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The Use of Monolithic Zirconia Restorations for Patients with Bruxism

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ABSTRACT: Patients with bruxism develop wear of occlusal surfaces of teeth, which may require an extensive rehabilitation. The treatment planning criteria for patients with bruxism involve a wide range of materials and procedures.
Introduction of monolithic zirconia ceramics (second generation of zirconia) opened a wide range of full ceramic applications. In fact, monolithic zirconia has a better translucency and preserve adequate strength and toughness. Its lower Alumina content optimally distributed within the material helps maintaining aging stability.
Our goal is to give an overview of different properties of monolithic zirconia and its use to treat patients with bruxism.

KEY WORDS: *zirconia, monolithic zirconia restorations, bruxism, full ceramic*

I. INTRODUCTION

Sleep bruxism(SB) is defined as a masticatory-muscle activity during sleep that is characterized as rhythmic (phasic) or non-rhythmic (tonic) and is not a movement disorder or a sleep disorder in otherwise healthy individuals.
Awake bruxism (AB) is defined as a masticatory-muscle activity during wakefulness that is characterized by repetitive or sustained tooth contact and/or by bracing or thrusting of the mandible and is not a movement disorder in otherwise healthy people.[1]
In the study of Lobbezoo et al [1], several techniques are available for the diagnosis of bruxism. Both non-instrumental approaches (notably self-report) and instrumental approaches (notably electromyography, polysomnography) can be employed to assess bruxism which, in otherwise healthy individuals, is not considered as a disorder, but rather as a behavior that can be a risk (and/or protective) factor for certain oral health outcomes.
Clinical examination and self-reporting of different clinical signs as teeth grinding during the night or day, abnormal attrition wearing facets on teeth, transitory pain or fatigue on waking felt in the jaw muscles and temporal headaches on waking help to evaluate the presence of bruxism.[2]
Reported prevalence is 22-30% for awake bruxism and 1-15% for sleep bruxism. [3]

The rehabilitation of patient with bruxism require a restorative material with adequate wear-resistance properties and fracture strength. [4, 5]

A recent consensus report summarizes that minimal invasive treatment with composite build-ups should be the first option of treatment when necessary. [6]

However, technical complications are expected and for some patients, minimal invasive treatment will not be satisfactory. [7, 8, 9]

In patients with severe bruxism, extensive attrition and erosion often necessitate the esthetic and functional rehabilitation of a full dentition. [10]

For this reason, metal-ceramic restorations have been considered for many years "the golden standard" in fixed prosthodontics in heavy grinders [11] and for full-coverage restoration of severely compromised teeth. [12]

II. MONOLITHIC ZIRCONIA

Three mol% yttria-stabilized tetragonal zirconia polycrystal (3Y-TZP) was introduced in prosthodontics as an alternative to metal due to its high strength and biocompatibility combined with a white appearance. 3Y-TZP has original properties. It is in a metastable state at room temperature and can transform from a tetragonal to a monoclinic (t-m) crystalline form under the effect of stress. [2] The tensile stress acting on a crack tip initiates a phase transformation from the partially stabilized tetragonal modification of zirconia to a monoclinic phase. [13] This transformation exhibits a 4% volume expansion. This unique behavior leads to development of a transformation zone, shielding the propagating crack tip and inhibiting further crack propagation, successfully enhancing toughness. [14] This property gives zirconia high toughness in comparison with other ceramic materials.

It is also known that the metastable tetragonal phase transforms into the monoclinic phase in a humid atmosphere without mechanical stress, beginning at the surface and entering the bulk of the material. This causes micro-cracks and a decrease in the strength of the material. This process is often referred to as low-temperature degradation (LTD) or aging. [15] However, this transformation occurs in a very slow, progressive and spontaneous process when the material is in contact with water. [16]

First-generation zirconia is the original (3Y-TZP), which is used to produce frameworks for veneered restorations.

