COMPARISON OF TRABECULAR PATTERN IN HEALTHY AND OSTEOPOROTIC WOMEN

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ÖZET

Sağlıklı ve Osteoporoz'e Sahip Kadınlarda Trabeküler Yapının Karşılaştırılması

Giriş: *Çalışmanın amacı, sistemik hastalığı olmayan osteoporoz ve kontrol hastalarında trabeküler yapıyı karşılaştırmaktır.*

Gereç ve Yöntem: *Bu çalışmaya, sistemik hastalığı olmayan 25 osteoporoz hastası ve 25 kontrol bireyi katıldı. Periapikal radyografiler alındı ve radyografiler dijitalize edildi. Anterior-posterior maksilla ve mandibulada yaklaşık 1 cm^2 lik alanlar seçildi. NIH Image Software 1.61 kullanılarak bir bilgisayar programı yazıldı ve literatürde tanımlandığı gibi seçilen bölgeler işlendi ve analiz edildi. İstatistiksel analiz olarak t testi kullanıldı $p \leq 0.05$ değeri istatistiksel olarak anlamlı kabul edildi.*

Bulgular: *Kontrol bireyleriyle karşılaştırıldığında, osteoporozlu hastalarda trabekül alanda ve trabeküler kemiğin perifer uzunluğunda azalma ve tüm bölgelerin kemik ilik alanında artma vardı. Bununla birlikte bulgular, anterior mandibulada istatistiksel olarak anlamlı değildi.*

Tartışma ve Sonuç: *Bu çalışmanın sonuçları osteoporoz değişikliklerini en iyi yansıtan bölgenin anterior maksilla olduğu hipotezini desteklemiştir. Sağlıklı kadınlarda ve osteoporozlu hastalarda, maksilla ve mandibulanın trabeküler kemik morfolojik özelliklerinin farklı olduğu gösterilmiştir.*

Anahtar Kelimeler: *Osteoporoz, Dental Radyograf, Dental Dijital Radyograf, Bilgisayar Destekli Görüntü Analizi.*

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SUMMARY

Objective: *To compare the trabecular pattern in otherwise healthy osteoporotic and control patients*

Methods: *The study population included 25 osteoporotic patients with no other systemic disease and systemically healthy 25 control patients. Periapical radiographs were made and the radiographs were digitized with a flatbed scanner. Regions of interests of approximately 1 cm^2 were selected in anterior and posterior maxilla and mandible. Using NIH Image software 1.61 (NIH) a custom computer program was written and the regions of interest were processed and analyzed, as described in the literature. Statistical analysis was made using the t-test (significance was defined as p£0.05).*

Results: *When compared to controls, there is a reduction in the area of trabeculae and length of the periphery of the trabecular bone, and an increase in the area of bone marrow in all quadrants, although the results were not statistically significant in anterior mandible.*

Conclusion: *The results of this study supports the hypothesis that anterior maxilla is the most definitive region in reflecting osteoporotic changes, and shows that the morphologic features of the trabecular bone of the maxilla and mandible are different in otherwise healthy osteoporotic and control groups of women.*

Key Words: *Osteoporosis, Dental Radiography, Dental Digital Radiography, Computer-Assisted Image Analysis.*

INTRODUCTION

Osteoporosis is manifested by loss of bone mass and structural changes in bone. There has been considerable interest in the association of osteoporosis and oral bone loss in dentistry. Radiomorphometric indices[1-4], the width and morphology of inferior cortext of the mandible[2-8], alveolar bone loss[7-10] and step-wedge-based densitometric measurements[11-13] were the radiographic methods used to demonstrate the mandibular bone changes. In addition, microradiography[5], single-and dual-photon absorptiometry[5], quantitative computed tomography[9,11] and dual-energy x-ray absorptiometry[14-17] had been used to demonstrate mandibular bone changes and to evaluate the association between osteoporosis and

oral bone loss.

Various techniques for computer-assisted image analysis of dental radiographs were also used to obtain quantitative information on trabecular architecture.[18-24] In the near past, White and Rudolph investigated the morphologic features of the trabeculae and marrow regions on digitized intraoral radiographs and compared osteoporotic patients with controls and they concluded that the patients with osteoporosis have an altered trabecular pattern in the jaws in comparison with normal subjects. However, the authors stated that the medical histories of the osteoporotic patients, except their bone mineral density (BMD) findings, were unknown.[24]

The aim of this study was to compare the morphologic features of the trabecular pattern in otherwise healthy osteoporotic and control patients in a larger sample.

