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WAYS OF IMPROVING DENTAL STRUCTURES FROM METAL-FREE CERAMICS. LITERATURE REVIEW

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Abstract

Over the last 10 years, the use of zirconium dioxide ceramics as a framework material for the manufacture of microprostheses, single crowns and small bridges has increased. Their use in dental practice became possible with the help of CAD/CAM technologies. Clinical studies of ceramic restorations based on zirconium dioxide showed promising clinical results and high survival rates. However, chipping and fragility of ceramic masses layered on frameworks made of zirconium dioxide remains an actual and urgent problem of modern orthopedic dentistry.

In modern global dental practice, layer-by-layer veneering on refractory models, CAD/CAM technology, and hot pressing techniques are used to achieve such results.

In modern dentistry, the IRS e.max Press technologies occupy a rather significant place due to the simplicity and manufacturability of the process, but their use is restrained by the fear of orthopedists-dentists related to the fragility of metal-free structures and the complexity of clinical stages. Therefore, most often in case of destruction of the crown part of the tooth, metal hip inserts are used, the manufacturing technology of which continues to be improved.

That is why in modern orthopedic dentistry, the problem of improving the quality of restoration of the frontal group of teeth by improving and approving the technology of pressed

ceramics is urgent.

Key words: metal-free hip insert; IPS e.max Press ceramics; tooth restoration; dental practice

In modern orthopedic dentistry, no one doubts that the main direction of the development of science for the next 30-40 years will be the improvement of various technologies of prosthetics with metal-free ceramics [1]. One of the most important directions in dental research of the 21st century is the improvement of metal-free structures [2].

Dental ceramics consist of a porcelain mass containing leucite crystals and one or more in mixtures of porcelain mass that does not contain it. Leucite forms the refractive skeleton, and glass fills the gaps, adding the special qualities needed for dental ceramics.

Leucite crystals have long been necessary for the creation of dental porcelain [3]. This made it possible to create porcelain masses with a high coefficient of thermal expansion for compatibility with various alloys used in dentistry. Leucite was chosen to increase the coefficient of thermal expansion of porcelains with the aim that it, having a close coefficient of thermal expansion, would contribute to the convergence of the same coefficient in metals. The coefficient of thermal expansion of glass is usually 8 ppt/°C or less; the coefficient of expansion of dental alloys is on average 14 ppt/°C; the coefficient of expansion of leucite crystals is 22 - 25 ppm/°C. It follows that the combination of leucite and glass creates thermally compatible and durable porcelain.

Discoveries made in the field of glass materials made it possible to vary the content of leucite [27-30]. The choice of glass and variation of the leucite content affects the formation of certain physical characteristics.

Discoveries made in the field of glass materials made it possible to vary the content of leucite. The choice of glass and variation of the leucite content affects the formation of certain physical characteristics [4].

Some of the low-temperature ceramics for the repair of prostheses do not contain leucite at all. Low-temperature, leucite-free ceramics work well as correction materials and have lower abrasion. However, these leucite-free ceramics have their disadvantages. The most serious of them is deformation as a result of repeated firing. When they are used as part of an enamel coating, it is necessary to carry out repeated firings in different temperature regimes [5].

Feldspared porcelain is commonly used for veneering the zirconium dioxide framework in ceramic restorations.

Numerous in vitro studies of bond strength between layered porcelain and zirconium dioxide ceramics have been published over the past two decades [6]. For a long time, metal-ceramic systems remained the most optimal option for the prosthetics of dentition defects both on natural teeth and on abutments in the form of implants, they proved to be a reliable option for fixed orthopedic dentistry and remain the gold standard [7]. It is believed that in the manufacture of metal-ceramic fixed dentures, according to the International Organization for Standards (IOS), a bond strength of more than 25 MPa between ceramic and metal is required. However, when it comes to metal-free restorations, no such standards have been defined.

Several test studies, namely: the influence of transverse loading, studies on bending at 3-4 points, studying resistance to stretching and tests on microelastic connection - have been proposed to evaluate the strength of ceramic materials. In the scientific literature, there are studies that proved that the study of transverse loads is one of the most optimal and indicative tests that determine the reliability of ceramic alloys. On the other hand, a number of authors recommended the use of tensile tests or microelastic testing for these purposes in order to exclude the occurrence of microcracks and the initial processes of irreversible deformation of ceramics [8].

