

CAD/CAM In Dentistry

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ABSTRACT

Information and communication technologies, including advanced dentistry structures, have found widespread applications in the healthcare sector. The process of obtaining a finished dental restoration through fine milling of ready ceramic blocks is recognized as CAD / CAM application in dentistry. (CAD) / (CAM), respectively, dental computer-aided design and computer-aided manufacturing processes of inlays, cutouts, crowns, and bridges. CAD / CAM software allows for the creation of two and three-dimensional models, as well as their materialization by numerically controlled machines. Many dental offices around the world are focusing on implementing cutting-edge IT solutions in daily practice in order to operate more efficiently, reduce costs, increase patient satisfaction, and achieve desired profits. Aside from professional clinic management software, inventory control, and so on, or hardware such as the usage of lasers in cosmetic dentistry or intraoral scanning, the use of CAD / CAM technology in the field of prosthetics has recently gained prominence. The paper discusses the benefits of using this technology, as well as the satisfaction of patients and dentists who use systems such as Cercon, Celay, Cerec, Lava, Everest, Lava, and Everest, which are essential in creating dental restorations in advanced dentistry.

Keywords: CAD/ CAM, 3D teeth printing, Prosthetic, Intraoral scanning, Dentistry, ceramic

Introduction

Greater use of information and communication technologies is required in modern dental practice. There are numerous advantages to assisting the dentist's work, but there are also dental service users who are becoming more aesthetically demanding, with a clearly expressed desire for the least amount of time spent in the dental office. The computer is becoming increasingly prevalent in prosthodontics practice as a method of interactive communication, both in dental offices and in dental technical laboratories. Specifically, when replacing pathologically altered tissue and fabricating fixed prosthetic inlays, Onlays, crowns, and veneers are indicated, or when it is necessary to replace missing teeth with bridges, CAD / CAM technology is used. The use of computer systems in therapy is a challenge for enthusiasts and visionaries who have pioneered a completely new field of computerized dentistry. With a plethora of current and potential applications in dental services, CAD/CAM systems represent the pinnacle of digital technology. Computer-aided design systems in dentistry are composed of three main components.

- 1) The first component is a device that reflects the preparation of teeth and other supporting tissues and oversees digitalizing spatial data.
- 2) The second component is a computer that plans and calculates the body form of the restoration, which corresponds to the CAD area
- 3) The third component is a numerically controlled milling machine that produces dental restoration from the basic shape, which corresponds to the CAM area.

Additional processing, such as polishing, is usually recommended by a dental technician or doctor.

Literature Review

The year 1985 was pivotal in the introduction of CAD/CAM technology in dentistry. In fact, this year, multidimensional measurement was performed using triangular cameras, allowing for the transfer of measurement data to a computer screen. The first silicate inlay restoration was achieved at the University of Zurich using a PC, image processing software, and connections to a CNC milling machine. It was almost unimaginable technology and the practical creation of a new concept in dentistry at the time.

In 1988, CAD/CAM technology was introduced into dental practice in Germany. When the minimum thickness of the restoration is less than the recommended thickness, modern software alerts the dentist to the problem. Furthermore, critical areas are marked and easily identifiable on the virtual model, which can be corrected using the tools provided. Technology progressed from machine copy milling to a fully computer-controlled system with a large base form of the tooth, allowing the automatic production of crowns and bridges, which are expected to have much greater use in producing fixed restorations in the future. CAD-CAM technique and countless studies resulted in a formula for making extremely faithful restoration that is not only aesthetically appealing but also extremely biocompatible. It is made of nonmetal ceramic. Depending on the nature of the tooth defect, these materials may be used to create crowns and bridges, dental veneers, or special fillings.

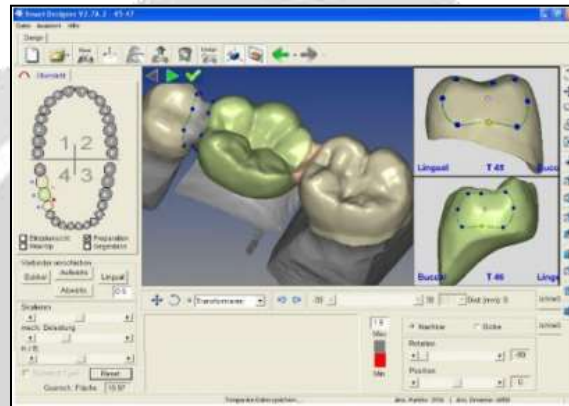


Figure 1: 3D – Model in CAD/ CAM

All these restorations are created in dental technology laboratories equipped with CAD-CAM technology (computer), which ensures exceptional precision and aesthetics. It enables the dentist to create a very precise and appropriate anatomical design of missing tooth substance by generating a 3D representation of gums and teeth on the screen. The generated 3D models are an excellent starting point for the restoration design. When designing, the connection with adjacent teeth and gums in the opposite jaw establishes appropriate contacts, but the relationship between restorations and soft tissue and gums is also considered. The CAD/CAM machine produces restoration of teeth that is an exact replica of the 3D drawings, i.e., the design of the restoration, which is done by a dentist via the CAD / CAM software, as seen in Production plant ceramic frames which are processed by the milling process, are made in several different shades, for the color corresponding to the requirements of patients, as well as the parameters that determine the high level of aesthetics.