MATERIALS AND METHODS

Patients enrolled in this study were selected from among the patients attending Selçuk University School of Dentistry, Department of Oral Diagnosis and Radiology for routine dental examination. Informed consent was obtained from all patients included in the study.

Patients in postmenopausal period, without a history of systemic and metabolic diseases, not taking any medications and who hadn't sought any examination for osteoporosis, were referred to Selçuk University School of Medicine, Department of Internal Diseases for dual energy x-ray absorptiometry (DEXA) scan. Measurements of hip and spina bone mineral density were made and BMD values greater than 2.5 SDs below the mean for young women were defined as osteoporotic. Twenty-five osteoporotic patients (mean age 56.7±3.2) and 25 patients (mean age 55.2±2.4) with no previous osteoporosis served as a control group, were included in the study. The age range for all the patients was 51-60 years.

Periapical radiographs were taken at 60 kvp, 7 mA, (Siemens Heliodent EC, Germany) with exposure times according to the anatomical sites. Anterior maxilla, posterior maxilla, anterior mandible and posterior maxilla regions were radiographed. Ektaspeed plus film (Agfa-Gevaert N.V., Belgium) and bisecting technique were used. Radiographs were processed with an automatic processing machine (XR 24 Nova, Dürr Dental, Bietigheim-Bissingen, Germany) with fresh processing solutions (Gulf Generafix, İstanbul, Turkey).

Radiographs were digitized with a flatbed scanner (Umax Astra 1220s, Taiwan) at 600 dpi. Regions of interests of approximately 1 cm2 were selected in maxilla and mandible, excluding teeth apices. More specifically, the regions of interest were: (a) Anterior maxilla (b) Anterior mandible (c) Posterior maxilla posterior to the last molar and inferior to the maxillary sinus. (d) Posterior mandible posterior to the last molar and superior to the mandibular canal (Figure 1).

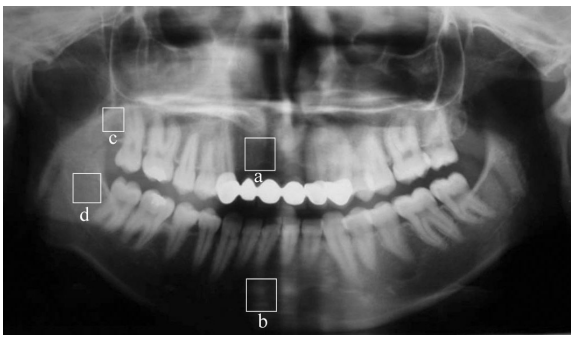

Figure 1. Regions of interest (a) Anterior maxilla (b) Anterior mandible (c) Posterior maxilla posterior to the last molar and inferior to the maxillary sinus (d) Posterior mandible posterior to the last molar and superior to the mandibular canal.

Using NIH Image software 1.61 (NIH)[25] a custom computer program was written at Selçuk University Data Processing Center (Konya, Turkey), and the regions of interest were processed and analyzed to measure the morphologic features of the trabecular pattern in digitized radiographs, as described by White and Rudolph[24]. In short, the region of interest was blurred through use of a Gaussian filter, and the resulting image was then subtracted from the original, and 128 was added to the result at each pixel location. The image was then made binary with a threshold level of 128. The resultant image was eroded and dilated once. The image of the trabeculae was then inverted and then skeletonized.

14 parameters for the trabecular area and 10 parameters for the marrow area were investigated to reveal the morphologic characteristics of both the maxilla and the mandible.

The mean values for each of parameters listed in Tables I and II were determined for control and osteoporotic groups by anatomical site. The means were compared by means of the t-test through use of a 2-tailed distribution and 2 samples of unequal variance. Significance was set at 0.05.

