Development and Implementation of Digital Technologies in Dental Practice

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Abstract

Innovative technologies are actively penetrating into all spheres of human life, and have made it possible to make a big breakthrough. The simulators used in medicine provide an opportunity for training and accreditation of dentists.

Modern dentistry is actively developing and requires the development of a large amount of knowledge, the acquisition of clinical skills and the ability to solve certain clinical problems. For example, important clinical skills in restorative dentistry include the preparation of carious cavities, endodontic treatment, restoration of the anatomical shape of the tooth.

In surgical dentistry, this is anesthesia, tooth extraction and implantation. Dental phantoms are designed to solve the problem, but such models do not give a complete picture of the work of the dentist.

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Introduction

In the preparation of specialists in the field of dentistry, training in the acquisition of clinical skills is of the utmost importance. With the help of dental simulators, it has become possible to conduct preclinical training of students, clinical residents and young professionals in manipulations that will be safe and as close as possible to the clinical conditions as when working with real patients[1,2]. Training with the help of simulation equipment can be attributed to an additional teaching method, which is aimed at consolidating the acquired knowledge by students, as well as acquiring and improving manual skills. Most often, special phantom models, artificial plastic teeth, are used for these purposes. For example, special endodontic blocks are used to improve manual skills in endodontics. In therapeutic dentistry, artificial teeth are used to train manual skills, on which cadets prepare carious cavities, perform aesthetic restoration of teeth with modern composite materials. Such a simulator creates a high-quality illusion of working with a real patient[3,4]. Each cadet, while working on a phantom, has the opportunity to improve his manual skills, acquire new practical skills with no risk to the patient, which is important for young "novice" doctors. There is also the possibility of unlimited repetitions for practicing a certain manipulation. There is no risk of irreparable medical errors. The doctor objectively controls his manipulations. When working on a phantom, the cadet gets a unique opportunity to study rare anatomical features of the structure of the teeth

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and the maxillofacial region. The use of phantoms allows dentists to effectively practice manual skills and facilitate the introduction of new treatment methods into clinical practice, eliminating the risk of errors and side effects[8].

Improving the manual skills of a dentist is the most important task of any healthcare institution. However, despite the increasing equipment of the dental departments of polyclinics with modern medical and diagnostic equipment and instruments, and the active introduction of new methods for diagnosing and treating major dental diseases, defects continue to occur in the provision of dental care with a trend towards an increase in their number that has emerged in recent years. This is one of the objective indicators of the insufficient level of quality of medical care, including dental care[9]. Often this is due to the fact that dentistry as a branch of science is developing quite quickly and doctors do not have time to learn new technologies. Another important reason is the reluctance of doctors with a long work experience to learn something new.

Among young specialists, completely different difficulties prevail. Often, novice doctors experience fear of the patient, lack of confidence in their manual skills. Also, young doctors face the following problem: when training on phantom models, they managed to perform manipulations well, but certain difficulties arise when working with a patient. For example, the most common problem is mandibular anesthesia.This is due to the fact that in all patients, the guidelines for the injection site of the needle are located individually[13]. Difficulties also occur at the stages of carious cavity preparation: doctors doubt the correctness of the formation of the cavity, how much tissue needs to be removed and left. [15]There are difficulties during the aesthetic restoration of teeth: the difficulty of restoring the anatomical shape of the tooth, the selection of the color of the restoration[15]. All these problems are associated with low awareness of the peculiarities of working with various groups of photopolymerization materials. Endodontic treatment of teeth causes the greatest difficulties for novice doctors.

Working on phantom teeth does not give a complete picture of endodontics, preparation of carious cavities, restoration and restoration of hard tooth tissues with composite materials[16]. The material from which plastic teeth are made does not have the hardness of enamel and dentin, creating the illusion of ease of work in the patient's oral cavity, and proper control is not provided when processing the root canals of artificial teeth. Due to technical limitations, the current method of teaching manual skills on phantoms does not provide the proper level of practical skills.

Also, despite the availability of modern equipment in dental clinics, most dentists do not know how to use it. This is due to the lack of awareness of doctors about the features of the operation of this equipment, the fear of breaking something from the equipment. And the most important problem is that on modern phantom models there is no possibility of a full-fledged development of manual skills in order to learn how to use it. Often this equipment stands, losing its relevance.

To date, the development of dentistry as a science has stepped far forward. Digital technologies play an important role in this and are becoming an increasingly important element of dental practice. Thanks to new technological advances in the field of computer-aided design and automated production of CAD / CAM systems, it has become possible to manufacture restorations of orthopedic structures with little or no involvement of a doctor. Among modern technologies in dentistry, telemedicine occupies a special place, which is used both for remote consultation and successful treatment of patients.

