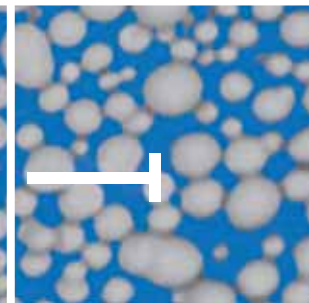
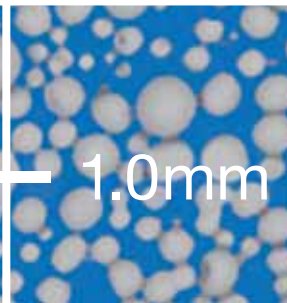
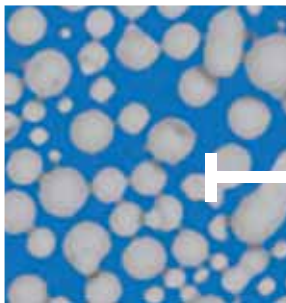


Scientific
Research
(Vol.III)

Cercon smart ceramics
The zirconia
all-ceramic system

2.0µm



1.0mm

Current research on Cercon at a glance

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Cover

Raw material is being processed at DeguDent to form a Cercon base blank.

The blank is processed in the Cercon brain scanning and milling system. Then it is sintered in Cercon heat, which will result in a homogeneous framework structure.

| | |
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Zirconia has become an established and indispensable material in all-ceramic fixed prosthodontics over the past few years after practical techniques had been developed that allowed yttria-stabilized zirconia to be processed in dental laboratories. Cercon smart ceramics is a CAM system designed for processing zirconia. It is the leading system of its kind worldwide, both from a technological viewpoint and in terms of sales. Cercon smart ceramics is the result of developments and findings made by study groups at the Swiss Federal Institute of Technology and the University of Zurich Dental School. Within just 5 years of its introduction, almost **2.5 million zirconia restorations have been fabricated with Cercon smart ceramics.**

Ever since 1998, this innovative procedure has been investigated and followed up in clinical trials. Today it is continuously developed further by close collaboration with renowned scientists and universities. As a result, its spectrum of indications keeps increasing. After a clinical observation period of more than 7 years, zirconia has proven to be an excellent framework material for crowns and multi-unit bridges in the anterior and posterior segments.

Studies are continuously being performed both in vitro and in clinical settings to investigate potential applications and new indications (e.g. extension bridges, inlay bridges or multi-unit bridge structures). Over 1,000 restorations are currently under observation in more than 10 clinical studies.

Thanks to successful results obtained over many years of clinical use, Cercon smart ceramics is today considered a reference for alternative all-ceramic fabrication techniques. Progress in hardware and software development has been giving new impulse to zirconia technology as well. It was therefore logical to add computer-aided design (CAD) functionality to the original CAM system of Cercon smart ceramics.

As a result, Cercon smart ceramics now offers both the option of designing frameworks by conventional wax-up and the option of accomplishing this task by CAD. New components such as the Cercon art CAD module or the Cercon eye desktop scanner have been added in the pursuit of expanding the innovative technology of all-ceramic materials in dentistry.

The compilation that follows will give you a current overview of relevant findings that have been obtained with Cercon smart ceramics both in the field of material science and in clinical studies. It is intended as a body of reference to support your daily work in the dental office or laboratory.

A brief history of Cercon

Properties and advanced processing of zirconia

Zirconia offers the highest fracture strength and the best fracture resistance of all dental materials currently available in the market. Its technical designation is Y-TZP (Yttria Stabilized Tetragonal Zirconia Polycrystals). This material is even suitable for large-span posterior restorations.

Y-TZP is an established material in general medicine. Despite its long-standing use in fabricating artificial hip joints, a number of procedural obstacles had to be overcome before this high-performance ceramic material could be used in dentistry. Preliminary attempts were made to use zirconia in a fully sintered state. However, this approach required extensive equipment and long processing times due to the extremely high strength of the material.

A team led by Dr. Ludwig Gauckler of the Swiss Federal Institute of Technology in Zurich, Switzerland developed a process allowing zirconia to be processed in a presintered state. Thus the groundwork was laid for a dental DCM (Direct Ceramic Machining) system, which was developed in collaboration with a dental study group led by Professor Schärer of the University of Zurich. This was the first system to offer a prospect of fabricating zirconia frameworks for fixed restorations in dental laboratories without incurring prohibitive costs.

The DCM system was used in a controlled prospective clinical study at the University of Zurich Dental School. Multi-unit bridges were inserted in the course of that study as early as 1998. The fracture strength of the zirconia frameworks involved turned out to be extraordinary. However, the study also indicated a need for improving the DCM both regarding the veneering ceramics and to obtain more precisely fitting frameworks.

Precision of fit

DeguDent GmbH (named Degussa Dental GmbH at the time) acquired the rights to DCM and used this system as a springboard to develop **Cercon smart ceramics** in close collaboration with both Zurich groups.

The precision of fit was considerably improved by proprietary hardware and software for a combined scanning and milling system (**Cercon brain**). Furthermore, a new veneering ceramic (**Cercon ceram S**, **Cercon ceram kiss**) was specifically developed for Y-TZP frameworks made from **Cercon base**.



First intraoral bridge fabricated with the DCM system. The bridge has meanwhile served in the patient's mouth for 8 years.

Marginal and internal fit of CAM-milled zirconia single-crown frameworks

Beuer F., Erdelt K. J., Spiegl K., Gernet W.
Munich, Germany (2004)

Objective

An in-vitro study was performed to investigate the marginal and internal fit of zirconia crown frameworks featuring a preparation angle of $a/2 = 6^\circ$, comparing the results obtained with two CAM software releases. Furthermore, the difference between adapted and non-adapted crowns was investigated. The non-adapted crown frameworks were included to demonstrate the degree of precision offered by the CAM system and to find out whether manual adaptation by the dental technician is required.

Materials and methods

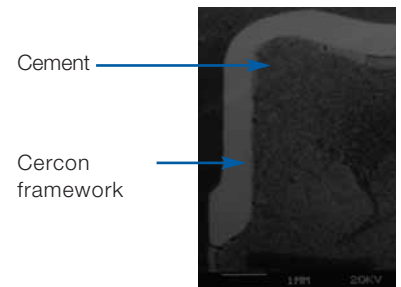
The Cercon CAM system (DeguDent, Hanau, Germany) was used to fabricate crown frameworks on 40 master dies with preparation angles of $a/2 = 6^\circ$. A total of 20 crowns were milled with an older software release (included when the system was first introduced in 2002) whereas another 20 crowns were milled with the latest software update (2004). Ten crowns were selected from either group and manually adapted by a dental technician. The time required to do so was recorded. A glass-ionomer cement was used to lute all 40 crowns to their original dies. The crowns were cut parallel to the milling direction and investigated by scanning electron microscopy (Stereoscan 250 Cambridge, Leica, Wetzlar, Germany).

Results

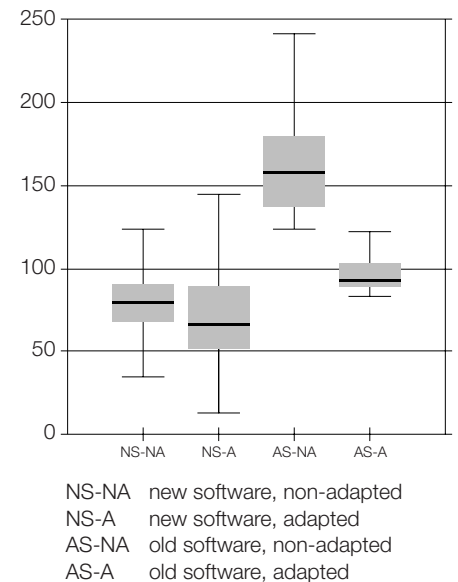
The mean marginal gap widths obtained with the crowns that were fabricated and adapted were $50.7 \mu\text{m}$ with the old software versus $40.3 \mu\text{m}$ with the new software. Statistically significant differences in precision of fit were obtained between the old and new software versions but also between the adapted and non-adapted crowns (Mann-Whitney U-test; $p < 0.05$). The crowns fabricated with the old software covered ranges of cement layer thickness as large as 15 to $560 \mu\text{m}$ based on adapted crowns and 5 to $1380 \mu\text{m}$ based on non-adapted crowns.



Placement of cuts parallel to the milling direction



Internal fit in μm



By comparison, the crowns that were adapted and milled with the new software exhibited a thinner and more homogeneous cement layer.

Conclusions

The new software version provides better compensation for the sintering contraction of zirconia blanks. The marginal and internal fit of restorations is significantly improved. However, adaptation of the frameworks by the dental technician is still required.

Note

This investigation was performed in continuation of a previous study dealing with the effect of preparation angles on the precision of fit. A summary of this previous study follows.

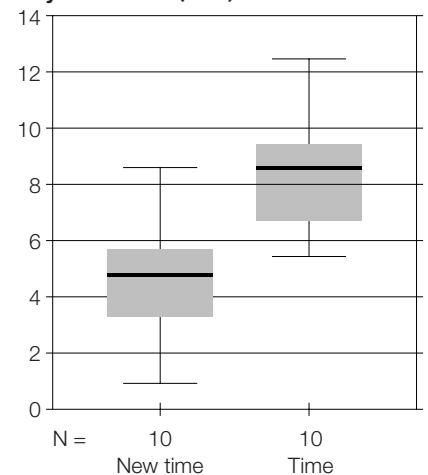
Marginale und innere Passung von CAM-gefrästen Zirkoniumoxid-Einzelkronengerüsten bei unterschiedlichen Präparationswinkeln

Beuer F., Fick K., Erdelt K.J., Gernet W., München (2003)

Summary:

An in-vitro study was performed to investigate which $a/2$ preparations offer an ideal marginal and internal fit of all-ceramic restorations fabricated with a zirconia milling system by DeguDent called Cercon smart ceramics. Crown frameworks were fabricated on 60 master casts with different $a/2$ convergence angles (2° , 4° and 6°). A total of 30 frameworks were adapted by the dental technician until an optimal fit was obtained. The other 30 frameworks were cemented to their master casts and cut. The marginal and internal fit was measured by scanning electron microscopy. The mean values for marginal gaps of the adapted crown frameworks ($50.7/56.0/72.7 \mu\text{m}$) of the $a/2$ convergence angles ($6/4/2^\circ$) were clinically within tolerable limits. In summary, it was demonstrated that the sintering shrinkage of zirconia blanks was precisely computed by the Cercon system, resulting in homogeneous cement gaps for the adapted crown frameworks.

