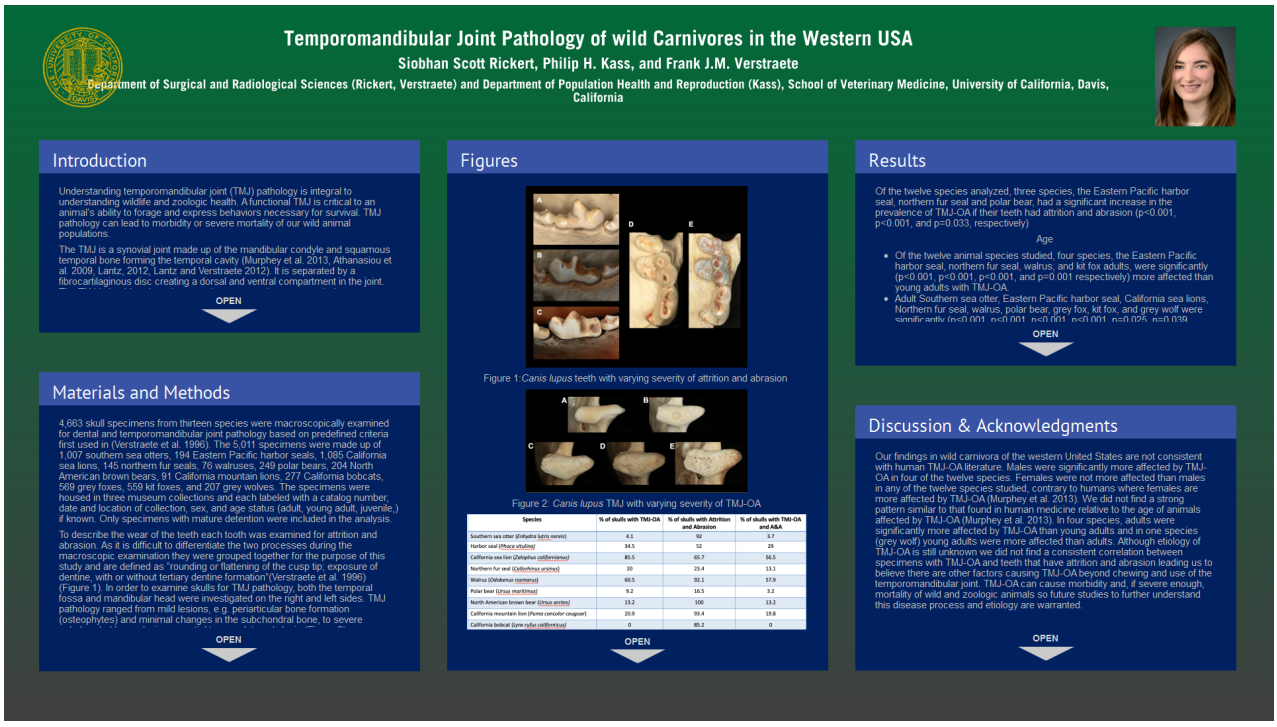
Temporomandibular Joint Pathology of wild Carnivores in the Western USA



Siobhan Scott Rickert, Philip H. Kass, and Frank J.M. Verstraete

Department of Surgical and Radiological Sciences (Rickert, Verstraete) and Department of Population Health and Reproduction (Kass), School of Veterinary Medicine, University of California, Davis, California

PRESENTED AT:


AAVMC
Association of American
Veterinary Medical Colleges


VSSS
Veterinary Summer
Scholars Symposium

INTRODUCTION

Understanding temporomandibular joint (TMJ) pathology is integral to understanding wildlife and zoologic health. A functional TMJ is critical to an animal's ability to forage and express behaviors necessary for survival. TMJ pathology can lead to morbidity or severe mortality of our wild animal populations.