Therefore, the task of training specialists with the help of modern simulation techniques becomes relevant, allowing the student to be involved in conditions that are as close as possible to real clinical ones[17]. Virtual reality today is one of such methods for training both an experienced clinician and for training beginners.

Purpose of the study: To study the relevance of the use of digital technologies in dental practice.

Materials and methods

In order to assess the level of practical skills of general dentists, a special questionnaire was developed. It contained questions related to various areas of therapeutic dentistry: examination of the oral cavity, diagnosis, preparation of carious cavities and restoration of hard tooth tissues using modern composite materials. Also, in the questionnaire there are

questions about the methods of endodontic treatment of teeth using modern methods of passage and filling of root canals. The survey was conducted among 31 dentist-therapists studying in advanced training courses at the Department of Dentistry of the Institute of "Volgograd Medical University" NMFO, using a Google form. The answers to the questions were evaluated on a scale: no problems, very easy, easy, sometimes difficult, difficult, extremely difficult, do not apply.

Results

When answering the question about work experience, 61.3% (19 people) of the respondents answered - more than 10 years, more than 3 years - 32.3% (10 people) and 2 people (6.5%) have less than 3 years of work experience.

When asked about difficulties during facial examination, the majority of respondents do not experience them - 58.1% (18 people), for 25.8% (8 people) facial examination is easy. However, 9.7% (3 people) sometimes experience difficulties. Perhaps these difficulties are associated with a short work experience of doctors, the lack of sufficient clinical experience.

When examining the oral mucosa, 38.7% (12 people) do not consider it difficult; for 16.1% (5 people) the examination procedure is easy. 38.7% (12 people) of the respondents sometimes experience difficulties when examining the oral mucosa, and for 3.2% (1 person) this manipulation is difficult. It can be assumed that difficulties in examining the oral mucosa are associated with insufficient knowledge of the features of the anatomical structure. For example, very often novice doctors mistake the duct of the sublingual salivary gland for a neoplasm.

When examining the gums, almost all doctors do not see any difficulties: 54.8% (17 people) answered “no problems”, 29% (9 people) - “easy”. Despite the apparent ease of this manipulation, 9.7% (3 people) sometimes experience difficulties. Perhaps this difficulty is due to the low clinical experience of these doctors.

Discussion

Examination of the tongue also presents certain difficulties for the respondents - 25.8% (8 people) have difficulty performing the examination (Fig. 1). 35.5% (11 people) of doctors answered “no problem”, 32.3% (10 people) – “easy” and 2 people (6.5%) answered “very easy”. Such a high percentage of doctors who have difficulties in examining the tongue is most likely associated with a large clinical variety of manifestations of various somatic diseases on the surface of the tongue and not always a sufficient level of knowledge about the manifestation of these diseases. It may be difficult for doctors to make a differential diagnosis of these diseases. It should be remembered that there are also diseases of the tongue itself, so the importance of making a correct diagnosis in the presence of pathology is very high.

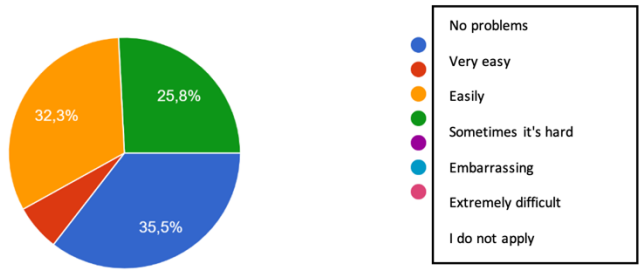

Figure 1. Chart of responses to the question "Language examination".

Evaluation of the state of bite for the majority of respondents is not difficult: 35.5% (11 people) gave the answer "no problem"; 25.8% (8 people) - "easy"; 4 people (12.8%) - "very easy" (Fig. 2). For 25.8% (8 people) of the respondents, this manipulation causes difficulties. Presumably, this is due to a wide variety of bite anomalies, the position of the teeth, which can cause difficulties for the respondents. It is also possible the influence of insufficient knowledge about the closure of the dentition, little clinical experience. And to improve this skill, there is no possibility of training on phantom models.

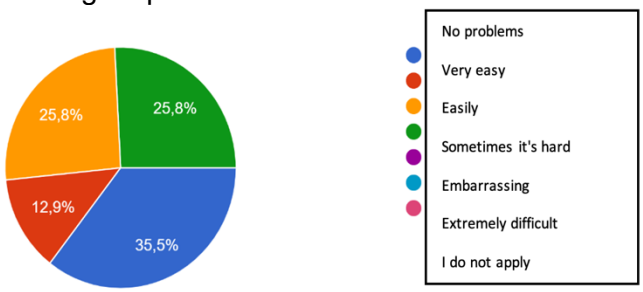

Figure 2. Chart of answers to the question "Evaluation of the state of bite".