TABLE-I
Trabecular Analysis of Maxilla

	Anterior Maxilla					Posterior Maxilla				
Morphologic Features	Osteoporosis		Control			Osteoporosis		Control		
Trabeculae	Mean	SD	Mean	SD	p value	Mean	SD	Mean	SD	p value
Trabecular area/Total area	0.48	0.03	0.53	0.04	.012	0.49	0.03	0.54	0.04	.024
Periphery/Total area	0.22	0.04	0.25	0.04	.008	0.21	0.02	0.24	0.02	.049
Periphery/Trabecular area	0.43	0.04	0.49	0.03	.054	0.49	0.04	0.51	0.04	.184
Length/Trabecular area	0.17	0.02	0.16	0.01	.568	0.15	0.01	0.15	0.01	.982
Length/Total area	0.08	0.01	0.09	0.01	.035	0.08	0.01	0.09	0.01	.354
Terminal points/cm²	654	145	905	172	.004	824	172	1086	164	.024
Terminal points/Length	0.17	0.04	0.22	0.04	.008	0.22	0.04	0.25	0.02	.032
Terminal points/Periphery	0.04	0.01	0.05	0.01	.007	0.06	0.01	0.08	0.01	.012
Terminal Points/Trabecular area	0.02	0.01	0.03	0.01	.011	0.03	0.01	0.05	0.01	.036
Branch points/cm²	272	48	326	55	.064	225	63	231	61	.924
Branch points/Length	0.08	0.01	0.08	0.01	.320	0.06	0.01	0.05	0.00	.420
Branch points/Periphery	0.03	0.00	0.03	0.00	.482	0.02	0.00	0.02	0.00	.254
Branch points/Trabecular area	0.01	0.00	0.01	0.00	.430	0.01	0.00	0.00	0.00	.422
Branch points/Terminal points	0.42	0.07	0.39	0.06	.046	0.27	0.06	0.22	0.06	.054
Marrow										
Marrow area/Total area	0.52	0.03	0.46	0.03	.008	0.54	0.02	0.47	0.03	.042
Length/Total area	0.10	0.01	0.12	0.01	.054	0.12	0.02	0.14	0.01	.264
Length/Marrow area	0.20	0.03	0.22	0.03	.024	0.24	0.02	0.30	0.01	.051
Terminal points/cm²	493	120	732	174	.004	575	142	794	106	.044
Terminal points/Length	0.08	0.02	0.11	0.02	.003	0.08	0.01	0.12	0.02	.051
Terminal points/Marrow area	0.02	0.01	0.03	0.01	.004	0.02	0.01	0.03	0.01	.032
Branch points/cm²	473	108	524	85	.063	543	58	602	62	.332
Branch points/Length	0.07	0.01	0.09	0.01	.043	0.08	0.00	0.07	0.01	.720
Branch points/Marrow area	0.02	0.00	0.02	0.00	.005	0.02	0.00	0.03	0.00	.054
Branch points/Terminal points	0.96	0.20	0.71	0.26	.034	0.99	0.24	0.79	0.17	.252

n=25

TABLE-II
Trabecular Analysis of Mandible

	Anterior Mandible					Posterior Mandible				
Morphologic Features	Osteoporosis		Control			Osteoporosis		Control		
Trabeculae	Mean	SD	Mean	SD	p	Mean	SD	Mean	SD	p
Trabecular area/Total area	0.52	0.06	0.55	0.04	.062	0.47	0.05	0.52	0.04	.036
Periphery/Total area	0.24	0.06	0.27	0.03	.053	0.24	0.03	0.28	0.03	.008
Periphery/Trabecular area	0.47	0.05	0.52	0.07	.074	0.48	0.03	0.52	0.03	.006
Length/Trabecular area	0.15	0.01	0.15	0.02	.224	0.13	0.01	0.15	0.01	.214
Length/Total area	0.06	0.03	0.09	0.02	.068	0.05	0.01	0.06	0.00	.049
Terminal points/cm²	832	243	1071	252	.052	820	161	1182	165	.007
Terminal points/Length	0.21	0.02	0.24	0.04	.204	0.22	0.02	0.24	0.03	.022
Terminal points/Periphery	0.06	0.01	0.07	0.01	.278	0.05	0.01	0.08	0.01	.026
Terminal Points/Trabecular area	0.04	0.01	0.04	0.01	.076	0.03	0.00	0.04	0.00	.007
Branch points/cm²	282	68	336	42	.213	256	89	283	42	.402
Branch points/Length	0.08	0.01	0.08	0.01	.254	0.05	0.01	0.05	0.01	.954
Branch points/Periphery	0.03	0.00	0.03	0.00	.932	0.03	0.01	0.03	0.00	.723
Branch points/Trabecular area	0.01	0.00	0.01	0.00	.176	0.01	0.00	0.01	0.00	.704
Branch points/Terminal points	0.34	0.08	0.31	0.9	.665	0.32	0.07	0.24	0.09	.238
Marrow										
Marrow area/Total area	0.48	0.06	0.44	0.04	.069	0.53	0.05	0.47	0.04	.032
Length/Total area	0.12	0.01	0.11	0.00	.254	0.13	0.02	0.14	0.01	.236
Length/Marrow area	0.21	0.03	0.24	0.03	.048	0.20	0.04	0.23	0.03	.028
Terminal points/cm²	648	184	832	162	.044	580	175	882	103	.009
Terminal points/Length	0.09	0.03	0.12	0.03	.040	0.08	0.03	0.12	0.01	.023
Terminal points/Marrow area	0.03	0.01	0.04	0.01	.039	0.03	0.01	0.03	0.00	.014
Branch points/cm²	525	64	554	73	.213	603	74	654	42	.742
Branch points/Length	0.08	0.01	0.08	0.01	.814	0.08	0.02	0.08	0.01	.314
Branch points/Marrow area	0.03	0.00	0.03	0.01	.062	0.02	0.01	0.02	0.00	.362
Branch points/Terminal points	0.98	0.36	0.66	0.20	.074	1.08	0.27	0.72	0.18	.026