The TMJ is a synovial joint made up of the mandibular condyle and squamous temporal bone forming the temporal cavity (Murphey et al. 2013, Athanasiou et al. 2009, Lantz, 2012, Lantz and Verstraete 2012). It is separated by a fibrocartilaginous disc creating a dorsal and ventral compartment in the joint. The TMJ is load-bearing when masticatory muscles contract during mastication (Tanka et al. 2008, Herring 2003).

In health, the TMJ is critical to normal teeth occlusion and mandibular movement which are key components for survival (Fanghanel and Gedrange 2007, Murphey et al. 2013). TMJ osteoarthritis or osteoarthrosis (TMJ-OA) commonly occur when the normal remodeling process caused by mechanical stress on the joint is overwhelmed, the adaptive capacity is exceeded, and the remodeling becomes pathologic. TMJ-OA is also characterized by deterioration and abrasion of the articular cartilage and local thickening and remodeling of the underlying bone. Although the etiology of TMJ-OA is variable and unknown it is believed to be the end results of different pathogeneses.

In human medicine, temporomandibular joint disorders effect up to 25% of the population, although not all people get treatment (Solberg et al. 1979). TMJ disorders disproportionately affect from two to eight times more females affected than males (Murphey et al. 2013). Although TMJ disorders are generally considered degenerative, the majority of humans presenting to hospitals are most commonly between twenty and fifty years old (Murphey et al. 2013).

MATERIALS AND METHODS

4,663 skull specimens from thirteen species were macroscopically examined for dental and temporomandibular joint pathology based on predefined criteria first used in (Verstraete et al. 1996). The 5,011 specimens were made up of 1,007 southern sea otters, 194 Eastern Pacific harbor seals, 1,085 California sea lions, 145 northern fur seals, 76 walruses, 249 polar bears, 204 North American brown bears, 91 California mountain lions, 277 California bobcats, 569 grey foxes, 559 kit foxes, and 207 grey wolves. The specimens were housed in three museum collections and each labeled with a catalog number, date and location of collection, sex, and age status (adult, young adult, juvenile,) if known. Only specimens with mature detention were included in the analysis.

To describe the wear of the teeth each tooth was examined for attrition and abrasion. As it is difficult to differentiate the two processes during the macroscopic examination they were grouped together for the purpose of this study and are defined as “rounding or flattening of the cusp tip; exposure of dentine, with or without tertiary dentine formation”(Verstraete et al. 1996) (Figure 1). In order to examine skulls for TMJ pathology, both the temporal fossa and mandibular head were investigated on the right and left sides. TMJ pathology ranged from mild lesions, e.g. periarticular bone formation (osteophytes) and minimal changes in the subchondral bone, to severe subchondral boney lysis, or, partial to complete ankylosis (Figure 2).

Statistical Analysis: All of the specimen information, attrition and abrasion, and TMJ pathology data from the twelve species was compiled. All data was analyzed by Fisher exact tests. A p value of <0.05 was considered statistically significant for all analyses.

