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ANALYSIS OF THE USE OF ANALOG AND DIGITAL TECHNOLOGIES IN ORTHOPEDIC TREATMENT OF PATIENTS

In the dental practice of an orthopedic doctor, there are more and more complications after fixing permanent structures, which is due to the need for digital planning, because it is at this stage that the doctor, technician and patient have the parameters of future fixed structures, even before the stage of tooth preparation. This makes it possible to plan the preparation, make it sparing and get the desired result of adapting the neuromuscular and articular complexes to the new occlusal-articulatory ratios of the jaws. The development of technologies is aimed at the following steps: early detection of signs of pathology, synchronization of modern methods and methods of research and innovative equipment for the manufacture of medical diagnostic and therapeutic structures, high accuracy of work, saving the doctor's work time, the maximum digital component of the process, minimizing manual analog management as a factor of avoiding the risk of error/ the introduction of digital technologies has significantly increased the power that is quantitative, the economic and qualitative performance indicators of both dental and technical laboratories and dental clinics in general have led to a radical change in the protocols, logistics and organizational interaction of specialists involved in the process of providing dental care. ***Purpose of the work.*** *Improving the effectiveness of orthopedic treatment of patients through clinical and economic justification and analysis of the basics of planning a dental clinic development strategy.* ***Materials and methods.*** *The T-Scan device of the American company Tekscan makes it possible to study and analyze various types of dentition occlusion. The T-Scan computer occlusion analysis system allows you to collect, systematize and analyze data on the sequence of contacts, the time of occurrence of the first contact and its localization, the sequence of occurrence of contacts in real time, the compression force of dentition rows for a certain period of time, monitor the change in occlusal ratios of dentition rows from the first contact to the maximum interhorbic contact, indirectly talk about the state of the masticatory muscles.* ***Conclusion****. The proposed complex of digital planning of dental treatment is clinically effective, since after it the patient and doctor are fully prepared for accurate preparation of teeth and fixation of permanent fixed structures.*

Key words: *digital method, analog method, occlusal ratios, partial tooth loss, occlusion correction.*

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АНАЛІЗ ЗАСТОСУВАННЯ АНАЛОГОВИХ І ЦИФРОВИХ ТЕХНОЛОГІЙ ПРИ ОРТОПЕДИЧНОМУ ЛІКУВАННІ ПАЦІЄНТІВ

У стоматологічній практиці лікаря-ортопеда все більше зустрічається ускладнень після фіксації постійних конструкцій, що зумовлено необхідністю проведення цифрового планування, тому що саме на цьому етапі у лікаря, техніка і пацієнта є параметри майбутніх незнімних конструкцій, ще до етапу препарування зубів. Це дає можливість спланувати препарування, зробити його щадним й отримати бажаний результат адаптації нервово-м'язового і суглобового комплексів до нових оклюзійно-артикуляційних співвідношень щелеп. Розвиток технологій направлений на наступні кроки: раннє виявлення ознак патології, синхронізація сучасних методів і методик дослідження та інноваційної апаратури для виготовлення лікувально-діагностичних та лікувальних конструкцій, висока точність роботи, економія часу роботи лікаря, максимальна цифрова складова процесу, мінімалізація мануального аналогового ведення, як фактор уникнення ризику похибки/ впровадження цифрових технологій значно збільшило потужність тобто кількісні, економічні та якісні показники роботи як зубо-технічних лабораторій так і стоматологічних клінік в цілому і призвело до кардинальної зміни протоколів, логістики та організаційної взаємодії фахівців, задіяних в процесі надання стоматологічної допомоги. ***Мета роботи.*** *Підвищення ефективності ортопедичного лікування пацієнтів шляхом клініко-економічного обґрунтування та аналізу основ планування стратегії розвитку стоматологічної клініки.* ***Матеріали та методи.*** *Апарат T-Scan американської фірми Tekscan дає можливість вивчити і проаналізувати різні види*

