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3D Printing of Ceramic Restorations

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Tooth-colored materials possess significant advantages when it comes to producing restorations with a natural appearance. A large number of new metal-free restoration possibilities and materials have been developed to meet the higher esthetic demands of both patients and dentists. Due to their excellent biocompatibility and outstanding optical properties, all-ceramic materials are nowadays seen as the material of choice. All-ceramic restorative materials have significant advantages over combinations of metal and ceramic materials, especially when it comes to the task of optical imitation of the natural tooth. [1].

Milling technology can produce restorations with high esthetics and mechanical properties, so why are so many resources being invested in developing additive technology?
Simply, 3D printing is expected to produce restorations with better esthetics and strength at lower costs than milling. Milling has some limitations regarding geometries and necessitates high maintenance costs for the machines [2]. Moreover, fine crown margins and perfectly shaped occlusal surfaces can be produced more easily using the additive technology. 3D printing also offers individualized and personalized colorings due to the layered structure created [1].

In 2022, a study was conducted to evaluate 3D printed versus milled zirconia crowns. They found that both production techniques were comparable to each other in terms of internal fit and marginal adaptation. The trueness of the occlusal and axial surfaces of 3D-printed crowns was better, whereas the trueness of fitting surface of milled crowns was better. 3D-printed crowns provided a higher level of precision than milled crowns [3].

3D Printing Techniques for Ceramics:

I- Indirect technique

Examples of this technique include:

• Trix print process by Dekema (Freilassing, Germany)

• IPS e.max Digital Press Design–Wax Tree by Ivoclar Vivadent (Schaan, Liechtenstein)

It combines the advantages of digital design with the proven efficiency of ceramic pressing technology.

The system maps the entire pressing workflow digitally in the following steps:

1- Scanning, CAD designing and Printing

Digital acquisition is done directly by intraoral scanner, or indirectly, by scanning a master cast. CAD software automatically designs the complete wax-up, including the placeholders [may reach up to three pressing plungers, in order to press up to three pressing pellets which can be of different shades]. CAM software determines the required layer pattern and sends it to the 3D printer to start printing using printable burnout material [4].

2- Investing and pressing

3D printing is followed by cleaning and curing the objects and investing them in special muffle. After heating in the preheating furnace and residue-free calcination, the pressable ceramic is inserted into the muffle. The project-specific pressing program was earlier sent to the pressing furnace from CAM software [4]. (Figure 1)

3- Finishing and glazing

After pressing, the restorations are finalized following standard procedure [4].

II- Direct technique

Examples of this technique include [1, 4]:

- SLA process: 3DCeram (Limoges, France)
- DLP process: LCM (lithography-based ceramic manufacturing) by Lithoz (Vienna, Austria)
- Binder jetting: 3D Systems (Rock Hill, SC, USA)

The most advanced approach is probably the patented LCM process by Lithoz (Vienna, Austria). Workflow steps of producing a ceramic crown using this technology are:

1- Scanning, CAD designing and Printing

After scanning and CAD-designing the restoration, the fully contoured crown is fabricated using Lithoz' LCM technology that is based on digital light processing (DLP). A photosensitive ceramic slurry is selectively cured, achieving a high filler content and a dense packing of the ceramic particles in the presintered form. This is necessary to produce defect-free and dense ceramic objects. The polymer network connects the ceramic particles.

Now, the produced crowns are available as "green bodies" that still contain the organic binder material, which needs to be removed [1, 4].

2- Thermal debinding, Staining and Drying

Thermal debinding is done at 1000 ◦C over a period of several hours. This creates the so-called "white body," which no longer contains any binder and will already have formed solid sintering bridges that prevent the object from disintegrating.

Individual staining is performed using staining solutions, with three options being available:

- Immersion in the staining solution.
- Custom painting using a brush and staining solution.
- Combination of immersion and painting.

After staining, Crowns are dried before the final sintering step, ideally using infrared light [1, 4].

3- Sintering and Glazing

Sintering is carried out at 1600 ◦C, at certain parameters. The crowns are finalized with a stain firing and a glaze firing at 770 ◦C. IPS e.max Ceram Stains were used for this purpose [1, 4]. (Figure 2)

Courtesy of Schweiger et al.[3]

Figure 1: 3D printed and pressed ceramic inlays.

Courtesy of Schweiger et al.[1]

Figure 2: 3D printed zirconia crown. in the green state (left), white state (middle) and fully sintered (right).0

Printable Ceramics:

Lithium Disilicate

Lithoz,is currently the only company that produced printable lithium disilicate ceramic. The great esthetic and mechanical properties of this material are the reason behind the investment in producing the printable form. Lithoz technology uses the same powders and furnaces as injection molding or milling and, thus, produces ceramic parts with comparable mechanical properties and surface quality. Restorations can be printed with edges as thin as 0.1 mm [4].

Zirconia

The most significant challenge to 3D printing permanent zirconia restorations has been the sintering process. Earlier, first-printed zirconia INNI-CERA material from AON took approximately 2 days to adequately sinter. AON stated that sintering process heating rate needs to be 0.1 ºC per minute to perfectly sinter a 3D printed crown without any cracks. AON has co-developed sintering schedules of 15 and 21 hours for its products [4].

DWS's 3D printable zirconia material, Irix Z, uses the stereolithography technology. Trials to increase in the density of the material is thought to shorten the debinding and sintering time required. It has Photoshade technology to produce natural color gradient of the tooth [4].

Lithoz has its LithaCon 3Y 210 zirconia, which has a formulation based on the standard commercial powders that are used to press milling blanks or to create ceramic injection molding materials. Lithoz's current thermal post-processing time is approximately 10 hours, but they are working to shorten it further [4].

Multi-Material 3D Printing of Ceramics

The latest development in this field was presented by Lithoz in mid-2020. A specially developed LCM printer (CeraFab Multi 2M30) makes it possible to produce objects from different materials in a single printing process. It is possible not only to combine different ceramics but also to create ceramo-metal and ceramo-polymer objects [4].

Multi-material printing capabilities is expected to facilitate exceptional esthetics with more lifelike results [4].

References:

1- Schweiger, J., Bomze, D. & Schwentenwein, M. 3D Printing of Zirconia–What is the Future?. Curr Oral Health Rep. 2019; 6: 339-343

2- Mazda J. The Printed Crown: 3D printing permanent restorations is now a reality, and options are expanding. Inside Dental Technology .2022; 13 (7).

3- Abualsaud R. and Alalawi H. Fit, Precision, and Trueness of 3D-Printed Zirconia Crowns Compared to Milled Counterparts. Dent. J. 2022; 10: 215.

4-Schweiger J, Edelhoff D and Güth J. 3D Printing in Digital Prosthetic Dentistry: An Overview of Recent Developments in Additive Manufacturing. J. Clin. Med. 2021;10(9):2010..

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