Today we can state with absolute certainty that computer information technologies could not help but find application in dentistry, providing dentists with modern solutions in the treatment of traditional dental diseases.

Technologies of the modern world, in particular dentistry, are developing rapidly. This allows us to ensure the maximum possible restoration of the functions and aesthetics of defects in the dentition at an appointment with an orthopedic dentist.

Digital technologies can be used at all stages of orthopedic treatment.

In this abstract we will look at modern computer technologies that are used to treat partial tooth loss.

Obtaining highly accurate digital impressions

The oral cavity, from the point of view of color perception, is divided into two zones: red and white, the balanced state of which determines the aesthetic perception of the oral cavity as one of the main elements of the human face. The aesthetics of the “red” zone affects the relationship between gums and teeth and dictates the need to recreate the natural appearance of the gums during prosthetics. Obtaining and analyzing information about the relief of the gums is of great importance for the success of orthopedic treatment. Dentures made with insufficient consideration of the anatomical and physiological characteristics of the gum tissue have an adverse effect on the tissue of the prosthetic bed and increase atrophic processes in the jaws. One of the main clinical tasks of dentistry is the complete restoration of chewing function due to the high quality of manufactured dentures. The peculiarity of orthopedic treatment of patients is that the direct production of various types of denture structures is carried out not by the doctor himself in the oral cavity, but by a dental technician in the laboratory using working plaster models. At the same time, one of the main connecting links in this process is the impressions of the prosthetic bed. Let's consider the method of obtaining impressions of the jaws using digital intraoral scanners. In order to determine how reliable digital impressions obtained from intraoral scanners are, it is necessary to distinguish such concepts as accuracy, precision and correctness. In the International Organization for Standardization (ISO 5725-1-2002), these definitions are as follows:

1. Accuracy – the degree of closeness of the measurement result to the accepted reference value. Accuracy includes precision and truth.

2. Precision - the degree of closeness to each other of independent measurement results obtained under specific regulated conditions. This indicator reveals how close the results of repeated experiments are to each other.

3. Trueness - the degree of closeness of the average value obtained on the basis of a large series of measurement results (or test results, 10 or more) to the accepted reference value. This indicator reveals how much the measurement results deviate from the true dimensions of the object. Also important characteristics of intraoral scanners are the size of their working part and the speed of the scanning process itself.

Advantages and disadvantages

Directly obtaining an impression reflecting the situation in the oral cavity, as digital data, has a number of significant advantages over the traditional procedure with the subsequent production of a plaster model:

 Real-time image acquisition: With the traditional method, defects are detected only after casting the plaster model, while with the digital method, defects can be detected immediately on the screen during or after data collection by analyzing the digital model.

 If the quality is unsatisfactory, a specific part or the entire digital print may be rescanned. This allows the dentist to image the entire dental arch step by step, paying special attention to critical areas.

 Ease of repeating the procedure: leakage of blood, release of the retraction thread from the groove along with the impression material, pull-ups and much more when receiving a traditional impression will lead to repetition of this procedure, which involves additional time and material costs. When receiving a digital print, most of these errors disappear, and if the image quality turns out to be unsatisfactory, then the scanning can be repeated without much difficulty.

 Obtaining sequential images of the required segments; the tongue and ramus of the mandible usually interfere with clear imaging of the distal jaw area. Digital impression systems have made it possible to selectively focus on specific segments. It is also possible to scan individual segments over extended areas, which is important when making complex indirect restorations of the entire dental arch.

 No need to disinfect or clean impressions and impression trays: the intraoral camera and all scanner surfaces can be easily treated with disinfectants and can even be autoclaved in some cases. Besides this

o You can use disposable plastic camera covers.

 Virtual design analysis without leaving the office: In addition to the ability to control preparation thickness based on future design parameters, some digital impression systems can also allow the user to check the insertion path of an indirect restoration. Using digital model analysis, it is easier to evaluate prepared teeth for extended structures than using a dental mirror.

 Fast data transfer via the Internet to the dental laboratory (without spending time and money on delivery).

 Unlike a plaster model, a virtual model cannot be damaged or broken during transportation, work, etc., and is available at any time.

