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Review Article

Advantages and limitations of monolithic zirconia restorations

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ABSTRACT

Due to their biocompatible nature and advantageous mechanical characteristics, zirconia treatments have been utilized effectively in by dentists for many decades. A zirconia core is typically veneered with porcelain as they are not translucent, which renders treatments poorer since the bonding between the two substances fails. All-ceramic zirconia treatments have recently been made available in the dentistry market in an effort to address this issue. In addition to the absence of chipping, monolithic zirconia (MZ) fillings appear to have the benefit of requiring less occlusal room. To advocate this comparatively recent approach for restorative therapy, however, requires scientific proof. MZ could be the optimum material for rear fixed partial prostheses in the case of powerful occlusal pressures and little occlusal restorative room, according to the findings of in vitro investigations. To come to a clear consensus, the findings should be validated by many more *in vivo* and especially in vitro investigations.

Keywords: MZ, Zirconia, Advantages, Limitations

INTRODUCTION

Monolithic zirconia (MZ) restorations which are only made using CAD/CAM method, have many benefits, including large flexural strength, need for more conservative tooth preparation, minimal wearing of the antagonists, favorable appearance, less need for laboratory work and lesser appointments, and no risk of chipping because they are monolithic.[1-3] Before recent times, their primary drawback was their poor aesthetic quality as a result of their failure to obtain sufficient transparency.[2,4] MZ ceramics, on the other hand, are more translucent thanks to novel changes in constitution, form, and production techniques, although they are substantially less strong now.[5-8] Furthermore, as MZ is essentially a novel substance, little is known about its characteristics, constraints of application, long-term cosmetic effectiveness, susceptibility to low-temperature deterioration, and, importantly, clinical longevity. Individuals with an unsatisfactory occlusion, parafunctional behavior, a record of fracture, and situations in which there is insufficient room for restorative materials are all proposed considerations for the usage of MZ.[1,6,9] Although in vitro research shows that MZ restorations function better in terms of mechanical strength, academic studies are still necessary to substantiate these ideas.[10,11]

LITERATURE SEARCH

This study is based on a comprehensive literature search conducted on December 14, 2022, in the Medline and Cochrane databases, utilizing the medical topic headings (MeSH) and a combination of all available related terms, according to the database. To prevent missing any possible research, a manual search for publications was conducted through Google Scholar, using the reference lists of the previously listed papers as a starting point. We looked for valuable information in papers that discussed the information about advantages and limitations of MZ restorations. There were no restrictions on date, language, participant age, or type of publication.

