

## Cone Beam Computed Tomography (CBCT) Evaluation of Bone Height and Width in Edentulous Mandible

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### Abstract

**Background:** Residual ridge resorption is a chronic, progressive, irreversible process, and poses a clinical challenge to finding the appropriate methods and treatments for edentulous patients. The aim of this study was to assess patients with an edentulous mandible with regards to the height and width dimensions in molar, premolar, and symphyseal regions using Cone Beam Computed Tomography (CBCT).

**Methods and Results:** A CBCT was performed on 60 patients, edentulous for more than 5 years. The height of residual bone was measured on 7 sites of the mandible, whereas the width of residual bone was measured on 5 sites. The highest mean value of residual bone height (BH) was measured in the symphyseal region, while the lowest value was measured in the right side molar region. The highest mean value of residual bone width (BW) was measured in the symphyseal region, while the lowest value was measured in the right side premolar region. Male patients had significantly higher residual bone in the mandible. The residual BW was insignificantly higher in males than in females, excluding the symphyseal region.

**Conclusion:** Analysis of the characteristics of BH and BW by CBCT enables a dentist to achieve a higher degree of accuracy during the implant placement and to select the appropriate implant design. (*International Journal of Biomedicine*. 2022;12(3):417-422.).

**Keywords:** residual ridge • mandible • edentulous • CBCT

**For citation:** Alidema SH, Bundevska J, Bimbashi V, Maja S, Dimoski G, Halili R. Cone Beam Computed Tomography (CBCT) Evaluation of Bone Height and Width in Edentulous Mandible. *International Journal of Biomedicine*. 2022;12(3):417-422. doi:10.21103/Article12(3)\_OA13

### Abbreviations

AC, alveolar crest; BH, bone height; BW, bone width; CBCT, Cone Beam Computed Tomography; FMR, the first molar region; MFR, mental foramen region; MC, mandibular canal.

### Introduction

The presence of teeth stimulates and maintains the form and density of bone through the periodontal ligaments, prompting the bone to remodel and rebuild continually. The loss of teeth leads to alveolar bone resorption and a decrease in the gum tissue, and can cause psychosocial, functional,

and phonetic problems.<sup>(1)</sup> Consequently, this often leads to a situation in which there is no longer sufficient support for performing the proper function of complete dentures, particularly on the mandible.<sup>(2)</sup>

Residual ridge resorption is a chronic, progressive, irreversible process, particularly for individuals with an edentulous mandible, and varies from one individual to

another at different phases of life and even in different parts of the jaw of the same person.<sup>(3,4)</sup> It is a continuous process after tooth extraction, and it is more noticeable in the first few months after extraction than later.<sup>(4-6)</sup>

Alveolar ridge resorption is one of the major factors that is involved in the rehabilitation of complete denture wearers, particularly in the mandible, by causing serious problems for both the patient and the dentist. Therefore, considering its complex nature, bone resorption poses a clinical challenge to finding methods and treatments for preventing and managing alveolar ridge resorption in edentulous patients. The success of treatment may be dependent on the size of remaining edentulous tissues with regard to the denture-bearing surface area, as well as BH and BW for dental implant placement.<sup>(7)</sup> The common complaints of patients with conventional dentures are pain and minimal masticatory efficiency.<sup>(8)</sup> Recently, implant-supported dentures have allowed many patients to improve quality of life, compared to complete dentures, including the ability to chew and speak, and greater satisfaction with their appearance.<sup>(9,10)</sup>

Resorption of the alveolar ridge has been estimated with various radiographic techniques, such as lateral cephalometric radiographs, panoramic radiographs, and CBCT.<sup>(9-16)</sup> Panoramic radiography is a common imaging technique in routine examinations in dentistry. Its primary disadvantage is image distortion, especially in the anterior region.<sup>(11)</sup> On the other hand, CBCT has the advantages of precise three-dimensional imagery, low radiation exposure, ease of use, and short scan time.<sup>(12)</sup> Residual ridge resorption was measured by different methods, of which the most commonly measured landmarks used were MF (inferior and upper border), molar region, premolar region, and mandibular symphysis since the residual ridge resorption is usually more rapid in the premolar and molar regions than in the anterior region of the mandible.<sup>(13,17,18)</sup>

The aim of this study was to analyze the height and width dimensional characteristics of the mandible using CBCT in fully edentulous patients who were edentulous for more than 5 years.

