# Mandibular Bone Mineral Density Changes in Complete and Removable Partial Denture Wearers: A 6-Month Follow-up Study

*Dubravka Knezović-Zlatarić, DDS, MSD, PhD*[a]
*Asja Čelebić, DDS, MSD, PhD*[b]

**Purpose:** The purpose of the study was to determine the changes in bone mineral density of the mandible in complete and removable free-end saddle denture wearers over a 6-month period. **Materials and Methods:** Twenty removable partial denture patients and 20 complete denture wearers participated. Two dental panoramic radiographs were taken from each patient, the first prior to denture delivery and the second after 6 months of denture wearing. Bone mineral density measurements were performed on panoramic radiographs with a five-step copper stepwedge attached to each film cassette. Bone mineral density values of the measured regions of interest were expressed in equivalents of the stepwedge thickness (mm). **Results:** The results revealed minor changes in bone mineral density values of the examined regions in the 6-month period. Under the distal end of complete denture saddles, the bone mineral density values decreased, whereas the values under the distal end of removable partial dentures increased. However, the difference between the first and second measurements was not significant. In each of the examined groups, the bone mineral density values at the gonion increased significantly by approximately 20%. This was attributed to the increased strain forces of the masseter muscle at the gonion after denture delivery. **Conclusion:** Significant increase of bone mineral density values was registered 2 mm above the gonion in both complete and removable partial denture wearers. Age and gender were not related to the bone mineral density changes over a 6-month period. *Int J Prosthodont 2003;16:661–665.*

Reduction of the residual alveolar ridges could be described as a resorptive atrophy, a fundamental and physiologic reaction to loss of function and inactivity that presumably is influenced and modulated by individually varying factors, such as condition of the bone, period of edentulousness, denture-wearing habits, and unfavorable loading patterns.[1] Wearing of dentures is one of the factors associated with degree of alveolar bone loss in an individual. The number of mandibular dentures worn is usually correlated with the number of years of a person's edentulousness and the severity of alveolar resorption.[2,3] Some studies have shown that persons wearing complete dentures (CD) day and night lose more alveolar bone than those wearing their dentures only during the day.[4,5] However, this finding was not confirmed in other studies.[2,6]

Alveolar bone loss in the edentulous jaw is a continuous process that may proceed throughout the lifetime of the denture wearer.[4,5,7–9] According to several cross-sectional studies, patients with a long period of edentulousness lose a greater amount of mandibular alveolar bone than do patients with a short period of edentulousness.[2,3,10] Overload compression of edentulous alveolar ridges may also accelerate local bone loss in the jaws.[11] For example, if there are no other teeth in the mouth except the mandibular incisors, the bite forces directed toward the front of the maxilla may, through the maxillary denture, lead to additional bone loss in that area.[7,12]

[a]*Senior Assistant, Department of Prosthodontics, School of Dental Medicine, University of Zagreb, Croatia.*
[b]*Professor, Department of Prosthodontics, School of Dental Medicine, University of Zagreb, Croatia.*

***Reprint requests:*** *Dr Dubravka Knezović-Zlatarić, Department of Prosthodontics, School of Dental Medicine, University of Zagreb, Gundulićeva 5, 10000 Zagreb, Croatia. Fax: + 38514802159. e-mail: dkz@email.hinet.hr*

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In the case of CDs in both jaws, the average pressure per unit area in the mandible is about twice as high as in the maxilla because of the smaller area of contact with the underlying tissues.[13] Perhaps because of the thin cortical and thick trabecular bone mass in the maxilla, the mean rate of residual ridge resorption is 3 or 4 times faster in the mandible than in the maxilla.[7,9,14] Many longitudinal studies performed on lateral cephalometric radiographs reveal that residual ridge resorption is approximately 1 mm per year in CD wearers, with consequent decrease in facial vertical relation and counterclockwise rotation of the mandible.[15–17]

Follow-up studies of the bone mineral density (BMD) changes are not well-documented. It was therefore the aim of this study to observe if there are any significant changes in BMD of the mandible in CD as well as in removable partial denture (RPD) wearers over a 6-month period of wearing new dentures, and to assess if possible changes are related to gender and age of the patient. The hypothesis was that the decrease of BMD values would be greater under the CD saddles compared to RPD saddles.