The second generation of zirconia was introduced in 2012 to 2013. The changes in material composition and microstructure allow fabrication of a high-translucent zirconia which enables esthetic improvement. The number and grain size of the aluminium oxide (Al_2O_3) grains were reduced in this process and the latter were relocated. The repositioning of the Al_2O_3 grains, whose refraction index varies greatly from that of the zirconia grains, takes place on the grain boundaries of zirconia.[17] This meant that a higher transmittance of light with consistently good long-term stability and high strength were simultaneously achieved. [18]Because of this optimization the zirconia grain size is relatively small, hence it can be expected a good translucency with good mechanical properties. [17]

Monolithic zirconia restorations have been introduced to avoid veneer-ceramic chipping and reduce fabrication costs by automatic designing and milling to a full-anatomical contour by CAD/CAM technology. [19] It also requires minimal tooth reduction because there is no need for space clearance for the veneering material. [20, 21]

When the zirconia core is veneered with dental porcelain (*i.e.* zirconia-based crowns), zirconia is not directly exposed to the oral environment or to saliva. Thus, the influence of LTD could be limited. However, monolithic zirconia crowns will be directly exposed to saliva. Therefore, it is reasonable to assume that LTD might occur. LTD in non-veneered zirconia restorations may cause severe clinical problems after several years of clinical service. [22]

Also, monolithic zirconia crowns will be directly and repeatedly loaded during mastication. This is known to affect the strength of all-ceramic crowns.[23, 21]

High-strength monolithic zirconia restorations have become the treatment of choice in patients with bruxism due to their resistance in high-load-bearing areas. [24]

A third generation zirconia (also a full-contour zirconia) was introduced because second generation was still inferior to translucency of glass ceramics. It is described as fully stabilized zirconia with a mixed cubic/ tetragonal structure. The cubic portions was achieved through higher endowment of yttrium oxide 5 mol%). [17]

III. Wear

While selecting a restorative material, the wear of natural dentition is an important factor, particularly in the presence of parafunctional habits [19].

Restorative materials should possess wear properties similar to those of natural teeth. [18]

Enamel wear caused by opposing ceramic restorations is a progressive phenomenon associated with physical, microstructural, chemical, and surface characteristics of dental ceramics. [25]

One concern associated with the use of monolithic zirconia fixed dental prosthesis is the possible abrasiveness of the material toward enamel.[26, 27] The abrasive potential of ceramic is dependent on fracture toughness, the presence of porosities, crystal size, and surface finish. [28]

Clinical data about the wear behavior of dental Y-TZP against natural enamel are available.

Amer et al [30] in their study,concluded that the degree of enamel wear associated with monolithic zirconia was similar to conventional feldspathic porcelain.

The results of the study of Mitov et al indicate a correlation between antagonist wear and the finishing procedures for zirconia ceramic, resulting in higher antagonist wear rates after grinding with coarse diamond burs. [29]

To reduce the long-term wear of opposing enamel, a smoothly polished ceramic surface rather than a glazed surface is recommended. [30]

In the study of Stober et al, statistical analysis revealed that monolithic zirconia crowns generated more wear of opposed enamel than did natural teeth, but concluded that, because of the greater wear caused by other dental ceramics, the use of monolithic zirconia crowns may be justified. [31]

Regarding complications, the extensive wear of zirconia or antagonists against zirconia has been described and discussed but might be neglectable when premising a properly polished zirconia surface [32, 33].

When monolithic zirconia is used, surfaces should be carefully polished if grinding adjustments are necessary, since rougher surfaces lead to increased wear of antagonist enamel. [29]

Although wear protocols vary widely, there seems to be a consensus on the fact that glazed zirconia is more abrasive than polished or as-sintered zirconia. [34, 35, 36]

IV. Fracture strength

It was demonstrated that monolithic zirconia crowns with a minimal occlusal thickness of 0.5 mm could withstand a bite force in the molar region because of the high fracture resistance. [20]

According to the ISO 6872:2008 all tested monolithic zirconia materials (second generation) can be used for 3-unit fixed partial dentures (ISO minimum value: 500 MPa). [18]

Monolithic zirconia crowns may be affected by cyclic loading with an increased number of cycles though the stress distributions under cyclic loading for bridges and crowns will be different. [20]

In their study, Nakamura et al [21] found that even though LTD increased the monoclinic phase, resulting in lower strength, the fracture resistance of the monolithic zirconia crowns was still sufficient to withstand the loading conditions in the molar regions. Thus, monolithic zirconia crown seems to have sufficient strength even when assuming LTD occurs.

