

Background

Species: The Red Fox (*Vulpes vulpes*) is the most widely distributed land carnivore in the world. Several native and non-native subspecies are present in North America. Native subspecies are cold adapted and occur in low densities in boreal and high elevation mountain habitats, while non-native red foxes are generalists, living in a large variety of habitats, particularly urban environments^{1,5}.

Diet: Small mammals, birds, and anthropogenic food and items³.

Dental Pathology: Dental lesions and pathology may have impacts on the survivability of wild animals⁶ while also providing information about environmental pressures, genetics, disease history, and diet⁷. Links between oral and systemic health also suggest that dental pathology is important to consider when assessing overall health. Anthropogenic diets have been associated with poor oral health in species such as raccoons⁴, which may result in more severe dental pathology in the red fox.

Purpose: This study is a part of an ongoing investigation into the dental pathology of North American carnivores. The dental and temporomandibular joint (TMJ) pathology of the gray fox, island fox, arctic fox, and kit fox have previously been studied, and will serve as a comparison to determine how dental and TMJ pathology differs in prevalence and presentation between fox species.

Results

Pathology	Prevalence
Tooth Presence (Figure 2)	<ul style="list-style-type: none"> 12355 teeth present out of 12810 expected (96.45%) Congenital Absence: 0.56% of teeth <ul style="list-style-type: none"> Mandibular third molar teeth most frequent Acquired Loss: 0.76% of teeth <ul style="list-style-type: none"> Incisor teeth most frequent
Anatomical and Developmental Conditions:	
Tooth Form (Figure 3a)	12 teeth demonstrated abnormal form
Supernumerary Teeth	4 supernumerary teeth
Supernumerary Roots (Figure 3b)	<ul style="list-style-type: none"> 0.4% of teeth exhibited an extra root Supernumerary roots were present more frequently in premolar teeth
Fenestrations (Figure 4a)	<ul style="list-style-type: none"> 42 specimens exhibited fenestrations (13.77%) Most frequently occurred at the maxillary first molar tooth
Persistent Deciduous Teeth	10 persistent deciduous teeth, only persistent deciduous maxillary canine teeth were present
Enamel Hypoplasia	<ul style="list-style-type: none"> 51 (0.40%) of teeth affected by enamel hypoplasia 21 specimens displayed enamel hypoplasia (6.89%) Canine teeth most frequently affected
Acquired Conditions:	
Periodontitis (Figure 4)	<ul style="list-style-type: none"> 3.9% of teeth effected, 56.72% of specimens showed periodontal changes. Premolar teeth most frequently affected <ul style="list-style-type: none"> Stage 2: 2.87% of teeth, 48.2% of specimens Stage 3: 0.91% of teeth, 20% of specimens Stage 4: 0.12% of teeth, 3.93% of specimens 43.28% specimens showed no periodontal changes
Attrition and Abrasion (Figure 5)	<ul style="list-style-type: none"> 45.06% of all teeth <ul style="list-style-type: none"> Stage 1: 25.26% of teeth affected; 94.10% of specimens Stage 2: 11.97% of teeth affected; present in 68.52% of specimens Stage 3: 5.56% of teeth affected; present in 37.7% of specimens Stage 4: 2.27% of teeth affected; present in 35.74% of specimens. Most frequent on the canine and premolar teeth.
Dental Fractures	<ul style="list-style-type: none"> 2.97% of all teeth fractured, 50.83% of specimens had at least 1 fractured tooth Canine teeth were the most frequently fractured (8.36% of all canines) <ul style="list-style-type: none"> Enamel Fracture: 0.25% of teeth Uncomplicated Crown Fracture: 0.13% Complicated Crown Fracture: 0.81% Uncomplicated Crown Root Fracture: 0.04% Complicated Crown Root Fracture: 0.73% Root Fracture: 1%
Periapical Lesions	9 specimens had periapical lesions
TMJ Pathology (Figure 6)	<ul style="list-style-type: none"> 48 mild and 6 moderate osteoarthritis lesions 20 individuals had bilateral lesions, 14 had unilateral lesions
Other	<ul style="list-style-type: none"> 1 malocclusion 16 instances of gunshot wounds 6 specimens showed forms of bony proliferation/pathology

