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REVIEWS

Particularities of CAD-CAM commercial systems with applicability in the orofacial sphere; digital complete denture

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Abstract

CAD-CAM techniques are based on innovative procedures that have appeared in the last decades. They tend to expand in many domains while diversifying the products offered to the recipients.

Digital technology is also used in dental medicine, replacing a big part of the conventional fabrication procedures with modern procedures. In oral rehabilitation (e.g.: using a complete denture) there is a rising interest regarding these procedures. Laser beams and CBCT (cone beam computer tomography) have been recently used to gather data in the orofacial sphere. Some of the available commercial systems use subtractive techniques (using milling machines with 3 or 5 axes) or additive techniques such as rapid prototyping or stereolithography in the fabrication process of the final product. Knowledge regarding the particularities of different commercial systems is essential. The benefits of using these techniques are multiple: speed, precision, data reproducibility, comfort, higher efficiency and reduced costs due to the standardization of the treatment steps.

Key words: CAD-CAM commercial systems, digital denture, CAD-CAM denture, rapid prototyping, stereolithography, CNC milling machines

Introduction

Nowadays, more than ever, mankind is in a continuous search for performance, esthetics and functionality in all domains. Sport is one of the domains in which performance is often obtained by pushing physical resources beyond the organism's limits. This permanent wish for self-improvement leads to the best performances, though it calls for adequate equipment and protection means.

Recent developments in techniques and materials can lead to high quality products. CAD-CAM (computer-aided design – computer-aided manufacturing), is an example of such innovative technology, with a wide applicability in many fields.

CAD-CAM is also used in dental medicine, offering the possibility of complex rehabilitation in the orofacial sphere. An example of evolution from conventional techniques towards digital technologies is the fabrication of complete dentures using CAD - CAM systems.

Complete dentures have been fabricated with conventional techniques, using PMMA acrylic resins, for more than 80 years, without significant changes in the procedures and materials that are used (Janeva et al., 2017). These materials were introduced by the German chemists Otto Rohm and Walter Bauer, who synthesized the material for the first time in 1902. The material was commercially available in 1933. Although the fabrication process is usually based on traditional procedures, new and modern techniques that permit time and costs savings (Kattadiyil et al., 2013) are also used. CAD-CAM technology (design and machine fabrication) appeared in the 70's, and the progress in its development led to its application in dental medicine as well. Duret's major contribution, as a pioneer in digital techniques with his Sopha system in 1971, had a great impact on its future development. However, systems based on this technology first appeared in our profession only in the 80's, because of the complexity of the fabrication process. A complete denture was for the first time produced with digital techniques using 3D laser lithography in 1984 by Maeda, who developed a computer-aided system for tooth selection, occlusion, external surface and margins using a database (Maeda, 1994). The initial technique was improved with the contribution of Kawahata in 1997 - a duplicate denture obtained from a wax block using numerical control devices CNC after digital data collection (Kawahata et al., 1997). In 2009, Sun introduced laser

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scanning of the edentulous ridges (Sun et al., 2009). Kanazawa used CBCT for the first time in 2011 to gather data and a CNC milling machine to obtain a denture base from an acrylic resin block, followed by manual placement of the teeth (Kanazawa et al., 2011).