оклюзії зубних рядів. Система комп'ютерного аналізу оклюзії T-Scan дозволяє збирати, систематизувати і аналізувати дані про послідовність контактів, час виникнення першого контакту та його локалізацію, послідовність виникнення контактів в режимі реального часу, силу стискання зубних рядів протягом певного відрізку часу, прослідкувати за зміною оклюзійних співвідношень зубних рядів від першого контакту до максимального міжгорбкового контакту, побічно говорити про стан жувальної мускулатури. ***Висновок****. Запропонований комплекс цифрового планування стоматологічного лікування є клінічно ефективним, оскільки після нього пацієнт і лікар повністю готові до точного препарування зубів й фіксації постійних незнімних конструкцій.*
Ключові слова: *цифровим метод, аналоговий метод, оклюзійні співвідношення, часткова втрата зубів, корекція оклюзії.*

Relevance of the topic. In the dental practice of an orthopedic doctor, there are more and more complications after fixation of permanent structures, which is due to the need for digital planning, because at this stage the doctor, technician and patient have the parameters of future fixed structures, even before the stage of tooth preparation.

This makes it possible to plan the preparation, make it sparing and obtain the desired result of adaptation of the neuromuscular and articular complexes to the new occlusal and articulation relations of the jaws.

Dental care ranks second in the structure of medical care after visits to a family doctor. Diseases of the oral cavity are among the most common among the population of both countries of the world and Ukraine, which, if left untreated, lead not only to significant problems on the part of various organs and systems, but also to a deterioration in the quality of life and to problems in private life and at work. Dental disease is a medical and social problem that requires a comprehensive solution.

The development of technologies is aimed at the following steps: early detection of signs of pathology, synchronization of modern research methods and techniques and innovative equipment for the manufacture of medical diagnostic and treatment structures, high accuracy of work, saving the doctor's time, maximum digital component of the process, minimization of manual analog management as a factor in avoiding the risk of error. The need to develop research work in this area is dictated by the progressive increase in the number of patients with crown defects and dentition defects, the lack of effectiveness of traditional treatment of this category of patients, as well as the need to introduce highly effective treatment and diagnostic methods in accordance with modern digital technologies.

The active introduction of digital technologies into clinical practice, on the one hand, has reduced the number of errors and minimized the errors made in the manufacture of fixed structures using the analog method [Hazhva S.I., 2019], on the other hand, has significantly increased the requirements for an orthopedic dentist. It requires a fundamental revision of existing protocols, regulations governing the work of the orthopedic dental service and quality standards for the provision of relevant services to the population.

In addition, the introduction of digital technologies has significantly increased the capacity, i.e. quantitative, economic and qualitative indicators of both dental laboratories and dental clinics in general and has led to a radical change in protocols, logistics and organizational interaction of specialists involved in the process of providing dental care.

Today, there are no clearly justified indications and limits for the use of digital technologies at the stages of diagnosis, planning and manufacturing of fixed dentures, depending on the current clinical situation.

The purpose of the study. Improving the effectiveness of orthopedic treatment of patients through clinical and economic justification and analysis of the basics of planning a dental clinic development strategy.

Materials and methods. The T-Scan apparatus of the American company Tekscan makes it possible to study and analyze various types of dentition occlusion.

The T-Scan system of computer analysis of occlusion allows you to collect, systematize and analyze data on the sequence of contacts, the time of the first contact and its localization, the sequence of contacts in real time, the force of compression of the dentition over a certain period of time, to monitor the change in the occlusal relations of the dentition from the first contact to the maximum intercuspid contact, and indirectly indicate the state of the masticatory muscles. The T-Scan recording is similar to a video recording, as it can be played back unlimitedly. Occlusal forces are presented in the form of a color scale from blue (weakest contact) to pink (strongest contact).

Results of the study. Clinical studies of the state of the dentition were conducted in 54 patients who applied to the Dental Medical Center of the Bogomolets National Medical University, Institute of Postgraduate Education "Dentistry" and the Department of Prosthetic Dentistry for examination and prosthetics. Patients from private dental clinics also participated in our study. They were examined by us in the period from 2012 to 2023, and a control group of patients was also studied separately.

All patients were divided into groups depending on the type of prosthesis and into a control group.