Figure 2: CAD/CAM technology for manufacturing



Figure 3. CAD/CAM allows us to quickly restore damaged teeth with natural-colored ceramic filling

Methodology

1) Process of producing metal-free restorations by CAD/CAM technology

The CAD-CAM process of producing ceramic restorations is more precise than the traditional process of producing metal-ceramic crowns and bridges.

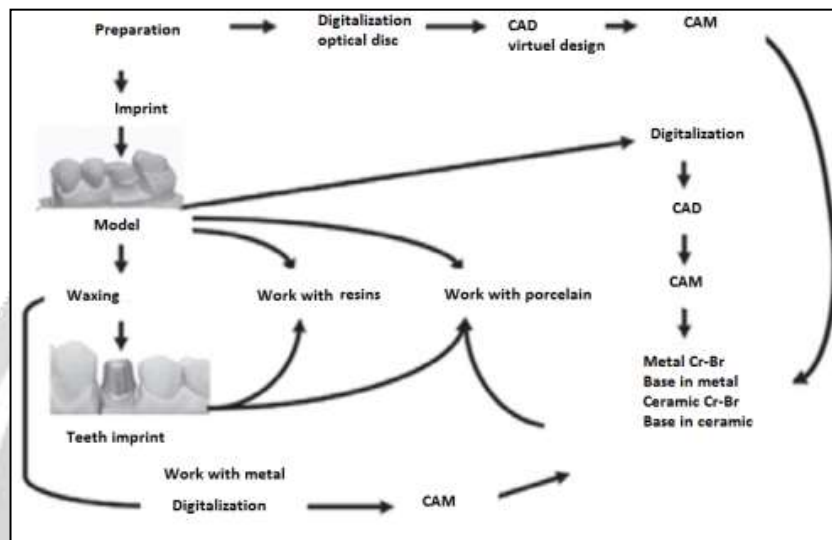


Figure 4. Display of dental CAD / CAM system in the process of producing crown-bridges

Prosthetic restoration is completed in several stages, which are listed below.

- 1) *Overview and History:* Based on the indications and the status of the tooth, the dentist diagnoses and recommends several options, explaining the pros and cons, depending on the indication.
- 2) *Preparation of teeth for placing prosthetic restorations:* The process begins by grinding of teeth and their suppression, which is carried out by the dentist depending on the type of ceramics to be used for certain clinical cases, i.e., to create the prosthetic restoration.
- 3) *Taking the tooth imprint:* The dentist performs the tooth imprint (one or more, depending on which prosthetic restorations works, on which it will carry out further construction and casting of prosthetic restoration.
- 4) *Casting of the model:* Based on the tooth imprint plaster model is cast, on which is carried out further work, based on tooth imprint.
- 5) *3D scan of the model:* The 3D oral camera captures teeth, after which the image is transferred to a computer and processed using the software. These cameras allow a high degree of accuracy and efficiency and are particularly suitable for the restoration of the individual crown.
- 6) *Modeling:* CAD / CAM software modeling the teeth based on the entered requirements.
- 7) *3D teeth printing:* Before you start teeth printing, you need to install ceramic blocks in the milling. The ceramic block is fixed on the wheel that allows the block to be inserted. The bridge is produced by a milling process based on the 3D model from the block set in the CAD-CAM device. A milling machine develops the desired shape in accordance with the instructions of a computer. The ceramic

block is processed by turning on its axis, a diamond disk rotates, moves up and down around the ceramic block, and processes it. The movement of the diamond disc is enabled via an electric rail.

- 8) *Cementation*: Prosthetic restorations are cemented with special aesthetic cement for metal-free ceramics. There are two types of cementing - temporarily and definitively. Temporary cementing of restoration is done in the period of adaptation of prosthetic restoration to the jaw, while definitive cementing is done after ensuring that the prosthetic restorations is accepted.

