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USE OF A TWO DIMENSIONAL ULTRASOUND TIME-OF-FLIGHT SYSTEM FOR LOCATION OF THE CENTRE OF GRAVITY IN DYNAMIC POSTUROGRAPHY MEASUREMENTS

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A method has been developed at Poole Hospital for objective assessment of balance using ultrasound time-of-flight (ToF) measurements to accurately locate the centre of gravity (COG) of a subject during dynamic postural measurements. Two 20 kHz ultrasound transmitters are mounted perpendicular to each other on the subject's waist at the height of the COG. Anterior/posterior and lateral motions are detected independently by measuring variations in the ToF from the transmitters to appropriately positioned wall-mounted receivers. The motion of the COG is accurately traced during the course of 20 second assessment periods as the subject stands on a solid surface with eyes open and eyes closed. The tests are repeated with the subject standing on a standardised compliant platform to reduce postural cues from foot pressure.

Trials of day-to-day repeatability and repeated tests on patients prior to therapy indicate there is no significant improvement to balance measures with experience of the system. Balance measures were significantly worse in patients suffering from symptoms of vertigo following traumatic brain injury, than for age-matched normals. Repeated measures post-therapy indicate significant improvement in balance measures following therapy in patient with vertigo.

We conclude that COG location using ultrasound ToF is a suitable method of tracking sway and thus assessing balance in normals and balance-compromised patients. This technique is simpler to set up and potentially considerably cheaper than equivalent commercial systems.

A STRATIFIED MODEL FOR ULTRASONIC PROPAGATION IN BONE

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Introduction Quantitative Ultrasound (QUS) measures ultrasonic waves travelling through cancellous bone in the os calcis. The porous microstructure of cancellous bone often has a dominant orientation in load-bearing bone. Ultrasonic attenuation and speed of sound are dependent on the direction of propagation relative to the trabecular alignment [1]. Previous authors [2] have used Biot's theory [3] to predict the speed of sound and attenuation in cancellous bone, but with limited success. The Biot theory does not model the behaviour of ultrasound in anisotropic media. The authors have therefore proposed a second theory, based on a stratified model of cancellous bone [4].

This paper compares the speeds of two longitudinal waves emerging from bovine femur over a range of angles, with those predicted by the authors' stratified model.

Theory The cancellous architecture was idealised as a series of parallel calcified plates and marrow layers. Ultrasonic propagation in these layers was investigated by applying Schoenberg's theory [5]. Two longitudinal waves (known as fast and slow waves) are predicted at all angles, except perpendicular incidence to the layers. The behaviour is explained by an angle-dependent dynamic coupling of the motions of fluid and solid.

Experimental Method Bovine bone samples were taken from the tibial epiphysis, which contained a well-oriented trabecular structure. The sample was co-axially aligned between two 1 MHz transducers, suspended in a water tank at a fixed separation. Ultrasonic pulses were transmitted through the sample, and the output was acquired as the sample was rotated in 5° increments.

Results and Conclusions Phase velocity and propagation angle were compared with those predicted by Schoenberg's theory. As shown in Figure 1, qualitative agreement was good. These results further demonstrate the anisotropic nature of ultrasound in cancellous bone.

Although the stratified model is a simplification of cancellous bone, it has potential for future application to this problem and the development of QUS.

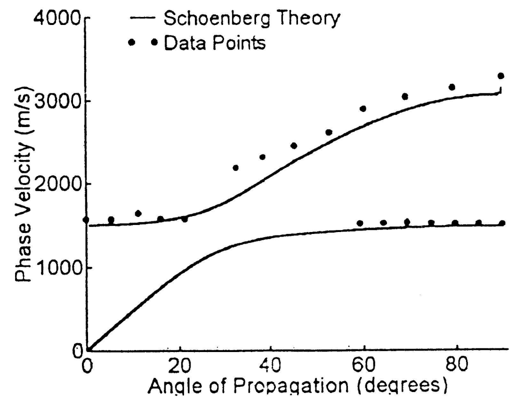

Figure 1 Phase velocity versus angle of propagation to dominant trabecular structure.

References
1. Gluer CC, Wu CY, Jergas M, Goldstein SA, Genant HK, *Calcif Tissue Int*, 55, 46-52 (1999).
2. Hosokawa A and Otani T, *J Acoust Soc Am*, 101(1), 558-62 (1997).
3. Biot MA, *J. Acoust. Soc. Am.*, 28, 168-78 (1956)
4. Hughes ER, Leighton TG, Petley GW and White PR, *Ultrasound Med Biol*, 25(5), 811-21 (1999).
5. Schoenberg M, *Wave Motion*, 6, 303-20 (1984)