Patient groups. Examination of patients regarding the need for a digital protocol in the manufacture of fixed aesthetic dentures.

Group 1: patients with defects in hard dental tissues and dentition defects who had veneers and artificial crowns made according to an analog protocol (metal ceramics, preskeramics). In this group, 23 patients were studied.

Group 2: patients with defects in hard dental tissues and dentition defects who had bridge prostheses made according to an analog protocol (metal ceramics, zirconium dioxide). In this group, 31 patients were studied.

After a detailed examination, diagnosis, and orthopedic treatment plan, we took a patient's medical history. Patients were examined according to the accepted algorithm in accordance with the documentation used in the work of dental institutions, regulated by the order of the Ministry of Health of Ukraine dated February 14, 2012, No. 110 (form No. 043/0).

"Medical record of a dental patient".

The study was conducted in the following stages: 1. Before prosthetics. 2. 6 months later.

During the study, among 31 patients, before the manufacture of permanent fixed prosthetic structures, temporary structures of bridge-like fixed prostheses made by the analog method were made, we had a complication in 5 patients – an overestimation of alveolar height (Fig. 1).

On the CT scan we see the contours of the heads of the articular condyles are clear, even, there is a flattening of the top of the articular head on the right, on the left – of normal shape; the articular fossa on the right has an uneven contour, deepened in the vertical direction; when examined in the closed-mouth position, the articular head on the right on the R-LL 17 section is 2.4 mm below the posterior slope of the articular tubercle; the contours of the articular fossa on the left are clear, even, and of regular shape; in the closed-mouth position on the left, the articular head is located in the central part of the articular fossa, on the L-LL 23 sections the height of the articular gap is 6 mm. (Fig. 2); in section L-LL 26, the height of the articular gap is 8.4 mm; the distance from the posterior slope of the articular tubercle to the articular head is 2.6 mm.

After redefining the central occlusion, new temporary bridges were fabricated. A CT scan was also repeated, and after a stable result and no complaints from the patient, he was prosthetized with permanent bridges.

During prosthetics in 2 patients of the second group, at the stages of manufacturing temporary structures, there was a complication of lowering the interalveolar height (Fig. 3).

The heads of the articular condyles are of the same shape; when examined in the closed mouth position, they are symmetrically located in the articular fissures, have clear, even contours, emphasized by a pronounced cortical layer, and compaction of the tops of the articular heads is noted; the contours of the articular fossa are clear, even, and of regular shape; on the right side of section R LL22 in the upper part, the size of the articular gap to the high point of the fossa dome is 3.3 mm; the distance from the posterior slope of the articular tubercle to the articular head is 2.0 mm; in the distal part, the width of the gap is 1.2 mm; on the left side of L LL20 in the upper region, the size of the articular gap to the high point of the fossa dome is 3.2 mm; the distance from the posterior slope of the articular tubercle to the articular head is 2.0 mm; in the distal region, the gap width is 1.2 mm; when examining the CT scans of the joints in the axial section R AR20 and L AR20, the distal position of the joint heads is noted, the articular gap in the distal region is sharply narrowed to 0.6 mm on the

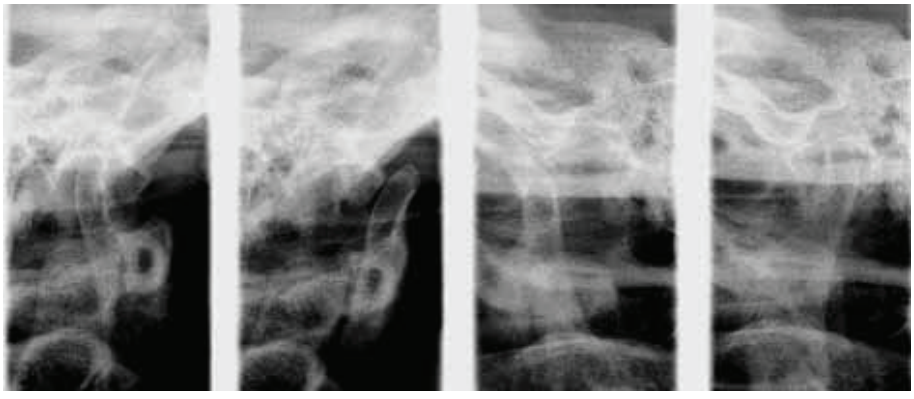


Fig. 1. CT scan analysis of the temporomandibular joint (TMJ) of a patient born in 1968