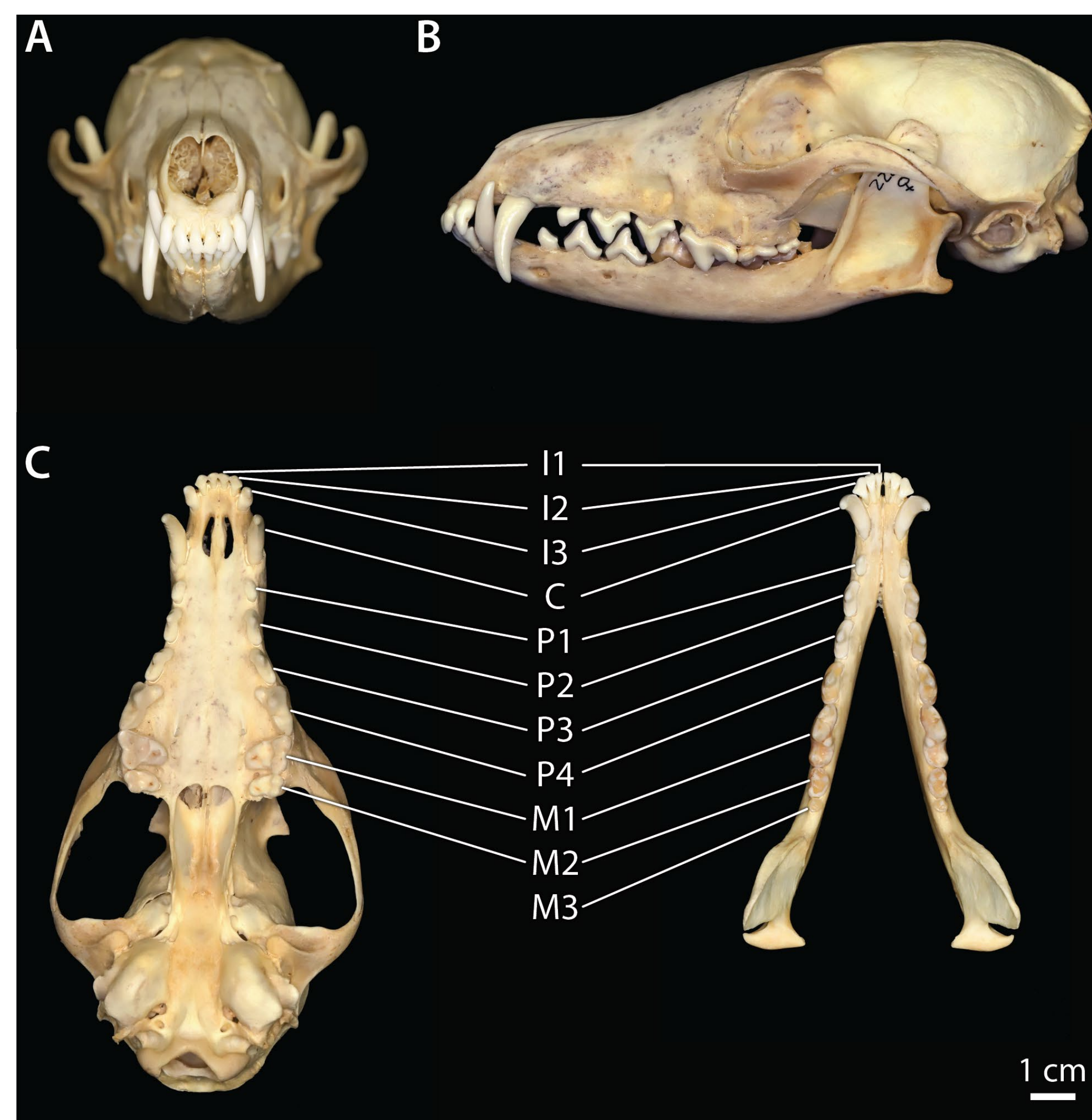


Figure 1: Normal dentition of the red fox (MVZ 222293)

