UDC 616.314-007.1:616.714/.716]-073.7:004.92
DOI: 10.14739/2310-1210.2021.2.228778

Importance of 3D CT imaging of the skull in diagnosis of maxillofacial anomalies

I. V. Kovach[A,F], **V. M. Khaletska***[A-F], **N. V. Aleksieienko**[B], **I. M. Shcherbyna**[B]

Dnipro State Medical University, Ukraine

A – research concept and design; B – collection and/or assembly of data; C – data analysis and interpretation; D – writing the article; E – critical revision of the article; F – final approval of the article

Key words:
3D CT scan, skull, cone beam computed tomography, teleradiography, orthopantomogram, maxillofacial anomalies.

Zaporozhye medical journal 2021; 23 (2), 250-258

***E-mail:**
duz100.vk@gmail.com

Knowledge of radiological diagnostic capabilities and application of the principles designed to minimize exposure to radiation nowadays are the basics of qualified dentistry. At the present stage, radiographic methods occupy a leading place in the complex of patient examination to diagnose dental diseases.

The aim of the work is to optimize the diagnosis of maxillofacial anomalies by a comprehensive examination of anatomical structures and parameters of the skull using 3D computed tomography.

Materials and methods. In total, 39 patients aged 10 to 23 years with maxillofacial anomalies were examined. The study used clinical and radiographic methods of examination. Radiography included only orthopantomogram and lateral teleradiography in 28 patients, 3D CT scanning of the skull was performed in 11 patients.

Results. The conducted study has revealed that 3D CT imaging of the skull can be used for the most complete diagnosis of maxillofacial anomalies, reveal sensitive differential diagnostic signs of pathological conditions as well as allow the principle of continuity between specialists to be adhered to at the stage of planning individual complex treatment for patients with maxillofacial anomalies.

Conclusions. 3D CT scanning of the skull is an integrated imaging technique that allows obtaining a complete image of the jaws, teeth, temporal-mandible joints, sinuses in one single examination, assessing the respiratory tract and chewing apparatus state as a whole, as well as carrying out cephalometric measurements of lateral and frontal teleradiography. This method is the most informative as it provides the possibility to precisely diagnose dental anomalies and choose an optimal treatment plan.

Ключові слова:
3D комп'ютерна томографія, череп, конусно-променева комп'ютерна томографія, телерентгенографія, ортопантомограма, зубощелепні аномалії.

Запорізький медичний журнал. 2021. Т. 23, № 2(125). С. 250-258

Значення 3D КТ черепа в діагностиці зубощелепних аномалій

І. В. Ковач, В. М. Халецька, Н. В. Алексєєнко, І. М. Щербина

Знання рентгенодіагностичних можливостей і застосування принципів мінімізації променевого навантаження – основи кваліфікованої стоматології. Нині рентгенологічним методам належить провідне місце в комплексі обстеження хворих під час діагностики стоматологічних захворювань.

Мета роботи – оптимізація діагностики зубощелепних аномалій шляхом комплексного вивчення анатомічних структур і параметрів черепа за допомогою 3D комп'ютерної томографії.

Матеріали та методи. Обстежили 39 пацієнтів віком від 10 до 23 років із зубощелепними аномаліями. Під час дослідження застосовували клінічні та рентгенологічні методи. Рентгенологічне дослідження у 28 осіб включало тільки ортопантомограму та телерентгенографію в бічній проєкції, 11 пацієнтам виконали 3D КТ черепа.

Результати. На підставі дослідження вдалося визначити, що завдяки 3D КТ черепа можна здійснити максимально повну діагностику аномалій щелепно-лицевої ділянки, виявляти тонкі диференційно-діагностичні ознаки патологічних станів, а також дотримуватися принципу спадкоємності фахівців на етапі планування індивідуального комплексного лікування пацієнтів із зубощелепними аномаліями.

Висновки. 3D КТ черепа – єдиний метод візуалізації, що дає змогу в одному дослідженні отримати повне зображення щелеп, зубів, СНЩС, придаткових пазух, оцінити стан дихальних шляхів і жувального апарату загалом, а також виконати цефалометричні вимірювання ТРГ у бічній і прямій проєкціях. Цей метод є найінформативнішим, дає змогу здійснити прецизійну діагностику зубощелепних аномалій і визначити оптимальний план лікування.

Значение 3D КТ черепа в диагностике зубочелюстных аномалий

И. В. Ковач, В. Н. Халецкая, Н. В. Алексеенко, И. Н. Щербина

Знание рентгенодиагностических возможностей и применение принципов минимизации лучевой нагрузки – основы квалифицированной стоматологии. На современном этапе рентгенологические методы занимают ведущее место в комплексе обследования больных при диагностике стоматологических заболеваний.

Цель работы – оптимизация диагностики зубочелюстных аномалий путём комплексного изучения анатомических структур и параметров черепа с помощью 3D КТ.

Материалы и методы. Обследовали 39 пациентов в возрасте от 10 до 23 лет с зубочелюстными аномалиями. В ходе исследования применяли клинические и рентгенологические методы. Рентгенологическое исследование у 28 человек включало только ортопантомограмму и телерентгенографию в боковой проекции, 11 пациентам проведена 3D компьютерная томография черепа.

Результаты. В результате исследования установили, что благодаря 3D КТ черепа можно провести максимально полную диагностику аномалий челюстно-лицевой области, обнаружить тонкие дифференциально-диагностические признаки патологических состояний, а также соблюдать принцип преемственности специалистов на этапе планирования индивидуального комплексного лечения пациентов с зубочелюстными аномалиями.

