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Clinical Application of Digital Chairside Operating System in Anterior Dental Aesthetics

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ABSTRACT

The digital CAD/CAM oral all-ceramic prosthodontic technology, digital impression, digital production of implant guides, rapid prototyping technology to make various dentures, and the development and application of digital prosthodontic technology are being converting the traditional clinical operation mode of oral prosthodontics and the production of the processing mode of prosthetics, promoting the development of oral prosthodontic treatment to minimally invasive, precise, convenient, automatic, efficient, high-simulation and more effective restoration of physiological functions, which representing the development trend and direction of oral prosthodontic technology, from manual operation to automation. The breakthrough transformation of intelligent processing represents the innovative technology of the future of oral prosthodontic technology in the field of digitalization, marking that the oral prosthodontic process has entered the computer age. Digital 3D imaging not only improves the accuracy of clinical diagnosis, but also directly intervenes in the design, development and implementation of treatment plans Therefore, this article provides a detailed review of Chair-side CAD/CAM technology, digital smiles design, and the application in clinical practice.

Keywords: Chair-side CAD/CAM System; Digital Smile Design; Virtual Reality Technology;Digital CAD/CAM Porcelain Veneers

Introduction

Function, aesthetics and minimally invasive are the three major concepts of today's oral prosthodontics, and digital oral aesthetic restoration technology is the perfect interpretation of all three. Duret introduced the concept of computer aided design/manufacture (CAD/CAM) to dentistry for the first time. Chair-side computer-aided design and computer aided manufacturing (CAD/CAM) technology is a kind of oral digital diagnosis and treatment system, with the development of ceramic materials and their processing technology and system module structure, CAD/CAM system is continuously optimized, related CAD software is constantly updated, implanted with new concepts and technologies, which completely changes the traditional system repair and production process. The accuracy and reliability are relatively high, the operation is relatively simple and convenient, the number of patient visits is minimized, mainly used by dentists or their assistants, and is highly integrated with related intraoral scanners and CNC cutting equipment. It has been recognized and favored by more dental medical personnel, and at the same time, with the improvement of living standards and aesthetic awareness, in addition to restoring basic functions of dental restoration, patients have higher expectations for dental aesthetics, and pay more attention to trying to improve facial beauty by adjusting the shape and color of front teeth. In order to meet the needs of this part of patients, the concept of aesthetic restoration came into being, and also promoted the development of all-ceramic aesthetic restoration.

Chair-Side CAD/CAM System

CEREC 3D is currently the world's only chairside CAD/CAM repair system. The CEREC system consists of two parts: hardware and software, the hardware mainly includes a three-dimensional measurement camera, a computer host and a grinding equipment, and the software is CEREC 3D and Biogenetic bioreengineering design software based on Windows operating platform [1]. CEREC AC system is

the most frequently used CEREC system, CEREC AC system includes blue light camera system, computer design system, grinding equipment system and so on. At the technical level, CAD/CAM technology includes data acquisition, database, data processing and CNC machining technology. Among them, data acquisition is the front-end technology of CAD/CAM, which is mainly used to collect the data information of the teeth to be repaired and provide a basis. Data management software is used to store, retrieve, and process large amounts of data, including textual and graphic information for the production of restorations. Through the use of computer technology, digital information and graphic detailed design of products, the edges and adjacent lines can be carefully marked, and the digital system can be used to accurately design the shape of the restoration, and then hand it over to clinicians for modification, and finally accurate three-dimensional data can be obtained.