Time for subsequent adjustments (min)



Analysis of the time spent on adjusting the crowns. Time requirements were greatly reduced when the new software was used (new time).

The box includes 50% of data and is delimited by the top and bottom quartiles. Horizontal bars indicate the median values (meaning that 50% of the values obtained are above and 50% are below this value).

Flexural strength of coloured and aged zirconia

Beuer F., Erdelt K. J., Schweiger J., Eichberger M., Gernet W.
Munich, Germany (2004)

All-ceramic materials are used because they offer high aesthetics and biocompatibility. Zirconia also offers a high degree of mechanical strength and is therefore a suitable material to fabricate bridges in posterior segments. Most all-ceramic systems are based on opaque white frameworks, which will detract from the aesthetic appearance of all-ceramic restorations. The LAVA system (3M Espe, Seefeld, Germany) relies on presintered zirconia for processing. The frameworks are coloured prior to sintering, resulting in a shade that will closely resemble natural dentin. Dental laboratories also use this colouring technique for other systems used to process presintered zirconia. Cercon smart ceramics (DeguDent, Hanau, Germany) is one of these systems. Its presintered zirconia blocks are available in white. A coloured version is available for enhanced aesthetics (Cercon base coloured).



Objectives

The present study was performed to investigate the effect of colouring on the flexural strength of zirconia. Furthermore, the aging process of coloured and white zirconia was analyzed.

Methods

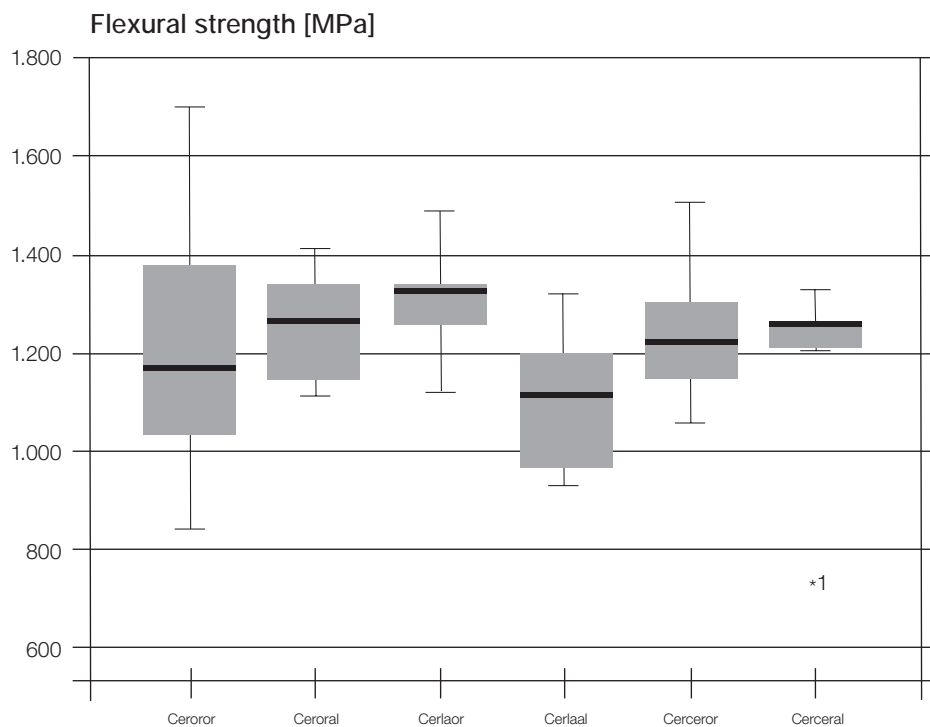
A total of 60 round specimens made from presintered zirconia were used. Twenty of them were prepared in accordance with the manufacturer's recommendations, 20 were coloured with LAVA Frameshade solution, and 20 were industrially coloured designs (Cercon base coloured). Ten specimens in each study group were subjected to artificial aging over a simulated period of 5 years. All specimens met the requirements defined in EN ISO 6782. This experimental setup allows calculating the flexural strength from the load at fracture.



Results

With an average flexural strength of 1320 MPa, white zirconia revealed the best behavior prior to aging. The industrially coloured framework material showed the best result after aging (1184 MPa). Remarkably, the specimens made of industrially coloured zirconia would scarcely lose any of their flexural strength following artificial aging. Also, the Weibull module is increased by industrial colouring of the zirconia framework.

- Ceroror: Cercon base white, non-aged
- Ceroral: Cercon base white, aged
- Cerlaor: Cercon base, manually coloured in the laboratory, non-aged
- Cerlaal: Cercon base, manually coloured in the laboratory, aged
- Cerceror: Cercon base coloured, not aged
- Cerceral: Cercon base coloured, aged



The box includes 50% of data and is delimited by the top and bottom quartiles. Horizontal bars indicate the median values (meaning that 50% of the values obtained are above and 50% are below this value).

Conclusions

Industrially coloured zirconia frameworks should preferably be used. They offer a significantly higher degree of flexural strength than white zirconia frameworks after artificial aging. This superior behaviour can be attributed to greater density of the grid structure, since the metal oxides of the colour solution are located between the zirconia molecules.

In-vitro marginal fit of CAM-fabricated Cercon crowns

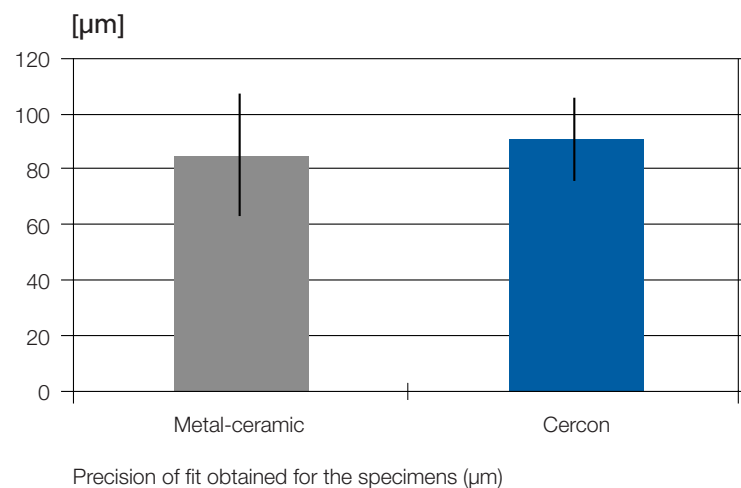
Chang J. Y., Yang J. H.
Seoul, South Korea (2004)

Objectives

To compare the marginal fit of Cercon single-tooth crowns fabricated by CAM versus metal-ceramic crowns in the anterior segment. An adequate number of specimens were measured at different sites.

Methods

The study was performed in vitro, measuring the marginal fit of Cercon and metal-ceramic crowns. The latter served as control group. The results were evaluated and compared. All crowns were prepared with the aid of a milling system on an extracted upper central incisor. Thirty specimens were fabricated with each system. A total of 50 sites at each crown were measured with respect to marginal fit. The results were statistically analyzed.



Results

Median values and standard deviations for marginal fit were $85 \pm 22 \mu\text{m}$ in the control group and $91 \pm 15 \mu\text{m}$ for the Cercon crowns.

Conclusions

While the marginal gaps were slightly larger with the Cercon crowns than with the control specimens, this difference was not statistically significant ($p = 0.05$).

In-vitro fracture strength of metal-ceramic bridges and all-ceramic bonded inlay bridges in the posterior segment

Kilicarslan M.A., Kedici P.S., Küçükesmen H.C., Uludag B.C.
Ankara, Turkey (2004)

Statement of problem

All-ceramic inlay bridges are minimally invasive restorations. Their fracture strength, however, remains to be settled in a definitive fashion.

Objective

This study was performed to evaluate the fracture strength of all-ceramic inlay bridges in comparison with conventional metal-ceramic bridges.

Materials and methods

A total of 32 bonded posterior restorations (RBFPD = resin-bonded fixed partial dentures) were divided into four groups. Each of the following group included 8 restorations: (1) conventional metal-ceramic bridges made from an NiCr-based alloy (Wirrolloy, Bego, Bremen, Germany) and veneered with ceramic (IPS d. SIGN, Ivoclar-Vivadent, Schaan, Liechtenstein) as control group; (2) inlay-retained metal-ceramic bridges made from the same materials as the control structures; (3) inlay-retained bonded bridges made from a lithium disilicate ceramic (IPS Empress 2, Ivoclar-Vivadent, Schaan); and (4) inlay-retained bonded zirconia-based bridges (Cercon, DeguDent). The control group was based on conventional bridge preparations including a 1.3-mm-circumferential, 90-degree flat shoulder with rounded angles. The inlay bridge specimens were prepared with occlusal cavity 2 mm deep but without bevels at the occlusal or gingival margins. Subsequently the specimens were loaded in a universal testing machine operated at a crosshead speed of 1 mm (load cell: 250 kgf), evaluating the maximum loads at which fracture occurred (N). The data obtained were statistically analyzed by ANOVA and Duncan test ($p < 0.01$).

