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Zirconia-based versus metal-based single crowns veneered with overpressing ceramic for restoration of posterior endodontically treated teeth: 5-year results of a randomized controlled clinical study

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ABSTRACT

Objectives: The aim of this 5-year randomized controlled trial was to compare the longevity and clinical behavior of single posterior crowns made with pressable ceramic on zirconia and on metal frameworks, and if failures occur, to delineate the contributing factors.

Methods: 72 patients, who needed the covering of at least a molar and/or premolar, were included in the study. All teeth were endodontically treated, with absence of periapical lesion or active periodontitis. Ninety single crowns were made with zirconia or metal framework and covered with pressable veneering ceramics. Two independent examiners assessed the survival of restorations at 6 months, 1–4 and 5 years after restoration placement including periapical radiographs, intraoral photographs, and USPHS modified criteria. The statistical analyses were performed with the Kaplan-Meier method.

Results: One core fracture occurred in Zircad/Zirpress crowns and one metal ceramic crown was lost for root fracture. Chipping fracture of the veneering ceramic was detected in 2 metal-ceramic crowns and in 3 zirconia-based crowns. The Estimate Cumulative Survival (ECS) and the Estimate Cumulative Success (ECSs) with standard deviation (SE) were respectively 97,73 ± 2,19 and 92,64 ± 4,14 for zirconia-based crowns whereas 97,44 ± 2,39 and 91,11 ± 4,27 for porcelain fused to metal crowns.

Conclusions: The present randomized controlled trial shows that the survival of zirconia-based and metal-based single crowns is similar over a follow-up period of 5 years. No significant differences in esthetic, functional and biological outcomes were demonstrated between the two groups. The main failure mode was the chipping fracture of the veneering ceramic in both materials. Study number on ClinicalTrial.gov NCT02758457.

Clinical significance: According to the results of this clinical study, zirconia-based rehabilitations with overpressing veneering technique represent a valid alternative to metal-based for posterior single crown restorations.

1. Introduction

Conventional metal ceramic restorations are recognized as a predictable solution and are still commonly used in prosthetic dentistry with good long-term clinical success [1].

However, the presence of gold or other metal alloys adversely affects the optical properties of the restoration, tends to cause a graying of the surrounding tissue, and may give rise to allergic or toxic reactions [2,3]. Moreover, realization of porcelain-fused-to-metal restoration needs a very careful approach, involves many steps, and is consequently more expensive. Moreover, the increased cost of the gold-based alloy has shifted the focus on the metal-free materials and on the CAD/CAM systems.

All-ceramic materials, such as densely sintered aluminum oxide ceramic (Procera AllCeram; NobelBiocare, USA) or lithium disilicate material (e-max CAD; Ivoclar Vivadent, Liechtenstein), have permitted an improved aesthetic appearance but have inadequate strength for especially for posterior application [4,5]. However, zirconia-based ceramic seems to satisfy both aesthetic [6] and mechanical needs [7].

In vitro studies of Yttria-Tetragonal Zirconia Polycristals (Y-TZP) samples have shown values of 900–1200 MPa for flexural strength and values of 9–10 MPa $m^{1/2}$ for fracture toughness [8], also the stiffness of the zirconia had a better effect on the marginal adaptation better than on the fiber-reinforced composite restorations [9]. However, due to the

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metastability of tetragonal zirconia, stress-generating surface treatments such as grinding or sandblasting are liable to trigger the tetragonal → monoclinic transformation with the associated volume increase, leading to the formation of surface compressive stresses [10]. This transformation toughness leads to an increase in flexural strength but can also alter the phase integrity of the material, increasing the susceptibility to aging through water absorption [11].

The strength of an all-ceramic restoration depends on the characteristics of the material used, thickness of the crown, design of the restoration, core-veneer bond strength, and cementation [12]. Several short-to-mid-term *in vivo* studies were conducted with zirconia restorations, proving great clinical performance. In most cases, the studies investigated zirconia fixed partial dentures (FPDs) in the posterior region [13,14], while single crowns have a small representation in published clinical trials [15].

A recent retrospective cohort study evaluated 1132 zirconia-based single crowns made with different finishing line preparations over a time period of up to 5 years. The cumulative survival rate of all restorations was 98.1%, while the cumulative success rate was 94.2%. Functional criteria showed the most failures, with only 1 fractured zirconia core, 13 delaminations, and 46 instances of chippings of the ceramic veneering. An association between parafunction and mechanical failure was found in patients with severe parafunction [16]. An interesting systematic review by Sailer et al. compared the survival of all-ceramic and metal-ceramic single crowns after a follow-up period of five years, describing the incidence of biological, technical, and esthetic complications. The survival rates of most types of all-ceramic single crowns were similar to those reported for metal-ceramic single crowns in both the anterior and posterior regions; however, the authors concluded that weaker feldspathic/silica-based ceramics should be limited to applications in the anterior region and the zirconia-based single crowns should not be considered as the primary option because of their high incidence of technical problems [17].

