INVESTIGATION OF BONE MINERAL DENSITY AND RADIOLOGICAL CHANGES OF PROXIMAL FEMUR OVER TIME

PROKSİMAL FEMURUN KEMİK MİNERAL YOĞUNLUĞU VE RADYOLOJİK OLARAK ZAMAN İÇİNDEKİ DEĞİŞİMLERİNİN ARAŞTIRILMASI

Engin Çakar[1], Evren Yaşar[2], M. Ali Taşkaynatan[2], Birol Balaban[2], Rıdvan Alaca[2], Haydar Möhür[2]

SUMMARY

Aim: We aimed to reveal the changes in bone mineral density (BMD), singh index (SI) scores, and geometric parameters of hip x-rays over time. We also aimed to determine the relation between these measurements.
Patients and Methods: We retrospectively examined records of the patients who had both hip dual-energy x-ray absorbtiometry (DXA) scans of at 18-24 months interval, and digital postero-anterior hip x-rays which were taken approximately at the same time with BMD (± 2 months). The patients were divided into three groups according to T scores of BMD: normal, osteopenic and osteoporotic. The changes in BMD, SI and geometric parameters were analyzed separately in each group.
Results: 50 patients were included in the study. Ten patients were normal, 24 were osteopenic and 16 were osteoporotic. In osteopenic group, there were statistically significant difference between first and second values of bone mineral density at femur trochanter and shaft (p=0.03, p=0.04 respectively). The difference between first and second shaft axis-head center distance measurements was found statistically significant (p=0.04) in the osteopenic group. Change in Singh index scores was not statistically significant in any group (p>0.05).
Conclusion: Over time, the changes in trochanter and shaft values with BMD and shaft axis-head center distance measurements in X-ray should be considered in follow-ups.
Key words: Geometry of proximal femur, bone mineral density, Singh index.

ÖZET

Amaç: Kemik mineral yoğunluğu (KMY, singh index (SI) skorları ve kalça X-ray geometrik parametrelerindeki değişiklikleri ortaya çıkarmayı amaçladık. Aynı zamanda bu ölçümler arasındaki ilişkiyi belirlemeyi de amaçladık.
Hastalar ve Yöntemler: Retrospektif olarak, hem 18-24 ay arayla kalça dual-energy x-ray absorbtiometre (DXA) taramaları ve KMY'ler ile yaklaşık olarak aynı zamanlarda çekilmiş (±2 ay) dijital postero-anterior kalça x-rayleri olan hastaların kayıtlarını inceledik. KMY T skorlarına göre hastalar normal, osteopenik ve osteoporotik olarak üç gruba ayrıldı. BMD, SI ve geometrik parametrelerdeki değişiklikler ayrı ayrı analiz edildi.
Bulgular: 50 hasta çalışmaya dahil edildi. On hasta normal, 24'ü osteopenik ve 16'sı osteoporotikti. Osteopenik grupta, femur trokanter ve şaftının birinci ve ikinci kemik mineral yoğunluğu değerleri arasında istatistiksel olarak önemli fark vardı (sırasıyla p=0.03, p=0.04). Osteopenik grupta, birinci ve ikinci şaft aksı-baş merkezi uzaklığı ölçümleri arasındaki fark istatistiksel olarak anlamlı bulundu p=0.04). Singh indeks skorlarındaki değişiklikler hiçbir grupta istatistiksel olarak anlamlı bulunmadı(p>0.05).
Sonuç: Zaman içinde, KMY trokanter ve şaft değerleri ve X-ray'de şaft aksı-baş merkezi uzaklığı ölçümleri hasta takiplerinde dikkate alınmalıdır.
Anahtar Kelimeler: Proksimal femur geometrisi, kemik mineral yoğunluğu, Singh indeksi

Yazışma Adresi / Correspondence Address:
Evren Yaşar, GATA Fiziksel Tip ve Rehabilitasyon Ankara Turkiye
e-mail: evrenyasar@yahoo.com

1 GATA, Fiziksel Tıp ve Rehabilitasyon, Ankara, Turkey
2 GATA Haydarpaşa Eğitim ve Araştırma Hastanesi, Fiziksel Tıp ve Rehabilitasyon, İstanbul, Turkey

INTRODUCTION

Osteoporosis is a major public health problem, especially in aging population. It increases the fracture risk with alterations in bone structure. Its definition is based on bone mineral density (BMD) measurement generally. Fracture related to osteoporosis is the most common reason of pain and immobility (1). However, 20% of women with hip fracture would be expected to die (2). Together with high treatment costs and disability rates, hip fractures have become the international barometer of osteoporosis (3).