FIGURES

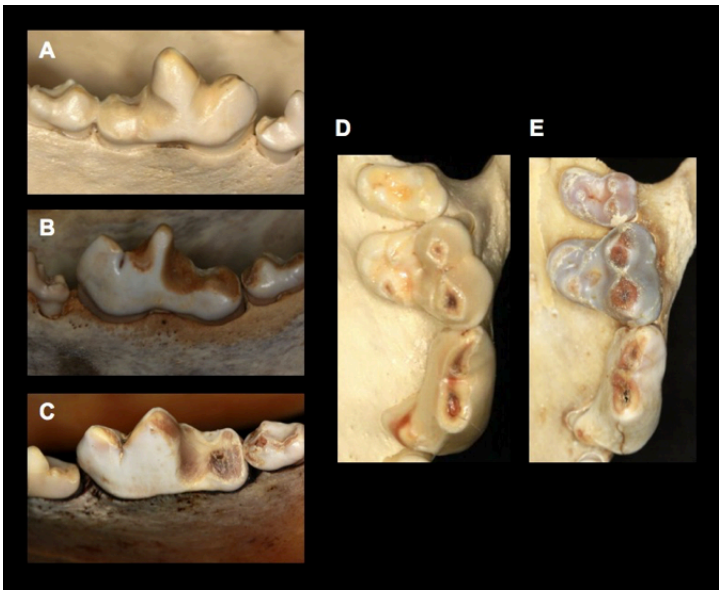


Figure 1:*Canis lupus* teeth with varying severity of attrition and abrasion

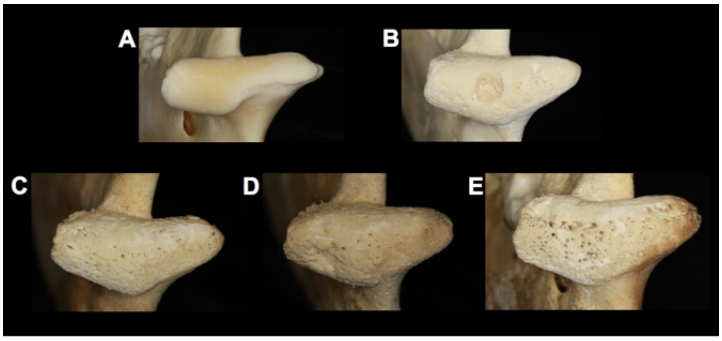


Figure 2: *Canis lupus* TMJ with varying severity of TMJ-OA

Species	% of skulls with TMJ-OA	% of skulls with Attrition and Abrasion	% of skulls with TMJ-OA and A&A
Southern sea otter (*Enhydra lutris nereis*)	4.1	92	3.7
Harbor seal (*Phoca vitulina*)	34.5	52	29
California sea lion (*Zalophus californianus*)	85.5	65.7	56.5
Northern fur seal (*Callorhinus ursinus*)	20	23.4	13.1
Walrus (*Odobenus rosmarus*)	60.5	92.1	57.9
Polar bear (*Ursus maritimus*)	9.2	16.5	3.2
North American brown bear (*Ursus arctos*)	13.2	100	13.2
California mountain lion (*Puma concolor couguar*)	20.9	93.4	19.8
California bobcat (*Lynx rufus californicus*)	0	85.2	0
Grey fox (*Urocyon cinereoargenteus*)	0	85.6	0
Kit fox (*Vulpes macrotis*)	6.3	90.5	6.3
Grey wolf (*Canis lupus*)	11.6	69	6.9

Figure 3: Percentages of specimens by species with TMJ-OA, attrition and abrasion, and specimens with both TMJ-OA and attrition and abrasion.

RESULTS

Of the twelve species analyzed, three species, the Eastern Pacific harbor seal, northern fur seal and polar bear, had a significant increase in the prevalence of TMJ-OA if their teeth had attrition and abrasion ($p<0.001$, $p<0.001$, and $p=0.033$, respectively)

Age

- Of the twelve animal species studied, four species, the Eastern Pacific harbor seal, northern fur seal, walrus, and kit fox adults, were significantly ($p<0.001$, $p<0.001$, $p<0.001$, and $p=0.001$ respectively) more affected than young adults with TMJ-OA.
- Adult Southern sea otter, Eastern Pacific harbor seal, California sea lions, Northern fur seal, walrus, polar bear, grey fox, kit fox, and grey wolf were significantly ($p<0.001$, $p<0.001$, $p<0.001$, $p<0.001$, $p=0.025$, $p=0.039$, $p<0.001$, $p<0.001$, and $p<0.001$ respectively) more affected with attrition and abrasion than young adults.
- Grey wolf young adults were significantly ($p=0.047$) more affected by TMJ-OA than adults.