Выводы. 3D КТ черепа – единственный метод визуализации, позволяющий в одном исследовании получить полное изображение челюстей, зубов, ВНЧС, придаточных пазух, оценить состояние дыхательных путей и жевательного аппарата в целом, а также провести цефалометрические измерения ТРГ в боковой и прямой проекции. Этот метод наиболее информативен, обеспечивает возможность провести прецизионную диагностику зубочелюстных аномалий и определить оптимальный план лечения.

Ключевые слова: 3D компьютерная томография, череп, конусно-лучевая компьютерная томография, телерентгенография, ортопантомограмма, зубочелюстные аномалии.

Запорожский медицинский журнал. 2021. Т. 23, № 2(125). С. 250-258

At the present stage, radiographic methods occupy a leading place in the complex of patient examination in the diagnosis of dental diseases. Any dental intervention can not be considered adequately planned without detailed radiographic monitoring [2,7].

X-ray examination performs several tasks in dentistry:

1. diagnosis of diseases – identification and visualization of clinically undetectable pathological processes;

2. evaluation of the quality and sufficiency of the medical measures provided;

3. timely identification of possible complications;

4. dynamic evaluation of the radiographic findings [1].

The simplest option is a spot image of a tooth. With this variant, a specialist receives minimal information about the disease. More informative is a dental panoramic radiography. However, both of these variants provide the image exclusively in two planes – 2D. With the development of new technologies, namely, cone beam computerized tomography (CBCT) has revolutionized the dental practice since 1998, as it became possible to construct three-dimensional (3D) images [3]. CBCT allows obtaining a high-quality digital X-ray image of the maxillofacial region, in particular the dentition system in three mutually perpendicular planes (frontal, sagittal and axial). CBCT has a very high reliability and informative value and greatly expands diagnostic capabilities in such fields of medicine as dentistry, otolaryngology and maxillofacial surgery. The specialized software for maxillofacial tomographs has provided clinicians with comprehensive data on such complex anatomical structures as tooth, TMJ syndrome, bones of the facial skull and skull base, thereby reshaping the view of specialists [4].

Until recently, for a number of reasons, CBCT as an examination method has been rarely used in dentistry. To date, this method is in demand in the practice of therapeutic dentistry, endodontics, periodontology, implantology, and dental orthopedics for assessing the status of preserved teeth, periapical tissues, parodontium, which determines the choice of orthopedic measures [5,6,8]. It is of great value in maxillofacial surgery, being used for diagnosing traumatic injuries, inflammatory diseases, cysts, tumors, congenital clefts of the alveolar process, hard and soft palate, as well as in planning various surgical interventions [10,11].

Knowledge of radiological diagnostic capabilities and application of the principles designed to minimize exposure to radiation nowadays are the basics of qualified maxillofacial radiography [12]. However, a compete analysis of the obtained CT data (multiplane reformation, volumetric rendering, arbitrary cross-section) requires skills of doctors to work with computer programs, excellent knowledge of anatomy, the totality of which must be applied in practice [13].

In orthodontics, standard radiographic diagnosis is based on panoramic and teleradiographic (TRG) images. This is considered sufficient in most clinical cases to obtain accurate information necessary for diagnosis and treatment planning. However, in very complex and combined anomalies, when traditional 2D imaging does not allow accurate assessment of the clinical situation, the use of CBCT is necessary. In such cases, this method is used as an additional to visualize the regions of interest based on volume rendering [15,16].

Scientific and practical studies in orthodontics have determined a number of basic indications for the CBCT implementation:

– defining a biotype of anomaly of development and position of teeth and jaws;

– presence of super-numerary teeth, position of impactions, cases of apical root resorption;

– evaluation of morphological parts of the facial skeleton;

– presence of vestibular cortical plate, evaluation of thickness and state of bone tissue in the area of tooth roots;

– defining the degree of ossification and structure of the palatal suture;

– evaluation of airway patency;

– diagnosis of morphological and functional disorders of the TMJ;

– cephalometric calculation of TRG in the lateral and frontal views;

– choosing place for mini-implants insertion;

– planning of orthognathic interventions;

– archiving of somatic and dental status initially, at all stages and at the end of active orthodontic treatment, in the retention period [9,14,17].

To solve these problems, a doctor needs to use several types of radiographic examination, which will significantly exceed the radiation dose, greatly increasing the costs of the performed diagnostics. Therefore, it is necessary to develop a rational diagnostic algorithm for a complex radiographic examination of patients depending on the nosological form of the disease and the tasks of further medical treatment.

Aim

The objective of the work is to optimize the diagnosis of maxillofacial anomalies by a comprehensive examination of anatomical structures and parameters of the skull using 3D computed tomography (3D CT).

Materials and methods

In total, 39 patients aged 10 to 23 with dental maxillofacial anomalies were examined. The study used clinical and radiographic methods. X-ray examination included

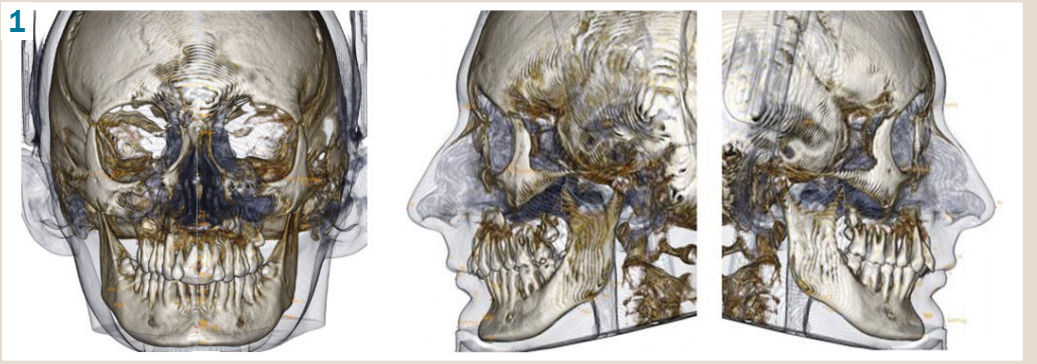


Fig. 1. 3D visualization.

