ORIGINAL ARTICLE

Mandibular residual ridge height in relation to age, gender and duration of edentulism in a Saudi population: A clinical and radiographic study

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Abstract   *Purpose:* The purpose of this clinical and radiographic study was to evaluate the effect of age, gender and duration of edentulism on the amount of mandibular residual ridge resorption in a Saudi population.

Material and methods: Partially and completely edentulous Saudi patients (50 male and 64 female) attending the outpatient clinics at College of Dentistry, King Saud University, Riyadh, Saudi Arabia were included. Current age, gender of subjects and date of start of edentulism were recorded. Digital panoramic dental radiograph less than 1 year old of each patient was examined. The height of edentulous mandible was measured as described in the American College of Prosthodontists Prosthodontic Diagnostic Index (PDI) classification. Students t-test and ANOVA post hoc tests, Pearson's correlation coefficient (r) and chi square (χ^2) analysis were performed as indicated. Level of statistical significance was set at 0.05.

Results: Male patients showed a significantly greater mandibular bone height compared to female patients. Age and bone height were statistically significantly negatively correlated (p = 0.0001). However, age and mandibular bone height in only male patients was negatively correlated and reached statistical significance (p = 0.001) A negative correlation was observed between duration of edentulism and mandibular bone height in both genders, but was not statistically significant (p > 0.05).

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Conclusions: In a Saudi population, men have greater mandibular bone height than women and also exhibit a negative correlation between age and mandibular bone height that is statistically significant. In contrast, women exhibited a negative correlation between age and mandibular bone height, but was not statistically significant.

1. Introduction

Residual ridge resorption (RRR) describes changes of alveolar ridge as a result of tooth extractions. Its degree and rate may influence residual alveolar bone height. It is a chronic, progressive and irreversible condition (Kumar et al., 2016). It can cause physical, psychological and economic problems for individuals (Singh et al., 2016). Differences in the amount and rate of alveolar bone loss exist between individuals. The differences have been attributed to several factors, including age, gender, facial anatomy, metabolism, oral hygiene, parafunctions, general health, nutritional status, systematic illnesses, osteoporosis, medications and the amount of time the patient has been edentulous. Residual ridge resorption is considered a multifactorial disease that occurs as a result of anatomic, metabolic, prosthetic and functional factors (Atwood, 1962; Gupta et al., 2010). Anatomic factors are related to the amount and quality of bone (Gupta et al., 2010). Metabolic factors includes nutritional, hormonal other metabolic factors that influence the osteoblasts and osteoclasts activity. Among the hormonal factors, thyroid hormone affects the activity of osteoblasts and osteoclasts whereas the parathyroid hormone affects osteoclasts (Gupta et al., 2010). Therefore, hormonal factors contribute strongly to bone resorption.

Age is another important factor that influences the extent of bone resorption. Edentulism and osteoporosis are commonly observed in the elderly (Gupta et al., 2010). As age increases, there is an increase in the amount of resorption [Al-Jabrah and Al-Shumailan, 2014; Jagadeesh and Patil, 2013; Jayaram and Shenoy, 2017). In older age groups (over 60 years of age), the progression of mandibular resorption in relation to duration of edentulism was faster than in a younger age group (40 to 60 years) (Jayaram and Shenoy, 2017). Furthermore, gender plays an important role in RRR, where a greater bone resorption was reported in women than men (Al-Jabrah and Al-Shumailan, 2014; Liang et al., 2014). Among the nutritional factors, the degree of absorption of calcium, phosphorous and proteins influences the growth and maintenance of bone (Gupta et al., 2010). Specifically, vitamin B, C and D affect bone cell metabolism (Gupta et al., 2010).

A difference between the rate of mandibular alveolar resorption and resorption of the maxillary alveolar process has been reported. The degree of mandibular alveolar resorption is three or four times higher than alveolar resorption in the maxilla (Atwood, 1974).

In prosthetic rehabilitation, the success of treatment may be dependent on the size of remaining edentulous tissues both with regard to the denture bearing surface area as well as bone quantity for dental implant placement and it is important to understand the contour, ridge height, ridge morphology, proximity to crestal bone height of soft tissue and muscle attachments in order to predict the prognosis of a removable dental prosthesis with respect to retention, stability and support (Singh et al., 2016). In particular, available bone height for implant placement is scrutinized carefully prior to placement of implants in the mandibular inter-foramina region.

