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Quantitative assessment of regional variability in mandibular bone density based on cone-beam computed tomography data

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Abstract. Despite the widespread use of cone-beam computed tomography, regional variations in cortical and trabecular bone density remain insufficiently characterised. The aim of this study was to assess mandibular bone density across different anatomical regions and to identify clinical situations in which pre-implant bone augmentation may be required. The methodology involved the analysis of cone-beam computed tomography data with quantitative assessment of bone density in the anterior, premolar, and molar regions of the mandible. The highest bone density values were observed in the anterior mandible, averaging 944.9 ± 207 HU in the control group and 910.2 ± 198 HU in edentulous patients ($p > 0.05$). In the premolar region, bone density decreased to 643.8 ± 162 HU in the absence of teeth, compared with 826.4 ± 175 HU in dentate individuals ($p < 0.05$). The most pronounced reduction was identified in the molar region, where values reached 512.5 ± 148 HU in edentulous patients versus 789.7 ± 160 HU in the control group ($p < 0.01$), confirming the adverse effect of prolonged posterior tooth loss on bone quality. Furthermore, reduced bone density in the distal mandible was associated with compromised cortical bone characteristics, potentially affecting the primary stability of dental implants. These regional differences should be taken into account when selecting implant dimensions and planning the extent of bone augmentation, particularly in patients with long-standing edentulism. The findings are clinically relevant for optimising implant treatment strategies, determining the need for bone augmentation, and improving the predictability of surgical outcomes

Keywords: mandible; bone tissue density; CBCT; regional variability; alveolar ridge; bone augmentation

INTRODUCTION

Dental implantation is widely regarded as one of the most effective approaches for the replacement of missing teeth and the functional rehabilitation of patients. The success of implant therapy is largely dependent on the condition of the jawbone, as both its volume and density directly influence the achievement of primary implant stability and the predictability of osseointegration. Particular attention should be paid to the mandible, where the density of cortical and trabecular bone may vary considerably depending on the anatomical region, patient age, and the duration of edentulism. In this context, accurate assessment of bone quality represents a critical stage in preoperative planning and in the selection of an appropriate surgical strategy. C.S. Park *et al.* [1] conducted a validation study of a quantitative method for assessing bone mineral density based on cone-beam computed tomography (CBCT) data using deep learning algorithms. Their findings

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demonstrated that this approach provided more accurate and reproducible density measurements compared with conventional CBCT analysis. These results highlight the potential of quantitative CBCT as a reliable tool for objective evaluation of bone quality in implant treatment planning.

According to G. Avila-Ortiz *et al.* [2], post-extraction resorption of the alveolar ridge is a physiological remodelling process characterised by a reduction in both bone height and width, most pronounced within the first months to years following tooth removal. This process may significantly complicate implant therapy and increases the need for techniques aimed at preserving and augmenting bone volume. Evidence from biomechanical as well as clinical and radiological studies indicates that insufficient bone volume represents one of the principal limiting factors for implant placement and is associated with an increased risk of postoperative complications. Furthermore, O. Yildirim *et al.* [3] emphasised the importance of CBCT-based assessment of bone morphology and quality, including Hounsfield unit (HU) values. It is the combined evaluation of parameters – such as alveolar ridge configuration, cortical bone thickness, and radiographic bone density – that plays a decisive role in the selection of the surgical approach and the accuracy of the intervention, including guided implant surgery. The authors demonstrated that cortical plate characteristics, as well as bone density and morphology in the posterior mandible, are associated with the risk of technical deviations and variability in clinical outcomes when digital surgical guides are employed.

In studies by J. Lorenz *et al.* [4] and T. Starch-Jensen *et al.* [5], particular emphasis was placed on measuring cortical bone thickness in prospective implant sites. The findings indicated that the cortical component plays a pivotal role in achieving primary implant stability and in establishing a favourable treatment prognosis. At the same time, the authors highlighted considerable interindividual variability in these parameters, underscoring the need for standardised CBCT-based criteria for the assessment of bone quality. According to P. Suthakar *et al.* [6], a distinct area of contemporary research focuses on the use of CBCT for the quantitative evaluation of mandibular resorption based on stable anatomical landmarks, including the mental region. The application of standardised reference points enables consistent morphometric comparisons in both dentate patients and those with partial or complete edentulism. However, the authors noted that most studies are limited to describing the extent of resorption without establishing clinically relevant threshold values necessary for evidence-based decision-making when selecting reconstruction techniques, such as guided bone regeneration (GBR), alveolar ridge splitting, the use of bone blocks, or vertical augmentation procedures.

The Proceedings of the 21st All-Russian Dental Forum report [7] that, between 2020 and 2024, considerable attention was devoted to analysing the outcomes of reconstructive techniques in the mandible, including GBR and horizontal augmentation. These advances have contributed to expanding the indications for dental implantation in patients presenting with pronounced alveolar ridge atrophy. At the same time, it was emphasised that, despite favourable clinical outcomes, a significant limitation remains the methodological heterogeneity of available studies, including differences in study design, osteoplastic materials and barrier membranes employed, follow-up duration, and criteria used to define treatment success. Such variability continues to hinder the development of a universally accepted, CBCT-based decision-making algorithm for selecting the optimal reconstructive approach. An important contribution to the regional body of evidence has been made by researchers from Kyrgyzstan. In particular, A.M. Eshiev & R.E. Abirova [8] demonstrated the clinical relevance of CBCT-based bone density assessment (in HU), highlighting regional variability in these parameters. The authors also presented a clinical case illustrating the management of a patient with severe atrophy, including mandibular involvement, using a digital treatment planning approach.

