the most prevalent diseases in dogs and cats. Recent studies indicate that the prevalence is higher than previously reported 80% of adult dogs and 70% of adult cats having some form of oral disease. Dental problems are among the top three pet owner's concerns in dogs and cats. Calculus and gingivitis are the most common conditions diagnosed by veterinarians in all ages of animals.

Why is the incidence of dental disease so high? Is it due to lack of compliance or lack of educating the client about the importance of dentistry? Pet's living longer lives is one reason that oral disease is more prevalent. We are already improving so many aspects of their lives, but dental care seems to be still lagging.

It is necessary to communicate the importance of dental treatment and oral care in many ways. It should become as routine as vaccinations and heartworm testing in your clinics.
Being aware of dental formulas, oral anatomy, and pathology, as well as terminology, is crucial to proper charting and diagnosis of the disease.

Being able to identify oral pathology and anomalies is essential. It is equally important to record the pathology on dental charts correctly. A thorough dental examination includes both conscious and anesthetized examinations as well as charting disease processes, pathology and anomalies, and treatment plans.

Periodontal Disease is defined as an infectious disease caused by plaque and the resulting inflammatory response. Periodontal disease is present when plaque bacterial-induced inflammation has affected the gingival and other tissues of the periodontium:

- Gingiva
- Periodontal Ligament
- Cementum
- Alveolar Bone

Gingivitis is an inflammation of the gingival tissue. It is preventable and reversible!!!! Undisturbed plaque can lead to gingivitis. Gingivitis is present before periodontal disease

and is characterized by erythema and bleeding.

Plaque is the soft gelatinous matrix consisting of bacteria and bacterial by-products
Plaque starts with a biofilm and is usually clear to light yellow. You may need to use disclosing agents to visualize

Subgingival plaque can create destruction of the periodontium. As the plaque grows below the gum line, the bacteria morph into gram-negative anaerobic bacteria. These black-pigmented anaerobic bacteria species have been identified as:

Porphyromonas gulae
Porphyromonas salivosa
Porphyromonas denticanis

These bacteria produce and release inflammatory mediators and cytokines that activate neutrophils and release proteolytic enzymes.

All the factors destroy the epithelial tissues, which increase sulcus depth, thus damaging the periodontal ligament, and eventually, the alveolar bone is destroyed.

Calculus is calcified plaque that is often blamed for causing periodontal disease. However, the calculus may irritate, and the roughened surface of the calculus gives more surface area for plaque to grow. The more calculus present, the more plaque, and vice versa.

Contributing factors for periodontal disease include:

Crowding
Deciduous teeth
Malocclusions
Diet
Trauma
Foreign Bodies
Genetic

Classification of Periodontal Disease
The degree of severity of periodontal disease relates to a single tooth; a patient may have teeth with different stages of periodontal disease. The diagnosis should be for the worst tooth in the mouth.

Stage of Periodontal Disease:
The stages of periodontal disease can be used to help price your periodontal therapies but also need to be recorded so that the progression of the disease can be determined. These stages are determined by either measuring clinical attachment level or radiographically.

- Stage 1 -Gingivitis only with attachment loss.
- Stage 2 - Less than 25% attachment loss. Grade 1 furcations present.
- Stage 3 - 25 to 50% attachment loss. Grade 2 furcations present
- Stage 4 - Over 50 % attachment loss. Grade 3 furcations present.

There can be multiple treatments for periodontal disease. Scaling & root planing (SRP) which includes subgingival cleaning could be the most crucial step in the procedure by eliminating or reducing the number of subgingival bacteria and toxic substances. Ultrasonic instruments are highly effective in the destruction of the bacteria.

Systemic antibiotics have been used for the treatment of periodontal disease, but there is little to no evidence-based guidelines for their use. Antibiotics do benefit some patients, especially in addition to SRP in severe periodontitis. The bacteria must be able to treat anaerobic bacteria and the dosage and length of treatment based on clinical judgment.

Additional treatments included Doxirobe or Clindoral for periodontal pockets greater than 5 mm.

Periodontal surgery is another option for treatment. Surgery should be considered for pockets greater than 5-6 mm when Stage 2 & 3 furcations are present. This surgery involves a flap procedure to expose the root surface, allowing for a more thorough cleaning and guided tissue regeneration.

For more severely affected teeth, extraction may be the best choice for treatment.

Home Care is a vital part of periodontal treatment. All treatments listed above will be temporary and may not be successful if the owner does not comply with home care instructions. Daily tooth brushing is the Gold Standard, but not every individual can or is willing to brush their pet's teeth. Investigate other proven options for home care and follow up with clients on the success of the product. Schedule regular follows up appointments with clients to continually assess the status of the patient's oral health.

References:

Available upon request.

