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Rationale for selecting bracket parameters prior to orthodontic treatment in Russian Ministry of Defense servicemen with occlusal anomalies

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ABSTRACT

BACKGROUND: This study evaluated the thickness of the maxillary alveolar process in the anterior teeth using cone-beam computed tomography (CBCT) to determine safe torque and bracket parameters prior to orthodontic treatment in servicemen with distal occlusion (distoclusion).

MATERIALS AND METHODS: In a medical examination in 2024, CBCT data from 58 male servicemen aged 22–30 years old diagnosed with occlusal anomalies (K07.1, K07.2, and K07.3 per the International Classification of Diseases, 10th Revision) were analyzed. Bone thickness at the incisors and canines of the maxillary alveolar process was measured on the buccal and palatal sides using CBCT images in a standard format for processing, storage, transmission, printing, and visualization of medical images (1500×1700 mm). The maximum palatal bone thickness was observed in the anterior teeth region in 68% of the participants. The mean values were 6.96 ± 0.09 mm for the central incisors, 5.67 ± 0.07 mm for the lateral incisors, and 8.6 ± 0.08 mm for the canines. The minimum thickness was 0.4–0.6 mm on the buccal side of the canines of 5% of the participants, whereas the maximum thickness reached 9.6–11.4 mm on the palatal side of the central incisors of 12% of the participants.

RESULTS: These values varied by pathology subclass and the presence of dehiscence or fenestrations identified on CBCT. When planning orthodontic treatment for patients with distoclusion, torque selection for self-ligating brackets on maxillary incisors and canines should account for the individual tooth bone thickness analysis from CBCT data. Brackets with high or standard torque are preferred because they optimize root positioning within the bone during tooth movement.

CONCLUSIONS: Thus, the pretreatment selection of bracket parameters facilitates root movement toward the center of the alveolar process, where bone volume is sufficient, ensuring stable interocclusal contacts. This approach to parameter selection corrects the bite and enhances overall somatic health.

Keywords: occlusal anomaly; interocclusal contacts; servicemen; self-ligating brackets; high torque; standard torque; distoclusion; orthodontic treatment.

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Обоснование выбора параметров брекетов перед ортодонтическим лечением у военнослужащих Минобороны России с аномалиями окклюзии

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АННОТАЦИЯ

Актуальность. Оценивается состояние толщины альвеолярного отростка верхней челюсти в области фронтальных зубов по данным конусно-лучевой компьютерной томографии для определения показаний безопасного выбора торка и параметров брекетов перед ортодонтическим лечением военнослужащих с дистальным прикусом (дистоокклюзией).

Материалы и методы. При проведении ежегодной диспансеризации в 2024 г. проанализированы данные компьютерных томограмм 58 военнослужащих-мужчин с диагнозом аномалия прикуса K07.1, K07.2, K07.3 (по Международной классификации болезней 10-го пересмотра) в возрасте 22–30 лет. Для определения толщины костной ткани в области резцов и клыков альвеолярного отростка верхней челюсти с вестибулярной и нёбной сторон использованы данные конусно-лучевых компьютерных томограмм в формате стандартной обработки, хранения, передачи, печати и визуализации медицинских изображений размером 1500 × 1700 мм. Наибольшая толщина костной ткани с нёбной стороны в области всех фронтальных зубов определялась у 68 % обследуемых. Средние показатели составили для центральных резцов 6,96 ± 0,09 мм; для боковых резцов 5,67 ± 0,07 мм; для клыков 8,6 ± 0,08 мм. Минимальная толщина у отдельных зубов составляла 0,4–0,6 мм в области клыков с вестибулярной стороны у 5 % обследуемых. Максимальная толщина составляла 9,6–11,4 мм с нёбной стороны в области центральных резцов у 12 % обследуемых.