Furthermore, in 2025, A.M. Eshiev & B.A. Israilov [9] published an observational CBCT-based study demonstrating the presence of destructive periapical bone changes in all examined patients. The study focused on the assessment of bone biotypes and the practical interpretation of CBCT-derived parameters in treatment planning for older patient cohorts.In addition, A.K. Abdymechinova *et al.* [10], in a review paper, highlighted the role of advanced technologies, including CBCT, as essential tools for diagnosis and treatment planning in maxillofacial dentistry, further supporting the need for the implementation of standardised approaches in clinical practice in Kyrgyzstan.

The aim of the present study was to determine the characteristics of bone density and volumetric parameters of the mandible across different anatomical regions, and to establish threshold values for horizontal and vertical bone deficiency at which bone augmentation becomes necessary to ensure predictable and long-term outcomes of dental implantation.

MATERIALS AND METHODS

The study was conducted at the Department of Oral and Maxillofacial Surgery, Osh State University, between 2024 and 2025. A prospective clinical and radiological assessment was performed in patients presenting with partial edentulism of the posterior mandible and scheduled for dental implant therapy. A total of 50 patients aged 45-70 years were enrolled and allocated into two groups. Group 1 (study group) comprised 25 patients with bilateral absence of posterior mandibular teeth (FDI positions 4.5-7.5). Group 2 (control group) included

25 patients with intact dentition. Only individuals without systemic bone disorders or significant inflammatory pathology in the intended implant sites were included. Exclusion criteria comprised osteoporosis, oncological diseases, active inflammatory-destructive processes, the use of medications affecting bone metabolism (e.g., bisphosphonates, glucocorticosteroids), and pregnancy. The duration of edentulism in the study group ranged from 6 months to 10 years and was considered a variable influencing morphometric parameters and relative bone density. CBCT was performed using the Planmeca ProMax 3D (Finland) following a standardised protocol (voxel size 0.2 mm; field of view 8×8 cm; 90 kV; 10 mA). Tomographic data were analysed using Planmeca Romexis 6.0. Measurements were obtained bilaterally in the premolar (4.5-5.5) and molar (6.5-7.5) regions of the mandible.

The region of interest (ROI) was defined at levels 1, 3, and 5 mm apical to the crest of the alveolar ridge. In each area, no fewer than three measurements of cortical plate thickness and relative bone density were obtained, followed by calculation of mean values. Bone density assessment was performed using CBCT in the planned implant sites, specifically within the premolar and molar regions bilaterally in the mandible. Density values were expressed in HU. Bone quality was classified according to the Lekholm & Zarb classification [11], based on the relationship between cortical and cancellous bone components. The evaluation incorporated CBCT-derived data, taking into account both the morphological characteristics of the alveolar ridge and quantitative density parameters. Statistical analysis was carried out using IBM SPSS Statistics 26. The results are presented as mean ± standard deviation (M ± SD). Differences between groups were assessed using Student's t-test and one-way analysis of variance (ANOVA), with the level of statistical significance set at $p < 0.05$. The study was conducted in accordance with the principles of the Declaration of Helsinki [12] and was approved by the local ethics committee of Osh State University (Protocol No. 4, dated 15 December 2024). Written informed consent was obtained from all participants prior to inclusion in the study.

RESULTS AND DISCUSSION

According to the CBCT findings, the mean bone density in the anterior mandible was 944.9 ± 207 HU, which markedly exceeds the corresponding values observed in the anterior maxilla (715.8 ± 190 HU) and, in particular, in the posterior maxilla (455.1 ± 122 HU). These values correspond to type D1 according to the Lekholm & Zarb classification [11], characterised by a predominance of dense cortical bone. Such structural features provide high mechanical strength and are favourable for successful implant osseointegration. Table 1 presents comparative data on mandibular bone mineral density across different anatomical regions, stratified by dentition status.

Table 1. Comparative values of mandibular bone mineral density (BMD) according to anatomical region and dentition status

Zone of research	Control group (n = 25)	Main group (edentulous, n = 25)	p
Anterior zone (3.3-4.3)	944.9 ± 207	910.2 ± 198	>0.05
Premolar zone (4.5-5.5)	826.4 ± 175	643.8 ± 162	<0.05
Molar zone (6.5-7.5)	789.7 ± 160	512.5 ± 148	<0.01

Source: developed by the authors

The data presented in Table 1 indicate that the highest BMD values are observed in the anterior mandible, where density exceeds 900 HU, corresponding to type D1 according to the Lekholm & Zarb classification [11]. Differences between the study and control groups in the anterior region were not statistically significant ($p > 0.05$). In the premolar and molar regions, a significant reduction in BMD was observed in edentulous patients, reflecting a shift in bone structure towards type D3-D4. Figure 1 illustrates the distribution of BMD across the anterior, premolar, and molar regions of the mandible. Patients with intact dentition exhibited significantly higher bone density compared with individuals with bilateral posterior tooth loss. The most pronounced decrease was observed in the molar region, where density values corresponded to type D3-D4. Mandibular bone is characterised by a high degree of homogeneity and low porosity, particularly in the anterior region. In this anatomical segment, the cortical layer is well-developed and constitutes a substantial proportion of the total bone thickness, providing increased rigidity and resistance to mechanical stress. The cancellous bone exhibits a dense, well-organised trabecular structure with relatively small inter-trabecular spaces, further enhancing the biomechanical stability of the bone matrix.The high degree of mineralisation and structural uniformity in the anterior mandible create favourable conditions for achieving reliable primary stability of dental implants. In the studied regions, the mean alveolar bone height was 8.2 ± 1.4 mm. This reduces the likelihood of early implant micromovements, minimises the risk of fibrous capsule formation, and supports complete osseointegration. Moreover, these morphological characteristics allow, in certain clinical scenarios, the use of immediate or early functional loading protocols, which can shorten the duration of prosthetic rehabilitation, improve treatment predictability, and enhance patient quality of life (Fig. 2).