Fig. 2. Panoramic reconstruction of dentition from the 3D CT scan.

only orthopantomogram and lateral teleradiography in 28 patients, 3D CT scanning of the skull was performed in 11 patients.

Results

We clinically examined 39 patients who sought advice and further orthodontic treatment. Some of them were referred to us by other specialists and already had different types of radiographs.

X-ray examination to diagnose maxillofacial anomalies was performed in 28 patients – an orthopantomogram and TRG. In the course of diagnosis and individual treatment tactics planning, 11 patients required consultations of other specialists, as well as additional methods of examination in the form of CT imaging of maxillar or mandibular separate segments and TMJ.

The results of 3D CT of the skull in 11 patients were comprehensively examined, including OPTG, TRG, CBCT and 3D scan data.

Here are some clinical examples that demonstrate accurate results of dental diseases diagnosis by using 3D CT images of the skull. This paper highlights the most benchmark cases.

Case report 1

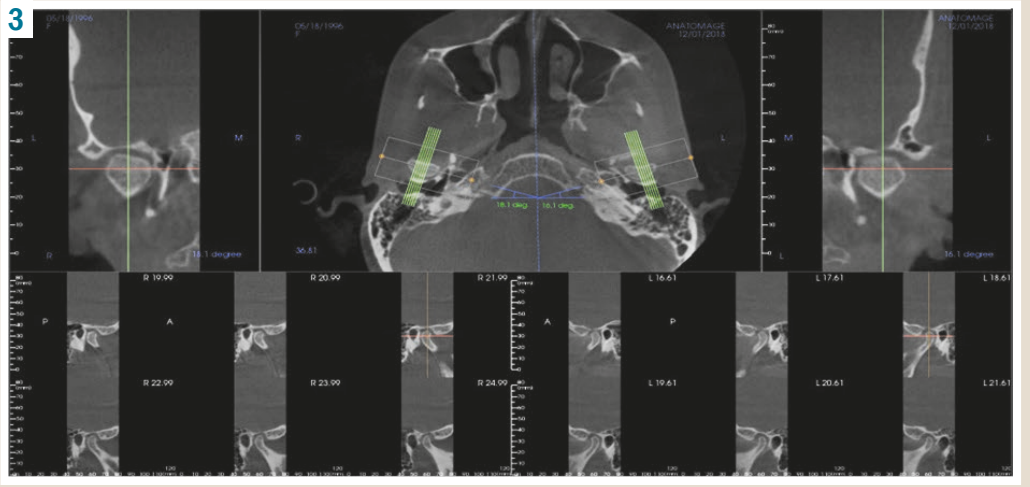
A 23-year-old patient was referred by a physician for consultation and further orthodontic treatment in order to correct the tooth positions in the dentition and occlusion.

In the therapeutic treatment course, spot X-ray images of 1.6.1.2.1.1 teeth were performed, showing a uniform loss of bone tissue. As the obtained diagnostic radiographs did not give adequate information about the condition of bone tissue in the area of inter alveolar septa of the frontal and lateral teeth, it became necessary to perform CT examination of the maxilla and mandible. For the diagnosis of maxillofacial anomalies, orthopantomogram and TRG (*Fig.2*) were taken in the lateral and frontal projections. The patient was referred for a 3D CT of the skull (*Fig. 1*). Following this examination, the horizontal bone loss was clearly visualized in the area of the 1.2, 1.1, 2.1, 2.2 teeth. In the 3D image of the examined area, bone loss of the maxilla and mandible of more than 2/3 was noted reaching root apexes in the region of the 1.5,1.4, 2.4,2.5,2.6,2.7 and 3.6,3.5, 4.6 teeth (*Fig. 3*). Based on a past medical history collected and the clinical examination performed, and mostly, due to the volume tomography, a diagnosis was made: “Severe chronic generalized periodontitis”.

To determine the treatment tactics for this patient, it was necessary to identify causes of extensive bone loss in the examined region. Therefore, the patient was advised to additionally consult with a surgeon-periodontist and a general practitioner.

Following a cephalometric analysis (*Figs. 5, 6, 7*), the patient was diagnosed with deep overbite with retrusion of incisors, enhanced Spee’s curve with a high occlusal plane in the molar region. In the distal areas, occlusal disorders were noted; mandibular angle was small, which corresponded to the brachycephalic type of face.

It is known that the loss of vertical height between the alveolar processes often leads to muscular dysfunction due to excessive shortening of the masticatory closing muscles, a functional overload of the supporting apparatus and, as a result, traumatic articulation develops. Occlusal disorders cause impairments in different anatomical structures: teeth,



