CAD/CAM in dentistry

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Contributor: Paweł Piszko

CAD/CAM stands for computer-aided design and computer-aided manufacturing. It is applied in different branches of engineering, science or even art as a rapid prototyping method for accelerating the design process and smoothening its transition into manufacturing.

Keywords: CAD/CAM ; mechanical properties ; dental materials ; dental ceramics ; resin composites ; biocompatibility

1. Introduction

The first versions of the system were invented in the 1980s [1]. The idea of the digital assisted prosthetic system was first developed and introduced as a result of the cooperation of three research centres, the first established by the University of Zurich and Brains and Brandestini Instruments of Switzerland, the second by Hennson International of France and the third group by the University of Minnesota [2]. The aim was to provide the patient with a prosthetic restoration in a fast and impressionless process. Moreover, the authors intended to make durable posterior teeth restorations in a natural colour [1]. Recent years have shown that it is an innovative, developing and forward-thinking method of designing and forming dental prostheses.

2. Advantages of CAD/CAM

The individual properties of CAD/CAM restorations depend, among others, on material which is used for manufacturing. There is wide range of benefits shared by all used materials, which make described technology very attractive both for the patient and dentist. Among them, we can list the following: shorter time of prosthetic treatment; patient's satisfaction; and avoiding the traditional method of making impressions, which has been replaced with user-friendly intraoral scanners [3][4]. There are randomised clinical trials that confirm higher efficiency and comfort using digital scanning compared to conventional impression [5][6]. Moreover, it provides the opportunity to combine high aesthetics, durability and functionality in one restoration [7][8]. The aspect of accuracy is very important as well. It was confirmed that the CAD/CAM restorations, such as single crowns, fixed dental prostheses and implant-retained fixed dental prostheses, are characterized by sufficient marginal adaptation [9][10]. This fact is significant for further plaque accumulation. Potential caries development is less likely to occur when the marginal adaptation is within the clinically acceptable marginal discrepancy range. Replacing the classical procedure of taking impressions by the digital technique helps not only to reduce procedure time [11] and increase the patient's positive feelings but also to maintain an adequate level of precision (4 to 80 μm for scans with a limited area) [12]. Furthermore, scanning oral cavity by an intraoral scanner provides an image of prosthetic substrate on the computer screen almost immediately and under magnification, which helps to control the preparation process as well as plan further restoration. This is an important benefit for many operators. The technology provides the opportunity to use new materials for prosthetic reconstruction and maintain the quality control of the process [13]. All these positive aspects of CAD/CAM technology are reflected in patients' satisfaction and long-term restoration success considering both ceramic [14][15] and composite restorations [16][17].

3. Limitations and Handling of the System

The technology of CAD/CAM, without a doubt, is very innovative and provides a broad range of opportunities. However, this technique is still considered expensive, and despite the development of new systems and increasing competition on the market, the prices remain high [18][19]. The whole process of creating a restoration using CAD/CAM comprises many steps, such as scanning the oral cavity by an intraoral scanner, computer designing using specific software and modelling a restoration either from a solid block of restorative material or using an additive technique [19]. All of this requires highly trained personnel [18], and the technique learning curve can range from a few days to several months [20]. Moreover, as opposed to the traditional way of planning prosthetic reconstruction, in the CAD/CAM system, the involvement of the patient is minimalised [21]. After scanning the oral cavity, the dentist decides the shade, shape and occlusal relation of the

prosthetic restoration. Considering clinical cases regarding patients with maxilla-mandibular disorders and occlusion distortions, the CAD/CAM system itself may not be sufficient to obtain correct teeth relation [22]. Moreover, the size of the blocks limits designing and milling restorations exceeding their sizes. This indicates clinical problems including inaccurate occlusal vertical dimension and incorrect centric relation [23].

The accuracy of digital scans depends on the length of the arch included in the impression and is favourable for short distances [24]. The survival rate of CAD/CAM restorations may vary for different types of materials. It is mostly presented in short- and medium-term studies, which makes it more difficult to evaluate and compare to conventional prosthetic restorations. For example, ceramic material Vita Mark II (VITA Zahnfabrik, Bad Säckingen, Germany) inlays showed survival rates of 90.6% after 8 years and 85.7–89% after 10 years [8][25][26][27]. Therefore, we observe that survival rate decreases over time. The mechanical aspects, such as the flexural strength or mean modulus of resilience, differ for various types of utilised materials [28]. It can be assumed that not all kinds of materials are suitable for all clinical applications. The prosthetic restorations made using CAD/CAM are not free of defects. The main reported complications are framework fractures and recurrent periodontal disease for reinforced glass ceramics and glass infiltrated alumina [11]. Thus, there is still room for improvements in the described technique.

Operators should be aware of certain limitations regarding patients with CAD/CAM restorations. For example, applying lasers for periodontal or conservative reasons among patients with zirconia-based restorations can be performed. It should be considered that the surface of the restorative material can be affected by the laser [29]. Moreover, mechanical limitations are of significant importance, which should not be omitted while describing CAD/CAM restorations. The study by Romanyk et al. shows that subtractive machining results in strength-limiting, surface and subsurface damage in the restorations, which may be clinically relevant [30].

4. Currently Used Dental CAD/CAM Systems

The list of producers offering CAD/CAM software (e.g. CEREC SW 5.1.3, Dentsply Sirona, York, Pennsylvania, United States) and manufacturing systems is broad and has rapidly grown in recent years. CAD/CAM systems can be classified as either in-office or laboratory systems [31]. The two most popular systems currently available on the market are CEREC by Dentsply Sirona (York, PA, USA) and Planmeca by Planmeca Oy (Helsinki, Finland) [32]. Both of them are complex and consist of numerous elements. For example, Sirona offers the CEREC Omnicam scanner, software for CAD/design and for CAM and also the milling unit, which is the CEREC MC, X and XL 4-axis milling machine [3]. Other recognized and used total CAD/CAM systems are Carestream Dental (Atlanta, GA, USA), Dental Wings (Montreal, QC, Canada) and Zfx (Dachau, Germany) [32]. There is also the possibility to buy parts included in a CAD/CAM system, which are offered separately by different companies. The choice of adequate system depends on the prosthetic experience of operators and the equipment of the dental office, but should be also dictated by the patient's therapeutic needs [33].

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