Review

CAD CAM in Prosthetic Dentistry: A Comprehensive Review

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Abstract

One of the developments occurring rapidly in the field of prosthetic dentistry is the application of computer-aided design and computer-aided manufacturing (CAD/CAM) to produce implant abutments and frameworks from metal or ceramic materials. Currently, CAD/CAM allows the construction of implant frameworks from different materials. Hence; in this review, we aim to highlight some of the important aspects of use of CAD CAM technology in prosthetic dentistry.

Key words: CAD CAM, Implant, Prosthodontic

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INTRODUCTION

Computer-aided design (CAD)/computer-aided manufacturing(CAM)is a field of dentistry and prosthodontics using CAD/CAM (computer-aided design and computer-aided manufacturing) to improve the design and creation of dental restorations, especially dental prostheses, including crowns, crown lays, veneers, inlays and onlays, fixed bridges, dental implant restorations, dentures (removable or fixed), and orthodontic appliances. CAD/CAM complements earlier technologies used for these purposes by any combination of increasing the speed of design and creation; increasing the convenience or simplicity of the design, creation, and insertion processes; and making possible restorations and appliances that otherwise would have been infeasible. Other goals include reducing unit cost and making affordable restorations and appliances that otherwise would have been prohibitively expensive. However, to date, chairside CAD/CAM often involves extra time on the part of the dentist, and the fee is often at least two times higher than for conventional restorative treatments using lab services. CAD/CAM is one of the highly competent dental lab technologies.[1]

Metal–ceramic-fixed dental prosthesis with CAD/CAM-fabricated substructures

Titanium has desirable properties for dental restorations, such as good corrosion resistance, low specific gravity, good mechanical properties, high biocompatibility, and low cost. Around the year 2000, dental computer-aided design (CAD)/ computer-aided manufacturing (CAM) technology began to strongly influence the fabrication of dental restorations. One of the first metals to be used for dental CAD/CAM frameworks was titanium, owing to its biological and mechanical properties. Milling titanium produces excellent fitting, avoids the α-case layer, and decreases the fabrication costs in comparison to copy milling, spark erosion, and laser welding. A recently published review on the in vitro performance of titanium–ceramic restorations strongly supported this treatment option.[2, 3]

OVERVIEW OF CAD/CAM

In brief, in-office dental CAD/CAM systems consist of a handheld scanner, a cart that houses a

personal computer together with a monitor, and a milling machine. The scanner head is placed intra-orally above the tooth preparation and the resulting data appear on the monitor as 2-dimensional (2-D) or 3-dimensional (3-D) images. Design work is done on the monitor and the instructions are sent to a computer-assisted processing machine for milling. Restorations are milled from prefabricated blocks of porcelain. Options include feldspathic, leucite, or lithium disilicate materials as well as blocks of composite. After the restoration is examined and approved, it is polished and inserted using conventional bonding techniques.[4, 5]

OFFICE-BASED DEVICES

Four products are presently available for digital impressions in the dental office: CEREC AC (Sirona, Charlotte, NC, USA), E4D Dentist (D4D Technologies, Richardson,TX, USA), iTero (Cadent, Carlstadt, NJ, USA), and Lava COS (3M ESPE, St Paul, MN,USA). Each system uses a different method to acquire the images. The first system introduced was the CEREC 1 in 1986. The CEREC 1, 2 (1994) and 3 (2000) systems (Sirona Dental) have all used a still camera to take multiple pictures that are stitched together with software. The E4D (D4D TECH) takes several images, using a red light laser to reflect off of the tooth structure and only requires the use of powder in some limited circumstances. The application of powder to the tooth is quick and simple, taking only seconds, and the powder is easily removed afterwards with air and water. The iTero system uses a camera that takes several views (stills), and uses a strobe effect as well as a small probe that touches the tooth to give an optimal focal length; this system does not require the use of powder. The LAVA Chairside Oral Scanner (LAVA COS, 3M ESPE) takes a completely different approach using a continuous video stream of the teeth. CEREC and LAVA currently require the use of powder for the cameras to register the topography.[6]

