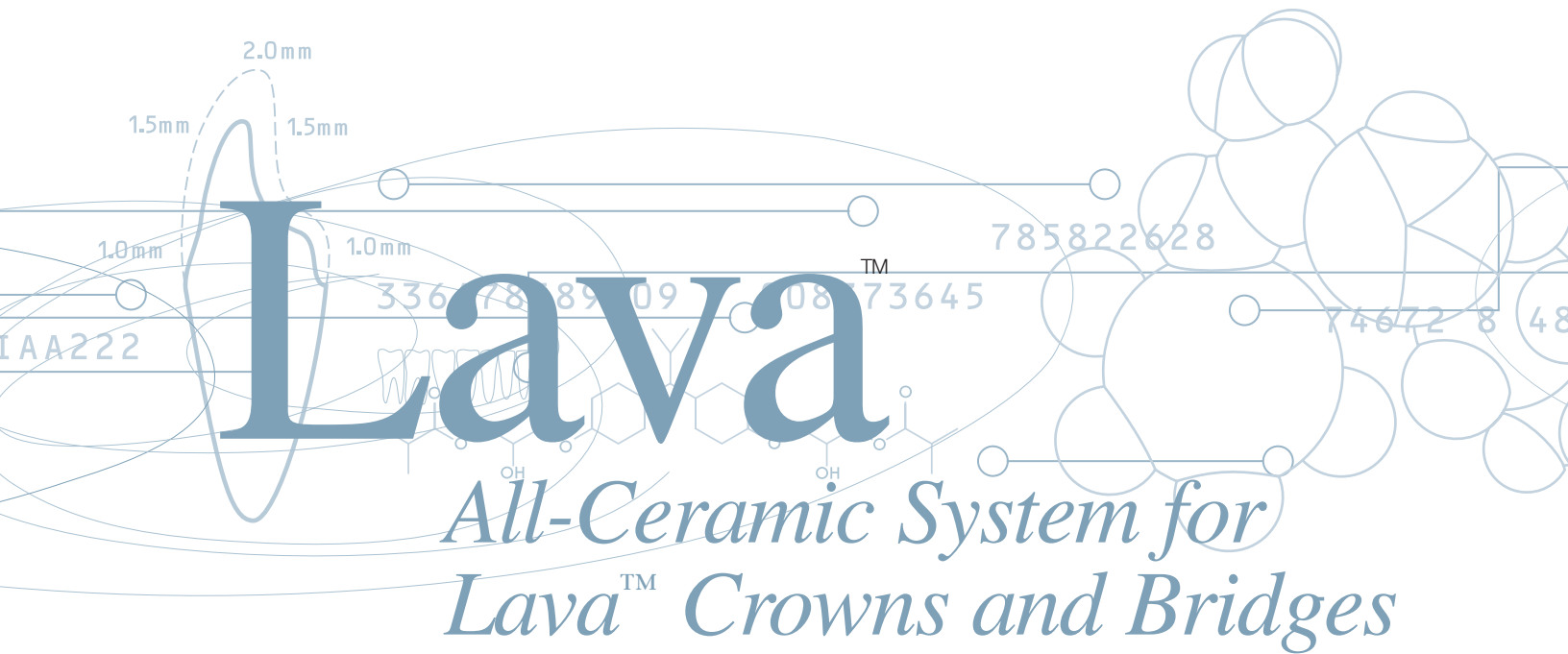


**3M** ESPE

A collection of scientific results



The graphic features the word "Lava" in a large, dark blue serif font. To the left of the "L" is a diagram of a crown with dashed lines and labels: "2.0mm" at the top, "1.5mm" on the sides, and "1.0mm" at the bottom. To the right of the "Lava" text is a diagram of a bridge with labels: "785822628" above it, "336788909" and "0873645" below it, and "74672 8 48" further to the right. Below the "Lava" text is a chemical structure diagram showing a chain of atoms with hydroxyl groups (OH). The background is white with faint, light blue geometric and molecular patterns.

**Lava**<sup>TM</sup>

*All-Ceramic System for  
Lava<sup>TM</sup> Crowns and Bridges*

83st IADR Meeting,  
Baltimore, USA, March 2005

ADM Meeting  
Geneva, Switzerland, October 2004

CED/NOF/ID Joint Meeting  
Istanbul, Turkey, August 2004

82st IADR Meeting  
Honolulu, Hawaii, USA, March, 2004

81st IADR Meeting  
Göteborg, Sweden, June, 2003

AADR/CADR Annual Meeting  
San Antonio, TX, USA, March, 2003

IADR/BSDR/CED  
Cardiff, UK, September, 2002

79th IADR Annual Meeting  
Chiba, Japan, June 2001

79th AADR/CADR General Session and Exhibition  
Chicago, IL, USA, March 2001

78th IADR/AADR/CADR General Session and Exhibition  
Washington, DC, USA, April 2000

Dear Reader,

With the introduction of Lava™ all-ceramic system for Lava Crowns and Bridges in 2001, 3M™ ESPE™ has made a substantial contribution to the exciting and steadily increasing market of all-ceramic dentistry and CAD/CAM technology. Since then the outstanding material properties of the Lava™ ceramic (Y-TZP framework and the overlay veneering porcelain) and the technological advantages of the Lava™ system have convinced the dental profession. Many well-known universities and scientific institutions have performed in vitro and in vivo studies showing excellent mechanical and optical characteristics of Lava Crowns and Bridges as well as very good clinical performance.

In this issue we have summarized the most important results from in vitro and in vivo studies which have been presented since 2000 on international conferences.

We very much hope the clinical results presented in this booklet will serve as a valuable source of information and as a basis for further discussion. Please feel free to contact us any time.

Yours sincerely,



Dr. Anke Behrens  
Scientific Affairs Manager  
3M ESPE AG  
ESPE Platz  
82229 Seefeld



Dr. Berthold Reusch  
Technical Marketing Manager  
3M ESPE AG  
ESPE Platz  
82229 Seefeld

### Lava™ All-Ceramic System for Lava™ Crowns and Bridges

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# 0560

### Fractographic Analysis and Material Properties of a Dental Zirconia

J.B. QUINN<sup>1</sup>, D. CHENG<sup>1</sup>, R. RUSIN<sup>2</sup>, and D. SUTTON<sup>2</sup>, <sup>1</sup> American Dental Association Foundation, Gaithersburg, MD, USA, <sup>2</sup> 3M ESPE Dental, St. Paul, MN, USA

Y-TZP zirconia is among the newest ceramics used in fabricating dental restorations. It is important to characterize the strength-limiting features this new class of dental materials.

**Objectives:** To determine the failure origins and material properties of a dental zirconia.

**Methods:** Y-TZP zirconia 3x4x45mm bend bars (n=39) were broken in four-point flexure in a 20mm inner- and 40mm outer-span fixture (ASTM C1161). The large number of specimens and long span lengths exposed a large flaw distribution to high stresses. Specimen fracture surfaces were examined both optically and by SEM to determine mirror sizes (n=8) and fracture origins (n=25) (ASTM C1322). Some broken bars were used for Knoop hardness tests at 2kg (n=9)(ASTM C1326) and SEVNB tests for fracture toughness (n=4)(CEN/TS 14425-5). One intact bar was saved for elastic modulus determination by impulse excitation (n=10 measurements)(ASTM C1259).

**Results:** All of the examined specimens broke from intrinsic, volume distributed flaws, ranging in size from approximately 10 to 50 microns. Most origins consisted of regions with different pore densities. One specimen failed from an internal inclusion. Mirror boundaries were difficult to delineate, but a mirror constant of about 10.8 MPa-m<sup>1/2</sup> was determined. The Knoop hardness was 11.2±0.2 GPa, toughness was 11.0±0.4 MPa-m<sup>1/2</sup>, modulus 216±2 GPa and mean strength 1066±131 MPa.

	4-point Flexural Test	Knoop Hardness	E-modulus	Toughness
values	1066±131 MPa	11.2±0.2 GPa	216±2 GPa	11.0±0.4 MPa-m <sup>1/2</sup>

**Conclusions:** Fractography enabled the strength-limiting flaws in a dental zirconia to be determined. The flaws were small and consistent with the high strength of this material. Three-point tests with a much smaller area under maximum stress would be expected to result in even higher mean strength values. Supported by ADAF, NIST and NIH DE14534.

**Aim of the Study:** The aim of the study was to determine the material properties of Lava™ zirconium oxide.

**Results of the Study:** Lava™ zirconium oxide shows excellent material properties. The flexural strength as well as the toughness of Lava™ zirconium oxide was shown to be very high.

# 2910

### Material Properties of All Ceramic Zirconia Prostheses

H. HAUPTMANN\*, D. SUTTOR, S. FRANK, H. HOESCHELER, 3M ESPE AG,  
82229 Seefeld, Germany

Yttria stabilized tetragonal zirconia ( $ZrO_2$ ) is currently investigated as a potential candidate for high performance all ceramic dental restorations due to its outstanding mechanical properties, its aesthetic appearance and its proven biocompatibility. In combination with suitable CAD/CAM systems and optical scanner devices precision fit prostheses can be realized, starting from conventional plaster models. As part of this ongoing work, a material data profile for the zirconia used has been established, including data on mechanical properties such as strength, reliability, toughness and subcritical crack growth (i.e. lifetime prediction), optical properties such as opacity and venerability. The material used was a three mole %  $Y_2O_3$  doped zirconia, yielding a predominantly tetragonal fine grained microstructure. Test bars were measured in three-pt. bending (15/30mm setup, test bars 3\*4\*35mm), which were also used for fracture toughness measurements (resistance to crack propagation), using a modified indentation technique. Reliability (failure probability as a function of load) was determined using well established Weibul statistics as common in the ceramics field, subcritical crack growth by a dynamic loading method. Lifetime prediction (in vitro) was made based on Weibul and crack growth data. Opacity was measured as a function of sample thickness using DIN procedures (DIN 53146). Three-pt bending strength ( $\sigma_0$ ) was determined to be 930 MPa with a Weibul modulus (m) of 9.8. Fracture toughness ( $K_{Ic}$ ) was 5 MPa  $m^{1/2}$ . Average fracture force as evaluated on simple bridge designs (three units) was 1650N connector cross section of 7.8mm<sup>2</sup>). The subcritical crack growth parameter (n) was 50, indicating minor susceptibility to slow crack growth. Opacity of dense materials (> 99% TD) was 85% (1.5mm) 65% (0.5mm), respectively. Preliminary lifetime predictions showed a failure rate of 2% after 5 years at a load of 450 MPa. The material was readily venerable with conventional systems without cracks or chipping at the interface.

**Aim of the Study:** The Lava™ zirconium oxide ceramic was evaluated with regard to all relevant dental ceramic properties and a preliminary lifetime prediction was deduced.

**Result of the Study:** The Lava™ zirconium oxide material shows outstanding mechanical and optical properties for the use as dental restoration material. Moreover, due to the very positive lifetime prediction, the fabrication of posterior bridges with Lava™ zirconium oxide material is possible.

### 0562

**Masticatory Fatiguing Effects on a Yttria-Stabilized Zirconia Ceramic**  
 A.R. CURTIS, and G.J. FLEMING, University of Birmingham, United Kingdom

**Objectives:** To examine the influence of simulated masticatory loading regimes on the strength of a yttria-stabilized zirconia (Y-TZP, Lava™ zirconium oxide, 3M™ ESPE™) ceramic.

**Methods:** Sixteen sets of 30 ceramic discs (13mm diameter, 1.55mm thickness) were selected. Six groups were fatigued for 2000 cycles at masticatory loads of 500, 700 and 800N either dry or immersed in water at 37±1°C during fatiguing. A further two groups were fatigued to a maximum load of 80N for 10,000 and 100,000 cycles. Mean fracture strengths, standard deviations and associated Weibul moduli (m) were determined and the surface hardness was assessed utilising Vickers Hardness indentations. The strength and hardness were assessed for significance at the 95% level using Tukey test comparisons.

**Results:** A significant increase in m was identified for specimens fatigued dry at 700 and 800N (13.2±2.4, 12.0±2.2) and wet at 500, 700 and 800N (8.6±1.6, 8.5±1.6 and 10.8±1.9) compared with the dry and wet controls (7.5±1.4 and 7.1±1.3). Extended fatiguing regimes to 80N at 10,000 and 100,000 cycles also highlighted a significant increase in m. The hardness results highlighted a significant increase in Vickers hardness number of specimens fatigued wet and dry (p<0.05) in the vicinity of the area of localised fatigue.

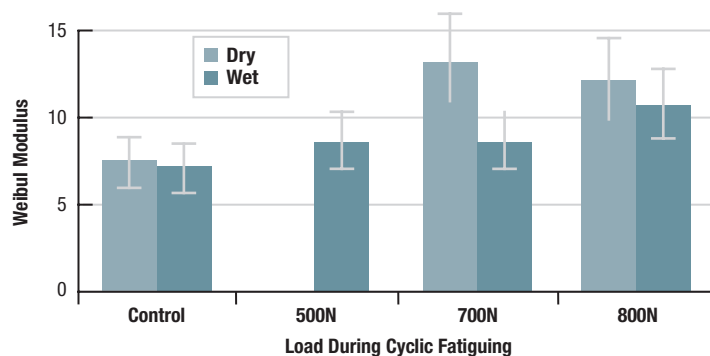
	Control	500N 2000 Cycles	700N 2000 Cycles	800N 2000 Cycles
Weibul modulus (dry)	7.5±1.4	—	13.2±2.4	12.0±2.2
Weibul modulus (wet)	7.1±1.3	8.6±1.6	8.5±1.6	10.8±1.9

**Conclusions:** The evaluation of bi-axial flexure strength data identified that the fatiguing regimes did not significantly influence the bi-axial flexure strength of the ceramic specimens. The reliability was increased following fatiguing regimes as a result of the formation of a layer of compressive stresses counteracting tensile failure prior to failure and this was confirmed by the Vickers hardness results. Moisture contamination was not identified to have a detrimental influence on the ceramic examined.