MOVE IT OR LOSE IT!
ORTHODONTICS FOR THE VETERINARY TECHNICIAN

Amy Edwards, RVT, VTS (Dentistry)

Orthodontics. As in braces? For animals? Well, yes, if the right opportunity presents itself. Orthodontics is the branch of veterinary dentistry that focuses on the eruption of primary and adult teeth into their correct position as well as the relationship of the jaws. The goal in veterinary medicine to ensure each animal has a comfortable and functional occlusion. Most malocclusions are genetic. Some breeds, i.e. brachycephalics, as their standard present with a malocclusion. There is an ethical line that must be made aware of when we discuss correcting a malocclusion for show animals. These animals represent the best of that breed. If most malocclusions are genetic, should we fix a problem in a genetically inferior animal? Signed consent and genetic counseling should be considered for show animals.

The normal occlusion of a dog and cat should present with the mandibular incisors resting on the cingulum of the maxillary incisors. The mandibular canines should slightly flare out towards the lips and rest in the interdental space between the maxillary third incisor and maxillary canine tooth. The mandibular premolars should interdigitate with the maxillary premolars in a pinking shears appearance. Meaning the cusp of the mandibular premolar crowns should rest in the interdental space of the maxillary premolars, sitting slightly lingual to the maxillary dental arch. The mandibular molars should rest close to the palatal surface of the maxillary premolars.

Any deviation in the normal occlusion in considered a malocclusion (MAL). There are 4 classes of malocclusion. These can be deviations just pertaining to the teeth (dental malocclusion) or the jaw length (skeletal malocclusion) and teeth.

Class 1 malocclusion (MAL1) or neutroclusion is the normal position of the jaws with 1 or more teeth in the incorrect position. The tooth/teeth that are in an incorrect position will be listed in the direction in which it is positioned.

- Distoversion (MAL1/DV)- tooth that is angled in a distal direction
- Mesioversion (MAL1/MV)- tooth that is angled in a mesial direction
- Linguoversion (MAL1/LV)- tooth that is angled in a lingual direction
- Palatoversion (MAL1/PV)- tooth that is angled in a palatal direction
- Labioversion (MAL1/LABV)- tooth that is angled in a labial direction
- Buccoversion (MAL1/BV)- tooth that is angled in a buccal directions

A crossbite (CB) also falls under a class 1 malocclusion. This is presented where a mandibular tooth or teeth is directed more in a labial or buccal position. There are two classifications of crossbite.

- Rostral crossbite (CB/R) - 1 or more mandibular incisors are directed labially.
- Caudal crossbite (CB/C) - 1 or more mandibular premolars and molars are directed in a buccal direction to the maxillary premolars/molars.

Treatment of a MAL1 may or may not be necessary. Evaluation of the occlusion when the mouth is closed is necessary to determine if there is any contacting teeth or soft tissue trauma present. Base narrow canines fall into this category. The jaw lengths are in normal position; however the mandibular canines are tipped in a lingual direction. If the malocclusion is slight, an area of gingivoplasty can be done at the interdental space of the maxillary third incisor and maxillary canine. This will create a clearing for the mandibular canine to sit. If the malocclusion is severe, palatal trauma and trauma to the palatal surface of the maxillary canines can occur. If caught at an early age, ball therapy may be an option. When the ball is carried in the mouth between the canines, force is applied to the mandibular canines to help push them out in the normal buccal flare. This will allow the mandibular canines to sit in the interdental space between the maxillary third incisor and maxillary canine. Orthodontic movement through an incline plane may be option also. An incline plane is made from acrylic or fabricated in a lab and attached to the maxillary canines. As the animal closes their mouth, the mandibular canines catch on the "ramp" and are directed in a buccal position. If orthodontic movement is not an option, crown reduction and vital pulpotomy may be the treatment of choice. This procedure will shorten the height of the crown to allow the jaw to close comfortably and without trauma. Then vital pulpotomy procedure is done to preserve and protect the vitality of the tooth/teeth. Extraction of the mandibular canines can also be elected. Lanced canines also fall into this category. The jaw lengths are normal, but the maxillary canine is tilted in a mesial direction. This prohibits the mandibular canine to sit in its normal position. Shelties and Persian cats are predisposed to this condition. Orthodontic movement with buttons and masel chains can be an option if caught soon enough. An orthodontic button is cemented to the maxillary canine, maxillary 4th premolar and molar or mandibular molar and a predetermined length of masel chain is anchored to the buttons. These chains are to be changed every two weeks at a progressively shorter chain length. This mimics the normal slow change to the teeth and supporting structures. This procedure is very time consuming and detailed. The right patient and owner are needed for this option. One or 2 incisors in a rostral crossbite can benefit from orthodontic movement also. Orthodontic buttons, masel chains, lab fabricated metal appliances, dental arch wires are potential treatment option materials. Again, care in patient/owner selection should be considered.

