

Non-Contact Ultrasound for Osteoporosis and Bone Imaging

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Our paper concerns two results that although very preliminary could have an impact on the diagnosis and treatment of osteoporosis, the thinning and loss of elasticity of bone that eventually affects everyone in advanced age. First of all we have used standardized samples of a human bone-like-material (created years ago to calibrate an x-ray machine for studying bones) to show that that ultrasound works almost as well as an x-ray to determine important information in bone. Specifically, we demonstrated that ultrasound attenuation (scattering and absorption) can reveal the mineral density of the bone-like material, which is made of a mixture of bone ash and Vaseline (surprising as it may seem, this mixture is highly similar to real bone in the way that it responds to an ultrasound signal).

Our first finding is significant because it suggests that routine bone tests might be made in the future without subjecting people to the anxiety and minimal damage of receiving a small dose of radiation. The finding also hints that may be able to use ultrasound alone to study the two major components of bone, calcium mineral and collagen, and thus investigate bone's composite nature which makes it strong, lightweight, and flexible (like spider webs and reinforced concrete rolled into one). Currently a technique developed by Chris Langton of the UK measures ultrasound attenuation and speed in the trabecular (spongy) bone of the heel. Langton probably did not realize that the attenuation technique could work so well that it might replace x-rays. We also have gotten new results on ultrasound attenuation applied to cortical bone, the smooth long bones that comprise 80% of the skeleton.

A second development is that our promising data on ultrasound attenuation was obtained using a newly available non-contact system. This means that the ultrasound scanner we are working on could be used like an x-ray machine with a standard scanning motion and without the need for a clinician to apply messy gels and run an ultrasound source/receiver over the patient's body. Thus getting an ultrasound test may be as simple as an x-ray in the not-so-distant future. If successfully realized, an x-ray-like ultrasound check-up may find widespread use among tens of millions of Americans and others who are concerned about aging bones or osteoporosis.

Non-contact ultrasound (NCU) has been developed over the past 15 years or so by a number of persons including Mahesh Bhardwaj of SecondWave Systems (a co-author on this paper and a specialist in non-contact transducers) and Joie Jones of UC Irvine.

Currently the only clinical usage of non-contact ultrasound is in a single study to determine the level of skin damage among patients with severe burns (Joie Jones and collaborators at UC Irvine Medical center have carried out this work in the past 3 years or so). NCU works by broadcasting a highly focused, relatively short but intense ultrasound beam to overcome ultrasound's substantial loss in intensity as it travels into, through, and out of the air. Specifically, ultrasound's intensity diminishes as it travels in air by an amount proportional to its propagation distance raised to the fourth power. So a trip of only a few inches can result in a significant loss of the ultrasound signal. To overcome this signal loss, NCU also uses a very clever detection technique that was perfected by Ian Nesson (ineeson@vninstruments.com), a scientist from Brockville, Ontario, just two hours west of Montreal by car on the Saint Lawrence Freeway. The detection method, known as the synthetic impulse technique, is similar to that of radars used by satellites to image the earth and other planets.

Another motivation for this work is the proper healthcare of astronauts in space. Interestingly, NASA initiated measurements of bone loss in the 1960s when it was realized that astronauts were coming down with a reversible form of osteoporosis due to weightlessness. Presently NASA is very concerned about the implications that space-induced bone loss and bone brittleness might have on manned missions to Mars or even extended stays on the International Space Station. In addition to helping people on Earth, an ultrasound-based tool for diagnosing bone disorders might therefore be ideal for astronauts in space.

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