Taking digital impressions allows dentists to do away with selecting trays, mixing materials and waiting for them to set, cleaning up the mess from the impressions, disinfecting the impressions, and shipping the impressions to a laboratory. The CEREC and E4D devices can be combined with in-office design and milling; whereas, the iTero and Lava COS devices are reserved for image acquisition only. In-office milling allows same-day restorations.[7, 8]

CAD/CAM technology in removable partial denture Prostheses

Fabrication of cast partial dentures can be done using Co-Cr Alloys or commercially pure Titanium and Ti-6Al-4VAlloy by utilizing CAD-CAM technologies. William et al have demonstrated a method of fabrication of removable partial denture framework design using CAD/CAM technologies. Using CAD/CAM software the removable partial denture framework design is built on a three-dimensional scan of the patient's cast.[9]

CAD/CAM Technology in Implant Prosthodontics

CAD/CAM allows simplified production of precise and durable implant components. The precision of fit has been proven in several laboratory experiments and has been attributed to the design of implants. Milling also facilitates component fabrication from durable and aesthetic materials. With further development, it is expected that the CAD/CAM protocol will be further simplified. Although compelling clinical evidence supporting the superiority of CAD/CAM implant restorations is still lacking, it is envisioned that CAD/CAM may become the main stream for implant component fabrication.[10, 11]

The assumption that CAD/CAM production is more accurate than the lost wax/casting technique is based on minimal human intervention and bypassing several fabrication steps such as waxing, investing, casting, and polishing. The literature that evaluated the accuracy of tooth-supported CAD/CAM restorations did not confirm that the accuracy of CAD/CAM copings improved when compared with conventionally produced copings. Although the level of fit of CAD/CAM copings was within the acceptable range, a degree of misfit was reported in relation to the restoration margin and the internal fitting surface. This was primarily attributed to the irregularities and variation on the prepared tooth surface that is recorded in the scanned digital image. From an engineering perspective, irregular surfaces are more difficult to scan which results in excessive surface noise. Subsequent image processing and noise elimination can cause rounding of the edges and loss of image sharpness. In relation to CAM design, several authors have proposed mathematical algorithms to compute the restoration external anatomy that fits within the arch and against the opposing dentition.[12, 13]

More recently, chair-side construction of an implant abutment can also be achieved using CAD/CAM and is available using the Cerec system (Sirona). This concept involves intraoral scanning of a prefabricated titanium cylinder

followed by designing and milling a definitive zirconia abutment to the optimal contour. The zirconia abutment is adhesively bonded on the prefabricated titanium cylinder.[14]

Significance for the dentist

In recent years, the use of CAD/CAM technology has above all strongly influenced dental-technical production procedures. If one ignores chair side prostheses, the significance of this technology for the dentist is not immediately clear. In recent years, CAD/CAM production has clearly expanded the palette of materials for dental prostheses by providing access to new ceramic materials with high dependability. The stability values of zirconium oxide ceramics permit, in many areas of indication, the use of this material as an alternative to metal frames for permanent prostheses.[15]

The production of long-term temporary prostheses has, as a result of the use of a virtual wax up on the computer, become faster, more convenient and more predictable. This method has already been implemented by computer-generated long-term temporary restorations, since it can be modified, by changing the form, to the functional and aesthetic satisfaction of the patient during a clinical test phase. The production of the definitive prosthesis should also be carried out by CAD/CAM technology and represents merely a copying process of the temporary prosthesis into the definitive prosthesis by a different material.[16]

Advantages of CAD/CAM systems

- No Traditional Impressions
- Produce Chair-side Restorations
- Less appointment
- High Precision and Accuracy
- Improve the Qualities of Restoration.
- Eliminates the Use of the Laboratory Equipments required for Conventional LOST-WAX technique.[15]

Potential benefits of CAD/CAM

- Accuracy of impressions
- Opportunity to view, adjust and rescan impressions
- Saves time and one visit for in-office systems
- Opportunity to view occlusion
- Accurate restorations created on digital models
- Potential for cost-sharing of machines
- Accurate, wear- and chip-resistant physical CAD/CAM
- No layering/baking errors
- No casting/soldering errors
- Cost-effective
- Cross-infection control

CAD/CAM systems can save time, and after consideration of the financial investment, they are cost-effective. The ad-vent of accurate scanning, transmission and fabrication of laboratory CAD/CAM restorations offers an opportunity to, in effect, cost share on the required equipment. Last but not least, CAD/CAM also aids cross-infection control.[16]

Limitations of CAD/CAM systems

- Initial High Cost of CAD/CAM Systems
- Time and Cost Investment to Master the technique
- Presently available dental CAD/CAM systems are unable to incorporate esthetic veneers with strong cores and frameworks.[17]

CONCLUSION

CAD/CAM units are still expensive to purchase and use. The advantages of CAD/CAM will most likely lead to an exponential growth in the utilization of this technology in implant dentistry.