Results

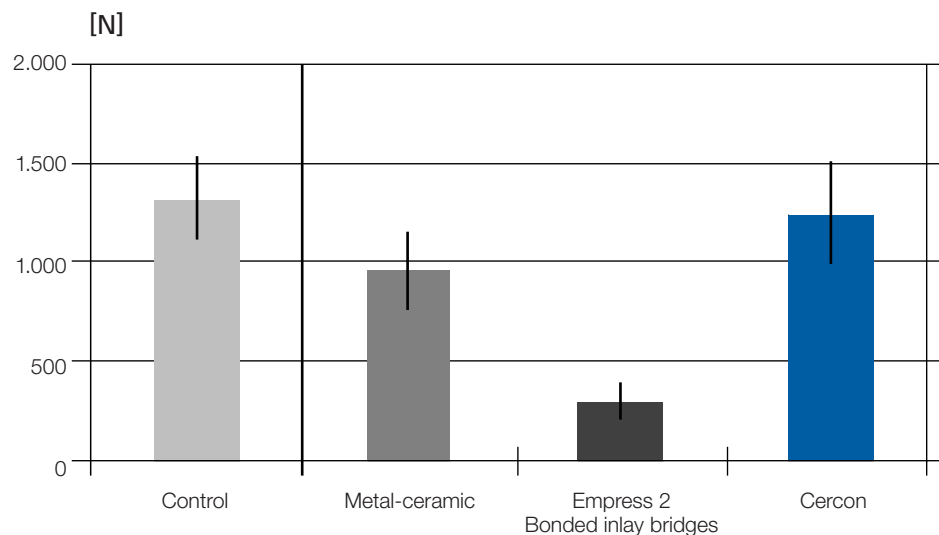
Fracture loads (mean \pm SA) were greatest in the control group (1318.43 \pm 211.00 N) and in the zirconia group (1247.70 \pm 262.51 N). Both groups yielded significantly higher fracture strength values than the groups made up of metal-ceramic inlay bridges and lithium disilicate restorations ($p < 0.001$). The metal-ceramic inlay bridges ranked third (958.01 \pm 194.29 N). Significantly lower fracture loads were obtained with the lithium-silicate restorations than in the other three groups ($p < 0.01$).

Conclusions

Zirconia-based all-ceramic bridges exhibited the highest mean fracture strength of all inlay bridges tested.

Clinical significance

These in-vitro results suggest that a restorative material is available that allows hard tissue to be preserved by offering the possibility of fabricating adequately strong inlay-retained bonded bridges. Zirconia-based inlay bridges exhibited the greatest mean fracture strength when compared to inlay-retained metal-ceramic bridges and inlay-retained bonded bridges made from lithium disilicate.



Fracture strength values of the three variants of bonded inlay bridges as compared to a conventional metal-ceramic restoration (control).

Adhesive strength of ceramic materials on yttria-stabilized tetragonal zirconia frameworks

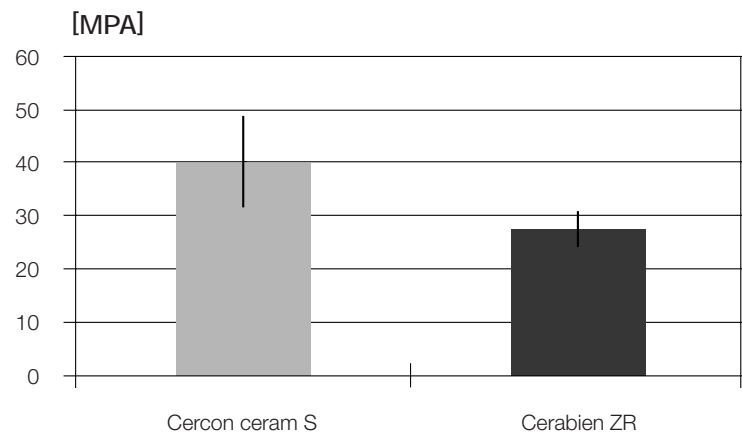
Nishimura M., Miura H., Suzuki M., Morikawa O., Yoshida K., Matsumura M.
Tokyo, Japan (2004)

Objectives

This in-vitro study was performed to investigate the adhesive strength of two ceramic materials that were bonded to yttria-stabilized tetragonal zirconia frameworks (Y-TZP).

Methods

A total of 24 Y-TZP frameworks (25 × 3 × 0.5 mm) were fabricated with a CAM system (Cercon smart ceramics, DeguDent) and divided into 4 groups. In two groups, the surfaces of the test objects were polished with SiC paper (grit size: 600). The surfaces of the frameworks were corundum-blasted with Al₂O₃ particles (100 μm). Two ceramic materials designed especially for zirconia restorations (Cercon ceram S, DeguDent, and Cerabien ZR, Noritake) were applied and fired to the surface as defined in DIN 13927 until a final thickness of 1.5 mm (including the framework) was reached. The specimens were subjected to 3-point flexural testing in a universal testing machine (1123 Instron). The data (median MPa ± SD) were analyzed with univariate ANOVA and the Tukey HSD test (p < 0.05).



Adhesive strength of both ceramic materials for zirconia veneering as determined by 3-point flexural testing (Schwickerath test).

Results

The surface roughness of Y-TZP frameworks was $Ra\ 2.82 \pm 0.57\ \mu\text{m}$ in the presence and $Ra\ 0.720 \pm 0.142\ \mu\text{m}$ in the absence of polishing with SiC paper. The adhesive strength was found to be $40.1 \pm 8.7\ \text{MPa}$ for Cercon ceram S and $27.5 \pm 3.5\ \text{MPa}$ for Cerabien ZR on Y-TZP frameworks in the absence of polishing. In the presence of polishing, the corresponding values were $45.2 \pm 8.7\ \text{MPa}$ and $30.6 \pm 3.6\ \text{MPa}$. The differences between both materials were statistically significant ($p < 0.05$).

Conclusions

The results demonstrate that Cercon ceram S and Cerabien ZR are suitable ceramic materials for use on Y-TZP frameworks.

Fracture strength of posterior zirconia bridges

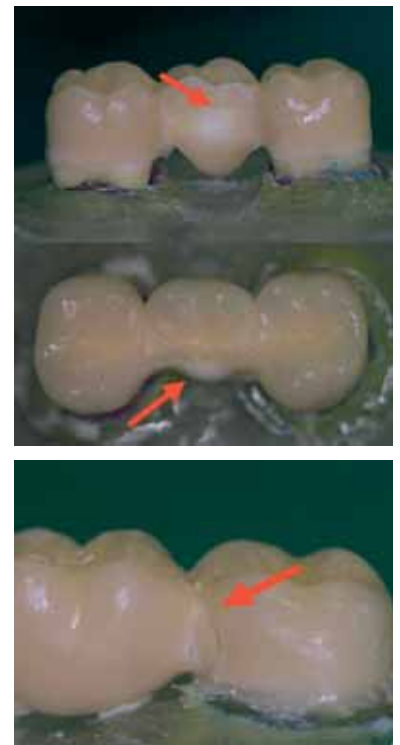
Rosentritt M., Behr M., Kolbeck C., Handel G.
Regensburg, Germany (2004)

Objectives

This in-vitro study was performed to determine the fracture strength of tooth-coloured bridges made from zirconia that were bonded into place with different cements.

Materials and methods

A total of 96 human molars were embedded in PMMA resin, simulating a three-unit clinical situation. The periodontium was simulated by covering the roots with a polyether layer (approximately 1 mm thick). 2 × 8 bridges of each series were fabricated from zirconia. They were delivered with an adhesive bonding system (Syntac classic/Variolink 2; Ivoclar-Vivadent, Liechtenstein) and by conventional means as recommended by the manufacturers: (A) Digizon/GC Initial (Fuji Plus, Girbach, Germany); (B) Lava/Lava Ceram (Ketac Cem, 3M Espe, Germany), and (C) Cercon/Cercon ceram S (Harvard, DeguDent, Germany). Eight bridges of each series were evaluated for fracture strength (UTM 1446; Zwick; $v = 1 \text{ mm/min}$) following thermal cycling and mechanical loading (TCML; $6000 \times 5^\circ\text{C}/55^\circ\text{C}$ and 1.2×10^6 at 50 N). The Mann-Whitney U-test was performed for statistical analysis ($p = 0.05$).

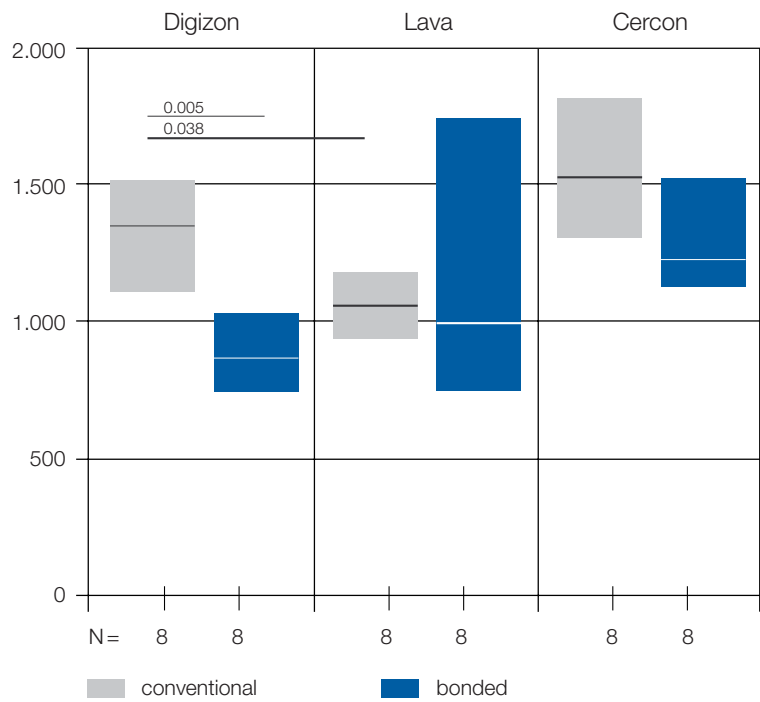


Results

| Cement | Digizon | | Lava | | Cercon | |
|----------------|-----------|-----------|-----------|-----------|-----------|---------|
| | Variolink | Fuji Plus | Variolink | Ketac Cem | Variolink | Harvard |
| Median | 843 | 1.332 | 992 | 1.062 | 1.227 | 1.525 |
| 25% percentile | 738 | 1.131 | 815 | 941 | 1.115 | 1.323 |
| 75% percentile | 945 | 1.474 | 1.596 | 1.146 | 1.467 | 1.802 |

Conclusions

The conventionally cemented zirconia bridges did not exhibit any statistically significant differences. All bridges revealed smaller loads at fracture when adhesive bonding was used, but the differences were only statistically significant with Digizon. Due to the range of fracture loads observed with all zirconia bridges, their clinical application in the posterior segment appears to be a promising option.



Box-plot representation of fracture strength values for three zirconia systems investigated.

