A clinical comparison of zirconia, metal and alumina fixed-prosthesis frameworks veneered with layered or pressed ceramic

A three-year report

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ABSTRACT

Background. The authors conducted a randomized controlled clinical trial to determine whether performance differed between metal, zirconia and alumina fixed partial denture (FPD) frameworks veneered with pressed or layered ceramics designed for each framework type.

Methods. Posterior three-unit FPDs (N = 293) of 10 different framework/veneer ceramic combinations were placed by 115 dentists in 259 patients from their practices according to a masked protocol. Yearly, the clinicians graded the prostheses and the opposing dentition in vivo according to 17 criteria, and two independent scientists graded them in vitro by using gold-sputtered dies, scanning electron micrographs and clinical photographs.

Results. Three metal and five zirconia frameworks tested were not statistically different, with zero and two fractures, respectively. Alumina frameworks were statistically worse, with 11 fractures. The veneer ceramics CZR Press (Noritake Dental, Aichi, Japan) and Pulse interface (Jensen Dental, North Haven, Conn.) performed best with zirconia and metal frameworks, respectively. Four nonleucite-containing veneer ceramics used with zirconia frameworks had substantially more fractures.

Conclusions. Five zirconia framework brands performed equally well and were statistically comparable with metal frameworks at three years. Two leucite-containing veneer ceramics applied by means of pressing techniques had the statistically lowest number of fractures.

Clinical Implications. Dentists can use metal or zirconia frameworks successfully if they are designed properly, but to avoid veneer ceramic surface crumbling and minimize chipping, use of leucite-containing pressed ceramics is indicated.

Key Words. Restorative dentistry; fixed prosthodontics; dental materials; CAD/CAM; clinical protocols.

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JADA CE CONTINUING EDUCATION ARTICLE 2

In the past decade, significant changes have occurred in materials and methods used to fabricate fixed partial dentures (FPDs). Machining of zirconia, electrophoretic deposition of alumina and pressing of veneer ceramics are just a few changes challenging the 50-year supremacy of cast metal hand veneered with ceramic. It has yet to be determined clinically if the innovations have resulted in improvements. Direct clinical comparisons of zirconia-ceramic, alumina-ceramic and metal-ceramic restorations are needed to optimize patient care.

Desire for esthetics and biocompatibility brought all-ceramic restorations into dentistry well over 100 years ago.[1-4] Although some all-ceramic restorative materials have served well in single-unit and anterior multiunit restorations, all-ceramic restorations have shown less durability in posterior multiunit applications.[1-3,5-11] Today, yttria-reinforced zirconium oxide—zirconia—shows promise as a robust and durable material for use throughout the oral cavity, including in posterior multiunit restorations.[12] It has the highest flexural strength and fracture toughness available in dental ceramics.[13-16] In the continuing search for durable, highly esthetic dental materials, zirconia now is the center of attention. Proposed applications for zirconia in the oral cavity beyond FPDs include implant

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abutments, posts and orthodontic brackets.[17-20]

Several aspects of zirconia dental restorations require investigation in randomized controlled clinical trials. These include possible differences in performance between zirconia from different sources and performance of the veneering ceramics formulated specifically for use with zirconia. These veneering ceramics do not have in their formulations the leucite that traditionally is present in ceramics used with metals. This exclusion compensates for differences in coefficients of thermal expansion between metals and zirconias. The clinical performance of the new ceramics for zirconia has been questioned[5,12,21-27] but not yet fully investigated in controlled clinical trials that included different types of metal-ceramic restorations for direct comparisons. Pressing versus hand layering is another aspect of the new veneering ceramics that lacks validation in controlled clinical trials. Only a few researchers have reported about the pressing of ceramics.[28-31]

The goal of our randomized controlled clinical trial was to compare the performance of different framework materials and different veneering ceramics by using a practice-based research protocol to simulate real-world conditions.

MATERIALS, PARTICIPANTS AND METHODS

Selection of materials. Table 1 lists the materials, their sources and the fabrication methods we selected for the study. The zirconias we selected were from three sources, fully sintered or presintered and fabricated by means of computer-aided design/computer-aided manufacturing (CAD-CAM) and by using direct ceramic machining or digital imaging. The alumina we selected used electrophoretic deposition, and the metals we selected used cast or hand-adapted technologies. We sought hand-layered and pressed veneer ceramics for the three framework categories. The two ceramics pressed to zirconia (CZR Press [Noritake Dental, Aichi, Japan] and IPS e.max ZirPress [Ivoclar Vivadent, Amherst, N.Y.]) entered the study one year later because they were unavailable initially. We planned for the study to involve 32 three-unit posterior prostheses composed of each of the 10 framework-veneer ceramic combinations.

Selection of participants. ***Dentists.*** Criteria for the dentists we selected to participate in the study were as follows:

- known clinical ability from past associations with the Technologies in Restorative and Caries Research Foundation, Provo, Utah;
- experience with an all-ceramic system;
- active participation in clinical practice;
- willingness to participate in a long-term clinical trial;
- a personal profile that contributed diversity typical of dentists in general.

The group consisted of 106 general dentists and nine prosthodontists, of whom 108 were male and seven were female. They had a mean practice experience of 24 years (range, 1-54 years), and they had practices in 28 states in the United States and in two other countries.

Patients. We drew the patient participants from the patient pool of the participating dentists' practices. Inclusion criteria were as follows:

- need for a three-unit posterior prosthesis;
- presence of dentition opposing and adjacent to the test prosthesis;
- good overall health;
- no untreated occlusal problems;
- no active periodontal disease;
- no known sensitivity to study materials;
- desire to participate in a clinical evaluation;
- geographical stability.

The 259 patients consisted of 96 men and 163 women, and their mean age was 50 years (range, 16-89 years).

The study protocol was reviewed and approved by the internal review board of our research institute (Clinicians Report Foundation, Provo, Utah). All participants received oral and written information regarding the study purposes, and all of them provided written informed consent.

Selection of laboratories, technicians and fabrication techniques. We asked the manufacturers of the products selected for study to choose two commercial laboratories within the United States to fabricate 16 prostheses each. In-house laboratories were not permitted. In each case, the manufacturer or laboratory administrator selected the framework technician and ceramist to perform the work. Table 2 (page 1320) lists the two laboratories that fabricated each framework/veneer ceramic combination. The laboratory technicians knew they were participating in a clinical comparative study and could identify the specific study cases because their laboratory pre-

ABBREVIATION KEY. CAD/CAM: Computer-aided design/computer-aided manufacturing. **FPD:** Fixed partial denture. **SEM:** Scanning electron microscope.