DISCUSSION

The material structure and chemistry are the main distinctions between MZ and traditionally veneered zirconia. The quantity of sintering compounds in the microstructure is generally what determines the optical characteristics of zirconia.[11] Light dispersion increases as a consequence of distinct physical processes produced by sintering agents, frequently metal oxides, which modify zirconia's refractive indices.[12] When light scattering is strong, a material becomes opaque because the incident light rays are greatly scattered. The zirconia addition that is most usually employed, aluminum oxide, hinders the formation of the zirconia crystallites while sintering.[13] The rise in zirconia's resistivity to the phenomena of low temperature deterioration (LTD) is also connected to the inclusion of alumina in the constitution.[14] Contrary to ordinary zirconia, which typically includes 0.43 mass% of alumina, MZ has alumina dispersed more evenly throughout the structure (0.1 mass%), which makes it more translucent.[15] Other elements including grain size, greater concentration, and less contaminants, defects, and porosities may further make the polycrystalline ceramic materials more translucent.[11,16-18] Zirconia ceramics processed with CAD-CAM often produce ultimate reconstructions that have a greater density and very low rates of defects, faults, and permeability. Manufacturing companies still face difficulties in regulating crystalline particle size, albeit.[19] Increasing the dimension of the crystalline grain inside the structure is a widely used method to make polycrystalline alumina ceramics more translucent.[20] Greater particle size in ceramics results in fewer granular boundaries and, hence, reduced light dispersion through the medium. However, zirconia could not use such a method because the coarser grains present in this ceramic significantly reduce the stability of the tetragonal structure and the physical characteristics of the material, which in turn raises the occurrence of the LTD phenomena.[21] Decreasing the dimensions of the crystalline grains has been suggested more lately in an attempt to make zirconia more translucent.[5] This method's fundamental concept is that the crystalline grain should be shrunk to a size where the effect of the birefringence phenomena can be decreased, producing lesser opacity.[22] Zirconia contains a significant proportion of tetragonal crystalline phase (>90%), which causes birefringence. Tetragonal crystals actually have various refractive indices depending on where in the structure they are oriented spatially. As a result, whenever light passes across zirconia, it experiences substantial anisotropic dispersion. According to earlier research, shrinking the crystal dimension can significantly reduce the birefringence in anisotropes, making the substance more translucent in the process.[5,22] However, there isn't an optimal mathematical model available yet to investigate how grain dimension decrease in size can affect the birefringence of MZ's tetragonal structures. Yet, it is predicted that zirconia crystalline particle dimension ought to possess an average diameter of approximately 120 nm to achieve translucency results comparable to those of feldspar.[22] With standard sintering furnaces, it is presently not conceivable to make zirconia ceramic blocks with such a particle diameter. However, it could be said that the MZ's translucent nature would greatly enhance with a decrease in the dimension of the particles and a decrease in the number of sintering agents in the formulation.[23,24] The color metrics of the provided material must be calculated according to the reflection of rays by the sample when it is put on various backdrops in an effort to determine the contrast between the two surroundings. Whenever a substance has great opacity, the variation will be barely noticeable, suggesting that it will cover dark substrates well. On the contrary, a substance is thought to be more translucent if it exhibits a significant color change if set against various backdrops. As a result, MZ typically has greater translucency values than traditional zirconia.[24] Tetragonal and cubic zirconia particles are combined inside the same microstructure in contemporary MZ ceramics. Because of the significant quantity of cubic zirconia (>25%) in these materials' structure, they could not be called to as Y-TZP.[25,26] Because the substance incorporates areas with isotropic refraction index, monolithic reconstructions comprising cubic zirconia stage exhibit unquestionably greater translucency than ordinary zirconia. Since the refractive index is regardless of the crystallographic structure of the particles in cubic zirconia, lower light dispersion is actually expected.[26] As a result, the residual tetragonal particles' role in the substance's birefringence occurrence would be diminished. It is important to highlight that cubic zirconia particles would induce a marked decline in the physical behavior of translucent MZ compared to those of the traditional ones, while simultaneously increasing translucency.[27] Although the MZ's acquired optical characteristics may be adequate for a number of purposes, more advancements are still necessary to enhance the front area's appearance. Because of this, low-fusing glazing ceramics with colored oxides are still used to glaze MZ FDPs.[28]

One way to measure the mechanical characteristics of ceramics is to employ measures like flexural strength, fracture toughness, and toughness. Zirconia has been described to as "ceramic steel" since its flexural strength is considerably greater than those of several other ceramics.[29] In comparison to typical veneered zirconia, MZ exhibits better flexural strength but comparable fracture toughness,[4] provided that these values are taken under static loading circumstances without taking fatigue factors into account. In comparison to the hardness values of feldspathic ceramic (4.5 GPa) and dental enamel (3.2 GPa), the hardness value of 13.1 could be regarded as being disproportionately high across all physical properties. Superior mechanic qualities and hardness values have the ability to wear down the restorative material or the antagonistic tooth. This increases to a problem when MZ replacements eliminate veneering ceramic, putting zirconia in immediate communication with the opposing teeth.[30] New studies have shown that zirconia may be polished and finished to an exceptional degree to greatly lessen opponent wear.[31,32] However, since there are currently few clinical data, MZ FDP surfaces and their antagonists must be frequently checked to guarantee the superiority of the surface texture and any prospective erosion.[33-35]