There are multiple advantages in using CAD-CAM techniques: for the patient, by reducing the time necessary for treatment with complete dentures and by reducing patients' dental visits (Janeva et al., 2017; Kattadiyil et al., 2013; Bidra et al., 2013), an important aspect especially for the very old or disabled; patient satisfaction when wearing CAD-CAM dentures was reported (Saponaro et al., 2016a); for the dentist, by reducing the clinical steps (Kattadiyil et al., 2013), and for the dental technician, by reducing the time needed for laboratory procedures. The data gathered can be saved and further used (Kattadiyil et al., 2013). The precision in the fabrication of the prosthetic reconstruction is greater compared to conventional procedures (Goodacre et al., 2016). The higher technical accuracy of the procedure, having a favorable influence on retention values (AlHelal et al., 2016), with an average accuracy deviation of 0.1 mm for the internal surface and 0.5 mm for the external surface of the denture (Kanazawa et al., 2011), is very important for future retention and stability. A minimum thickness of the denture base and also fine details (papillae, rugae) on the denture's external surface can be achieved. Pre-polymerized acrylic resins have better mechanical and biological properties than conventional resins, higher chemical and volumetric stability, reduced water absorption, all these improvements offering more favorable conditions during long-term use. They also have a good biocompatibility, lacking toxic and allergic substances - such as residual monomer - a very important aspect for materials used inside the oral cavity. There is no polymerization shrinkage (Kattadiyil et al., 2015), while finishing and polishing procedures are easy to perform. The material can also be colored to obtain the desired esthetic result. Trial dentures can be used as a guide for dental implant placement. There is growing interest in dental medicine in treatment based on CAD-CAM procedures, because of their standardized and efficient technological process and reduced costs (Kattadiyil et al., 2013).

Shortcomings are mainly related to the high costs of the devices, software and materials. The technique also requires high qualification and skills, being more accessible for experienced practitioners. A study conducted by Saponaro in 2016 evaluating student experience with digital dentures reported 3 types of complications: reduced retention, incorrect vertical dimension of occlusion, inaccurate centric relation (Saponaro et al., 2016b). Most of the available commercial systems still rely on conventional steps, especially for impression making and jaw relation determination. The scanning process is generally time consuming, tooth arrangement is not completely individualized, and perfect occlusal adaptation and balanced occlusion are hard to achieve.

Digital techniques for complete dentures use impression procedures based on laser or CBCT for data collection needed for design (CAD), while fabrication uses computer-aided manufacturing CNC, (simple or with 5 axes) or rapid prototyping, laser lithography (Fig. 1). Subtractive techniques (used by Avadent, Ceramill, Wieland and Baltic Denture) and also additive techniques (Dentca) are described.

Fig. 1 – 3D printing procedure - Dentca denture base for carbon printers (1)

Generally, using digital techniques, treatment is reduced from 5 to 2 or maximum 3 appointments (when using a trial denture). In the first appointment, conventional techniques are used for impression taking and jaw relation determination, with standard or special designed impression trays and transfer bows. The trial denture in the color of the future teeth is obtained by milling, or 3D printing, or just the denture base is milled and then the artificial teeth are bonded. Next, it is evaluated similarly to the conventional process, and the needed changes or adjustments for an adequate esthetic, phonetic and functional adaptation are made. In the last appointment, the final denture - fabricated as a single block or a base with bonded teeth, with enhanced adhesion and stability due to precision in fabrication - is applied, while checking the occlusion, esthetics and phonetics. Clinical adjustments can be made if needed. Yilmaz argues for the advantages of monoblock dentures: reduced risks for teeth fractures and material shrinkage (Yilmaz et al., 2017).

Particularities of commercially available systems used for the fabrication of CAD-CAM dentures

Avadent System (Global Dental Science Scottsdale, AZ, USA) uses subtractive techniques in the fabrication process. The old dentures or special thermoplastic trays, immersed for one minute in 80^0 C, are used for impression taking (Kattadiyil et al., 2013). The jaw relation determination is performed using AMD (Avadent Measuring Device), which consists of custom trays, a vertical screw for fixing the vertical dimension, a mandibular plate for gothic arch registration, a lip support placed on the upper tray, a ruler for measuring the inclination of the occlusal plane in the anterior region, a ruler for measuring the vertical dimension of the occlusion, and a transparent guide for tooth size assessment. Treatment is performed in 2 or 3 appointments - if a trial denture is requested (Baba, 2016; Kattadiyil et al., 2013).