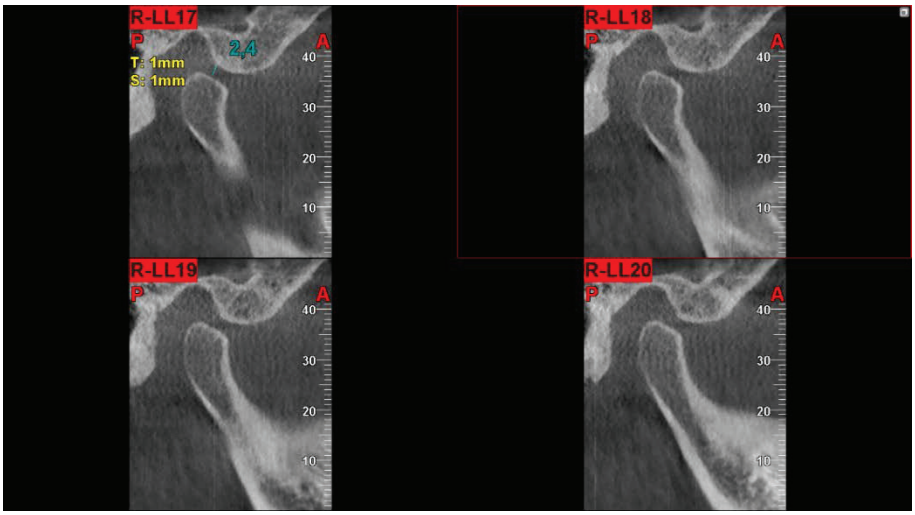


Fig. 2. CT analysis of the patient's TMJ, born in 1968

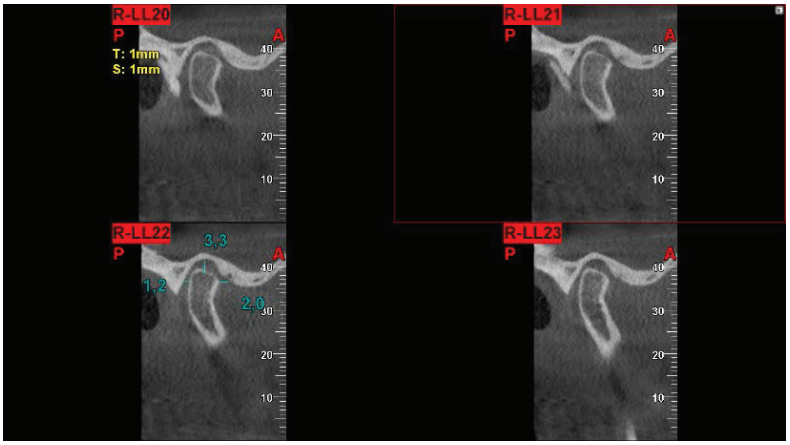


Fig. 3. CT scan analysis of the patient's TMJ, born in 1970

right and 0.9 mm on the left; in the sections R LL29 R LL30, the contact of the head surface with the inner surface of the fossa in the distal region is noted; on the left, in the section L LL14 L LL15, the articular gap is uniform throughout.

After redefining the central occlusion, new temporary bridges were fabricated. A CT scan was also repeated, and after a stable result and no complaints from the patient, he was prosthetized with permanent bridges.

The heads of the articular condyles are of the same shape; when examined in the closed mouth position, they are symmetrically located in the articular fissures, have clear, even contours, emphasized by a pronounced cortical layer, compaction of the tops of the articular heads is noted; the contours of the articular fossa are clear, even, and of the correct shape; on the right side of the R LL22 section in the upper area, the size of the articular gap to the high point of the fossa dome is 3.3 mm. (Fig. 4).

