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Relationship between the buccolingual width of the mandibular alveolar ridge and the vertical bone distance to the inferior alveolar canal in edentulous spaces, assessed via cone-beam computed tomography in Quito, Ecuador

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Abstract
Introduction: Implant planning in the posterior mandible requires a rigorous three-dimensional study of the alveolar height of the mandibular ridge and its relationship to the inferior alveolar nerve canal; the buccal-lingual distance will determine the choice and/or position of the implant.
Objective: To establish the relationship between the buccolingual predominance of the mandibular alveolar crest measured at the coronal, middle and apical levels and the vertical bone distance to the inferior alveolar canal using cone beam computed tomography (CBCT).
Methodology: This was an observational, analytical, cross-sectional, and retrospective study that included 138 TCCH patients between January 2024 and March 2026. Bilateral measurements were taken in the left and right mandibular alveolar ridge regions using BlueSkyPlan software. The analysis was performed using descriptive statistics, normality tests, parametric and non-parametric comparisons, and multiple linear regression, with a significance level of $p < 0.05$.
Findings: The mean alveolar height of the mandibular ridge was 13.25 mm for the left hemimaxilla and 13.15 mm for the right hemimaxilla, with no significant differences between sides. The buccolingual alveolar width showed a progressive increase from coronal to apical (3.4, 8.0, and 10.7 mm). In the multivariable model, coronal width maintained a positive and independent association with alveolar height ($B = 0.508$; $p < 0.001$). Sex also proved to be a significant variable ($B = -1.446$; $p < 0.001$), and the model showed overall statistical significance ($F = 7.809$; $p < 0.001$; adjusted $R^2 = 0.129$).
Conclusion: There is a significant relationship between the width of the buccolingual mandibular alveolar ridge and the vertical bone distance towards the inferior alveolar canal, being relevant in the coronal zone.

Keywords: Cone beam computed tomography, mandibular alveolar ridge, inferior alveolar canal, buccolingual width, vertical bone distance, dental implantology

Introduction

Dental implant rehabilitation in the posterior mandible presents a significant clinical challenge due to the relationship between the morphology of the remaining bone and relevant anatomical structures, particularly the inferior alveolar nerve canal. This procedure is frequently performed on edentulous individuals, as this condition causes functional, aesthetic, and nutritional alterations that can affect the patient's quality of life, especially in older age groups where tooth loss is prevalent (Chen *et al*. 2024; Kaaber. *et al*. 2024; Xu *et al*. 2023) [1–3].

Therefore, tooth loss involves initiating a progressive process of remodeling and resorption of the alveolar ridge that modifies both its vertical dimension and its buccolingual width and conditions the amount of bone available for implantation (Golshah *et al*. 2021; Kaaber *et al*. 2024; Rojo-Sanchis *et al*. 2021) [2, 4, 5].

The magnitude of the changes can vary between people and depend on several factors such as the time of edentulism, age, sex, bone characteristics and some systemic conditions, which will cause very different degrees of mandibular ridge atrophy (Ferreira *et al*. 2020; Golshah *et al*. 2021) [4, 6]. This implies the need for an individualized assessment of the available anatomy when defining the implant treatment plan.

During planning, it is important to consider the most surgically significant dental structures, such as the inferior alveolar canal (IAC), which contains the inferior alveolar neurovascular bundle (Schuster *et al*. 2022; Sivolella *et al*. 2020) [7, 8]. The distance between the residual alveolar crest and the upper edge of the IAC influences vertical bone availability (VB), implant length and position.

Excessive proximity to the canal could increase the risk of neurosensory injury, which can manifest as paresthesia, dysesthesia, hypoesthesia, anesthesia or allodynia, so its proper location becomes a primary element of surgical planning (Doh *et al*. 2024; Ferreira *et al*. 2020) [6, 9].

The amount of available bone depends not only on alveolar height. The width of the buccolingual ridge determines the transverse space available for the implant within the cortical limits and can even vary significantly from coronal to apical. Therefore, jointly assessing alveolar height and buccolingual width allows for a more comprehensive understanding of the morphology of the recipient site (Ferreira *et al*. 2020) [6].

Research has shown that tooth loss and subsequent bone remodeling can produce changes in the measurements of the alveolar ridge, which takes on a notable importance in those edentulous mandibular regions that are planned for rehabilitation through the use of implants; among the studies, it is worth mentioning the one carried out by Golshah *et al*. 2021 [4] and Rojo-Sanchis *et al*. 2021 [5].