Moreover, no *in vivo* study has compared the clinical behavior of pressable veneering ceramics when used on metal and zirconia frameworks. Few *in vitro* studies showed that among different zirconia veneering porcelains, the highest microtensile strength was obtained with pressable veneering ceramics [18].

The objective of this study was to compare the 5-year survival and clinical behavior of single posterior ceramic crowns made with pressable ceramic on zirconia or on a metal framework. If failures occurred, the further aim of the study was to delineate the factors contributing to the failure. The null hypothesis stated that the survival of zirconia-based restorations would be no worse that those made with metal-based material.

2. Materials and methods

2.1. Patient selection and inclusion/exclusion criteria

A randomised controlled clinical trial was conducted using a parallel group design. The study protocol was submitted and approved by the University of Bologna internal review board; 12/12/2007 and registered on ClinicalTrial.gov (study number NCT02758457). The study was conducted according to the Declaration of Helsinki and was conformed to good clinical practice (GCP) guidelines. Each patient was provided with written information about the proposed treatment involved, principles of treatment, potential discomforts, risks of the procedures. Each patient signed a written informed consent form prior to clinical examination.

2.2. Recruitment

All patients needing covering of at least one molar and/or premolar with a fixed prosthesis single crown were recruited from the Division of Prosthodontics and Maxillo-Facial Rehabilitation of the Department of Biomedical and Neuromotor Sciences of the University of Bologna.

2.3. Clinical examination

Before entering the study each patient received an intra-oral examination carried out by two calibrated clinicians with an inter-examiner agreement that was previously determined to be > 80% (kappa score 0.87). All patients who met the inclusion criteria were invited to participate in the study and each patient received an identification number.

2.4. Inclusion and exclusion criteria

The inclusion criteria for entering in the study were: age raging from 18 to 70 years; minimum of 20 teeth; moderate to good oral hygiene with the ability to perform mechanical oral hygiene techniques including tooth brushing; low to moderate caries risk, and no active periodontal disease. Caries risk assessment was defined taking in consideration clinical indicators such as recently placed restorations, heavy dental plaque and evident tooth decay or white spots. A maximum of four single crowns were placed for each patient. Teeth had to fulfill the following requirements to be included in this study: endodontically treated teeth; absence of active periodontitis; absence of periapical lesions; occluso-gingival dimension of at least 3.0 mm from the interdental papilla to the marginal ridge of the abutment teeth; and ferrule effect of at least 1 mm. The exclusion criteria were: unacceptable oral hygiene practices; allergic reaction or hypersensitivity to ingredients of the adhesive or restorative material; strong parafunction (*e.g.*, bruxism with marked wear facets) with or pronounced malocclusion (*e.g.*, cross bite); inability to follow preparation guidelines for single crowns. The choice to include only endodontically treated teeth was made for two reasons. First, most of vital teeth don't need a complete coverage crown and the treatment of choice is an adhesive partial crown restoration. Second, the structural difference between vital and endodontically treated teeth may introduce bias regarding the functional and biological behavior of the tooth/restoration complex.

2.5. Randomization

The patients were randomly allocated using a computer generated random assignment (SPSS software version 21; IBM). Patients randomization was done by a researcher and the allocation was hidden from the clinical operators using sealed and sequentially numbered white envelopes.

2.6. Data collection

Each patient received a medical record with general information about age, gender, general health, medical history, dental history and oral hygiene practices. During the clinical examination all details on carious lesions, restorations and teeth present were recorded. Plaque index and papilla bleeding scores was were recorded with a graduated periodontal probe at six sites of all posterior teeth [19,20].

2.7. Restorative procedures

At the end of the recruitment 72 patients (39 women and 33 men), with an age ranging from 18 to 70 years, were selected for the study. Patients were treated according to their allocated treatment group by five clinicians experienced in fixed prosthodontics. Sample size of 45 crowns for each group was calculated for 80% power, $\alpha = 0.05$ and anticipated effect size = 0,60 using sample size software (G*Power version 3.00.10, Germany). Ninety posterior teeth were restored with 45 single crowns consisting of a metal framework (IPS d.SIGN 91; Ivoclar Vivadent) supplemented by a pressable veneering ceramic for noble alloy (PoM; Ivoclar Vivadent) and 45 single crowns with zirconia