Mastering the art of dental technology

By Marc Chalupsky, DTI

SINGAPORE/BAD BOCKLET, Germany: Singapore and Germany are about 10,000 km apart. As long-time dental technicians and dealers discovered at this year’s International Dental Exhibition and Meeting (IDEM), the world’s most comprehensive range of dental laboratory products can be found at DT&SHOP, located in the town of Bad Bocklet about 200 km north-west of Nuremberg. Owing to the company’s latest inventory and delivery systems, orders arrive in Singapore and other Asia-Pacific countries within three working days. DT&SHOP has big plans for this thriving dental technology market.

According to a recent Transparency Market Research report, the Asia-Pacific dental laboratory market is projected to expand at a substantial rate in the next five years. Driven by rising dental tourism and a growth in the number of dental laboratories, the domestic sector will also see an increase in export demand, particularly regarding orthodontics, periodontics, crowns, and any other product availability, eco-friendly packaging and competent customer service, the company has proved itself to be a reliable partner for local dealers.

This year, DT&SHOP took the next step towards securing a major position in the Asia-Pacific market, by exhibiting at IDEM Singapore 2016. With a 90 m² booth, the company showcased its wide range of dental laboratory products from leading manufacturers. As a dental producer itself, DT&SHOP also presented the new FINOCAM A5 five-axis milling unit and the FINOSCAN RELATION high-quality optical 3D scanner.

“Most dental technicians at IDEM were impressed by our FINO CAD/CAM solutions. In fact, our FINO brand covers most of the dental laboratory needs, including orthodontic boxes, partial denture alloys, duplicating and addition-curing silicates, porcelain brushes and much more,” explained Roer. “I think that we have quite successfully mastered the art of offering the complete range of dental technology.”

Artists and dental technicians share a talent for colour, aesthetics and technical complexity. It therefore comes as no surprise that DT&SHOP’s corridors are filled with masterpieces, inspirational and vivid artworks from around the world. Roer has had a passion for art for most of her life. Her latest acquisition, a set of paintings from Canada, is awaiting a suitable space in one of the company’s new course and laboratory rooms.

In 2010, she travelled to Vietnam with partners and clients anywhere. Roer’s visits do not rush through the aisles of the building. They stop and see the beautiful work of local artists. The Asia-Pacific region and Vietnam in particular are known for their lively art scene. “Art has always been very important to me,” said Roer. “Our visitors do not rush through the aisles of the building. They stop and see the beautiful work by artists about 10,000 kilometres apart.”

Materials and systems for all ceramic CAD/CAM restorations

By Drs. Christian Brenes, Ibrahim Duqm and Gustavo Mendonza, USA

Dental crowns have been used for decades to restore compromised, heavily restored teeth, and for aesthetic improvements. New Computer Aided Design/Computer Aided Manufacturing (CAD/CAM) materials and systems have been developed and evolved in the last decade for fabrication of all-ceramic restorations. Dental CAD/CAM technology is gaining popularity because of its benefits in terms of time consuming, materials savings, standardisation of the fabrication process, and predictability of the restorations.

The number of steps required for the fabrication of a restoration is less compared to traditional methods (Fig. 3). Another benefit of CAD/CAM dentistry includes the use of new materials and data acquisition, which represents a non-destructive method of saving impressions, restorations. The increasing number of dental laboratories around the world is a positive trend that is set to continue.

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Seventh peak into the DT&Shop main building: In the foreground the DT&SHOP catalogue, in the background an artwork by a Vietnamese artist. (Photograph: Marc Chalupsky, DTI)
Table 1: Recommended dimensions for E-max CAD by Ivoclar Vivadent.

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<th>Material</th>
<th>Anterior</th>
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Lithium disilicate: Lithium disilicate is composed of quartz, lithium disilicate, and aluminum oxide. It is a ceramic material used for dental restorations.

Zirconia: Zirconia is a ceramic material used for dental restorations due to its high strength and fracture toughness.

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The purpose of this document is to provide a review of the literature regarding the different materials and systems available up until 2015 in the USA.

CAD/CAM materials: Glass ceramics

Glass ceramics: a new generation of all-ceramic restorations.

Table 1: Recommended dimensions for E-max CAD by Ivoclar Vivadent.