Sex

- Males were significantly more affected by TMJ-OA than females in four species walrus ($p<0.001$), polar bear ($p=0.005$), North American brown bear ($p=0.005$), California mountain lion ($p=0.004$).
- Males were significantly more affected by attrition and abrasion in California sea lions ($p=0.008$), polar bear ($p=0.009$).
- Female kit foxes were significantly ($p=0.011$) more affected by attrition and abrasion than males.

DISCUSSION & ACKNOWLEDGMENTS

Our findings in wild carnivora of the western United States are not consistent with human TMJ-OA literature. Males were significantly more affected by TMJ-OA in four of the twelve species. Females were not more affected than males in any of the twelve species studied, contrary to humans where females are more affected by TMJ-OA (Murphey et al. 2013). We did not find a strong pattern similar to that found in human medicine relative to the age of animals affected by TMJ-OA (Murphey et al. 2013). In four species, adults were significantly more affected by TMJ-OA than young adults and in one species (grey wolf) young adults were more affected than adults. Although etiology of TMJ-OA is still unknown we did not find a consistent correlation between specimens with TMJ-OA and teeth that have attrition and abrasion leading us to believe there are other factors causing TMJ-OA beyond chewing and use of the temporomandibular joint. TMJ-OA can cause morbidity and, if severe enough, mortality of wild and zoologic animals so future studies to further understand this disease process and etiology are warranted.

Acknowledgments

Data Contribution: S. Döring, N. Yangisawa, N. Sinai, J. Winer, A. Aghashani, E. Clark, T. Aalderink, and J. Evenhuis

M. Flannery of the Department of Ornithology and Mammalogy of the California Academy of Sciences, C. Conroy of the Museum of Vertebrate Zoology of the University of California Berkeley, L. Olsen and A. Gunderson of the Department of Mammalogy, Museum of the North, University of Alaska, Fairbanks for access to the collections.

Financial support: School of Veterinary Medicine, University of California Davis, Students Training in Advanced Research (STAR) Program: School of Veterinary Medicine – Lider endowment funds

ABSTRACT

4,663 skull specimens from: southern sea otter (Enhydra lutris nereis), harbor seal (Phoca vitulina), California sea lion (Zalophus californianus), Northern fur seal (Callorhinus ursinus), walrus (Odobenus rosmarus), polar bear (Ursus maritimus), North American brown bear (Ursus arctos), California mountain lion (Puma concolor couguar), California bobcat (Lynx rufus californicus), grey fox (Urocyon cinereoargenteus), kit fox (Vulpes macrotis), and grey wolf (Canis lupus) were macroscopically examined for dental and temporomandibular joint (TMJ) pathology. The presence of TMJ osteoarthritis (TMJ-OA) varied across species: 4.1% of Southern sea otter, 34.5% of harbor seal, 85.5% of California sea lion, 20% of Northern fur seal, 60.5% of walrus, 9.2% of polar bear, 13.2% of North American brown bear, 19.8% of California mountain lion, 0% of California bobcat and grey fox, 5.9% of kit fox, and 11.6% of grey wolf specimens had lesions consistent with TMJ-OA. TMJ-OA was significantly more prevalent in males over females in walrus, North American brown bear, polar bear, and California mountain lion ($p<0.001$, $p=0.005$, $p=0.005$, $p=0.004$). No other species showed a sex predilection. Adult specimens were significantly more effected than young adults in the harbor seal, fur seal, walrus (all $p=<0.001$) kit fox ($p=0.001$). Grey wolf young adults were significantly ($p=0.047$) more effected by TMJ-OA. Of the twelve species analyzed, three species, the harbor seal, Northern fur seal and polar bear had a significant increase in the prevalence of TMJ-OA if their teeth had attrition and abrasion ($p<0.001$, $p<0.001$, and $p=0.033$, respectively). TMJ-OA can lead to morbidity and mortality in wild animals but its etiology is not yet fully understood.