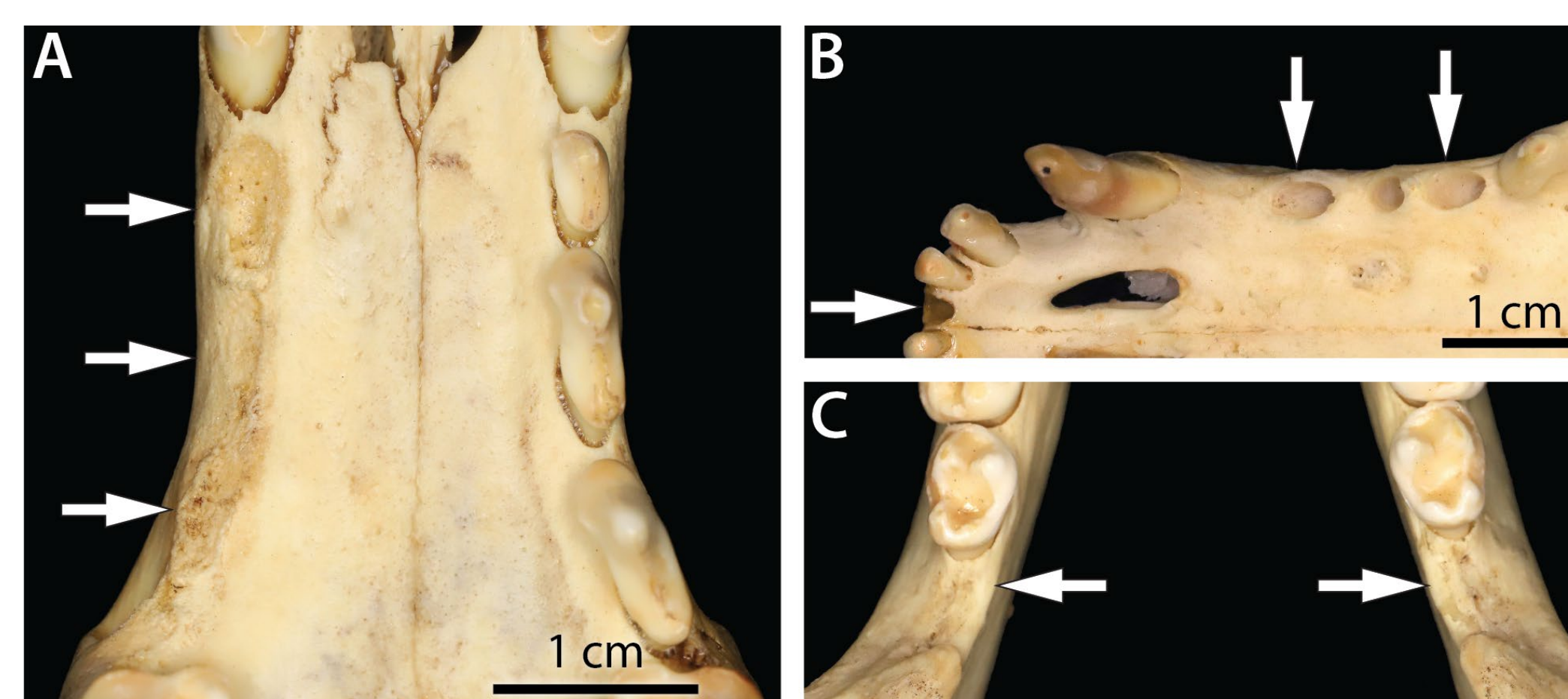


Figure 2: Tooth presence. A. Acquired tooth loss of right maxillary first, second and third premolar teeth (MVZ 46663); B. Artifactual absence of left maxillary first incisor tooth and first and second premolar teeth. C. Congenital absence of left and right mandibular third molar teeth (MVZ 4139)