The distance from the posterior slope of the articular tubercle to the articular head is 2.0 mm; in the distal region, the width of the gap is 1.2 mm; on the left in the upper section of L LL20, the size of the articular gap to the high point of the fossa dome is 3.2 mm; the distance from the posterior slope of the articular tubercle to the articular head is 2.0 mm; in the distal region, the width of the gap is 1.2 mm; when considering the CT scan of the joints in the axial section R AR20 and L AR20, the distal position of the joint heads is noted, the joint gap in the distal region is sharply narrowed to 0.6 mm on the right and 0.9 mm on the left; on the sections R LL29 R LL30, the contact of the head surface with the inner surface of the fossa in the distal region is noted (Fig. 5); on the left, in the section L LL14 L LL15, the articular gap is uniform throughout.

In response to these complications, we have developed a comprehensive digital approach. The implementation of which will reduce complications.

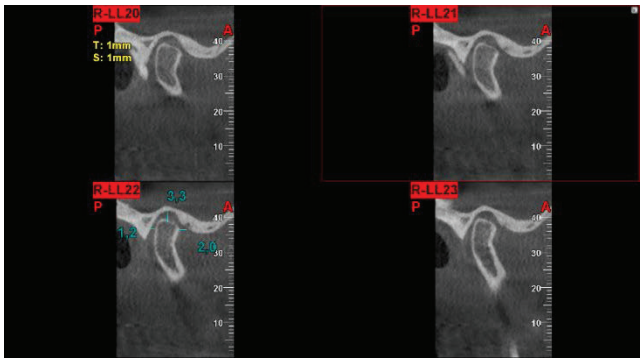


Fig. 4. CT scan analysis of the patient's TMJ, born in 1970

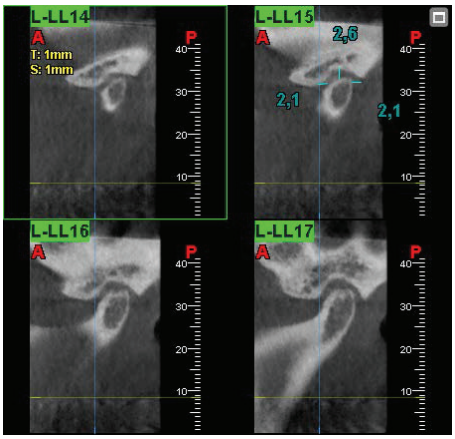


Fig. 5. CT scan analysis of the patient's TMJ, born in 1970

In the dental practice of an orthopedic surgeon, there are more and more complications after fixation of permanent structures, which is due to the need for digital planning, because at this stage, the doctor, technician and patient have the parameters of future fixed structures, even before the stage of tooth preparation. This makes it possible to plan the preparation, make it gentle and get the desired result of adaptation of the neuromuscular and joint complexes to the new occlusal and articulation ratios of the jaws.

The results of the developed integrated digital planning are shown in Figures 6-15.

1. Diagnostics.

2. Digital modeling of future temporary structures in the ExoCad program.

3. 3D printing of models, manufacturing and fixing of temporary structures.

Stage 1 – Diagnostics

CT scan of the upper and lower jaws and TMJ

CT scan of the upper and lower jaws

The results of the examinations in patients visualize uniform joint gaps.

For further prosthetics, the next step was to scan the lower and upper jaws (Fig. 8) and, without fail, scan the occlusal surface of the teeth.

The next task for the doctor is to analyze the diagnostics, then proceed to plastering the upper and lower models into the articulator (analog method)a

We start digital modeling of the future smile by modeling temporary structures in the ExoCad program (Fig. 10 a,b,c).

At the third stage, we printed 3D models, fabricated and fixed fixed temporary structures (Fig. 11).

After modeling the occlusal and articulation contacts of the teeth, we transfer them from the 3D models of the jaws to the patient's oral cavity using an impression from the model (silicone key) (Fig. 12).