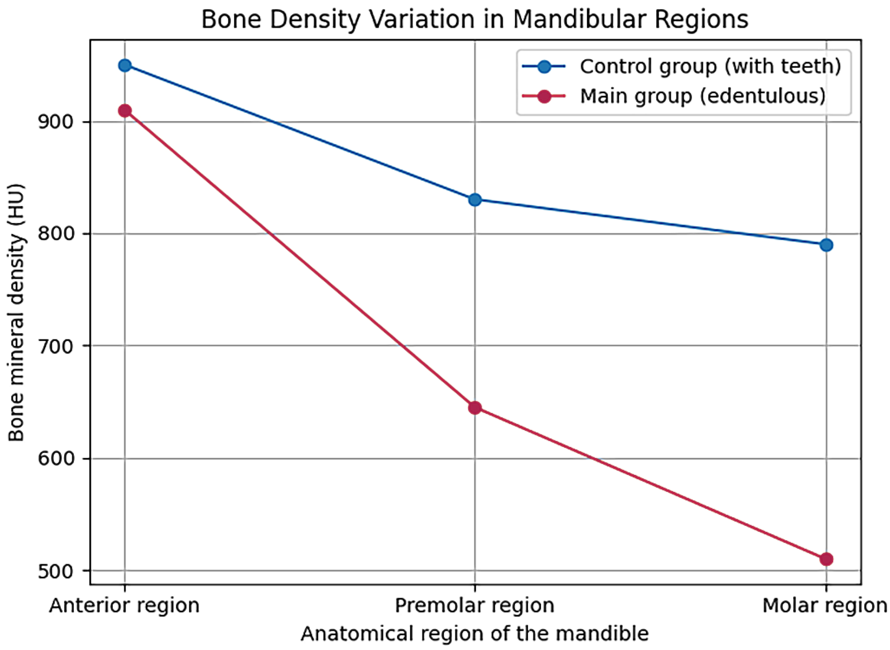

Figure 1. Mean BMD (HU) across different anatomical regions of the mandible in dentate and edentulous patients
Source: developed by the authors

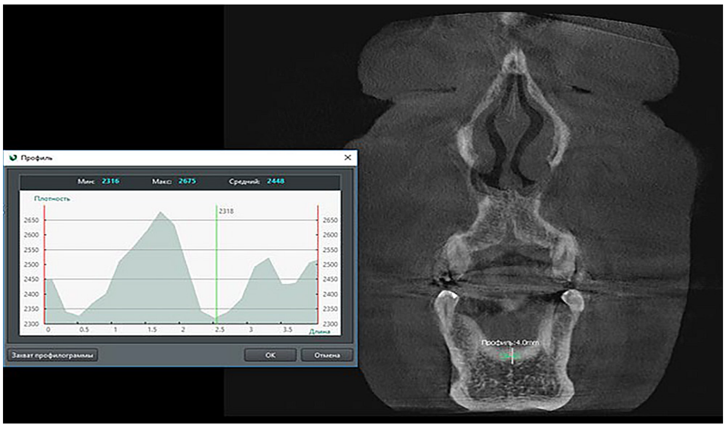

Figure 2. Morphological features bone tissue of anterior zone of mandible
Source: developed by the authors

According to CBCT data, a male patient demonstrated a mean bone density of 2,675 HU in the anterior mandible. These findings indicate an extremely high degree of bone mineralisation, with a pronounced predominance of dense cortical bone. Such values correspond to dense compact bone (type D1 according to the Lekholm & Zarb classification [11]), characterised by minimal cancellous bone and high mechanical strength. This bone type provides substantial primary implant stability due to its high density and resistance to deformation. However, when working with bone of such high density, a careful preparation protocol is required, including controlled drill speed and adequate irrigation, to prevent overheating and thermal necrosis of the bone tissue. The anterior mandible, with its high density and uniform structure, represents a preferred site for dental implant placement, particularly in the absence of posterior teeth. These anatomical and physiological features contribute to high primary implant stability and successful osseointegration, as confirmed by CBCT findings and clinical observations.

Assessment of the need for bone augmentation in cases of mandibular resorption requires comparing the residual alveolar ridge dimensions with the minimum requirements for reliable osseointegration and aesthetic rehabilitation. Evaluation criteria for resorption include horizontal deficiency: when the alveolar ridge width is less than 5 mm, the risk of inadequate implant–cortical bone contact increases, reducing primary stability. When the width falls below 3-4 mm, placement of standard implants without prior ridge augmentation is generally not feasible (Fig. 3).

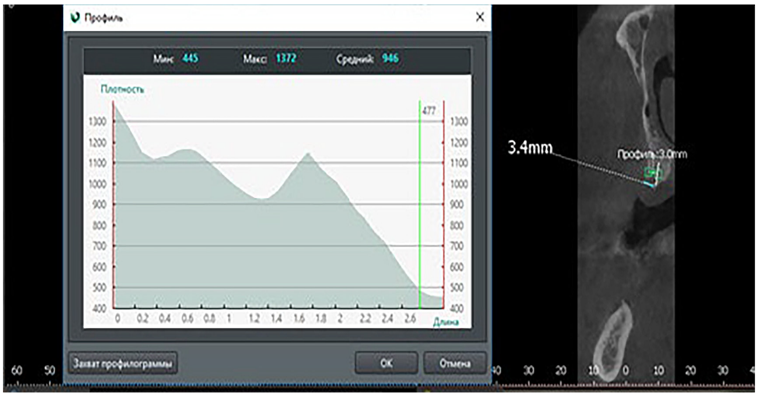

Figure 3. Horizontal bone deficiency due to reduced width of the mandibular alveolar ridge
Source: developed by the authors

CBCT revealed that the alveolar ridge width at the examined site measured 3.4 mm. These morphometric findings indicate a pronounced horizontal bone deficiency and a significant reduction in alveolar ridge volume in the bucco-lingual direction. At this ridge width, there is insufficient bone to provide an adequate circumferential support around the implant, which is essential for achieving primary stability and predictable osseointegration. According to widely accepted clinical criteria, the minimum bone width required for placement of standard implants (3.5-4.0 mm in diameter) should allow at least 1.0-1.5 mm of bone on either side of the implant. In the present case, the available bone falls considerably below these recommendations, increasing the risk of cortical plate perforation, loss of primary stability, and the development of early postoperative complications.