Результаты. Данные зависели от подкласса патологии и наличия дегисценций и фенестраций по результатам конусно-лучевых компьютерных томограмм. При планировании ортодонтического лечения пациентов с дистоокклюзией выбор торка для самолигирующих брекетов резцов и клыков верхней челюсти должен осуществляться с учетом анализа толщины костной ткани каждого из перемещаемых зубов с учетом данных конусно-лучевых компьютерных томограмм. Применение брекетов с высокими и стандартными значениями торка предпочтительно, так как они обеспечивают оптимальное положение корня зуба в пределах костной ткани при проведении перемещений зубов.

Заключение. Таким образом, предварительный выбор параметров брекетов на этапе диагностики способствует движению корня зуба в процессе лечения в середину альвеолярного отростка, где имеется достаточное количество костной ткани, что позволяет достичь стабильных межокклюзионных контактов. Такой подход к выбору параметров аппаратуры помогает пациенту не только получить исправленный прикус, но и улучшить состояние общесоматического здоровья в целом.

Ключевые слова: аномалия окклюзии; межокклюзионные контакты; военнослужащие; самолигирующие брекеты; высокий торк; стандартный торк; дистоокклюзия; ортодонтическое лечение.

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ЭКО•ВЕКТОР

BACKGROUND

Developing an orthodontic treatment plan for malocclusion is the most critical step in clinical orthodontic practice following obtaining patient consent. Clinicians should be familiar with management techniques for various nosologic forms of malocclusion, which allows achieving planned outcomes within optimal timeframes. According to recent studies [1–4], the most common malocclusions in Russia correspond to ICD-10 codes K07.1, K07.2, and K07.3.

Notably, concomitant dental conditions, such as multiple caries, gingivitis, and periodontitis, increase malocclusion prevalence up to 58.5%. In children and adolescents with systemic diseases, the prevalence increases to 74.6%. Dental and arch anomalies accounted for 39.2% of all cases, with overbite observed in 23.4%, class II malocclusion (distoclusion) in 20.1%, open bite in 19.5%, and class III malocclusion (prognathism) in 13.2%.

Our previous research determined high prevalence of dentofacial deformities and the need for orthodontic treatment among children and adolescents who represent the future military personnel reserve. This includes up to 40% of students in pre-university educational institutions of the Russian Ministry of Defense [5] and higher military educational institution applicants [6, 7].

Against previous assumptions, malocclusions do not self-correct with age. Zangieva et al. reported no decline in malocclusion rates in adults [8]. Cephalometric data showed that prevalence of distoclusion increases with age, reaching 59.1%–69.4%, depending on the assessment criteria, whereas that of class III malocclusion reach 12.2%–22.5%.

In clinical practice, the combined form of distoclusion is frequently observed, characterized by dental arch narrowing, a traumatic overbite, and mandibular displacement. Based on diagnostic findings and facial aesthetics, most treatments aim to distalize the posterior segments of the maxilla and create space in the anterior segment to allow for incisor retraction or torque adjustment. These reduce sagittal discrepancies and correct vertical relationships through anterior incisor intrusion and posterior teeth extrusion. The clinical presentation of class II anomalies varies. Cases range from incisor protrusion with sagittal discrepancy to palatal incisor positioning with traumatic occlusion in the anterior segment. In all sagittal plane anomalies, axial inclination of the incisors is disrupted. Given the diversity of clinical presentations, a universal and detailed treatment for this condition remains to be established [9].

In adults with distoclusion, treatment relies on maximum skeletal anchorage, with tooth movements performed within the alveolar bone in the anchorage zones and anterior region [10, 11]. The use of mini-implants (MIs) enables non-extraction approaches while preserving facial aesthetics and achieving optimal cusp-fossa interdigitation in the posterior region. Creating space allows correcting the anterior region. It is employed to distalize the posterior teeth, subsequently modifying the inclination of the anterior teeth to optimize occlusal vertical dimension and reduce sagittal discrepancies. Additionally, it enhances facial aesthetics by correcting anterior dental protrusion and altering lip posture. The success of this technique is characterized by proper placement of MIs, primary implant stability, and adequate space in the retromolar area for distal tooth movement. However, it may be ineffective in cases wherein extraction of the third molars is not feasible owing to their atypical position, associated complications, or contraindications related to the patient's general health. Thus, alternative or adjunctive methods to adjust tooth inclination and manage torque in the anterior segment remain critical.

