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Full-arch prostheses from translucent zirconia: Accuracy of fit

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ABSTRACT

Objectives. The aim of this study was to evaluate the marginal and internal fit of single crowns, compared to 14-unit frameworks made of translucent yttria-stabilized zirconia. We hypothesized that there is an influence of the type of restoration on the marginal and internal fit.

Methods. Eight teeth (FDI locations 17, 15, 13, 11, 21, 23, 25 and 27) of a typodont maxillary model were provided with a chamfer preparation to accommodate a 14-unit prosthesis or four single crowns (SCs). Ten 14-unit fixed dental prostheses (FDPs) and 40 single crowns were fabricated using a computer aided design (CAD)/computer aided manufacturing (CAM) system with pre-sintered translucent yttria-stabilized zirconia blanks. The restorations were cemented onto twenty master dies, which were sectioned into four pieces each. Then, the marginal and internal fits were examined using a binocular microscope. In order to detect the differences between the two types of restorations a non-parameteric test (Mann–Whitney-*U*) was carried out; to detect differences between the abutment teeth and the abutment surfaces non-parametric tests (Kruskal–Wallis) and pairwise post hoc analyses (Mann–Whitney-*U*) were performed after testing data for normal distribution (method according to Shapiro–Wilk). Level of significance was set at 5%.

Results. The mean (SD) marginal opening gap dimensions were 18 μm (14) for the single crowns and 29 μm (27) for the 14-unit FDPs ($p < 0.001$). Abutment 21 of the FDPs showed statistical differences concerning the location of the teeth in both marginal and internal fit ($p < 0.001$). The measured gaps (types I–IV) revealed statistical differences between all types, when comparing SCs to the FDPs ($p < 0.001$).

Significance. Single crowns showed significantly better accuracy of fit, compared to the 14-unit FDPs. However, both restorations showed clinically acceptable marginal and internal fit.

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1. Introduction

All-ceramic restorations are becoming increasingly popular because of their high esthetic potential and outstanding biocompatibility. Zirconia unites all of the positive characteristics of ceramics, although it has limited esthetics, due to its high opacity. Recent research by Stawarczyk et al. reveals that varying the sintering temperature can influence the translucency of yttria-stabilized zirconia. When using higher sintering temperatures, the material showed higher translucency, which led to better esthetic results. In a pre-sintered state, yttria-stabilized zirconia—which showed a flexural strength from 31 to 50 MPa—can be processed in a time-saving manner and with little wear on tools using most computer-aided design (CAD)/computer aided manufacturing (CAM) machines [1–7]. Predictable sinter shrinkage and avoiding sintering distortion are of paramount importance and depend on the uniform density of the blank.

Uniaxial, isostatic and biaxial molding procedures are commonly used to manufacture yttria-stabilized zirconia blanks [6]. The uniaxial pressed blanks showed high differences in density between the central and peripheral zones, which limits their application to single crowns and fixed dental prostheses (FDPs) of up to four units [8].

In the biaxial molding procedure, pressure is applied on the zirconia powder by an upper and lower rigid punch, which also rotate around their own axes [9]. The benefits of both biaxial pressing and isostatic pressing include minimum sintering distortion, achieving high flexural strength after sintering (over 1300 MPa), and better accuracy of fit [6,7]. The mechanical behavior of all-ceramic crowns, in terms of strength, resistance, and retention, is essentially influenced by the accuracy of a framework [10–12].

In clinical practice, the marginal and internal fit determines the durability of a restoration. There is a consensus between various authors that marginal openings below 120 μm are clinically acceptable [13–16]. Although gaps of less than 80 μm are difficult to detect in clinical practice, some authors postulate marginal gaps of 50–75 μm [17] and 70 μm (10) [18] as clinically acceptable limits. However, poor marginal adaptation of restorations increases plaque retention and changes the composition of the microflora, which can lead to the onset of periodontal disease [19,20]. Furthermore, the risk of secondary caries increases with the marginal gap width [21,22]. Concerning the influence of the internal fit on the durability of the restorations, cement layers above 70 μm tend to reduce the fracture strength significantly [23].

