A Digital Revolution in Ceramics

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Abstract

Now your smile comes with lifetime warranty….!

Advances in cosmetic dentistry and digital revolution in dental ceramic have started a new age in dental restorations. It is a dream of a clinician to achieve excellence in the form, function and esthetics to provide lifelike restorations. From improved marginal adaptation to perfect fits all parameters have seen marked improvement.

BUT… Can CAD/CAM restoration last a lifetime?

Prosthodontics have begun to establish itself as 'knowledge- based' speciality and not just a 'skill- based' speciality. In a small cross- sectional survey conducted among 150 dentist it was established that it is required to explore and give an insight into the application of digital ceramics in state-of-the-art teeth replacements and dental implant.

Keywords : Digital ceramics, Y-TZP (Yttrium-tetragonal zirconia polycrystals), CAD/CAM, Zirconia, Implant Abutments.

Introduction

Dental CAD/CAM is approaching 20 years of clinical experience and has a proven track record on all relevant aspects of clinical performance including fit, longevity, survival rates, sensitivity, structure and new technology to scan, digitise, render and rapidly create precise teeth replacements, cost effectivity. The technology, which is used in both dental office and dental laboratory can be applied to onlays, inlays, veneers, crowns, FPD'S, implant abutments and even full mouth reconstruction, dentures ,maxillofacial prosthesis, orthodontics and beyond.

CAD/CAM systems are available that either digitally scan and create fixed restorations chairside or that capture chairside digital impressions that are then sent to a laboratory. In office CAD/CAM allows clinicians to provide same visit indirect fixed restorations that are accurate and esthetically pleasing. Chairside digital impression making allows for the creation of accurate models that can then be used for either traditional or CAD/CAM fabrication of restorations and involves less chairside time.

Evolution of CAD/CAM in Prosthodontics

- 1789- Zirconium dioxide (ZrO_2) was identified by the German chemist Martin Heinrich Klaproth.
- 1979-Hetlinger & Rodder followed by Moerrmann and Brandesten in 1980 were the pioneers in the development of the CAD/CAM restoration.
- 1983- first CAD/CAM prototype was presented at the Garanciere conference (France)
- 1985-first crown was publicly milled & installed in a mouth without any laboratory involvement.
- 1989- In-Ceram Alumina (VITA Zahnfabrik), was introduced as the first all-ceramic system available for single-unit restorations and 3-unit anterior FPDs.

Y-TZP (Yttrium-tetragonal zirconia polycrystals). "Zirconium" (Arabic)= "Zargon"= golden in colour. CAD/CAM produced Y-TZP based systems are applied in esthetic zone and in stress bearing regions. Zirconium (Zr) is a metal with an atomic no. of 40. Zirconia is a polymorphic material that occurs in 3 forms. The tetragonal-to-monoclinic phase transformation occurs below 1170°C and is accompanied by a 3-5% volume expansion which causes high internal stresses.[12,13,14]

Yttrium-oxide (Y_2O_3 3% mol) is added to pure zirconia to control the volume expansion and to stabilize it in the tetragonal phase at room temperature.[15] This partially stabilized zirconia has high initial flexural strength and fracture toughness.[15] Tensile stresses at a crack tip will cause the tetragonal phase to transform into the monoclinic phase with an associated 3-5% localized expansion.[14] In the presence of higher stress, a crack can still propagate. The toughening mechanism does not prevent the progression of a crack, it just makes it harder for the crack to propagate.[6,14,15,16,17]

Yttrium-oxide partially stabilized zirconia (Y-TZP) has mechanical properties that are attractive for restorative dentistry; namely, its chemical and dimensional stability, high mechanical strength, and fracture-toughness. The cores have a radiopacity comparable to metal which enhances radiographic evaluation of marginal integrity, excess cement removal, and recurrent decay.[16]

Y-TZP can be manufactured in 2 methods through computer-aided design/computer-aided manufacturing (CAD/CAM) technology. First, an enlarged coping/ framework can be designed and milled from a homogenous ceramic soft green body blank of zirconia.[18] The framework structure has a linear shrinkage of 20-25% during sintering until it reaches the desired final dimensions.[19,20] Processing with this softer presintered material not only shortens the milling time, but also reduces the wear on the milling tools.[19] Although zirconia frameworks can be milled directly from a fully sintered prefabricated blank in the final dimensions[18,19] milling fully sintered zirconia may compromise the microstructure and strength of the material.[21,22]

Lava (3M ESPE) uses a Y-TZP (Fig. 1) framework with high flexural strength, high fracture toughness, and low elastic modulus compared to alumina, and exhibits transformation toughening when subjected to tensile stress.[6,15] Other CAD/CAM systems are also available for designing and milling zirconia restorations. Cercon (Dentsply Ceramco) requires conventional waxing techniques to design the Y-TZP framework, and the wax pattern is scanned.[23] DCS Precident (DCS Dental AG) uses fully sintered DC Zirkon ceramic containing 95% ZrO2 partially stabilized with 5% Y_2O_3.[23,24,25] Denzir (Decim AB) designs and mills ceramic inlays from yttrium-oxide partially sintered blocks.[26]