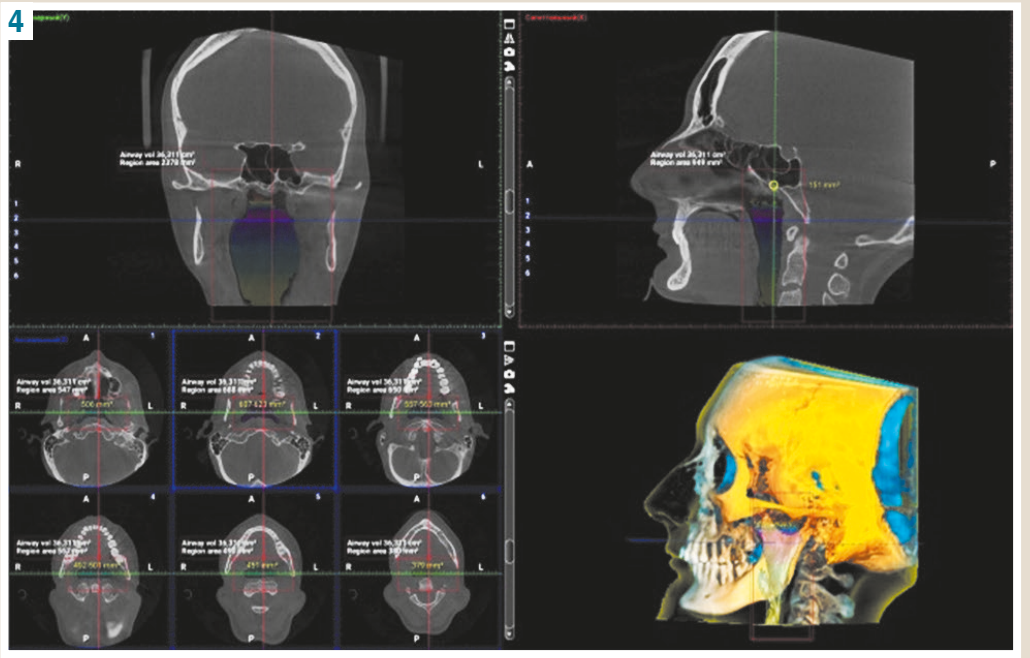


Fig. 3. Analysis of the TMJ.

Fig. 4. Airway assessment.

periodontal tissues, TMJ. The patient was subjected to additional methods of examination: myography, axiography.

Case report 2

A 17-year-old patient, sought medical advice for anomaly of occlusion which was characterized by malalignment teeth, right TMJ clicking. While visiting, he presented the orthopantomogram (*Fig. 11*), which was performed 10 months ago. This X-ray image was not enough to work-up proper diagnostics. Examinations such as TRG in the lateral (*Fig. 12*) and frontal views (*Fig.13*), CT of the TMJ, calculation of the airways volume (*Fig.4,10*) were necessary to evaluate the complete clinical picture of the case, so the patient was recommended to perform 3D CT of the skull (*Fig. 8*).

The patient had a past medical history of adenotomy at the age of 7 years, snore.

Based on the clinical examinations, it was determined: prevailing oral type of breathing, maximal mouth opening – 40mm, occlusal ratio in the area of the first molars bilaterally corresponded to class II Engle, sagittal fissure – 4mm, deep incisor overbite. Analyzing TRG and CT of the TMJ, it was determined that the median line of the lower dentition was displaced to the left. The lateral view revealed an insignificant anterior position of the maxilla and distal position of the mandible. The occlusal plane on the side of displacement was lower than that on the opposite side. When the mandible was displaced to the left, the left TMJ was blocked, and the low vertical distance caused condylar displacement backward and laterally (*Fig. 9*). Evaluation of the airways volume showed their narrowing – 75 mm (*Fig. 10*). Based on the examination results, it was determined: the third molars in the maxilla and mandible were involved in dental arch crowding; inclination of the crowns medially with pressure on the roots of the second molars.

The patient was also referred for additional examination – myography and axiography.

The CT data were sent to an ENT specialist and a dental surgeon, a joint consultation for further therapeutic measures, their features, advantages and disadvantages of certain methods was held resulting in a treatment tactics development.

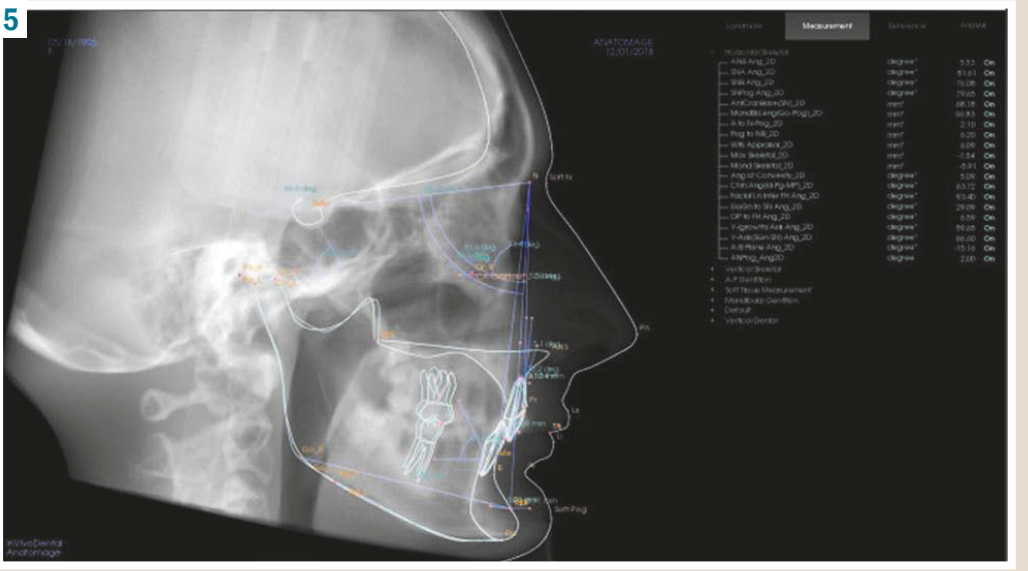


Fig. 5. TRG of the patient in the lateral projection with cephalometric calculation.