Dentca System (Dentca Inc, CA, USA) uses additive techniques (stereolithography) for trial denture (just the base or whole try-in denture) fabrication, while the final denture is made using the conventional procedure. Special impression trays (S, M, L) with detachable posterior

parts are used. The vertical dimension of the occlusion is determined by fixing the custom trays with the vertical screw, while the centric relation is registered by tracing the gothic arch on the maxillary plate (Baba et al., 2016). A special ruler is used for measuring the length of the upper lip - the distance between the incisive papilla and the lip border. The trial denture is fabricated with rapid 3D prototyping in the color of the future teeth, and it can be used as a guide for dental implant placement (Kattadiyil et al., 2013).

Wieland Digital Denture (Ivoclar Vivadent, NY, USA) is a commercial system that uses subtractive techniques. To determine the jaw relation centric trays for preliminary relations – occlusion, vertical dimension - registrations are used. A special UTS CAD transfer bow is then used for preliminary occlusal plane position, by measuring its inclination related to the bipupilar line and Camper plane. Custom trays provided with occlusal borders are used to take the final impression. After their fabrication on digital casts using the scanned occlusal relations, the preliminary impressions and the digitally determined preliminary occlusal plane are checked and adjusted if necessary (Baba et al., 2016). Jaw relation is determined by fixing the vertical screw for the corresponding vertical dimension of occlusion and registering the gothic arch on the mandibular plate. The trays are then fixed together using silicone-based impression material and the esthetic lines - median line, smile line, canine line and lip closure - are marked before sending them to the laboratory for scanning. A guide for tooth placement on the denture base is then produced. If requested, a trial denture milled from a single wax block is also made. The denture base is fabricated by first milling the external side with the alveoli for tooth placement, then the teeth (from a digital denture tooth library) are bonded and the mucosal side is milled, also reducing the tooth length (gingival extremity) if necessary (Baba et al., 2016).

Baltic Denture (Merz Dental, GmbH, Germany) uses special adjustable impression trays (Key Set) of different sizes, with preset teeth of different shapes and sizes, a transfer bow with an indicator for the midline plane of the face (Key Fin), and Key Lock, for registration of the already determined jaw relations. The teeth placed on the adjustable trays, specific for this system, facilitate a better esthetic evaluation regarding the occlusal plane position, the visibility, the arrangement of teeth and the general facial aspect. They also offer the patient the opportunity to evaluate the final aspect and to express their impressions and observations (Baba et al., 2016).

Ceramill Full Denture (Amann Girrbach, AG, Austria), designed mainly for dental technicians, is an open system that can be used together with other CAD-CAM systems. After the preliminary and final impression making, the final casts are mounted on the articulator using a transfer face-bow. The digital sequences start with the casts, trays and occlusal relations scanning, then anatomical landmarks for anterior teeth placement are marked on the digital casts. The denture base is milled from a pink wax block and then the teeth are bonded in the wax bases. The final denture is then fabricated using conventional techniques (Baba, 2016). A 4-month study processing the feedback from six dental technicians that made 250 complete dentures shows that the milling unit is easy to use, but the scanning process is time consuming, the software is difficult to learn, the scanning and the design are more accessible for experienced practitioners (2).

Together with the intraoral records, extra-oral facial scanning is associated to the digital workflow of CAD-CAM denture fabrication for a more rapid treatment and better esthetic and functional results (Eom et al., 2017; Hassan et al., 2017; Schweiger et al., 2016).

Conclusions

1. Practitioners in the dental medicine field are more and more interested in these digital techniques, considering their multiple favorable aspects: the speed, precision, quality of treatment, data reproducibility, patients' satisfaction and comfort by reducing the number of dental visits, the higher efficiency in dentists' activity, standardization of treatment steps and innovations brought in the treatment of complete edentation.

2. However, the contributions of the dentist and the dental technician cannot be substituted, at least for the time being, by digital procedures.

3. Continuous progress in CAD-CAM technologies permits the diversification of the obtained products in various fields, such as medicine, sports and leisure time industry.

Conflicts of interest

Nothing to declare.

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