Cone beam computed tomography (CBCT) becomes a technique for this evaluation, since it will allow obtaining

three-dimensional reconstructions and, likewise, linear measurements on bone structures, but with an acceptable level of spatial resolution (Basheer Taha *et al*. 2024; Ferreira *et al*. 2020) [6, 10].

This technique facilitates the location of the inferior dental canal, estimation of the buccolingual width of the ridge and evaluation of the available vertical bone distance. This provides sufficient information to choose the length and position of the implant, while at the same time decreasing the risk of injuring anatomical structures during the course of the surgical procedure (Kaaber *et al*. 2024; Yildirim *et al*. 2025) [2, 11].

Although there is scientific evidence on the dimensions of the alveolar ridge, the behavior of the mandibular canal and the modifications related to tooth loss, there are fewer investigations that jointly reflect on the association between buccolingual width and the free vertical distance to the CDI using three-dimensional morphometry (Fekry & Mahmoud, 2023; Saeed *et al*. 2022) [12, 13].

This is a clinically relevant relationship, since having adequate bone height does not imply that there is sufficient width for implant placement, and, conversely, having a favorable transverse dimension does not guarantee a sufficiently safe vertical distance from the inferior alveolar neurovascular bundle.

At the level of the posterior mandibular region, planning must include these dimensions according to the particular location of the implant, since the relationship between the implant and the ridge directly influences the choice of length, diameter, position and angulation of the implant (Göller Bulut *et al*. 2024) [14] ; a radiographic tomographic evaluation using CTHC can help determine anatomical limitations prior to surgical intervention, as well as optimize implant selection and reduce the risk of neurosensory complications (Sghaireen *et al*. 2020; Suthakar *et al*. 2025) [15, 16] .

Therefore, the objective of this study was to determine the relationship between the buccolingual width of the mandibular alveolar ridge, evaluated at the coronal, mid, and apical levels, and the vertical bone distance to the inferior alveolar canal using CT scans in the left and right posterior mandibular ridge regions. Furthermore, the analysis of these dimensions allows for the description of vertical and transverse bone availability in the posterior mandibular region and contributes to the morphometric description that can be applied to individualized, three-dimensional implant planning.

Methodology

The study is observational, analytical and cross-sectional focused on the retrospective study of cone beam computed tomography (CBCT) scans of partially or totally edentulous patients.

The population consisted of cone beam computed tomography (CBCT) scans performed at the RAXDENT radiology center between January 2024 and March 2026. The units of analysis were the images of adult patients, in whom it was possible to adequately identify the mandibular alveolar crest and the inferior dental canal.

The sample was a probabilistic convenience sample, calculated beforehand using the G* Power program, according to agreed-upon statistical parameters for calculating the necessary sample size. The sample consisted of 138 high-resolution computed tomography (HRCT) scans.

The unit of analysis is the TCHC of each patient, while for the morphometric analysis, the mandibular regions corresponding to the left and right posterior mandibular ridges were considered bilaterally. In each region, a measurement of the bone distance from the inferior alveolar canal and three measurements of the buccolingual width were taken: the coronal, the mid-width, and the apical width.

CT scans included in the study met the following criteria: Adult patients ≥ 18 years of age, mandible with some type of edentulism in mandibular anatomy 3-6 and 4-6. CT scan obtained with adequate diagnostic quality, with no artifacts that would indicate anatomical visualization. Complete visualization of the mandibular alveolar crest and the inferior alveolar canal. CT scans of patients without bone pathologies that alter the anatomical structures of interest.

The following CT scans were excluded: CT scans without bilateral partial edentulism in mandibular anatomy 3-6 and 4-6; bone pathologies, cystic or tumorous lesions that modify mandibular anatomy; history of surgery, bone grafts, or previous implants in the region to be analyzed; mandibular fractures, deformities, or resections; and distortion, low resolution, or artifacts that prevent obtaining sufficiently precise morphometric measurements.

Tomographic measurements were performed using BlueSkyPlan software, with multiplanar reconstructions and the corresponding standardized cross-section of the left and right posterior mandibular ridges. The residual alveolar ridge corresponding to each region and the inferior alveolar canal were excavated, maintaining an orientation perpendicular to the longitudinal axis of the residual alveolar ridge.