Zirconia: Zirconia has been used in dentistry as a biomaterial for crown and bridge fabrications since 2004, and it has been useful in the most posterior areas of the mouth where high occlusal forces are applied and where esthetics is limited interocclusal space.

Zirconia is a polymeric material that can have three different forms depending on the conditions: monoclinic at room temperature, tetragonal above 1270°C, and cubic beyond 2370°C. According to Piccon (1999) ‘the phase transitions are reversible and free crystals are associated with unmatched domains’. Recent works state that when zirconia is heated to temperatures between 2450°C and 2550°C and cooled, a volumetric shrinkage of 25 to 35 percent can occur that could affect marginal fit or passiveness of the restorations.

One of the most interesting properties of zirconia is transformation toughening. Kelly (2000) describes it as: ‘A phenomenon that happens when a fracture takes place by the extension of an already existing crack in the material structure, with the tetragonal grain changing to the monoclinic one’. This phase disintegrates partially or totally, which promotes progression of cracks in the restoration, there is a localized expansion of about 0.7 percent that increases the energy that opposes the crack propagation.

Zirconia restorations can be fabricated from fully sintered zirconium oxide or partially sintered zirconium oxide blanks (green-state). Propensity of milling partially sintered zirconia claim that fitness of restorations is better because it avoid volumetric changes during the fabrication process. On the other hand, the partially sintered zirconia (Fig. 4) is easier and faster to mill and proponents of milling partially sintered blanks claim that manufacturing a partially sintered restoration instead of the restoration during the milling process and it also requires more time and investment.

One of the first systems that used zirconia was In-Ceram Zirconia (Vident), which is a modification of the In-Ceram Alumina but with the addition of partially stabilised zirconia oxide to the composition. Recently many companies have integrated zirconia into their CAD/CAM workflow due to its mechanical properties which are attractive for restorative dentistry, some of these properties are: high toughness, radiopacity for marginal integrity evaluation, and relatively low fracture toughness.

Different manufacturers are using zirconia as one of their main materials such as: Ceramill Zolid (Amann Girrbach), Zirkonzahn (Glidewell Laboratories), Corin (DENTSPLY, BruxAir (Gliselwood Laboratories), IPS ZirCAD (Voc al Vivadent), Zentron (Zirkonzahn), In-Cor ZIR (Sirona Dental), VITA In-Ceram YZ (Vident), among others. Comparisons between the different materials have been made in combination with zirconia to improve its properties.
in different clinical situations. Lava Plus, for example, is a combination of zirconia and a nano-ceramic.

**CAD/CAM systems**

A variety of CAD/CAM systems are providing CAD/CAM solutions that generally consist of a scanner, design computer and a milling machine or 3-D printer. Laboratories are able to receive digital impression files from dentists or use a scanner to create digital models that are used for fabricating new or custom dental restorations. CAD/CAM systems vary in size, speed, axes, and also in which restorative materials can be milled; in this category milling machines could be classified as well depending on the materials that require rigidity.

The development of dental CAD/ CAM systems occurred around the introduction of the Sirona system developed by Dr. Francois Durst. A few years after that event, Dr. Werner Mormann and the electrical engineer Marcel Brandstein developed CEREC’s system for the first full digital dental system creating the ability to design, mill and fabricate in-office restorations. Since then, the continuous evolution of systems dedicated to this field has continued and has exponentially increased in the last decade [4].

CEREC systems have evolved into CEREC Bluecam scanner accuracies as close as 77 microns for a single tooth. Features have been reported by authors using high-precision digitizing systems, and CEREC Omnimate was introducing offering true colour digital impressions without the need for additional equipment. In a recent study by Neves et al. [5] on the marginal fit of CAD/CAM restorations fabricated with CEREC Bluecam, they compared lithium disilicate single-unit restorations to heat-pressed restorations and 8.8 percent of the specimens had a vertical gap of less than 15 microns [5].

The CEREC InLab CAD software (Si- rona Dental) was designed for dental laboratories for a wide range of dental capabilities that can be combined to create a single virtual design. The design computer is designed by the manufacturer and designed the restoration, once this process is completed, the file can be sent to a remote milling machine or a milling centre for fabrication in a wide range of materials.

