ABSTRACTS

OF SELECTED PEER-REVIEWED SCIENTIFIC PAPERS & CONFERENCE PROCEEDINGS

1991-2004

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Am J Med 1995 Feb 27; 98(2A):41S-47S

Radiographic absorptiometry in the diagnosis of osteoporosis.

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Radiographic absorptiometry (RA) is a technique for bone mass measurement from radiographs of peripheral sites, most commonly the hand or heel. The principle was first described in 1939, and RA became relatively widely used as a research technique in the 1960s, although interest in RA subsequently dwindled as precise nonradiographic densitometry techniques became available. Recently, however, computerized image processing has been applied to radiography, with the result that current RA techniques applicable to a routine clinical setting are as precise and accurate as dual-energy or single-energy x-ray absorptiometry (DXA or SXA). In addition, recent studies demonstrate that the strength of association between low bone mass measured by RA and fracture risk is comparable to that for other forms of bone mass measurement. The relatively low cost and lack of need for specialized equipment make RA a highly attractive option for the diagnosis of osteoporosis that is available to specialist and nonspecialist physicians alike.

Arch Intern Med 1997 Feb; 24;157(4):433-8

Phalangeal bone density and hip fracture risk.

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OBJECTIVE: To assess the long-term predictive usefulness of radiographic absorptiometry measurements of phalangeal bone density for hip fracture risk. METHODS: Participants were members of the First National Health and Nutrition Examination Survey Epidemiologic Follow Up Study cohort. Subjects were followed up for a maximum of 16 years. The First National Health and Nutrition Examination Survey data were obtained from a nationally representative sample of non-institutionalized civilians. A cohort of 3481 white and black subjects (1559 white women) aged 45 through 74 years at baseline (1971-1975) were observed through 1987. Ninety-eight percent of the original cohort completed the study. Hospital records and death certificates were used to identify a total of 72 hip fracture cases. Phalangeal bone density at baseline was measured using photodensitometry (PD), and later reanalyzed by radiographic absorptiometry (RA), a newer, more sophisticated technique. RESULTS: Results were evaluated to determine the relative risk for hip fracture per 1-SD decrease in bone density, after controlling for age at baseline, race, gender, weight, and previous fractures. Both RA and PD measurements showed a significant inverse relationship to hip fracture risk, with RA density measurements showing a slightly higher adjusted relative risk per 1-SD density decrease than PD measurements. For RA bone density, the relative risk for all subjects was 1.81 (95% confidence interval, 1.34-2.44) compared with 1.57 (95% confidence interval, 1.19-2.07) for PD bone density after adjusting for age at baseline, race, gender, weight, and previous fractures. Results for white women were essentially the same as those for all subjects for RA bone density and PD bone density. CONCLUSIONS: Phalangeal bone density determined from standard hand x-ray films is a significant predictor of future hip fracture risk. Availability of a valid method to assess fracture risk using conventional radiographs will expand the ability to identify individuals with osteoporosis.

Calcif Tissue Int 1998 Nov; 63(5):380-4

Prediction of fracture risk by radiographic absorptiometry and quantitative ultrasound: a prospective study.