The Figure shows the increasing reliability of Lava™ zirconia with cyclic fatiguing. The Weibul modulus is an indication of the reliability of a ceramic material.

**Aim of the Study:** The influence of masticatory loading on the strength of Lava™ zirconium oxide was analyzed.

**Results of the Study:** The fatiguing by cyclic loading did not significantly influence the strength of Lava™ zirconium oxide and also moisture was not identified to have a detrimental influence which underlines the long term stability of the material. Moreover, the reliability of the Lava™ zirconium oxide was even increased by fatiguing.



### 0243

#### Fracture Strength of Colored versus Uncolored Zirconia Specimens

A. BEHRENS, B. REUSCH, and H. HAUPTMANN, 3M ESPE AG, Seefeld, Germany

**Objectives:** The objective of this study was to show that the fracture strength of the Y-TZP core material Lava™ (3M™ ESPE™) is not effected by staining the zirconia core material with Lava shading liquid. Many in vitro studies in recent years with Yttrium oxide stabilized zirconia (Y-TZP) proved its superior material properties especially concerning strength and long-term stability as well as outstanding optical properties allowing high aesthetic results. However, by dying the zirconia core material the aesthetic of the overall restoration can considerably be improved by avoiding white margins. Additionally, the tooth preparation can be designed even less minimal invasive due to the advantage that an opaque layer can be omitted. The challenge is to ensure the same strength of the stained zirconia material.

**Methods:** In a biaxial bending test (punch on three balls) the fracture strength and Weibul parameters of Y-TZP specimens differently colored with shading liquid were determined. Uncolored specimens of Y-TZP served as control. The specimen diameters were 19mm and the thickness 1.5mm. The outer diameter circle measured 14mm, whereas the loading punch had a diameter of 3.5mm. For each color and control respectively 10 to 15 specimens were tested.

#### Results:

Shade	Fracture Strength (MPa)	Weibul Modulus
Uncolored Y-TZP	1115	12.7
Color FS1	1273	15.6
Color FS3	1034	11.6
Color FS4	1045	14
Color FS5	1182	10

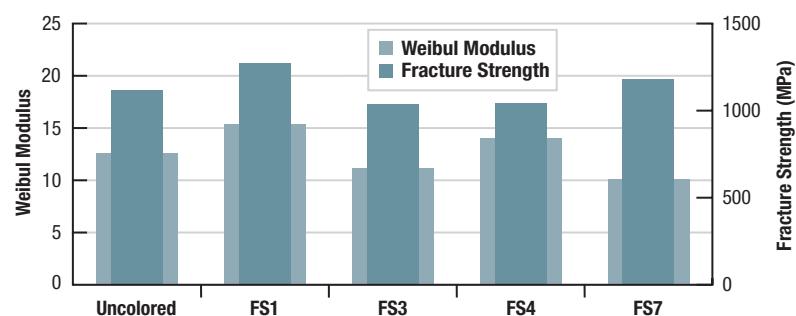
There is no significant reduction of the fracture strength and the Weibul modulus between the uncolored and stained core material. The values of the Weibul modulus stay above  $m=10$  indicating a low strength variation.

**Conclusions:** There is no loss of long term stability by staining the restorations, but a high aesthetic outcome which is further underlined by clinical cases.

**Aim of the Study:** The aim of this study was to show that the fracture strength of Y-TZP Lava™ zirconium oxide is not effected by staining the material.

**Result of the Study:** There is no significant reduction of the fracture strength and Weibul modulus of Y-TZP Lava™ zirconium oxide by staining the material.

Fracture Strength of Colored versus Uncolored Zirconia Specimens





1339

## Alumina Abrasion and Grinding Effects on Yttria-Stabilized Zirconia Ceramic

G.J.P. FLEMING<sup>1</sup>, A.R. CURTIS<sup>1</sup>, and P.M. MARQUIS<sup>2</sup>, <sup>1</sup> University of Birmingham, United Kingdom, <sup>2</sup> The University of Birmingham, United Kingdom

**Objectives:** To examine the pre-cementation and crown adjustment techniques (alumina abrasion and grinding) in dry and wet environments on yttria-stabilized tetragonal-zirconia-polycrystalline (Y-TZP, Lava™ zirconium oxide, 3M™ ESPE™) specimens.

**Methods:** Twelve groups of 30 discs (13mm diameter, 1.55mm thickness) were used. Eight groups were abraded with 25, 50 or 110µm alumina for 5s at 2cm and 4.8bar. Four groups were stored dry and four wet for 24h. Four groups were ground with high-speed diamond burs with fine (20–40µm) and coarse (125–150µm) grit sizes either dry or under water-spray. Mean bi-axial fracture strengths, standard deviations and associated Weibul moduli (m) were determined. Surface roughnesses were assessed using profilometry and the results were assessed for significance at the 95% level using Tukey test comparisons.

**Results:** A significant increase in m was identified for the 25, 50 and 110µm abraded specimens stored dry (10.7±1.9, 10.6±1.9 and 10.6±1.9) compared with the control (7.5±1.3) and specimens stored wet. Coarse grinding identified a significant decrease in m and mean bi-axial flexure strength of dry specimens (6.2±1.1 and 1057±179MPa) and under water-spray (5.7±1.0 and 1074±193MPa) compared with the control (7.5±1.3 and 1267±161MPa). Increasing from 25 to 50 and 110µm alumina resulted in a decrease in surface roughness (Ra=0.1965, 0.1902 and 0.1849) whilst grinding resulting in a significant increase (p<0.05) in surface roughness (1.736 and 1.967) compared with the control (0.2144).

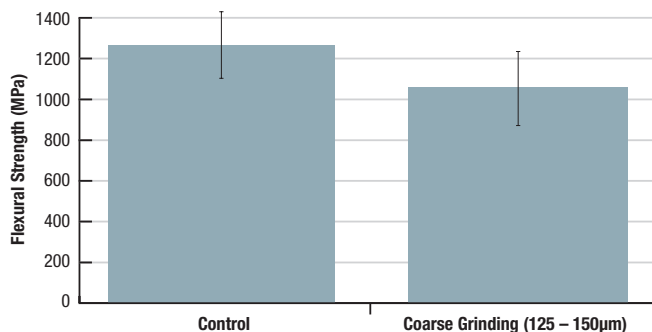
	Control	Abrasion 25µm	Abrasion 50µm	Abrasion 110µm	Grinding Fine	Grinding Coarse
Weibul Moduli (dry)	7.5±1.3	10.7±1.9	10.6±1.9	10.6±1.9	8.2±1.5	6.2±1.1
Weibul Moduli (wet)	7.1±1.3	7.7±1.4	7.8±1.4	9.6±1.8	8.3±1.5	6.2±1.1

**Conclusions:** Pre-cementation and crown adjustment techniques such as alumina abrasion and fine grinding did not significantly influence the bi-axial flexure strength of the Y-TZP ceramic specimens. However, the specimen reliability was increased following dry alumina abrasion potentially as a result of the modification of the defect population manifested as a reduction in the surface roughness. Coarse grinding regimes induced an increased population of larger defects with an increased surface roughness resulting in premature specimens fracture.

**Aim of the Study:** The influence of sandblasting (Alumina abrasion) or grinding on the strength of Lava™ zirconium oxide was analyzed.

**Result of the Study:** Pre-cementation and crown adjustment techniques (sandblasting or grinding with a fine bur) does not effect the high strength of Lava™ zirconium oxide (>1200 MPa). However, coarse grinding (125–150µm) may decrease the strength.

**Flexural Strength of Lava™ Zirconia without Treatment and After Coarse Grinding**



### 0558

#### Fracture Strength of Sandblasted and Silicatised Colored and Non-colored Zirconia

A. BEHRENS, H. NESSLAUER, and H. HAUPTMANN, 3M ESPE AG, Seefeld, Germany

**Objectives:** To get a chemical bonding between adhesive resin cements and zirconia, zirconia is first sandblasted followed by tribochemical silicatisation and silanisation of the ceramic material. In the first two procedures the material is bombarded with small particles of non-coated and coated Aluminium oxide. The aim of this study was to show that there is no strength reduction of colored and non-colored zirconia (Lava™, 3M™ ESPE™) due to the sandblasting or silicatisation process. In addition, the ceramic is tribochemically silicatised which could be shown by SEM, despite the high Vickers hardness of zirconia.

**Methods:** 60 zirconia discs were divided in two groups of 30 specimens each (1.5mm width, 19mm diameter), which were either sandblasted (Rocatec™ Pre, 110µm, 3M™ ESPE™) or silicatised (Rocatec™ Soft, 30µm, 3M™ ESPE™) with half of them (n=15) colored and half non-colored. In a biaxial bending test the fracture strength and Weibul parameters were determined (punch on three balls, Zwick Z020). The outer diameter circle was 14mm, whereas the loading punch diameter measured 3.5mm. The fracture strength was compared with uncolored and non-treated discs as control group.

**Results:** There is a significant increase in strength of the non-colored silicatised (Rocatec™ Soft) samples compared to the control, but no significant difference between the control and the remaining groups could be measured (Nonparametric ANOVA, Kruskal-Wallis test, p<0,05, Dunn's Posttest).

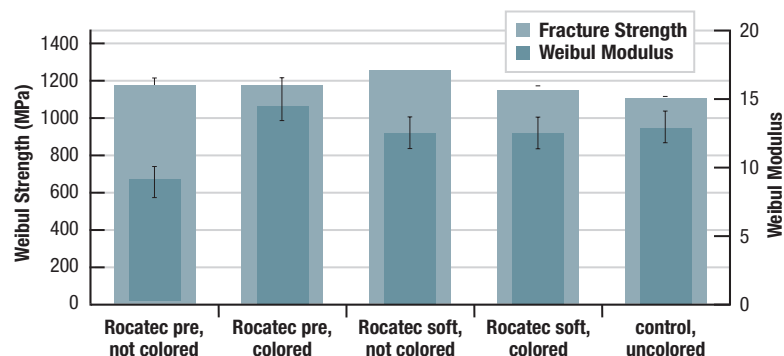
	Rocatec™ pre, not colored	Rocatec™ pre, colored	Rocatec™ soft, not colored	Rocatec™ soft, colored	Control uncolored
Weibul strength (MPa)	1197,6	1199,4	1249,3	1181,5	1115
Weibul modulus	8,98	14,6	12,6	12,52	12,7

Additionally, the surface analysis by SEM of the silicatised specimens showed a successful tribochemical reaction on the Zirconium oxide material.

**Conclusions:** There is no strength reduction of zirconia by sandblasting and silicatisation with the indicated grain sizes. Moreover, zirconia can tribochemically be coated by silicium oxide (Rocatec™ Soft).

**Aim of the Study:** The aim of the study was to show that there is no strength decrease of colored or uncolored Lava™ zirconium oxide due to sandblasting or silicatisation (Rocatec™ treatment).

**Results of the Study:** The strength of Lava™ zirconium oxide is not significantly reduced by sandblasting or Rocatec™ treatment.



# 1757

### Flexural Strength of High-Strength Ceramics after Sandblasting

J.L. CHAPMAN<sup>1</sup>, D.A. BULOT<sup>2</sup>, A. SADAN<sup>1</sup>, and M.B. BLATZ<sup>1</sup>, <sup>1</sup> Louisiana State University, New Orleans, USA, <sup>2</sup> Louisiana State University, Health Sciences Center School of Dentistry, New Orleans, USA

Sandblasting is the method of choice to pretreat high-strength-ceramic restorations for cementation. The effect of sandblasting on the fracture strength of those materials is widely discussed, but evidence is lacking.

**Objectives:** To evaluate the flexural strength of high-strength ceramic materials after sandblasting.

**Methods:** 60 specimens (n=10) were fabricated from the high-strength ceramic materials Procera® Allceram (Nobel Biocare, Group PROCER) Procera® AllZirkon (Nobel Biocare, Group PROZIR), Lava™ zirconia (3M™ ESPE™, Group LAVZIR) and their system-specific intaglio surface was left untreated (NO) or sandblasted (SAND) with 60micron aluminum-oxide particles (2.9bar). Three-point bending test was used to evaluate yield strength and ANOVA for statistical analyses ( $\alpha=0.05$ ).

**Results:** Mean flexural strength and SD were [MPa]: PROCER-NO 277.1±27<sup>a</sup>, PROCER-SAND 309.5±64<sup>a</sup>, PROZIR-NO 536.4±82<sup>b</sup>, PROZIR-SAND 564.7±142<sup>b</sup>, LAVZIR-NO 751.9±83<sup>c</sup>, LAVZIR-SAND 819.7±129<sup>c</sup>.

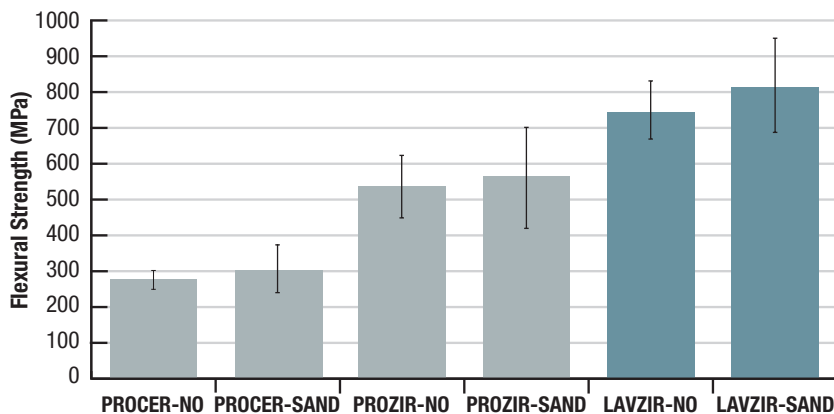
	PROCER-NO	PROCER-SAND	PROZIR-NO	PROZIR-SAND	LAVZIR-NO	LAVZIR-SAND
Flexural strength (MPa)	277.1	309.5	536.4	564.7	751.9	819.7
SD	27	64	82	142	83	129

**Conclusions:** Sandblasting had no significant effect on the flexural strength of the high-strength ceramic materials, and even slightly increased their flexural strength.