Transverse load tests have been criticized due to the non-homogeneous load distribution on the surface of the ceramic mass. The bending test has also been repeatedly criticized because the maximum strength loads occurred on the surface of the baked ceramic and led to the predicted strength failure. The strength test is also not an objective test due to difficulties with the geometry of the sample and the tendency to uneven distribution of the load on the surfaces [9]. In addition, the possibility of the presence of irregularities on the external surface of a dental nature (microprostheses, crowns, bridge-like structures) can lead to an incorrect distribution of loads with cohesive failure within the ceramic mass.

The destruction of samples after strength tests occurs more often in the ceramic base than on the surface of the ceramic sample. As materials and techniques for strengthening ceramic mass bonding have improved over the past decades, bond strength has become high enough to cause internal cracks deep in the ceramic mass. When the crack starts far from the surface of the ceramic sample, it means that the bond strength exceeds the bonding strength of the porcelain. Therefore, a thorough examination of the samples after the load tests is necessary for the correct interpretation of the data on the strength of ceramic masses.

Scherrer S. S. at a1. [10] recommended taking into account the above fact when calculating the strength of ceramic dental products. Thus, one should always rely in these studies on the microscopic assessment of the fractured surface. Scherrer S. S. at a1. [10]

recommended their approach to the assessment of fracture when studying the stability and strength of ceramics. Crack resistance (Kis), which is the material's resistance to crack propagation, or the stress energy release frequency (Gic) is an indicator that demonstrates the true ultimate resistance of the ceramic mass to fracture and chipping. Therefore, these tests are more useful for measuring the energy or work required to separate the bonding material to bond it to the ceramic, like luting cements.

Several studies have compared ceramic restorations and zirconium dioxide microprostheses in relation to the bond strength between the layered porcelain and the framework material, but the findings are conflicting [11]. Three papers verified that the resistance to transverse loads of a layered porcelain-to-zirconia-metal framework was the same or fairly close. In the study of Saito A. et al. the resistance to transverse loads of all-ceramic samples was dependent on the transverse strength of the layered porcelain. However, other studies have reported that bond strength in patients with all-cast zirconium dioxide frameworks was greater than in patients with metal-ceramic frameworks. The reason for these conflicting data may be differences in tested methods, research schemes, and properties of various materials used.

In order to achieve a strong bond, the coefficient of thermal expansion (CTE) of the framework material (zirconia ceramic) and the layered porcelain must be quite similar. In metal-ceramic systems, layered porcelain is recommended, with a slightly lower CTR than that of the frame material. The use of a frame material with a slightly higher KTR leads to a decrease in resistance to compressive loads in layered porcelain. In order to prevent chipping and cracking in layered porcelain, manufacturers have developed specific products that have a CTR slightly lower than or identical to that of zirconia ceramics.

The use of layered porcelain with a higher CTR than that of the zirconium dioxide frame leads to chipping of the veneer and the formation of many microcracks. A mismatch of KTR of approximately 2.0x10-6°C between the frameworks of zirconium dioxide and the layered material leads to spontaneous loosening of the layered porcelain after firing. However, the resistance to transverse loads at the border of the zirconium dioxide bond and the ceramic lining did not differ from the discrepancy of the KTR from 0.75 to 1.7x10-6°C.

A number of authors did not find any correlation between the resistance to transverse loading and the discrepancy between the KTR of zirconium dioxide and the layered porcelain. Although no ideal CTR has been established between zirconium dioxide frameworks and layered porcelain. Layered porcelain must have a lower CTR than zirconia frameworks to ensure adequate bonding.

The compression method used for ceramic layering allows you to create the desired tooth anatomy and reduces firing shrinkage that inevitably occurs with manual layering [12]. It should be noted that using the compression method, chipping of porcelain can be prevented due to a higher adhesion force with the facing layer and excellent quality of the transition zone between the two types of ceramics. A number of researchers have compared the compressive bond strength and delamination between the zirconium dioxide framework and the facing veneer. The authors suggest the use of sandblasting of the surface of zirconium dioxide - this reduces the chances of chipping and cracks in the thickness of the finished ceramic solid-cast structure.

The results of research by M. Ishibe et al are quite interesting. They proved that the strength of the bond between the layered porcelain and the zirconium dioxide is equivalent to the amount of pressing of the ceramic and the zirconium dioxide framework. However, excellent aesthetic results are more difficult to achieve with the pressing method, because the appearance depends on the shade of the ceramic blanks. To solve this problem, a double veneer method was proposed for single reconstructions and microprostheses. Thus, layered porcelain is superimposed on a pre-pressed veneer. The microelastic bond strength of zirconia and pressed ceramic double porcelain veneers was compared with zirconia veneers with pressed ceramic alone. The double facing method combines the high bond strength and excellent surface of pressed ceramic with the excellent aesthetics of layered porcelain.

