Shoulder ligament a linchpin in the evolution of flight

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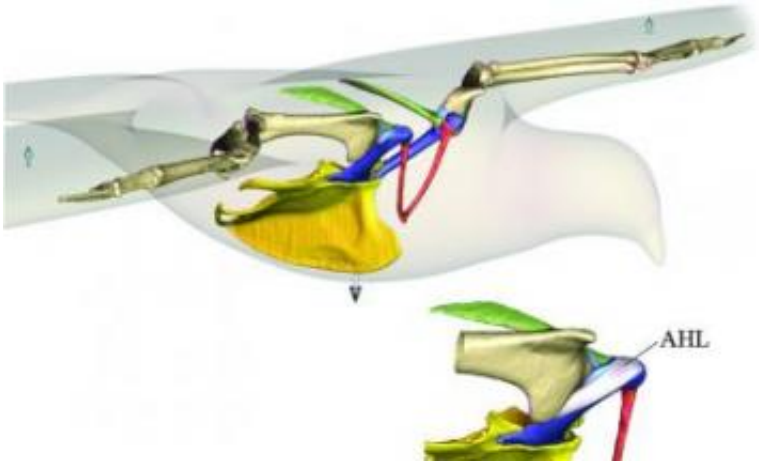

Using computer modeling, treadmills and the fossil record, researchers have shown that the acrocoracohumeral ligament (AHL), a short band of tissue that connects the humerus to the shoulder joint in birds, was a critical element in the evolution of flight. Credit: David Baier/Brown University

Brown and Harvard scientists have learned that a single ligament at the shoulder joint stabilizes the wings of birds during flight. In an advanced online publication of *Nature*, they explain how this tough bit of tissue evolved to become a linchpin for today's fliers.

"How animals got off the ground – how limbs became wings – is a fascinating question," said team leader David Baier, a post-doctoral research fellow in the Department of Ecology and Evolutionary Biology

at Brown. "What we learned here is that, in the evolutionary line to birds, a single ligament played an increasingly important role in flight."

Baier and his team focused on the shoulder joint, a place where powerful forces exerted by muscles converge. Why doesn't the joint dislocate" What keeps the wing stable during flight" Baier and his team tackled this question in a uniquely broad way, studying living animals and dinosaur fossils and examining the interaction of aerodynamic soft tissue and bony forces affecting the shoulder joint.

The team began with the pigeon. To better understand how the birds stabilized their wings during flight, they used CAT scans to make a 3D "virtual skeleton" and calculated the forces needed to maintain a gliding posture. They found that neither the shoulder socket nor the muscles could keep pigeon wings stable. The critical player, they found, is the acrocoracohumeral ligament, a short band of tissue that connects the humerus to the shoulder joint. The ligament balances all of the forces exerted on the shoulder joint – from the pull of the massive pectoralis muscle in the bird's breast to the push of wind under its wings – making it a linchpin for modern bird flight.

To find out if this ligament played the same shoulder-stabilizing role in primitive animals, the team looked to the alligator. Alligators are close relatives of birds and both are archosaurs, the "ruling reptiles" that appeared on the planet some 250 million years ago and evolved into the dinosaurs that dominated during the Mesozoic Era. So to understand the sweep of evolution, the alligator was a great starting place.

In the laboratory of Farish Jenkins Jr., a professor of biology and curator of vertebrate paleontology at Harvard University, the scientists put three alligators on motorized treadmills and took X-ray video. Baier and Brown evolutionary biologist Stephen Gatesy used the video to make a 3D computer animation that showed the precise positioning of the

shoulder as the animal walked. They found that alligators use muscles – not ligaments – to do the hard work of supporting the shoulder.

Then Baier hit the fossil record, studying the skeleton of Archaeopteryx lithographica, considered by many paleontologists to be the first bird. Baier even traveled to Beijing to examine the fossilized remains of Confuciusornis, Sinornithoides youngi and Sinornithosaurus millenii, close relatives of modern birds that were recently discovered in China.

If the acrocoracohumeral ligament was critical to the origin of flight, Baier expected to find evidence of it in Archaeopteryx. Surprisingly, however, the new ligament-based force balance system appears to have evolved more gradually within Mesozoic fliers.

"What this means is that there were refinements over time in the flight apparatus of birds," Baier said. "Our work also suggests that when early birds flew, they balanced their shoulders differently than birds do today. And so they could have flown differently. Some scientists think they glided down from trees or flapped off the ground. Our approach of looking at this force balance system can help us test these theories."

Source: Brown University