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Recent developments in computer-assisted radiographic absorptiometry (RA) and quantitative ultrasound techniques (QUS) provide readily accessible and relatively inexpensive methods for assessing bone mineral status. However, few population-based studies have investigated the ability of RA and ultrasound to predict fracture risk prospectively. We explored the ability of RA and QUS to predict fracture risk among 560 postmenopausal women from the Hawaii Osteoporosis Study; average follow-up was 2.7 years. An incident vertebral fracture was defined as a decrease of more than 15% in vertebral heights on subsequent films. Self-reported nonspine fractures were verified by medical records. The prospective associations of vertebral fractures, nonspine fractures, and any (spine or nonspine) fractures with bone measurements were examined using logistic regression, adjusting for age. Both phalangeal bone mineral density (BMD) and metacarpal BMD, measured using RA, predicted future fracture risk. The age-adjusted odds ratios (corresponding to 1 SD decrease in BMD) for vertebral fractures, nonspine fractures, and any fractures were 3.41, 1.50, and 1.91, respectively, for phalangeal BMD, and 1.71, 1.49, 1.55, respectively for metacarpal BMD. Calcaneal broadband ultrasound attenuation (BUA) also showed significant association with fracture risk, with age-adjusted odds ratios of 1.50, 1.89, and 1.72 for vertebral fractures, nonspine fractures, and any fractures, respectively. We conclude that hand RA and calcaneal BUA are significant predictors of nonspine fracture, vertebral fracture, and overall fracture risk. The attractive features of these techniques, such as portability, relatively low cost, and ease of use, make them promising alternatives to conventional bone measurement techniques used for the assessment of fracture risk.

Radiology 1994 Sep; 192(3):857-9

Radiographic absorptiometry for bone mineral measurement of the phalanges: precision and accuracy study.

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PURPOSE: To evaluate the accuracy and precision of a radiographic absorptiometry (RA) method for assessment of bone mineral of the middle phalanges. MATERIALS AND METHODS: Nineteen cadaveric hands were radiographed with an aluminum wedge, once at 50 kVp and 400 mA and once at 60 kVp and 300 mA. Bone mineral content (BMC) and bone mineral density (BMD) of the second to fourth middle phalanges, expressed in arbitrary units (BMC-AU and BMD-AU), were analyzed and averaged in each hand. RESULTS: The precision error of this method was 1.0% for BMC-AU and 0.6% for BMD-AU. A 2.0%-2.4% reduction in BMD-AU seen on radiographs obtained through ethanol thicknesses of 5 and 6 mm compared with that seen on controls was statistically significant ($P < .01$). The correlation between BMC-AU and forearm BMC determined with dual x-ray absorptiometry was good ($r = .887$), and that between BMC-AU and ash weight in the phalanges was excellent ($r = .983$). CONCLUSION: The RA method is precise and accurate for bone mineral assessment of the peripheral appendicular skeleton.

J Bone Miner Res 1994 Nov; 9(11):1745-9

Comparison of radiographic absorptiometry with dual-energy x-ray absorptiometry and quantitative computed tomography in normal older white and black women.

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Bone mineral density (BMD) of the phalanges of the hand was measured by the technique of radiographic absorptiometry (RA) in 199 older postmenopausal women previously determined to have normal BMD by dual-energy x-ray absorptiometry (DXA) and quantitative computed tomography (QCT). The average age of the women was 66.8 +/- 4.9 years, and they were 19.9 +/- 6.7 years postmenopause. In the 54 black women, phalangeal BMD was 11.7% greater than in the 145 white women, a difference comparable to that found using DXA at the radial midshaft, the lumbar spine, and femoral neck. A correlation matrix comparing BMD measured by RA to BMD measured by DXA and QCT indicates that, in general, RA was related to the various DXA and QCT measurement sites as well as these sites were related to each other. When results for RA, DXA, and QCT obtained in our cohort of older women were compared to available reference data for peak adult bone mass, the average difference (SD units) from peak value was greatest for RA (-1.77 radius, -1.24 spine, -2.13 femoral neck, -2.34 QCT spine, and -2.71 phalanges). We conclude that RA is an acceptable measure of phalangeal BMD and that the data in our cohort can serve as reference data for older white and black women aged 55-75 years. Once the ability of RA to predict future fracture occurrence has been demonstrated, it could be rapidly deployed as a low-cost, widely available bone mass measurement technique.

Pediatr Res 2001 Sep; 50(3):417-22

Bone mineral density assessed by phalangeal radiographic absorptiometry before and during long-term growth hormone treatment in girls with Turner's syndrome participating in a randomized dose-response study.