Ridge resorption may or may not occur in patients who do not wear dentures. López-Roldán et al. (2009) reported a decrease in bone loss in patients wearing mandibular overdentures. However, Al-Jabrah and Al-Shumailan (2014) reported a significantly increased mandibular bone resorption with increasing duration of complete denture wearing. Ozan et al. (2013) reported a higher vertical and horizontal alveolar bone resorption in patients wearing removable partial dentures when comparing the dentate and edentulous sites. It is important to understand the rate and amount of resorption to predict the prognosis of the removable prosthesis with respect to its retention, stability and support.

To date, there are no studies reporting on the effect of age, duration of edentulism and gender of Saudi patients on the mandibular bone height in an Arabic population of any kind. Given that conditions that may influence mandibular bone height may be different in an Arabic population than in populations from other parts of the world, the objective of this study was to clinically and radiographically evaluate the effect of age, gender and duration of edentulism on the amount of mandibular residual bone height in a Saudi population.

2. Material and methods

2.1. Ethical approval

The research was submitted to the Research Ethics Committee at King Saud University, Riyadh, and the Institutional Review Board (IRB) approval for the study was obtained.

2.2. Study population

The study included 114 partially and completely edentulous patients (50 male and 64 female) of Saudi origin who were attending the outpatient clinics at College of Dentistry, King Saud University, Riyadh, Saudi Arabia. The purpose of the study was explained to each patient. A written informed consent was signed by each patient, who agreed to participate in the research, before including him/her in this study.

2.3. Inclusion and exclusion criteria

The inclusion criteria were: Mandibular completely and partially edentulous cases. Partially edentulous subjects are those missing mandibular posterior teeth either unilaterally or bilaterally. The exclusion criteria for the patients were systemic diseases such as osteoporosis, other metabolic bone disease, or pituitary disease that could affect bone conditions, history of

bone transplantation, patients who have undergone prosthetic surgical procedures like sulcus deepening or ridge augmentation and patients with mandibular defects.

## 2.4. Clinical and radiographic examinations

Current age and gender of the patients, start of edentulism (start of loosening teeth) were recorded by interviewing each patient. The history and all relevant clinical data were also recorded. Clinical oral examination was performed to confirm the edentulous condition and that the patient was either partially or completely edentulous. The edentulous site location and extent was recorded. The digital panoramic dental radiograph (OPG) of each patient was then examined and was assigned an anonymous identification number. Only OPGs less than 1 year old were included. The lowest height of the edentulous mandible was measured by recording the distance between superior and inferior borders of mandible as described in the American College of Prosthodontics (ACP) classification (McGarry et al., 1999) (Fig. 1). Measurements of mandibular bone height were performed by two prosthodontists (examiners) using the same reference points required for obtaining the measurements as described by the ACP. Examiners were trained to measure mandibular bone height and reassessment of all radiographs was carried out to assure the intra-examiner reliability. To enhance inter-examiner reliability, measurements of some of the radiographs by one examiner were re-measured by the other one. Two readings were taken for the mandibular alveolar bone height on each OPG and the mean was calculated and recorded.

2.5. Statistical analysis

All data analysis was carried out using IBM SPSS version 23. The mean, standard deviation (SD) and standard error of the mean (SEM) were calculated for current age, gender, duration of edentulism and bone height. Male and female data were compared using Students t-test and ANOVA post hoc test. The significance of difference was assessed by p value. Pearson's correlation coefficient (r) was used to determine the extent and nature of correlation between the different parameters. Chi square (χ^2) analysis was performed using 2×2 or 2×3 contingency tables to test the difference between male and female data. Level of significance was set at 0.05.