Examination of the condition of the teeth is difficult only for 9.7% (3 people). The rest of the respondents did not experience any difficulties. Most likely, doctors have little clinical experience, which prevents this manipulation from being carried out in full. Perhaps this is also due to the difficulties of practicing this skill on phantom models.

Assessment of the state of fillings causes difficulties only in 2 people (6.5%). Perhaps this is due to the difficulties in diagnosing caries and its complications. It is also possible that due to the development of aesthetic restoration of teeth, sometimes it is difficult for a doctor to distinguish between restoration and hard tooth tissues. The rest of the respondents did not experience any difficulties.

The assessment of the hygiene status is quite easy for dentists: 41.9% (13 people) answered “no problem”, 12.9% (4 people) - “very easy”, 25.8% (8 people) - “easy” . For 16.1% (5 people) manipulation is sometimes difficult, 1 person (3.2%) does not use it in their practice. Presumably, this problem is associated with insufficient attention to the assessment of oral hygiene of the patient, sometimes doctors skip this stage. As a result, when it becomes necessary to determine the hygienic index, the doctor experiences difficulties.

When asked about making a diagnosis, the majority of respondents answered "sometimes difficult" - 38.7% (12 people). 10 people (32.3%) answered - "no problem", 6 people (19.4%) - "easy", for 3 people (9.7%) - "very easy" (Fig. 3). Such a high percentage of doctors who experience difficulties in making a diagnosis shows that doctors do not know the methodology for differential diagnosis of dental diseases, they do not know the symptoms of diseases. Obviously this is a big problem among doctors.

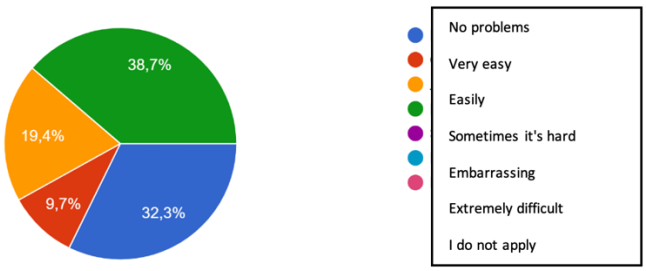

Figure 3. Diagram of answers to the question "Diagnosing".

When performing infiltration anesthesia, none of the interviewed doctors faced any difficulties. All respondents consider this manipulation quite easy: 51.6% (16 people) - "no problem", 45.2% (14 people) - "easy", 3.2% (1 person) - "very easy". Based on the data obtained, it can be seen that this manipulation is easy for doctors to perform. This is due to the training of this manual skill on phantoms, simulators. The technique of infiltration anesthesia is available to a specialist even with little experience.

However, when conducting conduction anesthesia, doctors experience difficulties: 48.4% (15 people) - "sometimes difficult", for 2 people (6.5%) - "difficult". Only 8 people (25.8%) answered “no problems”, for 6 people (19.4%) - “easy” (Fig. 4). Difficulties in conducting conduction anesthesia are almost always associated with insufficient knowledge of anatomical landmarks for its implementation, difficulties in determining them for each patient. Often, difficulties in conducting anesthesia are not associated with work experience, namely, with the lack of manual skills. Young doctors most often do not do conduction anesthesia on their own, sending the patient to the surgical department. This is due to the doctor's fear of manipulation. Therefore, among dentists-therapists, the development of this skill is an urgent problem.

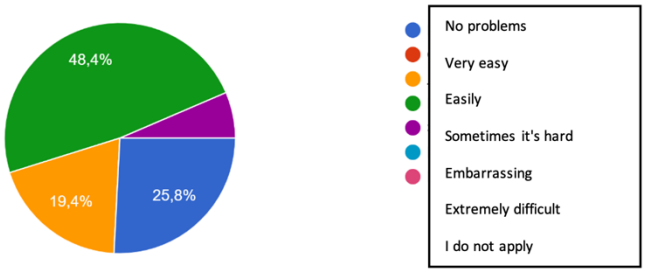

Figure 4. Diagram of answers to the question "Performing conduction anesthesia."

41.9% (13 people) do not use the installation of a rubber dam scarf, for 4 people (12.9%) the installation is difficult, for 8 people (25.8%) it is “sometimes difficult” (Fig. 5). Only 3 people (9.7%) answered “no problem”, 3 people (9.7%) answered “easy”. It can be assumed that such a large number of doctors who do not use rubber dams in their daily practice is due to the lack of manual skill in setting up this system, the relative high cost of the entire system. Also,

perhaps, doctors do not know where you can get training and learn the nuances of working with the cofferdam system.