To determine the risks of hip fracture, it is important to expose the characteristics of bone structure. Decrease in BMD may cause hip fractures, so it can be used to predict fracture risk (4).

Densitometric measurement of the bone is remarkable for clinic follow-up and planning of the treatment to prevent fracture due to osteoporosis. On the other hand, it is known that endurance of an object is related to its geometric structure. Therefore, hip geometry may be an important parameter in point of fracture risk. Singh index (SI) and hip geometry which are evaluated on radiographs may be useful to observe osteoporotic changes over time.

The relationship between BMD measurements and other radiological examinations have been investigated previously (2). To the best of our knowledge, the alterations in anthropometric measurements of hip radiographs and BMD levels have not been reported yet. Thus, this study was designed to investigate the changes in BMD values, SI scores and measurements of hip geometry over time.

METHODS

The medical records of our hospital were reviewed and the patients who had DXA (DPX-L, Lunar Radiation Corp, Madison, WI) bone mineral density measurements and hip graphs were determined. Those who had second DXA-BMD measurements and hip graphs together at 18th to 24th months after first examinations were included into the study. Subjects with history of any antiosteoporosis agent use, Paget's disease, inflammatory rheumatic diseases, metabolic bone diseases except osteoporosis, and hip fracture or hip surgery were excluded.

Dealing with first DXA measurements, patients were divided into three groups as normal (T score ≥ -1), osteopenic (-2.5 < T score < -1), and osteoporotic (T score ≤ -2.5) according to T scores which showed deviation from the mean of age-matched healthy controls.

Digital radiographs of the hips were obtained from Picture Archiving and Communication (PAC) system in our hospital. PAC system which was used in our hospital gave us an opportunity to make quite accurate and standard milimetric measurements on archived digital radiographs with its software.

All radiographs were examined and classified into six levels of SI that could give information about the trabecular structure of proximal femur (1). Level 1 demonstrated severe bone loss, although level 6 showed normal bone structure. In addition to this; anthropometric measurements including femur neck-shaft axis distance, intertrochanteric line, width of femur neck, shaft axis-head center distance, hip axis length, femur neck axis length, greater trochanter-intertrochanter distance, intertrochanter-pelvic rim distance, intertrochanter-inner head distance, intertrochanter-head center distance, and acetabular width were also measured in all radiographs (Figure 1).

Although SI was scored by two different researchers, computerized milimetric measurements were done on digital radiographs by single researcher. After that, the alterations between two different measurements of DXA, and SI scores and geometric measurements of hip radiographs were examined in nor-

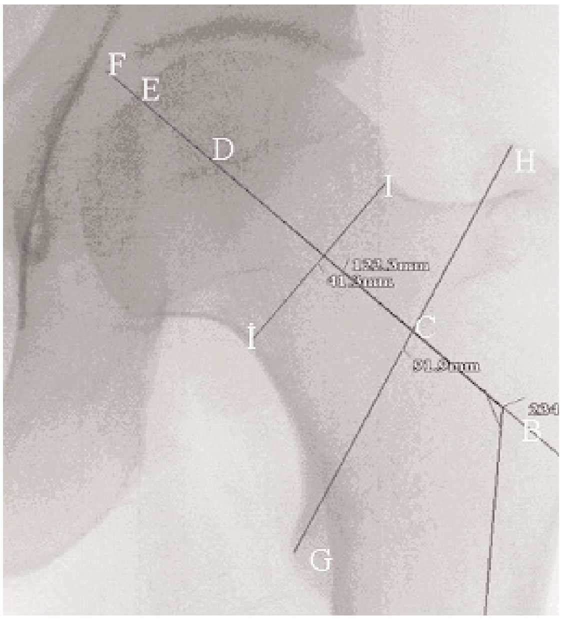

Figure 1. Geometric measurements: Femur neck-shaft axis angle; GH, intertrochanteric line; İİ, width o femur neck; AF, hip axis length; AE, femur neck axis length; CF, intertrochanter–pelvic rim distance; CE, intertrochanter–inner head distance; CD, intertrochanter–head center distance; BD, shaft axis–head center distance; EF, acetabular width; AC, greater trochanter-intertrochanter distance.

Tablo I

BMD values of proximal femur (g/cm^2).

