Researchers explore how chewing affects teeth on the nanoscale

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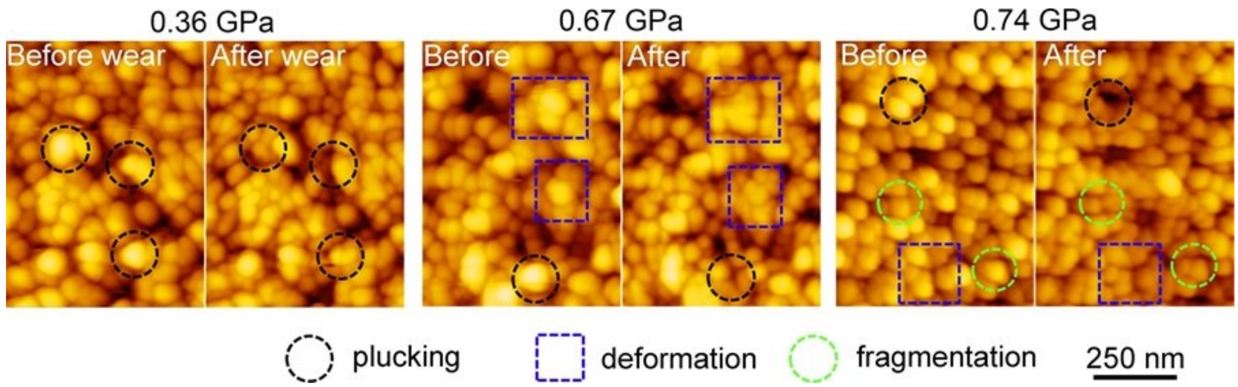

This image shows the nanoscale crystallites that make up tooth enamel before and after researchers applied pressure. Credit: University of Arkansas

Food leaves permanent traces on teeth. Cows chewing on grass, tigers tearing up a piece of raw meat and humans munching on tortilla chips all end up with tiny scratches and nicks on the enamel of their teeth. Examining these marks on the microscale—what researchers call "microwear"—has led to new discoveries about the nature of teeth and the diet of our human ancestors.

Now a team of researchers has taken an even closer look at teeth and documented the effects of chewing on the nano-sized structures that make up tooth enamel. Insights from their research have broad implications. They could lead to better dental care, but they also provide new tools for scientists studying fossil teeth as well as bioengineers building the materials of the future.

Peter Ungar, Distinguished Professor of anthropology, and Ryan Tian, associate professor of inorganic chemistry, worked with researchers at the Southwest Jiaotong University in Chengdu, China, on this project and their results are published in the *Journal of the Royal Society Interface*.

The researchers used high-powered microscopes to observe the effects of different kinds of wear on the nanostructures that make up tooth enamel. Enamel is composed of ribbon-like strings of nanoparticles called hydroxyapatite crystallites, which are stacked on top of each other and glued together by proteins.

"Hydroxapatite crystallites are the fundamental units of enamel, each less than 1/1000th the thickness of a human hair," said Ungar. "Most research on tooth wear to date has focused on effects at much larger scales, but we have to study enamel at this finer level to truly understand the nature of how the hardest tissue in our bodies resists wear and tear."

Using tips made from different types of material, the researchers applied pressure to the surface of human molars, which had been extracted for orthodontic purposes. They scratched the teeth, moving the tip across the surface to simulate the action of teeth moving against each other during chewing. They also indented the surface of the teeth, pressing the tip against the enamel to simulate the pressure caused by crushing food.

The researchers observed that at every level of pressure, scratching led to more damage than indentation, but that both types of stress resulted in three different kinds of damage. "Plucking" occurs when the crystallites are separated from each other. Applying more pressure on the enamel leads to "deformation," or the bending and squeezing of the crystallites.

At even higher levels of pressure, the chemical bonds holding the crystallites together broke. They called this "fragmentation."

Understanding the effects of chewing on this fundamental level has implications for a wide range of fields, from clinical dentistry to evolutionary biology to biomedicine.

"The findings in the surface tribological chemistry can help us understand the nature of the interfacial chemical bonding between the nanoparticles that Mother Nature uses to make biominerals of all types on demand," said Tian.

More information: Enamel crystallite strength and wear: Nanoscale responses of teeth to chewing loads, *Journal of the Royal Society Interface* (2017). rsif.royalsocietypublishing.or … .1098/rsif.2017.0456

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