Mormann is the first to apply a digital intraoral scanner to prosthodontics. The patient's oral information can be scanned directly by an optical scanner or indirectly scanned by a plaster cast obtained from an impression. Data acquisition systems are mainly divided into contact and non-contact digitizers, and the data obtained by various instruments and equipment is converted into a standard format for easy application in CAD/CAM systems [2]. Intraoral scanners currently available on the market include Lava COS (chairside oral scanner) from 3M, Trios from 3 Shape, iTero from Cadent and CEREC from Cadent and CEREC from Sirona. With CEREC Pre, the CEREC AC system is equipped with intraoral camera acquisition - the camera can be automatically exposed, and the clear image can be captured, and when the clear image is captured, the shutter can be automatically released, and the physician only needs to move the camera in the area where the image is collected in a regular manner, and the dental condition can be imaged at the right time. The blue light system uses short-wave blue light to scan directly [3]. By moving the camera to the near, middle or far middle, the optical model of the abutment, adjacent teeth and opposite jaw teeth is obtained, and the image of the median position of the closed mouth during tooth occlusion is collected according to the collected tooth morphology, and the occlusal surface suitable for the patient is reconstructed. A relatively virtual tooth model was constructed. The software included in the system can automatically delete information that cannot be used.

Database technology is an important component of denture CAD/CAM technology, which is characterized by the conversion of application material acquisition "physical impression" and "physical model" technology into the application of optoelectronic principle and digital processing system to obtain optical impression and model, which can improve the quality of restoration, and has a profound impact on the theory and practice of oral prosthodontic medicine. Digital impression is an important application in digital technology. In the traditional mold manufacturing, the impression is often made through the traditional mold making process. This way is not only time-consuming, but also low efficiency, and its manufacturing accuracy is difficult to guarantee. Digital printing mold through digital technology, the use of computer CNC processing equipment, make the printing mold manufacturing become more fast, accurate and convenient. The advantage of digital impression is that the design drawing, model or product can be scanned and collected through digital equipment (such as three-dimensional scanner), and then use computer CNC processing equipment for impression manufacturing. This way can not only improve the production efficiency, but also greatly improve the accuracy and quality of printing mold manufacturing, providing a strong support for the development of the manufacturing industry. The chairside CAD/CAM system is directly scanned in the patient's mouth, and a digital virtual model is formed, and the entire restoration design and production process is controlled by computer through CAD, Compared with traditional silicone rubber impressions, which increases the accuracy, reduces the error caused by many production links, and digital mold retrieval can improve work efficiency, make patients more comfortable to receive treatment, and obtain more accurate oral impressions and restorations, then processes the restoration through CAM.As a result, the possible errors in the process of restorations have become smaller and smaller, and the traditional restoration production methods have gradually been replaced. Using this technology to quickly and efficiently complete the restoration of tooth defects in a single visit, it subverts the traditional restoration model.

Chair-Side CAD/CAM Software Technology

The main functions of CAD / CAM software technology include product design, modeling, analysis, manufacturing, and management. CAD software helps engineers and designers create 3D models and 2D drawings, which can more accurately build products and components. The CAM software can use the data on the manufacturing devices to control and monitor their operation. Depending on the manufacturing process and workload, the CAM software automates steps that make the manufacturing process more rapid and efficient. In the field of medical devices, the software technology of technology side cad cam can help customers achieve more efficient and accurate design and production of medical devices. For example, in the field of medical surgical device manufacturing, the software technology of the technical chair side cad cam can help customers achieve more accurate surgical device design and production process, thus improving the accuracy and safety of surgery. Secondly, CAD / CAM software technology can improve product quality. By using 3D modeling and virtual simulation, we can more accurately predict the product behavior and solve possible problems in the design process in advance. The use of CAD / CAM software at all stages of product development can also improve production efficiency, thereby reducing production and operating costs. CAD/CAM systems have been developed for use in diagnostic and treatment procedures, as well as the manufacture of prostheses for prosthodontics; this has enabled the introduction of various materials into the dental field [4].

Digital Smile Design

Digital smile design is to realize the accurate measurement and analysis of tooth morphology and structure through digital technology, so as to generate and design accurate tooth models. The principle of digital laugh design mainly includes three aspects: digital scanning, 3 D modeling and digital design. Digital smile design can automate the process of tooth scanning, 3 D modeling and digital design, reducing the manual operation time. The digital model can be directly designed, eliminating the time waiting of traditional manual design and improving the work efficiency.

