

## Original Research Article

# Gender-based variations in autogenous bone block graft availability within the mandibular ramus: a cone beam computed tomographic comparative analysis

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## ABSTRACT

**Background:** Alveolar ridge resorption following tooth loss often necessitates regenerative procedures prior to implant placement. Autogenous bone grafts, particularly from the mandibular ramus, are widely used due to their favourable properties. However, anatomical variations influenced by gender and age can affect graft suitability. Objective was to evaluate gender- and age-related differences in the volume, density, cortical thickness, and vertical height of harvestable bone from the mandibular ramus using cone-beam computed tomography (CBCT).

**Methods:** This analytical cross-sectional study analyzed CBCT scans of 40 patients (20 males, 20 females) aged 20-60 years. Measurements of bone volume, density (gray values), cortical plate thickness, and vertical height were taken. Data were statistically analyzed, significance level set at  $p < 0.05$ .

**Results:** No significant gender-based differences were observed in bone volume (males:  $2.0 \pm 0.22 \text{ cm}^3$ ; females:  $1.92 \pm 0.25 \text{ cm}^3$ ), cortical thickness, height, or density ( $p > 0.05$ ). However, age had a significant inverse relationship with bone quality. Participants aged 20-40 years demonstrated higher bone density ( $1212.2 \pm 157.7 \text{ GV}$ ) and cortical thickness ( $2.32 \pm 0.18 \text{ mm}$ ) compared to those aged 41-60 years ( $975.8 \pm 59.6 \text{ GV}$ ;  $1.80 \pm 0.12 \text{ mm}$ ), with  $p < 0.001$  for both. Bone volume and height were not significantly affected by age.

**Conclusions:** Mandibular ramus offers a reliable intraoral donor site for autogenous bone grafting across genders. However, bone quality parameters such as density and cortical thickness decline significantly with age, highlighting the importance of age-specific assessment during preoperative planning.

**Keywords:** Age differences, Autogenous graft, Bone density, CBCT, Cortical bone, Gender analysis, Mandibular ramus

## INTRODUCTION

Alveolar ridge undergoes an average resorption of 3.87 mm horizontally and 1.67 mm vertically following exodontia.<sup>1</sup> This can compromise implant placement, necessitating bone augmentation. Autogenous bone grafts remain the gold standard due to their superior biological properties and minimal immunologic risk.<sup>2,3</sup> Intraoral donor sites, particularly the mandibular ramus, offer advantages such as local accessibility, reduced morbidity,

and favourable bone quality.<sup>4,5</sup> However, a precise preoperative assessment is recommended using CBCT. This study aimed to evaluate the volume, density, and dimensions of harvestable bone from the mandibular ramus, with a focus on age- and gender-related variations.

## METHODS

This analytical cross-sectional study included patients who were referred to both public and private dental

radiology clinics during the years 2022 and 2023. All CBCT images used in this study were originally taken from systemically healthy patients with all mandibular posterior teeth present seeking dental treatments like orthodontics, implants, and other procedures, not specifically for this study.

The exclusion criteria were as follows: fully edentulous patients, those with a history of trauma or major surgery, and patients with clear signs of cysts, tumors, or other pathologies in their radiographs.

CBCT scans were taken using the following settings: 90 kV, 8 mA, and a voxel size of 0.1 mm<sup>3</sup>. The scans were captured in facial mode with a field of view (FOV) of 7.5 × 10 cm and saved in DICOM format.

A panoramic curve was reconstructed in the axial view to help identify the spatial planes of the region of interest.

Each slice had a default thickness of 1 mm. The area available for autogenous grafting in the ramus extended from the middle of the first mandibular molar (the front point of the external oblique ridge) up to the middle of the third molar and mandibular foramen. The lower boundary was 2 mm above the inferior alveolar canal, and the outer boundary was 2 mm away from the root surface. The surface area and linear measurements of this region were analyzed using OnDemand software.

Then, the volume of the interval area between every two cuts was calculated using partial Frustum formula:

$$v = \frac{h}{3}(s1+s2+\sqrt{s1s2})$$

h = width of the slice, s1 and s2 = surface of the cut at each slice.

**Parameters measured**

- (1) Volume of harvestable bone block in ramus.
- (2) Height of available bone in the middle region, from crest to 2 mm above the inferior alveolar nerve in a line parallel to the tooth axis.
- (3) Thickness of cortical plate in the middle regions.

- (4) The density of the harvestable bone was measured with an ROI tool in gray value (GV).

Statistical analysis was performed using SPSS version 19 and p value <0.05 was considered significant. All measurements were conducted by a qualified examiner. To minimize errors, variables from 10 samples were measured again two weeks after the initial measurements. An intraclass correlation coefficient (ICC) greater than 0.8 confirmed acceptable consistency in the examiner’s measurements. For the evaluation of data normality, we used the Kolmogorov-Smirnov test. We applied independent t-test between gender and age.