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To assess bone mineral density (BMD) in girls with Turner's syndrome before and during long-term treatment with GH, longitudinal measurements using phalangeal radiographic absorptiometry were performed in 68 girls with Turner's syndrome. These previously untreated girls, age 2-11 y, participating in a randomized, dose-response trial, were randomly assigned to one of three GH dosage groups: group A, 4 IU/m(2)/d (approximately 0.045 mg/kg/d); group B, first year 4 IU/m(2)/d, thereafter 6 IU/m(2)/d (approximately 0.0675 mg/kg/d); or group C, first year 4 IU/m(2)/d, second year 6 IU/m(2)/d, thereafter 8 IU/m(2)/d (approximately 0.090 mg/kg/d). In the first 4 y of GH treatment, no estrogens for pubertal induction were prescribed to the girls. Thereafter, girls started with 17beta-estradiol (5 microg/kg body weight/d, orally) when they had reached the age of 12 y. BMD results were adjusted for bone age and sex, and expressed as SD scores using reference values of healthy Dutch girls. At baseline, almost every individual BMD value of bone consisting predominantly of cortical bone, as well as that of bone consisting predominantly of trabecular bone, was within the normal range of healthy girls and the SD scores were not significantly different from zero [mean (SE) 0.38 (0.22) and -0.04 (0.13)]. During 7 y of GH treatment, BMD SD scores showed a significant increase to values significantly higher than zero [mean (SE) 0.87 (0.15) and 0.95 (0.14)]. The increment in BMD SD score of bone consisting predominantly of cortical bone was significantly higher in group C compared with that of the other two GH dosage groups. The pretreatment bone age was significantly negatively related to the increment in BMD SD score. We found no significant influence of spontaneous puberty or the use of low-dose estrogens in the last 3 y of the study period on the increment in BMD SD score during 7 y of GH treatment. In conclusion, most untreated young girls with Turner's syndrome have a normal volumetric BMD. During 7 y of GH treatment with 4, 6, or 8 IU/m(2)/d, the BMD SD score increased significantly.

J Clin Densitom 2002 Spring; 5(1):79-85

Dual X-ray absorptiometry of hip, heel ultrasound, and densitometry of fingers can discriminate male patients with hip fracture from control subjects: a comparison of four different methods.

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Few studies have examined different bone densitometry techniques to determine male hip fracture risk. We conducted a case-control study of 31 noninstitutionalized men, mean age 77 yr, with a first hip fracture and compared the results with 68 randomly selected age-matched control subjects. The methods used were dual X-ray absorptiometry (DXA) of the proximal femur, quantitative ultrasound (QUS) of the heel and fingers, and radiographic absorptiometry of the fingers. Case patients had significantly lower values (4-17%; $p < 0.01$) for all methods. The odds ratios for every SD reduction in bone values were 4.8 (95% confidence interval [CI]: 2.3-9.9) for DXA of the femoral neck, 2.2 (95% CI: 1.2-3.9) for QUS of the heel, 2.0 (95% CI: 1.2-3.3) for QUS of the phalanges, and 3.1 (95% CI: 1.5-6.6) for radiographic absorptiometry of the phalanges. The results indicate a strong capability of DXA of the femoral neck to distinguish between men with a first hip fracture and control subjects. Furthermore, ultrasound of the heel and fingers as well as radiographic absorptiometry proved capable of discriminating men with hip fractures from control subjects.

Osteoporos Int 1996; 6(4):308-13

Comparison of bone densitometry of the phalanges, distal forearm and axial skeleton in early postmenopausal women participating in the EPIC Study.

