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Original article

A 3-year follow-up of ceria-stabilized zirconia/alumina nanocomposite (Ce-TZP/A) frameworks for fixed dental prostheses

Shinpei Tanaka DDS, PhD[a], *Masayuki Takaba DDS, PhD*[a], *Yuichi Ishiura DDS, PhD*[b], *Emi Kamimura DDS*[a], *Kazuyoshi Baba DDS, PhD*[a,*]

[a] *Department of Prosthodontics, Showa University School of Dentistry, Tokyo, Japan*
[b] *Department of Implant Dentistry, Showa University School of Dentistry, Tokyo, Japan*

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ABSTRACT

Purpose: Zirconia/alumina nanocomposite stabilized with cerium oxide (Ce-TZP/A) shows significantly higher mechanical strength than yttrium-oxide-partially-stabilized zirconia (Y-TZP) and allows post-sintered machining that does not require any subsequent treatment. The aim of this prospective study was to assess the clinical performance of veneered Ce-TZP/A frameworks for fixed dental prostheses.

Methods: Fifteen patients with 22 Ce-TZP/A fixed prostheses were included in this study. The fixed dental prostheses were cemented with resin cement (baseline) and were evaluated at baseline and at 1, 6, 12, 24 and 36 months after cementation. Clinical events, including fracture and loss of retention, secondary caries, and marginal integrity, were recorded. The biologic outcome was judged by comparing the pre-treatment and post-treatment bleeding on probing (BOP), and probing pocket depth (PPD) of the abutment teeth. Radiographic examination was also performed at 12, 24 and 36 months.

Results: The mean observation period was 35.9 ± 5.5 months. During this period, one abutment tooth was extracted due to root fracture and the survival rate was 95.2%. No significant change in BOP, PPD, and radiographic image was found during the 36-month follow-up period.

Conclusion: Within the limitations of this study, Ce-TZP/A was found to provide sufficient stability as a framework material in all regions. Special attention, however, must be paid to designing framework that provides sufficient support for the veneer. Furthermore, studies with longer observation periods and more patients are needed.

* *Corresponding author at:* Department of Prosthodontics, Showa University School of Dentistry, 2-1-1 Kitasenzoku, Ota-ku, Tokyo 145-8515, Japan. Tel.: +81 3 3787 1151x234; fax: +81 3 3784 7603.
E-mail address: kazuyoshi@dent.showa-u.ac.jp (K. Baba).

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1. Introduction

Metal ceramic restorations are commonly used as fixed dental prostheses because of their clinically acceptable biological stability, esthetics, and mechanical properties [1]. However, they have disadvantages such as opaqueness and discoloration in the gingival margin area due to the metal framework. In addition, they may cause metal allergy in some patients [2].

For these reasons, the demand for metal-free prostheses with increased translucency that mimic the natural dentition has arisen and led to the development of several ceramics that are esthetically pleasing and biocompatible. Feldspathic ceramics meet the esthetic demands of patients but do not provide adequate structural integrity, especially for posterior teeth. With the development of crystalline ceramics, alumina and zirconia came into use for fixed dental prostheses.

Zirconia is a crystalline dioxide of zirconium. In particular, yttrium-oxide-partially-stabilized zirconia (Y-TZP) has mechanical properties very similar to those of metals and color similar to teeth. With the development of computer-aided design and computer-aided machining (CAD/CAM), Y-TZP has been widely applied to fixed dental prostheses. However, one of the disadvantages of Y-TZP is low-temperature aging degradation [3,4]. Exposure to moisture for an extended period of time, even at the low temperatures found in the mouth, can have a detrimental effect on the properties of zirconia. This leads to formation of cubic grains, which affect the structural integrity of the material [5]. Therefore, zirconia frameworks should be covered by ceramics to increase their resistance toward the conditions of the oral cavity, but framework designs that do not support veneered porcelain, might result in chipping or fracturing of veneers, which is the most frequently reported technical complication. From the viewpoint of structural integrity, design modifications of the framework such as a high lingual shoulder connected to a proximal elongated strut have been proposed [6–8]. However, such a design should not be applied to Y-TZP because of the risk of low-temperature aging degradation.