The vertical bone distance to the inferior alveolar canal was measured by drawing a perpendicular line from the highest point of the residual alveolar ridge to the superior border of the inferior alveolar canal. This measurement was recorded in millimeters.

The bone distance around the vertical bone distance to the mandibular alveolar ridge was considered at three anatomical levels: coronal, mid-, and apical. At each level, a line perpendicular to the longitudinal axis of the alveolar ridge was drawn between the buccal and lingual cortical plates. This allowed for the determination of three independent measurements: coronal width, mid-width, and apical width, all expressed in millimeters. This procedure was performed bilaterally in the regions corresponding to the left and right posterior mandibular ridges, following the same protocol for anatomical orientation and identification of anatomical structures for all the CT scans analyzed.

Standardization involved identifying the highest point of the residual mandibular crest, the superior border of the inferior alveolar canal, and the buccal and lingual cortical plates. The same protocol was followed for the regions corresponding to the left and right posterior mandibular ridges for vertical bone distance measurements such as coronal width, mid-width, and apical width.

The researcher was previously calibrated using pilot CT scans that were not included in the final sample. For quantitative measurements expressed in millimeters, intra- and interobserver reproducibility was measured using the intraclass correlation coefficient, with a value equal to or greater than 0.80 considered acceptable.

The data were initially organized and cleaned in Microsoft Excel and subsequently processed using the IBM SPSS Statistics program.

Kolmogorov-Smirnov test, and subsequently, depending on the normality results, parametric or non-parametric tests were chosen to carry out the further analyses. The Student 's t-test for paired samples with a normal distribution was used, and, conversely, the Wilcoxon test was used when normality was not present.

To identify differences in these measurements according to sex, the Student's t-test for independent samples was used for variables with a normal distribution, and the Mann-Whitney U test was used for variables with a non-normal distribution. Pearson's correlation coefficient was used for variables with a normal distribution and Spearman's correlation coefficient for variables that did not meet this assumption of normality.

Independent models were constructed for the respective areas of the left and right posterior mandibular ridges. The threshold of statistical significance for all analyses was $p < 0.05$ and a 95% confidence interval.

Findings

Analysis of the 138 CT scans showed that 57.20% of the patients were female and 42.70% were male. Regarding age distribution, 27.5% were between 60 and 69 years old, 21% between 70 and 79 years old, and 16.7% between 40 and 49 years old.

Table 1 summarizes the average measurements obtained from the 138 tomographies. For alveolar height, the left posterior mandibular ridge has an average of 13.2486 ± 3.024 mm and the right posterior mandibular ridge, an average of 13.1475 ± 2.77613 mm. Regarding coronal, mid, and apical width, the left posterior mandibular ridge presented values of 3.4252 ± 1.7053, 8.0771 ± 2.5153 mm, and 10.7025 ± 2.2376 mm, respectively; The right posterior mandibular ridge presented values of 3.3935±1.5243 mm, 7.9898±2.0704 mm and 10.6482±2.1691 mm, in the specific case of the concentrations of the aforementioned ridge.

Table 1: Average alveolar height and coronal, mid and apical width (mm) of the teeth on the left and right posterior mandibular ridges

Left posterior mandibular border	n	Minimum	Maximum	Average	S.D.
Alveolar height	138	6.07	21.15	13,2486	3,02483
Coronal width	138	0.75	14.1	3.4252	1,7053
Average width	138	2.56	20.12	8,0771	2,51538
Apical width	138	5.68	17.96	10,7025	2,23764
Right posterior mandibular border					
Alveolar Height	138	5.09	19.67	13,1475	2,77613
Coronal width	138	1.06	12.67	3.3035	1.52431
Average width	138	2.88	13.42	7,9898	2,07047
Apical width	138	4.52	15.68	10,6482	2,16917

Source: SD: standard deviation. n: sample size

The measurements of alveolar height, coronal, mean and apical width found between the right and left sides were compared; the differences were not statistically significant ($p \geq 0.05$), which represents that the measurements found on both sides are equivalent.

Regarding the measurements obtained from the width of the mandibular alveolar crest and the vertical bone distance to the inferior dental canal with respect to the sex of the patients obtained in the tomographies, with respect to the alveolar height, where the alveolar height of both sides was statistically significant ($p \geq 0.05$).