Fig 1: Crowns fabricated with Y-TZP

Glass Ceramics

IPS Empress 2 (Ivoclar Vivadent) is a lithium-disilicate glass ceramic (SiO_2-Li_2O) that is fabricated through a combination of the lost-wax and heat-pressed techniques(Fig 2). IPS Empress 2 has improved flexural strength by a factor of 3 over IPS Empress, can be used for 3-unit FPDs in the anterior area[2]. The framework is veneered with fluoroapatite-based veneering porcelain (IPS Eris; Ivoclar Vivadent), resulting in a semitranslucent restoration with enhanced light transmission. IPS e.max Press (Ivoclar Vivadent) was introduced in 2005 as an improved press-ceramic material compared to IPS Empress 2. It also consists of a lithium-disilicate pressed glass ceramic.IPS ProCAD (Ivoclar) is a leucite-reinforced ceramic similar to IPS Empress, although it has a finer particle size.[3] Introduced in 1998, it is designed to be used with the CEREC inLab system (Sirona Dental Systems) and is available in numerous shades[3]. Vita Mark II (VITA Zahnfabrik), a machinable feldspathic porcelain introduced in 1991 for the CEREC 1 system (Siemens AG), has improved strength and finer grain size (4 μm) as compared to the Vita Mark.[3]

Fig 2: Crown fabricated with IPS-empress 2

Alumina-based Ceramics

In-Ceram Alumina (VITA), introduced in 1989, was the first all-ceramic system available for single-unit restorations and 3-unit anterior FPDs.[4] It has a high strength ceramic core fabricated through the slip-casting technique(Fig 3). Alumina blanks (VITA BLOCS In-Ceram Alumina; VITA Zahnfabrik). In 1994, In-Ceram Spinell (VITA) was introduced as an alternative to the opaque core of In-Ceram Alumina.[5] This material can also be machined with the CEREC in Lab system (Sirona), followed by veneering with feldspathic porcelain. Synthoceram (CICERO) is a high-strength glass-impregnated aluminum- oxide ceramic core fabricated through CICERO technology (Computer Integrated Ceramic Reconstruction). In-Ceram Zirconia (VITA) is also a modification of the original. In-Ceram Alumina system, with an addition of 35% partially stabilized zirconia oxide to the slip composition to strengthen the ceramic.[26] Procera (Nobel Biocare AB) was developed by Andersson and Oden with copings that contain ss 99.9% high purity aluminium oxide.[6] Combined with low-fusing veneering porcelain, Procera has the highest strength of the alumina-based materials and its strength is lower only than zirconia.

Fig.3: Crowns fabricated with In-ceram Alumina

CAD/CAM System

Different CAD/CAM Systems

1. Celay System (mikrona Technologie, Switzerland.)
2. Duret System (sopha, France).
3. Dux System / Titan System (dcs Dental Switzerland)
4. Procera System (nobel Pharma, Sweden).
5. Cerec System (siemens, Germany).
6. Denticad System (bego, Germany).

What's New in CEREC 3?

Fig 4: CEREC 3 SYSTEM

The new Cerec 3 software is Windows® based allowing greater compatibility and sharing possibilities

- milling chamber is separate from the imaging/designing unit
- the system is now Windows®-based
- Cerec 3 can be used in conjunction with a Cerec 2 by using the "Link" software
- Faster milling times (5 minute savings)
- Greater occlusal anatomy
- All design windows can be open at once
- Help screen runs automatically and guides you through the process

Blocks for CEREC

- 3M MZ1
- VITA Mark II and 3D Master 00
- Ivoclar ProCAD
- VITA Mark II Esthetic Line
- VITA Alumina and Spinell

Equipment Needed in Dental Office

3-D probe system, surface modeling, screen display and an automatic milling machine. An electro-optical method is used to obtain the impression. The light carries the volumetric information, which is digitized by the camera & fed into computer. The CAD system uses the encoded information to allow the operator to visualize an impression on a graphic screen and to design prosthesis. In the last step the preformed cubical block of the material is milled to fabricate prosthesis.

Preparation of the Tooth

- Avoid deep grooves. Too vertical proximal walls are avoided.

Preparation of the Impression Areas

Tooth is dried, a thin coating of non-toxic white powder sprayed on the tooth to enhance the quality of the image.

The Impression

The dentist starts the laser and the camera control. A laser source (diode) through an endoscope projects light on the desired picture area. A second endoscope, adjacent to the first, allows a camera to take the pictures in mouth.Time: 2-3 minutes.