The box includes 50% of data and is delimited by the top and bottom quartiles. Horizontal bars indicate the median values (meaning that 50% of the values obtained are above and 50% are below this value).

Impact of shoulder designs on the fracture loads of PTCercon crowns

van der Zel J.M., Grinwis T., de Kler M., Tsadok Hay T.
Hoorn, The Netherlands (2004)

Objectives

To evaluate the effects of shoulder design on the fracture load of Press-to-Cercon crowns (PTC crowns).

Methods

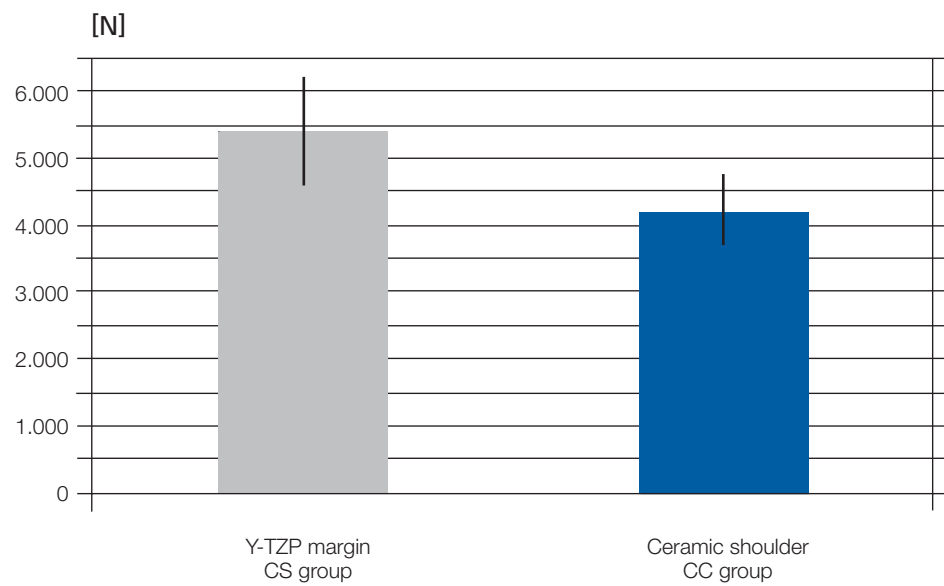
Two study groups of overpressed crowns were investigated: one included a non-zirconia PTC shoulder (CS), while the other one included a zirconia base extending to the crown margin (CC). The non-zirconia shoulder extended up to 0.8 mm above the framework margin. In each group, 8 zirconia frameworks with a standard thickness of 0.6 mm were fabricated for upper central incisors, using the Cercon CAM system (DeguDent, Hanau, Germany). After milling, the frameworks were sintered at a temperature of 1.350 °C until their final density was reached. Thereafter, the frameworks were waxed up to a standard contour. Then they were sprued and embedded in Carrara UniversalDustless Investment (Elephant, Hoorn, The Netherlands). The PTC ceramic was pressed to the zirconia frameworks at 940 °C. After divesting and sprue separation, the crowns were veneered with two layers of Cercon ceram S (DeguDent, Hanau). The crowns were cemented with zinc-phosphate cement to a CoCr die and subjected to a constant load of 5 kg during hardening of the cement. Load at fracture was measured with vertical force introduction at a cross-head speed of 0.5 mm/min, using a universal testing machine. The crowns were examined for surface fractures by scanning electron microscopy.

Results:

The loads at fracture ($N \pm SA$) were 4.228 ± 515 in the CS group and 5.408 ± 806 in the CC group.

Conclusions

Compared to the fully supported PTC crowns, the fracture strength was significantly reduced in the group with non-zirconia shoulders by 22% ($p < 0.05$). Analysis of surface fractures revealed that the site of crack initiation (which determines failure) was typically located along the ceramic-zirconia interface on the internal crown surface.



Static fracture strength of the anterior crowns investigated.

Strength and reliability of four-unit all-ceramic posterior bridges

Lüthy H., Filser F., Loeffel O., Schumacher M., Gauckler L.J., Hammerle C.H.F.
Zurich, Switzerland (2005)

Objectives

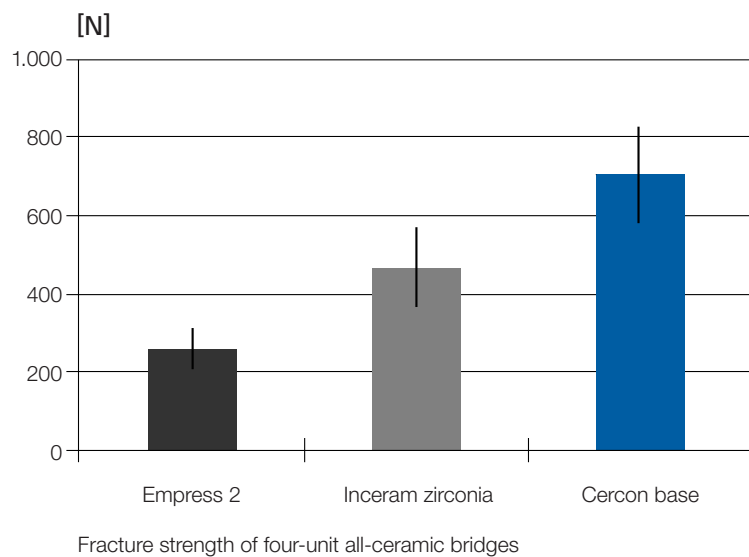
The purpose of this study was to determine the in-vitro load bearing capacity of four-unit posterior frameworks made of glass ceramic with lithium disilicate crystals (E2), of zirconia-reinforced glass-infiltrated alumina (ICZ) and of zirconia stabilized with 3 mol % yttria (CEZ).

Methods

All frameworks mimicked a four-unit posterior situation with 7.3 mm² interdental cross-sections and possessed exactly the same dimensions. The load bearing capacity was measured on a special bridge test setup with 15 specimens for each of the materials. The data were analyzed with Weibull statistics giving the characteristic load bearing capacity F₀ at 63% failure probability and the Weibull modulus m as indicator for the reliability and reproducibility.

Results

For the E2 frameworks the average load bearing capacity and the SD was 260 ± 53 N, the characteristic load $F_0 = 282$ N and the reliability $m = 5.7$. For the ICZ frameworks the average load bearing capacity was 470 ± 101 N, $F_0 = 518$ N and $m = 4.5$. CEZ frameworks revealed the highest average load bearing capacity of 706 ± 123 N, the highest characteristic load bearing capacity $F_0 = 755$ N and the best reliability $m = 7.0$.



Significance

CEZ frameworks showed the best mechanical properties as demonstrated by the high values of average load bearing capacity, reliability and characteristic load bearing capacity with respect to the other ceramics studied. However, for four-unit posterior CEZ frameworks the connector size of 7.3 mm^2 is insufficient to withstand occlusal forces reported in the literature. Four-unit posterior frameworks require a connector size larger than 7.3 mm^2 .

Fracture strength of all-ceramic posterior inlay bridges

Ludwig K., Uphaus A., Kern M.
Kiel, Germany (2005)

Objectives

This study was performed to compare static fracture strength and fracture behavior of three-unit posterior inlay bridges fabricated with a CAM procedure (Cercon, DeguDent, Hanau, Germany) and a lithium disilicate glass ceramic (VP2563, Ivoclar, Schaan, Liechtenstein) after dynamic cyclic loading.

Methods

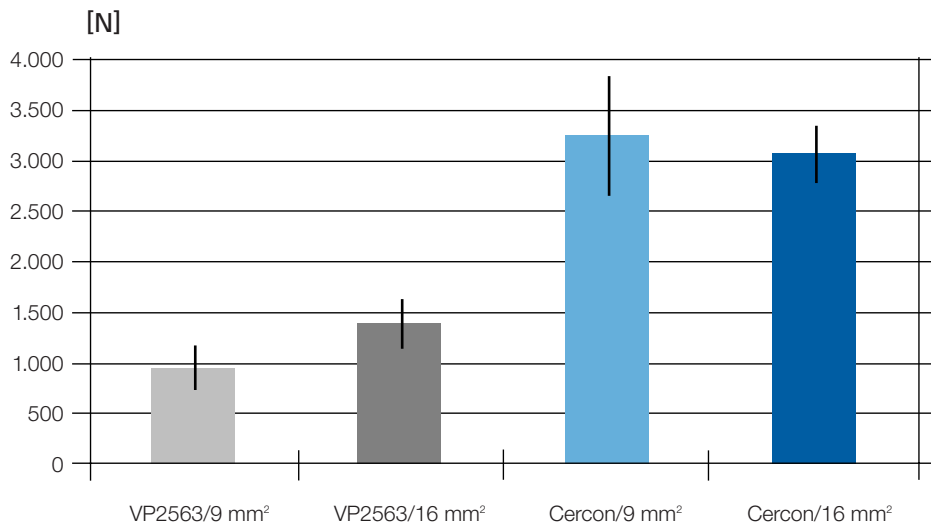
Posterior teeth (25 and 27) were prepared with mesio-occlusal and occluso-distal cavities, aiming to achieve connector surfaces for the proposed structures of 9 mm² and 16 mm², respectively. The preparations were then cast in a cobalt-chromium alloy. A total of 64 casts was fabricated, including resiliently placed metal dies. For each of both ceramic materials, 16 bridge structures were fabricated with connector surfaces of 9 mm² and another 16 structures with connector surfaces of 16 mm². All structures were bonded with a composite cement (Multilink, Ivoclar, Schaan). A universal testing machine (Zwick-Roell, Neu-Ulm, Germany) was used to test fracture strengths in 6 bridges per group, applying the loads in the center of each pontic. Fatigue behaviour was tested by cyclic axial loading of 4 bridges per group at 250 N in a chewing simulator (Willitec, Munich, Germany). Another 6 specimens per study group were tested by cyclic axial loading at 600 N in the chewing simulator.