Good Repeatability

Digitalization Scanning: Digital scanning is the process of accurately measuring and recording the morphology and structure of a patient's teeth. Digitized scanning can be performed using devices such as a laser scanner, an optical scanner, and an intraoral camera. Through digital scanning, accurate three-dimensional tooth data can be obtained. The integration of 3D data acquired from scanning systems and 2D images is usually limited to a single view mode, which may limit the accuracy of the smile design technique. The challenge of the available systems is to reproduce the 2D planning in 3D. The time required to reproduce the digital planning on a trial restoration is a further limitation. Recent technological advances have enabled clinicians to measure dynamic labral-tooth relationships and to incorporate this information into lists of orthodontic questions and biomechanical plans. Digital cameras and various software are particularly useful in smile analysis and doctor-patient communication.3D facial scanning technology is the foundation of dynamic smile design. It is through high-precision three-dimensional scanning technology to obtain three-dimensional data of the patient's face, including facial contours, soft tissues, jawbones, teeth, etc. There are two main types of 3D facial scanning technology: optical scanning and CT scanning. Optical scanning mainly captures multiple angle images of the patient's face through a high-speed camera, and reconstructs the three-dimensional facial data in a computer. CT scan mainly scans the patient's skull through medical CT equipment to obtain its three-dimensional facial data. Information on photographic views are required for smile designing. Various devices are now being used to visualize diagnosis and improve communication and enhance predictability throughout treatment.

3 D Modeling: 3 D modeling is a process of processing and analyzing the 3 D data of the teeth obtained by digital scanning to generate an accurate 3 D tooth model.3 D modeling can be implemented using techniques such as CAD software. Digital design: Digital design is the design of dental restoration, cosmetology, implant and orthodontics according to the actual needs of patients and their oral conditions. The digital design can be performed directly on 3 D tooth models, and the design results can be digitally preserved and communicated.

Three-Dimensional Smile Design

Facial dynamic expressions can be expressed in three different dimensions according to the different face shapes of individuals. At present, 3D measurement methods based on shot tracking technology are considered reliable and effective. By shooting at high speed, it is possible to effectively analyze the three-dimensional dynamic movement of tissues such as upper and lower lips and cheeks. Three-dimensional laughter design is to use professional computer processing software (such as CAD Inlab2.0) to do three-dimensional and visual analysis and design and obtain intuitive efficacy preview, to predict and select the final repair plan, so as to achieve a kind of aesthetic restoration means for doctors, patients and technology to participate in together. It can observe the aesthetic problems of patients more three-dimensional and realistic, strengthen communication and cooperation, patients can see the efficacy predictably, reduce the cost of material materials, and improve the efficiency of repair treatment. But the disadvantage is still the impossibility of a direct aesthetic transfer [4]. The ability to reproduce a patient's dynamic occlusion in CAD/CAM is very important, but remains problematic because no method is available for recording a particular patient's complex and individualized dynamic occlusion and mandibular movement. Therefore, current CAD/CAM prosthesis designs generally consider only static occlusion or the maximal intercuspation position (MICP) relationship, rather than dynamic occlusion.

The limitations include that the trial restorations are not appropriated for patients with extensive horizontal or vertical overlap because trial restorations require an additive approach. Additionally, integration of the mandibular arch STL file to evaluate occlusion is not available with the present version, restricting the use of the app for planning occlusal rehabilitations. It is only possible by having the virtual cast printed at a center, which can be a time consuming and expensive procedure, and requires a complex laboratory software program with an extended learning curve. The technical feasibility of the digital workflow in maxillofacial rehabilitation has been evaluated [5-7], with facial prostheses made with computer-aided design and computer-aided manufacturing (CAD-CAM) reported to have advantages over those made with the conventional method in terms of time efficiency, ease of production, and patient burden [4].