REFERENCES

1. https://en.wikipedia.org/wiki/CAD/CAM_dentistry
2. Att W, Kurun S, Gerds T, Strub JR. Fracture resistance of single-tooth implant-supported all-ceramic restorations after exposure to the artificial mouth. Journal of Oral Rehabilitation. 2006;33(5):380–386.
3. Att W, Kurun S, Gerds T, Strub JR. Fracture resistance of single-tooth implant-supported all-ceramic restorations: an in vitro study. Journal of Prosthetic Dentistry. 2006;95(2):111–116.
4. Sailer I, Pjetursson BE, Zwahlen M, Hämmerle CHF. A systematic review of the survival and complication rates of all-ceramic and metal-ceramic reconstructions after an observation period of at least 3 years. Part II: fixed dental prostheses. Clinical Oral Implants Research. 2007;18(3):86–96.
5. Haraldson T, Carlsson GE, Ingervall B. Functional state, bite force and postural muscle activity in patients with osseointegrated oral implant bridges. ActaOdontologicaScandinavica. 1979;37(4):195–206.

6. Marras I, Nikolaidis N, Mikrogeorgis G, Lyroudia K, Pitas I. A virtual system for cavity preparation in endodontics. J Dent Educ.2008 Apr;72(4):494-502.
7. Kiliaridis S, Kjellberg H, Wenneberg B, Engström C. The relationship between maximal bite force, bite force endurance, and facial morphology during growth. A cross-sectional study. ActaOdontologicaScandinavica. 1993;51(5):323–331.
8. Kokubo Y, Tsumita M, Sakurai S, Torizuka K, Vult Von Steyern P, Fukushima S. The effect of core framework designs on the fracture loads of all-ceramic fixed partial dentures on posterior implants. Journal of Oral Rehabilitation. 2007;34(7):503–507.
9. Williams RJ, Bibb R, Eggbeer D et al. Use ofCAD/CAM technology to fabricate a removablepartial denture framework. J Prosthet Dent2006;96(2):96-99.
10. Tan PL, Gratton DG, Diaz-Arnold AM, Holmes DC. An in vitro comparison of vertical marginal gaps of CAD/CAM titanium and conventional cast restorations. Journal of Prosthodontics. 2008;17(5):378–383.
11. Thompson WB, Owen JC, De SG, Stark SR, Henderson TC. Feature-based reverse engineering of mechanical parts. IEEE Transactions on Robotics and Automation. 1999;15(1):57–66.
12. Persson A, Andersson M, Oden A, Sandborgh-Englund G. A three-dimensional evaluation of a laser scanner and a touch-probe scanner. Journal of Prosthetic Dentistry. 2006;95(3):194–200.
13. Ender A, Mörmann WH, Mehl A. Efficiency of a mathematical model in generating CAD/CAM-partial crowns with natural tooth morphology. Clinical Oral Investigations. 2011;15(2):283–289.
14. Mehl A, Blanz V, Hickel R. Biogeneric tooth: a new mathematical representation for tooth morphology in lower first molars. European Journal of Oral Sciences. 2005;113(4):333–340.
15. Freedman M, Quinn F, O'Sullivan M. Single unit CAD/CAM restorations: a literature review. J Ir Dent Assoc. 2007Spring;53(1):38-45.
16. Örtorp A, Jönsson D, Mouhsen A, Vult Von Steyern P. The fit of cobalt-chromium three-unit fixed dental prostheses fabricated with four different techniques: a comparative in vitro study. Dental Materials. 2011;27(4):356–363.
17. Yüzügüllü B, Avci M. The implant-abutment interface of alumina and zirconia abutments. Clinical Implant Dentistry and Related Research. 2008;10(2):113–121.

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