 Creation of an archive of virtual models: does not require the allocation of a separate space, as for storing plaster models, and also makes it possible to easily and simply search the database.

 Saving material consumption.

 CAD/CAM option without leaving your office: computer-aided design technology, proposed by Sirona Cerec in the late 1980s, is today the most important for other developers of similar systems. CAD/CAM allows you to model and send the design of the future structure to the dental laboratory on the same day.

 After receiving an optical impression and creating a digital model, a temporary structure is manufactured from a block of polymer using CAD/CAM technology, the accuracy of which is many times higher than the fit of a temporary structure manufactured in a standard way.

 The scientifically proven benefit of the combined use of adhesive-sealants and permanent structures materials immediately after taking a digital impression is to provide protection against bacterial penetration. This eliminates the risk of bacterial invasion during the intermediate stage of treatment. The quality of the adhesive connection is not damaged by temporary cement, as happens with two-visit treatment. Moreover, the adhesive helps stabilize the structure of the tooth tissue. When using this technique, the treatment time itself is reduced, which most patients find very convenient.

 Virtual Cropping Feature: Allows the user to “cut and paste” unsatisfactory scanned areas. This function is also used for broader purposes, for example, even before the start of treatment, you can get an initial scan, from which you can “cut out” the teeth planned for restoration. These teeth are then re-scanned after preparation and automatically inserted into the original virtual model.

 Virtual tracking: Sequential digital analysis is performed to detect changes inside the mouth such as: tooth displacement, gum recession, progressive wear, etc.

 Color reproduction: Some digital impression systems have color reproduction capabilities that provide better perception of dental and gingival tissue.

 Overlay function: the ability to combine 3D tooth surface information with other systems, such as facial scans or CT scan data.

However, it is worth noting that not all digital impression systems have the characteristics described above. The devices available today are not universal and have certain disadvantages, such as:

 Experience and ability to operate scanners is required.

 Due to the current state of development, optical impression systems are not yet a complete alternative to traditional methods, in terms of the range of indications and required functions. For example, in the case of implant prosthetics, it is necessary to use a special transfer, which must be compatible with both the scanning system itself and the software in order to reproduce the restoration on a computer. Although numerous methods are now available for making models (such as milling and stereolithography) and creating indirect restorations on natural teeth, not all manufacturers of optical impression systems have solved the problem of obtaining high-precision models for implant restorations.

 3D capture of extended edentulous areas is not performed on all scanners. Most available optical impression systems are officially designed for the production of bridges with a maximum of two pontic units. A combined prosthesis, consisting of a fixed and removable part, is often easier and more cost-effective to produce using traditional impression techniques.

 Static and dynamic occlusion: Some optical impression systems need to improve the ability to record interocclusal relationships and simulate dynamic occlusion after extensive removal of support zones.

 Electricity consumption.

 Relatively high cost. Some systems charge a fee per scan when sending data to the laboratory.

The following intraoral scanners are known today:

1. CEREC ® AC Bluecam, CEREC Omnicam, Apollo DI – Sirona Dental System GMBH (Germany)

2. iTero – CADENT LTD (Israel)

3. Lava™C.O.S., True Definition – 3M ESPE (USA)

4. E4D – D4D TECHNOLOGIES, LLC (USA)

5. IOS FastScan – IOS TECHNOLOGIES, INC. (USA)

6. MIA 3DTM – DENSYS LTD. (Israel)

7. DPI-3D – DIMENSIONAL PHOTONICS INTERNATIONAL, INC. (USA) 7

8. 3D Progress – MHT S.p.A. (Italy) and MHT Optic Research AG (Switzerland)

9. PlanScanTM – Planmeca (Finland)

10. trios – 3SHAPE A/S (Denmark)

11. Condor – MFI (Belgium)

12. Bluescan-I - A-tron3d (Austria)

13. ElIOscan - Steinbichler Optotechnik GmbH (Germany)

14. Optic-DENT – VNIIOFI (Russia).

Let's consider all these existing devices with special attention to the principles of their operation, features and individual characteristics.