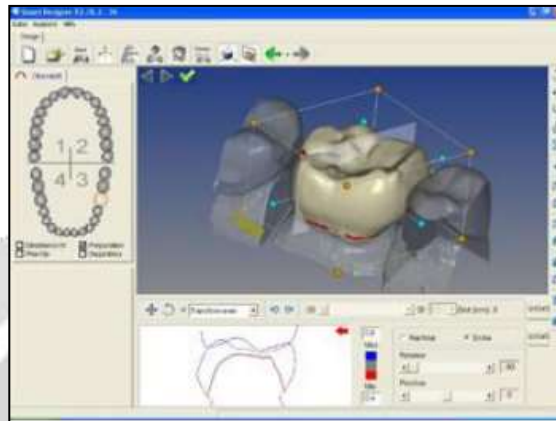


Figure 5. Display of the metal-free restoration by CAD / CAM technique

The advantages of metal-free ceramic compared to metal-ceramic works: -

- Complete biocompatibility of materials.
- The absence of allergy to this material (many patients with metal bridges suffer from allergic reactions because of the large amount of nickel in the metal alloy).
- Absence of bimetalism at metal-free works (creating low-voltage levels between the two metals, e.g., between metal-ceramic crowns).
- The firmness of works is 4 times higher than the metal used for metal-ceramic works.
- Persistence and not changing its physical and chemical properties even after long years spent in the mouth.
- The aesthetic superiority compared to metal-ceramic works.
- Beneficial effects on the gums, i.e., “gingiva” with which it comes into contact.
- The absence of dark discoloration of the “gingiva” at the junction of the crown and gums.

The disadvantages of metal-free ceramic compared to metal-ceramic works: -

- Due to the expensive and long-term development of this technology, expensive CAD-CAM machines, and expensive processes for manufacturing, metal-free crowns are more expensive than metal-ceramic works. However, considering the relationship between price and quality, it can be said that the ratio is on the side of metal-free ceramics.

Types of metal-free works

- 1) *Metal Metal-free crowns* are aesthetic restorations that are made in the dental laboratory of special blocks by using CAD-CAM techniques. Blocks have characteristics very similar to natural teeth, depth, and transparency so that the final product represents a faithful copy of natural teeth. Cemented by a special cement, which further contributes to the aesthetic characteristics of the crown.
- 2) *Inlay – Onlay*: These are dental restorations that represent a transition between crown and filling. They are used when there is not much remaining tooth structure and to avoid producing crowns. In the cases when dental caries too, much devastated the tooth structure, and when after the removal of caries, the resulting cavity cannot be adequately compensated by classical fillings (either of amalgam or composite), then it is produced inlays. Inlays are usually made of ceramic or metal. The main difference between the inlay and the fillings is, in

addition to the material from which it is made, that the inlay is made outside of the mouth. Therefore, for the manufacturing of inlays, it is needed at least two visits to the dentist. In the first visit to remove the carious mass and preparing the tooth for an inlay. Then making tooth imprints. Based on tooth imprints technician in the lab creates an inlay, which is then on the second visit cemented in the mouth of a patient.

Depending on the size of the inlay, i.e.. the extent of the cavity that is formed after the removal of caries, we distinguish two forms of this restoration

- Inlays (inlay) - which affects a maximum of two surfaces of the tooth
- Onlays (onlay) - that affect three or more surfaces of the tooth.



Figure 6. Inlay-Onlay bridges

- 3) *Inlay Bridges*: Inlay bridge is a minimally invasive method for metal-free dental restorations, excluding implants. In this type of bridge adjacent teeth are grounded to a minimum in the form of fillings. For all other types of bridges adjacent tooth is ground and onto it is set a crown in order to carry the missing tooth.

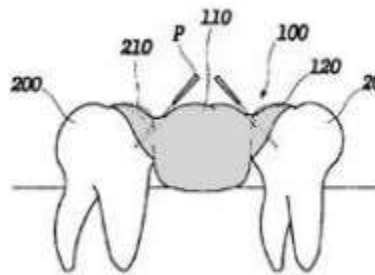


Figure 7. Inlay Bridges

Optical methods of spatial digitalization:

Optical methods of spatial digitalization, like mechanical, based on the criteria of space where the scan is performed, are divided as

- Intraoral
- Extraoral methods.

In relation to the size of the scanning area, they are classified as dotted and striped (surfaced). Intraoral scanning means work in a dental office, while the extraoral methods are mainly related to laboratory work. Both methods have been developed side by side, but today in the practical application is present only a single intraoral (two are in the announcement) and a great number of extraoral systems. The requirements set for them are different. For ergonomic reasons, the intraoral scanner should not be fixed to the remaining teeth. This affects the request of its shape, size, weight, and ability to maintain hygiene, but above all the speed of scanning. Empirically it is proven that trained users can keep the scanner head immovable and still versus the scanned tooth, mostly for 0.5 seconds. The data on the speed of data measurement acquisition, in addition to the resolution, is one of the most important in the choice of the system and its broad applicability. The size of the scanning field is minimally 14x14mm, and optimally

25x14mm. The range of scanning depth should be at least 10 mm, but should not be greater than 14 mm. Scanner resolution should be at least $\pm 25\mu\text{m}$.