**Aim of the Study:** The aim of the study was to show that sandblasting has no effect on the strength of Lava™ zirconium oxide.

**Results of the Study:** The flexural strength of the high strength ceramic material zirconium oxide is not effected by sandblasting. Moreover, Lava™ zirconium oxide shows a higher strength compared to other high strength ceramics available on the market.

**Flexural Strength of Different High Strength Ceramics Untreated (as milled, NO) and After Sandblasting (SAND; Procera® Allceram = PROCER, Procera® AllZirkon = PROZIR, Lava™ Zirconia = LAVZIR)**



### 0545

#### Effect of Some Parameters on Silica-Deposition on a Zirconia Ceramic

M. ÖZCAN<sup>1</sup>, L. LASSILA<sup>2</sup>, J. RAADSCHELDERS<sup>1</sup>, J.P. MATINLINNA<sup>2</sup>, and P. VALLITTU<sup>2</sup>,

<sup>1</sup> University of Groningen, Netherlands, <sup>2</sup> University of Turku, Finland

**Objectives:** In order to establish strong bond of resin cements to non-etchable ceramics, silica-coating using air-abrasion devices is advised (Özcan et al. Dent Mater, 2003). Particle deposition techniques work as a function of various parameters. This study evaluated the effect of nozzle distance, angle and deposition duration on the silica content on zirconia ceramic.

**Methods:** Disc shaped (10mm diameter, 2mm thickness) ceramics (LAVA™, 3M™ ESPE™) were obtained and wet ground finished to #600, 800 and 1200 grid in sequence and ultrasonically cleaned. The specimens were mounted in a specially designed apparatus with which nozzle distance (2, 5, 10mm) and angle were standardized. Particle deposition was performed using chairside silica-coating system (CoJet, 30µm SiOx, 3M™ ESPE™) for a period of 5, 13, 20 s at two nozzle angles (90° and 45°) under the pressure of 2.5 bar at three locations on each ceramic disc. Silica content in weight percentage (wt%) were measured from the surfaces using Scanning Electron Microscopy (SEM) (Model JSM 5500, JEOL Ltd, Japan) and Energy Dispersive X-ray Spectroscopy (EDS) analyses (Spirit, Princeton Gamma-Tech Inc., USA). The analysis were performed under x150 magnification where measurements were made at an area of 0.8x0.6mm (n=3/group).

**Results:** The highest silica deposition was obtained under 45° nozzle angle at all distance-time modes (16.7–28.2 wt%) that was significantly higher (P<0.05) than those of the same distance-time application modes under 90° nozzle angle (11.8–12.8 wt%) (ANOVA, Tukey's test, α=0.05). Not only SiOx but also Al2O3 traces were found on the surfaces.

**Conclusions:** When particle deposition techniques are employed clinically, parameters like nozzle distance, angle and duration should be cautiously controlled to achieve sufficient silica on zirconia ceramics prior to cementation.

**Aim of the Study:** Optimal conditions for silicatisation of Lava™ zirconium oxide with the Cojet system was determined.

**Results of the Study:** Highest silicatisation could be achieved by carefully controlling the angle (45°) of the particle beam to the sample, whereas the treatment duration and distance of the nozzle had only a minor effect.

### 3032

#### Surface Roughness of Stabilized Zirconia Ceramics After Different Polishing Treatments

J. FRUGE, N. POTIKET, A. RAIGRODSKI, S. VASTARDIS, and N.K. SARKAR,  
Louisiana State University, New Orleans, USA

**Objectives:** The purpose of this study was to measure the surface roughness of a stabilized zirconia dental ceramic after different finishing procedures.

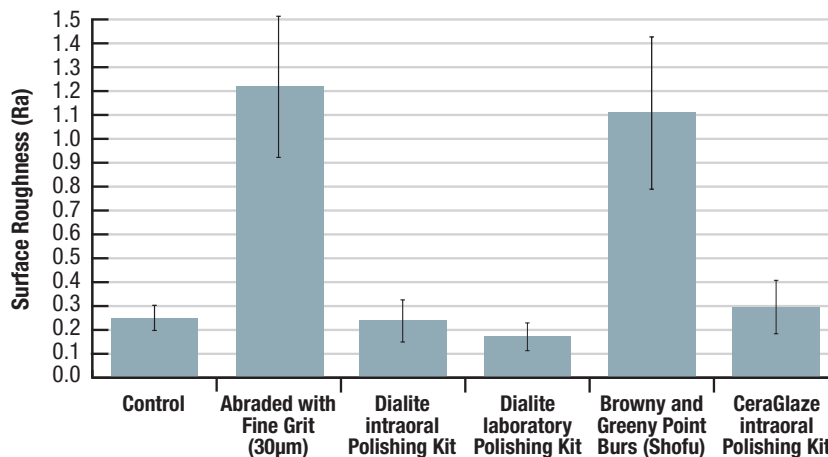
**Methods:** Sixty Y-TZP ceramic blocks, 5\*5\*2mm, received from its manufacturer (3M™ ESPE™) were divided into six groups (n=10). Group A, as received (control); all others were initially abraded with fine grit (30µm) diamond burs (Brassler) and then polished with the following: (B) as abraded, no polishing, (C) Dialite intraoral polishing kit (Brassler), (D) Dialite laboratory polishing kit, (E) brownny and greeny point burs (Shofu), and (F) CeraGlaze intraoral polishing kit (Axis). Five roughness (Ra) measurements were carried out in each block using a profilometer. The data was analyzed by ANOVA and Tukey's Multiple Comparison test at p<.05.

**Results:** The means and standard deviation for Ra values for different groups were the following: A: 0.249±0.053, B: 1.218±0.3, C: 0.236±0.088, D: 0.170±0.055, E: 1.105±0.32, F: 0.293±0.11. Significant (p<.001) differences existed between experimental groups with respect to their Ra values. Abrading control blocks with diamond bur (Group B) significantly increased surface roughness. With the exception of E, all other polishing methods (C, D and F) restored the roughened surfaced to the original smoothness of the control as received block A.

**Conclusions:** Commercial polishing kits such as Dialite intraoral, Dialite laboratory and CeraGlaze have the ability to polish roughened Y-TZP ceramics to a smooth (Ra 0.170 to 0.293) finish. Supported by 3M ESPE.

**Aim of the Study:** The aim of the study was to measure the surface roughness of Lava™ zirconium oxide ceramic after different finishing procedures.

**Results of the Study:** Commercial polishing kits such as Dialite intraoral, Dialite laboratory and CeraGlaze have the ability to polish roughened Lava™ zirconium oxide to a smooth (Ra 0.170 to 0.293) finish.



### 0555

#### In-Vitro Fracture Resistance of Four-Unit All-Ceramic Fixed Partial Dentures

M. STIESCH-SCHOLZ, P. SCHNEEMANN, and L. BORCHERS, Medical University of Hannover, Germany

**Objectives:** The aim of this in-vitro study was to compare the fracture resistance of posterior four-unit zirconium dioxide and lithium disilicate ceramic fixed partial dentures (FPDs). The influence of specific preliminary mechanical damage as well as artificial aging by way of cyclic thermomechanical loading on the fracture resistance was also to be analyzed.

**Methods:** In the plastic model of an upper jaw, teeth 24 and 27 underwent a chamfer type preparation and were duplicated using polyurethane-based resin. 40 sets of four-unit FPDs were manufactured from zirconium oxide ceramic and 40 from lithium disilicate ceramic. 20 FPDs of each type underwent specific preliminary mechanical damage. 10 predamaged and 10 non-predamaged FPDs underwent artificial aging by storage in water for 220 days and both thermal (10,000 cycles, 5°C/55°C) and mechanical cycling (106 cycles, 100N). After cycling all FPDs were fixed to the polyurethane base with glass ionomer cement and loaded until failure in a universal testing instrument at a crosshead speed of 1mm/min. The data were analyzed using t-test and two-factor univariate variance analysis (for  $p < 0.05$ ).

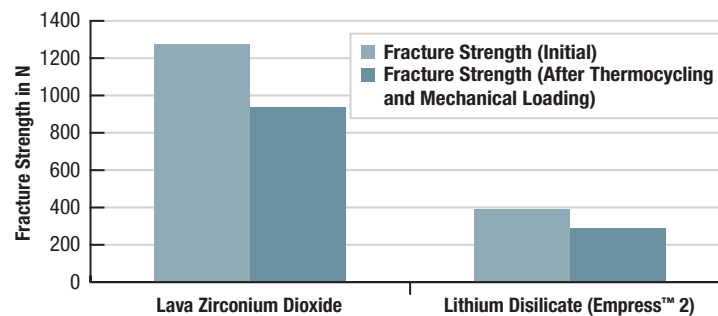
**Results:** Both with and without cyclic thermomechanical loading, with values of 1265N and 927N respectively, the zirconia FPDs did exhibit a significantly higher fracture resistance than the lithium disilicate FPDs, with values of 388N and 290N respectively. The cyclic thermomechanical loading resulted in a significant reduction of fracture resistance for both materials, while the mechanical predamage of the selected magnitude had no influence on loading capacity.

**Conclusions:** On the basis of the fracture resistance values obtained during the in-vitro study, it appears possible to extend the indication spectrum of zirconia FPDs to posterior four-unit FPDs.

**Aim of the Study:** The influence of preliminary mechanical damage as well as artificial aging on the strength of Lava™ zirconium oxide four-unit bridges in comparison to glass ceramic four-unit restorations was analyzed.

**Results of the Study:** The cyclic thermomechanical loading resulted in a reduction of fracture resistance for four-unit bridges of both materials, while the mechanical predamage of the selected magnitude had no influence on loading capacity. Moreover, Lava™ zirconium oxide showed a three times higher fracture strength.

**Fracture Strength of Four-Unit Lava™ Bridges with Two Pontics (Initial and After Thermocycling and Mechanical Loading)**



# 174

### Fracture Strength of Tooth Colored Posterior Fixed Partial Dentures

M. ROSENTRITT\*, M. BEHR, R. LAND, S. KLEINMAYER, G. HANDEL,  
 Department of Prosthetic Dentistry, University Clinics, Regensburg, Germany

The aim of this in-vitro study was to determine the fracture strength of adhesively luted tooth colored fixed partial dentures (FPD). 64 human molars were inserted in PMMA resin to simulate three-unit (10mm) oral situation. The roots of the teeth were covered with an about 1mm thick layer of polyether to simulate the periodontium. 8 bridges of each series were made of A) In-Ceram™ (Vita, G), B) Empress™ 2 (Ivoclar, FL), C) CAD/CAM Lava™ (3M™ ESPE™, G) and D) exper. design of fiber-reinforced composite and ceramic (Vectris-Empress™ 2, Ivoclar, FL). After thermal cycling and mechanical loading (TCML; 6000 thermal cycles [5°C/55°C], 1.2x10<sup>6</sup> mastication cycles [50N]) fracture strengths (UTM 1446; Zwick; v = 1mm/min) of 8 FPDs of each series were determined. Statistics: One-Way-Anova (p = 0.05).

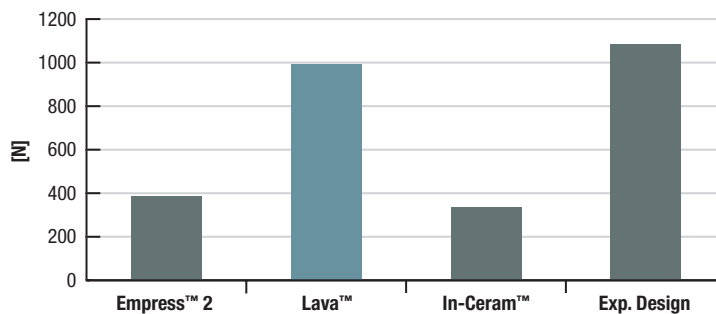
Fracture force [N]	Empress™ 2	Lava™	In-Ceram™	exp. Design
median	387	992	334	1087
25% percentile	330	815	315	968
75% percentile	445	1596	673	1215

In comparison to Lava™ and exp. FPDs the In-Ceram™ and Empress™ 2 restorations showed significantly lower fracture strength values. No differences could be found between Empress™ 2 and In-Ceram™, and between Lava™ and exp. Design. The fracture values are located at a limit where clinical application seems promising. This study was supported by 3M™ ESPE™, Germany.

**Aim of the Study:** The aim of this in-vitro study was to determine the fracture strength of adhesively luted tooth colored fixed partial dentures (FPD).

**Result of the Study:** In comparison to Lava™ zirconium oxide the In-Ceram™ and Empress™ 2 restorations showed significantly lower fracture strength values after thermal cycling and mechanical loading.

**Fracture Strength After Thermal Cycling and Mechanical Loading**





# 173

### In-Vitro-Investigations on the Fracture Strength of All-Ceramic Posterior Bridges of ZrO<sub>2</sub>-Ceramic

P. ROUNTREE\*, F. NOTHDURFT, P. POSPIECH, Dept. of Prosthodontics, Ludwig-Maximilians-University of Munich, Germany

All-ceramic bridges for the posterior region have been limited to the replacement of premolars due to the low tensile strength and fracture toughness of the available ceramic materials. However, with the introduction of new high-strength ceramic systems utilizing zircon-dioxide as the core-material, three- and four-unit-bridges should be possible. The aim of this in-vitro study was to investigate the fracture strength of three and four-unit-bridges made from zircon-dioxide ceca-mi (Lava™/3M ESPE). In addition, the influence of artificial aging on the fracture strength of these bridges was tested.