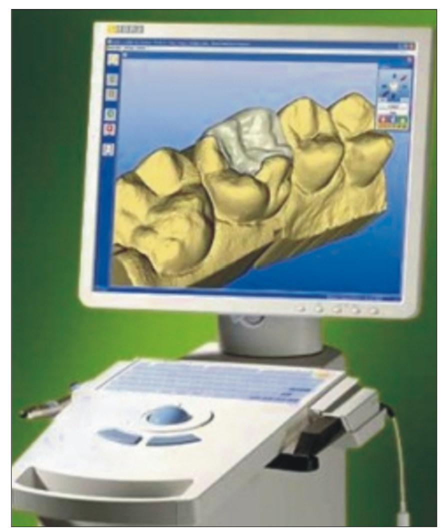

Fig 5: Digital impression with CEREC 3

All-ceramic Materials, Systems And Recommended Clinical Indications

Core Material	Systems	Clinical Indication
Glass ceramic • Lithium disillicate (SiO2-Li2O) • Leucite (SiO2-Al2O3-K2O) • Feldspathic (SiO2-Al2O3-Na2O-K2O)	• IPS Empress 2(Ivoclar vivadent), IPS e.max press (Ivoclar) • IPS Empress (Ivoclar), Optimal pressable ceramic (Jeneric pentron), IPS ProCAD • VITA BLOCS mark ii (VITA Zahnfabrik), VITA TriLuxe Bloc (VITA), VITABLOCS Esthetic line(VITA).	Crowns , Anterior FPD. Onlays, ¾ crown , crowns,FPD. Onlays, ¾ crown , crowns. Onlays, ¾ crown , crowns. Onlays, ¾ crown , crowns. Onlays, ¾ crown , crowns, veneers. Onlays, ¾ crown , crowns, veneers. Anterior crowns, veneers.
Alumina • Aluminium oxide(Al2O3)	• In-Ceram alumina (VITA), In-Ceram Spinell (VITA), Synthoceram (CICERO Dental Systems), In - Ceram Zirconia (VITA), Procera (Nobel Biocare).	Crowns, FPD. Crowns . Onlays, ¾ crown , crowns. Crowns, Posterior FPD. Veneers, Crowns, Anterior FPD.
Zirconia • Yttrium tetragonal zirconia polycrystals(ZrO2 stabilized by Y2O3)	• Lava (3M ESPE), Cercon(Dentsply Ceramco) • DC-Zirkon (DCS Dental) • Denzir (Decim), Procera (Nobel Biocare).	Crowns, FPD. Crowns, FPD. Crowns, FPD. Onlays, ¾ crown , crowns. Crowns, FPD, Implant abutments.

Work on the Video Model

Each image is projected on the high resolution video screen. Using the view of the picture on the screen the dentist defines a series of points along the desired portion of the margin. After which, the computer automatically calculates the 3-D structure and sends to CAD system which designs the virtual model.

Design of Crown

The crown to be designed is first retrieved from the memory bank of the theoretical teeth stored in the computer. A special programme builds a set of contours that will allow for the esthetic modification of the theoretical tooth to fit the existing morphology while respecting the buccal and lingual curvatures , the alignment of grooves and cusps and the contact areas of the arch.

Milling The Prosthesis

Performed by micro milling machine (28×20×20 inches), with four machining, coolant, and automatic tool change capabilities. Initially gross, followed by fine milling. The machine removes all the waste materials and the crown is ready to be removed from the machine. (Fig. 5)

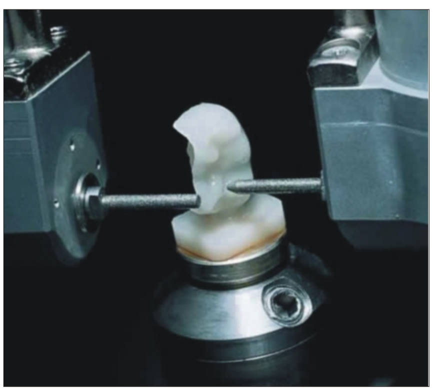

Fig 6: Milling of Zirconia crown.

Ceramic Implant Abutment

Success of implant supported prosthesis depends not only on intact osseointegration but also on harmonious integration of the crown into the dental arch.

Newer Generation Ceramic Abutments

Cer adapt -aluminum oxide & yttrium stabilized zirconium oxide (wohlwend innovative).

Zirconium Oxide Abutments

Excellent esthetics. Very high flexural strength - 3 times that of densely sintered pure aluminum oxide. Other mechanical properties such as modulus of elasticity are superior when compared to aluminum oxide.

The prosthetic restoration can be cemented definitively onto the abutment using a gold screw .

Conclusion

Multiple Future perspectives and many such emerging trends like additive manufacturing and continual development of computer hardware and software have inherent potential to revolutionize patient care.

We strive to make oral health span close to the life span of our population!

But the lure and the rush for the high technology is becoming fashionable in dentistry. Let us be judicious to choose technologies that help us as a powerful tool. Dentistry cannot be dictated by materials and techniques. The ultimate success of patient care requires best understanding of the demands of the case and not how meticulously we execute a procedure or technique.

Thus, from a global perspective;

Digital ceramics! A new frontier….. continues to be unravelled in the realms of Prosthodontics.

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