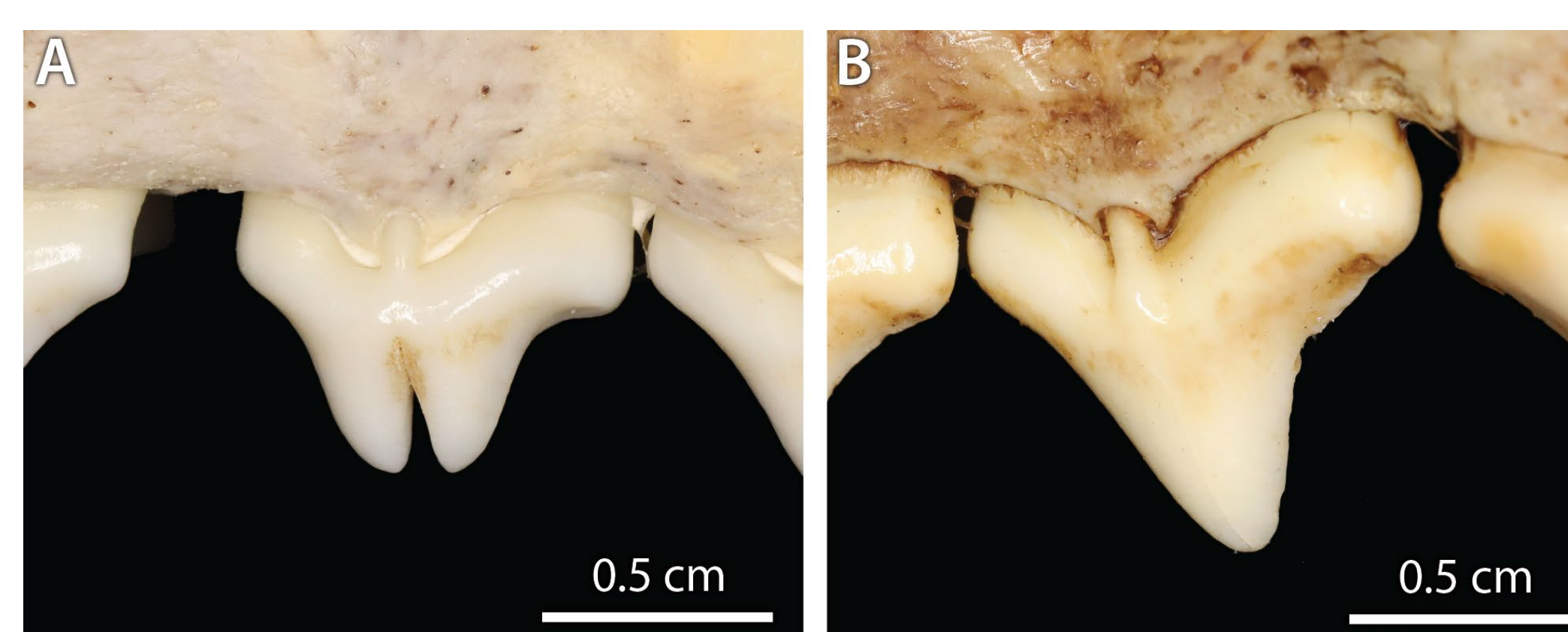


Figure 3: A. Tooth gemination (MVZ 222449); B. Supernumerary root (MVZ 40061)