Thus, performing implant placement without prior horizontal bone augmentation or other ridge-width enhancement techniques – such as GBR, ridge splitting, or the use of bone blocks – appears clinically unjustified and carries a high risk of treatment failure. Vertical deficiency, defined as alveolar bone height <8 mm, does not provide sufficient depth for the intraosseous portion of the implant (typically ≥10 mm). Classification based on residual bone height (A-D) is as follows: A (≥10 mm) – augmentation not required; B (7-9 mm) – short implants or minimal augmentation may be considered; C (4-6 mm) and D (0-3 mm) – mandatory pre-implant augmentation. This classification is illustrated in Figure 4.

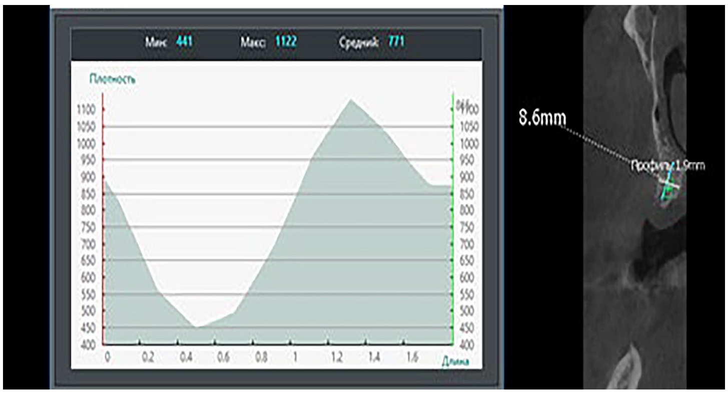

Figure 4. Vertical bone deficiency characterised by reduced height of the mandibular alveolar ridge
Source: developed by the authors

Thus, an alveolar ridge height of less than 8 mm is considered insufficient to ensure adequate depth for positioning the intraosseous portion of a standard dental implant. Under such conditions, the use of standard-length implants (10 mm or more) is limited, which increases the risk of inadequate primary stability and unfavorable distribution of occlusal load. When the bone height ranges between 7-9 mm (conditional category B), the use of short implants (6-8 mm) may be considered, provided that the ridge width is sufficient and bone density parameters are satisfactory. In such clinical situations, implant placement without prior vertical bone augmentation may be feasible; however, the decision should be made based on the morphology of the alveolar ridge, the thickness of the cortical plates, the proximity of critical anatomical structures (such as the mandibular canal), and the anticipated functional load. Therefore, the assessment of the vertical dimension using CBCT data plays a crucial role in selecting the appropriate implant length and determining the need for vertical bone augmentation. The classification of residual alveolar bone height (A-D) is an important tool in dental implant planning, particularly in cases of severe mandibular atrophy (Table 2). This system allows for evaluation of the necessity and extent of bone augmentation, as well as selection of the optimal surgical approach.

Table 2. Classification of residual bone height (A-D)

Class	Residual bone height (mm)	Clinical characteristics	Recommended treatment strategy
A	≥10 mm	Sufficient bone volume for implant placement without additional augmentation	Standard implant placement without the need for bone grafting
B	7-9 mm	Moderate bone height deficiency; implant placement possible with caution	Placement of short implants or minimal augmentation may be considered
C	4-6 mm	Significant bone height deficiency; increased risk of insufficient osseointegration	Preoperative vertical augmentation is required, e.g., GBR
D	0-3 mm	Critical bone deficiency; implant placement not feasible without substantial bone augmentation	Mandatory vertical augmentation with delayed implant placement after healing

Source: developed by the authors

Clinical significance of the classification: 1) Class A: allows implant placement without additional procedures, ensuring high primary stability of implants; 2) Class B: requires careful evaluation; the use of short implants or minimal augmentation may be considered to achieve sufficient stability; 3) Class C: necessitates vertical augmentation procedures, such as GBR, to obtain adequate bone volume prior to implant placement; 4) Class D: requires a comprehensive approach with mandatory augmentation and delayed implant placement following complete healing and the formation of new bone volume. Thus, the A-D classification of residual bone height provides clear guidelines for planning dental implant treatment in cases of mandibular atrophy. It facilitates the assessment of the need for and extent of bone augmentation, the selection of an appropriate treatment strategy, and the prediction of implant osseointegration outcomes. This classification is particularly important when deciding between immediate and delayed implant placement, as well as when planning the use of techniques such as GBR.

In cases of significant reduction in alveolar ridge width, typically associated with long-term edentulism in the posterior region, extensive horizontal bone atrophy develops (Fig. 5). Under such clinical conditions, the available bone volume is insufficient to provide a circumferential bone envelope around the implant, which is a critical requirement for achieving primary stability and subsequent osseointegration.

