FRACTURE STRENGTHS OF CEROMER CROWNS SUPPORTED ON THE VARIOUS ABUTMENT CORE MATERIALS

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Statement of problem. The effects of various core buildup materials which differs in the mechanical properties on the fracture strength of metal-free crowns is unknown.

Purpose. This study was carried out to evaluate the fracture strengths of Artglass ceromer crowns supported by 3 different core materials in clinically simulated anterior tooth preparation.

Material and methods. Ten crowns from each group were constructed to comparable dimensions on the various dies made by gold alloy, Ni-Cr alloy, and composite resin. The ten crowns were then cemented onto the dies and loaded until catastrophic failure took place. Fracture resistance to forces applied to the incisal edges of the anterior crowns supported by three types of dies was tested.

Results. The ceromer crowns on the composite resin dies fractured at significantly lower values(287.7 N) than the ceromer crowns on the metal dies(approximately 518.4 N). No significant difference was found between the fracture values of the ceromer crowns on the dies of gold alloy and Ni-Cr alloy.

Conclusion. The failure loads of the ceromer crowns on the metal dies were almost the same and not affected by the differences of casting alloys. However, the fracture values of the ceromer crowns on the resin dies were significantly reduced by the relative weak properties of composite resin core material.

Key Words

Ceromer, Fracture strength, Resin cement, Metal die, Composite die

CLINICAL IMPLICATIONS

This in vitro study showed the ceromer crowns on the cast metal cores of the different strength and the modulus elasticity exceeded normal masticatory forces which suggests suitable for restorations of carefully selected patients. However, the ceromer crowns on the composite resin core should not be used for the patients with strong biting forces.

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The esthetic appearance of a restoration, as well as its functionality, is extremely important. This is particularly true in anterior locations, where restorations that are the same color as natural teeth are in great demand.

Several esthetic restorations including all-ceramic systems have become available for anterior teeth. The recently introduced ceromer/fiber-reinforced composite system, which provides an attractive alternative to ceramic and resin materials, has enhanced the physical properties, improved esthetics, and increased the durability.[1,2] Several brands of filled polymers for individual crowns are available; they include Artglass® (Heraeus Kulzer, Wehrheim, Germany), Belleglas® (MicroDental Laboratories, Girbach, Pforzheim, Germany), Sculpture/FibreKor® (Generic Pentron, Wallingford, Conn.), and Targis/Vectris® (Ivoclar, Schaan, Lichtenstein). Artglass® was introduced as a new composite with a combination of conventional dimethacrylate monomer and additional multifunctional methacrylate monomers. Furthermore, Artglass® added rheologic glass(silica: average size 1㎛) to improve consistency. Artglass® offered an elevated fracture toughness and degree of conversion compared with a conventional composite material.[3]

The fracture resistance and marginal fit are important criteria for long-term success.[4] With regard to the fracture strength of materials, this was dependent on the modulus of elasticity of the supporting substructure, properties of the luting agent, tooth preparation design, surface roughness, residual stress, and restoration thickness.[5-11] The clinical performance of all-ceramic crowns has been evaluated by many authors.[12-18] In several studies, the main mode of failure was fracture, but bonding with resin adhesive cements significantly enhanced fracture resistance. It was reported that some ceramic crown systems had enough fracture strength to withstand normal occlusal forces.[19-21] Using resin dies with different elastic moduli, Scherrer and de Rijk[6] found that increased crown length corresponded to increased fracture resistance of all-ceramic restorations. This effect was attributed to the difference in the elastic moduli of the ceramic material and the supporting die. It was concluded that when the crown' s occlusal surface was loaded in compression, the fracture load increased markedly with the increase in elastic modulus of the supporting material. Bonilla et al[22] compared the fracture toughness of several core materials and found that amalgam and composite were able to withstand stresses generated in the mouth during mastication. However, there have been few reports on the fracture strength of the ceromer crown accoding to the core materials.

The aim of this study was to determine the influence of 3 core materials (Ni-Cr, gold and composite resin) on the fracture strengths of the ceromer crowns.

MATERIAL AND METHODS

Three core materials were selected for this study: Ni-Cr alloy (Rexillium III®, Jeneric Pentron, U.S.A.), gold alloy (Neocast3®, CM, Swiss), and autopolymerizing composite resin (LuxaCore®, DMG Hamburg, Germany)(Table I).

To avoid the influences of preparation design, loading direction, and loading stylus radius, an identical abutment analog and loading apparatus was used for all test specimens. A resin maxillary central incisor analog (dental study model, Nissin Dental Products Inc, Kyoto, Japan) was prepared with a 5-degree convergence angle and a 90-degree, 1-mm shoulder. The incisal edge was reduced by 2 mm, and the axiogingival and axioincisal line angles were rounded. A mold of this tooth was made with vinyl polysiloxane impression material (Aquasil®, Densply, U.S.A.) (Fig. 1).

