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Original article

Comparison of mandibular bone mineral density in osteoporotic, osteopenic and normal elderly edentulous subjects measured by the dual-energy X-ray absorptiometry technique

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Comparison of mandibular bone mineral density in osteoporotic, osteopenic and normal elderly edentulous subjects measured by the dual-energy X-ray absorptiometry technique

Objective: The aim of this study was to compare the mandibular body bone mineral density according to bone mineral density status of spine and femur measured by dual-energy X-ray absorptiometry (DXA) technique in elderly edentulous individuals.

Background: One of the factors that affect the survival rate of implants is bone mineral density (BMD) of the jaws.

Materials and methods: Fifty edentulous elderly patients' (27 women and 23 men) spine, femur and the mandibular body BMDs were measured using DXA technique. BMD scans of the AP lumbar spine (L2–L3) and femur were classified using World Health Organisation criteria for bone mass.

Results: There was a statistically significant difference between the normal femur group's–osteoporosis group's mandibular body BMD ($p = 0.001$) and femoral osteopaenia group's–osteoporosis group's mandibular body BMD ($p < 0.001$). The femoral osteoporosis group's mandibular body BMDs were lower than those of both the normal femoral and the femoral osteopaenia group subjects'.

Conclusion: Classification of edentulous mandibles according to low and high bone mineral densities is a problem in implant dentistry. The results of this study demonstrated that femoral bone mineral density status may be used to provide preliminary information about the bone mineral density of the mandibular body region in elderly edentulous subjects.

Keywords: bone density, edentulism, mandible, femur, spine.

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Introduction

Implant therapy and the factors affecting it are gaining importance in edentulous elderly people as life expectancy increases. Long-term success rates of dental implants are related to a lot of factors, such as volume and the quality of the bone[1]. One of the bone quality components affecting the survival rate of implants is bone mineral density (BMD) of the jaws[2–6]. It has been shown that identical implants (10-mm-long, 3.25-mm-diameter self-tapping implants) can be achieved in different jawbones using an identical surgical technique, leaving only bone quality and quantity to affect the initial implant stability[7]. In addition, composite apparent density showed the highest association with initial implant stability as measured by both Osstell and Periotest devices[7].

Although rehabilitation of tooth loss is important in any age, for the elderly patients, it may constitute a more significant problem with the decrease in their BMD because of dietary and metabolic impairment[8]. Elderly edentulous patients, especially postmenopausal women, are densitometrically monitored regularly to detect any impairment in BMD values and to prevent fractures occurring because of advanced age[9]. BMD of the jaws also seems to be of great importance not only in primary

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implant stability but also in the predictability of oral implant outcome[10]. However, because of the fact that the clinical settings in which patients receive implants may vary from a university hospital to a general dental clinic, many patients with osteoporosis or osteopaenia are not properly diagnosed[11]. For this reason, in the dental literature, the relationship between BMD of the skeleton and jaws has been investigated[12–17]. Using known skeletal BMD values to predict the local BMD (for mandible) may be a helpful guide for clinicians to plan dental implant therapy surgically and prosthodontically. The aim of this study was to compare the mandibular body bone mineral density according to bone mineral density status of spine and femur measured by dual-energy X-ray absorptiometry (DXA) technique in elderly edentulous individuals.

Materials and methods

Fifty edentulous elderly patients (27 women and 23 men) in Prosthodontics Department of Suleyman Demirel University Dentistry Faculty were solicited by a written announcement to participate in the study. Local ethics committee approval and informed consent from all the patients were obtained. None of the patients were smokers (the smoking period was more than 10 years for the ex-smokers). Their systemic conditions were not evaluated because the study was only investigating the relationship between local (mandibular) BMD and systemic BMD (g/cm^2) values. At the dental clinics, dental panoramic radiographs were taken to detect any pathological changes or residual root of the mandible.