	NORMAL		OSTEOPENIC		OSTEOPOROTIC	
	Mean ± SD (g/cm^2) **Measurements**		Mean ± SD (g/cm^2) **Measurements**		Mean ± SD (g/cm^2) **Measurements**	
	1st	2nd	1st	2nd	1st	2nd
NECK	0,99±0,26	0,95±0,12	0,78±0,19	0,77±0,12	0,59±0,38	0,57±0,89
WARDS	0,84±0,29	0,83±0,10	0,62±0,11	0,61±0,12	0,46±0,12	0,46±0,15
TROCHANTER	0,84±0,13	0,95±0,99	**0,66±0,19***	**0,61±0,87***	0,51±0,39	0,46±0,39
SHAFT	1,25±0,21	1,27±0,19	**0,96±0,91****	**0,93±0,33****	0,69±0,12	0,69±0,18

p= 0.03, ** p= 0.04
SD: Standart deviation

Tablo II

Geometric measurements obtained from digital radiographs (mm).

	NORMAL		OSTEOPENIC		OSTEOPOROTIC	
	Mean ± SD (g/cm^2) **Measurements**		Mean ± SD (g/cm^2) **Measurements**		Mean ± SD (g/cm^2) **Measurements**	
	1st	2nd	1st	1st	2nd	1st
Width of femur neck	33,90±2,68	33,00±2,51	35,76±4,66	34,55±3,41	40,67±6,55	39,40±6,67
Intertrochanteric line	68,50±2,25	67,10±2,39	65,03±9,12	63,75±9,25	79,55±12,40	78,50±13,94
Hip axis length	108,50±3,46	107,50±3,99	110,70±8,87	108,40±7,28	114,25±9,71	113,06±12,89
Femur neck axis length	103,06±4,50	99,80±4,04	103,80±9,14	101,80±7,13	108,97±10,04	108,20±13,72
Acetabular width	5,43±1,22	5,10±1,20	6,60±1,41	6,20±0,90	5,27±0,35	4,86±0,97
Intertrochanter–pelvic rim	69,26±1,34	68,30±1,29	66,90±6,46	66,40±8,54	62,65±6,66	58,16±5,1
Intertrochanter–inner head	64,16±2,21	66,70±2,43	60,36±6,24	60,20±8,80	57,62±6,72	53,30±5,8
Intertrochanter–head center	47,00±1,64	48,90±1,62	43,60±14,77	41,53±8,73	40,22±5,79	35,33±5,40
Shaft axis–head center	70,73±2,376	71,30±2,56	**70,00±8,07**	**64,83±7,05**	70,05±5,99	68,16±9,04
**Femur neck-shaft axis angle ** **	121,33±6,65	125,00±6,65	125,00±2,71	127,50±4,41	127,75±6,94	128,00±4,58

* p= 0.04, ** Mean degree

mal, osteopenic and osteoporotic groups separately with Wilcoxon Two Related Samples Test using SPSS 10.0 programme for Windows.

RESULTS

Fifty patients (age range 45-85 years; 20 men, 30 women) were included in our study. 10 of them (20%) were normal, 24 of them (48%) were osteopenic and 16 of them (32%) were osteoporotic according to T scores of first measurements. There was statistically significant difference between first and second BMD measurements of femur trochanter and shaft in osteopenic group ($p<0.05$) (Table 1). When we compared first and second radiographs in osteopenic group, we found significant difference in the measurement of shaft axis-head center distance ($p<0.05$) (Table 2). However, osteopenic group showed no statistical difference between them in the measurements of femur neck-shaft axis distance, intertrochanteric line, width of femur neck, hip axis length, femur neck axis length, greater trochanter-intertrochanter distance, intertrochanter-pelvic rim distance, intertrochanter-inner head distance, intertrochanter-head center distance, and acetabular width over time ($p>0.05$).

On the other hand, no significant difference was observed between first and second examinations of BMD values and radiographic geometries in normal and osteoporotic groups according to T scores of the first DXA examinations ($p>0.05$). Similarly, SI scores on first radiographs were not different statistically from second ones in all groups ($p>0.05$).

DISCUSSION

Measurement of BMD is the principal method to determine osteoporosis at present. But, BMD is incapable to evaluate bone quality which reflects the rate of bone fragility. It is essential to examine trabecular structure of bone and computerized tomography (CT) can give this information (5). Nevertheless, CT is too expensive to search the crowd of people thoroughly.

To have knowledge about bone quality, SI is a simple method. It provides information about proximal femur trabecular structure on conventional radiographs. However, its clinic use is controversial because of different opinions in literature about its validity to determine bone mechanic features (6).