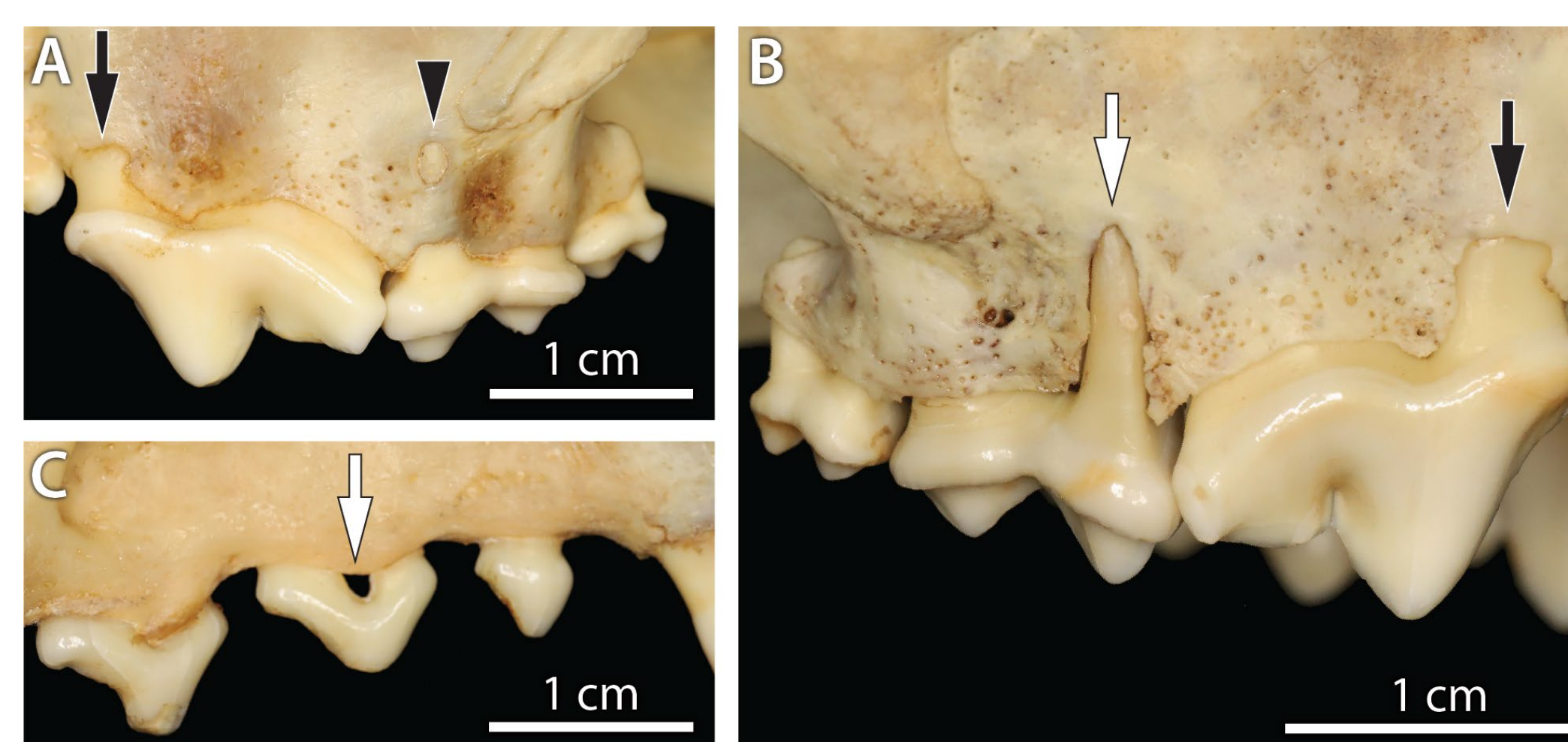


Figure 4: A. Stage 2 periodontitis and fenestration (MVZ 4139); B. Stage 3 periodontitis (black arrow), and stage 4 periodontitis (white arrow) (MVZ 35280); C. Stage 4 furcation lesion (MVZ 122525)