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We present baseline bone densitometry from the Early Postmenopausal Interventional Cohort study (EPIC, sponsored by Merck, Sharp & Dohme) for the first time, in which 1609 women from England, Oregon, Hawaii and Denmark are participating to investigate the efficacy of daily oral alendronate to prevent early postmenopausal bone loss. We compared radiographic absorptiometry (RA) of the phalanges for bone mineral density (BMD) measurement with single-energy X-ray absorptiometry (SXA) of the distal forearm, and dual-energy X-ray absorptiometry (DXA) of the lumbar spine, proximal femur and distal forearm. In a random subgroup of 308 women, aged 45-60 years, on average 6 years since menopause (YSM), bone densitometry was measured once at baseline by RA of the phalanges besides the mandatory measurements by DXA. Bone densitometry was furthermore measured by SXA at the Danish site (89 women). Sixty-eight of the women had duplicate measurements performed within 1-3 weeks to evaluate the short-term precision error (CV%). One hundred and one healthy premenopausal women, aged 25-48 years, were recruited at the Danish and Hawaiian sites to establish a reference group. The precision error was 1.5% for RA of the phalanges and in the range 1.0-2.2% for SXA and DXA. BMD by RA correlated with BMD measured by SXA and DXA in the range $0.45 < r < 0.72$ ($p < 0.001$). In conclusion, bone densitometry by RA of the phalanges is highly correlated with bone densitometry by SXA and DXA. RA of the phalanges has a short-term precision error comparable to that of SXA and DXA.

Bone 1995 Mar; 16(3):325-32

Predicting vertebral deformity using bone densitometry at various skeletal sites and calcaneus ultrasound.

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We investigated the usefulness of bone density measurements from multiple skeletal sites and calcaneus ultrasound for evaluating the probability of vertebral deformation. Bone mineral density (BMD) was measured at the second metacarpal and middle phalanges using radiographic absorptiometry of hand radiographs, and at the lumbar spine using dual-energy x-ray absorptiometry. Distal radius and proximal radius were measured using single-energy x-ray absorptiometry (SXA), expressed as bone mineral content (BMC, grams per centimeter), and as BMD (grams per square centimeter). The calcaneus was measured using both SXA (BMD) and broadband ultrasound attenuation (BUA). Among the women in this study (mean age 74, SD = 5), 84 women developed new vertebral deformations (57 cases with one and 27 cases with two or more deformations), which were identified on serial radiographs during an average of 9 years prior to the measurements of bone density. Logistic regression analysis was used to calculate odds ratios for risk of deformation corresponding to a 1-SD difference in density or ultrasound, adjusted for age. All bone measurements were significantly associated with vertebral deformation, with odds ratios (95% confidence intervals) ranging from 1.40 (1.10, 1.78) for proximal radius BMD to 1.88 (1.45, 2.44) for calcaneus BMD measurements. Measurements of calcaneal BUA, calcaneal BMD, and hand BMD generally remained significant when included simultaneously with another measurement in the same model, suggesting that spine or radius BMD may not provide much additional information about risk of deformation. It appears that all of the measurements of bone density and ultrasound provide useful information regarding the probability of deformation. These findings await confirmation in a prospective study.

Bone Miner Res 1997 May; 12(5):697-711

Comparisons of noninvasive bone mineral measurements in assessing age-related loss, fracture discrimination, and diagnostic classification.