Class 2 malocclusion (MAL2) or mandibular distoclusion is an abnormally shorter mandible compared to the maxilla. Palatal trauma from the mandibular canines +/- incisors may be seen with this malocclusion. Treatment options for this are similar to base narrow canines. An incline plane may correct this malocclusion if the mandibular canines are not sitting on the palatal surface of the maxillary canines. Crown reduction and vital pulpotomy is the treatment of choice if orthodontic movement is not an option. Extraction of the mandibular incisors may also be needed. This typically presents in the deciduous dentition also. As the mandibular canines puncture the palate or maxillary gingiva, a dental interlock is created. This prohibits the mandible to grow. Extraction of the mandibular canines +/- the mandibular incisors is done as soon as possible to allow the jaw to grow without any inhibitions. The permanent dentition must be monitored closely as they may follow the same path.

Class 3 malocclusion (MAL3) or mandibular mesioclusion is an abnormally longer mandible compared to the maxilla. Brachycephalic breeds have a class 3 malocclusion which is normal for their breed. There may be no trauma present; therefore no treatment is necessary. This malocclusion can also be present in the deciduous dentition. If the maxillary incisors are hitting the gingiva on the lingual surface of the mandibular incisors, extraction of the maxillary incisors may be needed. The same is true for the adult dentition. Trauma to the lingual surface of the mandibular canines may develop, predisposing them to periodontal disease. Attrition on the lingual surface of the mandibular canines may also be present from the maxillary 3rd incisor. Pre-emptive extraction of the maxillary 3rd incisors may help with trauma to the mandibular canines. A level bite, where the maxillary and mandibular incisors occlude on top of each other falls into this category. Treatment is usually extraction of the mandibular incisors.

Class 4 malocclusion (MAL4) or maxillomandibular asymmetry occurs when there is there is a discrepancy in the jaw length on one side of the skull. These asymmetries are classified as the direction in which they are presented. Wry bite is no longer an acceptable term.

- Maxillomandibular asymmetry in a rostrocaudal direction (MAL4/RC)- one side of the face is in normal alignment while the other side presents with a mandibular mesioclusion or distoclusion.
- Maxillomandibular asymmetry in a side-to-side direction (MAL4/STS)- the midline of the maxilla and the midline of the mandible do not line up.
- Maxillomandibular asymmetry in a dorsoventral direction (MAL4/DV)- is the presence of an abnormal space between the maxilla and the mandible when the mouth is closed. Also termed an open bite.

If there is trauma or an open bite present, treatment is warranted. Usually extraction or crown reduction and vital pulpotomy are the treatments of choice. The goal is to have the animal have a comfortable, functional occlusion.

Lab fabricated appliances or incline planes require stone models and bite registrations to be made. This often falls on the veterinary technician. Impression trays, soft rubber mixing bowls, spatulas, vibrators, model trimmers, alginate, dental stone and bite wax are needed to make a stone model of the mouth. Select an impression tray that fits the mouth with enough room so the teeth do not hit the side of the tray. Mix the alginate according to manufacturer's directions. Pour the alginate in the impression tray, tapping the side to remove an air bubbles. Contact the teeth in a caudal-rostral direction. Once the tray is in position, hold the position steady until the alginate is set. Remove the alginate from the teeth in one firm snapping motion. Check for any voids or bubbles. Place and mold a strip(s) of boxing wax around the alginate mold and secure with a rubber band. This will allow a buildup of stone on the alginate. The stone model should be poured within 30 minutes. If longer, the mold can be wrapped in moistened paper towels and placed in a bag. The stone should be mixed according to manufacturer's directions in a rubber bowl. Mix the stone on top of the vibrator to eliminate air bubbles. Once mixed, the alginate mold is placed at an angle on top of the vibrator and a small amount of the stone is poured into the middle of the tray. The vibrations will allow the stone to fall into the voids of the mold. Let the mold stay on the vibrator for a few seconds as this will help eliminate air bubbles. After the voids are filled, a thicker layer of stone is poured over the model. The stone is placed on a flat surface and allowed to set for 10-15 minutes. Another layer of thicker stone can be added to make the base of the model. After 24 hours, the alginate can be cut off the model. Care should be taken to not break off the crowns of the model. A bite registration will also be required for the lab to check the occlusion. Place a sheet of bite wax in a bowl of warm water for a few minutes. This will soften the wax and make it more pliable. Lay the bite wax on the maxilla and press the jaws together. Allow the canines and premolars/molars to pierce the wax. This same technique should be done to both the maxilla and the mandible to get an accurate representation of the bite. When the stone models are dry, place the layer of bite wax between the maxilla and mandible to send to the laboratory.

