Applications of Heat-pressed Ceramics for Single Tooth Restorations

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Currently, several methods have been used for fabricating all-ceramic restorations. Among them, heat-pressing technique was a well-established method utilizing lost-wax technique. The aim of the study was to evaluate the feasibility of application of dental heat pressing technique in processing dental ceramics and the marginal fit of obtained single tooth restorations. All the processing steps were developed to achieve different single tooth restorations. The staining technique was used. Heat-pressing technique used in the present study has been considered as easy processing, less time-consuming and with optimal marginal fit.

Key words: dental ceramic, heat pressing technique, marginal fit

The availability of different dental ceramic systems provides solutions for different types of restorative problems in esthetic dentistry, from conservative to extensive. Many years ago, all-ceramic restorations were limited for the anterior region. Today we have the ability to use ceramics also in the posterior areas and they are sufficiently strong. Since 1965, it can be seen an increase in strength and fracture toughness due to an increase in the crystalline content of the ceramic materials. This is also the period where dentistry transitioned to advanced technology and processing methods. Regarding to esthetics and costs, materials for all-ceramic restorations become even more attractive. Further, the ability to fabricate all-ceramic restorations in a monolithic form, rather than layering, becomes essential for dentists. Because of the large variety of this kind of ceramics, it is important to know the materials and their characteristics [1].

However, the demand for metal-free materials with increased optical properties, which mimic the natural teeth, has been increasing [2 - 5]. All-ceramic restorations have been advocated for super esthetic accompanied with acceptable mechanical properties [6, 7]. Properties of ceramic materials were closely related to the microstructure and preparation technique [8, 9]

Ceramics can be divided by their microstructure (i.e., amount and type of crystalline phase and glass composition), processing technique (powder/liquid, pressed, or machined), and clinical application. To provide the reader with a better understanding of ceramics, the authors give a classification based on the microstructure of ceramics, with the inclusion of how the ceramics are processed, which affects durability. At a microstructural level, ceramics can be defined by their composition of glass-to-crystalline ratio. There can be infinite variability of materials microstructures; however, they can be divided into four basic compositional categories with a few subgroups [10, 11]:

• Category 1: glass-based systems (mainly silica)

• Category 2: glass-based systems (mainly silica) with fillers, usually crystalline (typically leucite or a different high-fusing glass)

This category has a large range of glass-crystalline ratios and crystal types, so much so that the authors subdivided this category into three groups. The difference is varying amounts of crystal types have either been added to or grown in the glassy matrix.

Subcategory 2.1: low-to-moderate leucite-containing feldspathic glass

Subcategory 2.2: high-leucite (approximately 50%)-containing glass, glass-ceramics

Subcategory 2.3: lithium-disilicate glass-ceramics

- Category 3: crystalline-based systems with glass fillers (mainly alumina)

- Category 4: polycrystalline solids (alumina and zirconia) [10]

Currently, several methods have been used for fabricating all-ceramic restorations. Among them, heat-pressing technique was a well-established method utilizing lost-wax technique [12]. Heat pressing technology, which involves the simultaneous application of heat and pressure to prefabricated ingots in a previously invested mold cavity, has been used in dentistry for over 40 years to fabricate single crowns and partial fixed dental prostheses. Ceramics can be pressed onto a substrate or formed as a monolithic restoration, depending on their use and the esthetic needs of the patient [2].

Lithium disilicate glass ceramic system was developed with good mechanical properties and suitable translucency for dental restorative applications [13]. As a potential restorative material, the ability to easily fabricate dental restorations with commercially available dental heat pressing equipment was evaluated in different studies. The properties of heat-pressed mica-based glass ceramic were reported to be closely related to the heat-pressing procedures, such as temperature and holding time [14, 15].

Heat pressing of glass ceramic materials for dental applications is a proven method of fabricating fixed prosthodontic restorations. These restorations are translucent because of the absence of a metal substructure and thus offer an excellent opportunity for achieving life-like esthetic restorations. The microstructure consists of 70% lithium disilicate crystals embedded in a glassy matrix. Extensive research into the mechanical properties and clinical performance of heat-pressed glass ceramics has been carried out over the past 2 decades [16-22]. Some studies show promising results and give good insight into re-pressed materials. However, studies have only tested a

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single reuse of the material, whereas, in practice, it could be reused several times, depending on the amount of material left over. Routine mechanical strength tests revealed no adverse consequences for lithium disilicate when it is reused and that dental laboratories may be routinely and unnecessarily discarding excess material [21, 22].

Lithium disilicate is composed of silica, lithium dioxide, alumina, potassium oxide, and phosphorous pentoxide, which is melted together and then cooled. The glass is heated at specific temperatures to produce crystalline growth. When optimal crystalline growth has occurred to maximize the material's strength, the ceramic is pulverized into powder. The powder can be pressed into ingots or processed using other techniques. These processes result in raw materials that are either CAD/CAM milled or heat-pressed to reach a strong, monolithic, final restoration. Lithium disilicate, when used properly as a monolithic, full-contour restoration, represents a major and significant change for dentistry [1].

The geometry of tooth preparation for ceramic prosthetic restorations has been the subject of many debates without clear evidence that one type of tooth preparation or method of fabrication provides consistently superior marginal fit.

A well-designed preparation has a smooth and even margin. Rough, irregular margins substantially reduce the adaptation of the restoration. The cross-section configuration of the margin has been the subject of much analysis and debate. The minimization of marginal gaps is an important goal in prosthodontics.

Experimetal part

The aim of the study was to evaluate the feasibility of application of dental heat pressing technique in processing dental ceramics and to evaluate the marginal fit of obtained single tooth restorations.