REFERENCES

Aalderink MT, Nguyen HP, Kass PH, Arzi B, Verstraete FJM (2015a) Dental and temporomandibular joint pathology of the northern fur seal (Callorhinus ursinus). Journal of Comparative Pathology, 152, 325-334.

Aalderink MT, Nguyen HP, Kass PH, Arzi B, Verstraete FJM (2015b) Dental and temporomandibular joint pathology of the Eastern Pacific HarbourSeal (Phoca vitulina richardii). Journal of Comparative Pathology, 152, 335-344.

Abbott C, Verstraete FJM (2005) The dental pathology of northern elephant seals (Mirounga angustirostris). Journal of Comparative Pathology, 132, 169-178.

Aghashani A, Kim AS, Kass PH, Verstraete FJM (2016) Dental pathology of the California bobcat (Lynx rufus californicus). Journal of Comparative Pathology, 154, 329-340.

Aghashani A, Kim AS, Kass PH, Verstraete FJM (2017) Dental and temporomandibular joint pathology of the California mountain lion (Puma concolor couguar). Journal of Comparative Pathology, 156, 251-263.

Arzi B, Leale DM, Sinai NL, Kass PH, Lin A, Verstraete FJM. 2015 The temporomandibular joint of California sea lions (Zalophus californianus): Part 2 – osteoarthritic changes. Archives of Oral Biology 60(1), 216-222

Arzi B, Winer JN, Kass PH, Verstraete FJM (2013) Osteoarthritis of the temporomandibular joint in southern sea otters (Enhydra lutris nereis). Journal of Comparative Pathology, 149, 486-494.

Clark EJ, Chesnutt S, Winer JN, Verstraete FJ (2017) Dental pathology of the American black bear (Ursus americanus). Journal of Comparative Pathology, 156, 240-250.

Doring S, Arzi B, Winer JN, Kass PH, Verstraete FJM (2018) Dental and temporomandibular joint pathology of the grey wolf (Canis lupus). Journal of Comparative Pathology, 160, 56-70.

Evenhuis JV, Zisman I, Kass PH, Verstraete FJM (2018) Dental pathology of the grey fox (Urocyon cinereoargenteus). Journal of Comparative Pathology, 158, 29-50.

Herring SW (2003) TMJ anatomy and animal models. Journal of Musculoskeletal and Neuronal Interactions, 3, 391-394.

Murphy MK, MacBarb RF, Wong ME, Athanasiou KA (2013) Temporomandibular Joint Disorders: A Review of Etiology, Clinical Management, and Tissue Engineering Startegies. Int J Oral Maxillofac Implants, 28 (6), 393-414

Sinai NL, Dadaian RH, Kass PH, Verstraete FJM (2014) Dental pathology of the California sea lion (Zalophus californianus). Journal of Comparative Pathology, 151, 113-121.

Winer JN, Arzi B, Leale DM, Kass PH, Verstraete FJM (2016) Dental and temporomandibular joint pathology of the walrus (Odobenus rosmarus). Journal of Comparative Pathology, 155, 242-253.

Winer JN, Arzi B, Leale DM, Kass PH, Verstraete FJM (2016) Dental and temporomandibular joint pathology of the polar bear (Ursus maritimus). Journal of Comparative Pathology, 155, 231-241.

Winer JN, Arzi B, Do!ring S, Kass PH, Verstraete FJM (2017) Dental and temporomandibular joint pathology of the North American brown bear (Ursus arctos horribilis, Ursus arctos middendorffi and Ursus arctos sitkensis). Journal of Comparative Pathology, 157, 90-102.

Winer JN, Liong SM, Verstraete FJM (2013) The dental pathology of southern sea otters (Enhydra lutris nereis). Journal of Comparative Pathology,149, 346-355.

Yanagisawa N, Wilson RE, Kass PH, Verstraete FJM. 2019 Dental and temporomandibular joint pathology of the kit fox (Vulpes macrotis). Journal of Comparative Pathology 167:60-72.