Results

Both ceramic materials revealed statistically significant differences in static fracture strength, with mean values of 3244 ± 565 N (Cercon 9 mm²), 3065 ± 260 N (Cercon 16 mm²), 947 ± 196 N (VP2563 9 mm²) and 1385 ± 216 N (VP2563 16 mm²) (ANOVA, $p < 0.05$). Significant differences were also observed for the number of load changes until fracture, based on the specimens that were subjected to cyclic axial loading at 600 N. None of the Cercon specimens fractured when cyclic axial loading was applied at 250 N; this result was obtained throughout the testing period with 1.200.000 load changes involved. The VP2563 specimens featuring connector surfaces of 9 mm², by contrast, would fracture after a mean of 986.000 load changes during cyclic axial loading at 250 N. Those featuring connector surfaces of 16 mm² would fail after a mean of 1.150.000 cycles.

Conclusions

Considering the expected levels of maximum chewing force, Cercon appears to be a suitable material for the purpose of fabricating three-unit posterior inlay bridges. Structures made from VP2563 should feature connector surfaces of at least 16 mm² for this purpose.



Fracture strength of bonded inlay bridges made from two different materials and featuring differently sized connectors.

Bonding strength of resin on contaminated zirconia following application of different cleaning methods

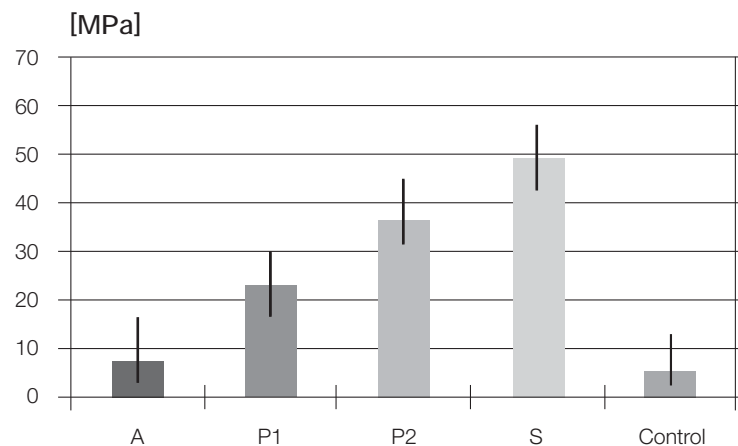
Quaas A.C., Yang B., Kern M.
Freiburg and Kiel, Germany (2005)

Objectives

The purpose of this laboratory study was to investigate the effect of using different cleaning techniques on the bonding strength of resin on zirconia after contamination with saliva and following application of a silicone marker.

Methods

Plexiglas tubes filled with a composite resin (Clearfil FII, Kuraray, Japan) were bonded to corundum-blasted zirconia disks (Cercon, DeguDent) with Panavia F2.0 composite resin (Kuraray, Japan), a bonding agent containing phosphate monomers. The ceramic bonding surface was cleaned using four different approaches after contamination with both saliva and a silicone marker (Fit-Checker, GO, Japan). The surfaces were cleaned (A) in 96% isopropanol for 15 seconds; (P1) with 37% phosphoric acid for 1 × 60 seconds; (P2) with 37% phosphoric acid for 2 × 30 seconds; or (S) by corundum blasting with 50- μm particles of Al_2O_3 at 2,5 bar for 15 seconds. The control group (C) included specimens that were not subjected to cleaning on applying the silicone marker.



Bonding of resin strength on contaminated zirconia after using different cleaning methods

A: A: Cleaning with 96% isopropanol for 15 s.
P1: P1: Cleaning with 37% phosphoric acid for 1 × 60 s.
P2: P2: Cleaning with 37% phosphoric acid for 2 × 30 s.
S: S: Corundum blasting with 50 μm Al_2O_3 (2.5 bar, 15 s).
Control: No cleaning.

Eight specimens per group were bonded with Panavia F2.0, using a linear test design. The test groups were stored in tap water at 37 °C for 3 days. Subsequently, a universal testing machine (Zwick Z010/TN2A, Ulm, Germany) was used to evaluate the tensile strength at 2 mm/min, using a test design that would allow for undisturbed axial load introduction.

Results

Mean MPa results for tensile strength were 8.2 ± 5.5 (A), 23.6 ± 6.4 (P1), 37.2 ± 4.8 (P2), 49.9 ± 7.4 (S) and 6.6 ± 5.7 (C). The Kruskal Wallis test was applied and yielded statistically significant differences between the test groups ($p < 0.001$). Corundum blasting of the ceramic surfaces resulted in a significantly higher mean tensile strength than the other cleaning techniques. The specimens cleaned with isopropanol did not exhibit higher values of tensile strength than the control specimens (C).

Conclusions

Different cleaning techniques applied on ceramic materials after try-in will give rise to significantly different strengths of resin bonding. Corundum blasting of zirconia turned out to be the most effective approach.

Clinical success of three- and four-unit posterior Cercon bridges: a prospective longitudinal study

Rödiger M., Wehle J., Rinke S., Hüls A.
Göttingen, Germany (2005)

Background

Zirconia is increasingly gaining importance in dentistry. This growing interest is mainly driven by demands for greater strength of posterior bridges. Numerous CAD/CAM and CAM systems are available to process zirconia. One example is the Cercon system by DeguDent.

The purpose of the present study was to evaluate the long-term survival of posterior Cercon bridges spanning three and four units. Conventional cementing was selected as the primary method of intraoral delivery. Emphasis was placed on three aspects: (1) strength of framework ceramics, (2) longevity of veneering ceramics, and (3) feasibility of conventional cementing.



Clinical case: preparation.



Clinical case: occlusal view of bridge in situ.



Clinical case: lateral view of bridge in situ.

Materials and methods

A total of 84 three- and four-unit posterior bridges were inserted in 68 patients between January 2001 and February 2005. Part of the frameworks were veneered with an experimental veneering ceramic (46 bridges = group A). Beginning in early 2002, the remaining frameworks were veneered with Cercon ceram S (38 bridges = group B), a specially optimized ceramic material that continues to be available today. All restorations were bonded with a zinc-oxide-phosphate cement. Clinical examinations were performed in 6-month intervals, using a standardized approach that was based on partially modified CDA criteria. The mean observation period is currently 32 months.



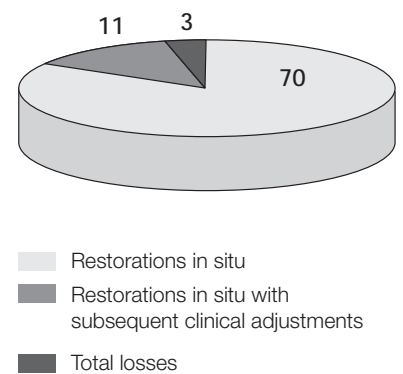
Insufficient abutment height (< 4 mm) of tooth 37. Loss of retention ensued.

Results

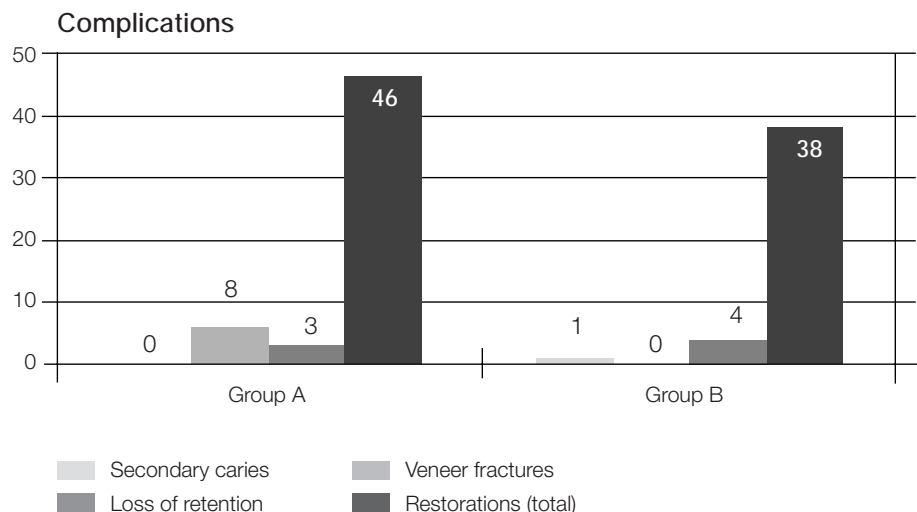
No framework fractures have occurred to date. Six bridges in group A have exhibited fractures and chipping of the veneering ceramic but have been preserved in situ after smoothing. Loss of retention was observed in 7 cases and was successfully amended by re cementation in 5 of them while resulting in secondary caries and total loss of the restoration in 2 cases (both in group A). It should be noted that both patients had not complied with recall visits for several years but only came back after symptoms had emerged.

Conclusions

One bridge was lost in group B after an endodontically treated abutment had been affected by secondary caries. Thus there have been 3 total losses out of 84 bridges. A total of 70 bridges have remained in situ without requiring clinical adjustment. The mean follow-up is currently at 42 months in group A (Kaplan-Meier probability of survival: 82.7%; n = 46) and 21 months in group B (Kaplan-Meier probability of survival: 97.6%; n = 38).



Cercon ceram S exhibits better probabilities of survival than the experimental veneering ceramic that was previously used. The frameworks showed a good initial fit, such that subsequent adjustments for proper seating were rarely needed. Loss of retention was observed more frequently in the mandible than in the maxilla (ratio 6 : 1) and could not be clearly attributed to preparation flaws. It is therefore recommended to use adhesive cementation in the mandible, or at least to use adhesive recementation after loss of retention has occurred. Furthermore, restorations that were implemented under less-than-ideal clinical conditions (e.g. on residual tooth structures < 4 mm high) should be placed on an appropriately tight recall schedule.



Clinical success of zirconia-based implant abutments after 24 months of service

Rinke, S.
Hanau, Germany (2005)

Objectives

This study was performed to investigate the clinical success of zirconia-based implant abutments (Cercon Balance, Friadent) in a private dental practice.

Methods

A total of 23 anterior implants (Ankylos, Friadent) were inserted in 14 patients (10 women and 4 men) between July 2001 and July 2003. All implants were fitted with zirconia abutments (Cercon Balance, Friadent) and all-ceramic single-tooth restorations based on zirconia (Cercon, DeguDent). All restorations were bonded with a temporary cement (Temp-bond, Kerr-Hawe). Modified Ryge criteria were used to evaluate the restorations at baseline as well as after 6, 12 and 24 months.

