Original Article

STUDY OF THE POSSIBILITIES OF USING AUGMENTED REALITY IN DENTISTRY

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ABSTRACT

Using augmented reality glasses with the HoloDoctor program for implantological treatment, a new method of simulating implantological and surgical treatment in the maxillofacial region demonstrated good visualization of the anatomical features of the implant placement area, the possibility for the surgeon to carefully study the intervention area before the operation, performing surgery in the conditions of the real anatomy of the patient including the use of navigation in augmented reality, which allows us to practice the skills of operations on a virtual patient using phantom dummies (made using 3D printing) that are linked to holography in real-time. Computed jawbones tomography was performed. The impressions of antagonists and the lower jaw were obtained and plaster models were made from the impressions, and were later scanned. Implants were virtually installed with the help of the planning program and a 3D reconstruction of the image of the jaws was performed, and a template was designed. The model of the jaw and the template are printed on 3D scanners. According to the template and based on the accepted protocol, the implants were inserted into the plastic model.

Key words: 3D Scanner, Simulation system, Augmented reality glasses, Robotic-assisted surgery.

Introduction

Restoring defects in the maxillofacial region is an urgent modern dentistry problem [1-4]. Due to the various causes leading to the loss of hard and soft tissues of this area, the clinical picture can be very diverse, from a defect in a part of the tooth to extensive defects involving several anatomical formations of the maxillofacial and adjacent areas [5-8].

3D technologies allow us to eliminate the need to make calculations and drawings by hand and manual labor. Modern software allows us to see the model from all angles on the screen and eliminate the identified shortcomings not in the process of creation, as is the case with manual manufacturing [9, 10], but directly during the development and prototyping of the model [11-17]. At the same time, the possibility of inherent errors in manual work is practically excluded. Modern software for processing images obtained during cone-beam CT and MRI is supplied together with the devices. The functions of these programs are sometimes not enough to perform more complex work with the obtained data, including differentiation of tumors in various diseases [18-20].

Our previous scientific works [2, 21-32] showed the main shortcomings in this direction:

1. Lack of information about the use of AR- technology and augmented reality holographic glasses to combine simulation and reconstruction on a patient in real-time;
2. Lack of programs for planning and tracking the results of treatment based on objective indicators in dentistry.

The solution is associated with the creation of a new type of simulation system for planning and navigating surgical interventions. The purpose of this work was to test in practice the methodology developed for planning and performing surgical interventions on the maxillofacial region with the assessed technology of additional reality.

Materials and Methods

To achieve this purpose, we developed an additional functional module for dentistry using augmented reality glasses. The module can help with the practice of operations on a virtual patient using phantom dummies (made using 3D printing) that are linked to holography in real-time. This technology in response to the actions of interns, not only shows the physiological parameters of the patient that are

automatically changed, but also intraoperative, endosurgical, angiographic, and ultrasound images.

For this simulation technique, the PAX-i3D cone-beam computed tomography (CBCT) device with a FOV 10X8.5 (12X9) sensor and Ez3D-I software. The Avantis 3D implant treatment planning program, the 3Dison Multi 3D printer, and an out-of-mouth 3D scanner was used. For the diagnosis, specialized programs have been used that process the data of CBCT, allowing the diagnosis and subsequent planning of the operation. The planning system is based on computer data processing and the provision of information on the planning of the operation consists of the assessment of the state of the size and quality of bone tissue, the selection of a place for the installation of implants. This takes into account the location of the real teeth, the maxillary sinus, and the maxillary nerves.

The module for glasses developed by us is controlled by gestures, i.e. the medical specialist can point to the desired organ or instrument (tooth, surgical template), and remove it from the illustration. The software module interacts with the surgical dummy, using previously taken medical data of CT, MRI.

The simulator module allows the surgeon to make notes in the virtual treatment plan before the operation begins. The resulting image is transmitted to the augmented reality glasses (HoloLens).

The developed method was tested based on the Dolgalev Dental Clinic (Stavropol, Russia).

Results and Discussion

To test the developed method, we used the data of a 48-year-old patient who went to a Dolgalev Dental Clinic with complaints of difficulty chewing food, due to lack of chewing teeth in the lateral part of the lower jaw on the left. Diagnosis: partial loss of teeth, terminal defect of the lower jaw on the left. Treatment plan: installation of implants in the area of the teeth 3.6, 3.7.

Using the software, three-dimensional images were obtained and stereolithographic models were made of plastic, completely copying the anatomy of the patient's jawbones **(Figures 1 and 2)**.