3. Results

Table 1 presents means of current age, age at start of edentulism (start of loss of teeth) and mandibular bone height in both male and female patient groups. Comparable values of current age and age at start of edentulism of both genders were observed. However, they were not statistically significant (p = 0.50 and p = 0.701 respectively). All types of residual ridge bone height of Prosthodontic Diagnosis Index classification existed in both genders (13.1–34.2 mm in male and 14.4–28.7 mm in female patients) except Type IV. Male patients showed a significantly higher mandibular bone height measurements compared to the female patients (p = 0.0001). This means that there was a statistically significant increase of mandibular RRR that was reported more in female than in male patients.
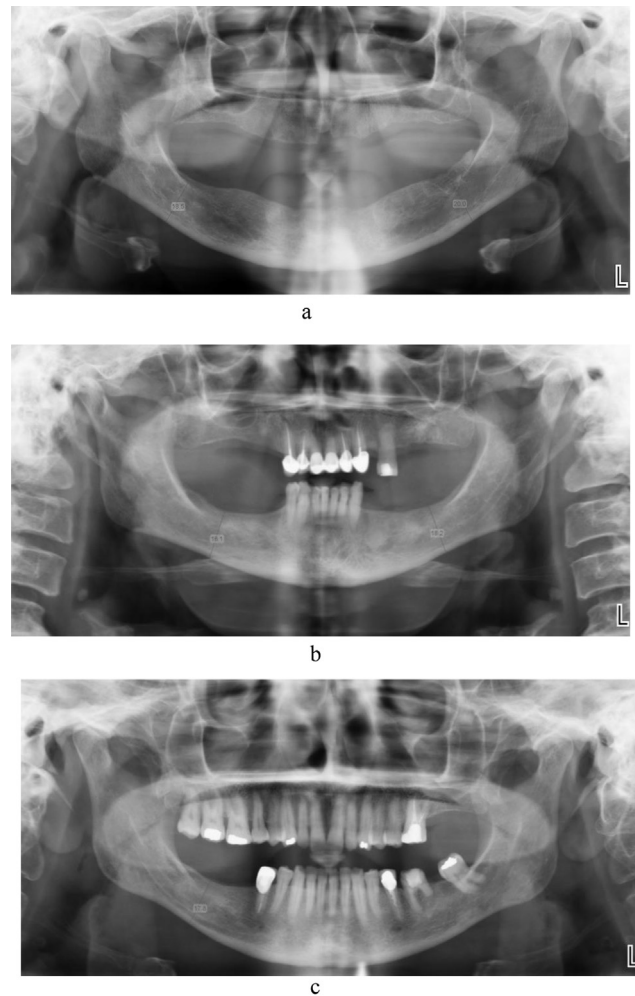
Fig. 1   Measurements of mandibular bone height as described by the American College of Prosthodontists (ACP) in a mandibular completely edentulous case (a), mandibular bilaterally edentulous case (b) and mandibular unilaterally edentulous case (c).

Fig. 2 presents the frequency distribution histogram of age of both genders. Almost 50% of males and female patients were in the age group of less than 50 years. In Fig. 3, more mandibular bone height was evident in male than female patients (24.57% and 21.62% respectively). Therefore, greater bone resorption was evident in female than male patients. Both male and female patients started edentulism (loss of teeth) at about 40 years of age (Fig. 4).

Table 2 presents results of assessment of site, type and area of edentulism of both genders. In general, most of male and female patients (54% and 54.68% respectively) showed bilateral than unilateral edentulism (37.5% and 36% respectively). Most of patients (91.23%) presented with partial edentulism that was little more in female (92.19%) than male (90%) patients. Most of patients (52.63%) had lost molar teeth; that was observed more in female (59.38%) than male (44%) patients. However, there were no statistically significant differences in site, type and area of edentulism between genders (p > 0.05).

Table 3 shows correlation of age and mandibular bone height in both genders. In general, age correlated negatively with bone height in both genders. This means that as age

Table 1 The current age, mandibular bone height and age at start of edentulism (start of loss of teeth) in both genders.

Variable	Sex	Mean	Median	SD	SEM	Percentile range	p-value
Current Age (years)	M	46.80	50.00	14.458	2.040	21.6–77.3	0.50
	F	48.67	49.50	11.836	1.480	25.8–71.9	
Age at Start of Edentulism (years)	M	39.63	42.00	15.54	2.212	12.8–69.2	0.701
	F	40.62	40.00	11.65	1.456	18.9–60.4	
Mandibular Bone Height (mm)	M	24.57	24.57	4.350	0.635	13.1–34.2	0.0001
	F	21.62	21.6	3.242	0.406	14.4–28.7	