## Material and Methods

This study was conducted at Alma Mater Europaea Campus College "Rezonanca" (Pristina, Kosovo) with prior approval from the Ethical Committee (AD-3063/21, 18.06.2021) of this institution and enrolled 60 edentulous patients. Inclusion criteria were edentulous mandible for at least 5 years, and no health problems in terms of any disease that could affect bone metabolism, radiation, and immunosuppressive therapy. All patients were informed about the entire procedure, including the exposures to CBCT, and signed an agreement for inclusion as participants of the study. All CBCTs were performed by the same operator using the same imaging device, Orthophos SL 3D Fov11x10 CB/CT, Sirona Sidex 4 Galileos Implant Planning, Sicat Applications. The images were saved in DICOM format for further processing. BH measurements on the mandible were evaluated in 7 sites for each patient, whereas BW measurements on the mandible were assessed in 5 sites.

The following BH measurements were obtained:

-FMR right side (BH-A): a distance from the inferior border of the mandible to alveolar crest, 16 mm distal from mental foramen (Figure 1; Figure 2A).

-FMR left side (BH-A<sub>1</sub>): a distance from the inferior border of the mandible to alveolar crest, 16 mm distal from mental foramen (Figure 1; Figure 2A).

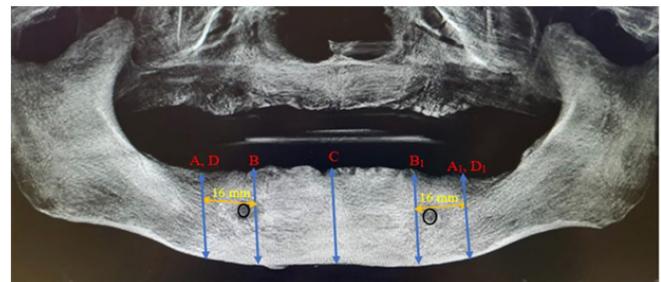
-FMR right side (BH-D): a distance from the upper border of mandibular canal to alveolar crest, 16 mm distal from mental foramen (Figure 1; Figure 2D).

-FMR left side (BH-D<sub>1</sub>): a distance from the upper border of mandibular canal to alveolar crest, 16 mm distal from mental foramen (Figure 1; Figure 2D).

-MFR right side (BH-B): a distance from the inferior border of the mandible to alveolar crest, 2 mm mesial from mental foramen (Figure 1; Figure 2B).

-MFR left side (BH-B<sub>1</sub>): a distance from the inferior border of the mandible to alveolar crest, 2 mm mesial from mental foramen (Figure 1; Figure 2B).

-Region of symphysis menti (BH-C): distance from lower border of the mandible to alveolar crest (Figure 1; Figure 2C).



**Fig.1.** Panoramic view of height measurements. Landmark A- molar region right side; landmark D - molar region right side (distance from upper border of MC to AC); landmark B - premolar region; landmark C- symphyseal region; landmark B1- premolar region left side; landmark A1- molar region left side; landmark D1- molar region left side (distance from upper border of MC to AC).

The following BW measurements were obtained:

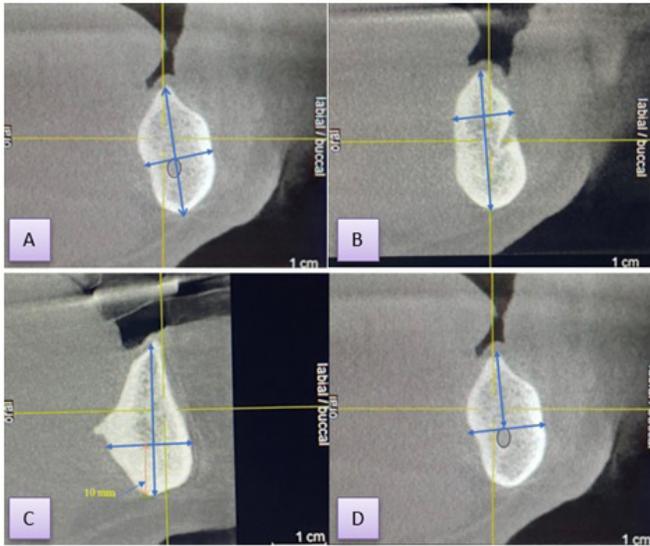
-FMR right side (BW-A): a distance between lingual and buccal sites of residual bone in level with the upper border of mental foramen, 16mm distal from mental foramen (Figure 2A).