n=25

RESULTS

Morphologic features of maxilla and mandible in osteoporotic and healthy postmenopausal women are shown in Table 1 and Table 2, respectively.

When compared to controls, there is a reduction in the area of trabeculae and length of the periphery of the trabecular bone, and an increase in the area of bone marrow in all quadrants, although the results were not statistically significant in anterior mandible (p=0.074, p=0.224). The number of trabecular and marrow terminal points were lower in osteoporotic patients (anterior maxilla; p=0.004, posterior mandible; p=0.007). The number of branch points did not show any difference between osteoporotic and control patients (anterior maxilla; p= 0.063, posterior mandible; p=0.742).

Almost all of the changes were statistically significant in anterior maxilla and posterior mandible (Table I and Table II).

DISCUSSION

Osteoporosis is a metabolic disease affecting people worldwide and is responsible for bone fractures. Dental radiographs may provide an inexpensive and rapid method of monitoring osteoporosis with minimal additional exposure to radiation if oral radiographic predictors of osteoporosis can be determined. However, most of the suggested methods have several disadvantages. Although radiomorphometric indices have been used relatively successfully in academic research, there has been high variability in these measurements among the general practitioners, and the authors concluded that there was considerable doubt on their potential value due to the problems with repeatability and measurement precision.[26-28] Step-wedge-based densitometric measurements may not be practical for routine screening. Single-and dual-photon absorptiometry, quantitative computed tomography and dual-energy x-ray absorptiometry techniques are also not suitable for routine screening from both economic and availability viewpoints.

Digital analysis of dental radiographs, on the other hand, may provide an inexpensive and rapid method of monitoring osteoporosis with minimal additional exposure to radiation if the patterns of trabecular alteration peculiar to osteoporosis can be determined.[24] If such a determination can be made, dedicated computer programs may become available in future to determine the patients at risk for osteoporosis.

Morphologic features of bone is independent of x-ray exposure orientation and optical density of the radiograph if it is in the diagnostic range.[29] However, the judgement that a radiograph is in the diagnostic range may be subjective and this may result in some errors. Therefore in our study, exposure parameters were selected according to the anatomical sites and radiographs were processed with automatic processing machines with fresh solutions prepared according to the manufacturer's recommendations.

The patterns of trabecular alteration may show variations in different diseases. For example, in sickle cell anemia the number of skeletal branch points were found to be fewer than in healthy control subjects whereas the number of branch points did not differ between osteoporotic and control subjects.[24,30] The reduction in the area of trabeculae and the increase in the area of bone marrow without a reduction in the number of branch points may be a feature of osteoporosis. However, the trabecular analysis should be performed for other diseases affecting bone to investigate the different patterns of alterations. In our study, the osteoporotic and control groups were otherwise healthy; and therefore, there were no interfering diseases that may affect the results.

Anterior maxilla is the most sensitive site for distinguishing osteoporotic patients from controls probably because of its relatively large amount of trabecular bone and the relatively low cortical bone thickness.

The results of this study supports the hypothesis that anterior maxilla is the most definitive region in reflecting osteoporotic changes24, and shows that the morphologic features of the trabecular bone of the maxilla and mandible are different in otherwise healthy osteoporotic and control groups of women.

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