M: Male; F: Female; SD: Standard Deviation; SEM: Standard Error of Mean.
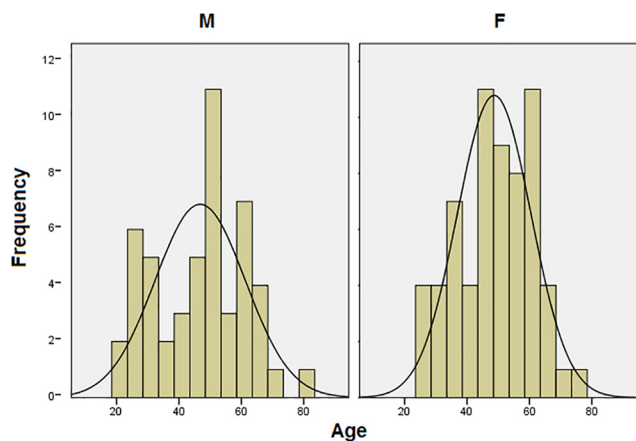
Fig. 2 Frequency distribution histogram of current age of both genders (M: Male; F: Female).
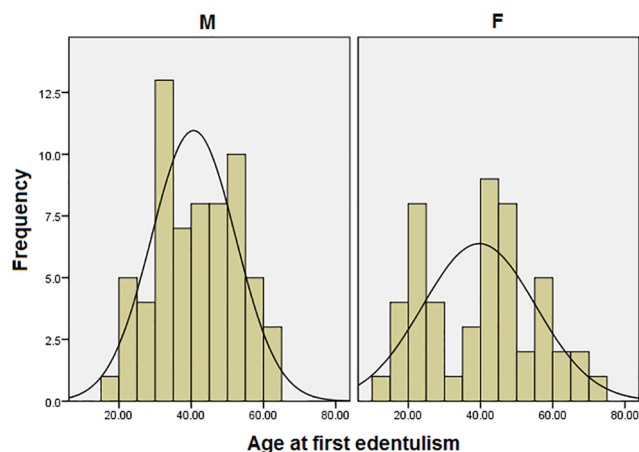
Fig. 4 Frequency distribution histogram of age at start of edentulism in both genders (M: Male; F: Female).
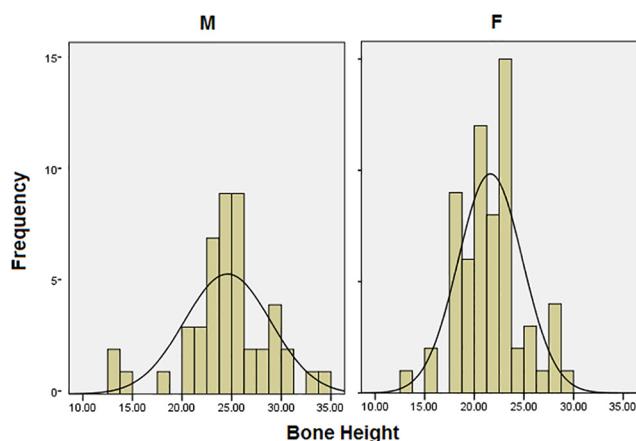
Fig. 3 Frequency distribution histogram of mandibular bone height of both genders (M: Male; F: Female).

increased, the bone height decreased (Fig. 5). This correlation was statistically significant (p = 0.0001). However, when the correlation between age and mandibular bone height was made for each gender, it was found to be negative and statistically significant only in male patients (p = 0.001).

Table 4 shows a negative correlation of duration of edentulism and mandibular bone height in both genders. As the duration of edentulism increased, the mandibular bone height decreased (Fig. 6). However, there were no statistical significant differences (p > 0.05).

4. Discussion

In this study, panoramic (OPG) radiographs were used to measure mandibular bone height because it is the most simple and widely used tool that provides information about resorption of the residual mandibular alveolar bone (Wilding, 1987). The mandibular bone height and ridge resorption may also be measured using Cephalometric roentgenograms, Dento-contourographs, measuring calipers or other tools (Jayaram and Shenoy, 2017). Several methods of classification have been described to assess mandibular bone height or resorption on panoramic radiographs such as those published by American College of Prosthodontics (ACP) (McGarry et al., 1999), Cawood and Howell (1988), Wical and Swoope (1974) and Xie et al. (1997). Anatomic landmarks used and rating criteria of these four classification methods are different. In Cawood's, ACP's and Wical's classifications, mandibular bone height was recorded using the data measured from the panoramic radiographs, while in Xie's classification, mandibular ridge resorption was evaluated by rating the resorption of mental foramen and the wall of the mandibular canal. Cawood & Howell used the midline anteriorly and the mental foramen posteriorly. In Wical and Swoope analysis method, resorption in the mandibular residual ridges was assessed by using the

Table 2 The site, type and area of edentulism in both genders.