Table I. Core materials used for the this study

Materials	Elastic modulus (MPa)	Tensile strength (MPa)	Manufacturer
Ni-Cr	225,520	1,135	Rexillium III®, Jeneric Pentron, U.S.A
gold	97,000	765	Neocast3®, CM, Swiss
composite	9,838	60	LuxaCore®, DMG Hamburg, Germany®®

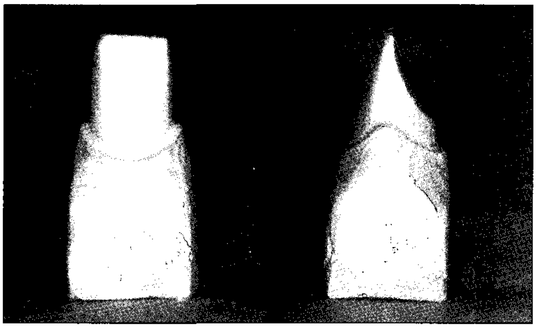
Fig. 1. Labial and proximal view of the master die.

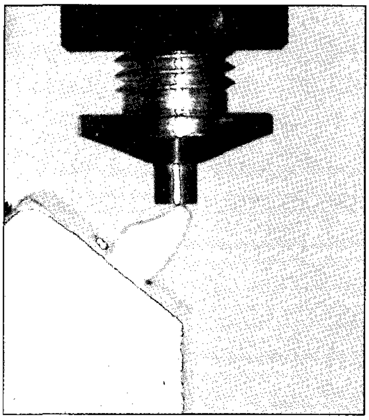
Fig. 2. Crown secured for testing in metal jig on universal testing machine.

Ten wax patterns were made from the mold and cast in a Ni-Cr alloy for the fabrication of Ni-Cr dies, from which 10 ceromer crowns were fabricated. Ten wax patterns were made from the mold and cast in a gold alloy for the fabrication of gold dies, from which 10 ceromer crowns were fabricated. Ten composite dies were made from the mold and cured with composite resin, from which 10 ceromer crowns were fabricated.

Thirty Ceromer (Artglass®, Heraeus Kulzer, Wehrheim, Germany) crowns were fabricated with the die and in accordance with the manufacturer' s guidelines. A space medium was applied on the surface of the dies, and the surfaces were isolated with an insulating gel. The buildup process consisted of layering various Artglass® composite materials of differing opacities, which simulated optical tooth characteristics. Each layer was polymerized in a light chamber (Dentacolor XS; Heraeus Kulzer) for 90 seconds. The external surfaces were polished with an Artglass finishing and polishing kit, and the internal surfaces were air-particle abraded with 50-μm aluminum oxide at low pressure (20 psi).

The die surfaces were air-particle abraded with 50-μm aluminum oxide. All of finished crowns were luted to the dies with a resin cement (Panavia F®, Kuraray medical Inc, Japan); constant finger pressure was applied, and the cement was allowed to set for 14 hours. All specimens were stored in the water bath at the room temperature for 1 month.

The crowned specimens were positioned in customized metal jig. A universal testing machine(Inston 4302, Inston company, England) was used to determine the fracture strength of the crowns. The load was directed at the incisolingual line angle, at 130 degrees to the long axis of the specimen, until catastrophic failure occurred. This position was selected to reproduce the occlusal forces directed against a maxillary central incisor. Each specimen was checked against a matrix to ensure that identical angles were used during each trial. A 5-mm-diameter rod was used to load the artificial crowns, with the center of the rod in contact with the crown surfaces (Fig. 3).

A crosshead speed of 1 mm per minute was used. Analysis of variance and the Tukey multiple comparisons test ($P<.05$) were applied to the data.

RESULTS

The mean fracture strengths were as follows: 524.8 ± 85.3 N for the Ni-Cr die specimens, 511.9 ± 95.2 N for the gold die specimens, and 287.7 ± 22.0 N for the composite die specimens (Fig. 3, Table II).

The fracture resistance of the ceromer crowns on the composite die specimens was significantly smaller($P < .05$) than on the other die specimens. No significant difference was found between the fracture values of the ceromer crowns on Ni-Cr die specimens and gold die specimens (Table II).

The crowns on the Ni-Cr and gold die specimens exhibited similar fracture patterns, in which the crowns were separated along the proximal surface

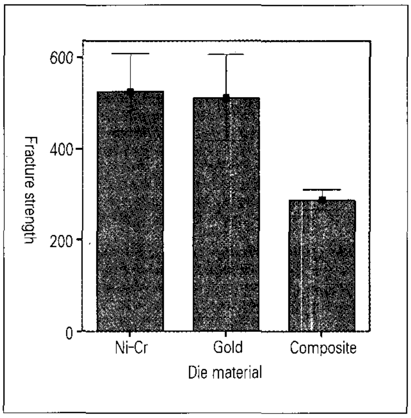

Fig. 3. Comparative mean fracture strengths of crown on different die material.

Table II. Mean fracture strengths(N) of ceromer crowns on different die materials

Die material	N	Mean ± SD	Tukey analysis*
Ni-Cr	10	524.8 ± 85.3	A*
Gold	10	511.9 ± 95.2	A
Composite	10	287.7 ± 22.0	B

*Means with same letter were not significantly different at $P<.05$.