Results

All implants survived this initial phase of clinical observation without any clinically detectable problems. The restorations were followed up for a mean of 625 ± 179 days. No fractures of zirconia abutments and no instances of screw loosening were observed during the observation period. No framework fractures occurred, and there was no loss of retention or chipping of the veneering ceramic. Marginal fit was rated alpha in 19 restorations and beta in 4 abutments. Colour match and anatomical shape was rated alpha in 22 restorations and bravo in 1 restoration. Patient satisfaction with the quality of functional rehabilitation was reported to be excellent in 10 cases and as very good in 4 cases. All patients regarded the aesthetic outcome as excellent.



Conclusions

Within the limitations imposed by the clinical observation period, the success of zirconia-based implant abutments in the anterior segment can be considered promising after 24 months. Temporary cementation does not appear to increase the risk of retention loss, while ensuring that the superstructure can be removed without being damaged. Combining the zirconia abutments herein investigated with zirconia restorations gives rise to aesthetic outcomes and greater patient satisfaction than usual..

Fracture strength of molar crowns made from zirconia compared to laser-sintered and cast alloys

Thaller C., Rosentritt M., Behr M., Handel G.
Regensburg, Germany (2005)

Objectives

This in-vitro study was performed to test the fracture strength of molar restoration designs, including two metal-ceramic designs (cast and laser-sintered alloys) with full-coverage veneering and one all-ceramic design fabricated by CAM. Retention methods included conventional cementation and bonding.

Methods

Single molar restorations were fabricated based on a high-gold alloy (Bio Pontostar, Bego). Three different fabrication techniques were used: (A) casting as reference method; (B) computer-assisted laser sintering; and (C) all-ceramic CAM processing of zirconia (Cercon/Ceram S, DeguDent). A subset of 8 restorations per group was bonded with Syntac Classic/Variolink2 (Ivoclar-Vivadent, Schaan, Liechtenstein). Another 8 restorations per group were bonded with a zinc-phosphate cement (Harvard, Richter + Hoffmann, Berlin, Germany). The human roots of the molars were covered with a polyether layer 1 mm in thickness to simulate periodontal function. Chewing function was simulated by subjecting the restorations to thermal cycling and mechanical loading (TCML: $6.000 \times 5^\circ\text{C}/55^\circ\text{C}$, $1.2 \times 10^6 \times 50 \text{ N}$, 1.66 Hz). Then the restorations were axially loaded to failure in a universal testing machine (Zwick 1446; $v = 1 \text{ mm/min}$). The fracture deactivation threshold for error detection was set to 10% of the maximum force. The Mann-Whitney U-test was performed for statistical analysis ($p = 0.05$).



Typical failure pattern of veneering ceramic in one all-ceramic and one metal-ceramic restoration after fracture load testing.

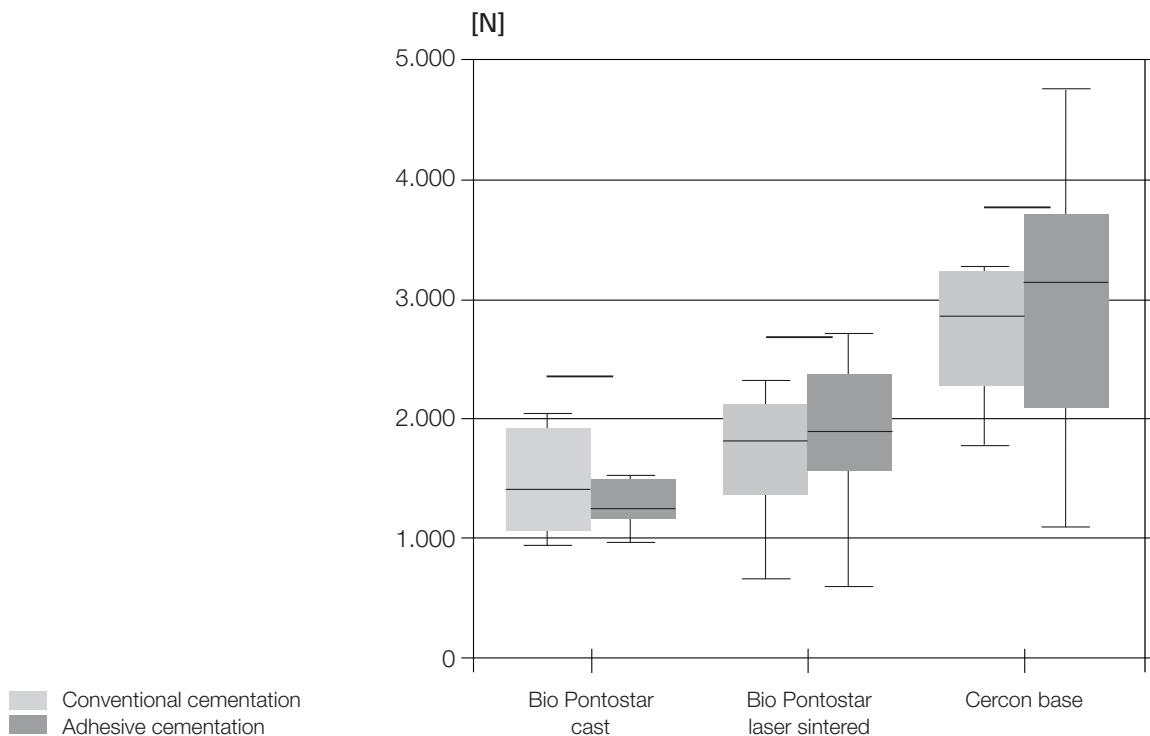
Results

| | Cast alloy | | Laser-sintered alloy | | Cercon | |
|----------------|------------|-------|----------------------|-------|---------|-------|
| | adhäsiv | konv. | adhäsiv | konv. | adhäsiv | konv. |
| Median | 1471 | 1221 | 1823 | 1875 | 2886 | 3097 |
| 25% percentile | 1141 | 1183 | 1410 | 1654 | 2288 | 2287 |
| 75% percentile | 1872 | 1515 | 2050 | 2199 | 3246 | 3622 |

Conclusions

Fracture strength values were highest for the zirconia restorations, followed by the restorations that featured laser-sintered frameworks, while the specimens with cast-alloy frameworks exhibited the smallest degree of fracture strength. Fracture strengths did not vary with the retention methods used.

Both the zirconia restorations fabricated with a CAM system and the laser-sintered metal-ceramic restorations fabricated by CAD/CAM exhibited suitable levels of fracture strength after artificial aging. Therefore both appear to be suitable options for use in the posterior segment.



Fracture strength of metal-ceramic and all-ceramic restorations

The box includes 50% of data and is delimited by the top and bottom quartiles. Horizontal bars indicate the median values (meaning that 50% of the values obtained are above and 50% are below this value).

Shear bond strength of zirconia-resin interfaces

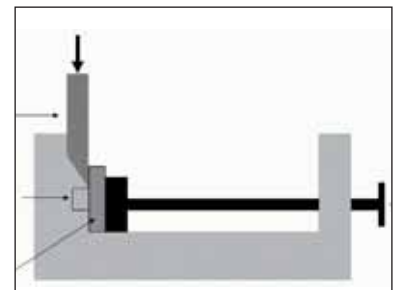
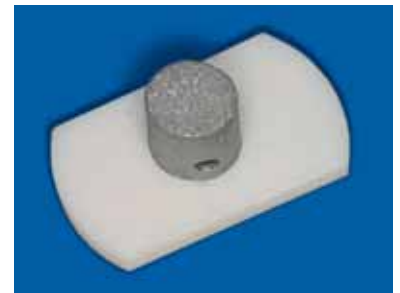
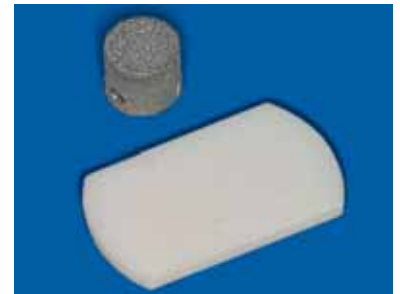
Behr M., Rosentritt M., Kolbeck C., Handel G.
Regensburg, Germany (2006)

Objectives

Conventional bonding techniques that were developed for feldspathic or glass ceramics have failed when bonding was required between zirconia and resins. The present study was performed to investigate the shear bond strength (SBS) of interfaces between zirconia and resin cement. Different adhesive concepts were used.

Methods

Plane-parallel zirconia objects (Cercon, DeguDent) were bonded to CoCr cylinders (5 mm in diameter and 3 mm high) on narrowly confined areas (5 mm in diameter). A resin cement was used for bonding. The interface was corundum-blasted with Al_2O_3 particles (110 μm , 2.8 bar, 10 s). Alloy Primer (Kuraray) was applied to all CoCr bonded surfaces. The following resin cements were applied, following manufacturers' recommendations with or without priming of the zirconia surface: Enacem (GDF): Tender Bond, Tender paste; Maxcem (Kerr): no primer; Panavia F 2.0 (Kuraray): no primer; Rely X Unicem (3M Espe): no Primer; Rely X Unicem plus silicoating with Rocatec. All cements were allowed to harden at 37 °C, protected from light. SBS values were determined after 24 hours of storage in water and 17 days of thermal cycling (12 000 cycles at 5 ° C/55°C). Cohesive versus adhesive fractures were distinguished and analyzed. Each group included 8 specimens. ANOVA was used for statistical analysis, including median values and standard deviations.



Fabrication of specimens to evaluate shear bond strength.

Results

| SBS [MPa] | Enacem Tender Bond | Maxcem | Panavia | Rely X Unicem | Rely X Unicem Rocatec |
|---------------|-----------------------|----------|----------|------------------|--------------------------|
| 24 hours | 20,1 ± 3 | 20,9 ± 5 | 23,5 ± 3 | 21,7 ± 4 | 27,8 ± 4 |
| Thermocycling | 18,7 ± 5 | 27,2 ± 6 | 19,9 ± 5 | 26,7 ± 5 | 26,9 ± 4 |

Shear bond strengths did not reveal any statistically significant differences after 24 hours of storage in water and after thermocyclic loading. Failure would occur on the ceramic side when Enacem, Maxcem or Panavia were used. All CoCr bonding surfaces were covered with a resin cement. Cohesive fractures were only observed in specimens bonded with Rely X Unicem, regardless of whether Rocatec was used in addition.