## Materials and Methods

### *Participant Selection*

Twenty Kennedy Class I RPD wearers (5 men, 15 women) and 20 CD wearers (7 men, 13 women) participated. In both groups, all patients were wearing CDs in the maxilla. In the group of RPD wearers, all patients had teeth remaining anterior to and including canines and/or first premolars in the mandible (six to eight remaining teeth). Thirteen patients were wearing tooth- and mucosa-supported RPDs with indirect retainers placed on the mandibular first premolar abutment teeth. The rest of the RPD wearers were wearing lingual plate mucosa-supported RPDs with buccal clasps.

Patients were randomly chosen from a group of CD and RPD wearers at the Department of Prosthodontics, School of Dental Medicine, University of Zagreb, Croatia, who had undergone a dental panoramic radiograph examination as part of preprosthetic treatment. All patients were screened for the need of diagnoses and future prosthodontic treatment planning by dental panoramic radiograph prior to the treatment. The ethics committee of the dental school approved this study. Voluntary written informed consent was obtained from each patient.

There were 12 male patients (mean age 72.7 years, range 56 to 84 years) and 28 female patients (mean age 69.7 years, range 52 to 86 years) in the examined groups. All patients were grouped into two age groups (1 = $<$ 70 years; 2 = $\geqslant$ 70 years). Eighteen CD wearers and 15 RPD wearers (83%) received a replacement (second) pair of dentures, and their occlusal vertical dimension was raised by 2 to 5 mm compared to their original dentures. Seven patients received their first dentures.

### *Radiographic Examination*

Panoramic radiographs were performed with a constant current of 16 mA, exposure time of 16 seconds; the voltage varied between 65 and 78 kV (Siemens). All films were processed in an automatic dark-chamber processor (XR 24 Nova, Dürr Dental) for 12 minutes.

### *BMD Assessment*

During the exposure, a copper stepwedge was attached to the bottom of a film cassette (not to cover any bone structure) to provide a reference image on the radiographs. The stepwedge was composed of five steps of thicknesses from 0.1 to 0.5 mm, and it was made by the authors in cooperation with the Institute for Physics, Zagreb. Panoramic radiographs were digitized using a Lynotype-Hell scanner (Saphir model No. TA-3). Before the measurement of gray levels, black and white colors of the images were inverted.

BMD was measured on the first panoramic radiograph (prior to denture delivery) and then again 6 months later on the second radiograph of each patient (after 6 months of denture wearing). The mean gray levels were measured (using Scion image, Beta 4.0.2, probe dimension 4 $\times$ 4 pixels) on each of the steps on the copper stepwedge and on the different regions of interest, representing the regions of the cortical bone alone at the inferior border of the mandible (BMD sites 5 and 10), as well as the cortical and trabecular bone together at the other sites on the mandibular image (BMD sites 1 to 4 and 6 to 9) (Fig 1). The mean gray levels were also measured on the angle of the mandible, 2 mm above the gonion, representing the BMD of the cortical bone alone (BMD site 11). In addition, superimpositions of the chin rest, airway, and bony shadows were avoided during the measurement.

The measurement was performed bilaterally on the mandible. All measured gray levels were first expressed in optical densities.[18–20] Optical density values of the copper stepwedge were corrected by subtracting the optical densities of the immediately adjacent soft tissue image (below the inferior border of the copper stepwedge). Then, optical density values of each of the steps on the stepwedge were plotted against the related thickness of the step of the copper stepwedge to express all optical density values of

