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Correlation of Hand Bone Mineral Density with the Metacarpal Cortical Index and Carpo:Metacarpal Ratio in Patients with Rheumatoid Arthritis

Salih Ozgocmen[1], Belgin Karaoglan[1], Ercan Kocakoc[2], Ozge Ardicoglu[3], and Zeynep Rezan Yorgancioglu[1]

Abstract

This study proposed an assessment of the correlation of hand bone mineral density measured by dual energy x-ray absorbtiometry (DXA) with the carpo:metacarpal (C:MC) ratio and metacarpal cortical index (CI) in patients with rheumatoid arthritis (RA). The correlation of total hand BMD, CI and C:MC ratio with BMD at other sites, the Health Assessment Questionnaire (HAQ) and Larsen scores were also examined. The hand and axial BMD of 30 female patients were also compared with 29 age-matched healthy female controls. Total hand BMD values of patients were significantly lower than the control group. There was no significant difference between groups in axial measurements. CI correlated moderately with the second metacarp (II.MC) midshaft and total hand BMD. The C:MC ratio correlated with II.MC midshaft and total hand BMD. Total hand BMD correlated moderately with the AP spine (L2-L4) and femoral neck BMD. Larsen scores showed weak negative correlation with II.MC midshaft BMD and CI. Grip strength correlated weakly only with total hand BMD. The results indicated that CI may reflect cortical bone mass of the hand accurately and did not predict bone density of the spine or hip in patients with RA. The C:MC ratio is a useful method for evaluating progression of wrist involvement and may be related to the loss of hand bone mineral density associated with disease process.

Key Words: Hand bone mineral density, rheumatoid arthritis, cortical index, carpo:metacarpal ratio

INTRODUCTION

The measurement of bone mass by radiogrammetry was first developed by Barnett and Nordin.[1] Metacarpal radiogrammetry (MR) is a technique applied to the midshaft of the second metacarpal, by which cortical thickness is measured and then expressed as the metacarpal index on a standard hand film. From MR-implementable on computerized machines with a degree of automation reached for radiographic absorptiometry-various indices of cortical bone volume and area can be derived.[2,3] This method has been used for the evaluation of metacarpal bone mass in patients with rheumatoid arthritis (RA).[4-7] Recently, bone mineral density (BMD) measurements of the hand by dual-energy X-ray absorptiometry (DXA) have been described in patients with RA. Hand BMD measurements by DXA have been found to be an accurate, repeatable and sensitive method in these studies.[8-11] This method has also been suggested as a useful routine clinical measure of disease activity and progression.[11] The correlation of hand BMD with measures of disease activity, functional capacity (ie. Health Assessment Questionnaire (HAQ), grip strength) and also with lumbar and femoral BMD has been assessed.[8-11]

Our aim was to determine the relationship of total hand and second metacarp midshaft BMD measured by DXA to the cortical index (CI) and carpo: metacarpal (C:MC) ratio in patients with RA which had not been assessed in prior research. The correlation of total hand BMD, CI and C:MC ratio with BMD at other sites, HAQ and Larsen scores were also examined. The hand and axial BMD of patients were also compared with age-matched healthy controls.

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[1]Department of Physical Medicine and Rehabilitation, Ankara State Hospital, Ankara, [2]Department of Radiology, Sivas State Hospital, Sivas, [3]Department of Physical Medicine and Rehabilitation, Division of Rheumatology, Faculty of Medicine, Firat University, Elazig, Turkey
Address reprint request to Dr. Salih Ozgocmen, Fakulteler mah. Ozsoy sok. No:24/16, TR-06340 Cebeci, Ankara, Turkey. Fax: 90 424 237 7411, E-mail: sozgocmen@hotmail.com

MATERIALS AND METHODS

Thirty female patients (aged 22–70; and 18 postmenopausal, 12 premenopausal) who met American Rheumatism Association (ARA) 1987 criteria for the diagnosis of RA, functional classes I-III, with disease duration of 3–252 months were selected consecutively from the out-patient clinic. Patients who were under treatment of steroid therapy and had a history or biochemical evidence of diseases other than RA which was likely to interfere with bone metabolism were excluded. Twenty-nine sedentary healthy housewives aged 30–70 years (17 postmenopausal, 12 premenopausal) were included as a control group. All of the women in the control group had to meet the following criteria: (1) no history of renal, cardiac, endocrine, or rheumatological disorders; (2) no evidence of compression fracture(s), degenerative arthritis or other metabolic bone diseases on roentgenogram of the spine and hands; (3) no history of estrogens or prolonged steroid use; and (4) ambulatory and independent in daily living.

The study protocol was designed to record demographic data such as age, weight, length, duration of RA and questions about social status. Previous intra-articular injection therapy and other forms of medical treatment were also recorded. None of the patients had a history of wrist and/or hand joint injection.