Ceramic opac is often used to mask the white color of the zirconium dioxide framework and to improve the bond between the frameworks and the layered porcelain. There are several reports on the negative effects of opaque layers on the strength of ceramic structures. Also, they should not be used in combination with pressed ceramics, as this will reduce the strength of the connection of ceramic layers. However, in recent years there have been studies that have shown that the use of opaque layers has the opposite effect - they increase the strength of the bond between some layers of porcelain and zirconium dioxide frameworks.

Temperature changes when working with ceramics and the number of firing cycles did not affect the strength of bonds in ceramic layers in studies on the strength of adhesion between layered porcelain and zirconium dioxide ceramics. This stability correlates with earlier findings of authoritative scientists.

Zirconium dioxide has a lower thermal conductivity than other framework materials used to make microprostheses and crowns. Excessive quenching loads lead to the appearance of microcracks inside the layered porcelain, caused by an increase in temperature during the cooling process. In metal-ceramic structures, the degree of residual stress on the surface of the connection between the layered porcelain and metal frameworks depends on the thermal treatment of the ceramics. Therefore, the bond strength between the layered porcelain and the metal frameworks could be stronger if a controlled cooling rate was used after the firing procedures.

In the works of Gostemeyer G. et al. and Komine F. et al. in vitro studies determined the influence of different cooling rates (fast and slow) on the strength of the bond between layered porcelain and zirconium dioxide ceramics. Gostemeyer G. et al. showed that the bond strength after slow cooling (5 minute cooling inside the furnace) was lower than after rapid cooling (immediate removal from the furnace). However, the study of Komine F. et al. showed that bond strength was greater after slow cooling (4 min cooling outside the oven) than after rapid cooling (immediate removal from the oven). These conflicting findings are likely a consequence of the different cooling and testing methods used in these studies.

As for the aesthetic result, zirconium dioxide ceramics have a significant disadvantage - they are white and matte. In order to solve this issue, it was recommended to use opaks or to increase the thickness of the cladding. Underpainting of frames made of zirconium dioxide was once offered by companies producing ceramic masses for a better color matching of structures. To tint the zirconia framework, special pigments can be added to the original zirconia ceramic, crushed zirconia can be dipped in dissolved coloring agents, or an opaque material can be applied to the powdered zirconia framework.

Aboushelib M. N. studied the effect of white and colored zirconium dioxide on the bond strength of various layered porcelains. The bond strength of white unpainted zirconia with facing materials was significant compared to painted zirconia.

The effect of different surface treatments (such as grinding, sandblasting, grinding and opaque application) on the bond strength varied between white and colored zirconia.

Based on the above, it follows that the problem of manufacturing structures from zirconium oxide that are subjected to increased transverse loads, such as hip tabs, inlay tabs, onlays, overlays, is a relevant topic for scientific research aimed at improving the quality of aesthetic microprosthetics. Ways to solve the problem, presented in the latest studies, summarized in this review, in the improvement of methods of final processing of zirconium oxide frames and / or refusal of layer-by-layer application of ceramic facing masses, final processing of the finished structure.

All-ceramic restorations (inlays, veneers, etc.) are currently one of the most common types of structures used in the practice of modern orthopedic dentistry. A necessary condition for achieving stable positive results in microprosthetics with ceramic inserts is a thorough and careful performance of all manipulations provided for by the technology, both at the clinical and laboratory stages, guided by the most important clinical aspects [13].

The mechanical strength of ceramics is a very important parameter that determines the durability of ceramic structures, although its absolute value should be considered only in combination with other factors. The results of in vitro studies do not allow us to give an accurate assessment of the durability of structures made of one or another material in the oral cavity. For two-component systems, such as a frame and facing materials, the structure of the frame is of great importance. This factor must be taken into account when assessing in vivo strength. Another factor is the ratio of the size of the frame and the layer of facing materials.

Each of the components performs its function: the frame provides the necessary stability and strength of the restoration, and the facing layer of ceramics serves to achieve a highly aesthetic result. Today, various two-component systems are used in dentistry: metal/facing ceramic, zirconium dioxide-based ceramic/facing ceramic, and lithium disilicate glass-ceramic/facing ceramic. If it is necessary to increase the strength of the structure, then it is necessary to increase the thickness of the frame.

At the same time, the amount of free space that can be used for applying facing materials decreases. Until recently, when making restorations with increased aesthetic requirements, they tried to minimize the thickness of the frame and modeled them in the form of a thin-walled mouthpiece. The frame of this shape does not provide the necessary support for the facing materials between the bumps and pits, which significantly increases the risk of the ceramics shaking. The use of modern high-strength materials makes it possible to manufacture reliable frameworks of optimal anatomical shape without deteriorating the aesthetic characteristics of restorations.