Men had an average measurement of 14,111 ± 2,955 mm and women 12,602 ± 2,930 mm for the left side. For the right side, men had a higher average measurement of 14,141 ± 2,783 mm compared to women's 12,405 ± 2,543 mm. Regarding the width of the alveolar ridge at the mid-anatomical level, men's measurements were also statistically higher than women's ($p \geq 0.05$), while no differences were observed at the other anatomical levels. See Table 2.

Table 2: Student's t-test of measurements according to sex

Measurements	Sex	n	Average	S.D.	p
Alveolar height of the left posterior mandibular ridge	Male	59	14,112	2,955	0.003
	Female	79	12,603	2.93	
Average width of the left posterior mandibular ridge	Male	59	8,791	2,646	0.004
	Female	79	7,543	2,287	
Apical width of the left posterior mandibular ridge	Male	59	11,218	2,281	0.019
	Female	79	10,315	2,138	
Alveolar height of the right posterior mandibular ridge	Male	59	14,141	2,783	≤ 0.001
	Female	79	12,405	2,543	
Average width of the right posterior mandibular ridge	Male	59	8,598	2,118	0.003
	Female	79	7,535	1,924	
Apical width of the right posterior mandibular ridge	Male	59	11,151	2,108	0.018
	Female	79	10,272	2.15	

Source: *t*= student 's t, UM-Wb= U Mann Whitney, p= significance value ≤0.05

To establish the relationship between coronal, mid-, and apical length and width, correlation tests were performed. These tests revealed a statistically significant association between the coronal and apical width measurements of the left and right posterior mandibular ridges, as well as the mid-width of the right posterior mandibular ridge. These tests indicated a mild to moderate positive correlation, suggesting that greater width is associated with a tendency toward increased alveolar height, a relationship that was more pronounced on the right side (see Table 3).

Table 3: Relationship of alveolar height to coronal, middle and apical width

Variable	Coronal width of the left posterior mandibular ridge (mm)	Coronal width of the right posterior mandibular ridge (mm)
Height (mm)	rs = 0.259	rs = 0.323
p	0.002	0.001
Variable	Average width of the left posterior mandibular ridge (mm)	Average width of right posterior mandibular ridge (mm)
Height (mm)	r = 0.155	r = 0.249
p	0.069	0.003
Variable	Apical width of the left posterior mandibular ridge (mm)	Apical width of the right posterior mandibular ridge (mm)
Height (mm)	r = 0.179	r = 0.216
p	0.036	0.011

Source: r = Pearson correlation coefficient; p = statistical significance $p < 0.05$

To predict coronal, mid-alveolar width, and apical width based on alveolar height, a multiple linear regression was performed. This regression showed statistical significance (F=4.153; p=0.008), although its ability to explain this relationship was low, explaining only 6.5% of the variations in bone height (adjusted R^2 =0.065). Coronal width did show a statistically significant association with height (B=0.562; p=0.006), but mid-alveolar and apical widths did not show statistical significance ($p \geq 0.05$). (See Table 4)

The multiple linear regression model for the right side, using coronal, mid, and apical widths as predictors of alveolar height, was significant (F = 5.259; p = 0.002), although it only explains a small part (8.5%) of these variations according to the adjusted R^2 of 0.085. Regarding the analysis of the coefficients independently, the coronal width of the right posterior mandibular ridge did show statistically significant differences (B = 0.466; p = 0.014), meaning that for every millimeter increase in the coronal width of the right posterior mandibular ridge, the alveolar height increases by approximately 0.466 mm. (See Table 4)

In the third multiple linear regression model, where the variable "side" was included along with all other measurements (n=276), the model was statistically significant (F=6.601; p<0.001). In this model, coronal width showed a strong and statistically significant relationship with height in this study, showing B=0.504; p<0.001; while mid-, apical, and mandibular lateral widths were not statistically significant (p=0.337, p=0.105, and p=0.904, respectively), confirming that there were no differences in bone height between the right and left sides. (See Table 4)