Conclusions

All resin cements investigated are potentially capable of successful bonding to zirconia.

Clinical success of zirconia bridges with overpressed ceramic veneers

Beuer F., Aggstaler H., Fischer T., Fick K., Schweiger J., Gernet W.
Munich, Germany (2006)

Objectives

This prospective study was performed to investigate the clinical success of metal-free bridges on zirconia frameworks that were veneered with a novel overpressing technique.

Materials and methods

A total of 12 three-unit bridges were investigated. The structures were used to replace single premolars or molars. Preparations were conducted in accordance with the manufacturer's recommendations. Following impression-taking with a polyether material, the restorations were fabricated on stone casts (Cercon smart ceramics, DeguDent, Hanau). Zirconia frameworks were used. A novel overpressing technique instead of conventional layering was used for veneering. A try-in was performed to adjust the occlusion, proximal contacts, colour and individual parameters. The bridges were then delivered with a glass-ionomer cement. Clinical examinations were performed 14 days and 12 months after insertion. A visual analogue scale (VAS) ranging from was used for patients and clinicians to rate their degree of satisfaction with the functional and aesthetic outcomes (lowest/highest rating: 0/10).



Overpressed Cercon framework after pressing.



Cercon bridge with overpressed veneering.

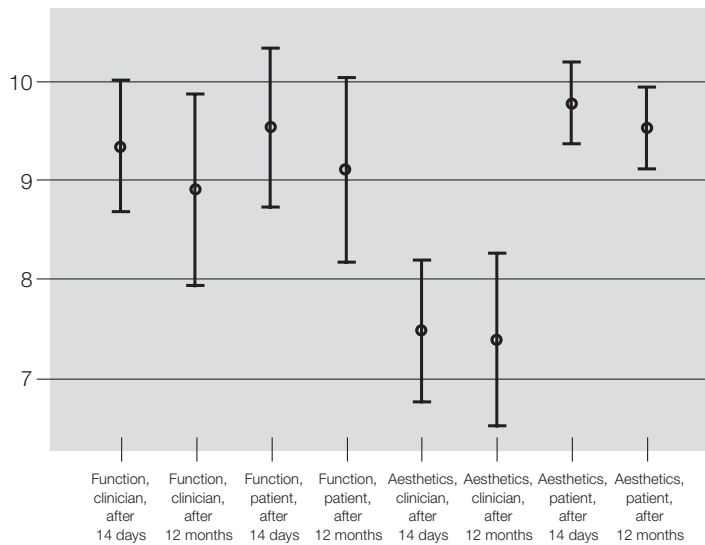
Results

No fractures or complications had occurred after 1 year. Thus the Kaplan-Meier survival estimate yielded a probability of survival of 100%. Plaque and bleeding parameters did not significantly change after treatment. Mean VAS scores for aesthetic outcome were 9.52 (SD: 0.873) as rated by patients and 7.39 (SD: 1.91) as rated by clinicians. This difference was statistically significant ($p = 0.001$, Wilcoxon's test). Mean VAS scores for functional outcome were 9.10 (SD: 2.02) as rated by patients and 8.90 (SD: 2.01) as rated by clinicians.

Conclusions

Within the limitations of a relatively short observation period, the use of posterior bridges with overpressed zirconia frameworks can be recommended. These restorations are advantageous because they offer both a perfect marginal fit and high aesthetics due to the ceramic shoulder. Patients have been satisfied with the functional and aesthetic outcomes. The clinical investigation will be continued, such that conclusions can be drawn about the long-term outcomes.

VAS (visual analogue scale) score



VAS scores for inserted PTC restorations (Cercon base/Cercon ceramic) as rated by clinicians and patients.

Effect of thermal cycling on bond strength of luting cements to zirconia ceramic

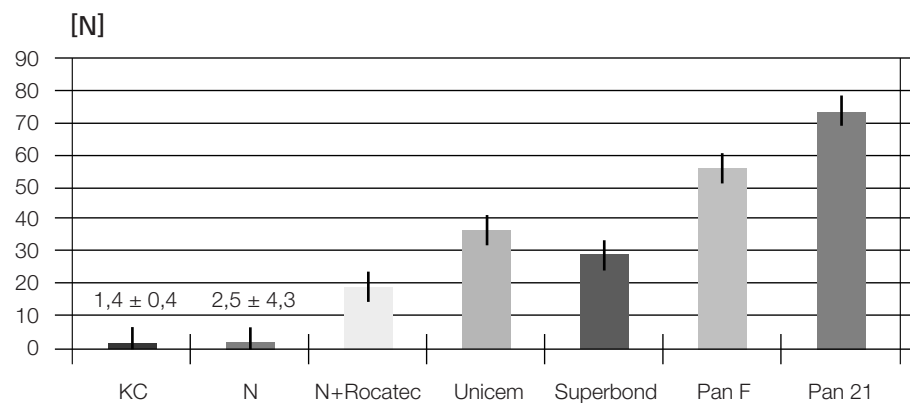
Lüthy H., Filser F., Loeffel O., Schumacher M., Gauckler L.J., Hämmerle C.H.F.
Zurich, Switzerland (2006)

Objectives

The aim of this study was to evaluate the shear bond strength of different cements to densely sintered zirconia ceramic after aging by thermal cycling.

Materials and methods

The following luting cements for bonding ZrO₂-TZP (tetragonal zirconia polycrystals) were used in this study: Ketac-Cem, Nexus, Rely X Unicem, Superbond C&B, Panavia F and Panavia 21. Groups of 30 test specimens were prepared by bonding stainless steel cylinders tribochemically silica-coated with the Rocatec-system to sandblasted ZrO₂-TZP ceramic disks (Cercon smart ceramics). Prior to testing all bonded specimens were stored in distilled water (37 °C) for 48 h and half of them (n = 15) were additionally aged by thermal cycling (10,000 times).



Shear strength of different cements on densely sintered zirconia after thermal cycling.

KC: Ketac-CEM

N: Nexus

N+Rocatec: Nexus + Rocatex

Unicem: Rely X Unicem

Superbond: Superbond C & B

Pan F: Panavia F

Pan 21: Panavia 21

Results

None of the fractures occurred at the interface of the metallic rods. The assemblies failed either at the interface between the ceramic surface and the cements or within the cements. Thermal cycling affected the bond strength of all luting cements studied except for both Panavia materials and Rely X Unicem.

Significance

Within the limits of this in vitro study the results showed that-after thermal cycling-bond strengths for Ketac-Cem and Nexus were quite low. Nexus in combination with tribochemical silica-coating of ceramic surface produced a higher bond strength. The four adhesive resin cements (Rely X Unicem, Superbond C&B, Panavia F and Panavia 21) gave superior results. The strongest bond to zirconia was obtained with Panavia 21.

Clinical success of all-ceramic extension bridges after 2 years of service

Rinke S.
Hanau, Germany (2006)

Objectives

A retrospective study was performed to evaluate the clinical success of all-ceramic extension bridges based on zirconia.

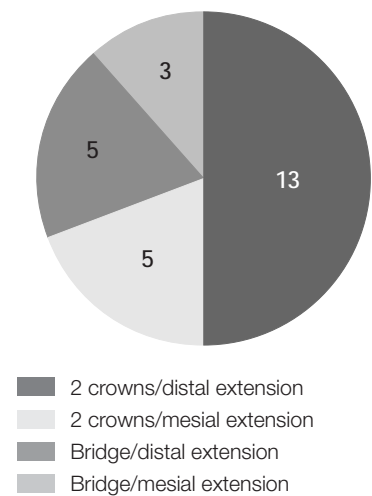
Methods

A total of 26 all-ceramic extension bridges made from yttria-stabilized zirconia (Y-TZP) were inserted in 21 patients between June 2002 and April 2004. The frameworks were fabricated with a CAM system (Cercon, DeguDent, Hanau). They were cemented following an intraoral trial phase of 2 weeks. The following evaluation parameters were selected base on modified Ryge criteria: loss of retention, framework fractures, cracks in the ceramic veneers, colour match, marginal integrity, postoperative sensitivity and assessment of aesthetic and functional treatment outcomes by the patients.

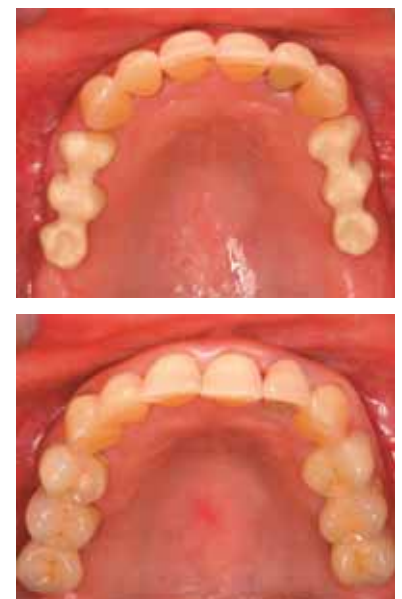
Results

The restorations were followed up for a mean of 629 days. No instances of retention loss or failure of the veneering ceramic occurred during that period. Framework fractures were not observed either. Thus the probability of success based on in-situ criteria was 100%. Colour match was rated alpha in 85% of restorations and bravo in 15%. Marginal integrity was rated alpha in 45 and bravo in 7 abutment teeth after 12 months. At total of 19 patients regarded the aesthetic outcome as excellent or very good. The quality of functional rehabilitation was reported to be excellent or very good by 18 patients. One abutment tooth required endodontic treatment, but there was no need to remove the restoration.

Distribution of inserted restorations



Total: 26 restorations
Patients: 21
Period: June 2002 to April 2004



Restoration of a bilateral cantilever situation with all-ceramic extension bridges.

Conclusions

These initial results with all-ceramic extension bridges do not indicate an increased risk of material-related failure. Nevertheless, a greater body of long-term data is needed before all-ceramic extension bridges can be generally recommended.