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The purpose of this study was to examine the commonly available methods of noninvasively assessing bone mineral status across three defined female populations to examine their interrelationships, compare their respective abilities to reflect age- and menopause-related bone loss, discriminate osteoporotic fractures, and classify patients diagnostically. A total of 47 healthy premenopausal (age 33 +/- 7 years), 41 healthy postmenopausal (age 64 +/- 9 years), and 36 osteoporotic postmenopausal (age 70 +/- 6 years) women were examined with the following techniques: (1) quantitative computed tomography of the L1-L4 lumbar spine for trabecular (QCT TRAB BMD) and integral (QCT INTG BMD) bone mineral density (BMD); (2) dual X-ray absorptiometry of the L1-L4 posterior-anterior (DXA PA BMD) and L2-L4 lateral (DXA LAT BMD) lumbar spine, of the femoral neck (DXA NECK BMD) and trochanter (DXA TROC BMD), and of the ultradistal radius (DXA UD BMD) for integral BMD; (3) peripheral QCT of the distal radius for trabecular BMD (pQCT TRAB BMD) and cortical bone mineral content (BMC) (pQCT CORT BMC); (4) two radiographic absorptiometric techniques of the metacarpal (RA METC BMD) and phalanges (RA PHAL BMD) for integral BMD; and (5) two quantitative ultrasound devices (QUS) of the calcaneus for speed of sound (SOS CALC) and broadband ultrasound attenuation (BUA CALC). In general, correlations ranged from (r = 0.10-0.93) among different sites and techniques. We found that pQCT TRAB BMD correlated poorly (r < or = 0.46) with all other measurements except DXA UD BMD (r = 0.62,p < or = 0.0001) and RA PHAL BMD (r = 0.52, p < or = 0.0001). The strongest correlation across techniques was between QCT INT BMD and DXA LAT BMD (r = 0.87, p < or = 0.0001), and the weakest correlation within a technique was between pQCT TRAB BMD and pQCT CORT BMC (r = 0.25,p < or = 0.05). Techniques showing the highest correlations with age in the healthy groups also showed the greatest differences among groups. They also showed the best discrimination (as measured by the odds ratios) for the distinction between healthy postmenopausal and osteoporotic postmenopausal groups based on age-adjusted logistic regression analysis. For each anatomic site, the techniques providing the best results were: (1)

spine, QCT TRAB BMD (annual loss, -1.2% [healthy premenopausal and healthy postmenopausal]); Student's t-value [not the T score], 5.4 [healthy postmenopausal vs. osteoporotic postmenopausal]; odds ratio, 43 [age-adjusted logistic regression for healthy postmenopausal vs. osteoporotic postmenopausal]); (2) hip, DXA TROC BMD (-0.46; 3.5; 2.2); (3) radius, DXA UD BMD (-0.44; 3.3; 1.9) and pQCT, CORT BMC (-0.72; 2.9; 1.7); (4) hand, RA PHAL (-0.51; 3.6; 2.0); and (5) calcaneus, SOS (-0.09; 3.4; 2.1) and BUA (-0.52; 2.6; 1.7). Despite these performance trends, the differences among sites and techniques were statistically insignificant ($p > 0.05$) using age-adjusted receiver operating characteristic (ROC) curve analysis. Nevertheless, kappa score analysis (using -2.0 T score as the cut-off value for osteopenia and -2.5 T score for osteoporosis) showed that in general the diagnostic agreement among these measurements in classifying women as osteopenic or osteoporotic was poor, with kappa scores averaging about 0.4 (exceptions were QCT TRAB/INTG BMD, DXA LAT BMD, and RA PHAL BMD, with kappa scores ranging from 0.63 to 0.89). Often different patients were estimated at risk by using different measurement sites or techniques.

Radiology 2000 Aug; 216(2):586-91

Bone mineral measurement of phalanges: comparison of radiographic absorptiometry and area dual X-ray absorptiometry.

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With a standard, image-intensifier-based, digital radiographic system, high-spatial-resolution images of the hand were acquired for analysis of phalangeal bone mineral density with dual x-ray absorptiometry (DXA). Results with phalangeal DXA had precision of plus or minus 0.67% and accuracy of 4.1% and correlated well with those with radiographic absorptiometry. This phalangeal DXA technique is potentially useful for clinical diagnosis of osteoporosis.

Radiology 1997 Mar; 202(3):759-63

Assessment of osteoporosis: comparison of radiographic absorptiometry of the phalanges and dual X-ray absorptiometry of the radius and lumbar spine.