The role of the Veterinary Technician is vital in orthodontics. This is a very detail oriented branch of veterinary dentistry with a long list of materials and equipment that we need to know. Setting up the equipment and arranging them in the order in which they will be needed, and preparing the molds and models often falls on the veterinary technician. Our knowledge base will help the veterinarian do their job better and in a more effective manner. More importantly, you are vital in client communication. Explaining the problem their pet is experiencing and explaining treatment options.

Veterinary Dentistry Principles and Practices. Wiggs and Lobprise, Lippincott-Raven; Philadelphia; 1997

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A TECHNICIAN'S ROLE IN THE DENTAL OPERATORY

Candice Hoerner CVT, VTS-Dentistry

Credentialed veterinary technicians and veterinary assistants have a prominent role in canine and feline dental care. Highly efficient veterinary dental practices fully use and empower them in both the exam room and the dental suite. I strongly encourage veterinary practices to support the training and education of their veterinary technicians and assistants to assume a larger and appropriate role in dental practice. In the exam room, they should obtain a patient medical and dental history. They should be able to explain to the client the dental procedures indicated, answer questions, translate veterinary diagnoses into lay terms, and reassure the client by demonstrating expertise in dentistry.

In the dental suite, a credentialed veterinary technician should perform both a conscious and anesthetized initial oral exam and dictate charting to a veterinary assistant, take diagnostic radiographs, perform cleaning procedures, and place regional blocks if indicated. Because extractions are considered oral surgery, they should not be performed by veterinary technicians. Veterinarians need to provide the appropriate level of oversight and supervision as required by their state practice acts. It is the position statement of the AVDT that technicians should not perform extractions regardless of that state's practice act.

Veterinary technicians and assistants are the veterinary team's patient advocates and client educators. They should spend time with the pet owner before and at the time of discharge, explaining the procedures and treatments performed, home oral hygiene, and medications. In addition, they should interview the client to determine the best home dental care options for the pet and advise, demonstrate, and instruct the owners on how to provide quality home oral hygiene for their pet.

Practices should encourage continuing education and training of veterinary team members. Enabling team members to increase the level of their training and education brings satisfaction and contributes to the retention of skilled personnel. Delineation of duties based upon the training and education of the staff also benefits the practice by fully using the team and ensuring patient safety. Many skills in dentistry should be only performed by credentialed veterinary technicians with the knowledge base to understand how to perform a skill and understand why a procedure is performed and the risks associated with each task.

The highest level of training and certification is the Veterinary Technician Specialist in Dentistry, designated as VTS (Dentistry). This certification is issued by the Academy of Veterinary Dental Technicians and awarded to credentialed veterinary technicians who complete a rigorous 2-year process of education. VTS (Dentistry) training includes both didactic and experiential learning culminating in a credential examination. For more information please visit the Academy of Veterinary Dental Technicians' website, AVDT.us Although most credentialed veterinary technicians may not have the interest to pursue VTS (Dentistry) training, companion animal practices should support and encourage basic and advanced continuing education in dentistry for all team members. Trained veterinary assistants are valued members of the practice team and should act as assistants to the credentialed veterinary technician. Care should be given to assure that veterinary assistants are only performing tasks appropriate to their skill level and their state's practice act.

Here are some common tasks that are considered critical in the dental technician's job description:

- *Client Education*
- *Patient Advocate*
- *Team training*
- *Workflow coordinator*
- *Exam Room Assistant*

- *S.O.P. creation*
- *C.O.R.E. provider*
- *Oral Surgery Assistant*
- *Maintenance of equipment*

It is important to communicate with pet owners the importance of dental disease prevention strategies, beginning at the first visit and then throughout the patient's life stages. It is particularly important to emphasize individualized prevention strategies that should be maintained on an ongoing basis. Some companion animal practices use progress visits to evaluate oral health and home oral hygiene efforts by pet owners. The most important step in achieving compliance with oral health recommendations is getting the client to understand the value and believe in the importance of regular dental care. This awareness generally results when client realizes that oral pathology is a source of pain and infection for their pet.

A fundamental aspect of delivering high-quality veterinary dental care is for the practice team to use consistent dental care terminology and messaging with the client. When this is consistently done using tools such as a written treatment plan, client compliance with your oral health recommendations will generally follow.

Team training is essential in creating a cohesive dentistry message. Remember to include ALL staff members of your hospital in the education process. When a unified oral health campaign is established within your practice then all team members are equipped with the knowledge to convey the importance of oral health to your clients. There are many individuals and companies that can provide training within the hospital setting or the practice can send staff to continuing education events to gain this knowledge.

