Osteoporosis effect on posterior mandible in preimplanted area for postmenopausal females using cone-beam computed tomography

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Abstract:
Background: Hormonal changes in women affect bone mineral density, especially during and postmenopausal years, which leads to susceptibility to osteoporosis which interfere with implantation. Aims: This study aims to use cone-beam computed tomography (CBCT) viewer program to predict patients with osteoporosis which may decrease the success rate of implantation and to evaluate osteoporosis effect on the posterior mandible. Settings and Design: This cross-sectional study consists of 60 Iraqi females who were divided into three groups: Group 1 consisted of 20 nonosteoporotic females aged 20–30 years as a control group, Group 2 consisted of 20 nonosteoporotic females aged 50 years and above, and Group 3 consisted of 20 osteoporotic females aged 50 years and above. Materials and Methods: The posterior mandibular first molar area was examined for alveolar bone height and radiographic density (RD) using CBCT. Statistical Analysis Used: Statistical analysis was computer assisted using the Statistical Package for the Social Sciences (SPSS version 21). Interclass correlation coefficient was used for calibration. Normally distributed variables were assessed using one-way ANOVA, and Dunnett test with control and not normally distributed were assessed by Kruskal–Wallis test, and multiple Mann–Whitney U-test with Bonferroni adjustment. Results: RD showed a significant difference between Group 2 and Group 3 (P = 0.000, MD = 158.554). On the other hand, alveolar bone height showed a significant difference between Group 1 and Group 2 (P = 0.039). Conclusions: RD in the posterior mandible first molar area is significantly affected in osteoporotic patients and it can be used as a predictor for the presence of osteoporosis using CBCT.

Key words: Alveolar bone height, cone-beam computed tomography, radiographic density, osteoporosis

INTRODUCTION
Osteoporosis is a metabolic bone disease that affects the whole skeleton; it is recognized for low bone density and degeneration of microarchitecture of bones and increased fracture rate.[]

The diagnosis of osteoporosis is done by dual-energy X-ray absorptiometry (DEXA) which measures bone mineral density (BMD) level.[]

The success of dental implant largely depends on the amount of local bone and its condition.[]

Alveolar bone may be affected by osteoporosis which may interpose various types of dental work particularly dental implantation.[]

The cone-beam computed tomography (CBCT) viewer program gives multiple tools to ensure the capability of proper analysis and the studying of the obtained three-dimensional (3D) image.[]

Implantologists often refer patients for a CBCT imaging so that they can make a proper treatment plan to improve the success rate of implantation; this study evaluated those patients for the presence of osteoporosis and its effect on the posterior mandibular area, trying to obtain an adjunctive way to predict osteoporotic patients.

MATERIALS AND METHODS
This study was cross sectional, and the sample consisted of 60 Iraqi females who had been...
referred for CBCT scan, from December, 2016, to May, 2017, especially those who needed dental implantation at the mandibular posterior first molar area. Each patient was asked to have a BMD evaluation by DEXA scan, and then, the sample was divided into three groups according to their age and osteoporotic status: Group 1 composed of 20 nonosteoporotic females aged 20–30 years as control group, Group 2 composed of 20 postmenopausal nonosteoporotic females aged 50 years and above, and Group 3 composed of 20 postmenopausal osteoporotic females aged 50 years and above.

The procedure followed was in accordance with the ethical standards conducted in the Helsinki Declaration of 1975, as revised in 2000. All patients who participated in this study were volunteers and they were well informed about it, free to withdraw at any time they want, and then get their approval by signing in a special consent form prepared for each patient.

Exclusion criteria included the patients suffering from other diseases that affect bone metabolism, smokers and alcoholics, pregnancy, acute traumatic injury to the mandible, cancers with bone metastasis or renal impairment, patients on specific medication that affects bone metabolism, patients with no extraction at lower posterior area, or those with new extraction (<1-year extraction duration).

DEXA measurements of T-score in the lumbar spine was done by DEXA scanner (Stratos_anglais_03, DMS, France), which uses a pencil-beam scanning method with microemission of X-ray (no need for radiation-blocking room), with scan time “90 s.” It withstands patient’s weight up to “150 kg,” connected to a computer system for image viewing and manipulation (LCD monitor, type LG, Korea).

CBCT machine gives a 3D image of the skull, and the CBCT machine used in the study was cone-beam 3D system (Kodak 9500, Care Stream, France), the production year 2012.

Large mode was used “field of view (18 cm × 20.6 cm)” region of interest: from the bottom of the chin to the top of the sinus (full skull), “the tube current, voltage, exposure time, and voxel size were 10 mA, 90 kV, 10.08 s, and 300, respectively;” the viewer software (Carestream 3D imaging developed by the same CBCT manufacturer) was used to analyze the CBCT images.