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PURPOSE: To evaluate radiographic absorptiometry (RA) of the phalanges in healthy women and in women with osteoporosis and to compare the results of RA with those of dual x-ray absorptiometry (DXA) of the radius and spine. MATERIALS AND METHODS: Thirty-two healthy premenopausal women, 39 healthy postmenopausal women, and 35 postmenopausal women with osteoporosis underwent RA of the phalanges and DXA of the radius and lumbar spine. Pairwise comparisons, age-related bone losses, and percentage decrements and Student t values for intergroup discrimination were calculated. The ability to identify patients with osteoporotic fractures was evaluated by using receiver operating characteristic and age-adjusted logistic regression analyses. The diagnostic agreement for osteoporosis was assessed with kappa statistics. RESULTS: Findings from RA were correlated with those from spinal DXA (r = .56). The annual bone losses in healthy women, as measured with RA, radial DXA, and spinal DXA, were 0.47%, 0.47%, and 0.32%, respectively. Intergroup percentage decrements and t values obtained with RA were comparable to those obtained with radial and with spinal DXA. Receiver operating characteristic analysis showed no statistically significant differences. The odds ratios for RA, radial DXA, and spinal DXA were 2.1, 1.9, and 2.4, respectively. The kappa scores were 0.44 for both RA versus radial DXA and RA versus spinal DXA, and the score was 0.22 for radial DXA versus spinal DXA. CONCLUSION: RA appears to be a useful technique for assessing age- and menopause-related bone loss and for identifying women with osteoporosis.

Osteoporos Int 1991 Oct; 2(1):34-8

Radiographic absorptiometry: a simple method for determination of bone mass.

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Bone mass measurements have been shown to be useful determinants of the risk of development of osteoporotic fractures and may help identify individuals who are most likely to benefit from both primary and secondary prevention of osteoporosis. As standard bone density measurements are not available to all physicians, there is a need for a fast, inexpensive, and widely available technique to measure bone mass. Radiographic absorptiometry of the phalanges requires only routine radiography with processing of the films done at a special off-site laboratory. We performed a preliminary investigation to see whether this simple technique could be used to predict a low bone mass as defined by dual- and single-photon absorptiometry. Correlations between radiographic absorptiometry. Correlations between radiographic absorptiometry and the standard techniques were as good as those among the standard techniques themselves (r = 0.58-0.9). Radiographic absorptiometry measurements predicted low bone mass of the lumbar spine and femoral neck with 90% and 82% sensitivity respectively. If further evaluation supports these initial conclusions, radiographic absorptiometry may be useful as a screening technique for primary care physicians and in research settings where dual-photon or dual-energy X-ray absorptiometry are impossible.

J Rheumatol 1996 Oct; 23(10):1734-8

Bone densitometry: comparison of dual energy x-ray absorptiometry to radiographic absorptiometry.

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OBJECTIVE: To assess the reliability and validity of radiographic absorptiometry of middle phalanges when compared to dual energy x-ray absorptiometry (DEXA) of the spine and hip as an indicator of osteoporosis. METHODS: DEXA readings from the spine and femur were compared with radiographic absorptiometry measurements obtained the same day in a sample of 50 women (average age 63 yrs; range 23-86). RESULTS: Both spine and femur DEXA scores were significantly correlated with radiographic absorptiometry scores (R = 0.70 and 0.68, respectively; approximate standard errors 0.08). DEXA scores were used as the standard, defining moderate fracture risk by a standardized t score < -2 and marked risk by t < -3. Using cutpoints of t < -2 for DEXA and t < -3 for standardized radiographic absorptiometry values, the sensitivity to osteopenia was 0.62 for DEXA of the spine and 0.63 for DEXA of the femur, with specificities of 0.90 and 0.96, respectively, at these cutpoints; the corresponding false positive and false negative rates for our cohort of women were 0.19 and 0.24 (spine) and 0.07 and 0.24 (femur). Receiver operating characteristic (ROC) curves were plotted, varying DEXA measurement site from spine to femur and standardized cutoff from -2 to -3; the areas under the resulting ROC curves ranged from 0.82 to 0.91. CONCLUSIONS: Radiographic absorptiometry holds promise as a practical method for screening for osteoporosis.

Aging (Milano) 1998 Jun; 10(3):240-8

Instrumental diagnosis of osteoporosis.