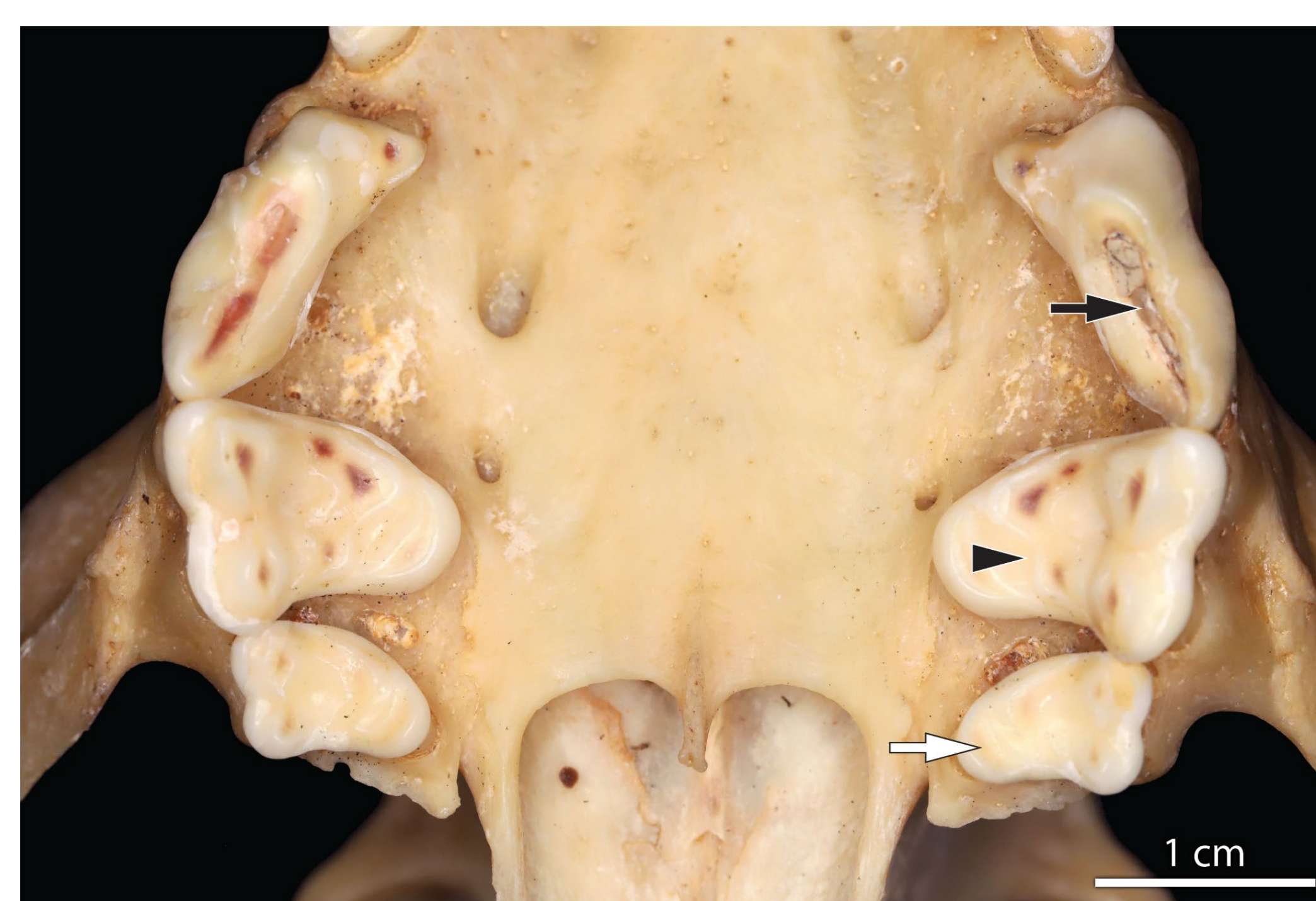


Figure 5: Attrition and Abrasion – Stage 2 (white arrow), Stage 3 (black triangle), stage 4 (black arrow) note pulp exposure (black arrow) (MVZ 4337)