**Material and Methods:** In total 32 models with identical preparation designs (0.8mm chamfer) and resilient abutments were fabricated for two different situations: 1. missing lower first molar (three-unit); 2. missing lower second premolar and first molar (four-unit). The models were divided into four groups (table). Veneered zircon-dioxide bridges were fabricated according to the manufacturer's instructions. Core-dimensions and veneer-thickness were the same in all cases. 24 hours after cementation with Ketac™ Cem®, 8 bridges from each situation were artificially aged via a computer-controlled artificial-mouth (1.2 million cycles with 50N) and simultaneously a thermocycling process (10,000 cycles) was performed between 5 and 55°C with a dwelling time of 30 seconds. The fracture strength was tested by static loading of the bridges in the center of the pontics under an angle of 90°. Statistical analysis was performed using Mann-Withney-U-Test.

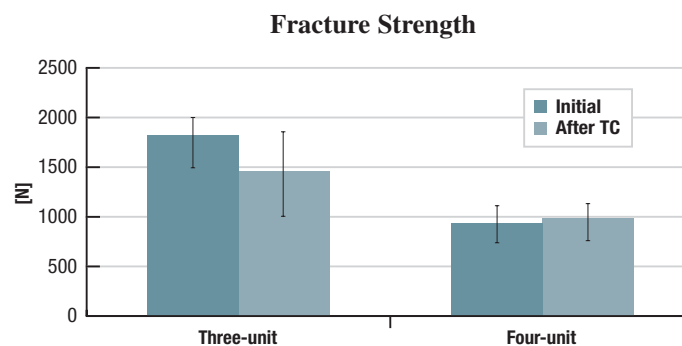
**Results:** The four-unit-bridges exhibited a significantly lower fracture strength in comparison to the three-unit-bridges. Artificial aging significantly lowered the fracture strength of the three-unit-bridges, whereas the fracture strength of the four-unit-bridges was not affected.

**Conclusion:** The fracture strength of the three-unit-bridges is adequate to justify their use in the posterior region, however, further investigations on the four-unit-bridges should be conducted before a general recommendation for their use can be made.

Group	Span-width	Chewing Simulation	Fracture Strength (mean/standdev.)
1	Molar	No	1816.9N/234.0
2	Molar	Yes	1457.6N/407.3
3	Premolar and Molar	No	930.3N/212.5
4	Premolar and Molar	Yes	978.5N/245.2

**Aim of the Study:** The aim of this in-vitro study was to investigate the influence of artificial aging on the fracture strength of three- and four-unit posterior Lava™ bridges out of zirconium dioxide as core material.

**Result of the Study:** The fracture strength of three-unit and four-unit bridges is sufficiently high for their use in the posterior region, even after thermocycling.





910

## Fracture Resistance of Posterior All Ceramic Zirconia Bridges

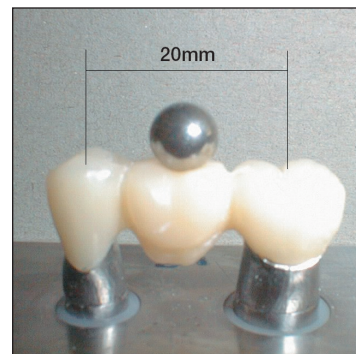
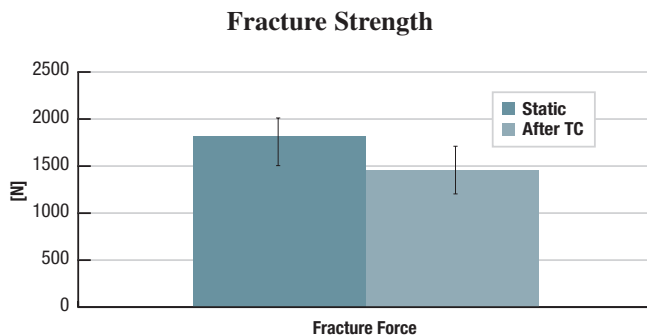
D. SUTTOR\*, H. HAUPTMANN, S. FRANK, S. HOESCHELER, 3M ESPE AG, Seefeld, Germany, P. POSPIECH, LM University of Munich, Munich, Germany

New all-ceramic restorations for posterior bridges, based on CAD/CAM technologies and polycrystalline ceramics, are currently investigated due to their outstanding physical properties. The aim of this study was, to compare the static and fatigue fracture resistance of three-unit posterior bridges (45-47) made with the Lava-System. Lava™ is a new all-ceramic system using CAD/CAM-manufactured zirconia frameworks. In total 16 identical frameworks with two posterior resilient supported metal-dies were fabricated. Cross section of the connector area was 11mm<sup>2</sup>, coping wall thickness 0.8mm and the span width 20mm. All bridges were veneered with a veneer ceramic specially developed for zirconia and cemented with Ketac™ Cem® (3M™ ESPE™). The bridges were divided into 2 groups. The static fracture strength of 8 bridges was tested in an universal testing machine (Instron, MT, USA). The load was applied perpendicular at the centre of the pontic until complete fracture occurred. For the fatigue tests 8 bridges were cycled at 50N over 1,200,000 cycles using a mastication and thermocycling (5°/55°) simulator (Willytec, Munich, Germany). The samples were then subsequently tested according to the static test setup until complete fracture occurred. The data of the static fracture strength (non-cycled) is comparable to other values of zirconia frameworks (Tinschert et al. DZZ 2000; 55:610-616). However, there was a significant difference between the cycled and non-cycled samples (pairwise t-test, 95% confidence level). This investigation showed, that although a strength reduction of approximately 20% between as received and fatigued samples is observed, the overall strength level of zirconia is sufficient for at least three-unit posterior frameworks.

Fracture Force [N]	Mean	SD
Static	1816	288
Cycled	1457	265

**Aim of the Study:** The aim of this study was to compare the initial static and fatigue fracture resistance of three-unit all ceramic posterior Lava™ bridges based on zirconium oxide and veneered with Lava™Ceram.

**Result of the Study:** Fatigue leads to a strength reduction, but the overall strength level of Lava™ bridges is still very high for the use in the posterior region.



### 0723

**Investigation of Connector Cross-sections for four-unit Zirconia Oxide Bridges**  
 H. HAUPTMANN, and B. REUSCH, 3M ESPE AG, Seefeld, Germany

**Objectives:** To achieve high aesthetic results and to create enough space for soft tissue management connectors should be kept as small as possible. Mechanical properties of frame ceramics could limit the minimal value of cross sections due to the fact that bite forces up to 1000N in cases of bruxism have been described in literature. The outstanding mechanical properties of zirconia like Lava™ frame (3M™ ESPE™) offers new opportunities for high loaded and highly aesthetically designed posterior bridges. The aim of this study was to determine the bending strength of different connector cross sections in a standardized posterior four-unit bridge situation.

**Methods:** The experimental set-up follows the suggestions described by P. Pospiech et al [JDentRes 79IADR Abstracts 2000/1014]. Series with 10 samples of a four-unit bridge (2 units between 2 abutments) were cemented on flexible embedded stainless steel stumps. The dimension of the 3 connectors per bridge was altered between 9mm<sup>2</sup> and 13mm<sup>2</sup>, and the shape was varied. An analytical evaluation of the Weibul parameters with the maximum likelihood method was used.

**Results:** Table listing the Weibul strength  $\sigma$  and Weibul modulus  $m$  for circularly shaped connectors.

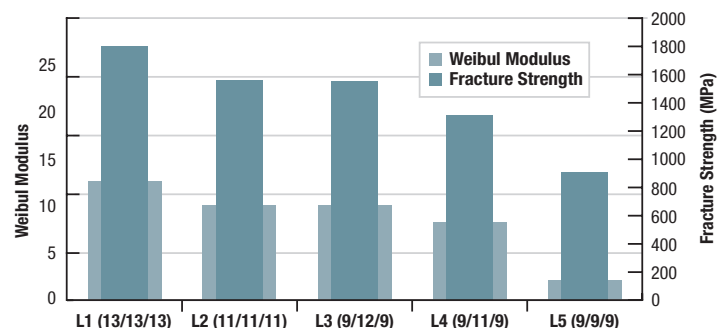
Serial	Connector Dim. [mm <sup>2</sup> ]	$\sigma$ [N]	Weibul Modulus $m$
L1	13/13/13	1801	10.8
L2	11/11/11	1558	9.1
L3	9/12/9	1554	9.2
L4	9/11/9	1311	7.7
L5	9/9/9	912	1.9

**Conclusions:** A connector cross section of 16mm<sup>2</sup> in minimum was recommended by some glass ceramic manufacturers for a posterior three-unit bridge. Zirconia overcomes these limiting factors both mechanically and aesthetically; four-unit bridges are now possible. The results shown allow us to predict the life time of the frame and give us the database for clinical studies.

**Aim of the Study:** Connector cross sections of bridges should be as small as possible due to aesthetic and functional reasons, but is often limited by the mechanical properties of the materials used. Some glass ceramics demand a connector cross section of 16mm<sup>2</sup>. The aim of this study was to obtain information about the stability of different connector cross sections for Lava™ bridges out of zirconium oxide.

**Result of the Study:** Based on the results for four-unit Lava™ bridges out of zirconium oxide a connector cross section of 9/12/9mm<sup>2</sup> is recommended for prosterior bridges optimizing aesthetic as well as functional demands.

**Weibul Strength Dependent on Connector Cross-sections**



998

## Fracture Strength of All-Ceramic Anterior Fixed Partial Dentures

K. LUDWIG\*, M. KERN, S. KLOPFER, Christian-Albrechts University at Kiel, Germany

The clinical success of all-ceramic restorations depends on the fatigue strength of the used ceramics. New systems with high fracture toughness are recommended to fabricate three-unit fixed partial dentures (FPDs). The aim of this study was to compare the static and fatigue fracture strength of anterior FPDs made from Lava™ (3M™ ESPE™, Germany) and Empress™ 2 (Ivoclar, FL). Lava™ is a new all-ceramic system using CAD/CAM-manufactured zirconia frameworks veneered with Lava™Ceram. Empress™ 2 is a new lithium-silicate based glass ceramic using the hot pressing procedure. In total, 36 casts with two anterior resilient supported metal-dies for the replacement of a first upper incisor were fabricated. 18 FPDs with identical dimensions (area of connectors between pontic and abutments 16mm<sup>2</sup>) were fabricated for each ceramic system. All FPDs were cemented with ProTec CEM (Ivoclar, FL). The FPDs were divided into 6 subgroups. The static fracture strength of 6 FPDs of each material was tested in a universal testing device. The load was applied at the center of the pontic at an angle of 30° to the long axis of the teeth. In the fatigue tests 6 bridges of the materials were treated with cyclic loading at 250N and 600N up to fracture events (veneer chipping or complete fracture) using a chewing simulator at 250N with thermocycling process. Results were listed and compared using the Kruskal-Wallis test (p<0.05). For the static fracture strength means are significantly different (Lava™: veneer chipping, Empress™ 2: complete fracture). The numbers of load cycles for first fracture events at 600N show no significant differences. Over 1,200,00 load cycles of 250N FPDs of both ceramics did not fracture.

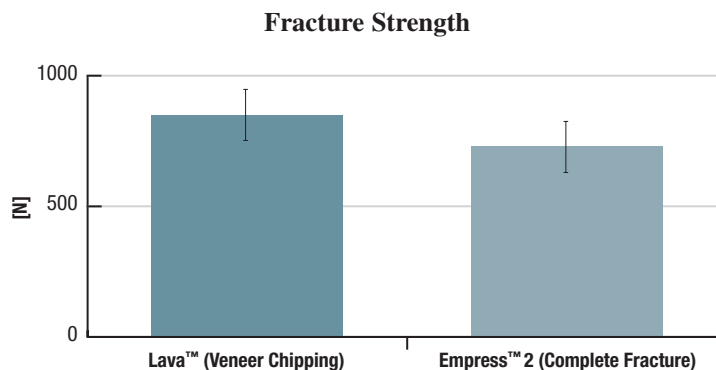
Considering the maximum chewing forces it seems possible to use the Lava™ as well as the Empress™ 2 system for anterior three-unit FPDs with high fatigue resistance.

This study was supported by Ivoclar and 3M™ ESPE™.

Ceramics	Static Load (Mean/SD) (Lava™: Veneer Chipping, Empress™ 2: Complete Fracture)	Amount of Cycles at 600N until Fracture (Mean/SD) (Veneer Chipping or Complete Fracture)
Lava™	848±68N	985±379
Empress™ 2	729±59N	765±308

**Aim of the Study:** The aim of this study was to compare the static and fatigue fracture strength of anterior three-unit fixed partial dentures made from Empress™ 2 or Lava™ zirconium oxide veneered with Lava™Ceram.

**Result of the Study:** Considering the maximum chewing forces, Lava™ bridges out of zirconium oxide and veneered with Lava™Ceram are recommended for three-unit FPDs with high fatigue resistance.



### 115

#### Fracture strength of Colored Zirconia Copings with Reduced Wall Thickness

A. BEHRENS, B. BURGER, H. HAUPTMANN, 3M ESPE AG, Seefeld, Germany

**Objectives:** The objective was to show that copings out of colored Lava™ Y-TZP-ZrO<sub>2</sub> (3M™ ESPE™) with a reduced wall thickness of 0.3mm have sufficient fracture strength for the anterior region in order to allow the clinician a less invasive preparation. By fractographic analysis the fracture mode of the copings was ensured to be similar to clinically occurring fracture modes.