In a study by Sun et al. [38], fracture strength of monolithic zirconia crown with a thickness of 1 mm was found equal to metal-ceramic crowns. It was also reported that strength of monolithic zirconia was higher than veneered zirconia, lithium disilicate and metal-ceramics. [37]

V. Optical properties/ translucency

The creation of acceptable esthetic result with monolithic zirconia restorations is challenging. [22]

The translucency of the monolithic zirconia restoration is also essential for optimized esthetic outcome.[22]

Harianawala et al, observed that the transmittance value of translucent zirconia was significantly lower than lithium disilicate.[38]
When compared polished and glazed monolithic zirconia with veneered zirconia, it was stated that polished zirconia showed higher light translucency.[39]
It was observed in a further study with regard to the change in layer thickness of monolithic Y-TZP ceramics (second generation) that an increase in layer thickness has negative effects on translucency.[40]
Udea et al measured the permeability of visible light (400 to 700 nm) through four different layers of a multilayer-color zirconia block. Light permeability was expressed as a percentage of the passing light. The multilayered colored zirconia blank showed different capacities for light permeability in the different layers. For this reason, it appeared reasonable to use this material to increase the esthetic appearance of fully anatomical zirconia. [41]
Application of coloring liquids, surface characterization, glazing and polishing of zirconia are the procedures to look like natural teeth.[42]
The increased number of coloring liquid application reduced the lightness and opalescence. [42]
The aesthetic properties of monolithic zirconia crowns other than translucency such as texture and opalescence need to be investigated. [19]

VI. DISCUSSION

In this paper interest is focused on the different properties of second-generation zirconia such as wear, fracture strength and translucency who allowed their use for the rehabilitations of patients with bruxism.
Zirconia can be clinically applied with a minimum thickness of 0,4 mm. [43]
For the patients with compromised occlusion or parafunction, monolithic zirconia crowns may be fabricated with as little as 0.5 mm of occlusal reduction. [44]
Monolithic zirconia fixed dental prosthesis (FDP) may be a reliable clinical solution, especially in molar areas with large occlusal forces. However, still exists some worries that need to be measured clinically, such as the long-term chemical stability or the clinical wear behavior. More investigations are required in the medium term and long term to allow for evidence-based decision making.[17]

In the short-term clinical study of Pahncke et al, the use of multi-unit FDPs fabricated from monolithic zirconia in the posterior region can be recommended. [45]
In a clinical study by Wang et al. [46], esthetic, wear and fracture were evaluated in 35 monolithic zirconia crowns in 30 patients after 24-month visit. No fracture was found, the esthetic was satisfactory but antagonist enamel wear was observed.
There is a lack of studies about clinical outcomes with zirconia monolithic prostheses used in patients presenting high occlusal stress, such as those with bruxism. However, manufacturers often recommend monolithic zirconia restorations for this indication. [2]
Patients with para-functions such as grinding are usually excluded from the study populations. [11]
Levartovsky et al concluded, within the limitations of their study, that the survival and success rate of monolithic zirconia restorations (Prettau, Zirkonzahn) installed in 10 patients with bruxism and a mean observation period of 28.2 (+/-16.8) months, was excellent. [10]
For monolithic zirconia crowns in the esthetic zone, Hansen et al showed in their study (with heavy grinders with severe tooth wear prior to restorative treatment) a low level of complications and a good acceptance by patients. They concluded that monolithic zirconia crowns may provide a valid treatment modality of severe tooth wear in the aesthetic zone where minimal invasive treatment fails. [11]
In their prospective study, Koenig et al found a good global survival rate of the second-generation zirconia restorations, despite a high number of patients (61.7%) showing clinical signs of bruxism. FPDs showed excellent short-term results but further research is needed for single-unit restorations considering that the sample size for crowns on natural teeth (n=13) was small. They also bring significant short-term data about 48 monolithic zirconia implant crowns.
On the other hand, the treatment success rate after two years (81.8%) was not as high as expected.
The weak link is the restoration support or the antagonist tooth, one hypothesis being that zirconia stiffness and lack of resilience do not promote occlusal stress damping.

Indeed, the presence of implant loss, minor chipping, root as restoration fractures of antagonistic teeth, must also be highlighted. Most complications (76.9%) occurred in patients with bruxism clinical signs. [2]

VII. CONCLUSION

Monolithic zirconia has become popular because of their high flexural strength, natural tooth color, less wear on the antagonists and minimum tooth preparation.[47, 48]

Further studies of larger series of monolithic zirconia restorations in patients with bruxism are warranted. Monolithic zirconia might, however, be an acceptable treatment choice for heavy grinders. The need to understand the mechanisms of long-term failure of zirconia is important as a crucial element in finding guidelines for bruxism treatment.

Therefore, clinicians should be careful about the indications and limitations when making decisions regarding monolithic zirconia.

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