BONE DENSITOMETRY

Michael McGlamry, DPM

Bone densitometry is a science which has been around in one form or another since the turn of the century. Advances have taken this study, which allows the quantification of the mineral content of osseous structures, from crude to exact. When in its infancy, this science was only capable of recognizing gross changes and produced inconsistent results. Today, depending upon the method chosen, densitometry studies give repeatable results which are accurate within 2-5%.

It becomes apparent why one would want to evaluate bone density more exactly when one realizes that standard radiographs require as much as a 30% change in bone mineral content (BMC) before becoming apparent.

ORIGIN

Densitometry in its most neophytic stages consisted of quantification of light transmission through plain film radiograms. Price, an American dentist first tried this technique on dental radiograms around 1901. This method of measuring light transmission through plain films became more exacting as light meters and other technological advances progressed. Difficulties with this method included variability of the roentgen source and film development, as well as nonlinear relationships between film blackening and bone mineral content. This method was ultimately abandoned due to these difficulties.

MODERN DENSITOMETRIC METHODS

Most of the modern methods of densitometric analysis are dependent on quantification of transmission of photons of energy across a structure. In its simplest form this means that the greater the BMC the less apparent the transmission of photons will be. Methods based on this idea include single photon absorptiometry, dual photon absorptiometry, dual photon x-ray and compton scatter.

Single Photon Absorptiometry

Single photon absorptiometry (SPA) utilizes a radionuclide source and detector situated on opposite sides of the structure to be evaluated. This method is commonly utilized for evaluation of the forearm, specifically the radius. The radionuclide source and detector are passed over the tissue to be evaluated and a collection of points is obtained representing a plot of transmission versus position. SPA requires that the structure to be evaluated be of flat, parallel surface geometry. This geometry is accomplished by enclosing the structure in water or another soft tissue equivalent. The radionuclide sources most commonly utilized are Iodine 125 and Americium 241.

Dual Photon Absorptiometry

Dual photon absorptiometry (DPA) also utilizes radionuclide sources, however it differs from SPA by utilizing two different sources or one source with two distinct emitted radiations. Sources commonly employed for DPA are Americium 241 and Cesium 137, or Gadolinium 153 (A single source with two distinct emitted energies). Advantages of DPA over SPA include the lack of necessity to enclose the part to be studied in a soft tissue equivalent. DPA is utilized widely for spine and femur evaluation where SPA is utilized more commonly on the radius and calcaneus. DPA scans have a precision of one to three percent depending on the site being evaluated.

Dual Energy X-Ray Absorptiometry

Dual energy x-ray absorptiometry (DEXA) is similar to DPA but with several distinct advantages, such as improved resolution and precision, and greatly decreased scanning time. This method utilizes a constant voltage x-ray tube with a filter to produce a dual energy beam, as contrasted to the two distinct radionuclide energies utilized in DPA. Mazess and Barden quoted typical precision for this method as being one half and one percent respectively for in vitro and in vivo studies. This increase in precision and speed is accomplished with no increase in radiation exposure as compared with SPA and DPA.

Compton Scatter

Compton scatter is a similar method of evaluating BMC based on electron density. This method uses a single source and multiple detectors to evaluate transmitted and deflected photons of energy and to evaluate the change in energy of those photons, a reflection of the BMC. This is a method which is merely of academic interest since there are no commercially available units which utilize this system.

Quantitative Computerized Tomography

Another method of evaluating BMC is quantitative computerized tomography (QCT). This method is less accurate than other methods already mentioned and carries a much greater radiation exposure. One of the difficulties with this method lies in the fact that the machines are utilized for many other applications where calibration will not affect the result of the study. Due to the costly nature of this equipment few institutions would be willing to dedicate a scanner strictly for densitometric evaluation.

APPLICATIONS

Presently applications of bone densitometry have been reserved for evaluating osteopenia patients where results would guide decisions for future treatment such as hormone replacement therapy. It is also indicated for evaluation of BMC in patients on long term glucocorticoid therapy, such as the rheumatoid patient.

Possible future uses of densitometric studies might include earlier diagnosis and intervention of the patient with suspected reflex sympathetic dystrophy. This could be accomplished by comparing the symptomatic and asymptomatic extremity to detect decreased BMC. Another possible usage would be in the evaluation of the suspected and recovering avascular necrosis patient. The precision and repeatability of the evaluation could be helpful in determining appropriate treatment and rehabilitation time-lines.

Densitometry evaluations could also possibly be helpful in preoperative planning as fixation alternatives are considered in the osteopenia patient. A possible correlation of fixation application and bone density could be accomplished as has already been done for correlation of fracture risk and bone density.

SUMMARY

Bone densitometry is a fairly young field with a currently limited application. The studies are relatively inexpensive, with minimal radiation exposure (1-5 mrem for SPA, DPA, and DEXA) and provide a quantitative evaluation of bone stock. This paper postulates other possible applications which include preoperative evaluation of bone stock in the osteopenia patient as well as monitoring and evaluation of the patient with suspected reflex sympathetic dystrophy and avascular necrosis. Potentially these studies could be used as an adjunct in the evaluation of any patient with questionable bone stock by history or radiographic evaluation.

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