

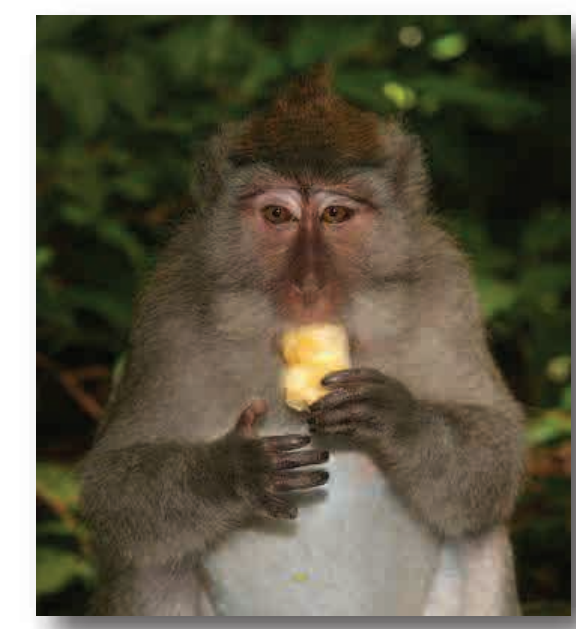
Macaque Attack: Dental topography through a wear sequence in *Macaca fascicularis*

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Introduction

Primate molars are under strong selective pressure to maintain functionality while resisting the effects of abrasive foods and dietary grit. The vast majority of functional morphology studies of dentition have focused on unworn or relatively unworn molar teeth and thus encompass a relatively short period of the functional life of the tooth. In part, this may be due to the difficulty inherent in quantifying the variable morphology of worn teeth and in creating appropriate and informative measures of function. One homology-free measure that has been used in a variety of primates is dental relief (M’Kirera and Ungar, 2003; Dennis et al., 2004; Boyer, 2008; Allen et al., 2015; Pampush et al., 2016). This is calculated as a ratio of the true 3D surface area of a tooth crown –cropped either along the cemento-enamel junction (CEJ) or at the lowest point in the basin–against the 2D planar surface area of the outline of the tooth.



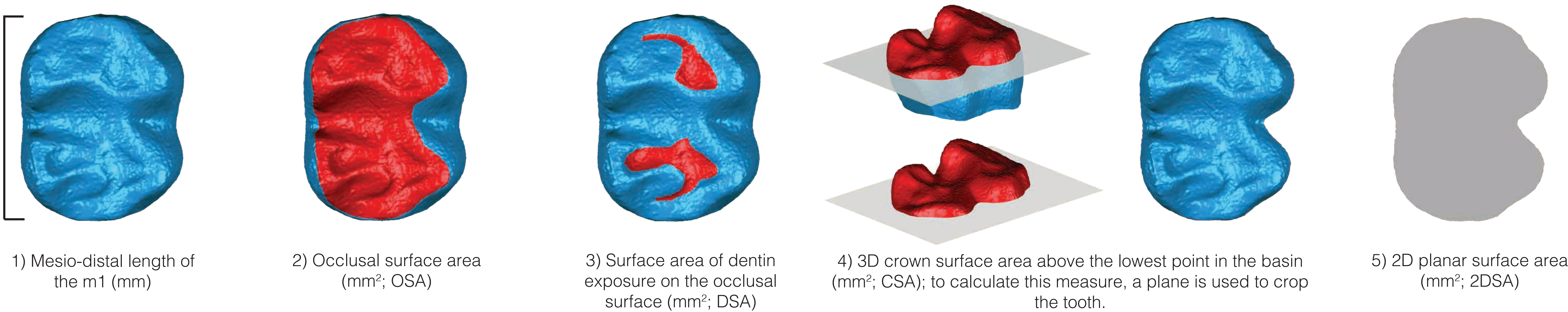
Here, we examine changes in dental relief through a wear sequence in a sample of *Macaca fascicularis* – a largely frugivorous Southeast Asian primate. We ask the following research questions:

- 1) Is dental relief maintained through the wear sequence?
- 2) Does *M. fascicularis* lose occlusal surface area as a tooth wears?
- 3) Are there patterns of left and right symmetry or asymmetry through the wear sequence?

Materials and Methods

The sample included 25 female and 25 male *M. fascicularis* individuals drawn from the collections of the Field Museum and the Smithsonian Institution. The tooth rows were molded using Coltene/Whaledent President Jet and cast using Epotek 301 epoxy resin. All epoxy casts were scanned using a R4X white light scanner (GoMeasure3D) with the macro lens extension to create 3D scans. The interpoint distance for the 3D scans averaged 20-30 µm.