Tooth movements should be substantiated by cone-beam computed tomography (CBCT) of alveolar bone thickness. During diagnosis, the orthodontist determines the core biomechanical approach and anticipates clinical challenges in tooth movement that may occur during treatment.

Therapy involves selecting bracket prescriptions with torque options to improve tooth positioning and achieve optimal esthetic outcomes. In this context, torque refers to the inclination or angulation of a tooth during treatment. General guidelines for torque selection consider the pretreatment positioning of the anterior teeth and malocclusion classification.

Recommendations for torque selection are often inconsistent; some are based on individual tooth positioning and others on malocclusion class. Notably, torque values correlate with arch size and dental arch length. Devising a treatment plan is challenging for novice clinicians, as torque may need to be selected not for an entire tooth group but for each tooth.

This study aimed to assess the thickness of the maxillary alveolar process using CBCT to establish safe torque parameters and bracket selection criteria prior to orthodontic treatment in servicemen with distoclusion.

MATERIALS AND METHODS

As part of the 2024 annual medical examination, CBCT scans in DICOM format (Digital Imaging and Communications in Medicine format, which is the standard for processing, storing, transmitting, printing, and visualizing medical images) of 58 male servicemen aged 22–30 years serving under contract and diagnosed with distoclusion were analyzed. CBCT was performed using the CS 9000 3D scanner (Carestream Dental, USA). Alveolar bone thickness was measured on the vestibular and palatal sides in the anterior maxillary region at the central and lateral incisors and canines (teeth 1.3–2.3).

The inclusion criteria were presence of malocclusion classified under ICD-10 codes K07.1, K07.2, and K07.3; diagnosis of class II malocclusion (distoclusion); and absence of chronic cardiovascular or endocrine disorders.

To determine tooth angulation and cortical plate thickness, the tooth axis was established using two reference points along the root canal visible on the radiography. Then, the area of periosteal attachment was identified. Vestibular and palatal cortical plate thickness was measured as the perpendicular distance from the tooth axis to the cortical surface at the apex and midpoint between the apex and periosteal level on the palatal side.

The scanning field included the jaws, maxillary sinus, and orbit. The scanning conditions were as follows: voltage, 60–99 kV; current, 4–10 mA; minimum informative slice thickness, 0.2 mm; voxel size, 0.2–0.3 mm; and radiation dose, 90 μSv. The scan field size was 1,500 × 1,700 mm.

CBCT assessed for dehiscence and fenestrations, including their distribution in different teeth, as these limited torque selection (Fig. 1*a*). Sagittal slices were evaluated for localized dehiscence or fenestration affecting specific teeth (Fig. 1*b*, *c*). Data were entered into each patient's medical record.

Statistical analysis was performed using Microsoft Excel and Statgraphics Plus 5.1. Results are presented as $M \pm m$ (M: mean; m: standard error of the mean). $P < 0.05$ indicated significant differences.

This study was approved by the Ethics Committee of the S.M. Kirov Military Medical Academy (protocol no. 260, February 22, 2022).

RESULTS AND DISCUSSION

The study examined CBCT data of patients with skeletal class II malocclusion, divisions 1 and 2. These subclasses

