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Effects of ageing on surface textures of veneering ceramics for zirconia frameworks

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ABSTRACT

Objectives: To evaluate the effects of ageing on surface textures of veneering ceramics for zirconia frameworks.
Methods: Five different veneering ceramics for zirconia frameworks, Vintage ZR (ZR), Cerabien ZR (CZR), VitaVM9 (VM9), Cercon ceram KISS (KISS), and IPS e.max ceram (e.max), and one veneering ceramic with metal frameworks, Vintage MP (MP), were evaluated. Twenty specimens were fabricated from each veneering ceramic. All specimens were divided into two groups, one of which was subjected to accelerated ageing. The other was used as the control. Accelerated ageing was performed on the distilled water for 5 h at 200 °C and 2 atm. Surface textures were examined using laser profilometry, X-ray diffraction (XRD), scanning electron microscopy (SEM), and energy dispersive spectroscopy (EDS).
Results: Compared to unaged specimens, surface roughness parameters (Ra, Rp, Rv) of all aged specimens except e.max were significantly greater ($P = 0.000$). Compared to the unaged specimens, sodium and potassium on the surfaces of all the aged specimens significantly decreased ($P < 0.05$). However, oxygen levels increased significantly ($P < 0.05$). Silicon showed a tendency to decrease in all aged specimens, and that of ZR, KISS and e.max have a significant decrease ($P < 0.01$). Numerous ruffled cracks were observed on the surfaces of all aged specimens, as shown by SEM. The peaks of all crystalline phases on the surfaces of all specimens changed after accelerated ageing.
Conclusion: Surface textures of all examined veneering ceramics were changed by the accelerated ageing test.

1. Introduction

Numerous veneering ceramics matching the zirconia framework have appeared in the dental market with the comprehensive applications of zirconia-based restorations in prosthetic dentistry. Although low-temperature degradation of zirconia, the chipping of veneering ceramics, the design of framework and prosthesis fit have currently attracted extensive attention of the researchers, there have not been many studies concerning the ageing of these veneering ceramics.[1–8]

With both zirconia-based restorations and metal-based restorations, the materials directly exposed to the oral environment are primarily veneering ceramics. The oral environment tends to be very harsh because such factors as temperature changes, shifts in pH, wear, and mechanical load.

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The durability of veneering ceramics is especially important for maintaining the mechanical properties, aesthetics, and longevity of the restorations and for preventing abrasions to antagonist teeth.[9–15]

Water is the primary chemical species in the humid oral environment. It can make the glass dissolve by hydration, hydrolysis, and ion-exchange reactions, and result in the selective leaching of alkali ions in ceramics and changes in surface characteristics.[16–20] Some investigations have shown that a large number of inorganic elements can leach out from the different ceramics in an aqueous environment. The major leaching elements were found to be potassium and sodium. In addition, acid-corrosion experiments have shown that silicon, aluminium, yttrium, and calcium can leach.[21–26] It has also been frequently reported that the surface roughness of numerous dental ceramics can be changed by ageing and corrosion.[27–31] Cracks can be caused by the K^+/H^+ ionic exchange in the surfaces of the glass ceramics. These cracks then slowly grow.[6,17,32]

Traditional dental ceramics are mainly multiphased silicate glass phase ceramics, glass ceramics, monophased glasses containing various crystal phases, densely sintered alumina, and zirconia. They all exhibit some compositional and microstructural differences, depending on the type of ceramics. The chemical durability of ceramic materials is influenced by a variety of factors, such as the composition and microstructure of ceramic materials, the chemical character of the exposure medium, the exposure time, and the temperature.[13,31,33,34]

The composition and microstructure of newly launched veneering ceramics used with zirconia frameworks may differ from those of traditional ones, and this can affect the chemical durability. The reliability of these ceramics cannot be extrapolated from measurements of one ceramic formulation to another or one set of conditions to another. Therefore, the purpose of this study was to evaluate the effects of accelerated ageing on surface texture of veneering ceramics for zirconia frameworks. The null hypothesis is that there accelerated ageing does not create differences in the surface texture of veneering ceramics.

2. Materials and methods

Six types of commercial veneering ceramics in a dentine (body) colour were used in this study (Table 1). Five of these ceramics are used in zirconia-based systems. One (MP) was used in the PFM technique.

2.1. *Specimen preparation*

Twenty specimens of each type of veneering ceramic were fabricated. Ceramic powder and an appropriate amount of the indicated liquid were mixed in vacuum to form a slurry. The ratio of powder to liquid was selected according to traditional layering techniques used in dental laboratories. This was then poured into a rectangular silicon mould with internal dimensions of 12 mm × 12 mm × 3 mm. The mould was filled with the slurry and carefully condensed. Excess liquid was removed with a tissue. After vibration–condensation, these specimens were placed on the plane tray and fired according to the manufacturers' instructions. Firing was performed in a vacuum porcelain furnace (Twin Mat, Shofu, Kyoto, Japan). After firing, these specimens were machined to dimensions of 0.8 ± 0.2 mm in width and 1.2 ± 0.2 mm in thickness using 100-, 400-, and 800-diamond discs. They were finally polished with media containing 15–20 μm diamond grit. Twenty specimens were randomly divided into two groups for each type of veneering ceramic. The accelerated ageing test was performed on ten specimens (aged group), and the other ten specimens acted as controls (non-aged group).

2.2. *Accelerated ageing test*

Accelerated ageing testing was performed in an electric drying oven (DRA330DA, Advantec, Tokyo, Japan) and a decomposition container consisting of an inner Teflon vessel and an outer stainless steel vessel. Specimens were washed 3 times with ethyl alcohol, dried, and sealed into Teflon vessel. Inside this vessel, the specimens were supported by Teflon support screens and immersed in the distilled water. The specimens were treated at 200 °C and 2 atmospheric pressures for 5 h. To reduce the risk of microcrack formation, the temperature of the electric drying oven was slowly increased until the storage temperature of 200 °C was reached. Guideline ISO 13,356: 2008 is referenced in this study.[35]

2.3. *Surface roughness*

After accelerated ageing testing, the specimens were removed from the Teflon jars, cleaned ultrasonically in distilled water for 10 min, and dried in the air. The surface roughness of the unaged and aged specimens was evaluated by the laser profilometry, using a 3D laser microscope (LEXT OLS4000, Olympus, Tokyo, Japan). The diameter of the laser beam used was 0.2 μm, and the wavelength of the laser was 405 nm. The

Table 1 – Veneering ceramics used in the investigation.

Veneering ceramic	Code	Shade	Manufacturer	Composition[a]
Vintage ZR	ZR	A2	Shofu, Kyoto, Japan	Aluminosilicate glass, leucite, etc.
Cerabien ZR	CZR	A2	Noritake, Nagoya, Japan	Potassium aluminosilicate glass, leucite, etc.
Vita VM9	VM9	2M2	Vita, Zahnfabrik, Bad Säckingen, Germany	Feldspar, alumina, cerium oxide, leucite, etc.
Cercon ceram KISS	KISS	A2	DeguDent, Hanau, Germany	Silicon dioxide, alumina, etc.
IPS e.max ceram	e.max	A2	Ivoclar-Vivadent, Schaan, Liechtenstein	Nanofluorapatite, etc.
Vintage MP	MP	A2	Shofu, Kyoto, Japan	Aluminosilicate glass, leucite, etc.

[a] Composition as given by manufacturers.