Fig. 13 shows the results of CT and T-Scan scans, 1 month after fixation of the structures, which indicate the rapid adaptation of the masticatory apparatus to the new occlusal and articulation surfaces of the teeth and the new interalveolar height of the patient. The implementation of this algorithm makes it possible to obtain individual parameters of future permanent orthopedic structures.

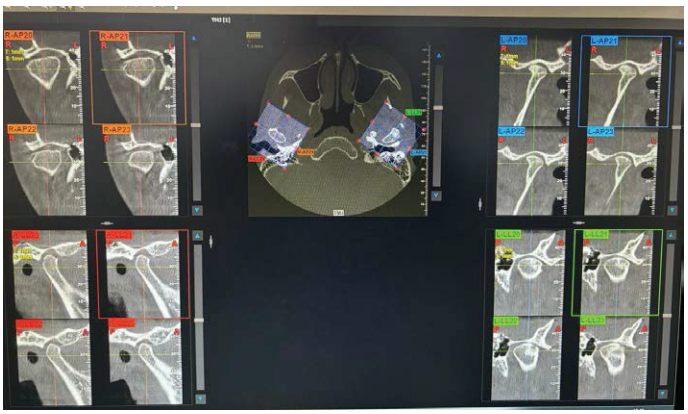


Fig. 6. CT examination of the joints of the upper and lower jaw of patients

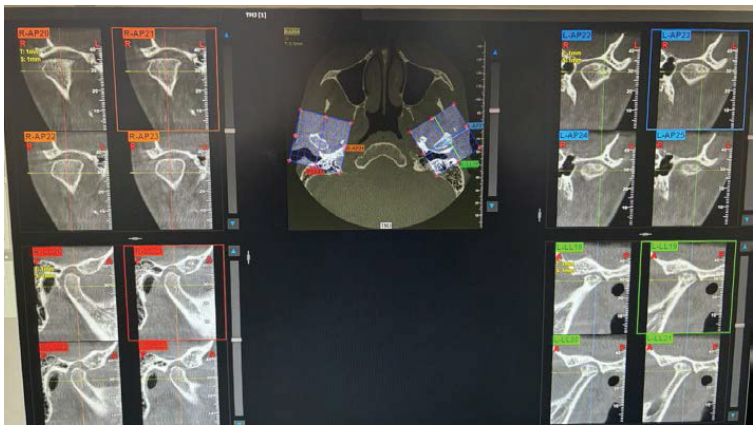


Fig. 7. CT examination of the joints of the upper and lower jaw of patients (malocclusion)