Due to the growing demand for long-span FDPs, more scientific studies concerning the fit of full arch restorations compared to single crowns are needed. Therefore, the aim of this study was to examine the marginal and internal fit of single crowns, compared to 14-unit frameworks made of yttria-stabilized zirconia (ICE Zirkon Translucent, Zirkonzahn S.r.l., Gais, Italy). The working hypothesis of this approach is that the type of restoration (single crowns or 14-unit FDPs) will show an influence on the internal and marginal fit.

2. Materials and methods

A maxillary typodont model (standard working model AG-3, Frasaco GmbH, Tettnang, Germany) with eight abutment teeth was used. Therefore, the maxillary central incisors, canines, second pre-molars and second molars were provided with a 360° 1.0 mm chamfer preparation. The occlusal and incisal reductions were 1.5–2.0 mm. Twenty polyether impressions (Impregum, 3 M ESPE, Seefeld, Germany) of the typodont model were made with metal impression trays (U3, Orbilock, Orbis Dental Handelsgesellschaft mbH, Münster, Germany). Subsequently, twenty models of a class IV special scan die stone (Rocky Mountain orange label, Klasse 4 Dental GmbH, Augsburg, Germany) were fabricated.

The models were digitized (Fig. 1) with a white light projector scanner (S 600, Zirkonzahn S.r.l.) showing details of less than 10 μm (unpublished data Zirkonzahn S.r.l.).

The single crowns and 14-unit zirconia FDPs were designed with a CAD software (Zirkonzahn.Modellier, Zirkonzahn S.r.l.): the full-contour design was reduced by 0.8 mm for the veneering porcelain, with a minimum thickness of 0.5 mm for the framework. For the 14-unit zirconia framework design, distances between the pontics and the gingiva of 0.1 mm and a connector with a round cross-section and a minimum area of 9 mm^2 were used. Further milling parameters for the crown foundation were the following: cement-gap thickness of 0.035 mm starting 0.3 mm of the preparation margin. At the transition from the axial wall to the occlusal surface 0.45 mm cement gap thickness were used while 0.4 mm were used for the occlusal surface. All parameters were chosen according to the manufacturer's recommendations [10]. The design was sent to CAM software (Zirkonzahn.Nesting, Zirkonzahn S.r.l.) to position it in a virtual zirconia blank. In this case, the software automatically shrank the volume of the sintering foot, to fit the 14-unit framework. The aim was to avoid deformation of the curved arch in the anterior during the following sintering process.

All restorations were milled with a 5 + 1 axes milling unit (M5, Zirkonzahn S.r.l.), using three different burr diameters

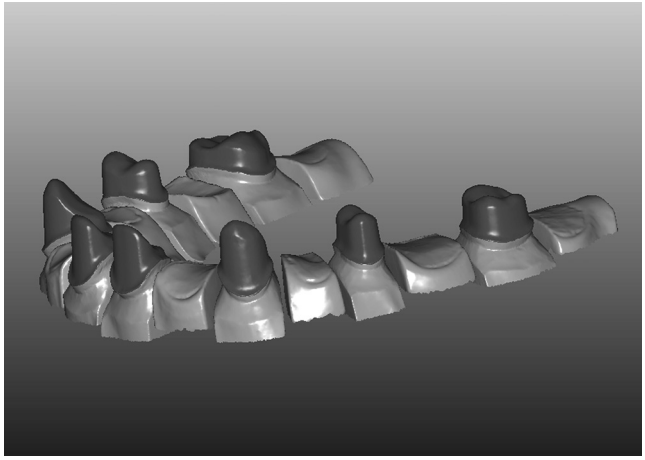

Fig. 1 – Screen-shot of the digitalization of a maxillary model with eight abutment teeth (FDI locations 17, 15, 13, 11, 21, 23, 25 and 27).