Dynamic Smile Design(DDS)

Dynamic facial capture technology is at the heart of dynamic smile design [8]. It is a high-precision facial capture device that captures the patient's face in real time and analyzes it in real time in a computer. Dynamic facial capture technology can simulate different smile forms through software and observe the facial changes in different forms in real time [9]. Because the patients' spontaneous smiles might differ significantly from the posed smiles by showing more maxillary and mandibular teeth and more gingival display. Facial expression causes different parts of the facial region to change over time

and thus dynamic descriptors are inherently more suitable than static descriptors for recognizing facial expressions. Facial dynamic expressions can be expressed in three different dimensions according to the different face shapes of individuals. In this process, the doctor can design the most suitable smile form for the patient based on the patient's needs and facial features Nevertheless, the common reference used to be a static smile position. Dynamic facial capture technology is characterized by high accuracy, real-time, and visualization. It can accurately capture small changes in the face and display them on a computer screen in real time. This provides the basis for doctors to design the most suitable smile shape for the patient.

Virtual Reality Technology

At present, 3D measurement methods based on shot tracking technology are considered reliable and effective. By shooting at high speed, it is possible to effectively analyze the three-dimensional dynamic movement of tissues such as upper and lower lips and cheeks. Considering facial anatomy and lip movements, a virtual patient can be created with the merging of facial scans and computer manipulation. A method is presented for obtaining a virtual 4-dimensional patient that replicates the intended treatment. The process involves facial and oral scanning to acquire records and software manipulation to enable a virtual waxing of the smile. Once the digital design is complete, patient information can be merged to create an animated video of the projected rehabilitation. The described technique introduces the integration of facial and oral scans with a smile design to create a dynamic 4D patient. A final animated video of the smile path can be created with the help of this protocol. The possibility of evaluating the smile in movement is a promising diagnostic instrument to predict treatment outcomes [10]. (4D) Dynamic virtual patients include the transfer of temporomandibular joint (TMJ) kinematics and occlusal dynamics to the virtual joint system. This workflow can simulate postoperative effects during different smile positions dynamically while taking into account the desired position and contour of esthetic restorations. The combination of 3D face scanning technology, dynamic face capture technology and dynamic simulation technology provides a complete technical chain for dynamic smile design. It helps doctors design the most beautiful smile form and provides patients with a display of the final smile effect.

Clinical Practice of Digital CAD/CAM Porcelain Veneer

Digital CAD/CAM porcelain veneer repair is a technology that uses computer to design and make prosthetics, which makes optical models through intraoral scanning, displays the shape of the restorations on the computer through mirror copy technology, and uses DSD design to obtain reasonable anterior teeth proportions and length and width values to guide the production of diagnostic wax patterns [11]. Patients can know the final restoration effect before the irreversible tooth body is ready for operation, and can make a bionic form satisfactory to both doctors and patients, and obtain satisfactory aesthetic restoration effect [12,13]. In addition, CAD/CAM digital porcelain veneer restoration does not require repeated adjustment and grinding of the tooth body, which has little damage to the tooth, can promote the recovery of tooth function and morphology, and can also realize chairside restoration [14,15]. With the popularization of bonding technology and the application of various veneer restoration materials, and veneer restoration can well preserve natural tooth tissue in the process of tooth preparation, effectively reduce the length of the edge of the restoration, which is conducive to the health of periodontal tissue, veneer restoration technology has gradually been widely accepted and has become a commonly used clinical restoration technology. All-ceramic veneers have the advantages of beautiful color, wear resistance, less damaged tooth tissue, convenience and speed, etc., and are welcomed by patients [16].

CAD/CAM porcelain veneers belong to the cutting molding technology, and due to the characteristics of cutting molding, special requirements are placed on tooth preparation [17]. Traditional veneer production is made on the model, using cast paraffin wax to make the restoration, while CAD/CAM is done by cutting, due to the cutting diameter and angle restrictions, there are many precautions for tooth preparation [18]. For patients with large anterior teeth and a small amount of dental reserve, the use of veneer restoration can quickly achieve dental aesthetics [19]. Close the gap between the front teeth and pay attention to preventing the formation of the black triangle of the gums, adjust the contact point, and be able to avoid the appearance of the black triangle [20]. At the same time, to avoid excessive width of the restoration due to the gap of the anterior teeth, the imbalance of the aspect ratio occurs, and the normal anterior tooth morphology is pointed mesh morphology, square mesh morphology, etc., and the tooth morphology can be changed by increasing the abduction gap [21]. With the help of CAD/CAM system, good fit can be achieved, firmness can be improved, not easy to fall off, and secondary caries will not be formed [22]. The application of chairside CAD and CAM technology makes the porcelain veneer repair process simpler, making the precision machining of high-strength ceramic materials possible. The edge gap under the CAM/CAM porcelain veneer is smaller than that of traditional cast porcelain veneer, and the clinical upper edge gap is acceptable at 50~10, indicating that the edge gap of the CAD/CAM chairside system porcelain veneer has advantages [23].