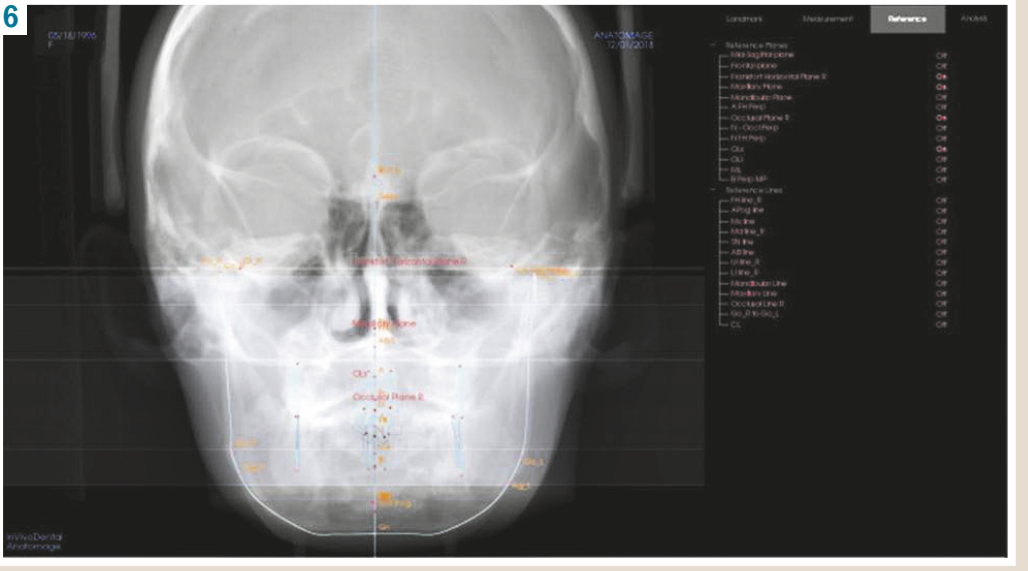


Fig. 6. TRG reconstruction from the 3D CT scan in the frontal projection with cephalometric calculation.

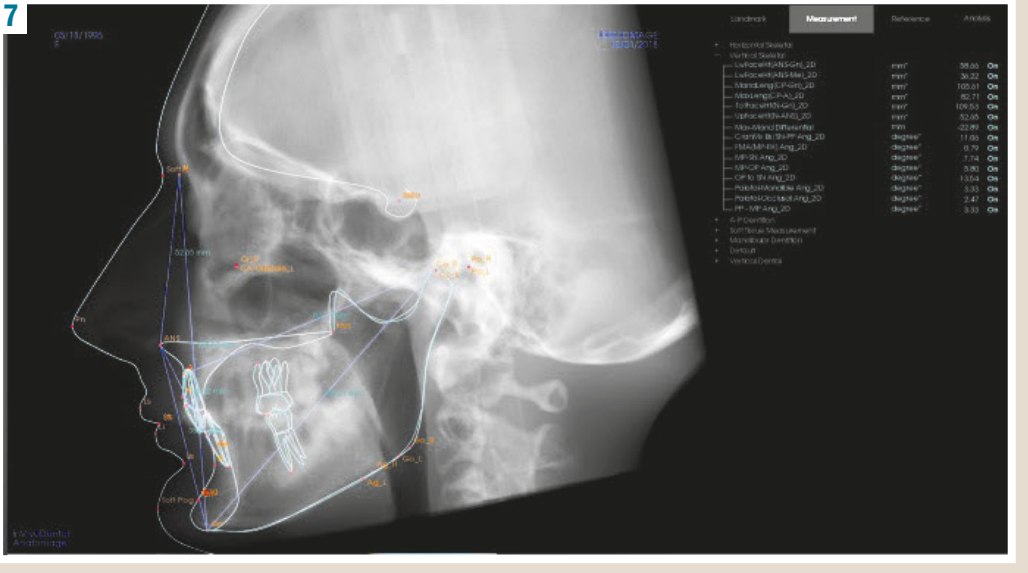
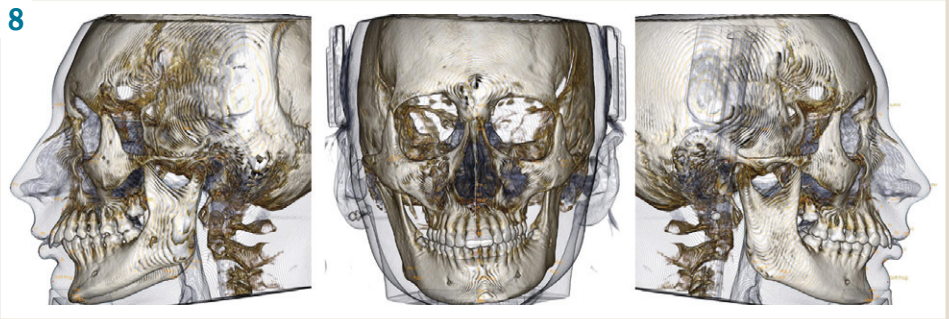
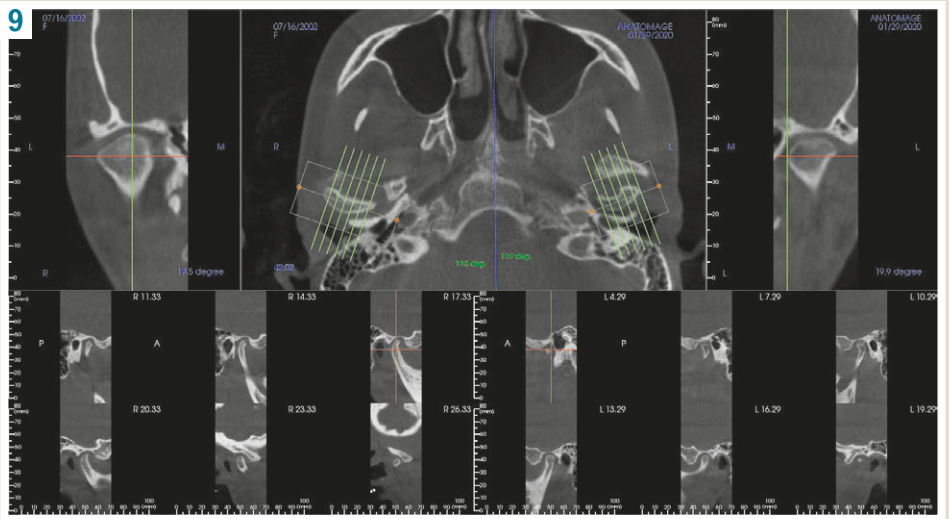
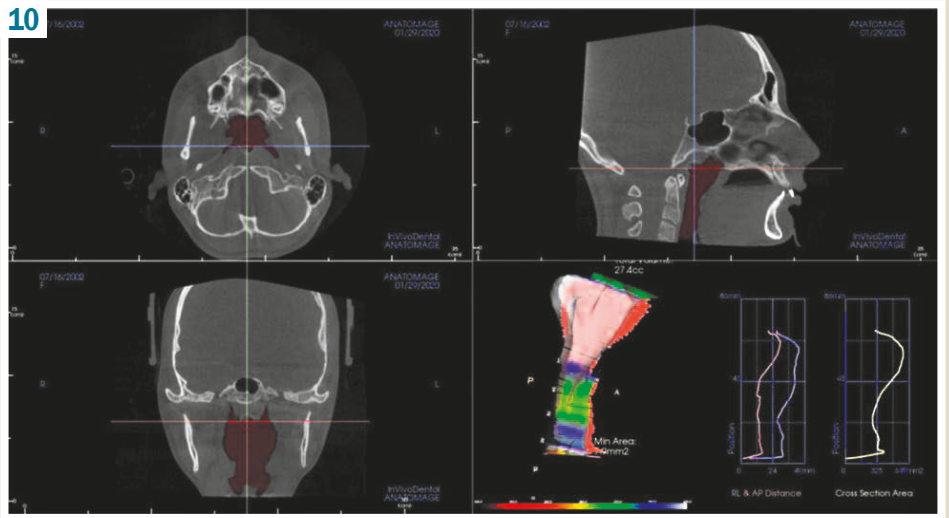