The accurate fit of a fixed dental prosthesis is considered mandatory for a restoration to achieve acceptable longevity. Minimal marginal gap results in less gingival irritation [9,10], cement dissolution, recurrent caries, and marginal discoloration [11,12]. An ideal internal fit has been shown to enhance the mechanical behavior of all-ceramic crowns in terms of strength, resistance, and retention [13]. Nowadays, owing to the ease of milling pre-sintered blanks together, along with its cost effectiveness, pre-sintered machining has become more popular and is utilized by a majority of the commercially available systems [14]. Pre-sintered machining is based on milling an oversized pre-sintered restoration to the required design and then sintering it at high temperature. However, the sintering procedure results in approximately 25% shrinkage that has to be compensated in the milling procedure, and it may degrade the degree of adaptation of the prostheses to the abutment [15], which can be responsible for the above-stated clinical problems.

Recently, a tough and strong material, Ce-TZP/A, has been developed [3]. This material has an interpenetrated intragranular nanostructure, in which either nanometer-sized Ce-TZP or Al_2O_3 particles are located within submicron-sized Al_2O_3 or Ce-TZP grains, respectively. Several studies reported that the Ce-TZP/A showed significantly higher mechanical strength than Y-TZP [16–21] and has complete resistance to low-temperature aging degradation in water-based conditions such as the oral environment [22]. In addition, the Ce-TZP/A allowed post-sintered machining which requires robust milling equipment. With this procedure, a high accuracy level can be achieved after milling a brittle material in thin section and no further treatment is required. In other words, this new system has potential to solve the clinical problems of Y-TZP, because it allows an optimal framework design with supporting form and precise fitting of the framework to the abutment teeth.

However, few clinical studies of fixed prostheses with Ce-TZP/A frameworks are available to validate these promising laboratory findings; Philipp et al. reported their advantages in 2009 [23]. The hypothesis is that fixed dental prostheses fabricated by Ce-TZP/A framework will have sufficient stability as a framework material. The aim of this case series was therefore to assess the clinical performance of veneered Ce-TZP/A frameworks used for fixed dental prostheses.

2. Materials and methods

2.1. *Subjects and setting*

Subjects were recruited at the Prosthodontics Department of Showa University. During the study period (data was collected in 1 month, February 2010), 15 consecutive patients who met the criteria described below were approached by the clinical staff. Inclusion criteria consisted of one missing mandibular or maxillary tooth, or extensive loss of tooth structure indicating full veneer crowns or crowns needing replacement, a healthy periodontium before the restorative treatment phase, and abutment teeth with probing pocket depths (PPDs) of 4 mm or less. Patients were excluded from being enrolled in the study if they reported pain in the orofacial region, presented with acute oral disease, bruxism or high caries activity. The majority of eligible individuals who met the criteria agreed to participate and provided written informed consent. The study protocol was approved by the Ethics Committees of Showa University (#2009-27, November, 2009).

2.2. *Prosthodontic procedures*

Patients were treated by clinicians with more than 10 years experience under guidance. Treatment was performed according to the standard techniques applied for metal-ceramic reconstructions. The procedures were published in detail elsewhere and will therefore be briefly summarized with respect to the abutment tooth preparation [24,25].

The abutment teeth were prepared as follows (Fig. 1): margin with a circumferentially rounded shoulder (width 0.8–1.0 mm), tapering angle of 6–10°, and occlusal reduction of 1.5–2.0 mm. In the case of lack of dentin for an adequate preparation, a composite resin core buildup was fabricated. Impression of the jaw with the abutment teeth was taken with a polyether impression material. Provisional restorations were