Bone mineral density (g/cm^2) was measured using DXA (Norland XR-46 bone densitometer with dynamic filtration; Norland Medical Systems, Inc., Fort Atkinson, WI, USA). The densitometer was calibrated daily 30 min after turning the apparatus on. Quality control was performed using calibration standard and QC (quality control) phantom. BMD measurements were performed on the body of the mandible (described in our previous study[14]), which has greater sensitivity and specificity compared with the ramus and the symphysis regions, as described by Horner *et al.*[15] Patients were positioned on their side with the neck extended to avoid the superimposition of the cervical spine. Mandible was scanned in a rectilinear manner starting from 1 cm above the temporomandibular joint and then through the whole of the mandible on one side. The image of the contra-lateral side was superimposed. When both sides of the mandible were not superimposed because of the positioning error of the mandible, the scanning was repeated[12]. After DXA scan images were recorded and displayed on the computer monitor, manual analysis of these scans was carried out using rectangular customised regions placed over the body of the mandible extending from the anterior ramus to the parasymphyseal region. The size of the selected regions was adapted to conform to the shape of the mandible of each patient. BMD (g/cm^2) of the selected region was calculated by the computer software used for measuring lumbar spine BMD. Mandibular DXA scans were analysed by only one experienced investigator. The reproducibility of the measurement system was assessed by repeating the analysis three times for each image. BMD scans of the AP lumbar spine (L2–L3) and femur were classified using the World Health Organisation (WHO) criteria for bone mass. The data were analysed using the statistical software SPSS 15.0 (SPSS Inc., Chicago, IL, USA). Mann–Whitney *U* test used to investigate the differences between mandibular body BMDs according to the femoral and spinal BMD status. Statistical significance level was chosen at $p < 0.05$.

Results

Patient characteristics are shown (mean ± SD) in Table 1. The minimum, maximum and mean (±SD) BMD (g/cm^2) values of the mandibular body according to the femoral and spinal BMD status are given in Tables 2 and 3 respectively. The minimum, maximum and mean (±SD) BMD values of the mandibular body are given for the female and male patients as well as the whole group in Table 4. Twenty-one patients had osteopaenia, and 11 patients had osteoporosis in the femur, while 14 patients had osteopaenia and 13 had osteoporosis in the lumbar spine. There were six cases of osteoporosis identified within the group according to the WHO criteria for bone mass at both the lumbar spine and the femur. As regarding to femoral BMD status, there was a statistically significant difference between mandibular body BMD measurements of osteoporotic-normal subjects ($p = 0.001$) and osteoporotic–osteopaenic subjects ($p < 0.001$) (Table 2). Additionally, there was no statistically significant difference between normal and osteopaenic subjects' mandibular body BMD measurements ($p > 0.05$). There was also no statistically significant difference between normal, osteopaenic and osteoporotic subjects mandibular body BMD measurements ($p > 0.05$) regarding to spinal BMD status. The mandibular body BMD measurements of the normal femoral and the femoral osteopaenic

Table 1 Clinical characteristics of the study group.

	Whole group (n = 50)	*Males (n = 23)*	*Females (n = 27)*
Age (years)	63.18 ± 8.04	61.47 ± 7.78	64.62 ± 8.12
Weight (kg)	72.72 ± 10.16	74.78 ± 9.20	70.96 ± 10.76
Height (cm)	162.56 ± 7.34	166.47 ± 7.71	159.22 ± 5.11
BMI (kg/m^2)	28.83 ± 2.14	27.60 ± 2.63	28.49 ± 1.55
Period of edentulism (years)	18.44 ± 6.62	17.52 ± 5.50	19.22 ± 7.45

Table 2 The mandibular body bone mineral density values (with standard deviation) (g/cm^2) with regard to femoral bone mineral density status.

	Minimum	*Maximum*	*Mean (SD)*
Osteoporosis (n = 11)	0.51	0.95	0.76 ± 0.15[a,*]
Osteopaenia (n = 21)	0.59	2.37	1.26 ± 0.38
Normal (n = 18)	0.83	1.73	1.23 ± 0.23

[a]Osteoporotic group vs. osteopaenic group: $p < 0.001$;
*Osteoporotic group vs. normal group: $p = 0.001$.

Table 3 The mandibular body bone mineral density values (with standard deviation) (g/cm^2) with regard to spinal bone mineral density status.