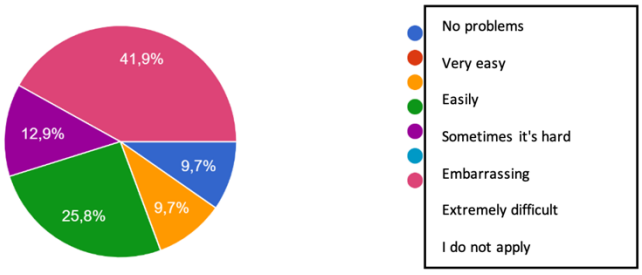

Figure 5. Diagram of answers to the question "Installing the rubber dam scarf".

When asked about work with the use of additional optics - binoculars or an operating microscope - 74.2% (23 people) answered "I do not use" (Fig. 6). Such a high percentage of doctors working without magnification is obviously related to the rather high cost of this equipment. For example, binoculars are adjusted individually by an ophthalmologist, taking into account vision, interpupillary distance of a dentist. It also incurs additional costs. 1 person (3.2%) - "difficult", 2 people (6.5%) "sometimes difficult", 2 people (6.5%) - "easy", 3 people (9.7%) - "no problems." The difficulties of working with the use of additional optics are presumably due to the lack of training seminars on how to work with the use of optics. Doctors have to master the work with magnification on their own, which can cause certain difficulties.

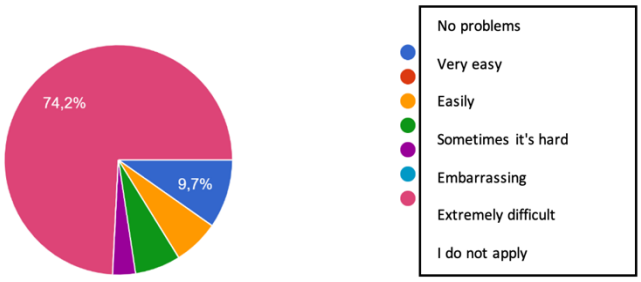

Figure 6. Diagram of answers to the question "Work with the use of additional optics (binoculars, operating microscope)".

When asked about the preparation of carious cavities of various classes according to Black, the majority of respondents answered “no problem”. Doctors sometimes experience difficulties in the preparation of carious cavities of 2, 3 and 4 classes according to Black - 16.1%. This is due to the peculiarities of the preparation of these classes. Most likely, when working on phantom models, the doctors did not experience great difficulties, however, when working with a patient, they encountered certain difficulties. This is due to the fact that phantoms are made of plastic, which differs in hardness and aesthetic characteristics from the hard tissues of the tooth. Carrying out professional oral hygiene does not call for difficulties for respondents: 32.3% (10 people) answered “easy”, 61.3% (19 people) - “no problems”, 6.5% (2 people) - “very easily". Doctors are good at this skill, since they begin to carry out professional hygiene from their student days, work out this skill and subsequently no longer experience difficulties in their work.

Endodontic processing of easily passable root canals with hand instruments practically does not cause difficulties - 41.9% (13 people) answered "easy", 41.9% (13 people) - "no problem", 9.7% (3 people) - “very easy”, 1 person (3.2%) – “sometimes difficult”. Perhaps doctors experience difficulties in endodontic treatment due to the insufficient level of manual skills, poor knowledge of root canal passage and processing techniques, and difficulties in choosing endodontic instruments. 1 person (3.2%) – “I do not use”. Most likely, the doctor performs endodontic root canal treatment with machine tools.

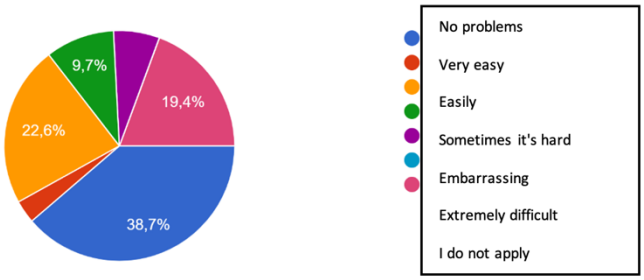

Figure 7. Diagram of answers to the question "Endodontic treatment of easily passable root canals with machine tools".

Endodontic processing of easily passable root canals with machine tools causes more difficulties for doctors. 19.4% (6 people) answered “I don’t”, 2 people (6.5%) – “difficult”, 3 people (9.7%) – “sometimes difficult” (Fig. 7). It can be assumed that this situation is associated with the absence or weak manual skill in working with machine tools, insufficient knowledge of the methods of root canal passage with machine

tools, the anatomical features of root canals, and difficulties in choosing machine endodontic instruments. Most likely, these answers are not related to the length of service of doctors. However, 38.7% (12 people) answered “no problem” to this question, 22.6% (7 people) - “easy”, 1 person (3.2%) - “very easy”.