The Procera system, introduced in 1994, was the first system to provide fabrication using a restorative design registered to a computer. The digital design is sent to a computer-aided design computer and a milling machine or 3-D printer. Laboratories or 3-D printers can be delivered to dental laboratories for porcelain layering and finishing [6].

Another system that was developed around 1995 was the Diatek system, which fabricated feldspathic restorative materials through a copying/milling process. The system duplicated an acrylic resin pattern replica of a restoration. Zirkonit Material, a manufacturer of zirconia polycrystals, provided that it was possible to copy-zirconia patterns and restorations out of a replica of the restoration. Some years after, the system was used for a CEREC system (CEREC 2) was able to design and mill zirconia restorations out of a wax pattern [7].

Almost at the same time that these companies developed their first copy mill prototypes, Lena MS (ESP) introduced in 2001 the fabrication of mono-crystalline zirconia polycrystals (Y-TZP) cores and frameworks for all ceramic restorations. With the Lava system, the die is scanned to produce a volumetric optical process, the CAD software designs and enlarges the restoration or framework that is delivered from a pre-bent-skeletoned study. X-ray imaging of this model suggests that Lava restorations have a marginal fit that can be as low as 25 microns [7]. Some other systems that were able to mill zirconia were DCS Zirkonit/DCS Dent and InLab [6].

In the last decade, companies have decided to fabricate dental products by having a full CAD/CAM platform by producing on specific areas of expertise. Dental software and intraoral scanners; these companies can claim open platform be able to export universal files such as STL or OBJ (Fig. 3) to be used with the majority of restorative milling machines that are able to import them.

Defenders of closed platforms claim that the integration of different CAD/CAM systems does not allow for a good integration between parts and probably leads to the incorporation of limited software’s limitations of accuracy. All of these limitations of technology and accuracy of the CAD/CAM systems and materials show that it is possible to fabricate restorations with the same marginal fit expect from conventional methods and within the range of clinically accepted restorations. When comparing both methods the advantage of using CAD/CAM technology is not to obtain the most precise level of fit, but rather to obtain a high level of re-producibility in a large number of restorations; especially when high producing levels are expected. However, there are a limited number of clinical studies and the diversity of the restorations materials and systems does not allow us to give a definitive conclusion.

Some of the main concerns from clinicians on all-ceramic CAD/CAM restorations is the marginal fit of the restoration. Previous studies have attempted to determine the limits of accuracy of CAD/CAM restorations. The Artis/M5 from Zirkonzahn is a key factor for fabricating good restorations, the computer software per se was introduced to provide a pre-operative tool to create an excellent dental restoration from scratch [8].

**Discussion**

Several advantages can be drawn from the use of digital technology, 3D scanning and the use of material for all ceramic restorations. Even though clinical studies have shown that marginal fit of CAD/CAM restorations is comparable to conventional restorations the fabrication of dental restorations is still a complex task that requires experience, knowledge and skills.

The incorporation of new systems and materials bring not only concerns regarding system implementation, capabilities and mechanical properties of the different materials. One recent study by Londesborough et al. still re- main to CAD/CAM dental systems is the accuracy of each step in the CAD/ CAM chain, from digital impression to the milling step. Using computer aided manufacturing is dependent on the calibration of hardware with software in the workflow. Furthermore, the virtual configuration of the die spacer between the tooth and the restoration is essential for the accurate of the marginalized fit and has to be calibrated for each one of the systems. Weinstein et al. demonstrated that the difference of fit between CAD/ CAM restorations is directly related to the gap parameters from the computer program and also related to the intrinsic properties of the CAD/CAM system [6].

**Conclusion**

This review of current and past litera- ture regarding the evolution, characteristics, and marginal fit of milled CAD/CAM, all-ceramic resto- rations and materials systems and show that it is possible to fabricate restorations with the same marginal fit expected from conventional methods and within the range of clinically accepted restorations. Comparing both methods the advantage of using CAD/CAM technology is not to obtain the most precise level of fit, but rather to obtain a high level of reproducibility in a large number of restorations; especially when high producing levels are expected. However, there are a limited number of clinical studies and the diversity of the results between systems and protocols does not allow us to give a definitive conclusion.

**References**