Fig. 8. Scanning of the lower and upper jaws

Fig. 9 a. Patient's teeth in central occlusion

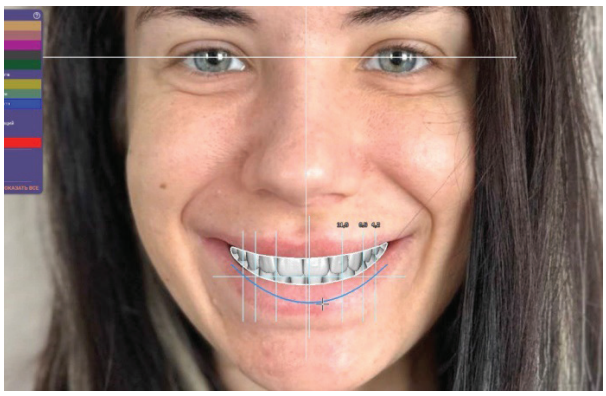
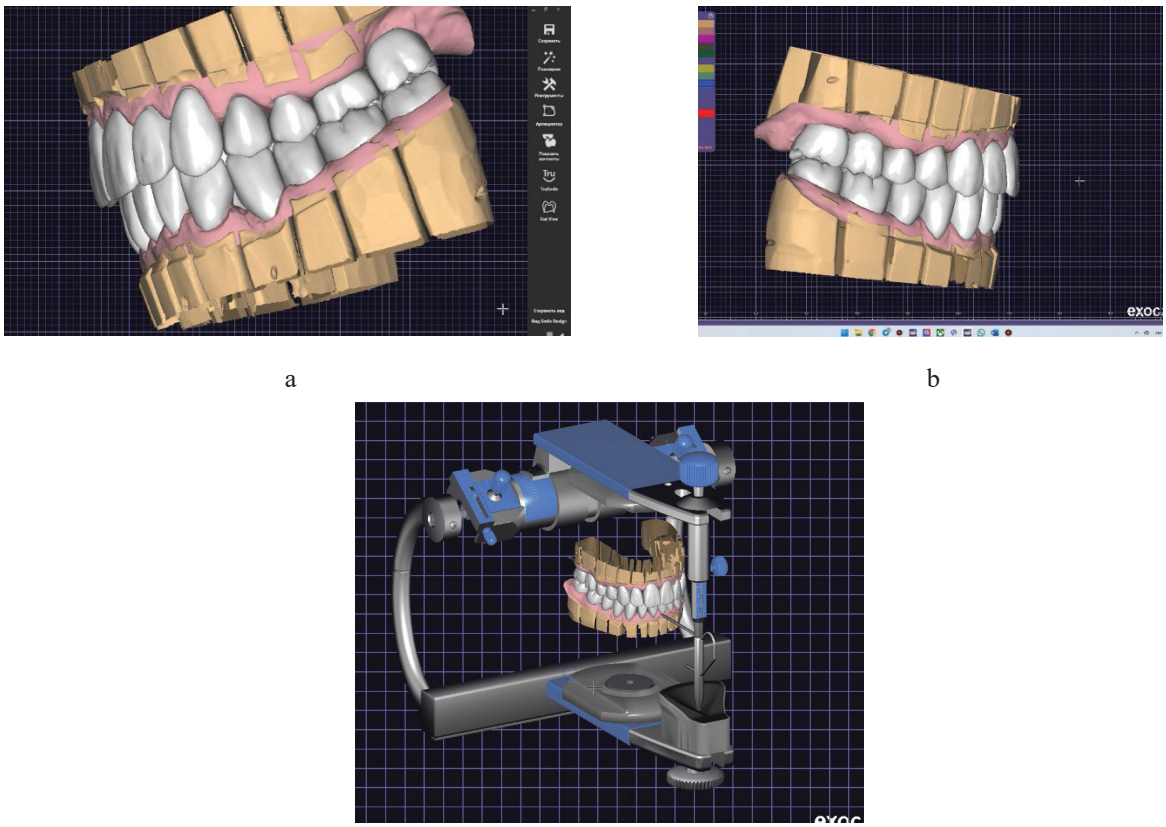


Fig. 9 b. Working in the ExoCad program (Smile Design)



a b

c

Fig. 10. New occlusal and articulation relationships of the jaws

Fig. 11. Printing 3D models of the upper and lower jaws in the printer

Fig. 12. View of the patient's oral cavity, modeled occlusal and articulation contacts of the teeth

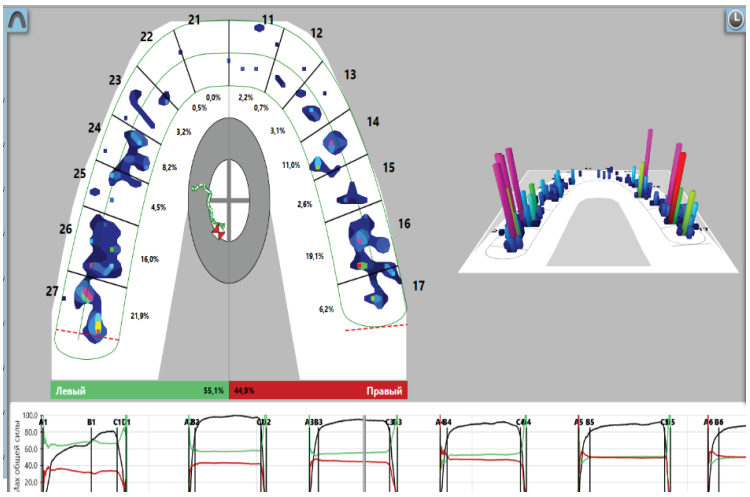


Fig. 13. Schematic representation of the T-Scan study

Thus, the introduction of comprehensive digital treatment planning for patients with dental defects has been proven to be clinically effective. The advantage of the algorithm is the accuracy and confidence of the doctor, who is fully prepared for gentle tooth preparation and fixation of permanent fixed structures. The priority of the algorithm makes it possible to plan prosthetics and obtain the desired result, and most importantly – rapid adaptation of the neuromuscular and articular complexes to new occlusal and articulation surfaces of the teeth (Fig. 14).