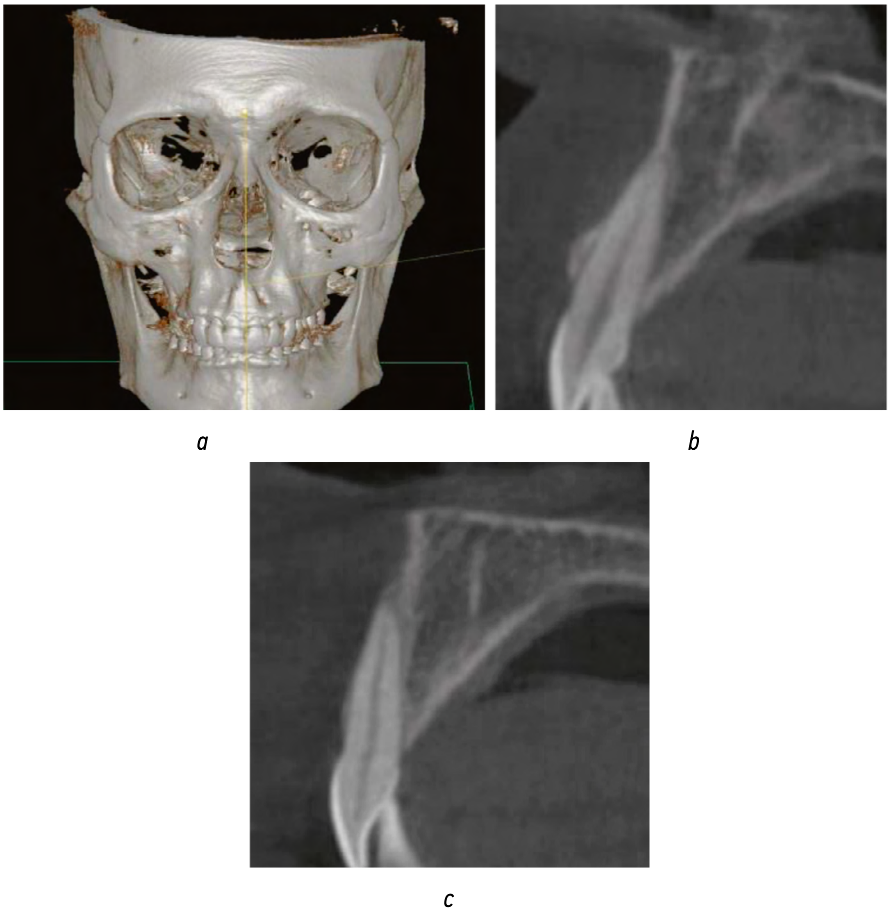

Fig. 1. Cone-beam tomography of a patient with distoclusion: (*a*) 3D reconstruction (16×16 cm); (*b*) sagittal section with fenestration of tooth 1.2; (*c*) sagittal section with dehiscence of tooth 2.1

Рис. 1. Конусно-лучевая томография пациента с дистооклюзией: *a* — 3D-реконструкция 16×16 см; *b* — сагиттальный срез с фенестрацией зуба 1.2; *c* — сагиттальный срез с дегисценцией зуба 2.1

were not analyzed separately because, per treatment protocol, patients with division 2 (incisor retrusion) are initially managed as division 1 (protrusion), following which standard division 1 protocols are applied.

Bone thickness of the six anterior maxillary teeth was evaluated (Fig. 2*a*). Bone thickness on the vestibular side was measured as the distance from the perpendicular (tooth axis defined by 2 points along the canal) to the vestibular surface at the level of the apex (Fig. 2*a*, distance *A*). On the palatal side, it was measured as the distance from the perpendicular (tooth axis defined by 2 points along the canal) to the palatal surface at the level of the apex (Fig. 2*a*, distance *B*). Moreover, palatal bone thickness was measured as half the distance from the apex to the tooth axis at the level of the periosteum on the palatal side (Fig. 2*a*, distance *C*). The measurements were significantly different in the regions of the central and lateral incisors and the canines (Fig. 2*b*, *c*, *d*).

The most pronounced bone deficiency was observed on the vestibular side of teeth, closer to the cementoenamel junction. Clinically, gingival recessions were found in the region of these teeth. Conversely, the palatal bone near the apex was adequate (Table 1).