Workflow coordinating is often an overlooked skill vital to maintain a healthy workplace environment. Daily time management can be complicated when trying to coordinate several dentistry and surgical cases as well as daily appointments. The hospital management must be aware of the fact that additional staff is required to relieve the burden of a busy schedule. This is often the most frustrating part of day to day management in a veterinary hospital and can lead to staff burnout and turnover. As a workflow coordinator you will be tasked with daily case management and timing of procedures (a.k.a. "the puppet master") You must be able to anticipate the timing of your dentistry cases. One way to achieve a proper workflow is to incorporate dental grading into the exam room. When a patient is seen for their examination a dental grade can be applied to the patient and noted in the medical record depending on what is seen on the conscious oral exam. In general, it will directly relate to the Periodontal Disease Stage. This means a patient with periodontal disease stage 1 (gingivitis only) would receive a grade of PD1. We know that it is likely these patients would require an anesthetized C.O.R.E. (Comprehensive Oral & Radiographic Examination) procedure with dental scaling and polishing. We could also anticipate that this would be a fairly "routine" procedure with no oral surgery. Typically, these PD1 graded patients will take far less time to complete. Whereas a patient with periodontal disease stage 4 would be graded as PD4 and would not be a "routine" procedure due to the necessity of oral surgery for numerous extractions. These cases are usually much lengthier procedures. As workflow coordinator you can manipulate the schedule based on the grading of the patient and anticipation of the length of procedure to create a smooth flowing daily schedule.

The creation of standard operating procedures (S.O.P.'s) sets the standards that should be followed by all team members. The dentistry SOP should closely follow the 2019 & 2013 AAHA Dental Care Guidelines for Dogs and Cats. This document is available to download from the AAHA website and provides the veterinary team the gold standards of dental care. Individual hospital & clinics can utilize this tool to train and educate staff members and follow for excellent patient care.

Your role as the practice dentistry technician will of course involve performing the C.O.R.E. procedure. The essential steps to the C.O.R.E. procedure are as follows:

1. Conscious oral examination before administration of anesthesia
2. Continuous monitoring of patient vitals, maintaining patient temperature, open airway via intubation, IV fluid administration and pain management.
3. Full mouth intra-oral radiography
4. Periodontal probing and charting of the oral cavity (use of four-handed charting recommended)
5. Scaling (supra & sub-gingivally) of the teeth using an ultrasonic scaler followed by hand instrumentation
6. Polishing of the coronal surfaces of the teeth
7. Irrigation to remove debris and polishing paste
8. Additional periodontal therapies as indicated (performed by the veterinarian) with informed consent from the owner
9. Provide discharge instructions for the owner incl. written instructions, photographs & oral hygiene recommendations
10. Follow-up instructions for continued oral health

Oral surgery assisting in the veterinary patient is very similar to human oral surgical assisting. Patient monitoring of anesthesia must be dedicated to the patients' anesthetist and not the surgical assistant. The goal is to provide the veterinarian with the correct surgical instruments at the appropriate time. Knowledge of procedure is critical in anticipating which instrument will be needed in the next step. This can be of great time savings to the veterinarian. The surgical assistant will also maintain a clear field for the veterinarian by retracting tissue, continuously swabbing or suctioning fluids and debris as well as gentle lavage when needed. Trimming of suture, adjustment of lighting or patient positioning will fall to the surgical assistant. The dental technician can also perform nerve blocks as needed before the veterinarian begins any therapies or surgery.

The dental technician will also be in charge of maintaining all dental related supplies and equipment. Creation of a checklist is helpful to schedule equipment maintenance. Below is an example list of required materials and equipment for the dental operatory.

- Antiseptic rinse
- Fine grit prophy paste & prophy angles/cups
- Hemostatic agents
- Needles & syringes
- Gauze sponges
- Endotracheal tubes
- Local antimicrobial agents
- Local anesthetic drugs
- Resorbable suture material
- Bone augmentation material
- Patient warming equipment
- Patient vital monitoring equipment
- Dental radiograph machine
- Pressurized dental delivery unit w/high & low speed handpieces
- Ultrasonic dental scaler w/ various tips
- Various dental burs
- Surgical Instruments
- Hand scaling instruments
- PPE, loupes & lighting
- Adjustable seating

Maintenance of dental equipment will include:

- Sharpening of hand instruments and surgical instruments
- Repair or replacement of damaged instruments
- Daily cleaning & sterilization of instruments
- Maintenance of dental delivery unit per manufacturers operator manual
- Periodic radiation leak checks of dental radiography equipment

As dental care is now considered essential to the well-being of our patients, it is critical that the entire veterinary team maintains a high level of dentistry knowledge and can clearly communicate to our clients. The lack of dental training, poor equipment and inadequate amount of time leads to frustration and a disinclination to do what is necessary. Your patients need quality dental care and the best way to convey this to your clients is by properly educating yourself and informing the client of their pets' dental health care needs. When you take the time to educate yourself on the subject and understand the pathology and physiology and the effects on the animal, you will then be able to share this information with the client and provide a tremendous benefit to the patient. If you are informing the client of the proper care with passion, enthusiasm and sincerity they are more likely to accept your recommendation.