Table III. Fracture mode after compressive loading of ceromer crowns

Die material	Fracture mode		
	crown/cement+die	crown+cement/die	crown fx. with die
Ni-Cr	3	7	
Gold	1	9	
Composite	0	3	7

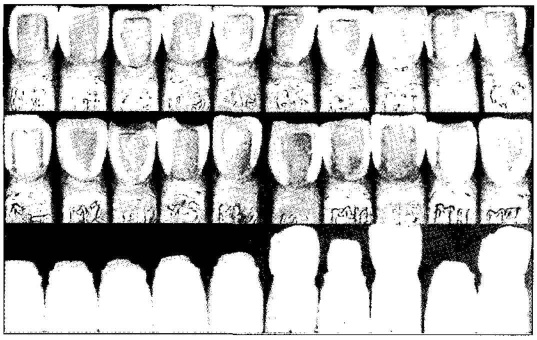
Fig. 4. Fractured specimens after loading.

into labial and lingual parts. Most specimens demonstrated only minimal remnants of cement on the inner surface of the crown, and most of the cement remained on the teeth. Most of the crowns on the composite dies fractured with the supporting die at the same time (Fig. 4, Table III).

DISCUSSION

For the restoration of extensively damaged teeth, the clinicians may choose from cast metal post and cores and direct core buildups using composite resin, glass ionomer or amalgam. Previous research on various core buildup materials showed all the core materials except glass ionomer were likely to withstand the stresses generated during mastication.[12,22] In our experiment to evaluate the fracture strength of ceromer crowns supported by three different core materials, cast gold alloy, Ni-Cr alloy and composite resin were used as core materials under ceromer crowns tested.

Adhesive resins have shown increased retention when compared with conventional zinc phosphate, glass ionomer cements. There is evidence that the use of resin-bonding with non-metallic crowns has enhanced these restorations by improving their fracture resistance. This strengthening effect has been demonstrated in laboratory experiments.[23] The mechanism for the strengthening is not known for certain, but it is probably due in part to prevention of crack propagation from the internal surface by the bonded resin.[24] In our experiments, the die surfaces were air-particle abraded with 50-μm aluminum oxide. All of finished crowns were luted to the dies with a resin cement (Panavia F®, Kuraray medical Inc, Japan).

The fracture strength of restorations was dependent on the modulus of elasticity of the supporting substructure, properties of the luting agent, tooth preparation design, surface roughness, residual stress, restoration thickness and restoration material.[5-11] As ceromer crowns tested in this experiment were fabricated with the same Artglass® material, and laboratory processed in accordance with the same guidelines, the difference of fracture strengths of each group was probably due to the differences of physical properties of die materials. The values of elastic modulus and tensile strength of composite are approximately 1/10 and 1/20 of gold and Ni-Cr alloy respectively(Table I). The fracture strength of ceromer crown specimens on the composite resin die was 287.7 ± 22.0 N, while the specimens for the Ni-Cr die specimens and the gold die specimens were 524.8 ± 85.3 N and 511.9 ± 95.2 N respectively(Fig. 3, Table II). The fracture values of the ceromer crowns on the resin die were significantly reduced by the relative weak properties of composite resin core material. But the failure loads of the ceromer crowns on the gold dies and the Ni-Cr dies were almost same and not affected by the differences of casting alloys.

The mode of failure also differed for the metal die groups and composite die group. In metal die groups, labial part of ceromer crown detached from the dies and crowns were separated along the proximal surface. Most of the crowns on the composite die fractured with supporting die and crowns at the cervical margin area which indicates the strength of composite resin die material is weaker than the ceromer material.

In terms of human biting forces, there are some disparities in the available research results: Kiliaridis et al.[25] found that biting force varied substantially with age, sex, and facial profile; Waltimo and Kononen 26 recorded mean maximal incising forces of 263 N for men and 243 N for women; while Gibbs et al.[27] reported occlusal loads of 263 N during normal chewing and 297 N during swallowing.

Finally, the ceromer crowns on the cast metal dies in this study had significantly greater fracture resistance than the average biting force. But, the mean failure loads placed on the ceromer crowns on the composite resin core was 287.8 N, which is similar to the magnitude of normal biting force. For anterior use, the ceromer crowns on the cast metal cores will probably survive functional loads. But the ceromer crowns on the composite resin cores could not withstand the occlusal loads during normal chewing and swallowing.

Long-term follow-ups of clinical situations will eventually determine the usefulness of ceromer crowns on the various core materials tested in this experiment.

CONCLUSION

Within the limitations of this in vitro study, the failure loads of the ceromer crowns on the metal dies were almost same and not affected by the differences of casting alloys. However, the fracture values of the ceromer crowns on the resin die were significantly reduced by the relative weak properties of composite resin core material.

This in vitro study showed the ceromer crowns on the cast metal cores of the different strength and the modulus elasticity exceeded normal masticatory forces which suggests suitable for restorations of carefully selected patients. However, the ceromer crowns on the composite resin core should not be used for the patients with strong biting forces.

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