CEREC® - Sirona Dental System GMBH (Germany). CEREC ® (short for office-based economic restoration with esthetic ceramics) was introduced by SIEMENS AG (now Sirona Dental System GMBH) in 1985. The system has undergone a number of technological improvements, leading to the introduction of CEREC AC® BlueCam®, introduced in January 2009 year, and CEREC Omnicam, introduced in August 2012. The latest versions of the CEREC ® system are able to collect information about the topography of objects and design inlays, onlays, crowns, veneers and bridges. The CEREC ® system combines a 3D digital scanner with a milling device to create dental indirect restorations by coating teeth with a special powder to ensure uniform surface reflectivity. The main difference of the CEREC Omnicam system is that there is no need to use powder, and 3D images are obtained in natural color.

In April 2013, the Apollo DI system was released, which has the best price/quality ratio of Sirona's entire line of intraoral scanners.

iTero - CADENT LTD (Israel). The Cadent iTero digital impression system from Cadent LTD, IL went on sale in early 2007. The iTero system uses parallel confocal microscopy. Confocal microscopy is one of the optical microscopy methods that has significant contrast compared to conventional classical microscopes. A distinctive feature of this method is the use of a diaphragm that can cut off the flow of background scattered light. In a confocal microscope, an image of one current of the object is recorded at each moment of time. A complete image is obtained by scanning the movement of the sample or rearranging the optical system. After the objective lens, a small diaphragm is located so that the light emitted by the point under study passes through it and is recorded, and the light emanating from other points is delayed by the diaphragm. This technique allows images to be captured of all structures and materials present in the oral cavity without the need for reflective powders. The scanning procedure itself includes five sequential steps: image capture occlusally

th, lingual, buccal surfaces, and interdental contacts with adjacent teeth. This takes about 15-20 seconds for each tooth being prepared. At the end of the procedure, the patient is asked to close his mouth in the position of central occlusion, and the dentition is scanned in a closed state. Overall, 3D upper and lower quadrant models and a virtual bite register can be obtained in less than 3 minutes.

Lava™ Chairside Oral Scanner (C.O.S.) - 3M ESPE (USA). The Lava™ Chairside Oral Scanner (C.O.S.) was created by Brontes Technologies in Lexington, Massachusetts and was acquired by 3M ESPE (St. Paul, MN) in October 2006. The intraoral scanner was officially introduced in February 2008. Lava C.O.S. system consists of a processor, a touch display and the scanner itself. The camera grip weighs 390g and the head width is 13.2mm. The basis of the Lava C.O.S. The principle of active sampling of frontal waves with the projection of structured light is based. This method was called “3D-in-Motion technology”. Computer processing in the Lava C.O.S system. allows you to create a real-time video sequence from 3D images, the shooting speed of which is 20 frames per second. To perform scanning, you need to use a special powder. The system automatically ends the scanning procedure as soon as the dentist returns to the tooth where he started. The dentist then confirms the scan by obtaining images of other teeth in the arch. If low-quality images are detected, just scan a specific area, and the software will correct the error itself. The procedure ends with scanning the teeth at maximum fissure-tubercle contact, while the buccal surface of one side of the 12 jaw is covered with powder. After which the 3D models of the upper and lower jaws are distributed into the articulator on the screen. The system's computer software creates a stereolithography (SLT) model, which can be sent to the dental technician's laboratory via the Internet.

True Definition – 3M ESPE (USA). On October 16, 2012, 3M ESPE (USA) introduced the “True Definition” intraoral scanner, the handle of which is much smaller and lighter than the previous version. Other benefits include: design; interactive, multi-touch monitor; free connection with other systems through the 3M Connection Center and support for STL image files. True Definition is a self-contained system with built-in milling equipment. The system has anti-fog optics.

