А.Д. Цыретарова

ПЛОТНОСТЬ КОСТНОЙ ТКАНИ ЧЕЛЮСТЕЙ У ЖЕНЩИН МОЛОДОГО ВОЗРАСТА: КЛКТ-ИССЛЕДОВАНИЕ ДЛЯ ПЛАНИРОВАНИЯ ХИРУРГИЧЕСКИХ ВМЕШАТЕЛЬСТВ И ДЕНТАЛЬНОЙ ИМПЛАНТАЦИИ

Научный руководитель: канд. мед. наук, доц. Е.В. Максимович
Кафедра хирургической стоматологии
Белорусский государственный медицинский университет, г. Минск

A.D. Tsyretarova

BONE DENSITY OF THE JAWS IN YOUNG FEMALES: A CBCT-BASED STUDY FOR SURGICAL AND DENTAL IMPLANTOLOGY PLANNING

Tutor: PhD in Medicine, associate professor E.V. Maksimovich
Department of Oral Surgery
Belarusian State Medical University, Minsk

Резюме. Проведено КЛКТ-исследование у 13 женщин (медиана 38,5 года) на фоне стабильного уровня эстрогенов. Измерения выполнены в шести апикальных областях. Установлен градиент: область резцов (779,3 HU) > нижнечелюстные моляры (694,3 HU) > верхнечелюстные моляры (615,3 HU). Кость D4 не выявлена, что отражает защитное действие эстрогенов.

Ключевые слова: плотность костной ткани, КЛКТ, классификация качества кости по Misch, дентальные имплантаты, эстрогены.

Resume. A CBCT-based study of 13 young females (median 38.5 years) with stable estrogen levels was performed at six apical sites. A density gradient was established: incisors (779.3 HU) > mandibular molars (694.3 HU) > maxillary molars (615.3 HU). No D4 bone was observed, reflecting estrogen's protective effect.

Keywords: bone density, CBCT, Misch bone density classification, dental implants, estrogens.

Relevance. The success of oral surgical interventions–from extraction of impacted second molars to achieving primary stability in dental implants–depends critically on alveolar bone quality. Bone density, measured in Hounsfield Units (HU) using Cone Beam Computed Tomography (CBCT), reflects bone strength [1,2]. According to the Misch classification, bone density is categorized into four types: D1 (>1250 HU), D2 (850–1250 HU), D3 (350–850 HU), and D4 (150–350 HU) [3]. Estrogens play a fundamental role in bone homeostasis. In young females of reproductive age (18–44 years according to WHO definition), stable physiological estrogen levels preserve bone mineral density, in contrast to the postmenopausal state where estrogen deficiency leads to accelerated bone resorption with an annual loss of 1–3% of bone mass [4,5]. Understanding bone density distribution under normal hormonal conditions is clinically critical for surgical planning before age-related decline begins.

Aim: to characterize bone density values (in HU) at six anatomical sites of the maxilla and mandible in young female patients using CBCT, classify them according to Misch, and formulate clinically applicable conclusions for surgical and dental implantology planning.

Objectives:

1. To measure mean bone density (HU) at six standardized apical sites: mandibular second molars (right/left), mandibular central incisors (right/left), and maxillary first molars (right/left).

2. To assign a Misch bone density class to each anatomical site.

3. To assess right-left symmetry of bone density values.

4. To formulate evidence-based clinical recommendations for extraction difficulty prediction and dental implant planning based on the obtained density values.

Materials and methods. A retrospective CBCT analysis was conducted on 13 young female patients attending the 20th Outpatient Polyclinic in Minsk. Age ranged from 20 to 43 years, median age 38.5 years (lower quartile 34 years, upper quartile 41 years). All patients were of reproductive age without postmenopausal influence on bone metabolism. Bone density was measured using CBCT at six standardized apical sites: Sites 1–2 – right and left mandibular second molars; Sites 3–4 – right and left mandibular central incisors (symphysis); Sites 5–6 – right and left maxillary first molars. Mean and standard deviation were calculated for each site. The Misch classification was applied for clinical interpretation.

Results and their discussion. The analysis of CBCT scans revealed distinct patterns of bone density distribution across the six anatomical sites. Beginning with the mandibular second molars (Sites 1–2), the mean bone density was 694.3 ± 117.1 HU on the right side (fig. 1) and 686.0 ± 143.4 HU on the left (fig. 2). Both values correspond to Misch class D3, which is characterized by thin porous compact bone. Notably, the difference between the right and left sides was only 8.25 HU, confirming excellent bilateral symmetry in healthy young females. These findings are consistent with previously reported mean densities of 650–700 HU in the mandibular molar region of young adults [6].