**Methods:** A total of 48 coping were produced out of colored Y-TZP-ZrO<sub>2</sub>. 24 copings were prepared from a tangential and 24 from a champher preparation and each of these were further splitted in subgroups of 12 for the fabrication of wall thicknesses of 0.3mm and 0.5mm. The copings were cemented with glass ionomer cement (Ketac™ Cem®) on brass dies and fracture strength has been subsequently determined in a universal testing machine (Zwick). The load was applied by an indented punch via a tin foil to ensure a load distribution similar to veneered copings. Fractography was done with scanning electron microscopy.

Fracture strength (N)

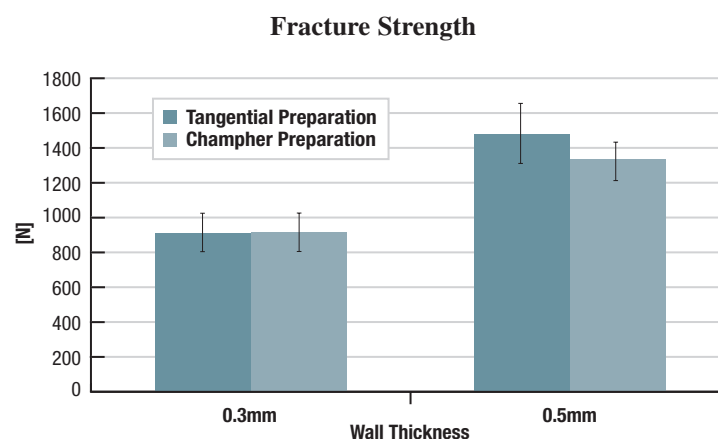
Wall thickness	Tangential Preparation			Champher Preparation		
	Mean (SD)	Min.	Max.	Mean (SD)	Min.	Max.
0.3mm	908 (115)	714	1185	913 (106)	729	1095
0.5mm	1476 (192)	1075	1672	1333 (107)	1180	1527

**Results:** There is no significant difference (Kruskal-Wallis test, Dunn's post test,  $p > 0.05$ ) of the fracture strength for co-pings fabricated with tangential or champher preparation but with the same wall thickness. However, there is a significant strength reduction between wall thickness of 0.5 and 0.3mm (Kruskal-Wallis test, Dunn's post test,  $p < 0.001$ ).

**Conclusions:** The fracture strength of Y-TZP-ZrO<sub>2</sub> copings with a wall thickness of 0.3mm is three times higher compared to the expected chewing forces in the anterior region.

**Aim of the Study:** The aim of the study was to show that a wall thickness of 0.3mm is sufficient in the anterior region for Lava™ crowns out of zirconium oxide.

**Result of the Study:** The fracture strength of the Lava™ crowns made out of zirconium oxide with reduced wall thickness was about three times higher compared to the expected chewing forces in the anterior region.



0578

**Bond Strength of a Self-adhesive Universal Resin Cement to Lava™ Zirconia after Two Surface Treatments**

D. BULOT<sup>1</sup>, A. SADAN<sup>1</sup>, J.O. BURGESS<sup>2</sup>, and M.B. BLATZ<sup>1</sup>, <sup>1</sup> Louisiana State University Health Sciences Center School of Dentistry, New Orleans, USA, <sup>2</sup> LSUHSC School of Dentistry, New Orleans, LA, USA

Surface treatment and cement selection are crucial for a strong resin bond to CAD/CAM-fabricated zirconium-oxide ceramic restorations (e.g., Lava™, 3M™ ESPE™). Current bonding systems require multiple adhesive steps and may be technique sensitive, unpredictable, and time consuming. The use of a self-adhesive resin cement might eliminate these disadvantages.

**Objectives:** This study measured shear bond strength of the self-adhesive universal resin cement RelyX™ Unicem (3M™ ESPE™, group I) to Lava™ zirconia compared to three common cement systems (Panavia™ F, Kuraray™ (group II); RelyX™ ARC, 3M™ ESPE™ (III); RelyX™ Luting, 3M™ ESPE™ (IV)). The ceramic surface was either subject to air-particle abrasion or Rocatec™ Soft (3M™ ESPE™) tribochemical surface treatment.

**Methods:** Lava™ zirconium-oxide ceramic samples were fabricated with the specific intaglio surface. 40 specimens were subject to air-particle abrasion (60µm aluminum oxide) and 40 specimens were subject to Rocatec™ Soft tribochemical surface treatment. Composite-resin cylinders (2.9mm dia.) were bonded to the ceramic samples with the above cements. After 72-h water storage, shear bond strengths were tested with an Instron model 4411. The data were analyzed with ANOVA and Duncan’s multiple comparison (α=0.05).

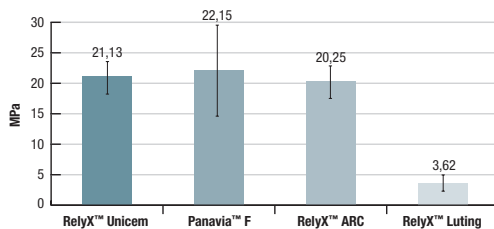
**Results:** Mean values [MPa] after sandblasting were: Group I 21.13±2.76 (a), Group II 22.15±6.78 (a), Group III 20.25±3.08 (a), Group IV 3.62±0.74 (b). Mean values after Rocatec™ treatment were: I 25.01±4.49 (c), II 25.38±4.07 (c), III 23.82±3.34 (c), IV 5.98±1.3 (d). Different letters in parentheses indicate statistically significant difference.

**Conclusions:** The self-adhesive resin cement RelyX™ Unicem of 3M™ ESPE™ revealed bond strengths comparable to or better than the other bonding systems under investigation. Bond strength with RelyX™ Luting was significantly lower than with the other cements. Surface treatment with the Rocatec™ system significantly improved bond strength for all bonding systems. Supported by 3M™ ESPE™.

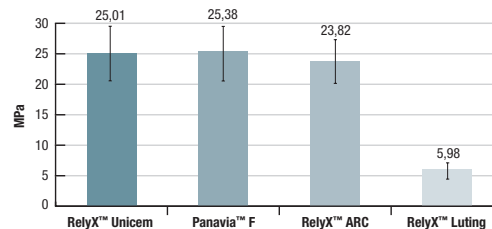
**Aim of the Study:** This study evaluated the shear-bond strength (MPa) of the self-adhesive universal resin cement RelyX™ Unicem™ to Lava™ zirconium oxide compared to three common cement systems after pre-treatment of air particle abrasion or tribochemical surface treatment with the Rocatec™ system. Shear-bond strengths were measured after 72-h water storage.

**Result of the Study:** The self-adhesive resin cement RelyX™ Unicem revealed bond strengths comparable to or better than the other bonding systems. Surface treatment with the Rocatec™ system significantly improved bond strength for all bonding systems.

**Shear Bond Strength [MPa] – Pretreatment of Lava™ Zirconium Oxide: Air Particle Abrasion**



**Shear Bond Strength [MPa] – Pretreatment of Lava™ Zirconium Oxide: Tribochemical Surface Treatment with Rocatec™ System**



1650

**Resin Bond to Lava™ Zirconia Intaglio Surface**

K. KOEHLER<sup>1</sup>, A. SADAN<sup>1</sup>, J.O. BURGESS<sup>2</sup>, and M.B. BLATZ<sup>1</sup>, <sup>1</sup> Louisiana State University Health Sciences Center School of Dentistry, New Orleans, USA, <sup>2</sup> LSUHSC School of Dentistry, New Orleans, LA, USA Cement Expansion in Saline

Clinical recommendations for resin bonding to CAD/CAM-fabricated high-strength ceramic copings (e.g., Lava™ zirconia, 3M™ ESPE™) widely depend on in-vitro studies that use ground and polished ceramic specimens. However, commercial products create a unique intaglio surface. In order to evaluate bond strength to a commercial product, one should use specimens with same intaglio surface the product has.

**Objectives:** Shear bond strengths of the bonding systems RelyX™ Unicem (UNI, 3M™ ESPE™), Panavia™ F (PAN, Kuraray™), RelyX™ ARC (ARC, 3M™ ESPE™), RelyX™ Luting (LUT, 3M™ ESPE™) were measured and compared to Lava™ zirconia intaglio surface. Bond strength to ground and polished Lava™ zirconia was the control.

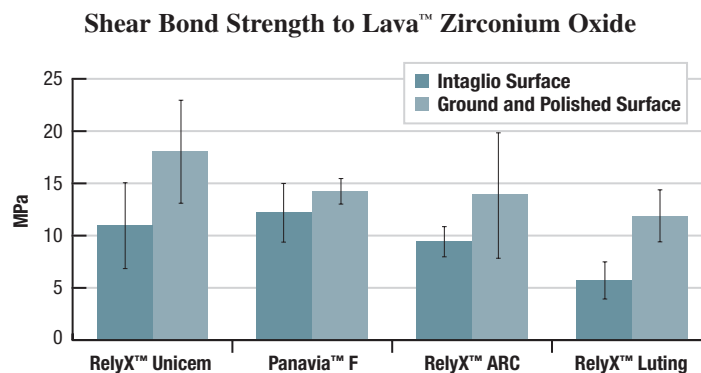
**Methods:** 80 square samples (10x10x2mm) were fabricated of Lava™ zirconia and randomly divided in two groups with different surfaces: (I) the system-specific intaglio surface and (II) a ground and polished surface. After ultrasonic cleaning, composite-resin cylinders were bonded to the zirconia specimens with the above cements. Shear bond strengths were tested with an Instron after 72 h storage in distilled water. The data were analyzed using ANOVA and Duncan's multiple comparison ( $\alpha=0.05$ ).

**Results:** For group I, mean bond strength values were: UNI 10.95±4.28 MPa (a), PAN 12.20±2.62 MPa (a), ARC 9.45±1.89 MPa (a), LUT 5.75±1.53 MPa (b). Mean values for group II: UNI 18.03±5.05 MPa (c), PAN 14.18±1.24 MPa (c), ARC 13.95±5.81 MPa (c), LUT 11.88±2.57 (d). Same letters in parentheses indicate no statistically significant difference.

**Conclusions:** Surface configuration had a significant influence on the bond strength to Lava™ zirconia: bond strength to the Lava™ intaglio surface was significantly lower than to the polished surface. UNI, PAN, and ARC were not different from each other but significantly higher than LUT, regardless of surface configuration. Supported by 3M™ ESPE™

**Aim of the Study:** The bond strength of different cements to Lava™ zirconium oxide was the subject of this study.

**Result of the Study:** The adhesive composite cements and RelyX™ Unicem showed significantly better adhesion than the resin-modified glass ionomer cement. By a process of grinding, the adhesion of all groups could be further increased.



0060

## Long-term Shear-bond Strength of Luting Cements to Zirconia Ceramic

A. PIWOWARCZYK, K. LINDEMANN, P. OTTL, and H.-C. LAUER, University of Frankfurt, Germany

**Objectives:** This study evaluated the long-term shear-bond strength of cements to zirconia ceramic (Lava™, 3M™ ESPE™) after two pre-treatment procedures.

**Methods:** One half of the zirconia samples were air-abraded with 100-micrometer alumina at 2.8 bar, 10 s at 10mm distance (pre-treatment I); the other half was tribochemically silica-coated with the Rocatec™ System (3M™ ESPE™) (pre-treatment II). Materials tested: 1a) PermaCem® self-cured (SC) (DMG), 1b) PermaCem® light-cured (LC), 2a) RelyX™ ARC SC (3M™ ESPE™), 2b) RelyX™ ARC LC, 3a) Panavia™ F SC (Kuraray), 3b) Panavia™ F LC, 4a) Variolink II SC (IvoclarVivadent), 4b) Variolink II LC, 5a) Nexus®2 SC (Kerr), 5b) Nexus®2 LC, 6a) Calibra® SC (DentsplyDeTrey), 6b) Calibra® LC, 7a) RelyX™ Unicem SC (3M™ ESPE™), and 7b) RelyX™ Unicem LC. Eight specimens per group were fabricated: Group (A) was aged and tested after 150d 37°C water storage; Group (B) 150d at 37°C water storage, then thermocycled (37.500X, 5-55°C). One-way ANOVA of variance was used to analyze the data (p<0.05).

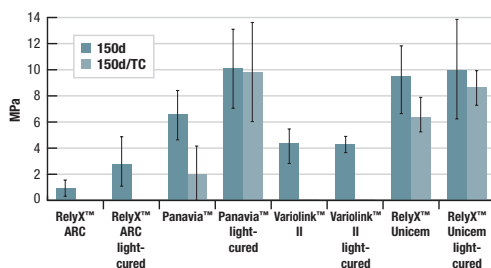
**Results:** Using pre-treatment I cements 3b, 7a and 7b showed highest shear-bond strengths independent of aging procedure. Using pre-treatment II the highest values were achieved by cements 7b and 1b with 13.4±1.1 MPa and 12.1±3.8 MPa in aging group (A). The highest results in aging group (B) were achieved for 4b with value of 11.2±4.5 MPa. 3b, 7b and 1b followed with results of 9.9±2.5 MPa, 8.9±2.1 MPa and 8.2±2.9 MPa respectively.

**Conclusions:** Bonding to air-abraded zirconia of cements 3b, 7a, and 7b was superior to all other materials independent of aging procedure. Most stable bonding to tribochemically silica-coated zirconia was found with cements 1a, 1b, 3b, 4b, 7a and 7b.

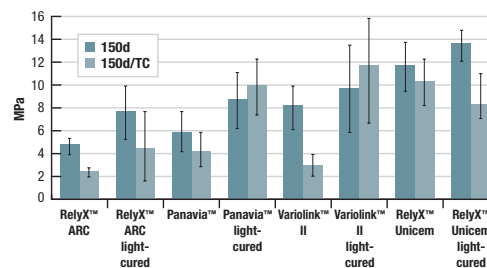
**Aim of the Study:** This study evaluated the shear-bond strength of different cements to Lava™ zirconium oxide after different pretreatments of the zirconium oxide surface and artificial aging after water storage and water storage in combination with thermocycling.