E4D - D4D Technologies LLC (USA). The E4 Dentist system was introduced by D4D Technologies LLC (Richardson, TX) in early 2008. It is a mobile unit consisting of a processor and monitor, a laser scanner, and a separate unit for milling. E4D does not require the use of reflective agent (powder). The scanner head must be at a certain distance from the surface being scanned. This is achieved using a rubber tip on the scanner head. The user holds down the pedal while the image is centered, and when the desired area is selected on the screen, he releases the pedal and the moment of shooting occurs. The diagram on the monitor shows how to orient the scanner to obtain the next image. Once all images are received, they are lined up in 3D

model. A touch screen monitor allows the dentist to view the tooth scan from all sides, which makes it possible to evaluate its quality. The E4D system is designed to automatically detect and mark the final preparation margin.

IOS FastScan™ - IOS Technologies Inc. (USA). iOS Technologies Inc. was founded in early 2007 with the goal of bringing its own proprietary intraoral scanners and digital impression devices to the market. And in July 2010, the company announced that the IOS FastScan intraoral digital scanner had been improved from its prototype and had successfully passed all clinical trials. The laser in the IOS FastScan system automatically moves on a track inside the handle, so the dentist only needs to hold the handle itself in three positions - buccal, lingual and occlusal - to scan the full arch. How Lava C.O.S. and iTero, iOS FastScan is a standalone scanner, so the dentist will have to collaborate with the laboratory. IOS FastScan scan data is output in an open-source stereolithography (STL) format that all laboratories can recognize, open, and manipulate. The system also includes a computer-aided design (CAD) module to obtain color, transparency and 3D shape information to display an accurate color representation of the future design. Color, transparency and surface information are combined into one file and sent electronically to the laboratory or CAD/CAM system for subsequent production. IOS FastScan™ Dental CAD software allows you to create a virtual model on which the preparation margin can be marked.

Densys3D - DENSYS LTD (Israel). Densys3d is a stand-alone device consisting of a processor, monitor and intraoral camera, created by DENSYS LTD (Migdal Ha'Emeq, Israel). The Densys3d system uses the principle of active stereophotogrammetry with structured light projection. The data obtained during scanning is archived into small files that can be used when working with various CAD/CAM machines from other manufacturers. Using this system, dentists can create and store small files that are ready for export to CAD/CAM devices in the clinic or in remote laboratories. The weight of the handle is about 100 g.

DPI - 3D from Dimensional Photonics International Inc. (USA). Dimensional Photonics International Inc. (DPI) is a developer of 3D measurement and image capture technology. The company's latest development is an intraoral DPI/O scanner, which is small in size and operates in real time. Patented DPI technology does not require the use of powder to produce an accurate image of a tooth or full arch. The system is immune to relative movement of the device and objects. Advantages of a DPI/O scanner over older "white light" scanners include less sensitivity to ambient light variation, higher accuracy, greater depth of field, enhanced scanning capabilities for shiny and transparent surfaces, and target-less scanning capabilities. and photogrammetric systems.

3D Progress from MHT S.p.A. (Italy) and MHT Optic Research AG (Switzerland). 3D Progress produced by MHT (Medical High Technologies) S.p.A. and created by MHT Optic Research AG (Switzerland), is a portable digital impression system that connects to a PC via a USB 2.0 cable. MHT Optic Research AG and MHT S.p.A were founded in 1995 by Markus Berner and Carlo Gobbetti. 3D Progress allows you to obtain a digital print in less than 1/10th of a second for a single scan, with speeds starting from 14 scans/second (depending on PC properties). A full arc can be scanned in approximately 3 minutes. The scanner does not require the use of powder to coat transparent surfaces. Scanned surfaces are first output in 16 point cloud form, and then in the final version, in STL format, compatible with most CAD systems. The main technical characteristics of the 3D Progress system are: a sensor that allows for fast and accurate scanning, automatic stitching of images of each individual scan in real time, the ability to pause / stop scanning at any time, automatic (or semi-automatic) determination of the preparation boundary , connection to PC using USB 2.0.

