ADA CE Program ARTICLE 1

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COVER STORY

Fracture resistance of computer-aided design and computer-aided manufacturing ceramic crowns cemented on solid abutments

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ABSTRACT

Background. Because no information was found in the dental literature regarding the fracture resistance of all-ceramic crowns using CEREC (Sirona) computer-aided design and computer-aided manufacturing (CAD-CAM) system on solid abutments, the authors conducted a study.

Methods. Sixty synOcta (Straumann) implant replicas and regular neck solid abutments were embedded in acrylic resin and randomly assigned (n = 20 per group). Three types of ceramics were used: feldspathic, CEREC VITABLOCS Mark II (VITA); leucite, IPS Empress CAD (Ivoclar Vivadent); and lithium disilicate, IPS e.max CAD (Ivoclar Vivadent). The crowns were fabricated by the CEREC CAD-CAM system. After receiving glaze, the crowns were cemented with RelyX U200 (3M ESPE) resin cement under load of 1 kilogram. For each ceramic, one-half of the specimens were subjected to the fracture resistance testing in a universal testing machine with a crosshead speed of 1 millimeter per minute, and the other half were subjected to the fractured resistance testing after 1,000,000 cyclic fatigue loading at 100 newtons.

Results. According to a 2-way analysis of variance, the interaction between the material and mechanical cycling was significant ($P = .0001$). According to a Tukey test ($\alpha = .05$), the fracture resistance findings with or without cyclic fatigue loading were as follows, respectively: CEREC VITABLOCKS Mark II (405 N/454 N) was statistically lower than IPS Empress CAD (1169 N/1240 N) and IPS e.max CAD (1378 N/1025 N) ($P < .05$). The IPS Empress CAD and IPS e.max CAD did not differ statistically ($P > .05$). According to a *t* test, there was no statistical difference in the fracture resistance with and without cyclic fatigue loading for CEREC VITABLOCS Mark II and IPS Empress CAD ($P > .05$). For IPS e.max CAD, the fracture resistance without cyclic fatigue loading was statistically superior to that obtained with cyclic fatigue loading ($P < .05$).

Conclusions. The IPS Empress CAD and IPS e.max CAD showed higher fracture resistance compared with CEREC VITABLOCS Mark II. The cyclic fatigue loading negatively influenced only IPS e.max CAD.

Practical Implications. The CEREC VITABLOCS Mark II, IPS Empress CAD, and IPS e.max CAD ceramic crowns cemented on solid abutments showed sufficient resistance to withstand normal chewing forces.

Key Words. CAD-CAM; ceramics; abutments; fracture resistance; implant.
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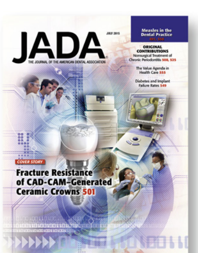
The success of implant-supported prosthetic rehabilitation, under the technical point of view, is directly related to key parameters such as the size of the crown, the implant position, the habits of the patient, the number of missing elements, and the type of denture.[1,2] The long treatment required for osseointegration and the rehabilitation with a prosthesis can be cited as disadvantages.[3] Thus, for the professional, the great challenge is in selecting the materials and techniques that reduce the time required to treat the patient.



One of the most important elements in treating a patient who receives an implant-supported prosthesis is the selection of prosthetic components, which involves assessing needs regarding the

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ease of fabrication, cost, esthetics, occlusion, effects of implant position on periodontal status, need for temporary restoration, type of restorative material that will be used, clinical performance, and implant type to which it is connected.[4]

The unit prosthesis on implants can be screwed or cemented in, and the attachment choice can affect the force transmitted to the components and to the bone-implant interface.[5] The screwed-in restorations have the main advantage of possibly being removed if necessary after installed, but they have an increased risk of fracture and microcracks in the ceramic,[5,6] a risk of bacterial contamination, esthetic problems,[5] and a chance for screw loosening.[7,8] Cemented restorations have the disadvantage of being permanent; however, they tend to be more resistant and have better esthetics, the loosening of screws is less frequent, and the cement acts as a biological seal to help prevent contamination.[4]