-FMR left side (BW-A1): a distance between lingual and buccal sites of residual bone in level with the upper border of MC, 16 mm distal from mental foramen (Figure 2A).

-MFR right side (BW-B): a distance between lingual and buccal sites of residual bone in level with the upper border of mental foramen, 2 mm mesial from mental foramen (Figure 2B).

-MFR left side (BW-B1): a distance between lingual and buccal sites of residual bone in level with the upper border of mental foramen, 2 mm mesial from mental foramen (Figure 2B).

-Region of symphysis menti (BW-C): a distance between lingual and buccal sites of residual bone, 10 mm above the lower border of the mandible (Figure 2C).



**Fig.2.** Cross-sectional view of height and width measurements. A - molar region; B - premolar region; C - symphyseal region; D - molar region (distance from upper border of MC to AC).

Statistical analysis was performed using Microsoft Excel (MS Office 2010 Microsoft Corp., Redmond, WA, USA) and the Statistical Package for Social Science (SPSS) version 21.0 for Windows (SPSS Inc, Chicago, IL, USA). The mean, standard deviation (SD), standard error of the mean (SEM), median, interquartile range (IQR), and confidence interval (CI) were calculated. Means of 2 continuous variables were compared by independent samples Student's t-test. A probability value of  $P < 0.05$  was considered statistically significant.

## Results

Table 1 presents the mean BH on 7 sites in both male and female patient groups. The highest mean value of residual BH was at the measurements in landmarks C, B1, and B ( $24.43 \pm 5.12$  mm,  $23.98 \pm 5.03$  mm, and  $23.5 \pm 5.07$  mm, respectively), while the lowest values were at the measurements in landmarks D and D1 ( $9.18 \pm 4.02$  mm and  $9.46 \pm 3.95$  mm, respectively).

The highest mean value of residual BW was at the measurements in landmarks C, A1, and B1 ( $12.24 \pm 2.27$  mm,  $10.75 \pm 2.33$  mm, and  $10.55 \pm 8.03$  mm, respectively), while the lowest value was at the measurements in landmarks A and B ( $10.26 \pm 2.08$  mm and  $9.74 \pm 2.24$  mm, respectively) (Table 2).

In all measured sites, the mean value of residual BH was significantly higher in males than in females ( $P < 0.0001$ ), with the largest difference in measurement at the B site (Diff. of Mean = -6.521), and the smallest difference at the D site (Diff. of Mean = -4.369) (Figure 3).

In all measured sites, the average value of residual BW was insignificantly higher in males than in females, except for the measurement at the C site, where the difference was significant. The largest difference was in the measured B<sub>1</sub> site (Diff. of Mean = -2.95), with the smallest difference measured in the A site (Diff. of Mean = -0.294) (Figure 4).

**Table 1.**

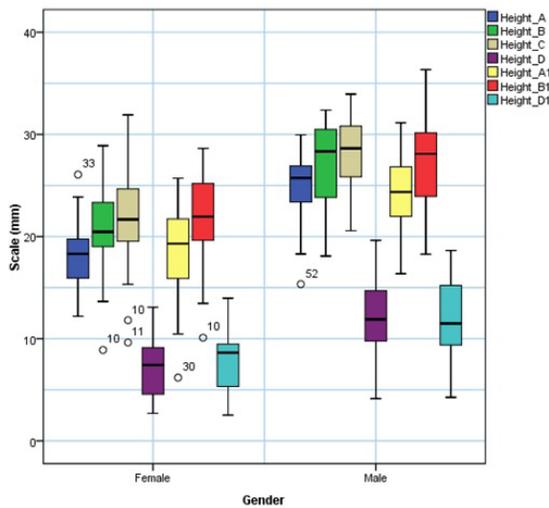
**Descriptive statistics for residual BH (mm) for each measured site.**