Figure 5. Severe horizontal atrophy of the alveolar ridge associated with long-term edentulism
Source: developed by the authors

CBCT revealed horizontal atrophy of the mandibular alveolar ridge, characterised by a reduction in its buccolingual width and thinning of the cortical plates. Morphometric parameters indicate a decreased bone volume in the planned implant site. The mean relative bone density in the examined area was 287 HU, corresponding to moderately dense bone with a predominance of cancellous structure and a relative reduction of the cortical component. These findings highlight the need for careful assessment of primary implant stability and possible modification of the surgical approach, taking bone quality into account. In cases of a characterised vertical defect of the alveolar ridge, accompanied by a reduction in bone height within a limited area, unfavorable conditions arise for optimal implant positioning. This type of atrophy is characterised by insufficient apico-coronal bone dimension while the ridge width remains preserved or relatively preserved. The most common indication for GBR in vertical deficiency is the need to restore alveolar ridge height to ensure proper three-dimensional implant positioning in accordance with prosthetic requirements and to achieve a stable soft tissue contour. Vertical augmentation enables the creation of sufficient bone volume to achieve primary implant stability, reduce the risk of thread exposure, and ensure a favorable aesthetic outcome in the peri-implant region (Fig. 6).

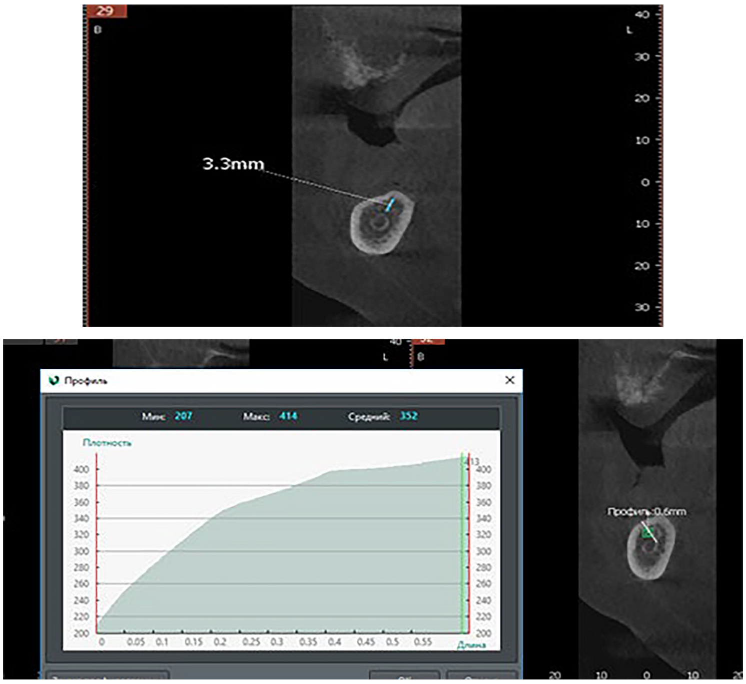

Figure 6. Localised vertical defect of the alveolar ridge as an indication for GBR
Source: developed by the authors

A reduced distance from the crest of the alveolar ridge to the mandibular canal was observed, which limited the use of standard-length implants without prior bone augmentation. The mean relative bone density in the examined regions was 414 HU, indicating bone of moderate to high density with a well-defined cortical layer. The analysis demonstrated that bone density values ranged from 287 ± 64 HU in cases of pronounced horizontal atrophy to 435 ± 58 HU in combined bone defects. Despite satisfactory bone quality, insufficient ridge height necessitated modification of the surgical approach, including consideration of vertical GBR or the use of short implants, taking into account anatomical constraints and the anticipated functional load.

Simultaneous reduction in both the height and width of the alveolar ridge resulted in combined bone deformities characterised by a pronounced three-dimensional volume deficiency. Such changes often developed following tooth extraction complicated by inflammatory processes (including cyst-related conditions), as well as as a result of traumatic injuries leading to significant bone loss. In the presence of combined horizontal and vertical bone deficiencies, simultaneous implant placement generally does not allow achievement of adequate bone support and primary implant stability. The mean width of the alveolar ridge in areas of partial edentulism was 4.6 ± 0.8 mm. In these clinical situations, a staged surgical approach is preferred: at the first stage, a bone "container" is created using GBR or onlay grafting techniques aimed at restoring the required ridge height and width; at the second stage, following completion of bone regeneration and remodeling, dental implant placement is performed (Fig. 7).

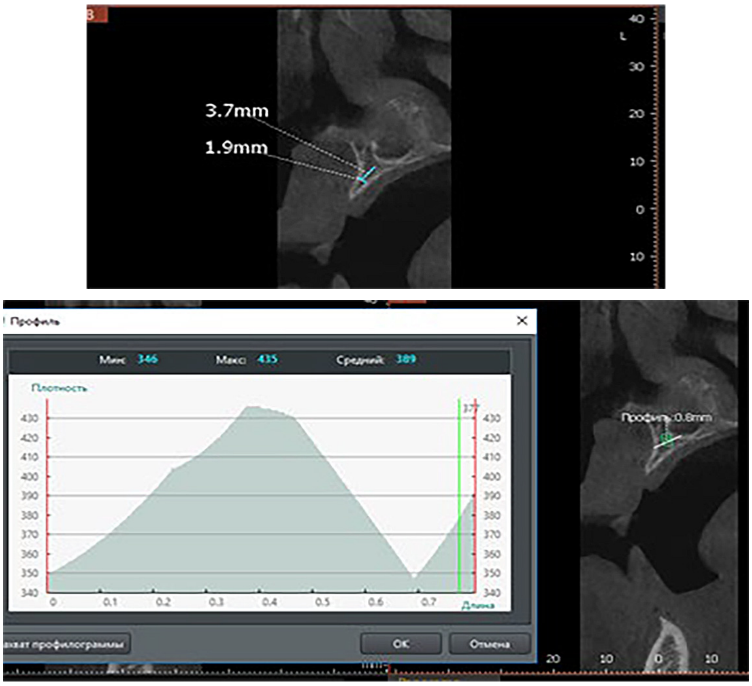

Figure 7. Combined atrophy of alveolar ridge (horizontal0vertical) as a stage of bone augementation
Source: developed by the authors

CBCT revealed combined (horizontal-vertical) atrophy of the mandibular alveolar ridge, characterised by a simultaneous reduction in ridge width in the buccolingual dimension and a decrease in its height in the apico-coronal dimension. Thinning of the cortical plates and alterations in the trabecular architecture were observed, indicating a pronounced three-dimensional bone deficiency in the planned implant site. The mean relative bone density in the examined region was 435 HU, corresponding to bone of moderate density with a relatively preserved cortical component. Despite satisfactory bone quality, the reduction in the linear dimensions of the alveolar ridge limits the possibility of simultaneous placement of implants of standard length and diameter. Under such clinical conditions, preliminary reconstruction of bone volume is required using both horizontal and vertical augmentation techniques to ensure adequate bone support and predictable osseointegration.