Fig. 1 – sSite 1 (right mandibular second molars). CBCT scans of three individuals showing nearest the cohort mean for periapical bone density (HU); a – 666 HU; b – 686 HU; c – 705 HU. Mean value for site 1 – 694.3 HU

Fig. 2 – Site 2 (left mandibular second molars). CBCT scans of three individuals showing nearest the cohort mean for periapical bone density (HU); a – 635 HU; b – 776 HU; c – 631 HU. Mean value for site 2 – 686 HU

Moving to the mandibular central incisors (Sites 3–4), a considerably higher density was observed. The mean values were 779.3 ± 125.9 HU on the right and 774.6 ± 117.1 HU on the left, approaching the D2 range (850–1250 HU) (tbl. 1).

Tbl. 1. Mean bone density values (HU) in mandibular central incisor region (symphysis)

Site	Mean HU	Misch class	Interpretation
Right (Site 3)	**779.3 ± 125.9**	Approaching D2	High density. Excellent primary stability. Preferred graft donor site.
Left (Site 4)	**774.6 ± 117.1**	Approaching D2	High density. Excellent primary stability.
Right–left difference	**4.67 HU**	–	Symmetrical

This region, known as the symphysis, represents the densest area of the human jaws. The minimal right-left difference of 4.67 HU further supports the presence of bilateral symmetry. Previous studies have demonstrated that the anterior mandible exhibits the highest cortical bone density values in females aged 20–40 years [7]. Moreover, the high density of the symphysis confirms its well-established suitability as the preferred donor site for bone grafting [8].

In contrast, the maxillary first molars (Sites 5–6) showed the lowest density values among all measured sites. The mean density was 541.6 ± 111.8 HU on the right and 615.3 ± 148.1 HU on the left, both remaining within the D3 range but substantially lower than the mandibular sites. Unlike the mandible, the right-left difference in the maxilla was more pronounced at 73.7 HU, suggesting higher inter-individual variability in this region. This variability is likely attributable to differences in maxillary sinus pneumatization among patients.

Taken together, these findings reveal a clear and predictable anatomical gradient: density is highest in the mandibular incisor region (approaching D2), followed by the mandibular molar region (D3), and lowest in the maxillary molar region (D3) (fig. 3).

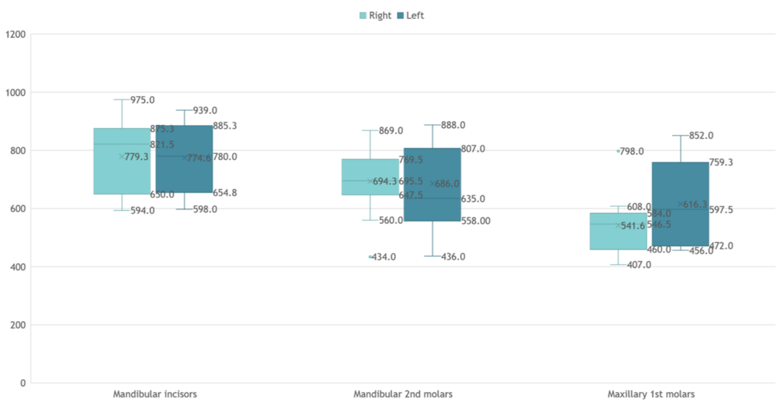

Fig. 3 – Bone density ranges site 1-6. Density is highest and most uniform in the symphysis, followed by mandibular molars and lowest, with widest variation in maxillary molars

Specifically, bone density decreases by approximately 35% from the symphysis (779.3 HU) to the maxillary molar region (541.6 HU). One of the most striking observations was the complete absence of D4 bone (150–350 HU) in any of the 13 patients. This finding strongly reflects the protective effect of stable estrogen levels against severe density reduction. By way of comparison, postmenopausal patients commonly develop D4 bone in the maxilla within 5–10 years after menopause, when estrogen deficiency accelerates bone resorption [4,5].