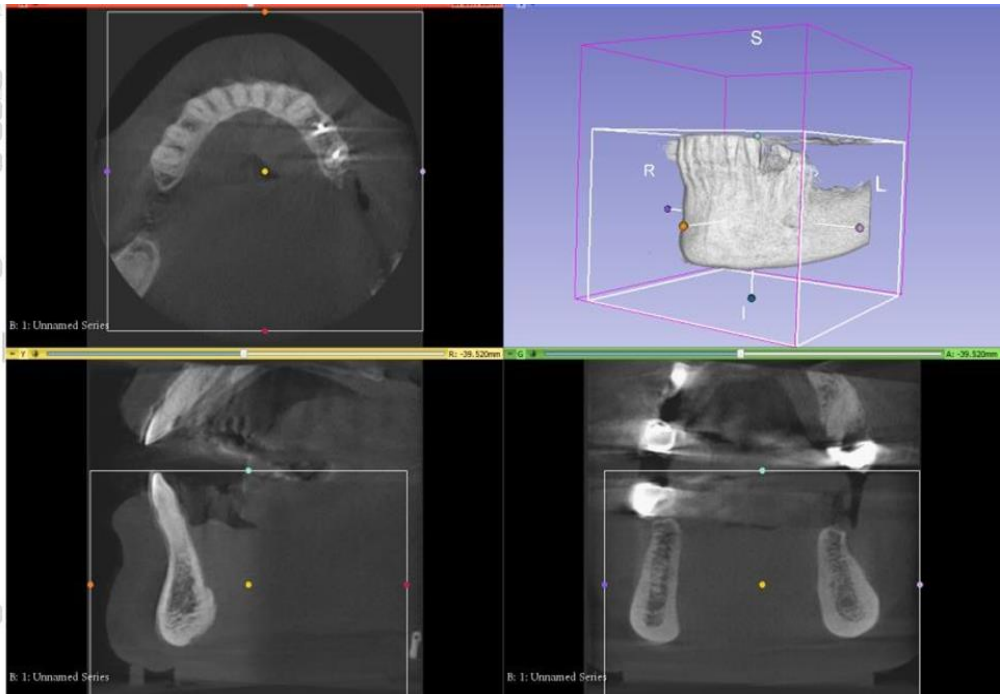

Figure 1. Cone-beam computed tomography data of the patient.

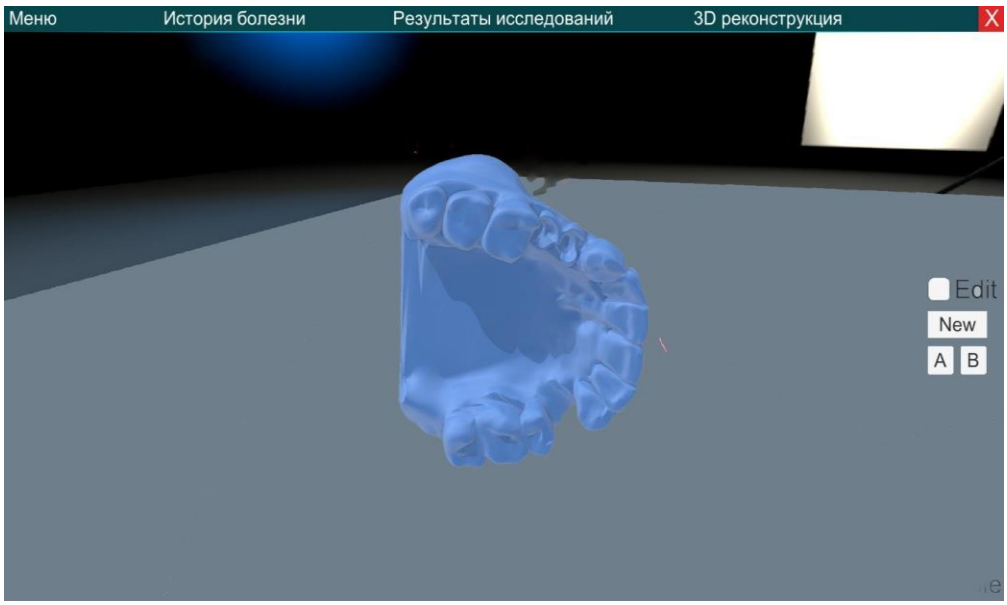

Figure 2. 3D model of the upper jaw processed for a surgical intervention simulator.

The obtained drawings and models allowed us to obtain complete information about the degree of atrophy of the bone tissue of the alveolar process, which significantly increases the accuracy of the implantation operation, as well as the prediction of the result of surgical intervention.

To simulate the process of implant placement, stereolytic plastic models of the jaws were made using DICOM files obtained using CBCT. The template was made according to the following method: the manufactured plaster models of the dentition were scanned using an extra-oral scanner and exported to a 3D template modeling program. This program allows you to superimpose a scanned model of the dentition in the form of STL files on a 3D reconstruction of the dentition obtained using CBCT. A 3D scene is created to model the template. The computer project is sent to a 3D printer, where a template is created that accurately displays the anatomy of the jaw area where the implants will be installed, and the correct position of the implant direction is already indicated on the anatomically verified template.

Conclusion

Computed jawbones tomography was performed. The impressions of antagonists and the lower jaw were obtained and plaster models were made from the impressions, and were later scanned. Implants were virtually installed with the help of the planning program and a 3D reconstruction of the image of the jaws was performed, and a template was designed. The model of the jaw and the template are printed on 3D scanners. According to the template and based on the accepted protocol, the implants were inserted into the plastic model.

The complex of additional reality can serve as a means of telemedicine, during the consultation of patients or surgical intervention.

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