The study results demonstrated statistically significant differences in morphometric parameters of the mandibular alveolar ridge between the main group (patients with pronounced atrophy requiring bone augmentation) and the control group (patients with preserved bone volume allowing implant placement without prior grafting).In the main group, the mean values of alveolar ridge width and cortical plate thickness were significantly lower compared to the control group ($p < 0.05$), which was accompanied by a decrease in relative bone density values according to CBCT data. These findings are consistent with systematic reviews indicating that horizontal bone resorption following tooth loss is more pronounced than vertical resorption and reaches clinically significant levels at early stages of edentulism [13, 14].

Comparative analysis showed that when ridge width was less than 5 mm and cortical plate thickness was less than 1 mm, the likelihood of requiring horizontal augmentation increased more than twofold compared to the control group. These data are in agreement with the conclusions of M. Esposito *et al.* [15], emphasising the key role of residual ridge width in selecting GBR techniques. Furthermore, the main group demonstrated greater variability in HU values, indicating heterogeneity of bone quality under atrophic conditions. Similar findings were reported by Y.H. Kim *et al.* [16], who demonstrated a correlation between reduced cortical bone density and decreased primary implant stability. In the control group, bone density and cortical plate thickness values remained within ranges that обеспечивают predictable osseointegration without additional bone grafting, which is consistent with the findings of R. Harikrishnan *et al.* [17] and M. Lyu *et al.* [18], highlighting the relationship between bone density and primary implant stability.

Particular attention should be given to the identified relationship between the duration of edentulism and the degree of ridge reduction: in the main group, with edentulism lasting more than 3 years, the decrease in bone width was significantly more pronounced compared to the control group ($p < 0.05$). These findings support the concept of progressive post-extraction atrophy described in contemporary reviews on alveolar bone remodeling [9]. In the context of regional studies, the obtained results are comparable with previously reported data demonstrating pronounced individual variability in bone density parameters among patients in Kyrgyzstan during implant planning. However, unlike those studies, the present research complements the diagnostic aspect with a comparative analysis including a control group, which allowed for the identification of clinically relevant threshold values of parameters influencing the choice of augmentation technique.

It should be noted that most publications from 2020-2025 focus on the effectiveness of specific reconstruction methods. In a systematic review, M. Eguren *et al.* [19] demonstrated that gray values (GV) obtained from CBCT cannot be directly converted into HU due to the lack of sufficient clinical validation of their diagnostic applicability. T.R.P. Arvind *et al.* [20], in a retrospective CBCT-based study, showed the effectiveness of fractal analysis for assessing the microstructure of alveolar bone around impacted maxillary canines. N.A. Hassan & A.S.D. Al-Radha [21] reported that CBCT is an effective method for evaluating both bone quality and quantity when planning immediate implant placement in the maxillary central incisor region, taking into account the dental arch form. M.S. Agrawal *et al.* [22], also using CBCT and fractal analysis, demonstrated differences in bone density between buccally and palatally impacted canines. At the same time, direct comparison of morphometric characteristics in patients undergoing different clinical treatment strategies remains limited. Y.-J. Choi *et al.* [23] described the use of CT/CBCT for pre-implant bone assessment, emphasising the importance of both bone quality and quantity for predicting primary implant stability. The conducted comparative analysis not only confirms existing literature data but also substantiates an integrative clinical decision-making algorithm. Thus, the differences identified between the main and control groups indicate that a combined assessment of ridge width, alveolar height, cortical plate thickness, and HU values based on CBCT data provides an objective basis for selecting the appropriate bone augmentation method. This approach enhances the predictability of implant treatment outcomes and aligns with current trends in evidence-based implantology.

CONCLUSIONS

The conducted clinical and radiological study enabled a comprehensive and quantitative assessment of the morphometric parameters of mandibular alveolar ridge resorption, as well as determination of their clinical significance in dental implant planning. The mean width of the alveolar ridge in areas of partial edentulism was 4.6 ± 0.8 mm. Notably, in 38.4% of patients, the ridge width was less than 5 mm, which is indicative of a pronounced horizontal bone deficiency and significantly limits the placement of standard-diameter implants without prior bone augmentation. The mean height of the alveolar bone in the examined regions was 8.2 ± 1.4 mm. However, in 31.7% of cases, the ridge height was below 8 mm, creating a risk of insufficient apical implant fixation and necessitating consideration of vertical augmentation or the use of short implants, taking into account anatomical limitations.

Analysis of relative bone density demonstrated values ranging from 287 ± 64 HU in cases of pronounced horizontal atrophy to 435 ± 58 HU in combined defects. These values predominantly correspond to D2-D3 bone types, indicating a moderate ratio between cortical and cancellous components. A statistically significant association ($p < 0.05$) was identified between edentulism duration exceeding 3 years and both a reduction in ridge width and a decrease in cancellous bone density, confirming the progressive nature of atrophic changes over time.