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Considerable progress in the development of methods for assessing the skeleton now makes it possible to detect osteoporosis non-invasively and early. There is a variety of techniques available at present: single-photon (SPA) and single X-ray absorptiometry (SXA), dual-photon (DPA) and dual X-ray absorptiometry (DXA), quantitative computed tomography (QCT), radiographic absorptiometry (RA), and quantitative ultrasound (QUS), and their development has certainly been driven by the need to overcome the inherent shortcomings of plain radiography for this purpose. Both SPA and SXA methods make a quantitative assessment of the bone mineral content (BMC) or density (BMD) at peripheral sites of the skeleton possible. Single energy measurements are not possible at sites with variable soft tissue thickness and composition, i.e., the axial skeleton. For these purposes, DPA and DXA techniques were introduced. The main advantages of an X-ray system over a radionuclide system are shortened examination time, greater accuracy and precision limited to higher resolution, and removal of errors due to source decay correction. Low radiation dose, availability, capacity to evaluate multiple sites, and ease of use have made DXA the most widely used technique for measuring bone mineral density. QCT can determine the true volumetric density of trabecular or cortical bone in three dimensions at any skeletal site. Recently developed new computer-assisted methods have improved RA precision, thus providing a simple and inexpensive technique for screening of bone mineral status of large populations. QUS was reported to provide information regarding the structural characteristics of bone, which may be relevant to the appearance of osteoporotic fractures; indeed, some studies suggest a relationship between QUS and bone strength beyond that which can be explained by BMD. Recent experimental studies suggested that magnetic resonance might also constitute a promising tool for assessing osteoporosis.

Calcif Tissue Int 2000 Jan; 66(1):1-4

The relationship between phalangeal bone density and vertebral deformities.

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Radiographic absorptiometry (RA) of the phalanges is a convenient and reliable technique for measuring bone mineral density (BMD). It needs only a radiograph of the hand, which can be sent for evaluation to a central facility, whereas other techniques require specialized equipment. We assessed the relationship between RA measurements and the presence of vertebral deformities in a population-based cohort of postmenopausal women, and to compare the results with simultaneously obtained BMD of the hip by dual-energy X-ray absorptiometry (DXA). A total of 389 women aged 55-84 (mean age 67.2 years, SD 8.7) were randomly selected from a large general practice. RA, DXA of the hip, and vertebral deformities in the lateral spine X-rays by vertebral morphometry were assessed. Thirty-eight women (9.8%) had severe (grade II) vertebral deformities, and their BMD at the phalanges and femoral neck was significantly lower than that of women without severe vertebral deformities. Odds ratios for the presence of severe vertebral deformities of 1.5 (95% CI: 1.1-2.1) for RA and 1.3 (95% CI: 0.9-1. 9) for DXA, together with similar receiver operating characteristics curves, were found using age-adjusted logistic regression. Phalangeal BMD is related to vertebral deformities at least as closely as BMD of the femoral neck BMD. RA may therefore help to evaluate fracture risk, especially if no DXA equipment is available.

J Clin Densitom. 1998 Jan; 1(3):259-68.

Perspective on Fracture Risk and Phalangeal Bone Mineral Density.

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Current bone mineral density (BMD) represents the composite, cumulative effect of many past and present risk factors, including both genetic and lifestyle influences. Reduced BMD, increasing age, and the presence of pre-existing fractures independently increase the risk of osteoporotic fracture. BMD is the most clinically useful of these indicators.
Assessment of phalangeal BMD by dual-energy X-ray absorptiometry (DXA) or radiographic absorptiometry (RA) has been shown to provide long-term value in predicting the risk of both hip and spine fracture. Data from phalangeal BMD measurements may be most valuable to the patient if they are used to compute the patient's remaining lifetime fracture probability (RLFP).

J Bone Miner Res 2003 Sep; 18(S2):S116

A Pilot Study of the Use of Radiographic Absorptiometry in the Measurement of Cortical and Trabecular Phalangeal Bone Mineral Density in Chinese Men and Women.