**Result of the Study:** Air-abraded Lava™ zirconium oxide showed one of the best bondings to RelyX™ Unicem LC and RelyX™ Unicem SC independent of the artificial aging. This was also confirmed by means of a pretreatment with the Rocatec™ System. Whereas in the case of a pretreatment with the Rocatec™ System the absolute values are higher in comparison to the sandblasted samples.

Lava™ / Al<sub>2</sub>O<sub>2</sub> Shear Bond Strength



Lava™ / Rocatec™ Shear Bond Strength





## 3178

### Adhesion of Glass Ionomer Cements to Crowns and Hard Tissues

A. FALSAFI, T.T. TON, B.R. BROYLES, and D.D. KRUEGER, 3M ESPE Dental Products, St. Paul, MN, USA

**Objectives:** The goal of this study was to compare the adhesion of different self-cure conventional and resin-modified glass ionomer luting cements to different crown materials. The cements used were three commercial RMGI materials: RelyX™ Luting or Vitremer™ Luting (RLC, 3M™ ESPE™), FujiCEM™ (FC, GC), FujiPlus™ (FP, GC); one commercial conventional GI: Fuji I (F1, GC); and one experimental RMGI cement (ExpC, 3M™ ESPE™). RLC, FP and F1 are powder/liquid systems while FC and ExpC are paste/paste.

**Methods:** For adhesion to Lava™, Procera® and Rexillum surfaces were sand-blasted. Five specimens of each category were cemented and allowed to cure at 37°C/95% RH for 20 minutes and immersed in 37°C deionized water for 24 hours. The bond strengths were measured in shear mode using Instron.

**Results:** The mean values including their standard deviations in the parentheses are summarized in the following table:

Luting Cement	Shear Bond Strength to Lava™ (Ad-L), MPa	Shear Bond Strength to Procera® (Ad-P), MPa	Shear Bond Strength to Metal (Ad-M), MPa
ExpC	27(3)	14(2)	11(3)
RLC	14(2)	11(3)	7(1)
FC	11(3)	9(1)	10(3)
FP	14(2)	10(3)	12(2)
F1	2.8(0.5)	2.8(1.6)	6.7(1.6)

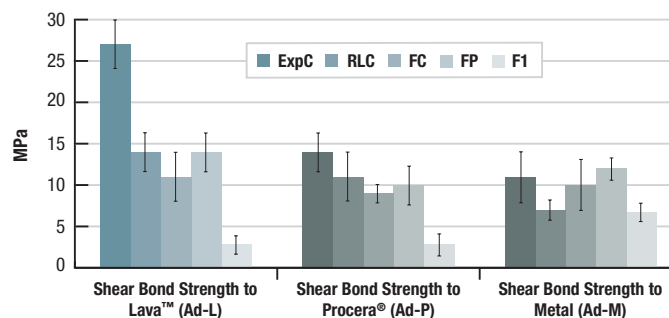
Comparison of different dispensing systems as well as adhesion to bovine enamel and dentin will be presented.

**Conclusions:** ANOVA analysis was performed at  $p < 0.05$ . ExpC had significantly higher adhesion to Lava™ and Procera® substrates than FC, FP, and F1. In general, resin-modified cements had significantly higher bond strengths to ceramics than F1 conventional cement.

**Aim of the Study:** The aim of the study was to measure shear bond strength of different selfcure conventional and resin-modified glass ionomer luting cements to Lava™ zirconium oxide in comparison to other crown materials.

**Result of the Study:** RelyX™ Luting Plus (=ExpC) had significantly higher adhesion to Lava™ zirconium oxide compared to the other crown and luting materials.

Adhesion of Glass Ionomer Cements to Crowns and Hard Tissues





1779

**Light Transmission Through All-Ceramic Framework and Cement Combinations**  
 D. EDELHOFF, University of Aachen, Germany, and J. SORENSEN, Oregon Health & Science University, USA

**Objectives:** This study quantified the light transmission through all-ceramic frameworks dependent on two luting materials (LM).

**Methods:** Disk shaped specimens (16x0.9mm) were made of various ceramics of shade A3 (Vident): **A)** Densely sintered Al<sub>2</sub>O<sub>3</sub>, **EX)** Experimental (OHSU-RWTH, Ivoclar Vivadent (IV)), **IA)** Infiltrated Al<sub>2</sub>O<sub>3</sub> (In-Ceram™ (IC) Alumina, Vident), **IS)** Infiltrated MgAl<sub>2</sub>O<sub>4</sub> (IC Spinell), **IAZ)** Infiltrated Al<sub>2</sub>O<sub>3</sub>/ZrO<sub>2</sub> (IC Zirconia), **L)** Lithium disilicate (Empress™ 2, IV), **Z)** ZrO<sub>2</sub>-Y<sub>2</sub>O<sub>3</sub> (Lava™, 3M™ ESPE™). Ceramic disks were covered with a 0.1mm layer of **1)** zinc phosphate (Harvard Dental) or **2)** dual cured resin cement (Variolink transparent, IV). As reference (**3)**), uncovered 1mm ceramic disks were employed. Samples (3/group) were tested after 30 days storage in artificial saliva. Light transmitted through the specimen was determined in a spectrophotometer (DU-7, Beckman) by direct transmission coefficient (t<sub>c</sub>) [%] for wavelengths (λ) from 400 to 700nm.

**Results:** Values are given as overall t<sub>c</sub>, calculated as integral 400–700 t<sub>c</sub>(λ)dλ, means (SD):

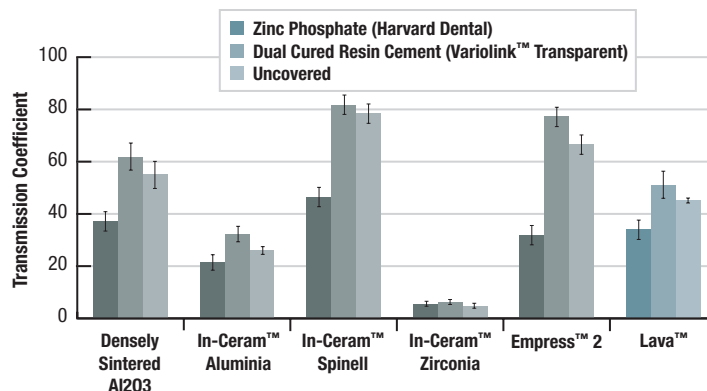
	Al <sub>2</sub> O <sub>3</sub>	EX	In-Ceram™	Spinell	In-Ceram™ Zirconia	Empress™	Lava™
1)	37.2 (3.0)ab	42.9 (3.8)b	21.6 (1.6)	46.6 (3.2)b	5.6 (0.7)I	31.8 (2.8)a	34.1 (2.3)a
2)	61.8 (5.0)c	400.6 (34.6)	32.4 (1.5)	81.8 (4.0)d	6.3 (0.9)I	77.3 (4.9)d	51.2 (5.8)Zc
3)	55.2 (4.4)	301.7 (47.8)	26.1 (0.3)	78.5 (3.6)	4.9 (0.6)I	66.7 (3.0)	45.3 (1.1)Z

**Conclusions:** ANOVA showed significant (p<0.05) differences among the overall t<sub>c</sub> values dependent on type of ceramic and LM (n.s.=same superscript). Overall t<sub>c</sub> increased significantly when LM-2 was used. Higher translucency ceramics showed greater sensitivity to luting material type than the more opaque ceramics.

**Aim of the Study:** The aim of the study was to show the dependence of light transmission on different luting cements.

**Result of the Study:** The more transparent materials showed a higher dependence on the luting material. Moreover, Lava™ zirconium oxide shows a high translucency compared to other materials like In-Ceram™, even though the lower wall thickness which is necessary for Lava™ restorations was not considered in this experiment and would further improve the translucency.

**Light Transmission Depending on Luting Material**



### P77

#### Bonding Characteristics of Lava™ Ceram on Lava™ Zirconia Core Material A. BEHRENS, B. BURGER and H. HAUPTMANN\* (3M ESPE AG, Seefeld, Germany)

**Objectives:** With the introduction of zirconia as core material new veneering porcelains have been developed. Lava™ Ceram (3M™ ESPE™, Germany) has been especially designed for the Lava™ zirconia (3M™ ESPE™, Germany) not only with respect to aesthetics, but also with respect to mechanical characteristics and thermal expansion coefficient. The aim of the study was to show the bonding mechanism between the core material and veneering porcelain with respect to the coefficient of thermal expansion and mechanical/chemical bonding.

**Methods:** Copings made of zirconia have been veneered with the veneering porcelain (Lava™ Ceram, 3M™ ESPE™), heated to different temperature and quenched in water to 23°C. The temperature where first crack formation in the overlain porcelain occurred was determined (thermo shock experiment) as indication of the residual stresses due CTE mismatch. Additionally, 22 zirconia specimens (d=15mm, h=2mm) have been veneered locally (d=6,1mm, h=4mm) with veneering porcelain, divided into two groups where one was immediately shear loaded until fracture whereas the other was first thermocycled (10,000, 5°/55°) and then shear load (1mm/min) has been applied. The fractured specimens were subsequently analyzed by light microscopy and/or SEM. Moreover, the veneering porcelain of a veneered zirconia specimen were partly etched in order to visualize and analyze the interface between the two materials. In comparison PFM samples (VitaOmega/Vita on Pors On 4/Degussa) were also shear bond tested.

**Results:** Thermoshock experiment showed a very high value of 150° which indicated very low presence of residual stresses which is in agreement with the small mismatch of the average coefficient of thermal expansion of DCTE≈0,5µm/m·K (e.g. Lava™ zirconia: 10,41µm/m·K, Lava™ porcelain MO A4: 9,97µm/m·K).

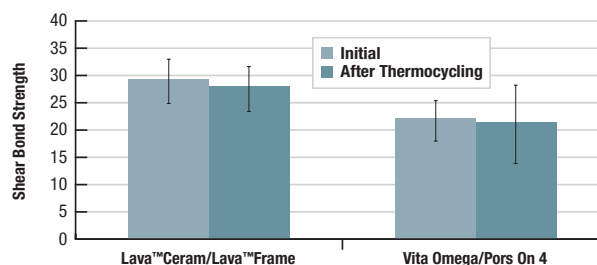
	Shear Bond Strength and StDev [MPa]	
	Initial	After Thermocycling
Lava™ Ceram/Lava™ Frame	28,9±4,0	27,5±3,9
Vita Omega/Pors On 4	21,6±3,6	20,9±7,0

The fracture in all cases was cohesive in the veneering porcelain. In comparison to the PFM system the shear bond strength is initially and after thermocycling on a very high level. As shown thermocycling has no significant impact to the shear bond strength.

**Conclusions:** The thermoshock tests, shear bond strength experiments in combination with SEM fracture analysis underline the results of clinical studies (see P. Pospiech University of Saarland, Homburg, IADR 2003, Abstract No. 0817, Gothenburg, SE) as well as other clinical cases over a observation period of more than 4 years.

**Aim of the Study:** The aim of the study was to show the bonding mechanism between Lava™ zirconium oxide and the veneering porcelain Lava™ Ceram with respect to the coefficient of thermal expansion and mechanical/chemical bonding.

**Result of the Study:** The results of this study show a very good and reliable bonding of Lava™ Ceram on Lava™ zirconium oxide.



### 0546

#### Strength of Zirconia Single Crowns Related to Coping Design

J. FISCHER, Dental School, Bern, Switzerland

**Objectives:** Zirconia frameworks for crowns and bridges can be manufactured by means of CAD/CAM. For esthetical reasons these frameworks have to be veneered with feldspar ceramics. Aim of this study was to evaluate the resistance of veneered zirconia single crowns to thermal stress and their fracture strength using two different framework designs.

**Methods:** A model of an upper canine with a circumferential shoulder was fabricated in a CoCr alloy and cast in stone. The stone die was scanned and 88 zirconia frameworks were produced (Lava™, 3M™ ESPE™, Seefeld, Germany). 44 of these copings were designed with a constant wall thickness, 44 were anatomically shaped to support the veneering ceramic, following the philosophy for the fabrication of metal-ceramic restorations. These groups were divided into subgroups with 22 frameworks either veneered with Lava™Ceram (3M™ ESPE™) or with Cerabien ZR (Noritake, Nagoya, Japan) using a gauge to get the same dimension for all veneers. Of each group 12 samples were subjected to a thermal shock test. For this test the samples were heated for half an hour to 90°C, quenched in ice water and examined under a microscope (40x) for cracks. This procedure was repeated, each time increasing the temperature by 15K up to 165°C. In addition with the remaining 10 samples of each group fracture strength was measured, cementing the crowns with a glassionomer cement (Ketac™ Cem®, 3M™ ESPE™) on the metal master die and applying a load in an angle of 45° to the incisal edge.

**Results:** The thermal shock test revealed no relevant differences between the four subgroups. Fracture strength of both Lava™Ceram and Cerabien ZR were similar, but fracture strength increased by 30% with an anatomical design.

**Conclusions:** It is advantageous to fabricate zirconia frameworks with an anatomical design.

**Aim of the Study:** The influence of an optimal support of the veneering ceramic by the zirconium oxide framework was analyzed.

**Result of the Study:** An anatomical design of the zirconium oxide coping created by the wax knife feature of the Lava™ software improved the strength of the whole restoration due to optimization of the veneering ceramic layer.

### 1764

#### Marginal Fit of Zirconia Restorations with Three/Four Abutment Teeth

G. HERTLEIN, R. FRANKE, C. WASTIAN, and K. WATZEK, 3M ESPE AG, Seefeld, Germany

**Objectives:** The clinical success of CAD/CAM produced restorations highly depends on the mechanical properties and the design of the restoration, but also on the accuracy of the CAD/CAM process. This accuracy is clinically expressed in the marginal fit. With increasing number of abutment teeth in restorations a good marginal fit becomes more challenging. The aim of this study was to determine the marginal fit of restorations made of zirconia with three or four abutment teeth.