Table 4: Multiple linear regression analysis

Model	Non-standardized coefficients		Standardized coefficients	T	P
	B	Dev. Error	Beta		
Alveolar height and bone width (coronal, middle and apical) of the left posterior mandibular ridge					
(Constant)	10,322	1,265	----	8,157	0.001
Coronal width of the left posterior mandibular ridge	0.562	0.202	0.317	2,781	0.006
$R^2 = 0.065$; F= 4.153; p = 0.008					
Alveolar height and bone width (coronal, middle and apical) of the right posterior mandibular ridge.					
(Constant)	10,166	1,138	---	8,935	0.01
Coronal width of the right posterior mandibular ridge	0.466	0.187	0.256	2,496	0.014
$R^2 = 0.085$; F= 5.259; p = 0.002					
Coronal, mid-, apical and lateral width, and side (right/left)					
(Constant)	10,478	0.983	----	10,664	0.01
Coronal width of the right posterior mandibular ridge	0.504	0.137	0.281	3,682	0.01
$R^2 = 0.075$; F= 6.601; $p \leq 0.001$					

Source: p = statistical significance $p < 0.05$

Finally, a multiple linear regression analysis was performed to determine the relationship between height and all the variables evaluated. The regression model showed a statistically significant relationship (F = 7.809; p = 0.000), being able to explain 14.8% of the variability in height (adjusted $R^2 = 0.129$).

Regarding coronal width, the model showed a positive and statistically significant relationship with height (B = 0.508; p = 0.000), as did sex (B = -1.446; p = 0.000): that is, male patients had higher height values than female patients, controlling for the effect of other variables. This latter result agrees with what had been observed in previous results. The other variables did not reach statistical significance, so no relevant associations were found with alveolar height. (See Table 5).

Table 5: Multiple linear regression analysis between alveolar height and coronal width, mean width, apical width, side (right/left), sex, and age

Model	Non-standardized coefficients		Standardized coefficients	T	p
	B	Dev. Error	Beta		
(Constant)	13,870	1,344	----	10,317	0.000
Right / Left side	-0.046	0.326	-0.008	-0.142	0.887
Coronal width	0.508	0.133	0.283	3,809	0.000
Average width	-0.201	0.137	-0.160	-1,463	0.145
Apical width	0.192	0.121	0.146	1,587	0.114
Age	-0.008	0.011	-0.039	-0.693	0.489
Sex (1)	-1,446	0.340	-0.247	-4,253	0.000

Source: V. Dependent=alveolar height, adjusted $R^2 = 0.129$; F= 7.809; $p \leq 0.001$, 1=male

Discussion

The analysis demonstrated that vertical bone distance and the width of the mandibular ridge region are associated, although the strength of this relationship varied according to the anatomical levels studied. These results support the alternative hypothesis of this research, but also demonstrate that the morphology of the mandibular ridge cannot be explained by a single dimension.

The mean vertical bone distance to the inferior mandibular canal was approximately 13.25 mm (left posterior mandibular ridge) and 13.15 mm (right posterior mandibular ridge), suggesting similar vertical availability between both sides. These values are analogous to those reported by Jolicoeur *et al*. (2024) [17], who, in the area of the edentulous mandibular molar, found a mean height of 12.55 ± 2.45 mm from the alveolar crest to the superior border of the mandibular canal.

This relationship is supported by the fact that a height close to 13 mm is a frequent finding in edentulous mandibular molar sites evaluated by CT. Regarding the buccolingual width, a greater distance was observed in the apical region; the left mandibular posterior ridge reached approximately 3.43 mm coronally, 8.08 mm midway, and 10.70 mm apically; the right mandibular posterior ridge showed slightly lower values of 3.4 mm, 8.0 mm, and 10.65 mm, respectively. This behavior shows a significant decrease in the crestal portion and greater bone availability in the apical direction. Regarding this, Jolicoeur *et al*. (2024) [17] a mean width of 9.62 ± 2.09 mm in the first mandibular molar, although the measurement was taken approximately 2 mm below the crest. However, the explanation can also be attributed to the variability factors of the anatomical reference point chosen to perform the measurement.

The differences according to sex in the dimensions they occupy were significant; in the study of Kolte *et al*. (2020) [18] in the posterior edentulous places using TCHC, the crestal width was: 4.50 ± 1.53 mm in men and 3.71 ± 1.31 mm in women, being: 9.57 ± 2.29 mm and 9.06 ± 2.22 mm at 5 mm from the crest, and reached 11.30 ± 2.43 mm and 10.47 ± 2.50 mm at 10 mm, respectively.