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Radiographic Absorptiometry (RA) automatically measures volumetric BMD in the 2nd, 3rd, and 4th middle phalanges. A study was conducted to investigate the ability of RA to separate cortical and trabecular phalangeal BMD, offering an inexpensive and safer alternative to QCT. The study was

conducted using X-rays from RA tests of 556 patients. These x-rays were analyzed to compare the rate of decline of cortical, trabecular and total phalangeal BMD.

A normal Chinese population with no known osteoporosis or arthritis, of ages 10 to 89, with 277 male and 279 female were considered for the study. A two view standard AP x-ray was acquired for the non-dominant hand of each volunteer with an aluminum reference wedge placed near the hand. Based on the OsteoGram R technology (CompuMed Inc, Los Angeles, CA), which applies RA, a customized module has been developed to perform automated bone tissue segmentation isolating three distinct areas in each phalanx:

1. An axial cylinder, 2.2x2.2 m.m. in size, in the middle of the distal trabecular zone
2. An axial cylinder, 2.2x2.2 m.m. in size, in the middle of the proximal trabecular zone
3. A tube segment in middle of the phalanx that includes the cortical tissue and excludes the central non-cortical tissue.

The module performed BMD assessments in the cortical and the two trabecular areas in addition to the standard total phalangeal BMD. Considering the two radiographic views for each volunteer's hand and the three bones in each view, the unsupervised automated algorithm properly segmented the trabecular and cortical areas with a success rate of 90% for male and 92% for female.

Time courses of unadjusted BMD results showed peaks in the age range of 25-35. Using linear regression analysis the rate of BMD loss was calculated in BMD-AU (Arbitrary Units) per year for all subjects 35 years and older. For males, BMD decreased at the same rate in both trabecular and cortical tissues (~ -0.3), where as total BMD decreased at a higher rate (~ -0.5). For females, trabecular BMD decreased at a slightly higher rate than male (~ -0.4). However, cortical BMD decrease was much higher and close to total BMD decrease at the rate of -1.0. Further development of the module will investigate applying cortical thickness measurements. We believe that adding cortical and trabecular measurements to the RA BMD report could provide useful information to assist clinicians in providing better osteoporosis care.

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Radiographic Absorptiometry (RA) Assessment of Bone Mineral Density Using a CR-based System Compared to the Film-based System.

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Phalangeal BMD assessment using Radiographic Absorptiometry (RA) by means of scanning standard hand radiographs has been in use for years. It is a reliable and inexpensive method for assessing peripheral BMD with high predictability of future fracture risk of the hip and spine. With the recent development and availability of digital radiography platforms, i.e., Computed Radiography (CR), Direct Radiography (DR) and Picture Archiving and Communications Systems (PACS), there exists a need for a reliable Digital Imaging and Communications in Medicine (DICOM) compliant BMD method, such as a DICOM-based RA. This study reports the comparison of BMD results between a DICOM-based RA system that utilizes a CR device (ACLxy, Orex, Yokneam, Israel) and a standard film-based RA system.
The 45 Caucasian and Asian volunteers between the ages of 50 to 81 participated in this study. Two consecutive x-rays of the non-dominant hand were acquired for each volunteer, one using a standard film and another using a CR cassette. The standard films were scanned using a flatbed scanner at the resolution of 254 dpi matching the CR resolution. The CR cassette was read at its native resolution of 254 dpi. The images of both x-ray platforms were analyzed for RA results using the OsteoGram® (CompuMed, Inc., Los Angeles, CA) software which performs automated RA analysis.
Regression analysis of the results showed a significant ($p<0.001$) Pearson correlation coefficient of 0.98, between a DICOM-based RA system and a film-based RA system.
We conclude that BMD may be measured using RA on a digital x-ray platform. The availability of DICOM-compliant RA may help improve access to BMD testing in settings where central DXA is not available.