Patient-based assessment (n = 21)

| | Aesthetic outcomes | Functional rehabilitation |
|-----------|--------------------|---------------------------|
| Excellent | 16 | 14 |
| Very good | 3 | 4 |
| Good | 1 | 3 |
| Fair | 1 | 0 |
| Adequate | 0 | 0 |
| Poor | 0 | 0 |



Cercon three-unit extension bridge (36 months after insertion).

Fracture strength and marginal fit of all-ceramic bridges

Rosentritt M., Sikora M., Behr M., Handel G.
Regensburg, Germany (2006)

Objectives

This in-vitro study was performed to evaluate the fracture strength and marginal fit of three-unit all-ceramic bridges.

Methods

Human molars were embedded in PMMA resin, simulating a three-unit clinical situation (10 mm). The periodontium was simulated by covering the roots with a polyether layer (approximately 1 mm thick). Eight bridges from each series were fabricated: CAM system (Cercon base/Cercon ceramic kiss), electrophoretic precipitation of glass-infiltrable alumina ceramic (Inceram Alumina-Wolceram), and Al₂O₃ slurry technique (Inceram Alumina, Vita) as control group. All bridges were delivered with an adhesive bonding system (Syntac classic/Variolink 2; Ivoclar Vivadent). The restorations were evaluated for fracture strength (UTM 1446; Zwick; v = 1 mm/min) following thermal cycling and mechanical loading (TCML; 6000 × 5 °C/55 °C and 1.2 × 10⁶ at 50 N. The fracture deactivation threshold for error detection was set to 10% of the maximum force. Marginal fit was evaluated at the cement-tooth (CT) and cement-bridge (CD) interfaces by scanning electron microscopy (Stereoscan 240, Cambridge Instruments, UK) before and after TCML. The result was considered “perfect” when the interface was homogeneous without showing interruptions in continuity. The Mann-Whitney U-test was performed for statistical analysis (p = 0.05).

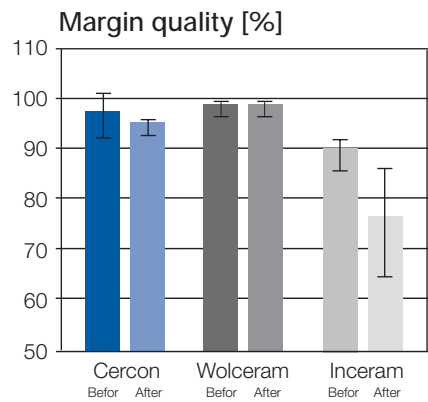
Results

| Fracture strength [N] (25 % /75 % percentile) | Cercon (1224/1428) | Wolceram (487/735) | Inceram (control) (315/673) |
|--|-----------------------|-----------------------|--------------------------------|
| Median | 1331 | 575 | 334 |
| Marginal fit [%] | | | |
| CT: before TCML | 95,5 (91,5/99,0) | 98,7 (96,8/99,3) | 91,3 (83,9/93,3) |
| after TCML | 98,0 (95,5/98,8) | 98,6 (96,8/99,6) | 86,9 (76,0/96,9) |
| CF: before TCML | 97,0 (90,3/100,0) | 98,4 (93,9/99,4) | 90,1 (86,3/92,3) |
| after TCML | 94,5 (87,8/98,0) | 97,9 (95,2/99,2) | 75,9 (69,1/89,8) |

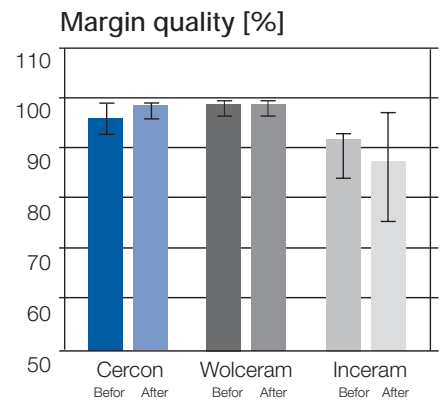
Conclusions

The fracture strength of CAM-fabricated zirconia bridges exceeded the strength of bridges fabricated from manually layered Al_2O_3 or by electrophoretic precipitation in a statistically significant fashion. Marginal fit was found to be significantly poorer only in the control group compared to the other groups.

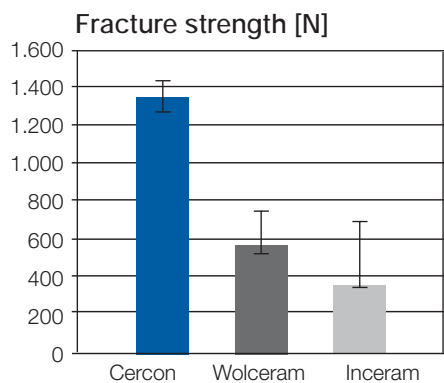
Bridge frameworks made from Al_2O_3 by electrophoretic precipitation should be used restrictively in the posterior segment. The zirconia bridges exhibited appropriate fracture loads and appear to be a promising option for clinical application.



Percentage of evaluated sites offering a "perfect" marginal fit before and after chewing simulation at the cement-bridge interface.



Percentage of evaluated sites offering a "perfect" marginal fit before and after chewing simulation at the cement-tooth interface.



Fracture strength of three-unit all-ceramic bridges after simulated chewing (columns indicate median values).

Literature

- 1) Beuer F., Erdelt K.J., Spiegl K., Gernet W.
Marginal and internal fit of CAM milled zirconia crowns.
J Dent Res 83 (Spec Iss A), Abstract 2949 (2004)
(www.dentalresearch.org)

Beuer F., Fick K., Erdelt K.J., Gernet W.
Marginale und innere Passung von CAM-gefrästen Zirkoniumoxid-
Einzelkronengerüsten bei unterschiedlichen Präparationswinkeln.
Dtsch Zahnärztl Z. Sep; 58(9): 517-21 (2003)
- 2) Beuer F., Erdelt K.J., Schweiger J., Eichberger M., Gernet W.
Flexural strength of coloured and aged zirconia.
J Dent Res 83 (Spec Iss B), Abstract CED 0113 (2004)
(www.dentalresearch.org)

Erdelt K.J., Beuer F., Schweiger J., Eichberger M., Gernet W.
Die Biegefestigkeit von weißkörpergefrästem Zirkonoxid.
In-vitro-Untersuchungen in Abhängigkeit von Einfärbung und künstlicher Alterung.
Quintessenz Zahntech 30, 942-954 (2004)
- 3) Chang J. Y., Yang J. H.
In-vitro marginal fit of the computer-aided milled Cercon crowns.
J Dent Res 84 (Spec Iss B) Abstract 0016 (Korean), (2004)
(www.dentalresearch.org)
- 4) Kilicarslan M.A., Kedici P.S., Kücükmen H.C., Uludag B.C.
In-vitro fracture resistance of posterior metal-ceramic and all-ceramic
inlay-retained resin-bonded fixed partial dentures.
J Prosthet Dent 92, 365-370 (2004)
- 5) Nishimura M., Miura H., Suzuki M., Morikawa O., Yoshida K., Matsumura M.
Bond strength of porcelain to yttria-stabilized tetragonal zirconia framework.
J Dent Res 83 (Spec Iss A), Abstract 1829 (2004)
(www.dentalresearch.org)
- 6) Rosentritt M., Behr M., Kolbeck C., Handel G.
Fracture strength of zirconia posterior fixed partial dentures.
J Dent Res 83 (Spec Iss B), Abstract CED 0110, (2004)
- 7) van der Zel J.M., Grinwis T., de Kler M., Tsadok Hay T.
Effect of shoulder design on failure load of PTCercon crowns.
J Dent Res 83 (Spec Iss A), Abstract 1371 (2004)
(www.dentalresearch.org)
- 8) Luethy H., Filser F., Loeffel O., Schumacher M., Gauckler L. J., Haemmerle C. H. F.
Strength and reliability of four-unit all-ceramic posterior bridges.
Dental Materials 21, 930-937 (2005)

- 9) Ludwig K., Uphaus A., Kern M.
Fracture strength of all-ceramic posterior inlay-retained fixed partial dentures (FPDs).
J Dent Res 84 (Spec Iss A), Abstract 0428 (2005)
(www.dentalresearch.org)
- 10) Quass A. C., Yang B., Kern M.
Resin bonding to contaminated zirconia ceramic after different cleaning procedures.
J Dent Res 84 (Spec Iss A), Abstract 0228 (2005)
(www.dentalresearch.org)
- 11) Rödiger M., Wehle J., Rinke S., Hüls A.
Prospektive klinische Langzeitstudie zur Bewährung drei- und viergliedriger
Cercon-Seitenzahnbrücken.
DGZMK-Jahrestagung, Posterpräsentation P-128. Dtsch Zahnärztl Z 60,
(Suppl) A147 (2005)
- 12) Rinke S.
Clinical performance of zirconia-based implant abutments: 24 months results.
Abstract number P-65, 20th Meeting of the Academy of Osseointegration,
Orlando 2005
- 13) Thaller C., Rosentritt M., Behr M., Handel G.
Fracture resistance of zirconia-ceramic, laser-sintered and cast alloy molar crowns.
Dent Res 84 (Spec Iss A), Abstract 0556 (2005)
(www.dentalresearch.org)
- 14) Behr M., Rosentritt M., Kolbeck C., Handel G.
Shear bond strength of the zirconia/resin interface.
J Dent Res 85 (Spec Iss B), Abstract AADR 0345 (2006)
(www.dentalresearch.org)
- 15) Beuer F., Aggstaler H., Fischer T., Fick K., Schweiger J., Gernet W.
Clinical performance of zirconia bridges veneered by pressable ceramics.
J Dent Res 85 (Spec Iss B), Abstract AADR 0268 (2006)
(www.dentalresearch.org)
- 16) Luethy H., Loeffel O., Haemmerle C.H.F.
Effect of thermocycling on bond strength of luting cements to zirconia ceramic.
Dental Materials 22, 195-200 (2006)
- 17) Rinke S.
Klinische Bewährung von vollkeramischen Extensionsbrücken: 2-Jahres-Ergebnisse.
Quintessenz 57, 129-136 (2006)
- 18) Rosentritt M., Sikora M., Behr M., Handel G.
Fracture strength and Marginal Adaptation of all-ceramic FPDs.
J Dent Res 85 (Spec Iss B), Abstract AADR 1879 (2006)
(www.dentalresearch.org)



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