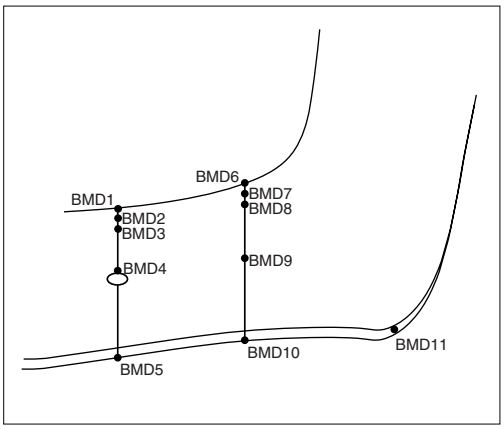


**Fig 1** Measured regions of interest on the left side of the mandible: in mental foramen projection (*bone mineral density [BMD] sites 1 to 3* = upper border of mandible; *BMD site 4* = upper border of mental foramen; *BMD site 5* = lower border of mandible), in distal projection, in front of the anterior border of the ascending ramus (*BMD sites 6 to 8* = upper border of mandible; *BMD site 9* = upper border of mental foramen; *BMD site 10* = lower border of mandible), and 1 mm above the gonion *(BMD site 11).*

the stepwedge in the equivalents of the actual stepwedge thickness, using the third-degree polynomial. Optical densities of the measured regions of interest were finally expressed in copper stepwedge thickness equivalents[18–20] using a computer program (DenEx 2001) designed by the authors.

### *Observer Training*

Two observers already experienced in BMD measurement and two general dental practitioners measured BMDs on all panoramic radiographs, and the measurement was repeated after a 1-week interval. Those with no previous experience of BMD measurement were given preliminary instruction via written description. No significant difference was noted between the first and second measurements ($P = .80$ for the general practitioners, $P = .89$ for the experienced observers; paired *t* test). The weighted kappa statistics showed satisfactory agreement between the experienced observers ($\kappa = .89$; confidence interval 0.78 to 0.93). Since the reliability of the measurements and agreement were satisfactory, the assessment of the most consistent experienced observer was considered for statistical analysis.

### *Statistical Analysis*

The data were analyzed with the SPSS 10.0 statistical package (SPSS). A paired sample *t* test was conducted for the comparison between the first (prior to denture delivery) and second BMD measurements (after the 6-month period of denture wearing) for each of the regions of interest on the mandible, separately for CD and RPD wearers.

Changes in BMD values within 6 months of wearing dentures (differences between the first and second measurements) were compared between different age, gender, and type of denture by one-way analysis of variance (ANOVA). The distribution of the BMD measurements of all measured regions of interest in this study was normal (one-way Kolmogorov-Smirnov test) for the examined population, so parametric tests were used. All measurements were made bilaterally on the mandibular panoramic radiographs in each patient. There was no significant difference between measurements on the left and right sides of the mandible ($P > .05$). Therefore, the mean of the two sides in each patient was used in all further statistical analyses.

## Results

At baseline (first examination), the BMD values of the examined regions of interest in the upper part of the mandible (residual ridge region, BMD sites 1 to 3 and 6 to 8) varied between 0.27 and 0.50 mm (standard deviation [SD] 0.06 to 0.21) in both CD and RPD wearers (Table 1). The highest values were obtained in the distal end of the ridge, BMD sites 6 to 8 (0.4 to 0.5 mm, SD 0.1), in both CD and RPD wearers.

There were minor changes in BMD between the two examinations: a decrease in the CD group (3% to 11%) and an increase in the RPD group (13% to 34%) in those regions under the denture saddles (BMD sites 1 to 3 and 6 to 8). However, there were no significant differences between the two measurements in either group ($P > .05$).

The only significant changes during the 6-month period were observed at the gonion region (BMD site 11) in both CD and RPD wearers. The BMD values 2 mm above the gonion increased significantly in both examined groups, by 20% in CD wearers and 21% in RPD wearers ($P < .05$). There was no statistically significant influence of gender or age on BMD changes during the 6 months of wearing the removable dentures in either CD or RPD wearers ($P > .05$).

