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REVIEW ARTICLE

A Comparison Review of reliability of multiple firing techniques on the Microtensile Bond strength in lithium Disilicate bases Ceramics: A review study

Hamid Jalali [1], Zeinab Bahrani[2*]
1- Assistant Professor of Prosthodontics, Department of Prosthodontics, School of Dentistry, Tehran University of Medical Sciences
2- Postgraduate Student of Prosthodontics, department of Prosthodontics, School of Dentistry, Tehran University of Medical Sciences
* Correspondence author email: zeinabbahrani@yahoo.com

ABSTRACT
Patient demand for aesthetic dentistry is steadily growing. Differences in core and veneer coefficients of thermal expansion, firing shrinkage, and speed of increasing and decreasing the temperature may generate stress in veneered all-ceramic restorations. This article presents a literature review on the resin bond to dental ceramics. A PubMed database search was conducted for reliability of multiple firing techniques on the microtensile bond strength in lithium disilicate bases ceramics. Available data suggest multiple firing cycles to achieve improved contour, color, and esthetics. In this paper we compared the accuracy and reliability of techniques on the microtensile bond strength in lithium disilicate bases ceramics. It is important to compare introduced methods for implant framework. New suggestions in prosthodontic introduced in this review. We hope this literature review cast light on hidden side of prosthodontics.
Key Words: *Multiple firing, Bond strength, Lithium disilicate, Ceramics*

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INTRODUCTION

The demand for tooth-colored restorations has grown considerably during the last decade. This phenomenon has been both a bane and a boon to the dental profession. Rush-to-market products, media-driven treatment plans, as well as dentists eager to please, have formed a disquieting triad with little regard for the risk/benefit calculus of dental rehabilitation. On the other hand, new materials wedded to precise techniques have emerged to blur the interface between biologic and artificial structures. For example, dentin is now understood as a biological composite of a collagen matrix, which is highly filled with nanometer-sized apatite crystals. Demineralizing the collagen fibrils and filling the voids with resin tags can result in a hybrid or a true biopolymer [5].

New all-ceramic systems are continually introduced because they are metal free restorations of a high aesthetic quality. However, the strength of the ceramic remains a problem for a restoration's longevity. To overcome this problem, most of these systems require the combination of two layers of ceramic material, such as a strong ceramic core and weak veneering porcelain with better optical properties [13]. For an all-ceramic system, the thermal compatibility between ceramic substrate and veneering porcelain is based on the same principle of thermal expansion/contraction mismatch. Now, in place of the metal at room temperature, the high-strength ceramic core is subjected to a tensile stress while the weak veneering porcelain is still subjected to compressive stress [12].

Therefore, dental ceramics do not only show a non-linear thermal dimensional behavior but they are not constant because of phase changes as a result of thermal history (i.e. number of firings) whereas this change in thermal dimensional behavior does not lead to compatibility problems for restorations systems, it may affect the thermal compatibility of the ceramic materials (i.e. ceramic core, veneering porcelain) used in all-ceramic systems [17]. So, obtain the best technique minimize subsequent abnormalities. In this paper we compared reliability of multiple firing techniques on the microtensile bond strength in lithium disilicate bases ceramics.

Ceramic Systems

Driven by a debatable need for metal-free restorations, the evolution of all-ceramic systems for dental restorations has been remarkable in last three decades. Processing techniques novel to dentistry have been developed, such as heat-pressing, slip-casting, and Computer Aided Design-Computer- Aided Machining (CAD-CAM). Concurrently, all-ceramic materials have been developed to match dental requirements, offering increasingly greater performance from a mechanical standpoint. As opposed to metal-ceramics, all-ceramics contain a significantly greater amount of crystalline phase, from about 35 to about 99 vol %. This higher level of crystalline is responsible for an improvement in mechanical properties through various mechanisms, such as crystalline reinforcement or stress induced transformation [1].

Heat Pressed Ceramic

The popularity of heat-pressed ceramics relies on the ability to use the lost-wax technique to produce dental ceramic restorations. Dental technicians are usually familiar with this technique, commonly used to cast dental alloys. In addition, the equipment needed to heat-press dental ceramics is relatively inexpensive. The first generation of heat-pressed dental ceramics contains leucite as reinforcing crystalline phase. The second generation is lithium disilicate-based. First generation heat-pressed ceramics contain between 35 and 45 vol % leucite as crystalline phase. Second generation heat-pressed ceramics contain about 65 vol % lithium disilicate as the main crystalline phase, with about 1% porosity [1]. Today, many framework structures for prosthetic restorations are fabricated in CAD/CAM procedures which mean that a major part in the working sequence is carried out by means of industrial machines. Recently heat pressed ceramics is introduced to the dentistry which are much more uses. According to their structure, they divided into 2 main groups, Leucite based and Lithium silicate based restorations [15].