**Methods:** Restorations of 5 different clinical situations of four-unit bridges and four splinted crowns, respectively, were manufactured from Lava™ zirconia by means of the Lava™ System (3M™ ESPE™ AG). After manufacturing each framework coping was cemented on the scanned dies and subsequently embedded into acrylic. Specimens were sectioned faciolingually and mesiodistally. A stereomicroscope and a special analyzing software (analysis, Soft Imaging-System GmbH) were used for the determination of marginal opening (MO) and absolute marginal opening (AMO) of the cross-sections. The data were compared to previous results of three-unit bridges with two abutments.

**Results:** There is a significant difference of the MO values between the three indications with a higher MO of four splinted crowns (One-way ANOVA,  $p < 0,05$ , Tukey Test). However, the marginal fit of four splinted crowns is comparable and better, respectively, than the literature despite the high number of abutment teeth (Tinschert et al. 2001, Boenig et al. 2000, May et al. 1998, Beuer et al 2003, Kerschbaum et al. 1998). The AMO values are not significantly different (One-way ANOVA).

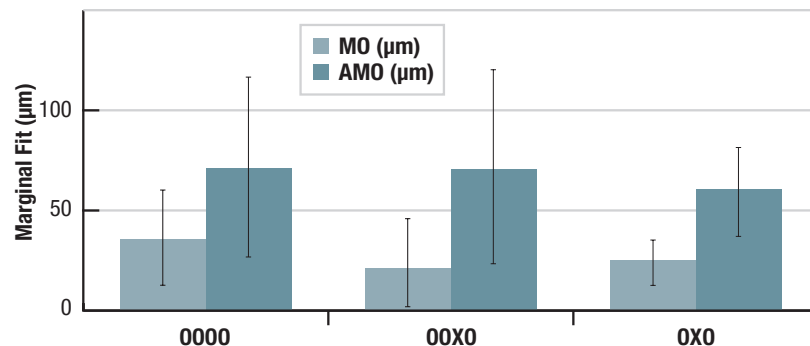
Indication	MO (µm)	AMO (µm)
OOOO	38±22 (n=20)	72±43 (n=20)
OOXO	24±20 (n=27)	71±46 (n=27)
OXO	25±10 (n=30)	59±21 (n=30)

O=abutment tooth, X=Pontic

**Conclusions:** With a mean MO value lower than 50µm, four-unit bridges with three abutments and four splinted crowns, respectively, made of zirconia showed a very good marginal fit.

**Aim of the Study:** The marginal fit of CAD/CAM fabricated Lava™ zirconium oxide restorations with three and four abutment teeth were determined.

**Result of the Study:** Four-unit bridges with three abutments and four splinted crowns made by the Lava™ system showed a very good marginal fit.



1455

**Milling Time vs. Marginal Fit of CAD/CAM-manufactured Zirconia Restorations**  
G. HERTLEIN, M. KRAEMER, T. SPRENGART, and K. WATZEK, 3M ESPE AG,  
Seefeld, Germany

**Objectives:** Faster manufacturing of all-ceramic restorations is the key factor for the economic performance of a CAD/CAM system. On the other hand clinical relevant parameters which are determining the quality of the final restoration should not be influenced by the milling time. The aim of this study was to determine whether the marginal fit of CAD/CAM manufactured zirconia bridges is deteriorating if the milling time is decreased. This reduction was achieved by optimizing the milling strategies and the processing parameters.

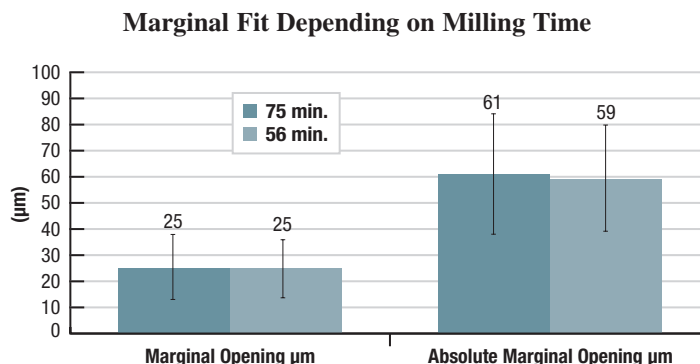
**Methods:** The Lava™ (3M™ ESPE™ AG) zirconia bridge frameworks were processed with the Lava™ System. After manufacturing each framework coping was cemented on the scanned dies and subsequently embedded into acrylic. Specimens were sectioned faciolingually and mesiodistally. A stereomicroscope and a special analyzing-software (analysis, Soft Imaging System GmbH) were used for the determination of the marginal opening (MO) and the absolute marginal opening (AMO) of the cross-sections (acc. to Homes et al., J. Prosth. Dent. 1989;62:405-408). Five samples (two anterior and three posterior 3 unit-frameworks) were milled in the standard process (75 min) and the optimized process (56 min). Six data points per sample were equally spaced around the margins (n=30).

**Results:** For the two milling times (75 and 56 min respectively) we found the following means for the MO- and AMO-values in  $\mu\text{m}$ : MO:  $25\pm 12$ ;  $25\pm 10$ ; AMO:  $61\pm 25$ ;  $59\pm 21$ . These values are comparable to the data of CAD/CAM manufactured In-Ceram™ zirconia bridges from Vita (Tinschert et al., Oper Dent 2001;26(4):367-374). No difference between the standard and the faster milling process was observed within the MO and AMO-groups by using additional statistical analysis (One-way ANOVA;  $p\geq 0,05$ ).

**Conclusions:** A reduction of the milling time for three-unit zirconia bridge frameworks by 25% results in the same precision of fit (AMO:  $59\pm 21\mu\text{m}$ ) like the standard milling process.

**Aim of the Study:** This study evaluated the influence of the milling time and the corresponding milling process optimization steps respectively on the marginal fit of Lava™ zirconium oxide bridges. The bridges were produced with the Lava™ CAD/CAM System. The time could be reduced by optimizing the milling strategies and the processing parameters.

**Result of the Study:** No difference between the standard and the faster milling process was observed concerning the marginal fit within the MO and AMO-groups. The Lava™ system makes it possible to reduce the milling times for three-unit bridges by 25% while ensuring the same quality.



# 1092

### Marginal Fit of CAD/CAM Manufactured All Ceramic Zirconia Prostheses

G. HERTLEIN\*, S. HOESCHELER, S. FRANK, D. SUTTOR, 3M ESPE AG, 82229 Seefeld, Germany

The use of presintered zirconia blanks for CAD/CAM manufactured prostheses has the advantage of reduced production time and less tool wear. However, in contrast to metals, the sintering shrinkage has to be controlled to a high accuracy. The aim of this work was to verify whether the same precision of fit can be achieved by using either presintered zirconia or metal (brass, titanium). The hereby used CAD/CAM system which 3M™ ESPE™ is currently developing consists of an optical scanner device, a software module and a three axis milling machine. Conventional cutting tools were used for shaping the coping. After manufacturing each coping was cemented on the scanned dies using a bonding (Nimetic-Bond®, 3M™ ESPE™) and subsequently embedded in epoxy. Specimens were sectioned faciolingually and mesiodistally. A stereomicroscope and a special analyzing-software (analySIS, Soft Imaging System GmbH) was used for the determination of the marginal opening (MO) and the absolute marginal opening (AMO) of the cross-sections (acc. to Holmes et al., J. Prosth. Dent. 1989;62:405-408). Anterior teeth, molar and premolar copings were used for these investigations. For each material five crowns with three points of measurements each were taken for statistic evaluation (see table below). All data points were equally spaced along the crown margins.

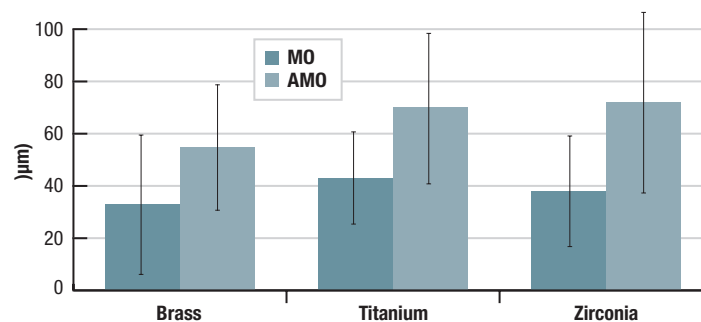
	Brass	Titanium	Zirconia	
MO:	33±25µm	43±19µm	38±20µm	(means ± standard deviations; n=15)
AMO:	55±24µm	70±22µm	72±36µm	(means ± standard deviations; n=15)

These values are comparable to the data of Procera® crowns (May et al., J. Prosth. Dent. 1998;80:394-404). No difference between the considered materials was observed within the MO and AMO groups by using additional statistical analysis (pairwise t-test, p≤0.05). This investigation showed that the used presintered zirconia blanks can be machined and sintered to the same high precision (AMO: 72±36µm) as achieved with metals, e.g. titanium (AMO: 70µm±22µm).

**Aim of the Study:** The aim of this work was to verify whether the same precision of fit can be achieved by using either presintered zirconium oxide or metal (brass, titanium) within the CAD/CAM process of the Lava™ system.

**Result of the Study:** No statistical significant differences between the investigated materials were observed. By using the Lava™ system presintered zirconium oxide blanks can be machined and sintered to the same high precision as achieved with metals, e.g. titanium. Milled Lava™ zirconium oxide restorations show an excellent marginal fit.

**Marginal Fit of Crowns**



## 0122

### Marginal Adaptation of CAD-CAM ZrO<sub>2</sub> Ceramic with Different Cements

M. ROSENTRITT\*, M. BEHR, R. LANG, G. GRÖGER, G. HANDEL, Department of Prosthetic Dentistry, University of Regensburg, Germany

The aim of this study was to investigate the marginal adaptation between CAD-CAM ZrO<sub>2</sub> all-ceramic fixed partial dentures (FPDs) and human teeth using different cements. 32 three-unit FPDs were fabricated of the CAD-CAM ZrO<sub>2</sub> all-ceramic Lava™/Lava™Ceram (3M™ ESPE™, G) and fixed on human molars using the resin composites Variolink II/Syntac Classic (Ivoclar-Vivadent, FL), Panavia F/ED (Kuraray, J), Compolute™/EBS™ Multi and a novel self-adhesive universal resin cement RelyX™ Unicem (both 3M™ ESPE™). Before and after thermal cycling and mechanical loading (TCML: 6000x5°/55°C, H<sub>2</sub>O, 2 min. each cycle, 1.2\*106x50N) the marginal adaptation was determined using scanning electron microscopy on resin replica. Microleakage was assessed at the cervical margins by a dye penetration test after TCML (0.5% fuchsine sol., 16 hrs).

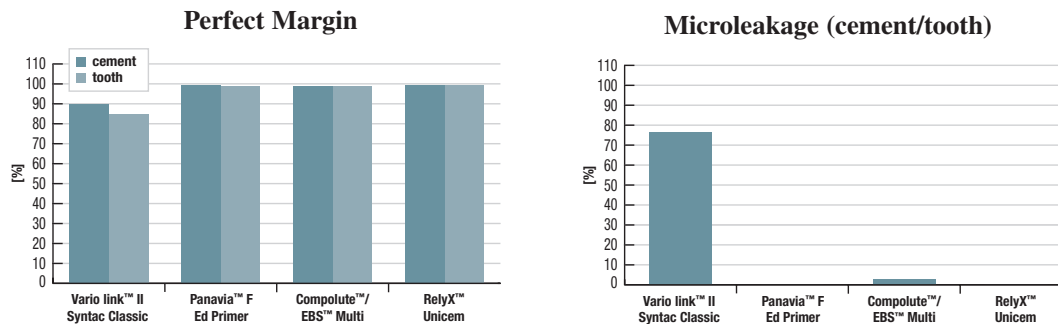
**Statistics:** Mann-Whitney-U-test (p ≤ 0.05).

Before/After TCML	Margin:	Variolink 2	Panavia F	Compolute™	RelyX™ Unicem
Perfect Margin [%]	cement/tooth	90.0/85.0	99.5/99.0	99.0/99.0	99.5/99.5
	cement/crown	92.0/85.5	99.0/99.0	100.0/98.5	98.5/98.0
Microleakage [%]	cement/tooth	76.5	0.0	3.0	0.0
	cement/crown	100.0	3.5	2.5	0.0

After stress simulation, all cements showed comparable good marginal adaptation to the CAD CAM ceramic Lava™, only for Variolink II significantly lower parts of perfect margin and higher micro-leakage were found. For RelyX™ Unicem without bonding no differences were found in comparison to Compolute™ or Panavia F. Panavia F, Compolute™ and RelyX™ Unicem showed no limitation for the cementation of CAD-CAM ZrO<sub>2</sub> FPDs.

**Aim of the Study:** This study examined the marginal adaptation and marginal seal of fixed Lava™ bridges out of zirconium oxide and veneered with Lava™Ceram that were cemented using different cements and subsequently were exposed to mechanical as well as thermal load in the mastication simulator.

**Result of the Study:** RelyX™ Unicem showed the same excellent results after the stress test as did Panavia™ F/Ed Primer and Compolute™/EBS™ Multi.





### 1355

**Clinical Connector Dimensions of CAD/CAM-produced All-ceramic FPDs**  
S. REICH, University of Erlangen-Nuremberg, Germany

**Objectives:** The aim of this investigation was to evaluate the clinical practicability of the connector dimensions of two machinable ceramic framework materials for three unit FPDs up to a maximum total length of 30mm.

