In vitro cytotoxicity of all-ceramic substructural materials after aging

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Abstract  Background/purpose: Several all-ceramic materials have been developed to meet the most challenging requirements in restorative dentistry. However, only limited reports have focused on the issue of biocompatibility of all-cermics. The purpose of this study was to evaluate the effects of different types of all-ceramic substructural materials to determine their biological performance under experimental conditions.

Materials and methods: We tested six all-ceramic systems [glass-infiltrated alumina-reinforced ceramic (In-Ceram Alumina, Turkom Cera), glass-infiltrated zirconia-toughened alumina ceramic (In-Ceram Zirconia), low-fusing ceramic (Finesse), yttria-stabilized tetragonal zirconia ceramic (Zirkonzahn), and lithium disilicate glass ceramic (IPS e.max)] using a tetrazolium assay prior to and 3 days after aging, to determine their ability to alter cellular mitochondrial dehydrogenase activity. Mann–Whitney U test and Wilcoxon t test were used for statistical analysis (α = 0.05).

Results: According to the results of the 3-(4,5-dimethyl-thiazol-2-yl)-2,5-diphenyl tetrazolium bromide tests, the toxic effects of Finesse and Zirkonzahn were statistically insignificant (P > 0.05) compared with the negative control group. In contrast, In-Ceram Alumina, In-Ceram Zirconia, Turkom Cera, and IPS e.max demonstrated statistically significant toxic effects (P < 0.05) compared to the negative control group. When effects of aging on cytotoxic properties were evaluated, In-Ceram Zirconia and Turkom Cera showed increased cytotoxic effects on the 1st day following the aging process, whereas IPS e.max and Zirkonzahn displayed cytotoxic effects on the 2nd day and Day 7, respectively. The cytotoxic effect of Zirkonzahn and IPS e.max was decreased on the 1st day and at the 2nd week, respectively.

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Introduction

In recent years, dental ceramics have become increasingly important materials in tooth restoration. Since patients desire tooth-colored restorations, more types of all-ceramics have inevitably been developed as more modern solutions to meet restorative needs. Several all-ceramic materials and processing techniques have been introduced to meet the most challenging requirements in restorative dentistry.

The prolonged contact of all-ceramics with the gingiva and oral mucosa makes the biocompatibility of these materials crucial in respect to their long-term safety. However, only limited information is available concerning molecules associated with dental ceramics that might promote gingival and periodontal inflammation. Recent in vitro tests involving aging techniques have been applied to alloys and composites in order to estimate long-term biologic responses to these materials. However, only a few reports have focused on the issue of loss of mass and biocompatibility of ceramics.

The purpose of this study was to evaluate how different types of all-ceramic substructural materials vary with respect to their response to exposure to gingival fibroblasts, both initially and after aging over time. Our results may facilitate estimation of the biologic risks of all-ceramic materials, and should provide guidance for additional in vitro and biological testing required to determine their risk in clinical use. Our first research hypothesis was that all tested all-ceramic substructural materials would not show any evidence of cytotoxicity in the 3-(4,5-dimethyl-thiazol-2-yl-)-2,5-diphenyl tetrazolium bromide (MTT) test during different time intervals. The second hypothesis was that aging process would not affect the proliferation of cells exposed to six different all-ceramic substructural materials.

Materials and methods

We studied the cytotoxicity of all-ceramic substructures used to fabricate dental restorations over different time intervals using L 929 mouse skin fibroblasts and the MTT test. After an initial test, the specimens were aged 96 hours under sterile conditions and then tested again at different time intervals.

Sample preparation

Modern all-ceramic materials have sufficient physical properties to be used in clinical conditions, such as for posterior crowns and fixed partial dentures. The most commonly used systems can be classified according to laboratory processing procedure (pressable, slipcasting, milling, or sintering) and chemical composition (feldspar: high leucite and low leucite; glass ceramic: lithium disilicate and mica; and core reinforced: alumina, magnesia, and zirconia). Based on the sintering temperature, dental ceramics are traditionally classified as high-, medium-, low- and ultralow-fusing ceramics. In general, the high-fusing feldspathic ceramics are more corrosion resistant than ceramics with lower sintering temperatures. Although, high- and medium-fused ceramics exhibit better corrosion resistance than low- and ultralow-fused ceramics, they are reported to create more wear of the antagonist. Some low-fusing ceramics (Finesse, Dentsply International Inc., Ceramco, NJ, USA) (Fs) have demonstrated less wear on the enamel than conventional feldspathic ceramics. Different all-ceramic materials are selected for testing their cytotoxicity and are described as follows.

The IPS e.max glass ceramic (IPS e.max; Ivoclar Vivadent AG, Schaan, Liechtenstein) (Li-E) is composed primarily of a modified lithium disilicate glass ceramic that forms the primary components of IPS Empress 2 (Ivoclar Vivadent AG). In comparison with IPS Empress 2, Li-E material exhibits substantially improved physical properties and greater translucency, and hence can be used to form a core or an entire crown.

The mechanical properties of high-performance alumina- and zirconia-based ceramics make them attractive as potential materials for all-ceramic restorations in high stress-bearing areas. In-Ceram Alumina (Vita-Zahnfabrik, Bad Sackingen, Germany) (In-A) is an alumina-reinforced ceramic that has been used as a core material for crowns and anterior three-unit fixed partial dentures since the early 1990s. In-Ceram Zirconia (Vita-Zahnfabrik) (In-Z) system combines glass-infiltrated alumina with 35% partially stabilized zirconia for core materials, to provide a stronger and tougher core material than In-A. Similar to the In-A system, this ceramic uses a slip-casting technique to create the framework.

Turkom-Cera all-ceramic material (Turkom-Ceramic SDN-BHD, Kuala Lumpur, Malaysia) (Tur-C) is a ceramic system that incorporates a crystal-hardened or glass-infiltrated high alumina core. A new all-ceramic alumina-core material, Tur-C, is being introduced in an attempt to provide a high-quality, high-strength, cost-effective coping that will result in improved clinical success.

The Zirkonzahn (ICE Zirkon; Zirkonzahn GmbH, Bruneck, Italy) (Zz) is an yttria-stabilized tetragonal zirconia, and has been used for posterior and anterior fixed partial dentures with the introduction of computer-aided design/computer-aided manufacturing (CAD/CAM) technology.

Zz blank is a partially sintered material, and its use involves designing an enlarged framework and milling the framework from the partially sintered zirconia blank.