This technique is using more light rays, in the form of lines, projected on the preparation (line hatched area). The rays in rapid oscillations move across the object so that in a short period of time is obtained three-dimensional shape of preparation. Similarly, to conventional photography, the camera at the time of recording should be kept as still as possible. Fixing the camera opposite to the object in this system is not necessary because the time required for data processing from all the 340,000 pixels is less than 0.5 sec.

Extraoral systems scan is carried out on the model, and for this reason, there is a need for a dental technical laboratory. In these systems, it is not critical for high-speed data collection, because the head of the scanner and the object that is scanned are immovable, but the width of the scanning and precision measurements. A different solution, to achieve the third dimension by using the CCD chips, gives the laser triangle procedure, if you focus laser dot air with an oscillating mirror for a CCD camera there will be a clear limited laser line. The great advantage of this system is the possibility of scanning undermined surfaces. This mode is for now only possible as extraoral methods.



Figure 8. Cerec Scan – integrated laser scanner, dot scanner

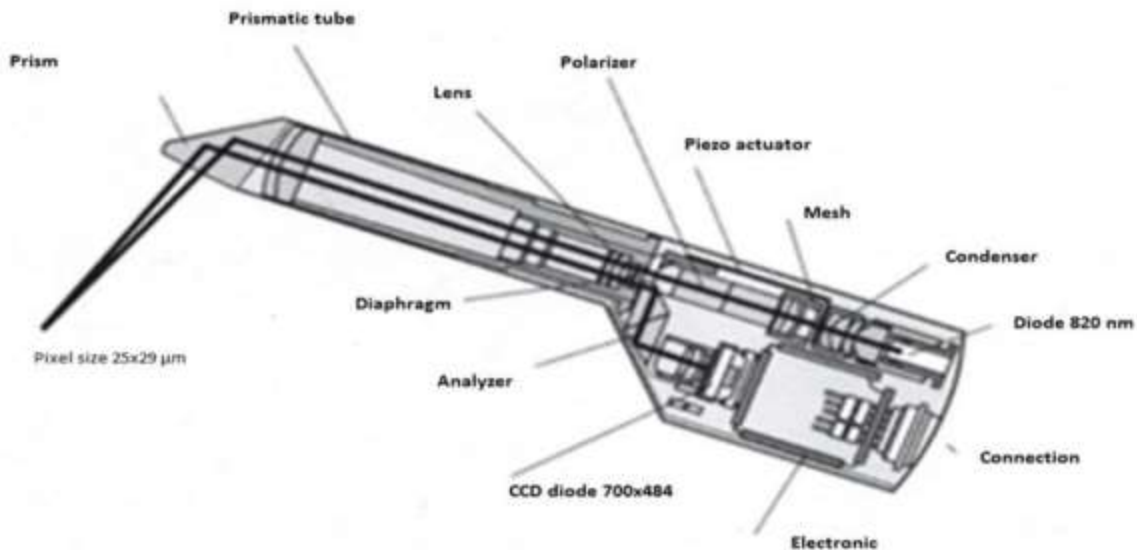


Fig 9: Scheme of Cerec 2 scanner head section

Advantages of using CAD / CAM technology for dentists are:

- The patient spends less time in the office

- A simplified procedure
- Significantly reduced costs for dental technical laboratories
- Reduced consumption of materials
- Increased productivity
- Easier way of producing
- Precisely produced restorations
- Increased productivity.

Advantages of using CAD / CAM technology in the dental-technical laboratory:

- Easier way of producing
- More precisely made restorations
- Lower consumption of materials
- Higher productivity.

Advantages of using CAD / CAM technology to produce Onlays:

- Very often saves the tooth structure compared to traditional crowns.

Advantages of using CAD / CAM technology to produce inlays:

- Much better restoration than traditional fillings.

Conclusions

If the dentist claims to be a leader in the development of inlays, onlays, crowns, and bridges, it is necessary to practice the application of CAD / CAM technology in aesthetic fixed restorations. The use of this technology provides high quality, professionalism, and profit, but also a steady increase of "new" and satisfied patients. Any progress in the field of information and communication technologies at the same time finds its application in various fields of medicine, including in dentistry. This work is further evidence of the necessity of applying IT in dentistry. The expansion of information and communication technologies will in the future contribute to an even stronger impact on the timely diagnosis, timely and adequate treatment, and monitoring of therapeutic effect, but also to achieve a high level of aesthetics in all branches of medicine and dentistry where would be necessary. The precision of restorations made by CAD / CAM technology in the function of all the individual errors of procedures and equipment, and that scanning is the initial source of possible inaccuracies, the higher resolution scanner will most significantly contribute to the quality of the entire system. The new technologies and development of services in dental medicine acquire aesthetic character. The use of CAD / CAM technology significantly shortens the time of creating prosthetic work, and CAD / CAM systems are easy to use.

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