The main difference lies in the coronal level. Zhang *et al*. (2015) [19] reported values of approximately 7–9 mm, while the present study reported a coronal width of approximately 3.4 mm. As can be deduced, this difference is associated with the area of edentulous zones underlying the edentulous condition of the mandibular shoulder sites; that is, tooth loss leads to resorption of the residual ridge. In contrast, the records obtained at the middle and apical levels are comparable to the results described in Zhang *et al*. (2015) [19].

The results are analogous to those of Kolte *et al*. (2020) [18], who, thanks to TCHC, were able to identify differences in the amount of alveolar bone between dentate and edentulous posterior regions, and Koç & Erdem (2020) [20], who specifically evaluated the dimensions of edentulous posterior mandibular ridges and highlighted that both the vertical and transverse components should be assessed before implant placement. Both publications form part of the theoretical basis that considers that tooth loss modifies the three-dimensional geometry of the ridge and that horizontal availability cannot be inferred from bone height (Koç & Erdem, 2020; Kolte *et al*. 2021) [18, 20].

While the differences in the various width levels were minimal, showing that, in population terms, there was a similarity between the mean dimensions of the two mandibular sides, this cannot be interpreted as anatomical symmetry of an individual. Basheer Taha *et al*. (2024) [10] and Göller Bulut *et al*. (2024) [21] have demonstrated by TCHC that the position, direction and shape of the mandibular canal vary between patients and between sides, with bifurcations or trifurcations even existing.

So much so that studies such as those by Sghaireen *et al*. (2020) [15] or Sharaan *et al*. (2020) [22] have highlighted the need to identify three-dimensionally the anatomical relationships before performing therapy in the area of the posterior mandibular region.

Coronal width, however, did not show a statistically significant difference between sexes in the initial comparative analyses. In the present study, males were found to have larger bone dimensions than females. These findings are consistent with the results of Saeed *et al*. (2022) [13], where the posterior mandibular region was studied using CT and a bone height of 16.11 ± 2.89 mm was found in males versus 15.23 ± 3.12 mm in females on the first molar slope. Therefore, sex appears to be associated with certain morphometric characteristics of the posterior mandibular alveolar ridge, although differences between populations do not replace tomographic evaluation of implant sites.

The age variable did not show statistically significant correlations with vertical distance or coronal, mid, or apical width, indicating that age cannot explain the variations observed in edentulous sites. This is related to bone remodeling, which is also influenced by the duration of edentulism, the resorption pattern, and functional conditions. Similar findings were reported in the study by Jolicoeur *et al*. (2024) [17].

The final multivariable model results have direct implications for implant planning in the posterior mandible. The average height (close to 13 mm) obtained from this study coincides with the values of 12.55 mm described by Jolicoeur *et al*. (2024) [17], with respect to edentulous first mandibular molars. Similarly, Kolte *et al*. (2020) [18] and Mai *et al*. (2025) [23] found ridge-canal distances of 16.13 ± 2.66 mm for first molars and 13.71 ± 2.79 mm for second molars, as well as ridge widths of 6.63 ± 2.16 mm and 5.46 ± 2.37 mm, respectively, for edentulous mandibular teeth.

Although the protocols and levels of measurement in the studies are very different, the results of this series as a whole demonstrate that vertical and transverse bone availability can vary independently and that a favorable (or at least optimal) height does not necessarily have to be accompanied by sufficient buccolingual volume for implant placement, thus justifying individual three-dimensional evaluation using CTHC.

The choice of implant length and diameter should be made from a joint assessment of the dimensions and not from population average values (Jolicoeur *et al*. 2024) [17]. The discrepancies found demonstrate that there is an anatomical bone distance that allows establishing margins around the implant, but their work also indicates that the relationship between the dimensions of the ridge and the size of the implants will depend on the location and anatomy.

Conclusions

The sample had a higher proportion of female subjects compared to male subjects, with most participants falling within the 60-69 age group. The average vertical bone distance between the residual alveolar ridge and the right

inferior alveolar canal was very similar to that of the left posterior mandibular ridge.

Age was found to have no statistically significant association with the vertical bone distance to the inferior dental canal, nor with the coronal, middle, and apical widths.

A positive and statistically significant relationship was identified between vertical bone distance and certain levels of buccolingual width. In the left posterior mandibular ridge region, the association was significant for coronal and apical widths, while in the right posterior mandibular ridge, the relationship was significant at all three levels. The correlations were of weak to moderate strength, implying that greater width tends to be associated with greater vertical potential, although neither dimension can predict the other on its own.

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