**RESULTS**

A total of 40 participants met the CBCT inclusion criteria comprising 20 males and 20 females. They were divided into two age range groups: 20 to 40 years and 41 to 70 years to evaluate the differences in bone volume and density associated with age.

Table 1 shows that the mean±standard deviation (SD) of bone volume was 2±0.22 in males and 1.92±0.25 in females with no statistically significant difference (p =0.36). The bone density values were similarly close: males averaged 1075±167.2 and females 1093±172.8, again showing no significant gender-based difference (p=0.97).

Cortical bone thickness also revealed nonsignificant differences: males exhibited a mean±SD of 2.04±0.33 while females showed 2.08±0.28 (p=0.68). Similarly, the vertical height of available bone did not differ significantly between genders: males averaged 9.805±0.30, and females 9.635±0.39, (p= 0.13).

Overall, the statistical analysis indicates that gender has no significant association with any of the measured bone parameters.

Table 2 details the effect of age on measured parameters. No statistically significant differences were observed in bone volume and vertical height between the age groups (p value >0.05). However, a significant inverse correlation was found between age and bone density: 20-40year age group exhibited a mean±SD density of 1212.2±157.7 while the 41-60-year group measured 975.8±59.6 (p<0.001).

**Table 1: Correlation of bone parameters with gender.**

	Male (mean±SD)	Female (mean±SD)	P value (t-test)
<b>Bone volume</b>	2±0.22	1.92±0.25	0.36
<b>Bone density</b>	1075±167.2	1093±172.8	0.97
<b>Cortical bone thickness</b>	2.04±0.33	2.08±0.28	0.68
<b>Height</b>	9.805±0.30	9.635±0.39	0.13

**Table 2: Correlation of bone parameters with age.**

	20-40 years (Mean±SD)	41-60 years (Mean±SD)	P value (t-test)
<b>Bone volume</b>	1.90±0.25	2.02±0.2	0.10
<b>Bone density</b>	1212.2±157.7	975.8±59.6	<0.001*
<b>Cortical bone thickness</b>	2.32±0.18	1.8±0.12	<0.001*
<b>Height</b>	9.65±0.33	9.79±0.37	0.22

\*Significant

Cortical bone thickness also showed a notable age-related decrease: the younger group (20-40-year) had a thickness 2.32±0.18, significantly greater than the 1.8±0.12 seen in the 41-60-year age group ( $p<0.001$ ).

The present study showed that age was significantly and inversely associated with bone density and cortical bone thickness ( $p<0.001$  for both), while bone volume and height remained unaffected by age.

## DISCUSSION

Alveolar ridge resorption is a common sequela of tooth extraction, trauma, periodontal disease, or congenital conditions such as alveolar clefts. These changes in alveolar bone volume and morphology can significantly compromise the placement and long-term success of dental implants, often requiring pre-implant regenerative procedures to restore adequate bone support. These findings are consistent with previous studies reporting similar volumes from the mandibular ramus reinforcing the reliability of this site regardless of sex.<sup>12-14</sup>

Several techniques have been developed to manage alveolar bone deficiencies, including guided bone regeneration (GBR), ridge splitting, protected bone augmentation, and block grafting. All these methods depend on the use of bone grafts to serve as scaffolds that support new bone formation and integration.<sup>15,16</sup>

The present study provides new evidence that gender does not significantly influence mandibular ramus bone volume, density, cortical thickness, or height, suggesting that both males and females offer comparable intraoral donor potential. In contrast, age emerged as a significant determinant of bone quality. Both bone density and cortical thickness declined markedly in participants over 40 years of age, while bone volume and vertical height remained unaffected. This pattern highlights a qualitative rather than quantitative change with aging, in agreement with prior reports linking reduced density to decreased physical activity, oxidative stress, and nutritional deficiencies.<sup>17,18</sup>

When selecting optimal donor sites for augmentation, factors such as bone density, volume, and the predictability of uneventful healing are of critical importance.<sup>6</sup> While extraoral donor sites can provide substantial bone volume, their use is often associated with

increased morbidity, longer hospital stays, and higher treatment costs, as reported in various studies.<sup>7-9</sup>

In contrast, intraoral bone harvesting offers several advantages, including minimal morbidity, absence of cutaneous scarring, and the convenience of being performed under local anesthesia within the same operative field. Among available graft materials, autogenous bone grafts offer superior biological properties, including osteogenic potential, osteoinductive capacity, and excellent osteoconductivity. These grafts are highly biocompatible and eliminate the risk of immune rejection or disease transmission. Clinically, autogenous grafts provide faster healing, superior bone quality, and cost-effectiveness.

Among the intraoral sites, the mandibular ramus and symphysis are the most commonly utilized, particularly for addressing localized alveolar defects.<sup>10</sup> Autogenous bone blocks, especially when harvested from the mandible, have become a widely accepted and effective method for ridge augmentation. Dense cortical bone blocks, in particular, are associated with reduced graft resorption and are preferred for site development where volume stability is essential. Their predictable outcomes make autogenous grafts a critical tool in contemporary implant dentistry and ridge augmentation protocols.