MZ restorations are expected to enhance therapeutic efficacy.[36-38] Medical research has demonstrated that MZ exhibits higher strength and toughness values than zirconia frameworks with laminate veneering.[33,39] Additionally, it has been demonstrated to lead to higher aesthetic appeal and a decrease in the usage of metal in the mouth.[33,37] If contrasted to metal restorative materials based on high-nobel alloys, whole arch MZ restorations have demonstrated comparable survival rate.[40] With an eight-year follow-up, there have been no reports of mass breaks or structural breakdowns in the research.[38]

Various causes might cause the ceramic in ceramometal fillings to flake or break. These comprise microdefects, injury, incorrect designing, impact and fatigue stress, occlusal pressures, variations in thermal conductivities, and poor elastic modulus of the metals. Following framework breakdowns, substantial repair work is necessary.[41] This issue seems to be resolved by full MZ occlusal contouring.[33,38,42] Zirconia-based fillings on dentition and implants frequently experience breaking of the veneering ceramic, a problem that can occasionally not be resolved by ceramic's polish.[34,37,39,42,43] It is uncertain what causes veneer cracking in zirconia core fillings. Adhesion force, core-veneer substance matching, and veneering ceramic toughness are three aspects that typically have a big impact. Because to the processing processes used to make ceramic, that included repetitive sintering in the furnace, the veneering approach may also have an impact on the ceramic cracking.[43] With the expertise that zirconia as a structure is particularly prone to superficial modification and inappropriate laboratory and clinical handling methods, staff need to obey precise steps in the manufacture of zirconia-based fillings to prevent chipping cracks of veneered zirconia prostheses.[39] Unevenness of the veneering ceramics due to bruxism or occlusal activity has been linked to chip-off cracks of the veneering ceramic.[38,39] Examination of the fault's orientation of development revealed that the ceramic's irregularity at the occlusal area of the cusps was the root cause of the chip breakdown. Only fine-grained diamonds ought to be utilized for occlusal corrections, and a complete polishing process should ensue.[39] The MZ's use of electronic cut back avoids the superficial unevenness that leads to veneer fracture development and chips. Translucent nature has been regarded as one of the key determinants of how ceramics would look on the surface. In contrast to other ceramic materials, zirconia has historically considered for its opacity. According to a new analysis, zirconia exhibits certain amount of translucency and is less susceptible to width than porcelain without leucite and lithium disilicate. But when the width shrank, the zirconia ceramics became exponentially more translucent.[44] The restorations can have a certain amount of translucency due to the computer-generated cut back in the MZ. One issue with glass ceramics for MZ restorations is that structures are vulnerable to rupture when exposed to occlusal loads because these materials have poor flexural strength levels. Furthermore, a high amount of cracking has been seen when glass ceramics are used with zirconia structures. In the treatments we looked at, zirconia veneers produced great aesthetic, excellent mechanical qualities, and less problems. There have been reports of enamel wearing away faster than zirconia ceramic, with all of the ridges displaying cracks or even cracks. Clinically, wear can be influenced by factors such the abrasiveness of foods, eating behaviors, parafunctional behaviors, the firmness and depth of enamel, and biting action. Enamel loss is anticipated because of zirconia's 210 GPa elasticity modulus and 1200 Vickers Hardness. Additionally, studies have demonstrated that polished MZ outperforms veneered zirconia, glazed zirconia coated with a glaze sprays, monolithic base alloys, and glazed zirconia coated with glaze ceramic in terms of least amount of wearing on an enamel opponent.[45,46] To stop deterioration of the opponent teeth, meanwhile, it is advised to employ a sleep guard after delivering the definitive MZ restoration.

CONCLUSION

Currently, MZ is being investigated as an option because traditional veneered zirconia ceramics could not entirely avoid cracking of veneering ceramic. However, optimal translucency continues to be a problem, and changing the translucency of a substance might result in physical deterioration that is ought to be thoroughly investigated before their wider therapeutic applications. Zirconia should be polished subsequently to avoid this scenario. Because of its superior fracture toughness relative to its veneered equivalents and other MZ ceramics even at minimal depths, restricted occlusal crown room could be another situation in which MZ must be employed.

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