	Minimum	*Maximum*	*Mean (SD)*
Osteoporosis (n = 13)	0.51	2.16	1.14 (±0.48)
Osteopaenia (n = 14)	0.60	2.37	1.20 (±0.45)
Normal (n = 23)	0.81	1.55	1.16 (±0.21)

Table 4 The minimum, maximum and mean (±SD) values of the mandibular body bone mineral density for the female and male patients as well as the whole group.

	Minimum	*Maximum*	*Mean (SD)*
Females (n = 27)	0.59	2.16	1.09 ± 0.35
Males (n = 23)	0.51	2.37	1.26 ± 0.34
Whole group (n = 50)	0.51	2.37	1.17 ± 0.35

groups were higher than those of the femoral osteoporosis group.

Discussion

There is no universally accepted practical numerical mandibular BMD classification in contemporary dental practice. Clinical investigation using dental panoramic radiographs and models could help the planning of implant therapy. However, there may be no relationship between BMD and bone parameters[6]. Seong *et al.*[7] showed that bone quality and quantity affect initial implant stability. Beer *et al.*[6] showed a strong correlation between BMD and insertion torque in implant surgery. In this study, the relationship between femoral BMD status and mandibular body BMD measured by DXA technique was indicated. Spine and femur are popular sites for BMD measurements because fractures associated with osteoporosis occur commonly at these sites[9]. A generalisation of the mandibular BMD using the femoral neck BMD could be drawn, and this idea may direct surgical implant procedures and immediate loading or delayed healing. This result may be used to plan implant therapy for edentulous patients and classify the patient's mandible as having high or low mandibular BMDs.

In this study, BMD measurements were performed on the body of the mandible that has greater sensitivity and specificity compared with the ramus and the symphysis regions, as described by Horner *et al.*[15] They emphasised that the poor precision of mandibular measurements may be improved with increasing practice because the operator becomes more familiar with the DXA technique. They also suggested that with increasing experience in positioning patients for mandibular DXA, it is likely that the incidence of errors would fall. In this study, the person who performed the mandibular DXA was the same person who conducted the mandibular DXA in the past two studies[12,14]. Superimposition is an important factor in the studies that use the DXA technique in the mandible. In the case of not achieving ideal superimposition, the obtained BMD value may be half of the real mandibular BMD or artificially high because of the superimposition of other bony structures. In the present study, the image was recorded by the computer after the desired superimposion was observed on the screen. An ideal superimposition of the body of the mandible was obtained in all the subjects. According to the results of the present study, the femoral osteoporosis

group's mandibular BMD values were lower than those of the normal femoral and the femoral osteopaenia groups. The changes in bone metabolism that occur in the jaw region seem to be the similar as those observed in long bones because both of them have a heavy muscle activity. In this study, BMD measurements were performed on the body of the mandible as the body of the mandible gives BMD data that are most predictive of BMD in the hip, spine and forearm and which produces greater sensitivity and specificity compared with the ramus and the symphysis regions, as described by Horner *et al.*[15] In our previous study conducted on chronic obstructive pulmonary disease patients under long-term inhaled corticosteroid therapy, there was a relationship between the BMDs of the femoral neck and the mandible. However, there was no relationship between the BMDs of the lumbar spine and the mandibular body. The reason for this result may originate from the changes in bone metabolism that occur in the jaw region, which seem to be the same as that observed in long bones[13].

In the present study, the mandibular BMD was 1.17 ± 0.35 g/cm^2 in edentulous individuals. The mandibular BMD was found higher from the study that conducted by Horner *et al.*[15] (1.105 ± 0.3 g/cm^2). However, they emphasised that in their study, superimposition was not achieved in all patients and those patients were not excluded from the study[14]. In the present study, the image was saved to the computer after an ideal superimposition was achieved. The results of the present study (1.17 ± 0.35 g/cm^2) was similar to the study that conducted by Pluskiewicz *et al.*[16] (1.221 ± 0.3 g/cm^2) and lower than the findings of the study that conducted by Drage *et al.*[17] (1.38 ± 0.39 g/cm^2). In the present study, BMD values comparing to the other studies may be related to the amount of the cortical and trabecular bone that may affect the density value of the jawbone. Horner *et al.*[15] and Pluskiewicz *et al.*[16] found a correlation between the mandibular body BMD and femoral neck BMD. However, in their study[15,16], they evaluated the numerical femoral neck BMD value (g/cm^2) instead of BMD status (as osteoporosis, osteopaenia and normal). In the dental practise, it may be troublesome for the dental clinicians to determine the patient's BMD status as osteoporosis, osteopaenia and normal using the numerical value of femoral or spinal neck BMD (g/cm^2).

