CLINICAL SCREENING OF
DEVELOPMENTAL DYSPLASIA OF THE HIP IN NEONATES
BY ACOUSTICAL TECHNIQUE

Xiaolin Huang, PhD
Department of Rehabilitation Medicine, The Tongji Medical University, Wuhan, People’s Republic of China

Early screening for developmental dysplasia of the hip in neonates remains problematic, especially in developing countries. This study attempts to develop an acoustical technique for the screening of DDH in neonates. The acoustical technique, based on a system analysis approach, was applied to examine acoustical transmission in the hip joints. Special experimental instrumentation was set up to measure the acoustical signals transmitted along a path from the driving point at the sacrum to the greater trochanters of both hips. A random vibratory force (pink noise) of up to 800 Hz was applied to the sacrum in the antero-posterior direction at S2, while acoustical signals were picked up by a pair of adult-size, stethoscope-microphone assemblies held by a compressive force at the greater trochanters of both hips. A dual-channel signal analyzer was employed for data acquisition.

The acoustical technique was shown to be reliable and reproducible in quantifying the transmitted sound signals in both hips, and in performing a comparative measurement to identify asymmetry of the anatomical configuration of the hip joints. Two key parameters for this acoustical technique were identified. The hip coherence confirmed the validity of a model proposed for the sacrum-pelvis-hip complex. Discrepancy defined from a modified form of transfer function was found useful in the identification of structural asymmetry between both hips.

The baselines for a group of normal adults, pre-school children, and neonates were established. The most optimal and effective testing frequencies were found in the frequency bands of 200, 250 and 315 Hz, in which there was a high coherence ($\gamma^2 > 0.9$) of signals and a small discrepancy (D < 3 dB) between both hips. The results obtained from 90 normal neonates showed a more reliable baseline in which there was the highest coherence ($\gamma^2 > 0.94$) and the smallest discrepancy (D < 2 dB) in the frequency range of interest, which can be used for clinical reference.

Seventeen patients with unilateral DDH were examined using the acoustical technique. The results suggested that a coherence consistently below 0.8 in at least one of the frequency bands of 200, 250 and 315 Hz was definitely indicative of structural asymmetry between both hips. The discrepancies estimated for the patients were clearly different from those of the normal patients. We confirmed that any structural changes in joint congruity, concentricity, and coverage of the femoral head resulted in an asymmetrical acoustical transmission across the hip joints. Discriminative analysis showed a significant difference between the groups of normal neonates and patients with unilateral DDH in the frequency bands of 200, 250, and 315 Hz. By setting the cut-off discrepancy at 2.0 dB, the best sensitivity of 100% and specificity of 75% would be achieved. Based on these figures and the baseline of the normal neonates, the acoustical technique could be used as a screening tool for DDH in neonates. The technique has served the purpose of a screening test for DDH in neonates by meeting the basic requirements of any screening tool. The objective measurement of discrepancy was also in good agreement with the clinical findings.

The findings from this study suggest that the acoustical technique can be developed further to a non-provocative, objective, and non-invasive screening tool for early detection of DDH, or asymmetry in the bone and joint configuration. A screening protocol has been established for DDH. An integrated system has been proposed for dedicated use in routine screening of dysplastic hips in a wider-scale application.

Chief supervisor: Dr. Kevin S.C. Kwong, PhD, Department of Rehabilitation Sciences, The Hong Kong Polytechnic University, Hung Hom, Kowloon, Hong Kong.

Co-supervisor: Professor Jack C.Y. Cheng, MD, Department of Orthopaedics and Traumatology, The Chinese University of Hong Kong, New Territories, Hong Kong.