Distance *A* (vestibular side at the apex) was lowest in the canines (tooth 1.3: 0.98 ± 0.09 mm; tooth 2.3: 1.17 ± 0.06 mm), significantly less than in the central incisors (e.g., tooth 1.1: 1.88 ± 0.09 mm; $p = 0.003$). This vestibular bone deficit in the canines increases the risk of iatrogenic recession during orthodontic movement. Distance *B* (palatal

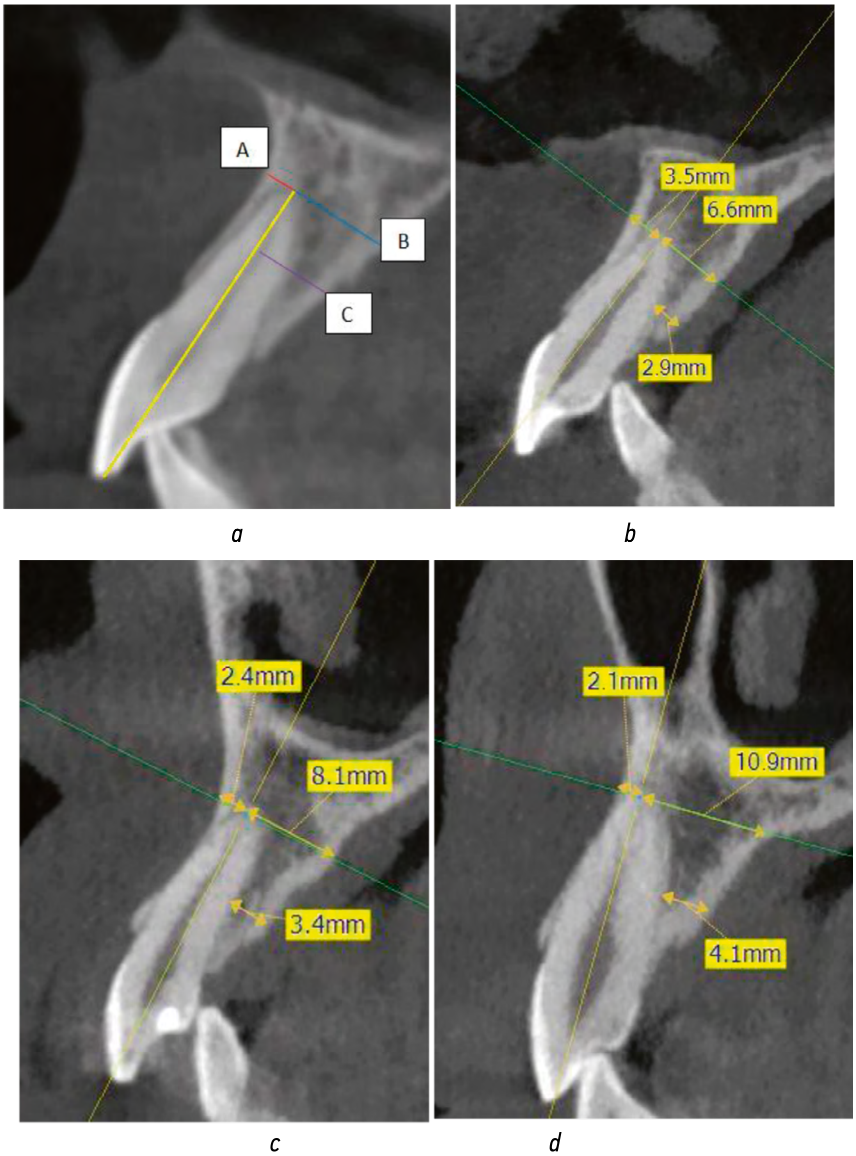

Fig. 2. Control measurements from cone-beam computed tomography images (sagittal sections) of the anterior teeth region: (*a*) standard dimensions; (*b*) tooth 1.1 region; (*c*) tooth 1.2 region; (*d*) tooth 1.3 region
Рис. 2. Контрольные измерения по изображениям конусно-лучевой компьютерной томографии (сагиттальные срезы) в области фронтальных зубов: *a* — типоразмеры; *b* — область зуба 1.1; *c* — область зуба 1.2; *d* — область зуба 1.3

Table 1. Bone thickness at various measurement points (*A*, *B*, and *C*) of the maxillary alveolar process in the anterior tooth region based on cone-beam computed tomography data ($M \pm m$)
Таблица 1. Толщина костной ткани в разных участках измеряемых расстояний (*А*, *В*, *С*) альвеолярного отростка фронтальной группы зубов верхней челюсти, по данным конусно-лучевой компьютерной томографии ($M \pm m$)

