# ULTRASONIC ABSORPTIOMETRY TO EVALUATE BONE DENSITY

J.M. Alves[1], J.J. Kaufman[2], G. Grabowski[3], G. Hermann[4], L.A. Ierardi[3], A. Chiabrera[5], S.J. Goldsmith[6], A.A. Pilla[2],R.S. Siffert[2]

**ABSTRACT** – Four males and two females patients with the Gaucher's disease had their bone mineral content evaluated by a new technique named **ultrasonic absorptiometry** or **broadband ultrasonic attenuation**. Among these, five were also evaluated by quantitative computed topography (QCT), and four by dual photon absorptiometry (DPA). The ultrasonic diagnostic method is based on the attenuation of the acoustic energy taken at the calcaneus of the patient. The received ultrasound waveform collected by a digital oscilloscope is transferred to a microcomputer for storage and off-line analysis. The waveform were processed using the Discrete Fourier Transform, and a estimate of the heel's frequency attenuation slope (Â), in dB/MHz over the frequency range 200-600 Khz, was obtained using a least square straight line fit. Results have indicated a correlation between the slope and bone mineral content.

## INTRODUCTION

Type I Gaucher's disease is a genetic disorder afflicting between 5,000 and 10,000 Ashkenazi Jews in the United States. It is characterized by the deficient activity of the lysosomal hydrolase, acid Â-glucosidase. The progressive infiltration and replacement of the bone marrow by "Gaucher cells" (lipid-filled macrophages) lead sequentially to diffuse osteopenia, localized destruction, ischemic necrosis, and osteosclerosis. Degenerative changes in the skeleton are the leading cause of osteopenia and osteolysis occurs in virtually all patients. However, the extent of bone disease is markedly variable, which makes it very difficult to predict the course of the disease once a diagnosis has been made.

The degree and severity of skeletal involvement is often difficult to assess by clinical and radiographic evaluations. Prior studies have attempted to assess bone marrow involvement by CT and scintigraphy (Hermann,1986). The objective of the present study was to characterize

[1] School of Engineering of São Carlos, University of São Paulo, São Carlos, SP, Brazil.

[2,3,4,6] Department of Orthopaedics, Division of Medical Genetics/Department of Pediatrics, Department of Radiology, Department of Physics and Nuclear Medicine. Mount Sinai School of Medicine, New York, NY, USA.

[5] Department of Biophysical and Electronic Engineering, University of Genova, Genova, Italy.

characterize quantitatively the bone tissue state in patients with Gaucher's disease, using a new method based on ultrasound, and to see if this technique could potentially be useful for monitoring the course of it.

## MATERIALS AND METHODS

Four males and two females with Gaucher's disease comprised the study group. They ranged in age from 13 to 78 years, with a mean of 38. Five patients were evaluated using quantitative computed tomograpghy (QCT) of the lumbar spine with a GE 9800 scanner. Four patients were also evaluated by dual photon absorptiometry (DPA) of the lumbar spine using a Lunar DP3 scanner. The ultrasound measurements were made with a technique similar to that reported by other researchers (Langton, 1984) In this approach, the patient's foot was immersed in a water tank which served as a coupling medium for the ultrasond energy. Two ultrasound transducers (Panametrics V314) each having a 1 MHz center frequency and 3/4 inch diameter, were coaxially located on either side of the foot, so that their central axis was in approximate alignment with the central portion of the calcaneus. The transducers were separated by a distance equal to twice the near to far field transition length, which in water corresponds to 2.4 inches. One transducer served to transmit an ultrasound pulse into the water, through the heel of the foot, and to the other transducer, which served as a receiver. The transmitting transducer was excited by a 0.2 Ô s/45V voltage pulse. The received ultrasound waveform was collected on a digital storage oscilloscope (LeCroy Model 9400) at a 50 MHz sampling rate, and transferred to a microcomputer for storage and off-line data analysis. An ultrasound pulse which propagated only through water was collected as a reference in the signal analysis. The waveforms was processed using the discrete Fourier transform, and an estimate of the heel's frequency dependent attenuation slope (Â), over the frequency range 200-600 Khz, in dB/MHz was obtained using a least-squares straight line fit. A minimum of four independent measurements, obtained by removing the foot entirely from the water tank and then replacing it back, were acquired from the right heel bone for each patient, and averaged to produce the final estimate of bone ultrasonic attenuation slope Â. The precision of the estimate was defined as the ratio between the standard deviation of Â values and the Â average value.

## RESULTS

The values of frequency dependent attenuation slope Â obtained from the six patients ranged from 49.7 dB/MHz to 107.2 dB/MHz, with a mean of 75.3 dB/MHz, and an average precision of 2.9 percent. A table with the patients' bone mineral content values using ultrasonic absorptiometry (Â), QCT, and DPA is showed.

TABLE: Patients' Bone Mineral Content

| PATIENT | AGE/SEX | Â (dB/MHz) | QCT ($mg/cm^3$) | DPA ($g/cm^2$) |
|---|---|---|---|---|
| 1 | 36/F | 64.8 | 147 | 0.76 |
| 2 | 13/F | 49.7 | N/A | N/A |
| 3 | 25/M | 74.4 | N/A | 1.26 |
| 4 | 32/M | 102.1 | 168 | 1.06 |
| 5 | 41/M | 107.2 | 182 | 1.18 |
| 6 | 78/M | 53.8 | 55 | N/A |

N/A - not available

## DISCUSSION AND CONCLUSION

We have used a relatively new means to non-invasively and safely assess bone tissue. The measurement, in contrast to those techniques which utilize ionizing radiation to measure bone mineral content (e.g., DPA,QCT), provides a free ionizing radiation technique for the same purpose. There was a much better correlation between the slope Â and bone mineral content as measured by QCT ($r^2=0.85$), than as measured by DPA ($R^2=0.47$). Further research should provide a better understanding of the ultrasonic attenuation slope Â and its relationship to various physiologic states related to Gaucher's and other bone related diseases, and thereby provide a means for non-invasive diagnosis and evaluating the course of treatment.

## REFERENCES

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