Evidence suggests saber-toothed cats held onto their baby teeth to stabilize their sabers

April 30 2024

A mechanical analysis of the distinctive canines of California's saber-toothed cat (*Smilodon fatalis*) suggests that the baby tooth that preceded each saber stayed in place for years to stabilize the growing permanent saber tooth, perhaps allowing adolescents to learn how to hunt without breaking them. Credit: Massimo Molinero

California's state fossil—are familiar to anyone who has ever visited Los Angeles' La Brea Tar Pits, a sticky trap from which more than 2,000

saber-toothed cat skulls have been excavated over more than a century.

Though few of the recovered skulls had sabers attached, a handful exhibited a peculiar feature: the tooth socket for the saber was occupied by two teeth, with the permanent tooth slotted into a groove in the baby tooth.

Paleontologist Jack Tseng, associate professor of integrative biology at the University of California, Berkeley, doesn't think the double fangs were a fluke.

Nine years ago, he joined a few colleagues in speculating that the baby tooth helped to stabilize the permanent tooth against sideways breakage as it erupted. The researchers interpreted growth data for the saber-toothed cat to imply that the two teeth existed side by side for up to 30 months during the animal's adolescence, after which the baby tooth fell out.

In a new paper published in the journal *The Anatomical Record*, Tseng provides the first evidence that the saber tooth alone would have been increasingly vulnerable to lateral breakage during eruption, but that a baby or milk tooth alongside it would have made it much more stable.

The evidence consists of computer modeling of saber-tooth strength and stiffness against sideways bending, and actual testing and breaking of plastic models of saber teeth.

"This new study is a confirmation—a physical and simulation test—of an idea some collaborators and I published a couple of years ago: that the timing of the eruption of the sabers has been tweaked to allow a double-fang stage," said Tseng, who is a curator in the UC Museum of Paleontology.

"Imagine a timeline where you have the milk canine coming out, and when they finish erupting, the permanent canine comes out and overtakes the milk canine, eventually pushing it out. What if this milk tooth, for the 30 or so months that it was inside the mouth right next to this permanent tooth, was a mechanical buttress?"

He speculates that the unusual presence of the baby canine—one of the deciduous teeth all mammals grow and lose by adulthood—long after the permanent saber tooth erupted protected the saber while the maturing cats learned how to hunt without damaging them.

Eventually, the baby tooth would fall out and the adult would lose the saber support, presumably having learned how to be careful with its saber. Paleontologists still do not know how saber-toothed animals like Smilodon hunted prey without breaking their unwieldy sabers.

A portion of the right maxilla of a saber-toothed cat, Smilodon fatalis, showing a fully erupted baby saber tooth with the adult tooth just erupting. Based on Tseng's tooth eruption timing table, he estimates that the animal was between 12 and 19 months of age at the time of death. The fossil is from the La Brea Tar Pits and is housed at the Natural History Museum of Los Angeles County. Credit: Jack Tseng, UC Berkeley

"The double-fang stage is probably worth a rethinking now that I've shown there's this potential insurance policy, this larger range of

protection," he said.

"It allows the equivalent of our teenagers to experiment, to take risks, essentially to learn how to be a full-grown, fully fledged predator. I think that this refines, though it doesn't solve, thinking about the growth of saber tooth use and hunting through a mechanical lens."

The study also has implications for how saber-toothed cats and other saber-toothed animals hunted as adults, presumably using their predatory skills and strong muscles to compensate for vulnerable canines.

Beam theory

Thanks to the wealth of saber-toothed cat fossils, which includes many thousands of skeletal parts in addition to skulls, unearthed from the La Brea Tar Pits, scientists know a lot more about Smilodon fatalis than about any other saber-toothed animal, even though at least five separate lineages of saber-toothed animals evolved around the world. Smilodon roamed widely across North America and into Central America, going extinct about 10,000 years ago.