Osteoporosis is defined by the WHO[18] as a disease characterised by low bone mass and structural deterioration of bone tissue, leading to bone fragility and an increased susceptibility to fractures, especially of the hip, spine and wrist. BMD measurements provide clinicians with a measurement called a T-score, a number value that results from comparing the bone density to optimal BMD[19]. When a T-score appears as a negative number (such as -1, -2 or -2.5), it indicates low bone mass. A T-score compares BMD to the optimal peak BMD for gender. A T-score of >-1 is considered normal. A T-score of -1 to -2.5 is considered osteopaenia, and a risk for developing osteoporosis. A T-score of <-2.5 is diagnostic of osteoporosis. The greater the negative the number, the greater is the risk of fracture[18,19]. Osteoporosis was described as type I (postmenopausal) or type II (senile)[18]. The primary type 1 or postmenopausal osteoporosis is referred to a form of osteoporosis most common in women after the menopause. After the seventh decade of life, primary type II osteoporosis (senile osteoporosis) occurs and is seen in both women and men at a ratio of 2:1[18]. Secondary osteoporosis may occur at any stage of life and affects equally both men and women and it originates from chronic medical problems or the use of some medications such as glucocorticoids (steroid- or glucocorticoid-induced osteoporosis)[12]. As the clinical settings in which patients receive implants vary from a university hospital to a general dental clinic, many patients with osteoporosis or osteopaenia are not properly diagnosed[11]. However, the femoral BMD measurements are easy to determine and most edentulous patients (especially women) are monitored regularly to detect any impairment in BMD. The results of the present study imply that the femoral neck BMD status may be used to provide information about the mandibular body BMD. At least for patients whose femoral neck BMD is low, some preventive measures can be taken, such as investigating mandibular structure with advanced imaging methods (e.g. quantitative computed tomography), a longer or normal healing period after surgery, selection of implant designs that assure stable bone-implant placement, and primary fixation of self-tapping implants without countersink procedures prior to and during dental implant treatment according to low/high density of the bone[20]. From this knowledge, the healing period should be extended by 2 months, that is, 8 vs. 6 months in maxilla and 6 vs. 4 months in low density mandibular bone[21–23].

The main limitation of this study was the small sample group of subjects with osteoporosis and osteopaenia. Although 50 patients' skeletal BMDs were scanned, only 11 patients had osteoporosis in the femur and 14 patients had osteoporosis in the

spine. Further investigations are needed in larger study groups.

Conclusion

Femur BMD status measured by DXA may be used to predict average BMD of the mandibular body in elderly edentulous individuals. However, further investigations are necessary to determine the validity of this conclusion for different regions of the mandible and the maxilla in larger study groups.

