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OSTII PRICES

NEW BONE MINERAL SCANNERS

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The following discussion is a description of scanners *Madison, Wis*

developed to determine the bone mineral content of humerus,
femur and os calcis. The linear humerus scanner has also been
used to make preliminary measurements on tibia and fibula.

Linear Humerus Scanner

A linear scanner, that is, one in which the photon source
and detector of scanner travel in a straight line, was constructed
to scan the humerus. A linear scan was desired to eliminate the
increase in apparent width, which causes about a 1% systematic
error in the measurement of bone mineral content of typical
adult humerus when one of our other scanners with a circular
scan path (radius of curvature 8.9 cm) is used. The linear
humerus scanner, constructed of lucite of 6.4 mm thickness, is
shown in Figures 1 and 2. The humerus is placed on a 75 cm by
35 cm scanning platform. The scanning mechanism is located
below this platform. The mechanism consists of a 10 cm by 35 cm
lucite sheet, 9.6 mm thick, mounted on two parallel steel rods
with a diameter of 1.27 cm. The lucite sheet slides on these
rods. A rack is mounted on the lucite sheet and the lucite
sheet is driven by a reversible synchronous motor that is spring
mounted. The photon source and detector are rigidly coupled.

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The photon source, Iodine-125, is mounted directly on the scanning mechanism. The detector is above the scanning platform and is mounted on the scanning mechanism with 2.54 diameter lucite rods.

The humerus is positioned on the scanner platform with an adjustable forearm stop. The posterior portion of the ulna is placed against the forearm stop, while the axis of the humerus is positioned perpendicular to the surface of the forearm stop. The position of the forearm along the forearm stop is located by an adjustable elbow stop.

Because a new scanning mechanism was used in this scanner the constancy of scanning rate was evaluated and the scanning rate measured. A lucite sheet with lead filled grooves milled at 0.5 cm intervals was scanned and the count rate was recorded on a strip chart recorder. The distances between minima on the chart recorder output were measured. The scanning rate was 2.8 mm/sec. The accuracy of these measurements was $\pm 3\%$. The distance between adjacent minima were equal to this accuracy. To compare the scanning rates in the two directions, the distance between minimum 7 cm apart on the lead lined lucite sheet were compared. These distance were equal to within an experimental error of 0.5%.

One of the advantages in measuring the humerus is that the thickness of tissue cover is approximately constant without compression. A requirement of our technique is a constant thickness of the sample being measured. A comparison of the intensity

of photon beam transmitted by tissue alone at each edge of the bone is an indication of variations in the total thickness. In a study of 140 humerus scans 90% of which were done on adult males, the average difference between the intensity of the photon beam transmitted on either edge of the bone was 20% and in 80% of the scans the difference was less than 30%. In a 30% difference the largest possible error was calculated to be approximately 5%, for a typical adult humerus measurement. More reasonable assumptions indicate that this error is approximately 2%.

Repeated measurements on normal adult subjects indicate the reproducibility of the measurement of bone mineral content to be at the 2% level. A graph showing typical results on normal subjects is shown in Figure 3.

Os Calcis Scanner

The scanner used in the measurement of bone mineral content of the os calcis is shown in Figure 4. The source (Iodine-125) and detector are mounted on a turntable at a radius of 8.9 cm. The turntable is driven on its rim by a rack and gear system. The axis of rotation of turntable is horizontal. The turntable is weighted so that the drive motor is always driving against a small torque. This produces a consistently smooth scan motion.

Reproducible positioning is obtained by having the subject place his heel in the corner of a lucite box. The lucite box is filled with water to maintain a constant total thickness of the measured sample. Only one site of the os calcis can be scanned,

because neither the position of the heel nor the position of the scanning mechanism is adjustable. Therefore, this device cannot be used to scan comparable sites on different individuals.

A radiograph is taken on each subject. Repeated radiographs of the same individual indicated the scan path is the same on repeated scans. The precision of this experiment was 1 mm. This should be compared with the diameter of the photon beam, which is about 3 mm.

Repeated measurements on a group of normal adults indicated the reproducibility of the measurement of bone mineral content of the os calcis is at the 2% level. Typical results for serial measurements on normal subjects are shown in Figure 5.

Femur Scanner

Since the femur is a weight bearing bone and constitutes a significant fraction of the total skeletal weight, it can respond to local stress or disuse and also indicate systemic skeletal mineral changes. We have constructed a device for measuring the bone mineral content of this particularly interesting bone.

Figures 6 and 7 show the device we use to make the measurements. This device is designed so the subject is sitting in a comfortable position during the scan. The photon source and the detector are mounted on a turntable at a radius of 8.9 cm. The turntable is driven on its rim by a rack and gear system with a reversible synchronous motor. This produces a curved rather than linear scanning path. For bones up to 3 cm diameter,

however, the apparent increase in bone width is less than 1%. This is a systematic error and does not affect the reproducibility of the bone mineral measurement.

To scan the femur, the bone is positioned by external physical landmarks; knee, top of leg and bottom of foot, as shown in Figure 8.

By adjusting the position of the knee the measurement of bone mineral content can be made anywhere between approximately the midpoint of the femur and the distal end. By jointly adjusting the foot rest and chair height, the axis of the femur can be made to coincide with center line (midpoint) of the scanning arc.

Am-241 is used in place of I-125 as the photon source because of the increased penetration of 60 keV as opposed to 27.4 keV photons. The latter are almost completely absorbed in the thigh (from our usual 100 mCi I-125 sources) making I-125 unsuitable for the measurement.

Figure 9 shows the results of a scan of the femur from a strip chart record. The device is now being tested for precision and accuracy.

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Figure 1 Linear Humerus Scanner

Figure 2 Linear Humerus Scanner

Figure 3 Serial Studies of Humerus

Figure 4 Os Calcis Scanner

Figure 5 Serial Studies of Os Calcis

Figure 6 Femur Scanner

Figure 7 Femur Scanner

Figure 8 Positioning of Femur

Figure 9 Typical Femur Scan