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Research Paper

Clinical and laboratory surface finishing procedures for zirconia on opposing human enamel wear: A laboratory study

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ABSTRACT

Aim: To investigate the effect of laboratory and clinical finishing procedures for zirconia on antagonistic enamel wear.

Materials and methods: Forty-eight yttria-tetragonal partially stabilised zirconia (Y-TZP) specimens were prepared and divided into four groups according to their surface preparation: laboratory polished (LP); laboratory polished and glazed (G); clinically adjusted (CA); and clinically adjusted and repolished (CAR). Enamel opposing enamel was used as a control.

Pre-testing surface roughness for each group was determined using contact profilometry.

Two-body wear resistance tests were conducted using a masticatory simulator. Enamel specimens were subjected to 120,000 cycles in distilled water (frequency 1.6 Hz, loading force of 49 N). Volumetric and vertical enamel losses were measured by superimposition of pre- and post-testing images using a three-dimensional laser scanner and software analysis.

Scanning electron microscopy was used for qualitative surface analysis of pre- and post-testing zirconia and enamel surfaces.

One-way ANOVA and multiple comparisons with Bonferroni corrections were used for statistical analysis at a significance level of $\alpha=0.05$.

Results: There was no statistical difference in volumetric and vertical enamel loss between CAR, G and LP.

CAR produced statistically significantly less volumetric enamel loss compared with CA and control, and statistically significantly less vertical enamel loss compared with CA. Volumetric and vertical enamel loss were highly correlated in all groups.

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Conclusions: Enamel wear by clinically ground zirconia is comparable to that of opposing enamel surfaces and greater than clinically repolished zirconia. Repolishing of zirconia restorations following clinical adjustment with diamond burs is effective in reducing antagonistic enamel wear.

1. Introduction

All-ceramic restorations are becoming increasing popular due to the increasing cost of metals, in particular gold, their tooth-like appearance and the use of CAD–CAM. The use of monolithic zirconia is rapidly increasing due to its interesting mechanical properties and relatively low manufacturing cost. However, concerns have arisen that monolithic zirconia, due to its hardness, may cause excessive wear of opposing tooth structure. Zirconia has a Vickers hardness value of 1200 HV (Piconi and Maccauro, 1999) whereas enamel has a Vickers hardness values ranging from 316 to 332 HV (Chuenarrom et al., 2009; Lupi-Pegurier et al., 2003) and as a consequence, zirconia may have a significant detrimental effect on the opposing enamel surface.

Several factors influence the wear of enamel by opposing materials, such as hardness, fracture toughness, porosity, surface finish (e.g. glazed, unglazed, polished), presence of staining materials and frictional resistance of the opposing materials (Oh et al., 2002). Contrary to what may be expected due to its superior physical properties, some studies have shown zirconia to induce less wear on enamel compared with other dental ceramics (Jung et al., 2010; Preis et al., 2011; Rosentritt et al., 2012).

With the increasing use of monolithic zirconia restorations, it is important that the effects of zirconia on the opposing dentition are understood. Several laboratory studies have been recently published on the effect of different surface roughness of zirconia on opposing enamel wear (Amer et al., 2014; Burgess et al., 2014; Ghazal and Kern, 2009a, 2009b; Kim et al., 2012; Janyavula et al., 2013; Jung et al., 2010; Lawson et al., 2014; Mitov et al., 2012; Mörmann et al., 2013; Stawarczyk et al., 2013; Wang et al., 2012). However, some studies did not report on clinically relevant surfaces (Ghazal and Kern, 2009a, 2009b; Kim et al., 2012; Mörmann et al., 2013; Wang et al., 2012) or did not include an enamel control for comparative purposes (Ghazal and Kern, 2009a, 2009b; Jung et al., 2010; Kim et al., 2012; Mitov et al., 2012; Stawarczyk et al., 2013; Wang et al., 2012). Of those that reported on clinically relevant surfaces (Amer et al., 2014; Burgess et al., 2014; Janyavula et al., 2013; Jung et al., 2010; Lawson et al., 2014; Mitov et al., 2012; Preis et al., 2011; Rosentritt et al. 2012; Stawarczyk et al., 2013), none of them reported on all clinically relevant surfaces, namely, laboratory polished, laboratory polished and glazed, clinically adjusted, and clinically adjusted and repolished surfaces. Although all different simulated clinical surfaces were tested across these studies, it is difficult to compare results due to variations in methodology, such as specimen preparation (enamel and/or zirconia) and measurement of enamel wear. Therefore, a study that measures enamel wear opposing all clinically relevant zirconia surfaces and an enamel vs enamel control for comparative purposes is necessary.

The aim of this study was to investigate the effect of zirconia surface roughness produced by different clinical and laboratory adjustment and finishing procedures, including the use of rotary instruments designed for polishing zirconia, on human enamel wear. The first hypothesis was that zirconia regardless of surface preparation versus enamel would cause less wear to enamel than the control group. The second hypothesis was that clinical and laboratory procedures that increase surface roughness of zirconia specimens produce greater antagonistic enamel wear.

2. Materials and methods

2.1. *Enamel antagonists*

Sixty similarly shaped enamel cusps were cut from extracted human maxillary and mandibular premolars and molars using a diamond bur under copious water irrigation (study approved by Human Research Ethics Committee of Western Sydney Local Health District). All teeth were non-carious, free of cracks, exposed to the oral cavity and neither hypo- or hypermineralised, nor hypo- or hyperplastic. Lingual cusps of mandibular premolars, distobuccal cusps of mandibular molars and enamel cusps showing visible signs of tooth wear with use of magnification were excluded. Enamel cusps were stored in 4% formaldehyde solution at room temperature for four weeks until needed for specimen preparation and testing.

Enamel cusps were luted (Panavia-F 2.0 cement, Kuraray Medical Inc., Tokyo, Japan) to hexagonal metallic nuts, which were luted (Panavia-F 2.0 cement, Kuraray Medical Inc., Tokyo, Japan) to round anodised aluminium stubs (G040, ProSciTech, Kirwan, Australia). Enamel cusps were randomly allocated equally into five groups.

2.2. *Specimen preparation (zirconia)*

Forty-eight unsintered yttria-tetragonal partially stabilised zirconia (Y-TZP) specimens (Vita Zahnfabrik, H. Rauter GmbH & Co. KG, Bad Säckingen, Germany, Material No. EC4YZ205, Batch No. 22410) measuring $6 \times 6 \times 6$ mm (pre-cut by the manufacturer) were provided by the manufacturer.

A randomly selected surface was chosen for preparation. Specimens were prepared using commercial metallographic preparation systems (TechPrep8; Allied High Tech Products Inc., Rancho Dominguez, California, USA and TegraForce-5;