The modified Stanford HAQ was performed on each patient.[12] In both groups, handgrip strength was measured with the Jamar dynamometer from the dominant side, which was the right side for all women. With the women standing and arms held straight at their sides, the dynamometer was gripped as hard as possible for 3 seconds without pressing the instrument against the body and without any flexion of the elbow. Three measurements were recorded and the mean values were calculated in kg. There was a 2-minute interval between measurements.

BMD of the antero-posterior (AP) spine, femoral neck, trochanter, and Ward's triangle (on the dominant right for all women-side) was measured with DXA by using a Lunar DPX bone densitometer. We used DXA methodology for the measurement of hand BMD by using the same device with an analysis package which was originally developed for the measurement of bone mass of small animals and modified for hand BMD measurements. Women sat at the end of the scanning table and placed their dominant hand flat (extended and palm facing down) on the forearm plate and along the longitudinal centre line of the scan field. The origin of the carpal bones was palpated and marked with the laser pointer at the start. Scanning was performed in slow-detail mode.

The analysis software used in this study made it possible to obtain BMD for any region of interest in the hand, so that BMD of the right second metacarp (II.MC) 1/3 midshaft area was obtained.

Postero-anterior hand radiographs of patients with RA were taken at a uniform 1m tube-to-film distance. These were assessed by three independent observers, one (EK) who scored X-rays using the Larsen Index[13] and the others (BK and OA) measured CI by using a special magnifying eyepiece with a millimetric rule and C:MC ratio by using a calliper.

C:MC ratio was determined by dividing the carpal by the third metacarpal lengths.[14] Metacarpal CI for the right second metacarp was obtained by the following formula:

$$\text{Cortical Index} = a+b/d$$

where, a,b = thickness of two cortical walls,
d = over-all metacarpal thickness.[1]

The relationship between variables was assessed using Pearson's correlation coefficients for parametric variables and Spearman's rank correlation for variables not normally distributed. Hand and axial BMD of controls and patients were compared by Mann-Whitney U test. Two-tailed p values at levels of 0.05 or less were considered to be statistically significant findings. Analyses were performed using SPSS software.

RESULTS

Hand, lumbar spine, and femoral scans were performed on 30 patients with RA and 29 healthy subjects. Characteristics, total hand and axial site BMD measurements of both groups are shown in Table 1. Total hand BMD values of patients were significantly lower than control group ($p<0.05$). There was no significant difference between groups in axial measurements. Grip strength of patients were significantly lower than control subjects ($p<0.001$). CI correlated moderately with II.MC midshaft and total hand BMD ($p<0.001$). Fig. 1. shows the

Table 1. Characteristics and Measurements of Patients and Controls

	RA (N=30) Mean±S.D.	Controls (N=29) Mean±S.D.
Age (years)	45.5±15.1	52.1±9.7
Weight (kg)	65.6±15.5	67.1±9.5
Height (cm)	155.9±7.2	155.0±4.3
Grip strength (kg)	16.6±7.7*	26.1±6.2
Total hand BMD (g/cm^2)	0.391±0.05†	0.413±0.05
II.MC midshaft BMD (g/cm^2)	0.524±0.14†	0.577±0.11
AP Spine BMD (g/cm^2)	1.03±0.15	1.02±0.17
Femur neck BMD (g/cm^2)	0.82±0.11	0.85±0.14
Ward's triangle BMD (g/cm^2)	0.70±0.13	0.70±0.15
Trochanter BMD (g/cm^2)	0.69±0.13	0.71±0.11
Carpo:metacarpal ratio	0.48±0.02	--
Cortical Index	0.52±0.10	--

*$p<0.001$
†$p<0.05$

correlation of CI with II.MC midshaft and total hand BMD (r: 0.76 and r: 0.63, $p<0.001$, respectively). C:MC ratio correlated with II.MC midshaft and total hand BMD (r: 0.66, $p<0.001$; and, r: 0.48, $p=0.007$, respectively).

Total hand BMD correlated moderately with AP spine (L2-L4) and femoral neck BMD (r: 0.59, $p=0.001$, and r: 0.65, $p<0.001$, respectively). II. MC midshaft BMD also showed moderate correlation with AP spine and femoral neck BMD (p: 0.56, $p=0.001$; and r: 0.62, $p<0.001$, respectively). CI correlated weakly with the AP spine (r: 0.22) and femoral neck (r: 0.29) BMD, but did not reach statistical significance.

Larsen scores showed weak negative correlation with II. MC midshaft BMD and CI (r: −0.40, and r: −0.39, $p<0.05$, respectively). C:MC ratio was inversely correlated with Larsen score (r: −0.77, $p<0.001$). Significant correlation was not obtained between HAQ scores and other parameters. Grip strength correlated weakly only with total hand BMD (r: 0.42, $p=0.02$).