A computer unit (type LG, Korea) window (XP, Microsoft, USA) was used as an operating system to study and analyze the CBCT scans.

After the exposure, the image presented on the screen as secondary reconstructed images in three orthogonal planes (axial, sagittal, and coronal), with the 3D image 3D, then curved slicing option was selected, then the coronal view was selected and manually created an arch (arch reconstruction), then it was selected and an arch line was drawn to reconstruct the orthopantomogram layout to be used for measurements, and the pathway of the inferior alveolar canal was located and drawn [Figure 1]; the sagittal view was selected for the selected sites, a line was drawn from top to one millimeter just above the inferior alveolar canal to represent the future implant site excluding the cortex, this line was measured, and this line represented the alveolar bone height [Figure 2].

After the alveolar bone height line was drawn, three points were selected on this line at top, middle, and bottom and the radiographic density (RD) was recorded, and then, the mean for these three points was calculated to represent the mean RD for the selected area [Figure 3].

**Statistical analysis**

Data were translated into computerized database structure. Statistical analysis was computer assisted using the Statistical Package for Social Sciences (SPSS version 21, IBM., Chicago, USA).

Interclass correlation coefficient was used to evaluate the inter- and intra-examiner calibration.

Frequency distribution for selected variables was done first using Shapiro–Wilk test; RD of the posterior mandible and T-score of DEXA scan were normally distributed.
These variables were described using one-way ANOVA test to assess the mean and standard deviation (SD).

Further exploration of statistical significance of means of normally distributed variables among the three groups was assessed by Dunnett test with control which is a multiple comparison test of groups with control (two-sided).

Age and alveolar bone height measurement were not normally distributed, so they were best described by Kruskal–Wallis test to describe the mean, SD, median, and mean rank.

Further exploration of statistical significance was best done by multiple Mann–Whitney U-test with Bonferroni adjustment. Statistical significance level was set at “P < 0.05.”

**RESULTS**

According to DEXA values and age, the study sample was divided into three groups to determine whether the variable is affected by age or by osteoporosis or both.

Table 1 shows that RD was significantly different among groups (P<0.05). Intergroup comparison using multiple comparisons of Dunnett test with control indicated that Group 1 and Group 2 did not differ significantly, while Group 2 was significantly higher than Group 3, “P<0.05,” with difference in means (158.554).

The results for alveolar bone height illustrated in Table 2 show that there was highly significant difference between groups “P<0.05.” Intergroup comparisons using multiple Mann–Whitney U-test with Bonferroni adjustment illustrated that Group 1 has higher mean rank than Group 2 with significant difference “P<0.05,” while Group 2 had higher mean rank than Group 3, but it was not significantly different “P>0.05.” Inter and intra-examiner calibration readings showed no statistical difference. “P>0.05” as illustrated in [Tables 3 and 4].

**DISCUSSION**

The current study shows that the RD of trabecular bone in the posterior mandibular first molar edentulous area using gray value of the CBCT is not significantly different with age although its mean for the first group was higher than the mean for the second group.

Kingsmill and Boyde measured the apparent density of mandibular slices taken from postmortem specimen or samples taken after orthognathic surgeries, and density was measured by dividing slice weight per slice volume. They stated that mandibular bone undergoes increase in apparent density with increasing age,[9] which could not be approved by the present study as RD was not statistically significant with age.

Cerroni et al. stated that bone mineral content increases with increasing age, but it decreases in later stages of aging.[10]

On the other hand, cortical bone was reported in several studies to be more fragile and more delicate with increasing age.[10–12]

The same can be said about trabecular bone that it gets weaker with increasing age.[13] Moreover, the percentage of fractures increases about 10-folds in older age groups than younger age groups.[14,15] We could not reach to an approving or disapproving result as our result was statistically not significant between RD and age.

In this study, RD was strongly affected by the presence of osteoporosis, and it was decreased as the mean for the third group (osteoporotic females aged 50 years and above) was lower than the mean for the second group (nonosteoporotic females aged 50 years and above) with high significance.

This result agrees with Barngkgei et al.[7] who stated that RD measurement of the mandibular body using a CBCT viewer program can predict patients with osteoporosis with high accuracy and also agrees with Chai et al.[16] who concluded that Hounsfield unit value of CT of the mandibular site can detect and diagnose patients with osteoporosis.