Endodontic treatment of hard-to-reach root canals with hand instruments is difficult for clinicians (Fig. 8). 45.2% (14 people) gave the answer "sometimes difficult", 3 people (9.7%) - "difficult". It can be assumed that this is primarily due to the peculiarities of the anatomical structure of the root canals. when practicing manual skills on endodontic blocks, it is almost impossible to repeat the complex structure of the root canal. This training does not give doctors an idea about working in difficult root canals. And this is not related to the experience of the doctor. However, despite the complexity of this manipulation, 29% (9 people) of the respondents answered “no problem”, 4 people (12.9%) - “easy”. It can be assumed that doctors have excellent manual skills, constantly improving them. It is possible that they also have a great work experience. 1 person (3.2%) answered “I do not use”. It is possible that the doctor in his practice uses exclusively machine endodontic instruments, or does not take into account these clinical cases.

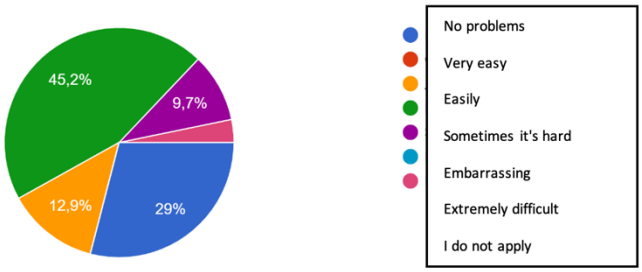

Figure 8. Diagram of answers to the question "Endodontic treatment of hard-to-pass root canals with hand instruments".

Endodontic processing of hard-to-pass root canals with machine tools, as the survey showed, is quite difficult for dentists-therapists (Fig. 9). 25.8% (8 people) answered “I don’t”, 1 person (3.2%) - “very difficult”, 1 person (3.2%) - “difficult”, 35.5% (11 people) - "Sometimes difficult." First of all, the refusal to work with machine files is associated with their high cost when purchased. Difficulties for doctors during endodontic treatment of hard-to-pass root canals with machine tools are most likely associated with the anatomical features of the root canals. Endodontic blocks do not repeat the anatomical structure of the root canal, and as a result, they do not allow the doctor to work out this skill in full. This problem is not related to medical experience. For 4 people (12.9%) this manipulation is easy, 6 people (19.4%) answered “no problem”. It can be assumed that doctors constantly work with the help of an endomotor and machine files, and have extensive clinical experience in working with complex canals. And as a result, they do not experience difficulties.

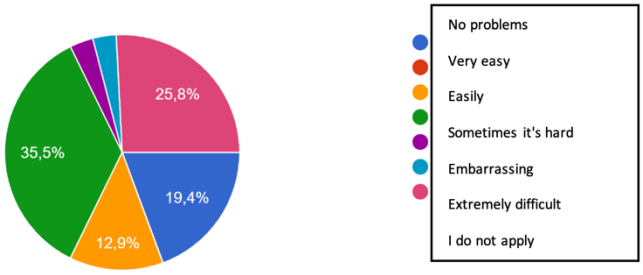

Figure 9. Diagram of answers to the question "Endodontic treatment of hard-to-pass root canals with machine tools".

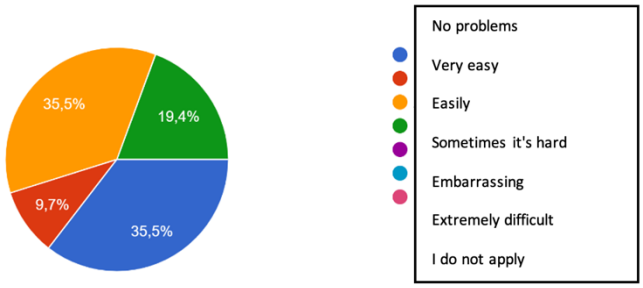

Figure 10. Diagram of answers to the question "Determining the length of the root canal by the electrometric method."

When determining the length of the root canal by the electrometric method, 35.5% (11 people) answered "no problem", 35.5% (11 people) - "easy", 3 people (9.7%) - "very easy" (Fig.10). Doctors do not experience difficulties when using the apex locator due to its user-friendly interface and ease of use. Apex locators of different companies have the same principle of operation, therefore, when changing the device of one manufacturer to the device of another company, doctors often do not experience difficulties. However, 19.4% (6 people) gave the answer "sometimes difficult". Perhaps this is due to little clinical experience with this device, non-

compliance with the manufacturer's recommendations when working with an apex locator. Or the doctor uses the apex locator in his practice from time to time, so he has difficulty using the apex locator.

