# Eavesdropping on Bones

*Acoustic emissions from bones under stress can supplement x-rays by identifying microfractures and pinpointing the time of healing*

The masts of a sailing ship creak reassuringly when the ship is underway in a brisk wind. A large house, or even a skyscraper, creaks rather more ominously under the influence of the same wind. In each case, some of the noise can be attributed to acoustic emissions, characteristic sounds given off by materials when they are stressed. Analysis of such emissions is a relatively well-known technique for detecting cracks and other defects in ceramics and metals, for determining the integrity of welds, and so forth. It might soon also provide a way to diagnose bone fractures and monitor their mending.

Acoustic emissions differ from ultrasonics, which are already widely used in medicine, in several major respects. Ultrasonics are above the upper limit of sounds that can be heard, typically well above 20,000 hertz, whereas acoustic emissions are generally (but not always) at lower frequencies. Ultrasonic waves are generally introduced into the material being examined by a transducer at one site and conducted in a more or less linear fashion to a second transducer, where they are monitored; acoustic emissions propagate in all three dimensions. Finally, and most important, ultrasonic waves are generated by an external source, while acoustic emissions are generated by the material being tested.

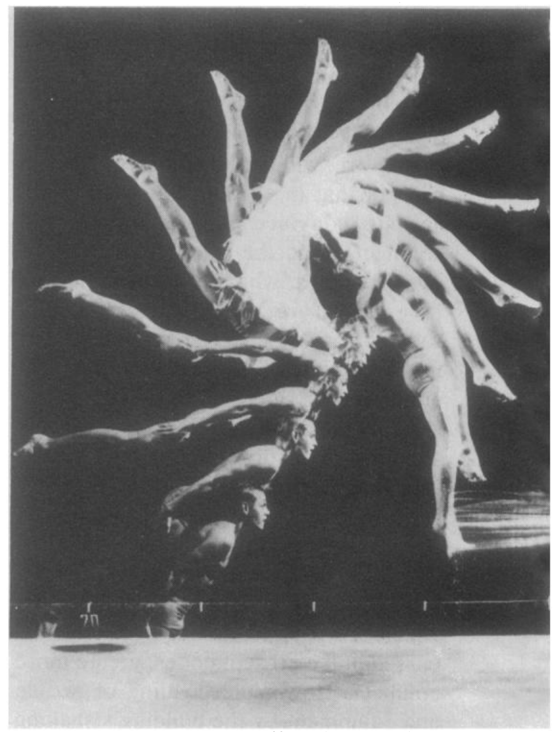
The first studies of acoustic emissions by bones were conducted in the early 1970's by Sathya V. Hanagud and his colleagues at the Georgia Institute of Technology, and subsequent studies were made by Hyo Sub Yoon and his associates at Rensselaer Polytechnic Institute. Both groups applied stress to the bones (typically applying force to both ends of a bone suspended on a fulcrum) and measured the characteristics of the emitted noises. Hanagud used machined cow bones that had been oven-dried or chemically conditioned to simulate the effects of the bone disease osteoporosis, while Yoon used fresh cow, dog, and pig bones. Both groups found that the noises emitted from the bones are more complex than those emitted by plastics or metals and that they are characteristic of the bones.

Both groups also simulated cracks and fractures in excised bones by drilling holes of various sizes. They observed that the presence and size of even very small defects could be easily determined from the pattern of acoustic emissions. They also found that the emissions are transmitted through attached flesh with some attenuation but without any significant loss of their important characteristics.

Acoustic emissions could have a ready application to human medicine, says Yoon. Microfractures such as those often developed by joggers are generally too small to be detected by x-rays, but are quite painful and often develop into major bone injuries. These can generally be detected by acoustic emissions. The extent of bone healing is also difficult to monitor with x-rays, and such monitoring may require repetitive exposures to radiation, which is undesirable. Healing can be followed much more readily with acoustic emissions. This application could be particularly important for professional dancers and athletes who need to get back in training as soon as possible after an injury.

Hanagud and Yoon developed different ways to measure the emissions in humans. Yoon reasoned that applying stress to an already injured limb would not be desirable, so he looked for an alternative way to induce acoustic emissions. He ultimately developed a system in which the bone is stressed by ultrasonic pulses emitted by a transducer attached to the skin. As many as five different characteristics of the sound (including amplitude, pulse width, and total number of pulses above a certain intensity) are measured and the results compared to signals obtained from a healthy limb, generally the patient's opposite limb.

Yoon has used his technique to study healing of fractured limbs in animals and has found that it provides a sensitive measure of the extent of healing. Working with Lyle J. Micheli of the Children's Hospital Medical Center in Boston, he has also monitored several human volunteers, some of whom had previous injuries from running or other accidents. His instrument was able to pinpoint defects in the bones, but he encountered several difficulties involving the complexity of the instrumentation and the need to locate transducers in precisely the same configuration for monitoring the control limb and for repetitive measurements. He is now working to modify the equipment to overcome these difficulties so that it could be used more easily in a clinical setting.



Harold Edgerton/NOVA

*Acoustic emission tests may eventually provide an important indication for athletes who need to get back in training as soon as possible after an injury.*

Hanagud, in contrast, reasoned that a small amount of additional stress, such as putting the limb in traction temporarily, could be withstood by the patient. In this case, acoustic emissions can be monitored directly. His apparatus uses five transducers attached to the skin—underneath the cast in the case of a known break. Preliminary studies show that this approach is quite promising, and Hanagud is now seeking permission from the human ethics committee of his institution to begin studies in human volunteers. He suggests that it could be as little as three years before the technique is used on a regular basis.

—Thomas H. Maugh II


0036-8075/81/1009-0172$01.00/0 