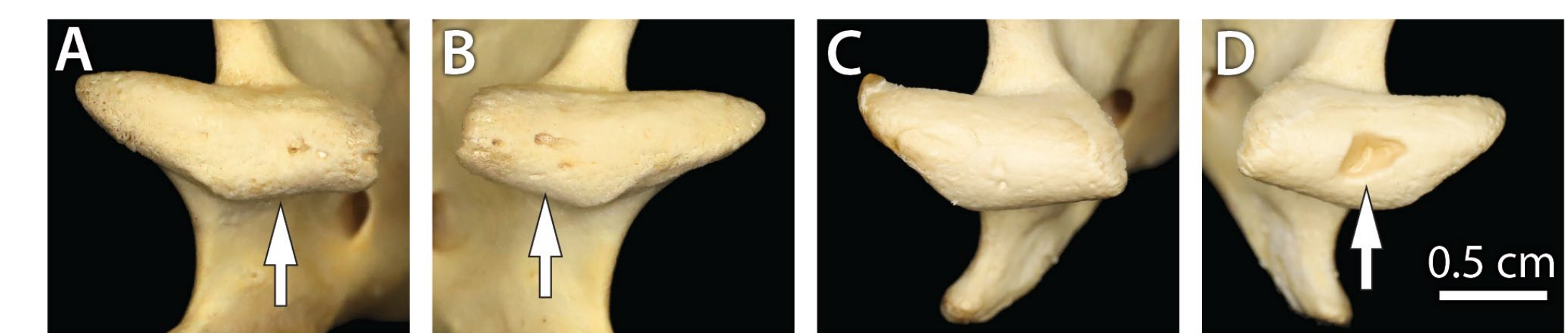


Figure 6: A&B Mild bilateral TMJ osteoarthritis lesions (MVZ 222445); C&D Moderate unilateral TMJ osteoarthritis lesion (MVZ 222299).

Hypothesis

Dental and temporomandibular joint (TMJ) pathology will have a similar presentation to that of the grey fox, island fox, arctic fox, and kit fox but will be more prevalent and severe due to urban habitat and consumption of anthropogenic foods.

Methods

- Macroscopic examination was performed on 305 out of the 390 specimens from the Museum of Vertebrate Zoology in Berkeley, California
- Specimen sex, collection location and date, and subspecies were recorded if provided
- Age was estimated based on cranial, presphenoid-vomer and basisphenoid-presphenoid sutures
- Juvenile, mixed dentition, and specimens from outside North America were not included in the study
- Consistent scoring criteria were used to assess each tooth individually for:
 - Tooth Presence: missing teeth were categorized as artifactual, acquired loss, or congenital absence.
 - Anatomical and Developmental Conditions: abnormal tooth form, supernumerary teeth, supernumerary roots, fenestrations, persistent deciduous teeth, and enamel hypoplasia
 - Acquired Conditions: periodontitis, attrition/abrasion, fractures, periapical lesions, and TMJ osteoarthritis.
- Prevalence of congenital absence, acquired loss, supernumerary teeth, supernumerary roots, fenestrations, enamel hypoplasia, periodontitis, attrition/abrasion, and fractures among tooth types was analyzed using a Chi-square test

Discussion

- Most common congenital lesions: Congenital tooth absence (0.56% of teeth) followed closely by fenestrations (0.51% of teeth). Molar teeth were more frequently affected by both lesions
 - Congenital lesions may be more prevalent within certain subspecies – *Vulpes vulpes kenaiensis* had more frequently congenitally absent molar teeth than other subspecies
- Acquired Lesions were more prevalent than congenital abnormalities
- Attrition/abrasion were present in almost all specimens
 - 96.07% of specimens showed some form of attrition/abrasion and affected 45.06% of all teeth
- Fractures were present in half of the specimens studied (50.83%)
- Periodontitis was present in over half of all specimens (56.72%)
 - However, percentage of individual teeth showing signs of periodontitis (3.9%) was lower than in other fox species^{2,8}
- TMJ osteoarthritis lesions were present in 11.15% of specimens
 - Most lesions were mild, with no severe lesions present in the study population.
- Next steps:
 - Prevalence of abnormalities compared between sex, age, subspecies, location, and collection date will be analyzed
 - Prevalence of pathology will be compared between native and suspected non-native specimens.
 - Comparisons with other North American fox species

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