Leucite based restorations

The leucite crystals in leucite reinforced glass ceramics (IPS Empress-Ivoclar Vivadent) compose 50% - 55% of the material, this material has a refractive index that is very close to feldspathic ceramics, in addition to that leucite reinforced ceramics have a faster rate of etching than base glass, this selective etching is the factor that provide tiny features for resin cements to enter creating strong micromechanical bond [7]. IPS ProCAD (Ivoclar Vivadent) is a leucite reinforced ceramic similar to IPS Empress although it has a finer particle size [3]. It was introduced in 1998 to be used with the CEREC inLab system (Sirona Dental Systems, Bensheim, Germany) and is available in different shades including bleached shade and an esthetic block line [16].

Lithium silicate based restorations

At a time when dentists and patients alike are seeking both esthetic and conservative smile makeover options, lithium disilicate glass ceramic is a unique material. Lithium disilicate glass-ceramics have been extensively studied. All studies seem to agree that the mechanisms leading to the crystallization of lithium disilicate in these systems are somewhat complex, due to the presence of nanosized crystal phases [4]. High temperature X-ray diffraction studies revealed that lithium metasilicate (Li_2SiO_3) and cristobalite (SiO_2) form during the crystallization process, prior to the growth of lithium disilicate ($Li_2Si_2O_5$) crystals [1].

With high strength, natural optical properties, and the ability to be pressed thin, lithium disilicate has the potential to provide new options for minimal-preparation veneers. Lithium disilicate is an esthetic, high-strength material that can be conventionally cemented or adhesively bonded. It also can offer a full-contour restoration fabricated from one high-strength ceramic, as well as be used in all areas of the mouth when specific criteria are met. Laboratory ceramists find that the versatility and performance of lithium disilicate enable the optimization of their productivity when fabricating restorations using this material, since lost-wax pressing or CAD/ CAM milling fabrication techniques can be used. Lithium disilicate is among the best known glass ceramics. Glass ceramics are categorized based on their chemical composition or application. IPS e.max lithium disilicate is composed of quartz, lithium dioxide, phosphor oxide, alumina, potassium oxide, and other components. This composition produces a highly thermal, shock-resistant glass ceramic as a result of the low thermal expansion that occurs when it is processed. This type of resistant glass ceramic can be processed with either lost-wax hot pressing techniques or modern CAD/CAD milling procedures [14].

The pressable form of lithium disilicate (IPS e.max Press) is produced using a unique bulk casting production process to create the ingots. This involves a continuous manufacturing process based on glass technology (melting, cooling, simultaneous nucleation of two different crystals, and growth of crystals) that is constantly optimized to prevent defects (e.g., pores, pigments). The microstructure of the pressable lithium disilicate material consists of approximately 70% needle-like lithium disilicate crystals that are embedded in a glassy matrix. These crystals measure approximately 3 um to 6 um in length. Polyvalent ions that are dissolved in the glass are utilized to provide the desired color to the lithium disilicate material. These color-releasing ions are homogenously distributed in the single-phase material, thereby eliminating color pigment imperfections in the microstructure [9].

Why Multiple Firings?

Some properties of ceramic materials such as color stability, biocompatibility and durable aesthetics made them the best choice for conservative restorations. However, there are many limitations for ceramic restorations; i.e. brittleness, more laboratory-handling procedures and their hardness that may subject opposite teeth to abrasion [12].

To achieve improved contour, color, and esthetics, multiple firing procedures are necessary for the fabrication of all-ceramic restorations, especially when using the standard layering technique to match the esthetics of the natural dentition [11]. The primary reason might be the thermal incompatibility between ceramic core and veneering porcelains, which can introduce residual thermal stresses resulting in fracture or cracking of the restoration. In the event of moderate residual thermal stresses, a ceramic structure can be permanently distorted. Most ceramics are brittle materials and approximately 0.1% deformation may result in fracture [6] due to the propagation of cracks, usually present on the surface, through the bulk of the material. This deformation limit has to be taken into consideration when a ceramic core and veneering porcelain materials are designed to be bonded together. Of course, layered all-ceramic systems are developed by their manufacturers to be compatible in order to prevent thermal residual stresses. However, incompatibility in commercially available systems sometimes arises. In addition to that, dental technicians tend, for economic reasons, to veneer a ceramic core with porcelains leftover from other all-ceramic systems. From the literature review it is known that some factors such as the magnitude of temperature change and differences in material properties, including the coefficient of thermal expansion (a), the glass transition temperature (Tg), and the viscosity (h), might affect thermal stress in layered ceramic structures [8, 19].