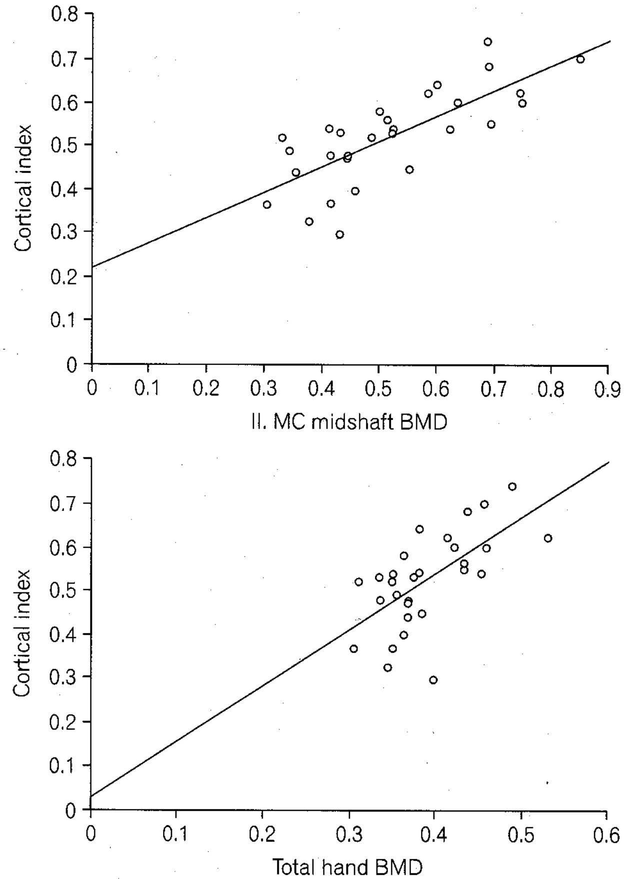

Fig. 1. Correlation of CI with II. MC midshaft and total hand BMD (g/cm^2) (r: 0.76; and r: 0.63, $p<0.001$, respectively).

DISCUSSION

Radiogrammometry of cortical bone is a simple and reducible method which measures bone mass indirectly. Good statistical relationships between the bone mass of the peripheral and axial skeleton, metacarpal bone and stature, cortical thickness and spinal porosity grades, cortical thickness and fat-free bone weight per unit volume of iliac crest biopsies have been documented.[15]

The highly significant correlation between CI and II.MC midshaft BMD indicates that CI indirectly reflects bone mass and may be an accurate method. Changes in cortical width show a high degree of correlation with the changes in mass of cortical bone.[15] Measurement of total hand BMD reflects a combination of cortical and trabecular bone mass, but II.MC midshaft BMD reflects almost entirely the cortical bone mass. This may explain why CI correlated strongest with II.MC midshaft BMD and weakest with BMD at axial sites.

In our study we did not observe any correlation between CI and functional activity measurements of RA such as HAQ and grip strength. This may be related to the nature of osteoporosis in RA. The disease is characterized by both localized (periarticular) and generalized osteoporosis.[16,17] Periarticular osteoporosis is one of the earliest radiological features of RA and it is difficult to quantify accurately by using plain radiographs.[11,18] CI reflects cortical bone quality but fails to show periarticular osteoporosis, especially in patients with early RA. Cohn et al. advocated that metacarpal measurements are insensitive to small decreases in bone mass since cortical thinning usually denotes an advanced stage of generalised osteoporosis.[19] However, hand BMD measurement by DXA denotes periarticular osteoporosis even in early disease,[9-11] where CI is insensitive.

The Carpo: metacarpal ratio is a useful radiographic method for evaluating the progression of wrist involvement. The correlation between the Larsen Index and C:MC ratio suggests that cartilage loss and bone erosion may be related processes in RA.[14,20,21]

The C:MC ratio correlated significantly with Larsen score, which was a method based on a gradation of radiological severity depending on the presence of osteopenia, joint space narrowing, erosion, loss of alignment and ankylosis. C:MC ratio also correlated significantly with total hand BMD, whereas Larsen score was not found to be significantly correlated (r: -0.48, $p=0.007$ vs. r: -0.29, $p= 0.112$). Changes in C:MC ratio are caused by disease-related processes- cartilage loss, joint space narrowing or carpal bone erosion- which occur simultaneously with loss of bone mineral density in the hand. Therefore, the C:MC ratio may be considered to be sensitive for changes in bone mass of the hand in RA.

The relation of total hand BMD and grip strength was investigated and found to be in accordance with the results of previous studies.[8-11]

Consequently, CI may reflect cortical bone mass of the hand accurately and did not predict bone density of the spine or hip in patients with RA. C:MC ratio is a useful method for evaluating progression of wrist involvement and may be related to the loss of hand bone mineral density associated with the disease process.

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