References

1. **Zarb GA**, **Schmitt A.** The longitudinal clinical effectiveness of osseointegrated dental implants in posterior partially edentulous patients. *Int J Prosthodont* 1993; **6:** 189–196.
2. **Jemt T.** Failures and complications in 391 consecutively inserted fixed prostheses supported by Brånemark implants in edentulous jaws: a study of treatment from the time of prosthesis placement to the first annual checkup. *Int J Oral Maxillofac Implants* 1991; **6:** 270–276.
3. **Fujimoto T**, **Niimi A**, **Nakai H** ***et al.*** Osseointegrated implants in a patient with osteoporosis: a case report. *Int J Oral Maxillofac Implants* 1996; **11**(4)**:** 539–542.
4. **Lugero GG**, **de Falco Caparbo V**, **Guzzo ML** ***et al.*** Histomorphometric evaluation of titanium implants in osteoporotic rabbits. *Implant Dent* 2000; **9:** 303–309.
5. **Cooper LF.** Systemic effectors of alveolar bone mass and implications in dental therapy. *Periodontol 2000* 2000; **23:** 103–109.
6. **Beer A**, **Gahleitner A**, **Holm A** ***et al.*** Correlation of insertion torques with BMD from dental quantitative CT in the mandible. *Clin Oral Implants Res* 2003; **14:** 616–620.
7. **Seong WJ**, **Kim UK**, **Swift JQ** ***et al.*** Correlations between physical properties of jawbone and dental implant initial stability. *J Prosthet Dent* 2009; **101:** 306–318.
8. **Johnell O**, **Kanis JA.** An estimate of the worldwide prevalence and disability associated with osteoporotic fractures. *Osteoporos Int* 2006; **17:** 1726–1733.
9. **Riggs BL**, **Melton LJ III.** Involutional Osteoporosis. *N Engl J Med* 1986; **26:** 314.
10. **Erdoğan O**, **Shafer DM**, **Taxel P** ***et al.*** A review of the association between osteoporosis and alveolar ridge augmentation. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 2007; **104:** 738.
11. **van Steenberghe D**, **Quirynen M**, **Molly L** ***et al.*** Impact of systemic diseases and medication on osseointegration. *Periodontol 2000* 2003; **33:** 163–171.
12. **Buyukkaplan US**, **Akkaya A**, **Yildiz M** ***et al.*** Mineral status of COPD patients under long-term inhaled corticosteroid therapy. *J Prosthodont* 2008; **17:** 462–467.
13. **Henrikson PA**, **Wallenius K**, **Astrand K.** The mandible and osteoporosis. 2. Method for determining mineral content of mandible and radius. *J Oral Rehabil* 1974; **1:** 75–84.
14. **Komerik N**, **Akkaya A**, **Yildiz M** ***et al.*** Oral health in patients on inhaled corticosteroid treatment. *Oral Dis* 2005; **11:** 303–308.
15. **Horner K**, **Devlin H**, **Alsop CW** ***et al.*** Mandibular BMD as a predictor of skeletal osteoporosis. *Br J Radiol* 1996; **69:** 1019–1025.
16. **Pluskiewicz W**, **Tarnawska B**, **Drozdzowska B.** Mandibular BMD measured using dual-energy X-ray absorptiometry: relationship to hip BMD and quantitative ultrasound at calcaneus and hand phalanges. *Br J Radiol* 2000; **73:** 288–292.
17. **Drage NA**, **Palmer RM**, **Blake G** ***et al.*** A comparison of bone mineral density in the spine, hip and jaws of edentulous subjects. *Clin Oral Implants Res* 2007; **18:** 496–500.
18. **WHO** (1994)**.** *Assessment of Fracture Risk and its Application to Screening for Postmenopausal Osteoporosis: Report of a WHO Study Group*. Geneva, Switzerland: World Health Organization, 1994: 1–129.
19. **Koda-Kimble MA**, **Young LY**, **Kradjan WA** ***et al.*** *Applied Therapeutics: The Clinical Use of Drugs*. Philadelphia: Lippincott Williams & Wilkins, 2008: 101–103.
20. **Bilhan H**, **Geckili O**, **Mumcu E**, **Bozdag E**, **Sünbüloğlu E**, **Kutay O.** Influence of surgical technique, implant shape and diameter on the primary stability in cancellous bone. *J Oral Rehabil* 2010; **37**(12)**:** 900–907.
21. **Beppu K**, **Kido H**, **Watazu A**, **Teraoka K**, **Matsuura M.** Peri-implant bone density in senile osteoporosis-changes from implant placement to osseointegration. *Clin Implant Dent Relat Res* 2011 doi: 10.1111/j.1708-8208.2011.00350.x.
22. **Gaetti-Jardim EC**, **Santiago-Junior JF**, **Goiato MC**, **Pellizer EP**, **Magro-Filho O**, **Jardim Junior EG.** Dental implants in patients with osteoporosis: a clinical reality? *J Craniofac Surg* 2011; **22**(3)**:** 1111–1113.
23. **Misch CE.** *Dental Implant Prosthetics*, 1st edn. St Louis: Mosby Inc., 2004: 511–531.

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