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Research paper

On the chipping and splitting of teeth

Herzl Chai[a,*], *James J.-W. Lee*[b], *Brian R. Lawn*[b,c]

[a] *School of Mechanical Engineering, Faculty of Engineering, Tel Aviv University, Tel Aviv, Israel*
[b] *Ceramics Division, National Institute of Standards and Technology, Gaithersburg, MD 20899, USA*
[c] *Department of Anthropology, Center for the Advanced Study of Human Paleobiology, George Washington University, Washington DC 20052, USA*

ARTICLE INFO

Article history:
Received 13 July 2010
Received in revised form
25 October 2010
Accepted 26 October 2010
Published online 2 November 2010

Keywords:
Teeth
Enamel
Chipping
Splitting
Critical load
Dietary history

ABSTRACT

One of the most frequent fracture modes in teeth is chipping. It can lead to deterioration and ultimate loss of tooth function. Chips in enamel can also be used to gain insight into the evolutionary history of extant animal and fossil hominin species. In this study, chipping tests are performed on the surfaces of as-received or flattened human molars using hard indenters. The chips exhibit a characteristic scallop shape, with some influence from tooth curvature as well as from enamel anisotropy and inhomogeneity. Chipping fracture tends to follow easy interprism pathways, but inevitably involves breakage of bundles of mineralized prisms in the last stages of spallation. A simple relation describes how critical loads for chipping scale with distance of the occlusal contact from the specimen edge. Measured loads fall well within the range of biting forces exerted during normal oral function. A transition from chipping to splitting occurs at higher loads for contacts nearer the central axis of the tooth.

1. Introduction

Teeth, along with their dental crown or bridge restorations, are susceptible to cyclic occlusal forces over a lifetime. Mammalian teeth consist of a hard but brittle enamel exterior layer on a soft but tough dentin interior. Cumulative microcontacts with hard μm-scale particles in diet at forces as low as 1 mN can wear cusps down to the dentin, exposing the tooth to degradation and decay (Lucas, 2004). Individual macro-contacts in the cuspal regions with hard mm-scale food objects (e.g. nuts, seeds and errant particulates) at forces in the order of 100–1000 N for humans and even higher for some great apes can lead to longitudinal fractures that run as ribbon cracks around the walls of the enamel shell (Chai et al., 2009a,b; Lawn and Lee, 2009; Lee et al., 2009). These cracks are oriented nearly normal to the tooth surface and remain contained entirely within the enamel. They can run either away from the occlusal contact toward the margin (radial cracks) or in the opposite direction (margin cracks), dependent on tooth dimensions, food object, and any damage prehistory. Such longitudinal cracks can be the precursor to irreversible tooth failure: at extremely high occlusal loading, and for hard food objects close to the center axis, longitudinal cracks may penetrate into the dentin and split the tooth. Such events can have potentially life-threatening consequences for animals in the wild.

* *Corresponding author.*
E-mail address: herzl@eng.tau.ac.il (H. Chai).

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doi:10.1016/j.jmbbm.2010.10.011