Computer-assisted design/computer-assisted manufacturing systems: A revolution in restorative dentistry

Arbaz Sajjad

Department of Prosthodontics, Al-Jouf Dental Centre, King Abdul Aziz Speciality Hospital Ministry of Health, Sakaka, Kingdom of Saudi Arabia

Abstract For the better part of the past 20 years, dentistry has seen the development of many new all-ceramic materials and restorative techniques fueled by the desire to capture the ever elusive esthetic perfection. This has resulted in the fusion of the latest in material science and the pen ultimate in computer-assisted design/computer-assisted manufacturing (CAD/CAM) technology. This case report describes the procedure for restoring the esthetic appearance of both the left and right maxillary peg-shaped lateral incisors with a metal-free sintered finely structured feldspar ceramic material using the latest laboratory CAD/CAM system. The use of CAD/CAM technology makes it possible to produce restorations faster with precision- fit and good esthetics overcoming the errors associated with traditional ceramo-metal technology. The incorporation of this treatment modality would mean that the dentist working procedures will have to be adapted in the methods of CAD/CAM technology.

Key Words: All-ceramic, computer-assisted design/computer-assisted manufacturing technology, zirconia

Address for correspondence:
Dr. Arbaz Sajjad, P.O. Box #1978, Sakaka 42421, Al-Jouf, Kingdom of Saudi Arabia. E-mail: baaz911@gmail.com
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INTRODUCTION

For the better part of the past 20 years, dentistry has seen the development of many new all-ceramic restorative systems. The need to develop such materials and associated technology has been driven by the patient expectations for excellent esthetics and by biocompatibility concerns of metals intraorally.[1,2] The combination of advancements in dental materials as well as in computer technology has made computer-assisted design/computer-assisted manufacturing (CAD/CAM) fabricated restorations possible and plentiful in dental clinics.[3,4] It is interesting to note that the term "CAD/CAM" does not provide any information on the method of fabrication.

All CAD/CAM systems consist of three components: (1) A digitization tool/scanner that transforms the geometry into digital data that can be processed by the computer. (2) Software that processes data and depending on the application, produces a data set for the product to be fabricated. (3) A production technology that transforms the data set into the desired product. Since its introduction in the early 1980s, it has evolved in three directions depending on the type of the production line, (a) chair-side production, e.g. Cerec™ System (Sirona®

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Dental GmbH; Salzburg, Österreich), (b) laboratory production, e.g., inEos X5 scanner and inLab MC XL milling unit (Sirona® Dental GmbH; Salzburg, Österreich), and (c) centralized fabrication in a production center, e.g. Nobel Procera™ (Nobel Biocare®, Zürich Switzerland).

The list of various materials that may be processed by CAD/CAM devices depends on the respective production system. Some milling units are specifically designed for the production of ZrO_2 frames; other more versatile ones accommodate a selection of materials from metals, resins, glass ceramics, and high-performance ceramics. Glass ceramics are grindable silica bases blocks and due to their higher stability values, lithium disilicate ceramic blocks are particularly important in this group; they can be used for full anatomical crowns and copings in the anterior and posterior regions, and for three-unit FPD frameworks in the anterior region due to their high mechanical stability of 360 MPa.[5-7] High-performance oxide ceramics are mainly of two types: (a) Aluminum oxide (Al_2O_3), and (b) yttrium stabilized zirconium oxide (ZrO_2, Y-TZP) a high-performance oxide ceramic which when compared to other all-ceramic systems, exhibits superior mechanical properties, high flexural strength (900 MPa to 1200 MPa), and higher fracture toughness (6 MPa to 10 MPa m1/2).[8,9]

CASE REPORT

A 19-year-old female of excellent health was referred to the Department of Prosthodontics for the esthetic restoration of peg-shaped right and left maxillary lateral incisors (LIs). During the examination, it was noted that the patient had congenitally missing maxillary canines on both sides and a midline diastema [Figure 1]. The treatment plan involved fabrication of full coverage crowns for the right and left maxillary LI's and ceramic veneers for both the maxillary central incisors. However, the patient had made it clear at the onset that she was seeking treatment only for restoring the shape of her LI's and wanted the midline diastema to be left as it was. The patient was given the option of a porcelain-fused-to metal or an all-ceramic restoration. For obvious reasons, the patient chose to have the LI's restored with the all-ceramic option. This clinical report describes the procedure for restoring the esthetic appearance of both the maxillary peg-shaped LI's with a metal-free sintered finely structured feldspar ceramic material using the latest laboratory CAD/CAM system.

Figure 1: Preoperative view

Procedure

1. During the first visit, diagnostic impressions are taken and the study models were articulated in a mean value articulator (E200 Simplex, Cori Dent, Daegu, South Korea). This was done to evaluate the occlusion and to plan for proper tooth reduction. The entire procedure, including the tooth preparation, restoration fabrication, and cementation, was scheduled for the second visit
2. At the second visit, preparations were carried out with both the maxillary LI's with a resultant shoulder finish line and vinyl polysiloxane impressions (Express™, 3M ESPE Dental Products; St. Paul, MN, USA) were made following gingival retraction using impregnated retraction cords (Ultrapak® E Cord #00, Ultradent Products Inc., St. Louis MO, USA). The models were poured in type IV gypsum (Gladstone 3000, Dentsply GAC, NY, USA)
3. The models were taken to our on-site laboratory which housed the inLab MC XL CAD/CAM station (Sirona® Dental GmbH; Salzburg, Österreich) and a new digital file was created using the inLab 4.2 software. After entering the dentist and patient information, the system prompted the operator to select various parameters that included the tooth number, type of restoration, type of bite, block selection among others, and the scan was initiated using the inEos Blue scanner
4. Individual scans of both the maxillary and mandibular models along with a buccal scan of the articulated models were performed and the system then generated a digital model using the composite images
5. The digital models were then aligned in the orientation mode and the margins were traced using the margin tools from the tool pane on the right side of the screen and the restorations were designed from the tooth library which contains thousands of biogeneric tooth morphologies [Figure 2]. The restorations were moved, resized, and then the interproximal and occlusal contacts were evaluated [Figure 3] using the model contact feature of the analyzing tool pane. The occlusion with the antagonist teeth was on the palatal middle third of the crowns and manually adjusted until the occlusal contacts were in the light blue color zone indicative of light contact (0–50 μm) in maximum intercuspation
6. Once satisfied, the location of the sprue and the position of the restorations in a multiblock data was