Techniques involving autologous block or split-block grafts have demonstrated consistently high implant survival rates ranging between 95% and 98%. Mandibular block grafts, in particular, provide a denser graft material, making them favourable for improving the quality of the recipient site.<sup>4</sup> However, it is important to acknowledge the potential risk of damaging the inferior alveolar nerve, especially when harvesting from the ramus area. Sensory disturbances of the mucosa following ramus harvesting were reported in only 8.19% of cases and were mostly temporary, making the mandibular ramus a relatively safe and favourable donor site for grafting.<sup>11,12</sup>

In the current study, the average volume of mandibular ramus available for bone grafting was found to be 2±0.22cm<sup>3</sup> in males and 1.92±0.25cm<sup>3</sup> in females. These results are consistent with the previous findings where Güngörmüş et al reported a graft volume of 2.36±0.76 ml; Yates and Brockhoff documented a mean volume of 2.02 cm<sup>3</sup>; and Zeltner et al found an average of 2.6±1.4 cm<sup>3</sup>.<sup>12-14</sup> Conversely, other studies showed considerable variation: Ataman-Duruel et al reported a bone block

volume of  $1.076 \pm 0.398 \text{ cm}^3$ , while Montazem et al reported a notably larger average bone volume of  $9.55 \text{ ml}$ , highlighting a contrast with the present findings.<sup>15,16</sup>

Despite these risks, the clinical outcomes of grafting procedures using mandibular bone are notably successful. Such interventions have been shown to significantly improve alveolar ridge dimensions, transforming deficient sites into ridges with adequate width and height for implant placement. Implants placed in areas augmented with block grafts consistently demonstrate high survival and success rates.<sup>9,13</sup> Beyond facilitating implant placement, these grafting procedures also play a crucial role in ensuring the long-term stability and functionality of dental implants.

Bone density differed significantly between the two age groups in the current study with notable higher bone density under 40 years of age group with no gender-based differences observed. This decline with age may be attributed to factors such as reduced physical activity, nutritional deficiencies and age-related mechanisms like oxidative stress and telomere shortening.<sup>17,18</sup>

Regarding bone height, our study documented an average available height of  $9.805 \pm 3 \text{ mm}$  in males and  $9.635 \pm 0.39 \text{ mm}$  in females. In comparison, Padayachee et al reported a mean distance of  $13.068 \pm 2.963 \text{ mm}$  from the alveolar crest to the inferior alveolar nerve.<sup>19</sup>

An important parameter for determining bone harvesting potential is the cortical-to-cancellous bone ratio (C/C), which significantly affects the revascularization capacity. Revascularization is faster in cancellous bone due to its abundant marrow spaces, whereas the dense lamellae of cortical bone slow this process. Despite its superior revascularization potential, cancellous bone is more prone to resorption under functional loading.<sup>13,14</sup> Based on our findings, the observed inverse correlation between bone quality and aging further emphasizes the importance of age consideration when selecting intraoral donor sites for grafting procedures.

The present study highlights that gender does not significantly influence mandibular ramus bone parameters, with comparable bone volume, density, cortical thickness, and height in both males and females. These results are in line with previous reports (Güngörmüş et al, Yates and Brockhoff, Zeltner et al), confirming the reliability of the mandibular ramus as an intraoral donor site across sexes.<sup>12-14</sup>

In contrast, age showed a significant inverse correlation with bone density and cortical thickness, while bone volume and height remained stable. Younger individuals (<40 years) exhibited higher density and thicker cortices, consistent with previous studies attributing age-related bone loss to reduced activity, nutritional deficiencies, and oxidative stress. Our observed bone volumes ( $\sim 2 \text{ cm}^3$ ) align with most prior findings, though variability in

reported values suggests population and methodological influences.

Clinically, these findings reinforce the mandibular ramus as a safe and predictable donor site, with minimal morbidity. However, the decline in bone density and cortical thickness with age suggests that graft stability and revascularization may be less favourable in older patients, warranting careful case selection and consideration of adjunctive regenerative approaches. Limitations of the present study include its modest sample size, cross-sectional design, and reliance on CBCT rather than histological evaluation. Future prospective studies are needed to directly link age-related bone quality differences with graft resorption, survival rates, and implant outcomes.

## CONCLUSION

Intraoral autogenous bone grafts, particularly from the mandibular ramus, are valued for their excellent biological properties, predictable outcomes, and high implant survival rates. Dense cortical blocks harvested from this region offer superior volume stability and improve the quality of the recipient site. Ramus bone harvesting remains a safe and dependable technique when preceded by thorough preoperative CBCT evaluation. Overall, autogenous bone grafting is a highly effective approach for rebuilding deficient ridges, supporting successful implant placement, and ensuring long-term functional stability.

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