Fig. 7. TRG of the patient in the lateral projection with cephalometric calculation.







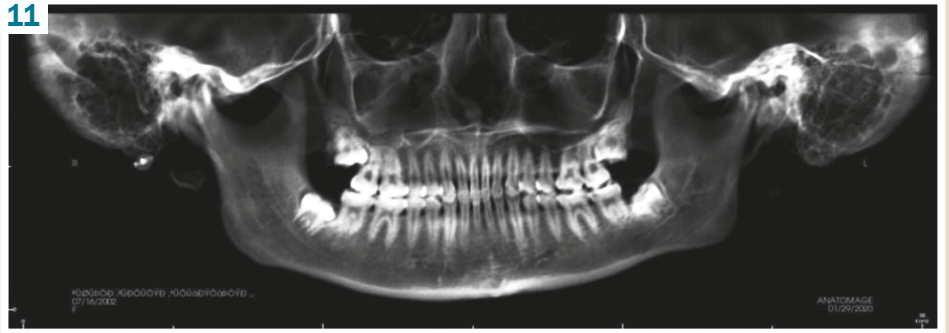


Fig. 8. Volume rendering.

Fig. 9. Analysis of the TMJ.

Fig. 10. Evaluation of the airways volume.

Fig. 11. Orthopantomogram.

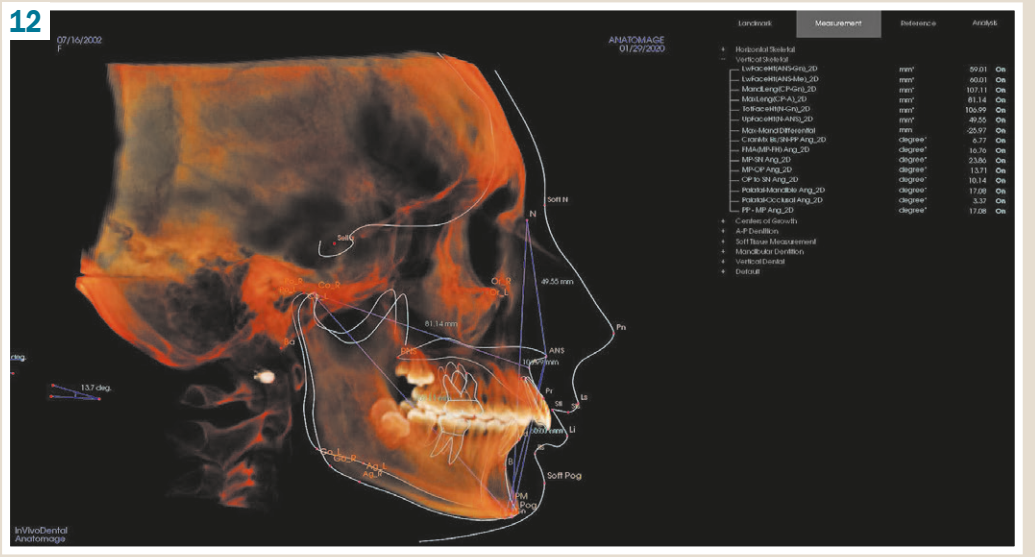


Fig. 12. TRG of the patient in the lateral view.

Fig. 13. TRG of the patient in the frontal view.

Thus, the above clinical examples show the diagnostic significance of 3D CT imaging of the skull. In each clinical case, the use of this examination gave significantly more diagnostic information, which definitely influenced the treatment plan. At all stages of planning individual complex treatment for patients with dentofacial deformities, we followed the principle of continuity. This method is highly effective and allows not only orthodontists but also doctors of different specialties to provide the most complete and qualitative assistance at all stages of dental treatment.

Discussion

If the patient undergoes a CT imaging of the skull, there is no longer any need to perform panoramic tomography and additional intraoral images, since the CT scan array data help to obtain TRG reconstruction, panoramic reconstruction of the dentition and an image of each individual tooth in any appropriate projection.