The clinical implications of these density gradients are substantial. To illustrate, consider the extraction of an impacted mandibular second molar, where the expected density is approximately 690 HU (class D3). During such a procedure, the surgical bur generates frictional heat. When bone temperature exceeds 47°C, thermal osteonecrosis occurs [9]. Because D3 bone is moderately dense, it tends to trap heat rather than dissipating it effectively. Therefore, generous irrigation (≥50 mL/min) combined with intermittent light pressure is strongly recommended to prevent bone injury. Furthermore, if the same patient requires a small bone graft, the surgeon must choose an appropriate donor site. The symphysis, with a density of approximately 777 HU (near D2), is clearly the preferred option. In contrast, lower-density grafts harvested from the maxillary tuberosity (approximately 580 HU) resorb significantly faster–up to 40% volume loss within 6 months. Turning to implant placement, the expected density in the mandibular molar region of a young female is approximately 690 HU. However, if a preoperative CBCT scan shows density below 500 HU, this should be regarded as a clinical red flag. Possible underlying causes include osteoporosis, vitamin D deficiency, or local inflammation such as a cyst or granuloma. It is critical to note that placing an implant in low-density bone without protocol modification increases the failure risk to 20–30%, compared to less than 5% in normal-density bone. Consequently, for the maxillary molar region which exhibits the lowest density (541.6–615.3 HU, low D3), cautious surgical planning is essential. The use of tapered implants, extended healing periods of 6–9 months, and mandatory preoperative CBCT density assessment are all recommended [10].

Conclusions. This study successfully achieved all four objectives. First, regarding the measurement of mean bone density at the six standardized apical sites, the obtained values were as follows: right mandibular second molar – 694.3 ± 117.1 HU, left mandibular second molar – 686.0 ± 143.4 HU, right mandibular central incisor – 779.3 ± 125.9 HU, left mandibular central incisor – 774.6 ± 117.1 HU, right maxillary first molar – 541.6 ± 111.8 HU, and left maxillary first molar – 615.3 ± 148.1 HU. Second, in terms of assigning Misch bone density classes, the mandibular incisor region approached class D2 (near 850–1250 HU), while both the mandibular and maxillary molar regions corresponded to class D3 (350–850 HU). Notably, no D1 or D4 bone was observed in any patient. Third, with respect to right-left symmetry, the mandible showed excellent bilateral symmetry with differences of only 8.25 HU for the molars and 4.67 HU for the incisors, whereas the maxilla demonstrated greater variability with a difference of 73.7 HU, likely due to individual differences in sinus pneumatization. Fourth and finally, based on the obtained density values, the following evidence-based clinical recommendations can be formulated: for extraction of mandibular second molars (density ~690 HU, class D3), generous irrigation (≥50 mL/min) with intermittent light pressure is recommended to prevent thermal osteonecrosis; for bone graft harvesting, the symphysis (near D2) is the preferred donor site as lower-density grafts resorb faster (up to 40% volume loss within 6 months); for implant placement in the maxillary molar region (low D3), tapered implants and extended healing periods of 6–9 months are advised; and any density below 500 HU in a young female patient should be considered a clinical red flag warranting further investigation for osteoporosis or local pathology.

Literature

1. Pauwels R. et al. CBCT-based bone quality assessment: are Hounsfield units applicable?//Dentomaxillofacial Radiology. – 2015. – Т. 44. – №. 1. – С. 20140238.

2. Gulsahi A. Bone quality assessment for dental implants //Rijeka: InTech. – 2011. – С. 437-52.

3. Rajaraman V. W. A. S. V. MINI-REVIEW REVISITING BONE DENSITY: A REVIEW ON MISCH CLASSIFICATION. – 2021.

4. Eastell R. et al. Postmenopausal osteoporosis //Nature reviews Disease primers. – 2016. – Т. 2. – №. 1. – С. 16069.

5. McClung M. R., Miller P. D., Papapoulos S. E. Osteoporosis: An overview //Primer on the Metabolic Bone Diseases and Disorders of Mineral Metabolism. – 2018. – С. 393-397.

6. Kukhlevskyy Y., Masna Z. CONE BEAM COMPUTED TOMOGRAPHY AS A METHOD OF ANATOMICAL AND FUNCTIONAL IDENTIFICATION OF MAXILLARY AND MANDIBULAR BONE CHANGES //Proceeding of the Shevchenko Scientific Society. Medical Sciences. – 2018. – Т. 52. – №. 1. – С. 148-155.

7. Musaina T. K. Z. et al. Assessment of variations in mandibular cortical bone thickness with its density and their correlation with age and gender–a cone beam computed tomography study //Journal of Indian Academy of Oral Medicine and Radiology. – 2024. – Т. 36. – №. 2. – С. 159-163.

8. Misch C. M. Comparison of intraoral donor sites for onlay grafting prior to implant placement //International Journal of Oral & Maxillofacial Implants. – 1997. – Т. 12. – №. 6.

9. Eriksson A. R., Albrektsson T. Temperature threshold levels for heat-induced bone tissue injury: a vital-microscopic study in the rabbit //The Journal of prosthetic dentistry. – 1983. – Т. 50. – №. 1. – С. 101-107.

10. Johansson B. et al. A clinical study of changes in the volume of bone grafts in the atrophic maxilla //Dentomaxillofacial Radiology. – 2001. – Т. 30. – №. 3. – С. 157-161.