**Methods:** 20 patients, who showed the indications of a three unit FPD were divided into two groups by chance. For group [A] In-Ceram™ zirconia frameworks [ZIR] were milled with the Cerec® Inlab™ system and for group [B] Y-ZrO<sub>2</sub> [ZRO] frameworks were manufactured with the Lava™ system. Before laminating, the mesial and distal connector dimensions, the mesial and distal maximum vertical dimension of the connectors and the distance between mesial and distal abutment were measured and compared with the respective manufacturers recommendations. The data of [ZIR] and [ZRO] were statistically compared with the CHI square test whether the recommended connector dimensions could be kept or not.

**Results:** In the [ZRO] group the dimensions of 19 out of 20 connectors (10 frameworks, 2 connectors each) were within the recommended dimensions. One connector (8.8mm<sup>2</sup>) was below its recommendation of 9mm<sup>2</sup>. In the [ZIR] group it was not possible to keep the recommended connector dimensions due to limited intraoral dimensions in 16 cases.

Group	N	Recommended Dimension Kept	Recommended Dimension Not Kept
[A]	20	4	16
[B]	20	19	1

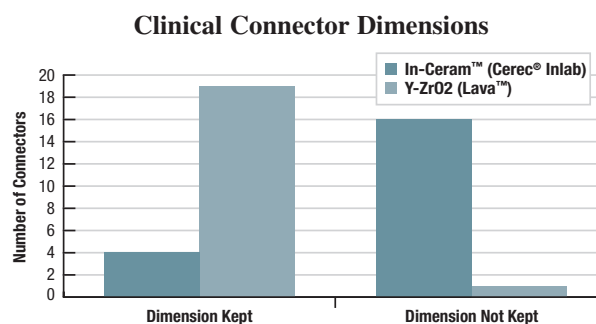
According to the CHI square test the data between [A] and [B] differ significantly at p≤.05.

**Conclusions:** The recommended connector dimensions for [ZIR] are still based on the zirconia slip cast technology and might not consider the improved material properties of standardized manufactured machinable [ZIR] material. According to the results of this investigation [ZRO] promises a wider range of indications. With respect to these facts pure ZrO<sub>2</sub> machinables have been developed for the Cerec® InLab™ meanwhile.

Granted by 3M ESPE AG, Vita Zahnfabrik, Sirona Dental Systems

**Aim of the Study:** This study evaluated the clinical practicability of the connector dimensions of In-Ceram™ zirconia frameworks (Cerec® Inlab™) and Lava™ zirconium oxide frameworks (3M™ ESPE™) for 3 unit bridges up to 30mm length.

**Result of the Study:** In the Lava™ zirconium oxide (3M™ ESPE™) group 19 out of 20 connectors kept the recommended connector dimensions whereas only four kept it in the In-Ceram™ zirconia (Cerec® Inlab™) group. Therefore, Lava™ zirconium oxide promises a wider range of indications from a functional as well as an aesthetical view.





0226

## Clinical Efficacy of Y-TZP-Based Posterior Fixed Partial Dentures

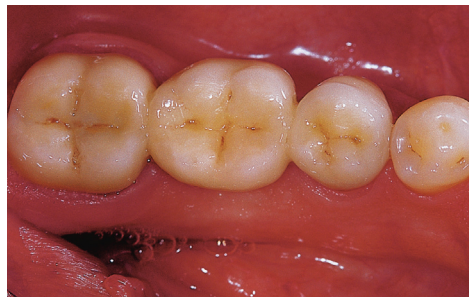
A.J. RAIGRODSKI<sup>1</sup>, G.J. CHICHE<sup>2</sup>, N. POTIKET<sup>2</sup>, J.L. HOCHSTEDLER<sup>2</sup>, S.E. MOHAMED<sup>2</sup>, S. BILLIOT<sup>2</sup>, and D.E. MERCANTE<sup>2</sup>, <sup>1</sup> University of Washington, Seattle, USA, <sup>2</sup> Louisiana State University, New Orleans, USA

**Objectives:** To assess the clinical efficacy of yttrium tetragonal zirconia polycrystals (Y-TZP)-based posterior three-unit fixed partial dentures (FPDs).

**Methods:** Subjects missing either a second premolar or a first molar, who have maintained their mesial and distal abutments and their opposing dentition, and who have signed a consent form approved by LSUHSC IRB, were enrolled in the study using specific inclusion and exclusion criteria. Twenty FPDs (Lava™, 3M™ ESPE™) were placed in 16 subjects. All abutment teeth were prepared in a standardized manner: Occlusal reduction of 1.5–2mm; axial reduction of 1–1.5mm with 10° taper; finish line design of a 360° rounded shoulder one millimeter in width, located 0.5mm subgingivally on the facial aspect and supragingivally on the lingual aspect on sound tooth structure; All line angles were rounded. Pontic design was modified ridge-lap type. Impressions were made with a vinyl polysiloxane material (Express™, 3M™ ESPE™). Y-TZP frameworks were fabricated using CAD/CAM technology with a thickness of 0.6mm, and a connector surface area of no less than 9mm<sup>2</sup>. The FPDs were luted with resin-modified glass ionomer cement (Rely-X luting, 3M™ ESPE™). Recall appointments were made after 2 weeks, 6, 12, 18, and 24 months. Clinical-fracture measurements, margin discoloration, marginal adaptation, radiographic proximal recurrent decay, and periapical pathoses were all assessed overtime with modified Ryge criteria.

**Results:** The mean follow-up period was 12.6 months (in September 2004), and all 20 FPDs but one were rated as alpha in all measured parameters. No failures were observed. Minor chipping of veneering porcelain was detected in one FPD rated beta.

**Conclusions:** Y-TZP posterior three-unit FPDs have performed well after short-term service. Additional follow-up is required to determine their long-term efficacy.



**Aim of the Study:** The clinical performance of posterior three-unit Lava™ zirconium oxide bridges have been determined.

**Result of the Study:** After a mean observation time of one year no failure of a Lava™ zirconium oxide restoration was observed. All FPD but one were rated as alpha in all measured parameters.

# 0817

### Clinical Evaluation of Zirconia-based All-ceramic Posterior Bridges: Two-year Results

P.R. POSPIECH<sup>1</sup>, P.R. ROUNTREE<sup>2</sup>, and F.P. NOTHDURFT<sup>1</sup>, <sup>1</sup> Saarland University/Homburg, Homburg/Saar, Germany, <sup>2</sup> Ludwig-Maximilians-University, Munich, Germany

With modern CAD/CAM-Systems high-strength zirconia ceramics can be used for the fabrication of all-ceramic crowns and bridges. Conventionally fixed bridges including the replacement of molars are now recommended by the manufacturer. Previous own in-vitro experiments on three and four-unit posterior bridges revealed high enough strength results that a clinical study could be ventured.

**Objectives:** The purpose of this prospective study was to observe the clinical performance of posterior bridges for the replacement of molars.

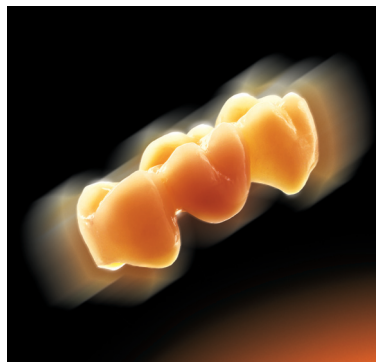
**Material and Methods:** Since October 2000 a total of 38 bridges were placed in 36 patients: All abutments were prepared for full crowns. A chamfer of 1.2mm depth was prepared in all cases. Impressions were made with the polyether materials Impregum™ Penta™/Permadyne™. The wall-thicknesses of the zirconia-core were constant 0.6mm, the connector area was designed with a cross-sectional plane of 9mm<sup>2</sup>. The bridges were cemented conventionally with the glass-ionomer cement Ketac™ Cem®. Recalls were made after 2 weeks, 6, 12 and 24 months. Judgments were made on the fit of the bridges on the abutments, discoloration of the marginal gingiva, the quality of the surface, failures and allergenic reactions.

**Results:** All bridges were only inserted with a perfect marginal fit. In three cases the zirconia frames had to be milled two times. The mean observation-period was 16.8 months (in October 2002). No total failures were observed, in one case a small chipping of the veneering material happened. No allergenic reactions and negative influences on the marginal gingiva could be observed.

**Conclusions:** After two years of clinical service one can conclude a good performance of zirconia based posterior bridges although the time of clinical service is not long enough for general recommendations. This study was supported by 3M™ ESPE™, Seefeld, Germany.

**Aim of the Study:** This study evaluated the clinical performance of posterior Lava™ bridges out of zirconium oxide and veneered with Lava™Ceram. The mean observation time was 16.8 months.

**Result of the Study:** No total failures, no allergenic reactions nor negative influences on the marginal gingiva could be observed. A very good performance of Lava™ posterior bridges can be concluded after two years.



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## Long-term Behavior of Zirconia-based Bridges (Lava™): Results After Three Years in Service

P. POSPIECH, F. NOTHDURFT Dept. of Prosthetic Dentistry and Dental Materials Science, Saarland University, Homburg, Germany

Using CAD/CAM-processing high-strength zirconia ceramics can be used even for the fabrication of all-ceramic bridges. The strength of the materials allows the conventional cementation which simplifies the daily clinical life. Some in-vitro studies on three- and four-unit posterior bridges revealed that the strength is high enough to run controlled clinical studies.

**Objectives:** The purpose of this prospective study was to observe the clinical performance of posterior bridges for the replacement of molars.

**Material and Methods:** Since October 2000 a total of 35 bridges were placed. All abutment teeth were prepared for full crowns. A chamfer with a depth of maximum 1.2mm was prepared in all cases. Impressions were made with the polyether materials Impregum™ Penta™/Permadyne™. The axial wall-thicknesses of the zirconia-cores were constant 0.6mm, the connector area was designed with a cross-sectional plane of minimum 9mm<sup>2</sup>. The bridge frameworks were veneered with the newly developed overlay porcelain Lava™Ceram. All restorations were cemented conventionally with the glass-ionomer cement Ketac™ Cem®. Recalls took place in December 2003 after an observation time of three years. 30 bridges could be evaluated at that time. Judgements were made on the fit of the bridges on the abutments, discoloration of the marginal gingiva, the quality of the surface, failures and allergic reactions.

**Results:** All bridges were only inserted with a perfect marginal fit. No changes in fit or secondary caries were observed. No total failures happened, in one case a small chipping of the veneering material took place. No allergic reactions and negative influences on the marginal gingiva could be observed.

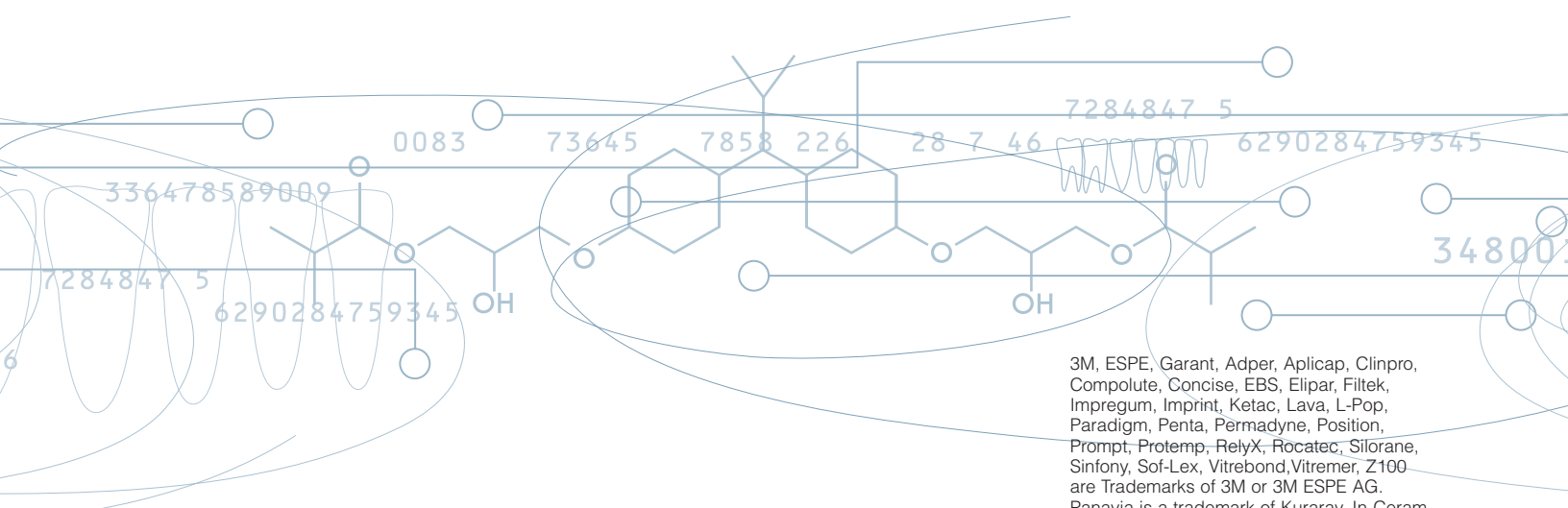
**Conclusions:** After three years of clinical service one can conclude a high performance of zirconia based posterior bridges.

This study was supported by 3M ESPE, Seefeld, Germany.

**Aim of the Study:** This study evaluated the clinical performance of posterior Lava™ bridges out of zirconium oxide and veneered with Lava™Ceram.

**Result of the Study:** No total failures, no allergic reactions nor negative influences on the marginal gingiva could be observed. A very good clinical performance of Lava™ posterior bridges can be concluded after up to three years.





## 3M ESPE

### Dental Products

3M Center  
Building 275-2SE-03  
St. Paul, MN 55144-1000  
USA

### 3M Canada

Post Office Box 5757  
London, Ontario N6A 4T1  
Canada  
1-800-265-1840 ext. 6229



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