With the development of dental implants, a significant advancement in computer-aided design and computer-aided manufacturing (CAD-CAM) technology has shortened a series of laboratory and clinical steps for rehabilitating patients' dentitions with dental implants. Through the use of this technology, professionals can design and manufacture custom esthetic abutments and all-ceramic crowns. Impression procedures have become optional. The development of CAD-CAM tools allows the dentist to perform long laboratory procedures in 1 day.[9,10]

Studies show that the prosthetic structures produced by CAM-CAM systems present results at least as good as those obtained by conventional methods.[11,12] This may in part be explained by the manufacturing process of the ceramic for CAD-CAM technology, which significantly reduces or even eliminates internal porosity. However, the high survival rates of crowns in the CAD-CAM system on natural teeth prove that the tooth crown and roots behave as a single body.[12] As with the components of dental implants, solid abutments make the implant and abutment a unique body, which would solve problems such as loosening, screw breakage, and thread damage that occur with some frequency in screwed abutments.[13]

Despite the assumption of behavior similar to natural teeth, questioning whether it is possible to use CAD-CAM prostheses on solid abutments still remains unanswered. The simplified use of this technique may facilitate reduced time for the doctor-patient consultation and satisfy, to the highest degree, the esthetic needs of the patient.[14] Also, this technique eliminates the use of metallic structures on the crown. However, in relation to the restorative material, there remains an open question: which ceramic material would behave better mechanically when cemented on the solid metal abutment?

We conducted a study to evaluate the fracture resistance of ceramic crowns made by the CAD-CAM CEREC system (Sirona) cemented on solid abutments, using variables such as the type of ceramic and the influence of cyclic fatigue loading on fracture resistance of these restorations. Our study was conducted under 2 hypotheses: there are statistical differences in fracture resistance among the ceramic materials and the cyclic fatigue loading influences the fracture resistance of the ceramic crowns.

METHODS

For the study, 60 regular neck (RN) implant analogs and RN synOcta solid abutments (Straumann), 4 millimeters in height, were used. Each body was embedded in acrylic resin, simulating an osseointegrated implant, because its mode of elasticity is similar to that of bone tissue.[15,16] The 35-newton tightening torque was applied on the pillars. The samples were randomly divided into 6 groups of 10 elements each in accordance with the literature.[11,17,18]

The crowns were made by CAD-CAM using CEREC software (Version 4.0.2, Sirona Dental Systems). The abutment received the VITA Powder Scan Spray (VITA Zahnfabrik) to create an opaque surface needed for scanning by an optical 3-dimensional intraoral camera, creating a 3-dimensional virtual model. The shape of the crowns was designed with an individual biogeneric copy from a right second premolar. The thickness of the ceramic restoration in the occlusal face was 1.6 mm, 2.0 mm in the proximal surfaces, and 3.0 mm in the buccal and palatal faces (Figure 1). The die spacer used was 50 micrometers.

Sixty crowns were fabricated in the milling unit: 20 in feldspathic ceramic (CEREC VITABLOCS Mark II, VITA); 20 in leucite-reinforced glass ceramic (IPS Empress CAD, Ivoclar Vivadent); and 20 in lithium disilicate-reinforced glass-ceramic (IPS e.max CAD, Ivoclar Vivadent). The crowns milled in IPS e.max were crystallized in a ceramic furnace (Programat P300, Ivoclar Vivadent) for 30 minutes at a final temperature of 850°C under vacuum. After removal of the sprue and polishing with rubber tips (DiaGloss, Edenta) at 12,000 revolutions per minute at low speed, all ceramics were glazed: the IPS Empress CAD and CEREC VITABLOCS Mark II at a temperature of 790°C, and the IPS e.max at 770°C.

The inner surface of the crowns was etched with 10% hydrofluoric acid Dentsply Porcelain Conditioner (Dentsply). The CEREC VITABLOCS Mark II (feldspathic) crowns received conditioning for 2 minutes, the IPS Empress CAD (leucite) crown for 1 minute, and the IPS e.max CAD (lithium disilicate) crown for 20 seconds. Different conditioning times for the 3 ceramics seem to be most successful to increase the surface area available for bonding.[19] After conditioning, all

ABBREVIATION KEY. CAD-CAM: Computer-aided design and computer-aided manufacturing. **LED:** Light-emitting diode. **RN:** Regular neck.