Gender	Edentulism								
	Site			Type		Area			
	B Freq. (%)	U Freq. (%)	All Sites[*] Freq. (%)	C Freq. (%)	P Freq. (%)	M Freq. (%)	M & PM Freq. (%)	PM Freq. (%)	All Areas[*] Freq. (%)
Male	27 (54)	18 (36)	5 (10)	5 (10)	45 (90)	22 (44)	19 (38)	4 (8)	5 (10)
Female	35 (54.68)	24 (37.5)	5 (7.82)	5 (7.82)	59 (92.19)	38 (59.38)	21 (32.81)	0 (0.0)	5 (7.8)
Total Freq. (%)	62 (54.38)	42 (36.84)	10 (8.77)	10 (8.77)	104 (91.23)	60 (52.63)	40 (35.09)	4 (3.51)	10 (8.77)
χ^2	0.173 (df = 2)			0.168 (df = 2)		6.785 (df = 3)			
p-value	0.914			0.682		0.080			

B: Bilateral; U: Unilateral; C: Complete; P: Partial; M: Molar; P: Premolar.
[*] Completely edentulous patients where all sites and all areas have no teeth.

Table 3 Correlation of current age and mandibular bone height in both gender.

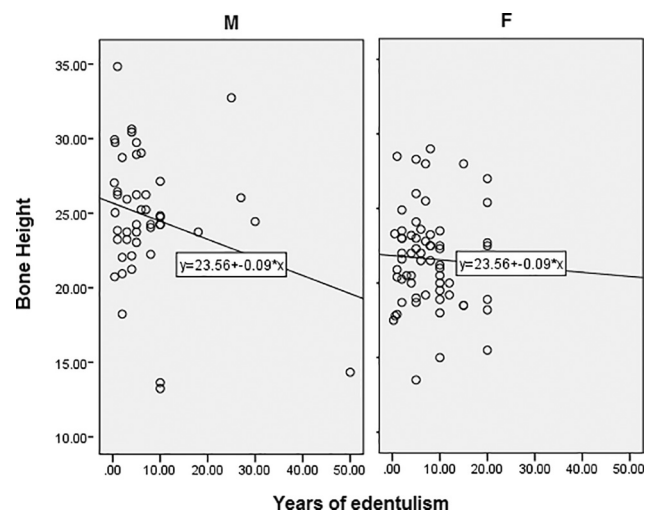| Gender		Correlation between current age and mandibular bone height
Male	r	−0.478
	p-value	0.001
Female	r	−0.167
	p-value	0.188
Total	r	−0.353
	p-value	0.0001

r: Correlation Coefficient.

Table 4 Correlation between duration of edentulism and mandibular bone height in both genders.

Gender		Correlation between duration of edentulism and mandibular Bone height
Males	r	−0.257
	p-value	0.085
Females	r	−0.53
	p-value	0.679
Total	r	−0.176
	p-value	0.066
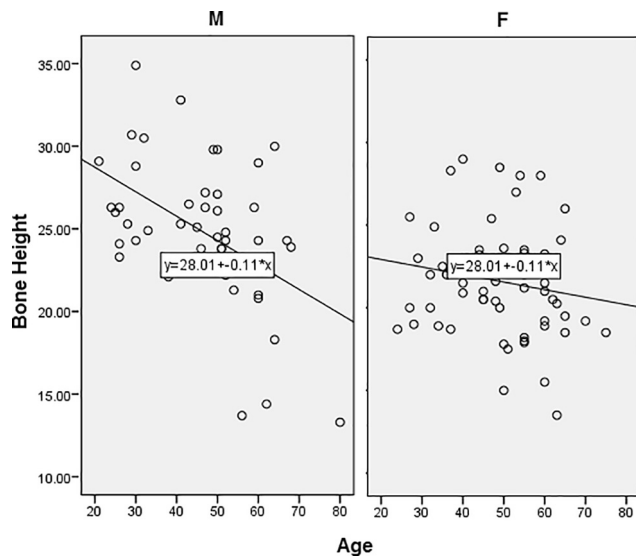
Fig. 5 Correlation between current age and mandibular bone height in both genders (M: Male; F: Female).