The results indicate that the need for bone augmentation in mandibular resorption is directly determined by the severity of horizontal and vertical bone deficiency. When ridge width is less than 5 mm and height is below 7-8 mm GBR, ridge splitting, or the use of bone blocks represent clinically justified preparatory stages prior to implant placement. The choice of technique should be based on a comprehensive evaluation of linear and spatial defect parameters, cortical plate quality, bone density, and the patient's overall systemic condition. Future research perspectives include the development of a standardised algorithm for interpreting CBCT parameters to predict primary implant stability, as well as the creation of a differentiated system for selecting bone augmentation methods based on the integration of morphometric, biomechanical and clinical risk factors.

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CONFLICT OF INTEREST

None.

REFERENCES

[1] Park CS, Kang SR, Kim JE, Huh KH, Lee SS, Heo MS, et al. Validation of bone mineral density measurement using quantitative CBCT image based on deep learning. Sci Rep. 2023;13:11921. DOI: 10.1038/s41598-023-38943-8

[2] Avila-Ortiz G, Elangovan S, Kramer KW, Blanchette D, Dawson DV. Effect of alveolar ridge preservation after tooth extraction: A systematic review and meta-analysis. J Dent Res. 2014;93(10):950–8. DOI: 10.1177/0022034514541127

[3] Yildirim O, Eberlikose H, Gulen O. Morphological and cortical bone assessment of the edentulous posterior mandible using CBCT implications for implant planning and mandibular cortical index evaluation. BMC Oral Health. 2025;25(1):1893. DOI: 10.1186/s12903-025-06951-x

[4] Lorenz J, Ghanaati S, Aleksic Z, Milinkovic I, Lazic Z, Magić M, et al. Horizontal guided bone regeneration of the posterior mandible to allow implant placement: 1-year prospective study results. Clin Oral Impl Res. 2024:36(1):100–16. DOI: 10.1111/clr.14363

[5] Starch-Jensen T, Vitenson J, Deluiz D, Østergaard KB, Tinoco EMB. Lateral alveolar ridge augmentation with autogenous tooth block graft compared with autogenous bone block graft: A systematic review. J Oral Maxillofac Res. 2022;13(1):e1. DOI: 10.5037/jomr.2022.13101

[6] Suthakar P, Gupta A, Chansoria H, Soni M, Pandey S, Patil M. Revolutionizing implant success: CBCT-guided mandibular ridge resorption assessment with genial tubercle as a key reference. J Pharm Bioallied Sci. 2025;17(2):1949–51. DOI: 10.4103/jpbs.jpbs_1663_24

[7] Proceedings of the 21st All-Russian Dental Forum, February 12-14, 2024, Moscow, Russia. Russ J Stomatol. 2024;17(2):35–75. DOI: 10.17116/rosstomat20241702135

[8] Eshiev AM, Abirova RE. Evaluation of bone tissue biotypes in the area of chewing teeth of the upper jaw in men and women of different age groups using cone beam computed tomography. Sci Rev Med Sci. 2025;6:5–11. DOI: 10.17513/srms.1460

[9] Eshiev AM, Israilov BA. Modified methods for the treatment of chronic periodontitis. Int J Hum Nat Sci. 2025;11–2:306–13. DOI: 10.24412/2500-1000-2025-11-2-306-313

[10] Abdymechinova AK, Bazarbekov MM, Avazali uulu M, Bakasov AT, Toktobaeva GA, Fayzullaeva AM, et al. Results of treatment of traumatic brain injury and its complications. Eur Asian Health J. 2020:12(4):21–9.

[11] Johansson B. Bone grafts and dental implants in the reconstruction of the severely atrophied, edentulous maxilla [Doctoral dissertation]. Uppsala: Uppsala University; 2001.

[12] The Declaration of Helsinki. 2013 [cited 2026 February 18]. Available from: https://www.wma.net/what-we-do/medical-ethics/declaration-of-helsinki/

[13] Materials of the 22nd All-Russian Dental Forum 2025, Moscow, Russia. Russ J Stomatol. 2025;18(3):88–144. DOI: 10.17116/rosstomat20251803188

[14] Tsitsiashvili AM, Panin AM, Lepilin AV, Chuvilkin VI, Akhmedov GD. Implant surgery in partially edentulous patients with alveolar bone deficiency. Stomatologiia. 2019;98(1):30–3. DOI: 10.17116/stomat20199801130

[15] Esposito M, Grusovin MG, Felice P, Karatzopoulos G, Worthington HV, Coulthard P. The efficacy of horizontal and vertical bone augmentation procedures for dental implants – a Cochrane systematic review. Eur J Oral Implantol. 2009;2(3):167–84.

[16] Kim YH, Shin JY, Lee A, Park S, Han SS, Hwang HJ. Automated cortical thickness measurement of the mandibular condyle head on CBCT images using a deep learning method. Sci Rep. 2021;11(1):14852. DOI: 10.1038/s41598-021-94362-7

[17] Harikrishnan R, Subhashree R, Ganesh SB, Ashok V. Relation between bone density and primary stability in the posterior mandibular region in patients undergoing dental implant treatment: A retrospective study. J Long Term Eff Med Implants. 2021;31(2):71–9. DOI: 10.1615/jlongtermeffmedimplants.2021035972

[18] Lyu M, Xu D, Zhang X, Yuan Q. Maxillary sinus floor augmentation: A review of current evidence on anatomical factors and a decision tree. Int J Oral Sci. 2023;15(1):41. DOI: 10.1038/s41368-023-00248-x

[19] Eguren M, Holguin A, Diaz K, Vidalon J, Linan C, Pacheco-Pereira C, et al. Can gray values be converted to Hounsfield units? A systematic review. Dentomaxillofac Radiol. 2022;51(1):20210140. DOI: 10.1259/dmfr.20210140

[20] Arvind TRP, Jain RK, Nagi R, Tiwari A. Evaluation of alveolar bone microstructure around impacted maxillary canines using fractal analysis in Dravidian population: A retrospective CBCT study. J Contemp Dent Pract. 2022;23(6):593–600.