Due to the information obtained from these examinations, the radiographic nuances of some anatomical structures, as well as various individual features of the dentition system structure were determined. Destructive and productive processes of the bone tissue as well as the difference in density and configuration pattern in the same pathological processes were studied via 3D imaging. The genuine area of bone damage in periodontal diseases was clarified.

In the process of preparing patients for orthodontic treatment and the joint consultation with physicians, latent tooth decay cavities, additional root canals of the teeth, chronic inflammatory processes located in the palate or in the area of root bifurcation, root cracks and perforations, proximity of the dental roots to the maxillary sinus were revealed. This led to extending the number of indications for tooth extraction and dental re-treatment before orthopedic procedures.

In three clinical cases, together with a dental surgeon, the spatial positioning and shape of impactions, the third molars in different imaging modes, the presence or absence of structure resorption were detected. In extraction or exposure of an impacted tooth crown, a better operative

approach to surgery with minimal trauma and orthodontic treatment with maximum efficiency was developed.

In four clinical cases, various pathological processes in the TMJ were identified (disc displacement, initial stages of arthrosis, ankylosis, abnormal development of articular elements, active remodeling).

At the same time, screening for the presence of concomitant pathology of adjacent areas – ENT-organs and spine was conducted. In assessing airways volume, the causes of their obstruction were revealed. Six patients were diagnosed with ENT pathology (anomalies of the structure, deflection or disruption of the nasal septum integrity, cysts, inflammatory processes in the sinuses, adenoids). Abnormalities revealed at this stage were the basis for an appropriate referral of patients to a specialist consultation.

Conclusions

1. 3D CT scanning of the skull is the only imaging technique that allows obtaining a complete image of the jaws, teeth, TMJ, sinuses in one single examination, assessing the respiratory tract and chewing apparatus state as a whole, as well as carrying out cephalometric measurements of lateral and frontal TRG according to different authors.

2. This method is the most informative, as it provides the possibility to precisely diagnose dental anomalies and choose an optimal treatment plan. It also provides a multidisciplinary analysis of the entire craniofacial complex in each clinical case.

3. Therefore, computerized tomography of the skull should be a mandatory standard in planning treatment for dentofacial deformities. 3D CT of the skull is the "gold standard" for diagnosis in orthodontics.

Prospects for further research. It is advisable to continue the study on the role of 3D CT imaging of the skull in the diagnosis, treatment planning and result assessment.

Conflicts of interest: authors have no conflict of interest to declare.
Конфлікт інтересів: відсутній.

Надійшла до редакції / Received: 01.09.2020
Після доопрацювання / Revised: 19.11.2020
Прийнято до друку / Accepted: 30.11.2020

Information about authors:
Kovach I. V., MD, PhD, DSc, Professor, Head of the Department of Pediatric Dentistry, Dnipro State Medical University, Ukraine.
ORCID ID: 0000-0002-5887-4136
Khaletska V. M., MD, PhD, Assistant of the Department of Pediatric Dentistry, Dnipro State Medical University, Ukraine.
ORCID ID: 0000-0002-8494-576X
Aleksieienko N. V., MD, PhD, Associate Professor of the Department of Pediatric Dentistry, Dnipro State Medical University, Ukraine.
ORCID ID: 0000-0002-0093-6744
Shcherbyna I. M., MD, PhD, Associate Professor of the Department of Pediatric Dentistry, Dnipro State Medical University, Ukraine.
ORCID ID: 0000-0002-6579-2307

Відомості про авторів:
Ковач І. В., д-р мед. наук, професор, зав. каф. дитячої стоматології, Дніпровський державний медичний університет, Україна.
Халецька В. М., канд. мед. наук, асистент каф. дитячої стоматології, Дніпровський державний медичний університет, Україна.
Алексєєнко Н. В., канд. мед. наук, доцент каф. дитячої стоматології, Дніпровський державний медичний університет, Україна.
Щербина І. М., канд. мед. наук, доцент каф. дитячої стоматології, Дніпровський державний медичний університет, Україна.

Сведения об авторах:
Ковач И. В., д-р мед. наук, профессор, зав. каф. детской стоматологии, Днепровский государственный медицинский университет, Украина.
Халецкая В. Н., канд. мед. наук, ассистент каф. детской стоматологии, Днепровский государственный медицинский университет, Украина.
Алексеенко Н. В., канд. мед. наук, доцент каф. детской стоматологии, Днепровский государственный медицинский университет, Украина.
Щербина И. Н., канд. мед. наук, доцент каф. детской стоматологии, Днепровский государственный медицинский университет, Украина.

