Strength under pressure

A UMBC professor is using engineering techniques to study why some people's teeth crack while others stay strong

By Chris Emery

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Doctoral students Devendra Bajaj (left), Ahmad Nazari and Juliana Ivancik and undergraduate student Heon Ryou check test results during an experiment at the University of Maryland, Baltimore County. (Sun photo by André F. Chung / October 30, 2007)

The closest thing China has to a tooth fairy might be Dwayne Arola, an engineering professor from the University of Maryland, Baltimore County who has a thing for Asian choppers.

Not long ago, Arola returned from a trip to Shanghai with a plastic lunch box containing a dozen prime specimens from Chinese dental patients - large, cavity-free wisdom teeth - destined to endure a regimen of abuse that he once reserved for aircraft parts.

How the Chinese molars hold up under Arola's stress tests may explain why Chinese teeth are more brittle than American teeth. Ultimately, that knowledge might lead to a dental Fountain of Youth: a high-tech process to make old teeth young again, and less prone to cracking under pressure.
"We are trying to figure out how fast cracks grow and why they grow faster in older people," said Arola, 41. "Ultimately, we'd like to figure out how to arrest those cracks."

As Americans live longer than previous generations, dentists are increasingly working on teeth made brittle by time. Meanwhile, modern dental care has allowed older patients to forego dentures and keep their natural teeth into old age.

Only two decades ago, 30 percent of Americans between the ages of 60 and 74 had lost all of their natural teeth, according to a Surgeon General's report. By 2024, only 10 percent of those in the same age group are expected to be toothless.

Dentists need to prepare for baby boomers reaching retirement age and beyond, experts say. "They are going to get slammed with them," said Janet A. Yellowitz, director of the geriatric dental program at the University of Maryland Dental School. "If you are a dentist in general practice, you are going to see more older adults than ever before."

Dr. Richard Price, a spokesman for the American Dental Association, said he noticed a few years ago that more patients were coming into his office with cracked teeth.

"I don't know that there is one reason for it," he said. "Things will happen to teeth as we get older. People shouldn't be opening bottles, cracking ice cubes and tightening guitar strings with their teeth - but they do."

Arola hopes to do dental damage control.

He didn't set out to be a dental engineer - almost no one does. His original specialty was aerospace engineering - studying how manufacturing techniques introduce imperfections in aircraft parts, and how those defects lead to failures. He moved east from the state of Washington to take advantage of Maryland's strong aerospace engineering sector.

All that changed in 1998, when he cracked a tooth on a piece of bone hidden in an Italian sausage sub. It was the second time he'd broken a tooth biting down on something hard.

Dwayne Arola holds a tooth he obtained while in Shanghai, China. The University of Maryland, Baltimore County engineering professor studies how teeth hold up under pressure and ways to make teeth stronger. (Sun photo by André F. Chung / October 30, 2007)

"The dentist told me it was pretty common," he said. "I started thinking, 'I'm going to figure out why ... this is what I'm going to study.'"

And so he reengineered his engineering lab at UMBC to apply the same techniques he used on aircraft parts to studying why teeth split.

"Your teeth see as much physical activity as anywhere else in your body," Arola said. "The magnitude of forces put on them
are far greater than those put on other parts of the body."

Molars, which undergo the most stress during hard chewing, are most likely to break. Tiny cracks often form in teeth repaired with fillings, starting at points where the filling touches dentin, the calcified layer sandwiched between the outer enamel and the inner pulp.

Chewing and grinding of teeth make the cracks radiate through the dentin, weakening the whole tooth and setting it up for failure.

To study how age, gender and ethnicity affect the speed of crack growth, Arola and his graduate students machine teeth to create "compact torsion specimens." The flat, two-millimeter-wide squares of dentin wind up in a $60,000 machine called a universal testing system that tugs repeatedly on opposite sides of the samples - simulating the forces of chewing.

Wisdom teeth make the best test subjects because they are typically larger and in better shape than other molars.

Arola discovered that fractures in the dentin of elderly Chinese people grow about 50 percent faster than American fractures. In the United States, cracks grow about 100 times faster in the teeth of patients older than 60 than in those of younger patients.

It's still unclear why Chinese teeth are more brittle, but diet and genetics might play a role. Arola said the Chinese thirst for tea might cause their teeth to absorb more minerals and harden more than nontea drinkers.

High levels of fluoride introduced to Shanghai's tap water might be another culprit. Although fluoride strengthens tooth enamel, Arola said, over a lifetime it might clog microscopic, fluid-filled tubules that run through the dentin.

The tiny tubes keep teeth hydrated and transmit sensation from the outer surface to the nerve. "When you feel pain in your tooth, that's what you're feeling," he said. Over time, the tubes clog with minerals, starving the dentin of moisture and making it harder and less flexible.

"What dentists see is the end result of brittle - people coming in with their teeth cracked," said UM's Yellowitz.

Arola hopes that finding out what makes some people's teeth less fracture prone will help him develop new dental techniques and materials to repair and prevent fissures.

For example, researchers might work on glues similar to those used to prevent windshield cracks from growing. Materials used to fill cavities could contain time-release chemicals that discourage cracks.

Dentists are already filling deep cavities with a human peptide known as Dentonin that encourages a tooth's pulp to protect itself by growing more dentin.

"When I started in dentistry, the basic materials were silver and gold," the ADA's Price said. "We're not bound by that anymore. This is something that dentistry has been pointing at since it began."

Arola said the first step is understanding how teeth age at the microscopic level. "Otherwise, we're not fixing the root cause," he said. "And I didn't mean that as a tooth joke."

The engineer's work requires a steady supply of teeth - Arola estimates he's worked through about 1,000 specimens so far. Last week, he had about 200 teeth collected from dentists in Maryland, India and China.
stored in a saline solution in a lab refrigerator.

Getting donations from patients at both ends of the age spectrum is the biggest challenge. "We can't get them from young people because they want to take them home and give them to the tooth fairy," Arola said. "We've even thought about taking out an ad and saying we'll give children more money than the tooth fairy."

And once adults make it past 50 years old with their wisdom teeth intact, they tend to keep them the rest of their lives. The scarcity of older teeth has prompted Arola to put off getting his own removed. "It's harder and harder to get teeth from people over 50," he said. "So I might just wait until later."

_Chris.Emery@baltsun.com_ Dwayne Arola was incorrectly identified as a UM professor when this article was published in the print edition. He is a professor at UMBC. The Sun regrets the error.

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