SBC and AW collected the following measurements on the 3D scans of left and right lower first molars (m1) in Geomagic Wrap (shown below on a right molar in occlusal view):



From these measures, we calculated:

- 1) Percentage of dentin exposure on the occlusal surface (DSA/OSA*100); this calculation serves as a proxy for the degree of dental wear.
- 2) Dental relief (2DSA/CSA)
- 3) The difference in percentage dentin exposure between the left and right sides (|right % dentin exposure - left % dentin exposure|); this measure was used to examine the degree of asymmetry.
- 4) Occlusal surface area relative to tooth length (OSA/length)

Results and Discussion

Relief is maintained throughout the wear sequence. There is no statistically significant difference in dental relief across individuals with different amounts of dentin exposure on the occlusal surface (Kruskal-Wallis; p>0.05); a RMA regression of percentage dentin exposure against dental relief has an r²=0.1 indicating a poor correlation between these variables. Maintenance of dental relief appears to occur as a result of the basins becoming deeper as molars wear. As dentin wears more quickly than enamel, individuals with heavily worn teeth have deep basins surrounded by a ring of enamel.

OSA relative to length (a proxy for size) increases through the wear sequence. Individuals with unworn or lightly worn teeth (<10% dentin exposure) have significantly less occlusal surface area (Kruskal-Wallis; p=0.002) than individuals with heavily worn teeth (>50% dentin exposure). This increase in surface area may compensate for a decrease in surface topography (i.e., tall cusps with shearing crests).

While dental relief and OSA were nearly identical on the right and left sides of unworn and lightly worn dentitions, these measures diverged through the wear sequence in some individuals. Individuals with heavily worn teeth (>50% dentin exposure) were more frequently asymmetrical than individuals with lightly worn teeth (<10% dentin exposure) (Kruskal-Wallis; p=0.01). This asymmetry may have implications for movements across the TMJ and potentially may affect the development of joint diseases.

Table 1. Mean values for several measures considered here by percentage of dentin exposure.

	>10%	11-20%	21-30%	31-40%	41-50%	61-70%	71-80%
N	11	8	10	5	4	1	7
Mean difference in % dentin exposure on left and right sides	2.63	5.46	14.89	22.42	8.37	11.84	7.10
Mean dental relief (left and right)	0.55	0.58	0.58	0.57	0.61	0.61	0.52
Mean left and right OSA / length (mm²/mm)	3.64	4.12	4.22	4.47	4.26	4.19	4.52

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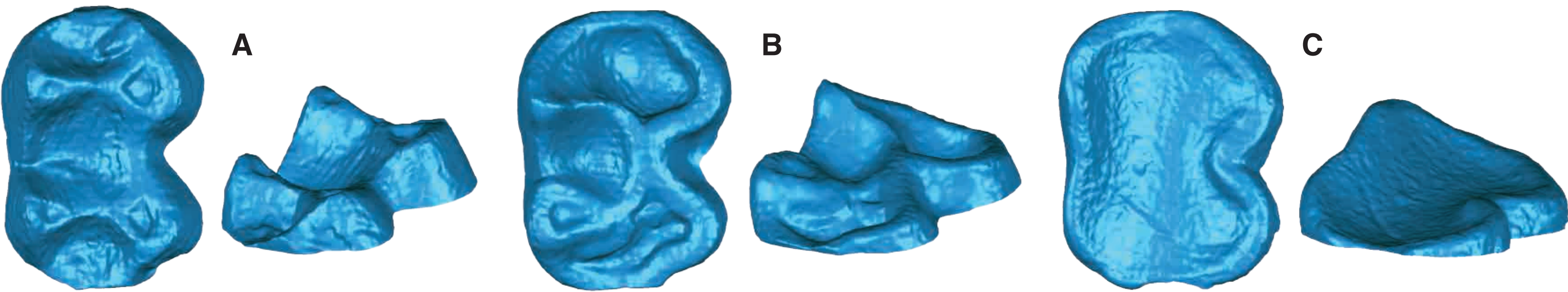


Figure 1. First lower right molars of *M. fascicularis* in occlusal (left) and disto-buccal (right) views. **A)** FMNH 66341; 2.94% of the occlusal surface has exposed dentin; dental relief is 0.59; **B)** USNM 156291; 35.01% of the occlusal surface has exposed dentin; dental relief is 0.53; **C)** USNM 151830; 78.12% of the occlusal surface has exposed dentin; dental relief is 0.52.