## Discussion

Initiation of residual ridge resorption is always preceded by loss of teeth, together with their periodontal

**Table 1** Means and Standard Deviations (SD) of Bone Mineral Density (BMD), and Differences Between First and Second Measurements in Complete Denture (CD) and Removable Partial Denture (RPD) Wearers at the 11 Sites

| BMD site† | CD, measurement 1 | | CD, change from 1 to 2 | | RPD, measurement 1 | | RPD, change from 1 to 2 | |
|---|---|---|---|---|---|---|---|---|
| | Mean | SD | Mean | SD | Mean | SD | Mean | SD |
| 1 | 0.32 | 0.18 | 0.03 | 0.04 | 0.27 | 0.16 | –0.08 | 0.03 |
| 2 | 0.35 | 0.18 | 0.01 | 0.07 | 0.29 | 0.18 | –0.07 | 0.03 |
| 3 | 0.35 | 0.18 | 0.04 | 0.01 | 0.29 | 0.16 | –0.10 | 0.05 |
| 4 | 0.32 | 0.15 | 0.03 | 0.05 | 0.30 | 0.13 | –0.06 | 0.02 |
| 5 | 0.30 | 0.19 | 0.00 | 0.10 | 0.25 | 0.11 | –0.05 | 0.00 |
| 6 | 0.43 | 0.21 | 0.03 | 0.07 | 0.40 | 0.15 | –0.10 | 0.07 |
| 7 | 0.47 | 0.21 | 0.03 | 0.11 | 0.40 | 0.15 | –0.09 | 0.05 |
| 8 | 0.47 | 0.16 | 0.04 | 0.05 | 0.43 | 0.13 | –0.06 | 0.05 |
| 9 | 0.39 | 0.10 | 0.02 | 0.02 | 0.39 | 0.14 | –0.01 | 0.05 |
| 10 | 0.31 | 0.14 | 0.04 | 0.04 | 0.27 | 0.09 | –0.04 | 0.03 |
| 11 | 0.29 | 0.06 | –0.06* | 0.01 | 0.32 | 0.06 | –0.07* | 0.01 |

*$P < .05$.
†See Fig 1 for site definitions.

ligaments, which have the ability to form bone.[21,22] Factors often used in correlation analysis with residual ridge resorption are gender; age; facial structure; duration of edentulousness; denture-wearing habits; number of dentures worn; oral hygiene; oral parafunctions; occlusal loading; denture quality; nutrition; general health; and osteoporosis, its treatment, and therapy.[23] Previous studies on residual ridge resorption in CD wearers revealed significant alveolar ridge bone loss of approximately 1 mm per year; however, resorption is more pronounced during the first few years after teeth loss.[7,15–17,24–28]

We found only a slight, nonsignificant decrease of BMD values under the base of CDs over a 6-month period (BMD sites 1 to 3 and 6 to 8), which is in accordance with those findings revealing residual ridge resorption in CD wearers.[7,15–17,24–28] Probably, a longer period of observation is necessary for BMD value decreases to reach a statistically significant level. Eighty percent of our patients had been edentulous for more than 5 years (their second pair of dentures), and it is known that the rate of residual ridge resorption is more rapid immediately after tooth extraction than in later periods.[5,6,8,9] The slight, nonsignificant increase of BMD values in RPD wearers registered in this study is not in agreement with the results of another study.[29] However, it is known from the literature that the rate of residual ridge resorption is slower if some teeth or implants are present in the mandible.[1,17,30,31]

Our RPD group consisted of 65% patients wearing dentures with indirect retainers and occlusal rests, so occlusal forces were not transmitted only to the edentulous parts of the mandible, but also to the remaining teeth in the jaw, reducing the stress on the denture-underlying tissues; this is in contrast to CD wearers, who might have overload compression of edentulous alveolar ridges. In addition, our RPD group had a CD in the maxilla, so we assumed that occlusal forces were lower than in cases of natural teeth in the maxilla.

The slight increase of BMD values in RPD patients registered in our study is in accordance with some previous studies.[32,33] The increase of BMD values in the gonion region during a 6-month period of denture wearing (BMD site 11) in both CD and RPD wearers may be attributed to the increased load of the strain forces of the masseter muscle, probably because of the increase of vertical relation, as well as the beginning of chewing activity in the patients with their first-ever dentures. CD or RPD use may change the extent of strain forces in place of masticatory muscle attachment to the bone, thus affecting BMD values.