Filling root canals with paste does not cause difficulties for dentists: 70% of respondents answered “no problem” and “easy”. 12.9% (4 people) gave the answer "sometimes difficult", 1 person (3.2%) - "difficult" (Fig. 11). Presumably, this is due to the insufficient experience of the doctor, the doctor has not yet worked out this manual skill.

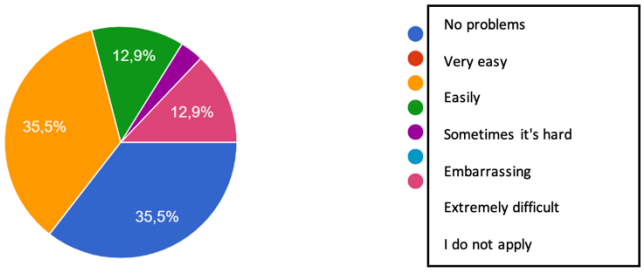

Figure 11. Diagram of answers to the question “Filling root canals with paste.”

Root canal filling using gutta-percha, as the survey showed, is a fairly popular method of canal filling and practically does not cause difficulties in work (Fig. 12). 35.5% (11 people) answered “no problem”, 9 people (29%) – “easy”. 19.4% (6 people) sometimes experience difficulties when filling root canals with gutta-percha. Presumably, this is due to the small experience of the doctor, insufficient development of this skill on phantom models. It is possible that on phantoms the doctor was able to seal the root canal with gutta-percha, but in practice the doctor experiences difficulties, since phantom models do not accurately reproduce the structure of the root canal system. 16.1% (5 people) answered “I do not use”. Most likely, doctors are just starting to work and this filling method seems difficult for them to perform.

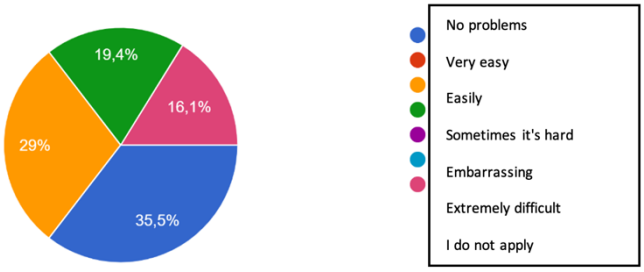

Figure 12. Diagram of answers to the question "Filling root canals using gutta-percha."

The majority of respondents do not experience difficulties in answering questions about filling carious cavities of various classes according to Black. However, when performing restoration in class 2, 19.4% (6 people) answered "sometimes difficult", when restoring class 3 - 22.6% (7 people) answered "sometimes difficult." This is due to the use of various matrix systems, their setting, restoration of the proximal walls with a composite. Performing restorations on phantom models is not difficult for a doctor, but when working with a patient, the doctor faces difficulties: difficulties in adapting the matrix, limited visibility, and patient fatigue. When restoring grade 3, you need to remember about aesthetics. Filling in class 5 is difficult for 2 people (6.5%). Most likely, doctors experience difficulties in adapting the material in the gingival area, frequent loss of restorations.

When asked about filling carious cavities with composite materials, 19.4% (6 people) answered “sometimes difficult”, 3 people (9.7%) answered “difficult” (Fig. 13). First of all, this is due to the high aesthetics of this area: the color, shape of the teeth. Phantom models, on which doctors work out their manual skills, are made of plastic, which is strikingly different in color and light refraction from the hard tissues of the tooth. Moreover, both young doctors and their more experienced colleagues face the difficulties of restoring this class.

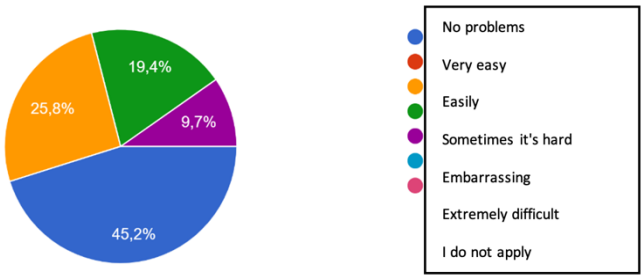

Figure 13. Diagram of answers to the question "Filling of carious cavities with composite materials."