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COMMON ORAL PATHOLOGY

Annie Mills LVT, VTS (Dentistry)

Veterinary dentistry should be approached as being proactive instead of reactive which has been the “norm” for many years. Many of the common pathologies found in dental patients and associated silent suffering can be avoided or prevented from advancing to the point where treatment is no longer an option. Dental assessment under sedation with full mouth dental radiographs and gross oral examination in patients as early as 12-18 months can identify early changes, especially with patients prone to periodontal disease, most commonly seen in the smaller or toy breeds. Early detection, treatment and prevention is the key to preventing unnecessary suffering for these patients. For patients that are not in that category, assessment starting at 18-24 months is recommended. Missing dentition, oral masses, congenital malocclusions are often seen in the larger breeds. Again, early detection can be critical in the ability to effectively treat these conditions.

Developmental Conditions including enamel hypocalcification (defects in quality or enamel) and enamel hypoplasia (defects in quantity of enamel) can be treated with restoration provided the radiographs show that the dentition is still vital. Root convergence is seen usually bilaterally in the first mandibular molar. Typically these teeth die when the patient is very young but are not detected until the patient becomes clinical (usually 3-4 years of age or later) or dental radiographs are taken. Unerupted teeth, especially in brachycephalic breeds and involving the 1st mandibular premolars, often cause dentigerous cysts. Bone destruction occurs as the cyst expands over time. Again, these are not found until later in the patient’s life when they become clinical. Extraction of the unerupted tooth will prevent further bone destruction if found early. When this condition is untreated, adjacent dentition becomes compromised due to progressive bone destruction. Maloccuusions are also congenital and, in some cases, cause trauma when there is tooth on tooth or tooth on soft tissue contact present. The approach is to assess the occlusion and determine if intervention is required to create an atraumatic bite for the patient. Class 1 malocclusion is noted when 1 or more teeth are out of alignment. Rotated premolars, linguoversion or mandibular canines (otherwise known as “base narrow”), or rostroversion of maxillary canines (otherwise known as “lance tooth”) are all examples of Class 1 Malocclusion. Treatment options may include orthodontic movement, alteration or extraction to eliminate the traumatic contact. Class 2 and Class 3 malocclusions are skeletal abnormalities and cannot be corrected. Class 2 is noted when the mandible is shorter than the maxilla. Class 3 occurs when the mandible is longer than the maxilla. Again, the approach is to create a comfortable bite for the patient.

Other commonly seen pathologies include oronasal fistula, gingival hyperplasia, stomatitis and juvenile onset gingivitis, chronic ulcerative paradental stomatitis (CUPS), in addition to periodontal disease, which is the most prevalent pathology seen in veterinary medicine. Oral masses are also commonly seen in patients with no specificity to breed, age or species. The majority of oral masses are benign and complete surgical excision is curative. However, some benign types of growths can be aggressive and locally invasive. Depending on the location of the tumor, complete surgical excision can be challenging, unless the mass is found early when it is still small and manageable. Peripheral odontogenic fibroma is the most common benign oral tumor, noted by slow progression, and is non invasive. Acanthomatous ameloblastoma is also a benign type of mass, however, it is locally invasive and the most aggressive type of benign mass. Compound odontoma, also benign, is most often associated with unerupted or partially erupted teeth in young dogs. Fibrosarcoma, malignant melanoma, an squamous cell carcinoma are neoplastic and may require chemotherapy and/or radiation therapy in addition to surgical excision. Prognosis is not as encouraging especially if undetected.

Conditions including abrasion and cavities are typically caused from inappropriate chewing and diet. Abrasion occurs when teeth are exposed to an abrasive surface repeatedly over time. The coating on tennis balls is typically very abrasive and causes significant wear on incisors. Patients that are “crate chewers” often have wear patterns on the distal aspects of the canine teeth. Cavities or caries are not seen as often as other conditions, but do occur with some frequency. Caries are typically seen in patients that consume high sugar diets or treats. These often occur in the 1st maxillary molar and are difficult to see on an awake patient due to the location of the cavity. When found early, these defects can be restored with composite filling.