References

[1] Sarment, D. (Ed.). (2016). Konusno-luchevaya komp'yuternaya tomografiya: prikladnoe ispol'zovanie v stomatologii i smezhnykh oblastyakh meditsiny [Cone beam computed tomography: practical use in dentistry and related areas of medicine]. TARKOMM. [in Russian].
[2] Petrovskaya, V. V., & Batova, M. A. (2017). 2. Analiz antropometricheskikh parametrov litsevogo otdela cherepa po dannym konusno-luchevoi tomografii [Cone-Beam Computed Tomography in Analyzing Anthropometric Measures of Maxillofacial Area (Lecture)]. Radiologiya – Praktika, (3), 54-65. [in Russian].
[3] Petrovskaya, V. V., Potrakhov, N. N., & Vasil'ev, A. Yu. (2019). Konusno-luchevaya komp'yuternaya tomografiya v analize endodonticheskogo lecheniya zubov (v eksperimente) [Cone Beam Computed Tomography in the Analysis of Endodontic Treatment of Teeth (in an Experiment)]. Vestnik rentgenologii i radiologii, 100(2), 89-94. https://doi.org/10.20862/0042-4676-2019-100-2-89-94 [in Russian].
[4] Averyanov, S. V., Avraamova, O. G., Akateva, G. G., Alpatova, V. G., Anokhina, A. V., Belyaev, V. V., Bimbas, E. S., Vasilev, A. Yu., Vasmanova, E. V., Gavrilova, O. A., Drobotko, L. N., Elizarova, V. M., Zakirov, T. V., Zoryan, E. V., Zueva, T. E., Ivanova, G. G., Kiseleva, E. G., Klyueva, L. P., Kovalchuk, M. A., … Yanovskaya, M. L. (2017). Detskaya terapevticheskaya stomatologiya [Pediatric therapeutic dentistry] (2nd ed.). GEOTAR-Media. [in Russian].
[5] Nazarian, R., Fomenko, Y., Shcheblykin, N., Kolesova, T., Golik, N., & Suhostavets, E. (2015). Primenenie komp'yuternoi tomografii v terapevticheskoi stomatologii [The use of computed tomography in restorative dentistry]. Sovremennaya stomatologiya, (4), 24-26. [in Russian].
[6] Ma, R. H., Ge, Z. P., & Li, G. (2016). Detection accuracy of root fractures in cone-beam computed tomography images: a systematic review and meta-analysis. International Endodontic Journal, 49(7), 646-654. https://doi.org/10.1111/iej.12490
[7] Takeshita, W. M., Chicarelli, M., & Iwaki, L. C. (2015). Comparison of diagnostic accuracy of root perforation, external resorption and fractures using cone-beam computed tomography, panoramic radiography and conventional & digital periapical radiography. Indian Journal of Dental Research, 26(6), 619-626. https://doi.org/10.4103/0970-9290.176927
[8] Leonardi Dutra, K., Haas, L., Porporatti, A. L., Flores-Mir, C., Nascimento Santos, J., Mezzomo, L. A., Corrêa, M., & De Luca Canto, G. (2016). Diagnostic Accuracy of Cone-beam Computed Tomography and Conventional Radiography on Apical Periodontitis: A Systematic Review and Meta-analysis. Journal of Endodontics, 42(3), 356-364. https://doi.org/10.1016/j.joen.2015.12.015
[9] Serova, N. S. (2015). Luchevaya diagnostika v stomatologicheskoi implantologii [Diagnostic radiology in dental implantology]. GEOTAR-Media. [in Russian].
[10] Blinov, V. S., Kartashov, M. V., Zholudev, S. E., & Zornikova, O. S. (2016). Otsenka vozmozhnostei konusno-luchevoi komp'yuternoi tomografii i panoramnoi tomografii zubnykh ryadov v diagnostike giperplotnykh obrazovanii chelyustno-litsevoi oblasti [Estimation of possibilities of the cone-beam computed tomography and panoramic tomography in diagnostics of radiopack lesions in the maxillo-facial region]. Problemy stomatologii, 12(2), 70-78. https://doi.org/10.18481/2077-7566-2016-12-2-70-78 [in Russian].
[11] Selina, O. B., Nekrylov, D. V., Shalaev, O. Yu., Solov'eva, A. L., Mashkova, N. G., & Shvyreva, S. A. (2016). Sravnitel'nyi analiz dannykh traditsionnoi rentgenografii i dental'noi konusno-luchevoi komp'yuter-

noi tomografii pri diagnostike khronicheskogo granuliruyushchego periodontita [Comparative analysis of traditional dental radiography and cone beam computed tomography in the diagnosis of chronic granulating periodontitis]. Rossiiskii stomatologicheskii zhurnal, 20(4), 201-205. https://doi.org/10.18821/1728-2802 [in Russian].

[12] Savrasova, N. A., Melnichenko, Y. M., Beletskaja, L. Y., & Tarasevich, O. M. (2016). Kontrol' luchevoi nagruzki pri konusno-luchevoi komp'yuternoi tomografii [Control of radiation exposure of cone-beam computed tomography]. Sovremennaya stomatologiya, (2), 19-26. [in Russian].

[13] Vansvanov, M. M., Talimov, K. K., Il'yasov, A. M., Konkachev, E. A., & Ilyasova, A. M. (2015). Komp'yuterno-tomograficheskaya diagnostika patologii chelyustno-litsevoi oblasti [Computed tomographic diagnosis of pathology of the maxillofacial region]. Vestnik Kazakhskogo Natsional'nogo meditsinskogo universiteta, (1), 85-89. [in Russian].

[14] Madsen, M. J., McDaniel, C. A., & Haug, R. H. (2008). A Biomechanical Evaluation of Plating Techniques Used for Reconstructing Mandibular Symphysis/Parasymphysis Fractures. Journal of Oral and Maxillofacial Surgery, 66(10), 2012-2019. https://doi.org/10.1016/j.joms.2008.06.013

[15] Popov, N. V., Ishchenko, E. A., Novikova, E. V., & Limanova, L. V. (2019). Tsifrovye dannye komp'yuternoi tomografii kak fundament razvitiya tsifrovykh metodov rekonstruktsii kostnoi tkani cheloveka [Digital data of computer tomography as a basis for the development of digital methods of reconstruction of human bone tissue]. Vestnik meditsinskogo instituta «REAVIZ»: reabilitatsiya, vrach i zdorov'e, (3), 208-211. [in Russian].

[16] Slabkovskaya, A. B., Kopetskiy, I. S., & Meskhiya, N. G. (2017). Lucheva diagnostika zubochelyustnykh anomalii. Sovremennoe sostoyanie voprosa [Radiation diagnostics of dentoalveolar abnormalities. The current issue]. Zhurnal nauchnykh statei zdorov'e i obrazovanie v XXI veke, 19(10), 149-153. [in Russian].

[17] Rossini, G., Cavallini, C., Cassetta, M., & Barbato, E. (2011). 3D cephalometric analysis obtained from computed tomography. Review of the literature. Annali di Stomatologia, 2(3-4), 31-39.