For the production of high-strength ceramic core material (150–650 MPa), lithium disilicate, high content leucite, aluminium oxide, or zirconium oxide crystals are used to produce a core by a variety of techniques, e.g. lost wax, slip-cast, or CAD/CAM. The procedure for the manufacturing of an allceramic crown restoration exposes the substrate and the veneering porcelains often to more than five firing cycles where the oven temperature rises from a starting temperature of 400 °C up to the required sintering temperature, which is several hundred degrees above the glass transition temperature (Tg) of the porcelain. At the end of each firing cycle, the restoration is rapidly air-cooled to room temperature at rates of approximately 600 °C/min. During the heating and cooling cycles, the different thermal behavior of the materials used could introduce stress in the restoration. This stress can be transient and/or residual. The former, if high enough, can cause immediate cracking of the porcelain, while residual stresses might affect the restoration's longevity. When additional stresses are applied to the restoration, the probability of fracture failure due to crack propagation might increase [5].

Because of the differences in thermal behavior of the materials, heating and cooling cycles could produce stress in layered restorations. Generated stress may have two statuses, passing and/or remaining. If the passing stress has sufficient value, the porcelain will crack instantaneously, while remaining stresses will reduce the restoration lifetime. Application of more loads to these restorations may cause them to be fractured. Thus, the clinical survival of a metal-ceramic or an all-ceramic restoration is dependent on the thermal characteristics of the used substances displayed via thermal expansion/contraction coefficient. The thermal mismatch of core and layering ceramic in allceramic systems follows the same concept used in metalceramic systems. In a perfect all-ceramic restoration, the differences between thermal contraction coefficients of layering ceramic and core material should not be notable. The thermal manner of core and layering ceramic in metalceramic restorations is simpler than that in all-ceramic restorations. Porcelains in metal-ceramic systems, which are composed of Lucite crystals embedded in a glassy matrix, display a variation in thermal dimension after firing cycles. This is because a modification in Lucite crystal amounts to a decoupling of Lucite from the glassy matrix throughout the cooling procedure and then recoupling to the glassy matrix through firing. In other words, dental ceramics display a nonlinear thermal dimensional manner, and as a result of a modification in phases after heat treatment, their structure modifies. Although this variation in thermal dimension does not lead to a problem in metal-ceramic restorations, it may have an effect on the thermal mismatch of core and veneer substances in all-ceramic restorations. To achieve improved contour, color, and esthetics, multiple firing procedures are necessary [20]. In a study Trindade et al., [18] on effect of multiple firings on microtensile bond strength reported specimens submitted to a single firing cycle presented the lowest bond strength values (14.1 MPa), two firing cycles provided intermediate bond strength values (15 MPa) and the other groups presented equivalently high values (18.1-18.4 MPa). The Weibull modulus did not change between the groups. They reported more than three firing cycles of veneer ceramic provided higher bond strengths between zirconia and the veneering ceramic.

The thermal behavior of ceramic core materials and veneering porcelains of all-ceramic systems is more complex. Studies have demonstrated that porcelains designed to be bonded to a metal, that are composed of leucite crystals embedded in a glass matrix, showed a change in thermal dimensional behavior with each heat treatment, while that of metal remained constant [2]. The change in thermal dimensional behavior observed in the porcelains is explained by a change in leucite content [10] as well as a decoupling of leucite from the glass matrix during the cooling process and their re-coupling to the glass matrix with repeated firings. Therefore, dental ceramics do not only show a non-linear thermal dimensional behavior but they are not constant because of phase changes as a result of thermal history. Change in thermal dimensional behavior may affect the thermal compatibility of the ceramic materials (i.e. ceramic core, veneering porcelain) used in all-ceramic systems [5].

CONCLUSION

Researches confirm the relation between firing techniques and ceramic strength. Lithium disilicate can be fabricated by milling or pressing. While studies suggest that the pressed variety is slightly stronger, this material fabricated in a full contour form (monolithic) is extremely strong. The demand for tooth-colored restorations has grown considerably during the last decade. This phenomenon has been both a bane and a boon to the dental profession. This paper is heading of our recent research which based on that we want to introduce firing techniques and ceramic strength. So, we are trying to introduce new methods instead of old time consuming and costly methods which have been used in implant framework in dentistry. Because lithium disilicate is the most preferred material in dentistry and on the other hand no existing research on effects of multiple firing techniques on the microtensile bond strength, this paper is part of our incoming research which based on that we want to investigate effects of multiple firing techniques on the microtensile bond strength in lithium disilicate bases ceramics. So, using the literature review of current paper, we started or incoming research project which the results will publish in recent future.

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