ROOT CANAL THERAPY INSTRUMENTS

Denise S. Rollings, CVT, VTS (Dentistry)

The purpose of endodontic therapy is to maintain and salvage a tooth. Endodontic therapy is performed to alleviate discomfort and infection while keeping function of the tooth. The advantages of performing endodontic therapy versus extraction include but are not limited to, the form and function of the tooth is preserved, more esthetically pleasing, the procedure is less invasive and often times more efficient. Conditions that warrant a root canal therapy include, but not limited to, complicated crown fractures, abrasion with pulp exposure, non-vital teeth, and periapical bone lysis seen radiographically.

The objective of a root canal therapy is to remove the necrotic or disease pulp and seal the apex of the tooth root to preserve the tooth. There are three parts to a root canal therapy and consist of accessing the pulp canal, cleaning and shaping the canal, and filling the canal.

A root canal therapy requires a multitude of equipment and supplies. Dental radiography is an absolute must and is utilized before, during, and after the procedure. A radiograph is obtained before the procedure to determine if a root canal therapy is warranted. A radiograph is obtained to determine if the file is all the way to apex and this is the working length. A radiograph is obtained to determine what the largest file size is and that it's all the way down to the apex of the root. This is called the master apical size. A radiograph is obtained to determine the appropriate sized gutta percha is all the way down to the apex of the root. A radiograph is obtained to determine that the fill does not have any imperfections. A final radiograph is obtained at the end of the procedure after the restoration has been completed. The different instrument all have an important role during each part. The veterinary technician can assist the veterinarian by having all the instruments and materials prepared. The files can be measured and handed to the veterinarian. All of the radiographs may be obtained by a veterinary technician as well.

Accessing the apical third of the pulp canal is the first step of root canal therapy and should be as straight as it can be to avoid ledging. Ledging can deflect the instruments during the process preventing them from working. The access may already be present due to a fracture. A pathfinder may be used to find the pulp canal. If not, one needs to be created. The materials used include a high-speed handpiece with either a number 2 or 4 round bur, 701 or 701L cross-cut tapered fissure bur, or a 330-pear bur. A Gates Glidden drill on a reduction angle using the low-speed handpiece may be used to enlarge the access.

A series of files is used in the next step to clean and shape the canal. This debrides the canal and removes all of the pulp tissue and dentin debris. The files are used starting with the smallest and ending with the largest possible. A measuring device is needed to measure the files at the appropriate length once the working length is determined. Different length files are used depending on the length of the tooth. A color system is used for the different sized files. The file sizes range from 15 to 160 with a rotating color pattern that is: white, yellow, red, blue, green, black. 8 (grey) and 10 (purple). The number of the number is the diameter of the working end of the tip. A size 15 hand file is 0.15mm wide at the tip and a size 90 is 0.9mm at the tip. The taper varies on the file. Hedstrom, or H files have a spiral groove and taper at the tip. H files are used in a push-pull motion only. Kerr files, or K files have cutting flutes and are used in a push-pull motion or a push-rotate clockwise and pull out motion. K-reamers are used in the same fashion and K files but can be rotated further than 90 degrees. Lightspeed files have a spade shaped tip and their sizes and lengths vary. Endodontic stops are little donut shaped rubber pieces that are used to mark a particular length on a file.

A diluted solution of sodium hypochlorite (bleach) and saline is used to disinfect the canal. Saline solution should be used as a rinse to help reduce the risk of burning the tissue. EDTA or other chelating agents are used to irrigate and lubricate the canal as well as remove the smear layer of organic and inorganic material between file sizes. The solutions are instilled into the canal using a syringe with an endodontic needle. An endodontic needle has a blunt tip. Sterile paper points are used to dry the canal and come in varies sizes and lengths. The canal is dried with sterile paper points using endodontic forceps. The canal is considered dry when the paper points come out of the canal completely dry.

The filling, or obturation, of the canal results in a fluid tight seal of the tooth. Non-irritating material is used. Gutta percha is an inert, bacteriostatic rubber material that is obtained from the Mazer tree. Gutta percha comes in points or cones in varying sizes and lengths. Gutta percha also comes as a flowable and lentulo paste filler is used to administer it into the canal. Speaders with a pointed end and pluggers with a flat end compact the gutta percha into all aspects of the canal. A heating device may be used to aid the compacting process. A sealer is used to seal the dentinal tubules.

Any residual gutta percha and sealer is removed from the coronal access site and can be performed using a bur on a high-speed handpiece or with an excavator. The final restoration of the coronal access is done with glass ionomers and composite restoratives. The goal of the final restoration is to protect the tooth from contamination. Glass ionomer is an intermediate layer and lays between the gutta percha and final restoration. It is not strong enough to be used as a final restoration. The glass ionomer is light cured. A bonding agent is then used to bond the final composite restoration to the tooth. Some bonding agents require acid etching. Newer generation bonding agents are all inclusive and do not require several steps. The bonding agent is then light cured. A composite restoration is then applied to the tooth and light cured. Composite restoration material is categorized by the size of the particles they contain. The final composite restoration is then smoothed using a system of discs. The discs start with the coarsest and decrease to the finest. A final layer of sealant may be applied to seal any imperfections.