PlanScanTM – Planmeca (Finland). The PlanScanTM intraoral scanner was introduced in March 2013. It can be directly integrated into the dental unit or can be used as a stand-alone device. The scanner itself has interchangeable tips of various sizes, depending on the patient’s oral cavity. In addition, these tips are sterilized in an autoclave, which prevents the spread of infection. In optical

The scanner system uses anti-fog technology. Real-time scanning can be performed on a single tooth or a full arch. Data is output in STL format. The PlanScanTM software can be installed on PCs running Mac OS and Windows operating systems. This system uses the triangulation method. The light source is a laser. During direct examination, the scanner head should be 15-20 mm away from the surface of the teeth. At the same time, the recording speed is more than 10 3D data per second, with an accuracy accuracy of less than 25 microns.

TRIOSTM from 3Shape A/S (Denmark). In December 2010, 3Shape announced an intraoral scanner called TRIOSTM, which was presented at the International Dental Show (IDS) in March 2011 in Cologne, Germany. And in March 2013, the company introduced TRIOS Color solution, with which you can obtain images in natural color. The TRIOSTM system operates on the principle of confocal microscopy. It does not require the use of powder. During the scanning procedure, the head of the handle should move smoothly, slightly away from the surfaces of the teeth. It has an integrated anti-fog mechanism for optimal visualization. To prevent the spread of infections, the scanner head is autoclaved. The image is acquired in real time. Data is recorded in STL format. The system allows you to take digital impressions for crowns, bridges, inlays, onlays, veneers, and crowns on implants.

Condor – MFI (Belgium). A new intraoral scanner developed under the supervision of Professor Duret, the founder of CAD/CAM technology. The system is

open and does not require the use of powder. The camera grip is small. The scanner was first presented at the international exhibition IDS in March 2013 in Cologne, Germany.

Bluescan-I - A-tron3d (Austria). Bluescan-I has dimensions of 25 X 22 X 216 mm and a tip weight (without cable) of 50 g. The design is similar to the handle of a toothbrush. It requires no calibration or maintenance and is sterilization resistant. During the scanning process, the head can touch the surface of the teeth, or stand 20 mm away. Area area (at 5mm distance): 21 x 17mm. Data is received in real time (8-15 frames per second). Light source: ultraviolet pulse. Scanning does not require special preparation of teeth or application of powder to their surface. The time required to study a full arc is 4 minutes. The format of the received data is STL files, or any other formats, depending on your wishes. The scanner software can be installed on a PC running Windows 7 (64-bit) operating system. Data transfer is carried out using USB 2.0.

ElIOscan - Steinbichler Optotechnik GmbH (Germany). In March 2013, the ElIOscan intraoral scanner was presented at the international exhibition IDS in Cologne. Handle length 200 mm, weight 40 g without cable. Head dimensions 10 x 26 mm. This system uses LED technology (BLUE-LED). The measurement principle is random correlation. The accuracy of the device is about 25 microns. The data processing process takes approximately 5 seconds. The system is under development.

Optik-DENT – VNIIOFI (Russia). In our country, Professor G. G. Levin (Dr. Sc., Prof., head of the laboratory of the All-Russian Research Institute of Optical and Physical Measurements, VNIIOFI) developed and patented a method for optically measuring the shape of the surface of a three-dimensional object, which led to the emergence of the domestic CAD/CAM system “Optic-DENT”. This is an in-office mini-system designed for the manufacture of inlays, veneers, crowns, and prosthetic frames. Optic-DENT includes: an intraoral video camera for non-contact measurement of the shape of the surface of a prepared tooth or plaster model; computer modeling part, the software of which allows for virtual restoration; milling machine. The intraoral camera for the Optik-DENT system has a short shooting time and pulsed lighting, which significantly eliminates the hand trembling factor when shooting. The camera dimensions are 48x65x255 mm (width × height × length). The computer program of the system contains a library of 3D dental models; 3D surface editing tools (movement, deformation, section viewing, scaling, rotation, local surface editing); digital modeling of restoration.

The use of 3D digital intraoral scanners has many of the advantages presented above, but there are also some disadvantages. For example, in some cases, to eliminate measurement errors and obtain stable focus, it is necessary to install the camera handle on the jaw and use special coatings on the teeth. In addition, a virtual 3D model is often reconstructed by processing single images (obtained in one plane); therefore, the reconstruction is not performed in real time with continuous capture of the entire volume of data. There is currently insufficient data on the accuracy of existing scanners.