Fig. 6 Correlation between duration of edentulism and mandibular bone height in both genders (M: Male; F: Female).

mental foramen and the inferior border of the mandible, as they appear in digital panoramic radiographs (Wical and Swoope, 1974). The authors suggested that the amount of bone below the foramen is a predictable proportion of total bone height (1:3). Hence this height helps to estimate the original mandibular height in edentulous subjects (Wical and Swoope, 1974). Prosthodontic Diagnosis Index classification by the American College of Prosthodontists (ACP) is as follows: Type I: residual ridge bone height of 21 mm or greater; Type II: residual ridge bone height of 16 to 20 mm; Type III:

residual ridge bone height of 11 to 15 mm; and Type IV: residual ridge bone height of 10 mm or less (McGarry et al., 1999). All of those measurements were done at the least vertical height of the mandible. This method was selected to be used in our study. In our study, all types of residual ridge bone height were demonstrated except Type IV.

In the present study, as age increased, the mandibular bone height significantly decreased. This finding was expected as was reported by previous studies (Al-Jabrah and Al-Shumailan, 2014; Gupta et al., 2010; Jagadeesh and Patil, 2013; Jayaram and Shenoy, 2017).

In this study, most of patients showed bilateral than unilateral partial edentulism. Loss of molar teeth was more evident in female than male patients. However, there were no statistically significant differences in site, type and area of edentulism between genders.

In our study, there was a statistically significant decrease in mandibular bone height in female patients. Therefore, gender of patients involved in this study had a significant effect on the mandibular bone height. This finding is supported by other studies that reported a greater bone resorption in women than men (Al-Jabrah and Al-Shumailan, 2014; Liang et al., 2014). Vaishnav et al. (2010) also reported resorption of the wall of mandibular canal that was more in edentulous women than men due to hormonal reasons.

In our study, a negative correlation between age and mandibular bone height in both genders, but was found statistically significant in male patients. In our study, osteoporosis was excluded. Therefore, the mandibular RRR may be mainly due to the effect of menopause in older female patients.

In the present study, as the duration of edentulism increased, the mandibular bone height decreased. This is also supported by a previous study which reported an increase in mandibular RRR as the duration of edentulism increased (Al-Jabrah and Al-Shumailan, 2014). Another study reported an early reduction in mandibular bone height that was followed by a slower resorption as the duration of edentulism increased (Jayaram and Shenoy, 2017). In this study, a negative correlation between duration of edentulism and mandibular bone height was also evident in both genders, but was not statistically significant. As length of edentulism period in male patients increased, a constant reduction of mandibular height was reported (Jagadeesh and Patil, 2013). However, that study was limited only to men to eliminate variables associated with osteoporosis and menopause in women (Jagadeesh and Patil, 2013). In our study, systemic diseases such as osteoporosis, that may influence bone condition, were excluded. This was done because osteoporosis results in a decrease of the jawbone density and induces residual edentulous alveolar ridge reduction (Poštić et al., 2013). Resorption of the mandibular canal was reported more in patients with systemic diseases when compared with those without systemic diseases (Vaishnav et al., 2010).

Finding of our study were supported by previous studies which reported that the duration of edentulousness had most significant impact on resorption followed by age and then gender (Al-Jabrah and Al-Shumailan, 2014; Jayaram and Shenoy, 2017).

Since RRR increases with duration of edentulism, as evidenced in our study, every attempt should be made to preserve bone by either retaining natural teeth or root to the longest time possible, or by the fabrication of tooth supported over-denture or early implant placement for implant-supported overdentures instead of the conventional complete denture therapy. This attempt should be made specifically for female patients who were found to experience more mandibular reduced bone height than male patients that could be due to problems associated with osteoporosis and menopause. In completely edentulous cases, whether or not prolonged duration of wearing mandibular complete dentures results in an increased mandibular bone resorption is still controversial. Therefore, further studies are needed to evaluate the effect of all variables such as gender, age including pre- and post-menopausal stages of female patients, duration of partial and complete edentulism, and duration of wearing dentures on mandibular bone height.

5. Conclusions

Within the limitation of this study, the following conclusions were drawn:

1. There was a statistically significant decrease in mandibular bone height that was reported more in female than in male Saudi patients.
2. Both male and female Saudi patients started edentulism (loss of teeth) at about 40 years of age.
3. As duration of edentulism was increased, the mandibular bone height decreased.
4. A negative statistically significant correlation existed between age and mandibular bone height in Saudi male patients.
5. Future studies are needed to evaluate the effect of all variables such as gender, age including pre- and post-menopausal stages of female patients, duration of partial and complete edentulism, and duration of wearing dentures on mandibular bone height in Saudi population.

Conflict of interest

There is no conflict of interest.

Ethical statement

This research does not require ethical approval. I followed the Helsinki declaration.

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