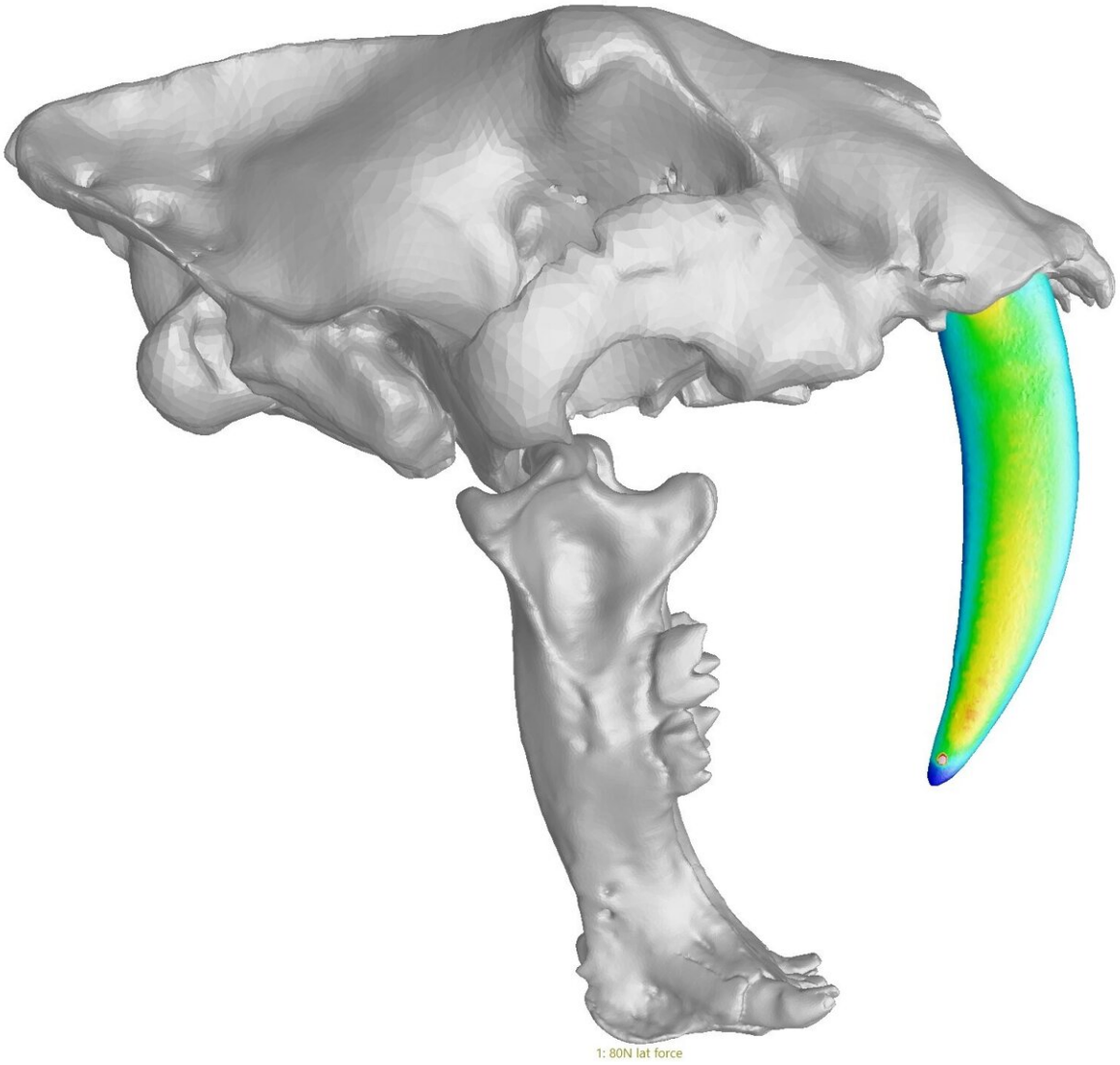
Yet paleontologists are still confounded by that fact that adult animals with thin-bladed knives for canines apparently avoided breaking them frequently despite the sideways forces likely generated during biting. One study of the La Brea predator fossils found that during periods of animal scarcity, saber-toothed cats did break their teeth more often than in times of plenty, perhaps because of altered feeding strategies.

The double-fanged specimens from La Brea, which have been considered rare cases of individuals with delayed loss of the baby tooth, gave Tseng a different idea—that they had an evolutionary purpose.

To test his hypothesis, he used beam theory—a type of engineering

analysis employed widely to model structures ranging from bridges to building materials—to model real-life saber teeth. This is combined with finite element analysis, which uses computer models to simulate the sideways forces a saber tooth could withstand before breaking.

"According to beam theory, when you bend a blade-like structure laterally sideways in the direction of their narrower dimension, they are quite a lot weaker compared to the main direction of strength," Tseng said. "Prior interpretations of how saber tooths may have hunted use this as a constraint. No matter how they use their teeth, they could not have bent them a lot in a lateral direction."



A finite element model of an adult saber tooth indicating saber bending stress. The warmer the color, the higher the stress and the more likely failure will occur in a particular area of the tooth model. The red dot near the tip is where the force was applied to measure the sideways bending stress. Credit: Jack Tseng, UC Berkeley

He found that while the saber's bending strength—how much force it can withstand before breaking—remained about the same throughout its

elongation, the saber's stiffness—its deflection under a given force—decreased with increasing length. In essence, as the tooth got longer, it was easier to bend, increasing the chance of breakage.

By adding a supportive baby tooth in the beam theory model, however, the stiffness of the permanent saber kept pace with the bending strength, reducing the chance of breaking.

"During the time period when the permanent tooth is erupting alongside the milk one, it is around the time when you switch from maximum width to the relatively narrower width, when that tooth will be getting weaker," Tseng said. "When you add an additional width back into the beam theory equation to account for the baby saber, the overall stiffness more closely aligned with theoretical optimal."

Though not reported in the paper, he also 3D-printed resin replicas of saber teeth and tested their bending strength and stiffness on a machine designed to measure tensile strength. The results of these tests mirrored the conclusions from the computer simulations. He is hoping to 3D-print replicas from more life-like dental material to more accurately simulate the strength of real teeth.

Tseng noted that the same canine stabilization system may have evolved in other saber-toothed animals. While no examples of double fangs in other species have been found in the fossil record, some skulls have been found with adult teeth elsewhere in the jaws but milk teeth where the saber would erupt.

"What we do see is milk canines preserved on specimens with otherwise adult dentition, which suggests a prolonged retention of those milk canines while the adult tooth, the sabers, are either about to erupt or erupting," he said.

More information: Z. Jack Tseng, Bending performance changes during prolonged canine eruption in saber-toothed carnivores: A case study of Smilodon fatalis, *The Anatomical Record* (2024). DOI: 10.1002/ar.25447

Provided by University of California - Berkeley