Descriptive statistics	Measured Site						
	BH-A	BH-B	BH-C	BH-D	BH-A1	BH-B1	BH-D1
Mean (SEM)	20.99 (0.60)	23.5 (0.65)	24.43 (0.66)	9.18 (0.52)	20.93 (0.65)	23.98 (0.65)	9.46 (0.51)
95% CI							
Lower Bound	19.79	22.19	23.11	8.14	19.63	22.68	8.44
Upper Bound	22.18	24.81	25.75	10.22	22.23	25.28	10.48
5% Trimmed Mean	20.92	23.6	24.63	9.06	21.08	24.08	9.36
Median	19.81	23.18	24.35	8.87	21.54	23.91	9.31
Variance	21.54	25.74	26.2	16.16	25.23	25.32	15.57
SD	4.64	5.07	5.12	4.02	5.023	5.03	3.95
Minimum	12	9	10	3	6	10	3
Maximum	30	32	34	20	31	36	19
Range	18	23	24	17	25	26	16
IQR	9	8	8	6	6	8	4
Skewness (SE)	0.25 (0.31)	-0.14 (0.31)	-0.39 (0.31)	0.36 (0.31)	-0.51 (0.31)	-0.26 (0.31)	0.36 (0.31)
Kurtosis (SE)	-1.07 (0.61)	-0.19 (0.61)	0.24 (0.61)	-0.47 (0.61)	0.29 (0.61)	0.02 (0.61)	-0.25 (0.61)

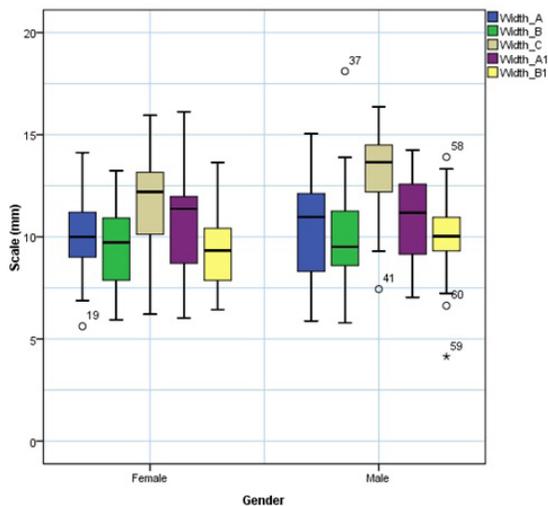
**Table 2.**

**Descriptive statistics for residual BW (mm) for each measured site.**

Descriptive statistics	Measured Site				
	BW-A	BW-B	BW-C	BW-A1	BW-B1
Mean (SEM)	10.26 (0.27)	9.74 (0.29)	12.24 (0.29)	10.75 (0.30)	10.55 (1.04)
95% CI					
Lower Bound	9.73	9.16	11.66	10.15	8.48
Upper Bound	10.8	10.32	12.83	11.36	12.63
5% Trimmed Mean	10.26	9.65	12.3	10.77	9.6
Median	10.34	9.56	12.83	11.23	9.77
Variance	4.306	5.039	5.128	5.412	64.484
SD	2.075	2.245	2.265	2.326	8.03
Minimum	6	6	6	6	4
Maximum	15	18	16	16	70
Range	9	12	10	10	66
IQR	3	3	3	4	3
Skewness (SE)	-0.004 (0.31)	0.78 (0.31)	-0.46 (0.31)	-0.11 (0.31)	7.07 (0.31)
Kurtosis (SE)	-0.30 (0.61)	2.03 (0.61)	-0.25 (0.61)	-0.70 (0.61)	52.99 (0.61)



**Fig. 3.** Gender-based comparison of the residual BH of each measured site.



**Fig. 4.** Gender-based comparison of the residual BW of each measured site.

## Discussion

In this study, patients were evaluated using the CBCT imaging technique, considered more accurate than panoramic radiographs. Other authors also used this technique.<sup>(12,19,20)</sup> The 7 landmarks (A, B, C, D, A1, B1, D1) selected for the present study appear to be a more useful reference and sufficiently entail justification of their use as a reference point in clinical studies.<sup>(12,13,15,17-19)</sup> Furthermore, Wical and Swope<sup>(13)</sup> rationalized that the bone below the foramen constitutes a predictable proportion of the total BH in most normal patients and is not significantly affected by resorption until extreme atrophy occurs.