The anatomical structure of the frame with the support of bumps and dimples (hybrid form) increases the strength characteristics of the structures. Since the refractive index of light also increases when the frame thickness increases, crowns with a thick frame appear lighter.

In the area of molars, as a rule, the main attention is paid to the strength of restorations, therefore it is recommended to make uncoated glass-ceramic crowns based on lithium disilicate.

The in vitro strength of the original material is an important parameter, but it does not allow us to draw an unequivocal conclusion about the durability of restorations in vivo. The structure of the frame is of great and sometimes decisive importance.

Properties of lithium disilicate-based glass-ceramics make it possible to make longlasting and aesthetic restorations, including in difficult cases, for example, in the presence of functional disorders.

The clinical use of ceramic hip inserts has undergone a long clinical study [14]. To date, the clinical use of hip inserts made of ceramics corresponds to the clinical protocol outlined below.

When choosing a clinical case, it is necessary to remember such contraindications as the presence of parafunctions in the patient (bruxism, bruxomania), the small height of the clinical crown (in cases with vital teeth), the location of the borders of the preparation below the level of the gingival margin. Some of them may be classified as relative upon special training.

It should also be noted that one of the main factors is the presence of preserved external enamel borders at the walls of the cavity, which, if other conditions are met, will allow reliable sealing of the borders of the preparation.

When preparing, the walls of the cavity should be even and have a clear, upper border. The taper of the divergence of the opposing walls should be up to 10°. The transitions from the walls to the bottom of the cavity, as well as between the walls, should be rounded to avoid stressful effects on the restoration and the fixing cement. You should try to form the bottom of the cavity flat.

In cavities of the MOD (medial-occlusal-distal) type, the isthmus between the proximal cavities should have a minimum width of 2 mm. The proximal and occlusal edges of the walls should end flat, without any bevels, the minimum depth of the formed cavity should be 1.5 mm in the area of fissures and 2 mm in the area of humps.

After obtaining a preliminary impression of the cavity, it is necessary to assess the adequacy of the thickness of the preserved tooth walls with a test load, necessarily taking into account the occlusal relationship with the antagonistic teeth.

Dentin sealing with adhesive systems can be carried out using 3 methods: one-, two- and three-stage, depending on the adhesive system used.

Despite the convenience of working with simplified adhesive systems (one- and two-stage), it is necessary to note their shortcomings. Many authors point to the imperfection of one-step adhesive systems, which consists in the fact that they are unable to resist the migration of fluid from the dental pulp, which is manifested by the "water tree" phenomenon, and, therefore, there is a decrease in the strength of fixation to dentin, and it also does not allow to achieve optimal polymerization of the composite. Another disadvantage is the incompatibility with composites of chemical and double hardening types. In the presence of sclerotized dentin, self-etching adhesives are unable to effectively etch the hypermineralized layer of dentin. Therefore, many clinicians prefer to use 3-stage systems.

For the manufacture of ceramic inlays and overlays, a one-stage single-layer or one-stage two-layer impression should be obtained [15-17]. The use of the two-stage technique is a gross and unacceptable mistake.

If one of the walls is located close to the gingival margin, then it is necessary to carry out retraction of the gingiva for a clear marking in the impression and, therefore, on the model of the border of the preparation and subsequent production of a high-quality construction.

When ceramic inserts arrive from the laboratory to the clinic, their performance should be evaluated in detail while still on the working model. First of all, the quality of the marginal fit of the tab to the cavity zones is evaluated. Tight marginal fit is extremely important and mandatory on all surfaces, both approximal, occlusal, and lingual.

It is not recommended to adjust the occlusal surface to permanent fixation, as due to the fragility of the inlay material, the edges can be split or damaged when the teeth are closed.

The stage of cementation is an important procedure that depends on both the long-term use of the restoration and the condition of the restored tooth. Not only the accuracy of the cementing technique, but also the choice of composite cement and adhesive system for fixation is of significant importance. Composite cements of both chemical and double hardening are used for ceramic inserts.

Naturally, fixation on a double-hardening composite cement is more convenient, however, when choosing a cement, it is necessary to take into account the specifics of working with the adhesive system added to the cement. When fixing ceramic inserts among double-hardening cements, the choice of material with a two-component primer of chemical hardening is shown.

Conclusions. All of the above indicates that the use of all-ceramic inserts is an effective and reliable method of restoring the lost anatomical shape of the crown part of the teeth.

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