adjusted [Figure 4], and the data were sent to the inLab MC XL milling unit. The selected block (Cerec S2 PC, 14, Sirona® Dental GmbH; Salzburg, Österreich) was fitted in the mill and the milling was initiated which lasted for approximately 8 min for each individual crown [Figure 5]

7. After completion of the milling, the crowns were retrieved and the sprue areas were ground smooth. A bisque try-in was done and the occlusion was adjusted minimally. The restorations were then sintered and luted with a dual-cure resin cement (Calibra® Esthetic Resin Cement, Dentsply Intl, NY, USA) [Figure 6].

Finally, the patient received postoperative care instructions, and a recall appointment was scheduled.

DISCUSSION

Irregularities in tooth morphology resulting from late disturbances during the differentiation process most commonly result in peg-shaped LI's.[10] The esthetic defect in patients with peg LI's consists of both the malformed teeth and the presence of diastema between teeth. The treatment includes two primary objectives: To restore the hypoplastic dental crowns and to close the diastema, but can vary according to patient demand as in this case wherein the patient requested the diastema to be left untouched. Treatment options for diastema closure include procedures such as fixed orthodontic therapy, porcelain laminate veneers as well as minimally invasive procedures such as direct resin composite bonding[11] and treatment options for the correction of peg-shaped LI's include metal-ceramic restorations and CAD/CAM all-ceramic crowns. The incorporation of the CAD/CAM technology in dentistry and the advances in recent years which include faster production, precision-fit, excellent esthetics, and the possibility of chair-side production made it the preferred choice.

At present, the expanded palette of materials for definitive prostheses production using CAD/CAM technology provides access to both newer and conventional materials[7,12,13] such as zirconium, titanium, titanium alloys, and chrome cobalt alloys. The stability values of zirconium oxide ceramics permit the use of this material as an alternative to metal frames for permanent prostheses.[14]

On the one hand, resin material blocks are being used for a full anatomical long-term temporary prosthesis and on the other hand, they can also be used for the milling of lost wax frames for casting technology.

CONCLUSION

The uniqueness of this report does not lay in the case selection

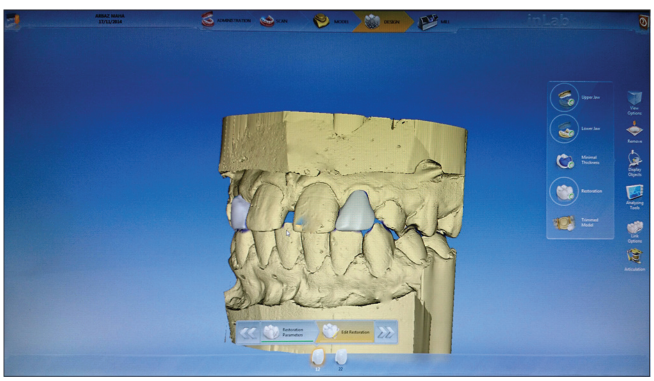

Figure 2: Final restoration design on the articulated digital models

Figure 3: Occlusal contacts being evaluated

Figure 4: The location of the sprue and position of the crown was adjusted in a polychromatic block

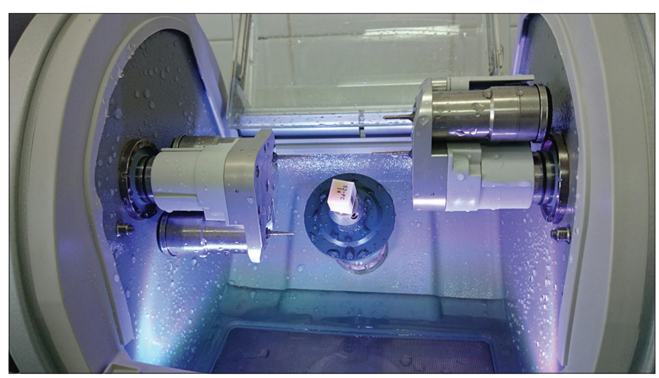

Figure 5: The selected block (Cerec S2 PC, 14/14) being fitted in the mill

Figure 6: Pre and post- operative view

itself, but the use of CAD/CAM technology which makes it possible to produce restorations faster with precision- fit and good esthetics overcoming the errors associated with traditional ceramo-metal technology. CAD/CAM technologies have started a new era of procedures and restorations in dentistry. Their popularity and application in various aspects of restorative dental practices is astounding. However, a major drawback of this technology is the high investment cost for the milling equipment which might hinder its growth in the lower wage third world countries. In spite of all the benefits of these new methods, the dentist working procedures will have to be adapted in the methods of CAD/CAM milling technology. These include appropriate tooth preparations with rounded contours and the creation of a continuous preparation margin, which is clearly recognizable to the scanner. Last but not least, CAD/CAM technology has made it possible to machine newer materials such as the high-performance oxide ceramics and titanium with high accuracy that meet industrial standards.

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Conflicts of interest

There are no conflicts of interest.

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