Tooth	Distance, mm		
	A	*B*	*C*
1.1	1.88 ± 0.09	7.24 ± 0.09	2.71 ± 0.07
1.2	1.57 ± 0.04	5.38 ± 0.06	2.11 ± 0.05
1.3	0.98 ± 0.09	8.65 ± 0.09	2.81 ± 0.06
2.1	1.72 ± 0.07	6.67 ± 0.08	2.75 ± 0.07
2.2	1.72 ± 0.04	5.93 ± 0.07	2.33 ± 0.08
2.3	1.17 ± 0.06	8.56 ± 0.06	2.96 ± 0.06

side at the apex) was highest in the canines (tooth 1.3: 8.65 ± 0.09 mm; tooth 2.3: 8.56 ± 0.06 mm), significantly more ($p = 0.001$) than in the lateral incisors (e.g., tooth 1.2: 5.38 ± 0.06 mm). Distance *C* (palatal side at root midpoint) ranged from 2.11 ± 0.05 mm (tooth 1.2) to 2.96 ± 0.06 mm (tooth 2.3).

Midway from the apex to the tooth axis at the level of the periosteum on the palatal side, the quantity of supporting alveolar bone was sufficient. Minimal vestibular bone thickness at point *A* indicated high-risk zones for torque application, especially with low torque. In such cases, root prominence may be visible through the mucosa, potentially placing the root outside the alveolar housing on the vestibular side and leading to patient complaints.

Previous studies [12–14] have reported various findings on cortical plate and alveolar bone thickness in the anterior maxilla and mandible using different measurement methods for specific clinical scenarios. The current study focused on identifying the criteria for torque selection in anterior maxillary teeth of patients with distoclusion. CBCT findings from routine examinations of servicemen support the recommendation to use self-ligating brackets with high or standard torque in this region. These choices are substantiated by differences in bone thickness at various root levels, from the apex to the alveolar cortical plate.

CONCLUSION

The use of CBCT in assessing alveolar bone thickness is feasible for evaluating bone parameters in areas targeted for root movement. In some cases, CBCT findings contradict the initial orthodontic treatment plan, particularly when negative-torque brackets have been preselected. High and standard torque values in prescriptions for self-ligating 0.022-slot brackets are preferable, as they induce favorable conditions for safe tooth movement within the alveolar bone. This planning strategy enables correction of malocclusions in servicemen with minimal use of additional devices such as MIs or tooth extractions—interventions that may cause complications during or after the procedure and hinder the performance of military duties. Streamlining treatments for malocclusion correction aims to resolve pathology, improve quality of life, and potentially reclassify military fitness categories for specific occupational specialties.

This study highlights the importance of radiography in orthodontics. Enhancing treatment protocols through 3D positioning and automated analysis can improve the visualization and outcomes of orthodontic interventions in military personnel.

ADDITIONAL INFORMATION

Authors' contribution. Thereby, all authors made a substantial contribution to the conception of the study, acquisition, analysis, interpretation of data for the work, drafting and revising the article, final approval of the version to be published and agree to be accountable for all aspects of the study.

The contribution of each author. N.P. Petrova, collection of primary data, data analysis, writing an article; N.A. Sokolovich, methodology and design of research, data analysis; D.A. Kuzmina, statistical data processing, translation and analysis of foreign literature; I.K. Soldatov, development of a general concept, data analysis, writing an article.

Ethics approval. The study was approved by the local ethical committee of the Kirov Military Medical Academy (Protocol No. 260 dated 02.22.2022).

Competing interests. The authors declare that they have no competing interests.

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Вклад каждого автора. Н.П. Петрова — сбор первичных данных, анализ данных, написание статьи; Н.А. Соколович — методология и дизайн исследования, анализ данных; Д.А. Кузьмина — статистическая обработка данных, перевод и анализ иностранной литературы; И.К. Солдатов — разработка общей концепции, анализ данных, написание статьи.

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