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The Foundation for Veterinary Dentistry operates exclusively for charitable, scientific, or educational purposes and was founded:

To educate the public about the importance of oral health in animals.

To advance the understanding of the science of veterinary dentistry among all veterinarians.

To further the knowledge of veterinary and related professions through education of veterinarians, veterinary technicians and other health-care professionals interested in veterinary dentistry and effective veterinary oral health care delivery.

To provide funding to colleges of veterinary medicine, veterinary technician schools, or other institutions, entities or individuals approved for funding by the Foundation to enhance the education of their students, provide appropriate equipment to facilitate teaching and delivery of effective oral care, and to support research projects in the field of veterinary oral health.

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REGIONAL COLLABORATIVE DENTAL EDUCATION CENTER (RCDEC) AT TUSKEGEE

1st year Annual Report (April 2019- May 2020)

In Spring 2019, Tuskegee University College of Veterinary Medicine (TUCVM) received support and dental equipment from the Foundation for Veterinary Dentistry as a pilot program of RCDEC with the goal of providing veterinary dental education classes and wet-labs for veterinary students and veterinary professionals. What is the RCDEC Program?

Tuskegee CVM was able to have a virtual Oath Ceremony for Class of 2020 on May 2, 2020 which included 16 dental elective students.

Below is an abbreviated summary of the first-year status of the dental program at TUCVM.

1. Summary of the hands-on dental education at TUCVM (2019-2020)

Veterinary students received introductory dentistry ed in the following course/rotation and completed items listed.

A) Junior (3rd year) surgery dental lab 3-29-2019:
All 56 third-year veterinary students (class of 2020) participated, Lab activities included oral examination, regional blocks, probing, charting, and extraction of upper 1st premolars, central incisors and upper canines

B) Dental sub-rotation: All 56 fourth-year students took part in the following activities:
Oral examination, cleaning (supra-gingival, sub-gingival, and polishing), probing and charting (approximately 15-20 students.), Dental radiography, Oral ATP procedures on patients, Awake oral examination (adult dog, adult cat, puppy +/- kitten), Review on AAHA dental guideline, Review on JAVMA Anesthesia Case of the Month

C) Dentistry elective course (2 credit hours): fall and spring semesters
9 students in fall, 7 students in spring, Dental radiography (full-mouth, pre- and post-extractions), Awake oral examination (5 pathological cases), 3 cleaning, probing and charting (patients), Regional blocks, Extractions of incisors, premolars, canines, premolars and molars at competent level, Periodontal therapy, Client communication on dental diseases. Review on AAHA guidelines: dental, pain management and anesthesia

2. Dental education outreach activity

Inaugural RCDEC dental lab was scheduled for March 21, 2020, as a part of 55th Tuskegee Annual Veterinary Medical Symposium, which was a 75th diamond anniversary of TUCVM. As many other conventions and meetings, our symposium was also cancelled due to COVID 19 pandemic, and so was the dental lab. We plan to host this CE at same venue with the same topic on feline extraction at next CVM symposium in March 2021.

We consider additional CE course for veterinary technicians during next academic year to compensate our CE obligation of 2019-2020, depending on the situation of the pandemic. There was no income generated through the outreach activity for the academic year of 2019-2020.

3. COVID 19

Our university shifted to all-virtual classes from March 23, 2020 (with extended Spring break from March 16-22, 2020), which mandated all dental labs be discontinued, including the dental CE lab, dental electives, and junior surgery dental extraction lab. Veterinary students will not be on campus at least until August 2020.

Current solution:

Students in class of 2020 and 2021 were encouraged to complete online dental education modules from University of Illinois, if not completed in the past, as well as those from Texas A&M to gain knowledge in small animal dentistry. Both courses were graciously offered during the pandemic at no charge to the students. The modules from University of Illinois remain as pre-requisite for the dental elective course at TUCVM, and modules from Texas A&M provided extra points for dental elective students in class of 2020.

Noriko Aoi, BVSc, MSc, Assistant professor
Department of Small Animal Clinical Sciences
Tuskegee University College of Veterinary Medicine

(A special expression of gratitude goes to Ron Anderson, Dentalaire, for his continued generosity to the Foundations' veterinary dentistry program overall and the Tuskegee RCDEC in particular. Thank you, Ron!!)

Foundation for Veterinary Dentistry would like to sincerely thank these Foundation contributors!

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Plan ahead for future conferences

Indianapolis, Indiana | October 21 - 24, 2021

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