The majority of the reports state that women have more advanced bone loss than men,[34–36] but some have not found such a difference.[37] In the present study, no significant difference in BMD changes between women and men was found, which could be attributed to the individual variation in the rate of the bone loss, age, and body mass index.

After the age of 40, the BMD of the skeleton decreases; by the age of 65, approximately one third of the bone minerals have been lost.[38] The reason we did not find significant differences in BMD between different age groups of patients probably lies in patient selection (typical range of elderly female and male patients with the need for prosthetic treatment).

According to the results of this study, it seems that denture wearing plays a role in BMD changes in the residual alveolar ridge region. Denture use and/or increase of occlusal vertical relation increase masseter strain forces above the gonion, resulting in significant increase of BMD values.

## Conclusions

1. No significant differences were found between BMD values during a 6-month period of wearing dentures ($P > .05$) in CD and RPD wearers, although BMD values slightly decreased under the saddles in CD wearers and slightly increased in RPD wearers.
2. Significant increase of BMD values was registered 2 mm above the gonion in both CD and RPD wearers ($P < .05$) and was ascribed to increased masseter strain forces.
3. In this sample, age and gender were not related to the BMD changes over a 6-month period.

## References


1. Sennerby L, Carlsson GE, Bergman B, Warfvinge J. Mandibular bone resorption in patients treated with tissue-integrated prostheses in complete-denture wearers. Acta Odontol Scand 1988;46: 135–140.
2. Kalk W, de Baat C. Some factors connected with alveolar bone resorption. J Dent 1989;17:162–165.
3. de Baat C, Kalk W, van't Hof MA. Factors connected with alveolar bone resorption among institutionalised elderly people. Community Dent Oral Epidemiol 1993;21:317–320.
4. Carlsson GE, Persson G. Morphologic changes of the mandible after extraction and wearing of dentures. A longitudinal, clinical, and x-ray cephalometric study covering 5 years. Odontol Revy 1967;18:27–54.
5. Carlsson GE, Bergman B, Hedegard B. Changes in contour of the maxillary alveolar process under immediate dentures. A longitudinal clinical and x-ray cephalometric study covering 5 years. Acta Odontol Scand 1967;25:45–75.
6. Bergman B, Carlsson GE, Ericson S. Effect of differences in habitual use of complete dentures on underlying tissues. Scand J Dent Res 1971;79:449–460.
7. Atwood DA, Coy WA. Clinical, cephalometric, and densitometric study of reduction of residual ridges. J Prosthet Dent 1971;26: 280–295.
8. Tallgren A. Alveolar bone loss in denture wearers as related to facial morphology. Acta Odontol Scand 1970;28:251–270.
9. Tallgren A. The continuing reduction of the residual alveolar ridges in complete denture wearers: A mixed-longitudinal study covering 25 years. J Prosthet Dent 1972;27:120–132.
10. Bairam LR, Miller WA. Mandibular bone resorption as determined from panoramic radiographs in edentulous male individuals aged 25–80 years. Gerodontology 1994;11:80–85.
11. Klemetti E, Vainio P. Effect of maxillary edentulousness on mandibular residual ridges. Scand J Dent Res 1994;102:309–312.
12. Kelly E. Changes caused by a mandibular removable partial denture opposing a maxillary complete denture. J Prosthet Dent 1972; 27:140–150.
13. Woelfel JB, Winter CM, Igarashi T. Five year cephalometric study of mandibular ridge resorption with different posterior occlusal forms. J Prosthet Dent 1971;36:602–606.
14. Mercier P, Lafontant R. Residual alveolar ridge atrophy: Classification and influence of facial morphology. J Prosthet Dent 1979; 41:90–100.