[21] Hassan NA, Al-radha ASD. CBCT Evaluation of quality and quantity of bones for immediate implant treatment planning in central incisor area in relation to arch form. Sci World J. 2023;2023:8863318. DOI: 10.1155/2023/8863318

[22] Agrawal MS, Nambiar SS, Agrawal J, Shetti SS, Fulari SA. A comparative evaluation of bone density surrounding buccally and palatally impacted canines utilizing fractal analysis: A Retrospective Cone-Beam Computed Tomography (CBCT) study. Cureus. 2025;17(4):e82761. DOI: 10.7759/cureus.82761

[23] Choi YJ, Jun SH, Song YD, Chang MW, Kwon JJ. CT scanning and dental implant. In: CT scanning – techniques and applications. London: InTech; 2011. P. 229–50. DOI: 10.5772/19250

Конус нурлуу компьютердик томографияны колдонуу менен астыңкы жаак сөөгүнүн ар кандай аймактарындагы тыгыздыгынын өзгөрмөлүүлүгүн баалоо

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Аннотация. Конус нурлуу компьютердик томография кеңири колдонулганына карабастан, кортикалдык жана трабекулярдык сөөктүн тыгыздыгынын аймактык айырмачылыктары азырынча аз изилденген. Бул изилдөөнүн максаты – астыңкы жаактын ар кайсы аймактарындагы сөөктүн тыгыздыгын баалоо жана имплантатты орнотуудан мурун сөөктү чоңойтууну талап кылган шарттарды аныктоо болуп саналат. Методологияга конус нурлуу компьютердик томографиянын маалыматтарын талдоо, астыңкы жаактын алдыңкы, премолярдык жана азуу тиштеринин аймактарындагы сөөктүн тыгыздыгын өлчөө киргизилген. Сөөктүн максималдуу тыгыздыгы астыңкы жаактын алдыңкы бөлүгүндө байкалып, контролдук топто орточо эсеп менен 944,9 ± 207 HU жана тишсиз бейтаптарда (адентия) 910,2 ± 198 HU түзгөн ($p > 0,05$). Премолярдык аймакта тыгыздык тишсиз бейтаптарда 643,8 ± 162 HU чейин төмөндөгөн, ал эми тиши сакталган бейтаптарда бул көрсөткүч 826,4 ± 175 HU болгон ($p < 0,05$). Тыгыздыктын эң байкаларлык төмөндөшү азуу тиштери бар бейтаптарда байкалган: тишсиз бейтаптарда бул көрсөткүч 512,5 ± 148 HU түзгөн, ал эми контролдук топто 789,7 ± 160 HU ($p < 0,01$) болгон. Алынган жыйынтыктар менен кошо жаак сөөгүнүн дисталдык бөлүгүнүн тыгыздыгынын төмөндөшү кортикалдык катмардын мүнөздөмөлөрүнүн начарлашы менен коштолорун, бул имплантаттардын баштапкы туруктуулугун төмөндөтүшү мүмкүн экенин көрсөттү. Астыңкы жаак сөөгүнүн тыгыздыгындагы аныкталган аймактык айырмачылыктарды имплanттардын өлчөмдөрүн тандоодо жана сөөктү чоңойтуу (аугментация) көлөмүн пландаштырууда, айрыкча узак мөөнөттүү адентия менен ооруган бейтаптарда эске алуу керек. Алынган маалыматтар имплантация тактикасын тандоо, сөөктү чоңойтуу зарылдыгын аныктоо жана хирургиялык дарылоонун алдын ала айтуу мүмкүнчүлүгүн жакшыртуу үчүн маанилүү болуп саналат

Негизги сөздөр: астыңкы жаак сөөгү; сөөктүн минералдык тыгыздыгы; морфометрикалык көрсөткүчтөр; альвеолярдык өсүндүсү; сөөк тканынын регенерациясы

Оценка вариабельности плотности костной ткани нижней челюсти в разных участках по данным конусно-лучевой компьютерной томографии

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Аннотация. Несмотря на широкое применение конусно-лучевой компьютерной томографии, региональные различия плотности кортикальной и трабекулярной ткани изучены недостаточно. Цель исследования состояла в оценке плотности костной ткани нижней челюсти в разных отделах и выявлении условий, при которых требуется предварительное увеличение объёма кости перед имплантацией. Методология включала анализ данных конусно-лучевой компьютерной томографии с измерением плотности костной ткани в переднем, премолярном и молярном отделах нижней челюсти. Обнаружено, что максимальная плотность костной ткани наблюдалась в переднем отделе нижней челюсти и составляла в среднем 944,9 ± 207 HU в контрольной группе и 910,2 ± 198 HU при адентии ($p > 0,05$). В премолярной зоне при отсутствии зубов плотность снижалась до 643,8 ± 162 HU по сравнению с 826,4 ± 175 HU у пациентов с сохранённым зубным рядом ($p < 0,05$). Наиболее выраженное уменьшение плотности выявлено в молярной области, где показатели составили 512,5 ± 148 HU при адентии против 789,7 ± 160 HU в контрольной группе ($p < 0,01$), что подтверждает влияние длительной потери жевательных зубов на качество костной ткани. Результаты также показали, что снижение плотности в дистальных отделах нижней челюсти сопровождается ухудшением характеристик кортикального слоя, что может снижать первичную стабильность имплантатов. Выявленные региональные различия плотности костной ткани следует учитывать при выборе размеров имплантатов и планировании объёма костной аугментации, особенно у пациентов с длительной адентией. Полученные данные важны для выбора тактики имплантации, определения необходимости костной аугментации и повышения предсказуемости хирургического лечения

Ключевые слова: нижняя челюсть; минеральная плотность кости; морфометрические показатели; альвеолярный отросток; регенерация костной ткани