The final processing of the restoration practically does not cause difficulties for dentists-therapists: 45.2% (14 people) answered this question “no problems”, 12 people (38.7%) - “easy”, 1 person (3.2%) - "very easy". 12.9% (4 people) answered sometimes difficult. Perhaps doctors do not follow the full polishing protocol, but are limited to only a few polishers or just a brush and polishing paste. It is possible that

when practicing this skill on phantom models, the stage of polishing the restoration was not given due attention, or the stage was skipped. Most likely, doctors with little experience experience difficulties.

Determining the color of teeth during the restoration of teeth, as the survey showed, is a problem for dentists-therapists, regardless of medical experience. 13 people (41.9%) answered “sometimes difficult”, 1 person (3.2%) answered “difficult”. When working on phantoms, attention is not paid to such an important component as color determination, since the color of the plastic is very different from the color of the teeth. Also, it does not have such characteristics as brightness, transparency. The proposed color palettes are also made of plastic, which makes it difficult for the patient to determine the color of the teeth. Often the doctor determines the color by eye, and this technique is not always accurate.

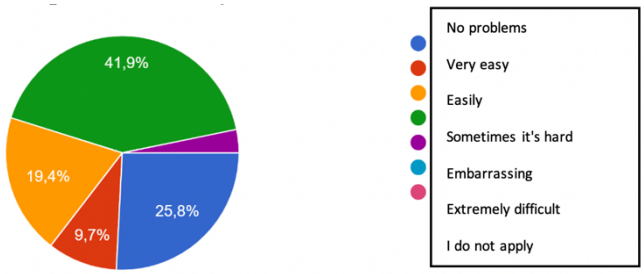

Figure 14. Diagram of answers to the question "Determining the color of teeth for dental restoration."

Conclusions

Medical education is impossible without obtaining the most important practical skills, which should be preceded by the stage of developing the skills to perform manipulations on simulators before working with real patients. As an alternative to phantoms, the development of simulators and simulators based on augmented and virtual reality technologies can become the most promising direction for using these innovative technologies in the field of education. In addition, this kind of simulators allow doctors to improve their skills by mastering new clinical procedures without risk to the health and life of the patient. Unlike existing phantoms, virtual reality simulators provide not only opportunities for interactive, standardized learning, objectification of the assessment of students' actions, but also involve cadets as much as possible in an independent learning process, and also significantly reduce the cost of training and contribute to a better formation of the practical skills of a future doctor, which It is extremely important for one of the most manual skills in the section of medicine - dentistry.

At the moment, there are quite a lot of simulators used in medicine. Virtual simulators are used in training in a wide variety of specialties: laparoscopy, ophthalmic surgery, intraluminal endoscopy, anesthesiology and resuscitation, emergency care in cardiology, pulmonology and toxicology, urology, angiography, arthroscopy. The introduction of simulation methods of training into the practice of training a doctor, into medical practice, is now a necessity, which in turn emphasizes the increase in professional requirements for the competence of healthcare workers and the improvement of the level of training of specialists. When performing medical manipulations, the risk of complications is high, in addition, the existing ethical and legal restrictions make simulation learning technologies one of the most popular in the process of professional training.

However, today there are certain difficulties for the widespread use of virtual reality technologies. One of the main problems is limited access to high-speed networks. Another problem is the small number of medical centers equipped to train cadets in virtual reality. To increase the potential for introducing virtual reality technologies into the Russian healthcare system, it is necessary to unite the efforts of scientists, teachers of medical universities, IT developers, healthcare organizers, doctors and the entire medical community.

Declaration of Interest

The authors report no conflict of interest.

References

1. Albuha Al-Mussawi RM, Farid F. Computer-Based Technologies in Dentistry: Types and Applications. J Dent (Tehran). 2016 Jun;13(3):215-222. PMID: 28392819; PMCID: PMC5376549.
2. Collaço E, Kira E, Sallaberry LH, Queiroz ACM, Machado MAAM, Crivello O Jr, Tori R. Immersion and haptic feedback impacts on dental anesthesia technical skills virtual reality training. J Dent Educ. 2021 Apr;85(4):589-598. doi: 10.1002/jdd.12503. Epub 2020 Nov 28. PMID: 33274441.
3. Custódio NB, Costa FDS, Cademartori MG, da Costa VPP, Goettems ML. Effectiveness of Virtual Reality Glasses as a