**Table 1: Descriptive, statistical, and multiple comparisons of radiographic density among study groups**

| Statistics | Groups | ANOVA | Multiple comparisons |
|------------|--------|-------|----------------------|
|            | Group 1 | Group 2 | Group 3 | Sig | P | Group 1 | Group 2 | Group 3 |
| Minimum    | 284.00  | 238.330 | 42.300 | 0.000 (sig) | 0.637 (NS) | 0.000 (sig) |
| Maximum    | 500.00  | 526.300 | 466.000 | 380.418±63.264 | 359.579±85.227 | 201.025±94.220 |
| Mean±SD    | 380.418±63.264 | 359.579±85.227 | 201.025±94.220 | 0.000 (sig) | 0.637 (NS) | 0.000 (sig) |
| NS – Not significant at P>0.05; Sig – Significant at P<0.05; SD – Standard deviation; P – P-value |

**Table 2: Descriptive, statistical, and multiple comparison test of alveolar bone height among study groups**

| Statistics | Groups | Kruskal-Wallis test | Multiple comparisons |
|------------|--------|---------------------|----------------------|
|            | Group 1 | Group 2 | Group 3 | Sig | P | Group 1 | Group 2 | Group 3 |
| Minimum    | 8.900   | 8.000   | 5.000   | 0.001 (sig) | 0.039 (sig) | 0.506 (NS) |
| Maximum    | 18.500  | 17.000  | 16.300  | 14.760±2.746 | 12.640±2.805 | 11.470±2.940 |
| Mean±SD    | 14.760±2.746 | 12.640±2.805 | 11.470±2.940 | 0.001 (sig) | 0.039 (sig) | 0.506 (NS) |
| Median     | 15.650  | 12.950  | 11.850  | 14.760±2.746 | 12.640±2.805 | 11.470±2.940 |
| NS – Not significant at P>0.05; Sig – Significant at P<0.05; SD – Standard deviation; P – P-value |
Results from this study show that alveolar bone height is related to age where the old age, nonosteoporotic females showed a smaller alveolar bone level than the younger nonosteoporotic group who demonstrated larger alveolar bone level.

This is agreed by Schei et al. radiographic examination to evaluate alveolar bone, it was found that alveolar bone loss was related to age, and also they concluded that patients with good oral hygiene had less alveolar bone loss.[17]

Streckfus et al. had the same opinion when they stated the presence of a radiographical evidence of aging effect on alveolar bone loss with equal effect on the upper and lower arches and they also suggested a loss rate 0.38 mm of total alveolar bone each decade in the presence of good oral hygiene.[18]

Some shrinkage of gingiva, attachment loss, and alveolar bone loss must be assumed as a consequence of aging process just like wrinkling of skin and decreased joint flexibility are expected with aging.

The current results also came in consistent with Streckfus et al. and Albandar et al. studies who suggested fast bone loss from 30 to 50 years with regularization of bone loss rate after 60 years.[18,19]

Taking into account the BMD and presence of osteoporosis, our second group of nonosteoporotic females 50 years and above was compared to a third group of the same age range, but they were all osteoporotic, and the result could not relate alveolar bone loss to osteoporosis although the third group had a lower median and mean rank of alveolar bone level than the second group, but the difference was not statistically significant.

Our result agrees with von Wovern and Kollerup study which concluded that loss of teeth and extensive resorption take place in the maxillary arch but not the mandible as the resorption was not of significant value.[20]

Furthermore, our result is consistent with Klemetti and Vainio study where they measured the alveolar bone height and trabecular BMD of the mandible and the relation with lumber and femur BMD, and they concluded no significant correlation between them.[21]

On the other hand, some other studies gave the opposite conclusions; Kribbs et al. and Balikonyte et al. concluded that BMD directly affects the amount of resorption of alveolar bone when the density decreases the resorption increases, and also, they correlate skeletal BMD, jaw bone mineral density with alveolar bone level, and resorption with tooth loss.[22,23]

Kribbs et al. suggested that the density of the mandible is correlated to skeletal bone density and alveolar bone level is affected by them; the lower the bone density, the more the resorption of alveolar bone.[22]

In our study, we agree with the first part but not the second because alveolar BMD was significantly lower in osteoporotic postmenopausal females, but their alveolar bone height was not resorbed with a significant amount.

However, the resorption of alveolar bone is multifactorial, it is directly affected by oral hygiene and presence of teeth, it is affected by number of teeth extracted and is it single or multiple extractions, the length of time since the tooth was extracted, whether the patient is using a denture or not, and whether the denture is fixed or removable, all of that with the bone mineral state and age of patient should be taken into consideration.

Limitations, drawbacks, and shortcomings in this study were as follows:
1. Patients were divided into osteoporotic and nonosteoporotic only, and patients with osteopenia were considered as nonosteoporotic
2. Patients were not divided according to their dental condition: dentate, partially edentulous, or completely edentulous
3. The using of any kind of prosthesis was not included too
4. Small sample size can also be considered a shortcoming for this study.

These points may directly affect the results but at the same time need larger sample size and longer time for the study.

**CONCLUSIONS**

RD for the mandibular posterior area using gray value of CBCT can be used as a very good indicator for osteoporotic patients, whereas alveolar bone height measurement is not reliable for BMD condition, whereas it is more affected by aging factor.

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**Conflicts of interest**
There are no conflicts of interest.

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