According to the improved USPHS repair evaluation criteria, for clinical research of porcelain veneer, foreign literature reported data is as follows: 3 years cumulative success rate: 92%;5 years repair success rate: 97%;10 years repair success rate: 91% for domestic scholars reported porcelain veneer repair data: 2 years success rate: 98.6% ;5 years success rate: 97.5% .Other studies also provides similar results: Dumfahrt etc observed 10 years of porcelain veneer, found 99% of porcelain veneer have good edge fit, complete rate of 10 years 91%.Fradeani et al reported a success rate of 94.4% at 12 years, and

Friedman reported a success rate of 93% at 15 years. Di Lisha [24] in the follow-up of chair side porcelain veneer for 3 years, and found that except for one case is considered acceptable in color matching, other cases performed well in edge fitting, anatomical morphology, surface smoothness, color matching and maintain, the repair shape, color and overall aesthetic satisfaction reached 100%. In addition, studies on CAD / CAM porcelain veneers: There are 36 patients [25] with CADs / CAM porcelain veneers, 34 were well-fitted, 34 were intact, 0 had secondary caries and 0 were dental sensitive. Huang Gang, et al. [26] used CAD / CAM all-porcelain patch to repair 52 patients and found that the edges were well fitted, 30 intact, 1 second caries and 0 tooth sensitivity. Additional studies have also pointed out that there is a marginal gap after the restoration of porcelain veneers, which can easily lead to microleakage, causing secondary caries and loss of restoration.

For the repair success and long-term stability, attention should be paid to the thickness of the repair material and the dietary habits of the patients. The effect of porcelain veneers and patient satisfaction were high during repair with appropriate thickness and avoidance of dark food. According to the existing literature, the success rate of porcelain veneers repair at different time points is more than 90%, but there are some differences between different studies. It should be noted that the definition of "success" may vary between studies, so the data cannot be compared directly. Integrity rate: The integrity rate of porcelain veneer can reflect its long-term repair effect, which is introduced in many documents. However, it should be noted that the integrity rate may vary in different time periods, and the repair time and follow-up time are not completely consistent in different studies. Edge fitting: Edge fitting of porcelain veneers is one of the important indicators of the success of porcelain veneers. Most of the existing literature introduces the good coordination of its edges. Secondary caries and tooth sensitivity: secondary caries and tooth sensitivity are one of the problems that may occur after porcelain veneer restoration, and the quality and retention of porcelain veneers may affect their appearance rate. In conclusion, the evaluation angles of porcelain veneers in different studies are not identical, and therefore need to be selected and analyzed according to specific situations. At the same time, it should be noted to the differences and limitations between different studies, and the data cannot be directly compared and generalized.

Summary

The application of digital manufacturing technology in the medical field is still in the research stage, many processes are not yet mature, and various processes are also in the exploration stage. At the same time, compared with traditional prosthetics, the choice of CAD/CAM system for oral prosthodontics requires more high-end sophisticated equipment, more cutting-edge technology, and higher costs, and many aspects of CAD/CAM prosthetic systems are still in the research stage and are not yet perfect. These are all difficult problems that we must face, and only through a large amount of practice accumulation and exploration and innovation can we gradually solve these problems. The conceptual foundation and clinical application of CAD/CAM technology bring shortened treatment courses, precision and efficiency, which not only brings great convenience to patients, but also reduces the burden on doctors and avoids waste of resources. The proposal of this concept and the application of technology is a great revolution in prosthodontics and will eventually replace the traditional form of prosthodontics.

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