Considering that the residual ridge resorption is more rapid in the premolar and molar regions than the anterior region of the mandible, it is important to analyze the BH and BW in these regions.<sup>(17)</sup> Moreover, the height and width of the residual alveolar

bone in these regions are important during implant placement, taking into account the location of the mandibular canal and mental foramen, particularly in a severely resorbed mandible. Short and narrow dental implants could be an alternative for the atrophied mandible.<sup>(21)</sup> The unfavorable combination of lower height and width of residual alveolar bone during implant placement should be analyzed diligently, particularly in the posterior regions. Numerous surgical techniques have been developed to enable the placement of dental implants that vary in their degree of complexity.<sup>(21)</sup> Likewise, the measurements of BH and BW in posterior mandibular regions are an important factor for the planning of complete dentures since, in cases of gross resorption, it can lead to compression and damage of the inferior alveolar nerve, and therefore, patients will complain of pain and discomfort.

In the present study, the average residual BH was  $24.43 \pm 5.12$  mm in the symphysis menti (landmark C) and  $23.99 \pm 5.03$  mm,  $23.5 \pm 5.07$  mm in the premolar region (landmarks B, B1), which is considered sufficient for implant placement. In the posterior region (landmarks D, D1), however, the average residual BH was  $9.18 \pm 4.02$  mm, and  $9.46 \pm 3.95$  mm, which limits the implant placement with adequate length. Similar results were reported by another study.<sup>(22)</sup>

Furthermore, our study found that the residual ridge was wider in frontal points of measurement of the mandible and decreased gradually towards the lateral regions. According to Mense et al.,<sup>(12)</sup> the mean symphysis width was  $13.30 \pm 2.19$  mm for both genders, which is similar to the findings of the present study.

The height measurement values at measured sites were significantly greater in the edentulous men than in the edentulous women ( $P < 0.05$ ). These results are supported by other studies, which reported that the women had a significantly greater amount of mandibular residual ridge resorption than the men.<sup>(12,22,23)</sup> This difference could be explained by the deficiency of estrogens in postmenopausal women, which may accelerate the resorption of the residual ridge.<sup>(24-26)</sup>

A study conducted by Pramstaller et al.<sup>(27)</sup> found that the mean values of BH and BW did not differ significantly between male and female patients, which is compatible with the present study in terms of BW results but not BH. The different results may be due to different locations of the height and width measurements of the bone. Also, this study is related to patients with a fully edentulous mandible, unlike the previously mentioned study, which is related to patients with one fully edentulous and one fully dentate mandibular posterior region. In addition, in a study by Bressan et al.,<sup>(28)</sup> gender showed a significant difference in BH, with males having, on average, a 2.8 mm greater height than females, however not in BW, which is supported by this study. Nevertheless, it is difficult to compare the results of this study with those of prior studies since previous studies had different landmarks of measurements.

## Conclusion

Within the limits of this study, the mean BH in posterior regions would dictate that implant placement can

be challenging. Using shorter implants may be considered optional. In premolar and symphyseal regions, BH and BW are sufficient for implant placement. Therefore, in cases where there is insufficient bone in the distal regions of the mandible, a good solution would be the placement of a 2- or 4-implant overdenture, which would be sufficient to adequately address a patient's functional needs.

## Ethics Approval and Consent to Participate

The study was conducted in accordance with the Declaration of Helsinki and approved by the Ethical Committee of Alma Mater Europaea Campus College Rezonanca, Pristina, Kosovo (AD-3063/21,18.06.2021). Written informed consent was obtained from all subjects involved in the study.

## Competing Interests

The authors declare that they have no competing interests.

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