Distraction for Children During Dental Care. Pediatr Dent. 2020 Mar 15;42(2):93-102. PMID: 32276674.
4. Dyachenko S.V., Makedonova Yu.A., Gavrikova L.M. Experience in the use of telemedicine technologies in the provision of dental care to patients who have undergone covid-19 // In the collection: Medical Education of the 21st Century: Information Computer Technologies in the Training of Medical Personnel. Collection of materials of the International scientific-practical conference. EE "Vitebsk State Medical University". 2021;147-149 (In Russ.).
5. López-Valverde N, Muriel Fernández J, López-Valverde A, Valero Juan LF, Ramírez JM, Flores Fraile J, Herrero Payo J, Blanco Antona LA, Macedo de Sousa B, Bravo M. Use of Virtual Reality for the Management of Anxiety and Pain in Dental Treatments: Systematic Review and Meta-Analysis. J Clin Med. 2020 Apr 5;9(4):1025. doi: 10.3390/jcm9041025. Retraction in: J Clin Med. 2020 Jul 28;9(8): PMID: 32260538; PMCID: PMC7231096.
6. Makedonova Yu.A., Vorobiev A.A., Kurkina O.N., Kabytova M.V., Dyachenko D.Yu., Osyko A.N., Yavuz I. Diagnostic algorithm of the masticatory musclehypertoniain dental patients // International Journal of Dentistry and Oral Research. 2021; 1(№ 2): 39-44.
7. Makedonova Yu.A., Mikhalchenko D.V., Gavrikova L.M., Dyachenko S.V., Naumova V.N., Veremeenko S. The role of psychoemotional stress in the development of inflammatory post□prosthetic complications // Archiv EuroMedica. 2021; 11(№ 3): 86-89.
8. Murbay S, Neelakantan P, Chang JWW, Yeung S. 'Evaluation of the introduction of a dental virtual simulator on the performance of undergraduate dental students in the pre-clinical operative dentistry course'. Eur J Dent Educ. 2020 Feb;24(1):5-16. doi: 10.1111/eje.12453. PMID: 31278815.
9. Makedonova Yu.A., Kabytova M.V., Dyachenko D.Yu. Prospects for the use of innovative teaching technologies in practical dentistry // In the collection: “Medical education of the XXI century: information computer technologies in the preparation of medical personnel. Collection of materials of the International scientific-practical conference. EE "Vitebsk State Medical University". 2021; 285-287. (In Russ.)
10. Nassar HM, Tekian A. Computer simulation and virtual reality in undergraduate operative and restorative dental education: A critical review. J Dent Educ. 2020 Jul;84(7):812-829. doi: 10.1002/jdd.12138. Epub 2020 Mar 8. PMID: 32147841.
11. Niharika P, Reddy NV, Srujana P, Srikanth K, Daneswari V, Geetha KS. Effects of distraction using virtual reality technology on pain perception and anxiety levels in children during pulp therapy of primary molars. J Indian Soc Pedod Prev Dent. 2018 Oct-Dec;36(4):364-369. doi: 10.4103/JISPPD.JISPPD_1158_17. PMID: 30324926.
12. Ougradar A, Ahmed B. Patients' perceptions of the benefits of virtual reality during dental extractions. Br Dent J. 2019 Nov;227(9):813-816. doi: 10.1038/s41415-019-0939-6. PMID: 31705100.
13. Serrano CM, Wesselink PR, Vervoorn JM. Echte patiënten in de virtuele realiteit: de schakel tussen fantoom en kliniek [Real patients in virtual reality: the link between phantom heads and clinical dentistry]. Ned Tijdschr Tandheelkd. 2018 May;125(5):263-267. Dutch. doi: 10.5177/ntvt.2018.05.17192. PMID: 29754155.
14. Shetty V, Suresh LR, Hegde AM. Effect of Virtual Reality Distraction on Pain and Anxiety During Dental Treatment in 5 to 8 Year Old Children. J Clin Pediatr Dent. 2019;43(2):97-102. doi: 10.17796/1053-4625-43.2.5. Epub 2019 Feb 7. PMID: 30730798.
15. Yeung AWK, Tosevska A, Klager E, Eibensteiner F, Laxar D, Stoyanov J, Glisic M, Zeiner S, Kulnik ST, Crutzen R, Kimberger O, Kletecka-Pulker M, Atanasov AG, Willschke H. Virtual and Augmented Reality Applications in Medicine: Analysis of the Scientific Literature. J Med Internet Res. 2021 Feb 10;23(2):e25499. doi: 10.2196/25499. PMID: 33565986; PMCID: PMC7904394.
16. Zelensky M.M., Reva S.A., Shaderkina A.I. Virtual Reality (VR) in Clinical Medicine: International and Russian Experience // Russian Journal of Telemedicine and E-Health. 2021;7(3):7-20; https://doi.org/10.29188/2712-9217-2021-7-3-7-20 (In Russ.)
17. Zitzmann NU, Matthisson L, Ohla H, Joda T. Digital Undergraduate Education in Dentistry: A Systematic Review. Int J Environ Res Public Health. 2020 May 7;17(9):3269. doi: 10.3390/ijerph17093269. PMID: 32392877; PMCID: PMC7246576.