Krischak et al reported a significant correlation between SI scores and mechanical endurance of bone (1). Cerrahoğlu et al also investigated the relationship between SI and BMD, and found that SI scores had a positive correlation with only Z scores of DXA (7). In another study, Karlsson et al claimed that there was a significant correlation among BMD, SI and measurements of proximal femur geometry (2).

On the other hand, it is known that any bone loss more than 30% in bone mineralization can give a sign. We examined any alteration in SI scores over time to reveal the changes in bone over time. But we observed no change, although a reduction appeared in bone mineral density.

In the light of the information, it might be expected that SI is not sensitive adequately in follow-up of the patients with osteoporosis. However, there were significant changes in BMD and geometric measurements. Calis et al reported the geometric measurements on conventional radiographs as important parameters in prediction of hip fracture (9). Hip axis length has been described as the most related measurement with fracture risk. It is followed by femur neck-shaft axis angle and femur neck width (8). Bergot et al made these geometric measurements on DXA scans to predict the fracture risk, and concluded that there was a relationship between fracture risk and intertrochanter line - inner head distance in patients with low bone density (10). In another study, authors suggested dealing BMD with geometric measurements of proximal femur in company for prediction of fracture risk, and they reported that geometric measurements should be used to determine the bone endurance (11). Michelotti et al stated that the measurement of shaft axis-head center distance was an important parameter in fracture risk (12).

In our retrospective trial, we determined an alteration at radiographic measurement of shaft axis-head center distance in patients who had reduction in BMD values of femur trochanter and shaft regions at the same time.

Significant bone mineral loss in the femur trochanter and shaft, and shortening of femur neck length shows that bone breakdown may start at these regions. In addition to this, the negative alteration in BMD and proximal femur geometry over time was observed interestingly in only osteopenic patients.

As far as we know, no literature has studied the bone changing in not only DXA but also radiographs until now. In spite of this property of our study, small population of our study group was the major limitation for us. But, it was not easy to find patients who had not used any antiosteoporosis drug despite being osteopenic or osteoporotic.

Finally, it is meaningful to be determined the negative changing in BMD and geometric measurements as two major risk factors of fracture. The fracture risk in osteopenic patients according to T scores of DXA should not be despised.

REFERENCES

1. Krischak GD, Augat P,Wachter NJ, Kinzl L, Claes LE. Predictive value of bone mineral density and Singh Index for the in vitro mechanical properties of cancellous bone in the femoral head. Clin Biomech 1999; 14: 346-51.
2. Karlsson KM, Sernbo I, Obrant KJ, Redlund-Johnell I, Johnell O. Femoral Neck Geometry And Radiographic Signs Of Osteoporosis As Predictors Of Hip Fracture. Bone 1996; 18(4): 327-30.
3. Cummings SR, Melton LJ. Epidemiology and outcomes of osteoporotic fractures. The Lancet 2002; 359(9319): 1761-7.
4. Miller PD, McClung M. Prediction of fracture risk. I: Bone density. Am J Med Sci 1996; 312:257-9.
5. Link TM, Majumdar S. Current diagnostic techniques in the evaluation of bone architecture. Curr Osteoporos Rep 2004 Jun; 2(2): 47-52.
6. Koot VC, Kesselaer SM, Clevers GJ, De Hooge HP, Weits T. Evaluation of the Singh index for measuring osteoporosis. J Bone Joint Surg Br 1996 Sep; 78(5):831-4.
7. Cerrahoğlu L, Duruöz T, Tıkız C, Ölçenler S. Postmenopozal osteoporozda singh indeksiyle kemik mineral yoğunluğu arasındaki ilişki. 1st Turkish Congress of Osteoporosis, Antalya, 2002, S4.
8. Brownbill RA, Ilich JZ. Hip geometry and its role in fracture: what do we know so far? Curr Osteoporos Rep 2003 Jun; 1(1): 25-31.
9. Calis TH, Eryavuz M, Calis M. Comparison of femoral geometry among cases with and without hip fractures. Yonsei Med J 2004; 45(5): 901-7.
10. Bergot C, Bousson V, Meunier A, Laval-Jeantet M, Laredo JD. Hip fracture risk and proximal femur geometry from DXA scans. Osteoporos Int 2002 Jul; 13(7): 542-50.
11. Pulkkinen P, Partanen J, Jalovaara P, Jamsa T. Combination of bone mineral density and upper femur geometry improves the prediction of hip fracture. Osteoporos Int 2004 Apr; 15(4):274-80
12. Michelotti J, Clark J. Femoral neck length and hip fracture risk. J Bone Miner Res 1999; 14:1714-20.