Wax patterns of different single tooth restorations were prepared and fixed by wax sprues with 3 mm in diameter and 3 mm length (fig. 1).

Fig. 1. Spruing of the wax patterns

Then the wax patterns were invested with investment material mixed with corresponding liquid (Cergo fit Speed, Degudent, Hanau, Germany) (fig. 2).

Fig. 2. Invested mold

The invested mold was transferred to a burnout furnace and heated from room temperature to 850°C and hold for 60 min to melt down wax. Then the invested mold was immediately transferred into commercially available automated dental heat-pressing equipment (Multimat 2 Touch & Press, Degudent, Hanau, Germany) which had been already preheated up to 700°C. After inserting the lithium disilicate glass ceramic ingot (Cergo Kiss, Degudent, Hanau, Germany), which was heated together with the mold, and an alumina plunger, the heat pressing procedure was used with a holding time and heat pressing temperature of 980°C under a pressure of 4.5 bar, about 45 min (fig. 3, 4).

Fig. 3. Invested mold in the heat-pressing equipment

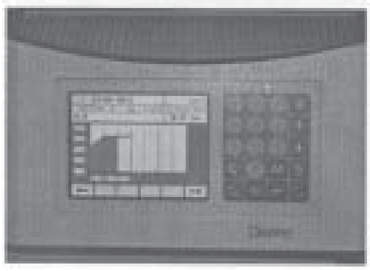

Fig. 4. Pressing process

Cergo Kiss is a pressable ceramic system for highly aesthetic and biocompatible restorations such as veneers, inlays, onlays, and crowns. After heat-pressing treatment, the specimens were carefully devested by sandblasting with glass powders (50 μm) at a pressure of 4 bar to remove investment material. Once the objects have become visible, abrading across the area was continued using reduced pressure (2 bar) (fig. 5).

Fig. 5. Pressed restorations after devesting

The sprues were cut and the restoration to be painted was finished using diamond burs or stones. The staining technique was used, that means modeling and pressing fully anatomic frameworks whose definitive shade is created by staining with LFC (Low Fusing Ceramic) stains, incisal stains, body stains, and glazing. The glaze firing was performed at 800°C, 1 min long (fig. 6, 7).

Traditional tooth preparation margin designs are still advised by most manufacturers for indirect restorations and were used for preparations for inlays, onlays and complete crowns. Two margin designs may be used for complete ceramic crowns: chamfer, and shoulder. A chamfer margin is particularly suitable for full crowns. It is distinct and easily identified, provides space for adequate bulk of material, although care is needed to avoid leaving a ledge of unsupported enamel. Shoulder margins always

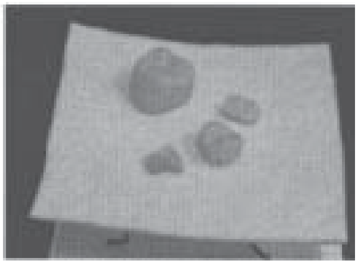

Fig. 6. Restorations prepared for glazing.

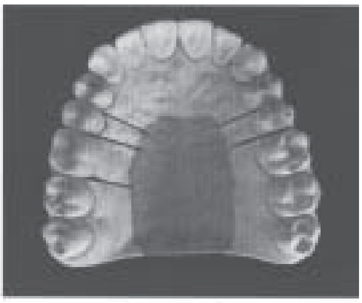

Fig. 7. Finished restorations on the cast.

offer space for the crown material. It should form a 90 degree angle with the unprepared tooth surface.

Marginal fit for all restorations were measured on the cross-sections. Each restoration was filled with the flow silicone, and then seated on the plaster die. The silicone from the restoration or the die was embedded in putty silicone and bucco-lingual and mesio-distal sections were made. The thickness of the flow silicone was microscopically measured in 2 points for each section.

Results and discussions

In the last few decades, there have been tremendous advances in the mechanical properties and methods of fabrication of ceramic materials. While porcelain-based materials are still a major component of the market, there have been moves to replace metal ceramics systems with all ceramic systems. Advances in bonding techniques have increased the range and scope for use of ceramics in dentistry. The new generation of ceramic materials presents interesting options, both in terms of material selection and in terms of fabrication techniques. A closer understanding of the dynamics of the materials with respect to design of the restoration and the intended use is required to enable these restorations to perform [11].

Pressed ceramic restorations are fabricated using a method similar to injection moulding. Monochromatic porcelain or glass-ceramic ingots are heated to allow the material to flow under pressure into a mold formed using a conventional lost-wax technique. The restoration may be cast to its final contours and subsequently stained and glazed to provide an esthetic match. Pressable ceramic systems may be used for inlays, onlays, veneers, and crowns [10].

The incomplete fit of restorations remains a critical problem for dentists, leading many researchers to study this problem. Marginal and internal accuracy of fit is valued as one of the most important criteria for the clinical quality and success of single tooth restorations. The means of the marginal fit measurements were calculated. The values are in the range of them which have been reported for the conventional fabrication techniques [23, 24] and are acceptable for clinical use: 156.83-180.21 μm for inlays, 79.59-107.83 μm for onlays, 59.01-116.92 μm for crowns.

Conclusions

Heat pressed ceramics single tooth restorations represent a solution of choice in many clinical situations. They give good results when used correctly and where indicated.

Heat-pressing technique used in the present study has been considered as easy processing, less time-consuming and with optimal marginal fit.

The hot pressed ceramic is a modern process, which is a easy prosthetic option within single tooth prosthetic restorations.

Regarding the marginal fit, the values are in the range of them which have been reported for the conventional fabrication techniques.

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