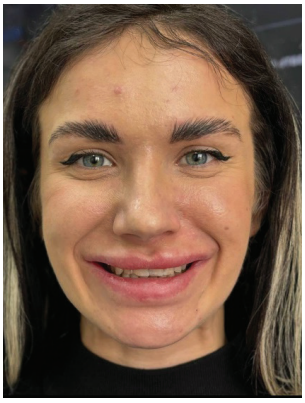


Fig. 14 a. Patient's smile before "Smile Design"

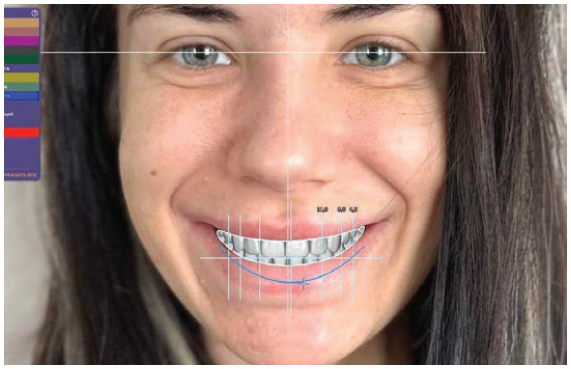


Fig. 14 b. Patient's smile during the "Smile Design" program

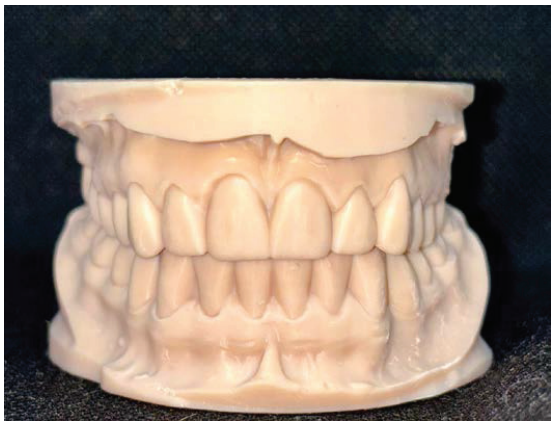


Fig. 14 c. Patient models

Fig. 14 d. Patient's smile with "Mock-up"

Conclusions. The conclusions are that the interalveolar height is too low, which leads to premature contact of the teeth with their subsequent overload. Traumatic occlusion occurs. First of all, changes occur in the periapical area: first, narrowing of the periodontal gap, then its expansion with the destruction of the periodontium and the bone of the alveolar ridge in this area. Such an overload has practically no effect on the marginal gums. Their changes occur in the future with significant destruction of the interdental septa.

Regarding the presence or absence of a ledge, changes in the marginal periodontium (primarily gingiva) occur immediately after the crown is fixed. It is believed that any irregularity between the edge of the crown (and) the root surface (crown without a ledge, crown edge larger than the ledge or smaller than the ledge, etc.) injures the gums, promotes the accumulation of plaque with the subsequent development of inflammation of the marginal gums (gingivitis). If this complication is not eliminated, it leads to the destruction of periodontal fibers, deep epithelial growth with the subsequent formation of a periodontal pocket. This happens quite quickly, in almost 6-12 months a periodontal pocket can form, the depth of which depends on the traumatic factor. All this time, the inflammatory process in the marginal gums and marginal periodontium is maintained. There is a lot of evidence that traumatic occlusion itself has little effect on the development of the pathological process in this area.

The proposed complex of digital dental treatment planning is clinically effective, since after it, the patient and the doctor are fully prepared for precise tooth preparation and fixation of permanent fixed structures.

Conflict of interest is absent.

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