15. Tallgren A. Changes in adult face height due to aging, wear and loss of teeth and prosthetic treatment: A roentgen cephalometric study mainly on Finnish women. Acta Odontol Scand 1957;15: 24–31.
16. Tallgren A. The reduction in face height of edentulous and partially edentulous subjects during long-term denture wear. A longitudinal roentgenographic cephalometric study. Acta Odontol Scand 1966;24:195–239.
17. Tallgren A. The effects of denture wearing on facial morphology. A 7-year longitudinal study. Acta Odontol Scand 1967;25: 563–575.
18. Krhen J, Knezović Zlatarić D, Kobler P, Čelebić A, Milat O, Džubur A. Intraoral computer-assisted microdensitometric study. Acta Stomatol Croat 2001;35:339–352.
19. Knezović Zlatarić D, Čelebić A, Milat O. Bone densitometric study in mandibular density using dental panoramic radiographs. Acta Stomatol Croat 2002;36:29–37.
20. Knezović Zlatarić D, Čelebić A, Kobler P. Relationship between body mass index and local quality of mandibular bone structure in elderly individuals. J Gerontol A Biol Sci Med Sci 2002;57: M588–M593.
21. Klemetti E. A review of residual ridge resorption and bone density. J Prosthet Dent 1996;75:512–514.
22. Miles AE. Sans teeth: Changes in oral tissues with advancing age. Proc R Soc Med 1972;65:801–806.
23. Carlsson GE. Clinical morbidity and sequelae of treatment with complete dentures. J Prosthet Dent 1998;79:17–23.
24. Campbell RL. A comparative study of the resorption of the alveolar ridges in denture wearers and non-denture wearers. J Am Dent Assoc 1960;60:143–153.
25. Atwood DA. Some clinical factors related to rate of resorption of residual ridges. J Prosthet Dent 1962;12:441–450.
26. Woelfel JB, Winter CH, Igarashi T. Five year cephalometric study of mandibular ridge resorption with different posterior occlusal forms. Denture constructions and initial comparison. J Prosthet Dent 1976;36:602–623.
27. Devlin H, Ferguson MWJ. Alveolar ridge resorption and mandibular atrophy. A review of the role of local and systemic factors. Br Dent J 1991;170:101–104.
28. Carlsson GE, Persson G. Morphologic changes of the mandible after extraction and wearing of dentures. J Prosthet Dent 1967;18:27–32.
29. Adams LP, Wilding RJC. A photogrammetric method for monitoring changes in the residual alveolar ridge form. J Oral Rehabil 1985;12:443–450.
30. Uctasli S, Hasanreisoglu U, Iseri H. Cephalometric evaluation of maxillary complete, mandibular fixed-removable partial prothesis: A 5-year longitudinal study. J Oral Rehabil 1997;24:164–169.
31. Crum RJ, Rooney GE. Alveolar bone loss in overdentures: A five-year study. J Prosthet Dent 1978;40:610–617.
32. von Wowern N, Gotfredsen K. Implant-supported overdentures, a prevention of bone loss in edentulous mandibles? A 5-year follow-up study. Clin Oral Implants Res 2001;12:19–25.
33. von Wowern N. In vivo measurements of bone mineral content of mandibles by dual-photon absorptiometry. Scand J Dent Res 1985;93:162–168.
34. Xie Q, Ainamo A, Tilvis R. Association of residual ridge resorption with systemic factors in home-living elderly subjects. Acta Odontol Scand 1997;55:299–305.
35. Xie Q, Wolf J, Tilvis R, Ainamo A. Resorption of mandibular canal wall in the edentulous aged population. J Prosthet Dent 1997;77:596–600.
36. Xie Q, Narhi TO, Nevalainen JM, Wolf J, Ainamo A. Oral status and prosthetic factors related to residual ridge resorption in elderly subjects. Acta Odontol Scand 1997;55:306–313.
37. Carlsson GE, Haraldson T. Fundamental aspects of mandibular atrophy. In: Worthington P, Brånemark P-I (eds). Advanced Osseointegration Surgery. Applications in the Maxillofacial Region. Chicago: Quintessence, 1992:109–118.
38. Gordan GS, Genant HK. The aging skeleton. Clin Geriatr Med 1985;1:95–118.